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Editorial

Information Technologies: From the Theory to Practice

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Information technologies are currently intensely deployed worldwide, being one of the key paradigms of the computer and internet technology. In this context, the application area generated by users is going to heavily spread in the near future, as a result of the variety of offers and services available to users. Thus, there is the need of performing an overview of current status of information technologies.

This Vol. 2016, No. 17A of RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao presents actual papers on main topics of Journal specialization, namely the application of information technologies in the real world from the theory to practice. All the 30 selected extended articles were presented at the panel discussion on Information Studies and Research held in July 2015 in China, which aims to promote the exchange of ideas that will help develop the computer engineering, information technology, online engineering education and other relevant spheres of the global community.

This edition is the continuation of our publishing activities, all the included contents were anonymously reviewed to maintain academic excellence and integrity. We would like to thank all those who kindly contributed to this issue. We hope this issue of the journal will be interesting for research community.

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Revista Ibérica de Sistemas e Tecnologias de Informação
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Research of Trust Prediction Frameworks Based on the Trust Network and User Rating Behavior

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Abstract: With the rise and development of social networks, a large number of people have become social network members, and most networks have a trust relationship. Connecting users in the trust network can largely improve the quality of their recommendations. Trust assessment of user rating behavior requires future user trust ratings, and therefore it is necessary to scientifically predict the behavior trust ratings of future users. Focusing on the trust relationship among social network members, according to the basic norm of user trust ratings, the Bayesian network mathematical model based on trust in user rating behavior is employed to build a trust prediction framework grounded upon trust network and user rating behavior. By introducing user trust degree as a supplement to similarity, trust degree and similarity of user tastes in social networks are considered to predict to what extent other users trust the target user in a social network, including global trust and local trust. The actual metric analysis has found that the prediction model for user rating behavior based on the trust network in this paper has accurate predictions of trust degree of the target users.

***Keywords**:* Trust network; User rating behavior; Trust prediction; Global trust; Local trust

1. Introduction

In social networks, each user has their own attributive characters, so this paper sets forth from user attributive characters to quantitatively analyze their attributes by using user individual data. Some domestic companies have begun to carry out works in terms of trusted computing terminal and network security, and the 3rd Chinese Conference on Trusted Computing and Information Security was held in October 2008 (Bakio lu B S., 2015), but trusted computing currently merely provides only the computer platform trust but not the whole network trust. Therefore, efforts should be made to be further extend trust to the entire network. In 2008, the National Natural Science Foundation of China (NSFC) also highlighted content related to network trust (Marsh H., 2015); the Network Control Research Group in Department of Computer Science and Technology of Tsinghua University has performed a large number of prospective studies regarding trusted networks (Yakovlev A., 2006), trusted network development and research of scientific problems (Bell M, Walsh C A., 2015), trust evaluation, prediction and control of user rating behavior (Guillemin F M, Mazumdar R R., 2015), from trusted computing to trusted network (Schaffer V., 2015), the next generation of controllable, trusted and scalable Internet system (Meghanathan N., 2015), and stochastic models and evaluation techniques of network security (Hu G, Liu W., 2015), among others. On the basis of describing the trust network, a trust prediction model for user rating behavior is constructed. In this model, control based upon trust in user rating behavior is to make dynamic control decisions according to user behavior, and the game theory is appropriately applied to analyze success and failure, which gear to actual circumstances in applications.

2. An Overview of Trust Networks

The trust network in this paper is different from the trust concept in information security; trust in information security studies user authentication and access authorization control, while trust in the trust network shows the relationship between users in a system and depends on user performance in the system. User performance consists of publishing content, making comments and ratings and so on. And a user's performance may not be the same to different users, so the system cannot assess it (Velásquez, E., Cardona, A., & Peña, A., 2014). The best way is that the user makes an assessment himself/herself. If users believe the user's comments are valuable and have reference significance, a trust relationship can be established and developed. However, the author does not think so, and thus the relationship is not created. Many systems use the trust network concept. Below the practical applications of the trust network are briefly introduced (Brouhle K, Graham B, Harrington D., 2015).

2.1. Definition of Trusted Networks

Golbeck defines trust in the literature, If Alice thinks that making decisions based on Bob's behavior will produce a good outcome, then Alice trusts Bob. Trust has the following attributes.

1. Difference,

Pursuant to the definition of Golbeck, what is a good outcome? The answer depends on the users themselves. There are vastly differences among user interests and viewpoints, so the same user has different levels of trust in different users. Also, if user A is an electronics enthusiast but just knows little about cars, obviously the level of trust in user A by the same user may vary from different decision areas.

2. Non-symmetry,

Trust is a one-way relationship. If user A trusts user B, B may not trust A; or A trusts B at level 0.8, but B trusts A at level of 0.7.

3. Transitivity,

Trust has transitivity among users. User A trusts user B and user B trusts user C, then A is likely to trust C. But it is not equivalent transfer but with certain attenuation. The longer the trust transfer chain, the greater the attenuation.

(4) Compositionality,

User A and user E are not directly connected, but A can reach E through three paths (B, C, D) can be, as shown in Figure 1. Then how much A trusts E? Under normal circumstances, A will consider the trust relationship between E and those directly trust E, including B, C and D. But there is not a specific function concerning how to compose these relationships. It depends on the specific circumstances.

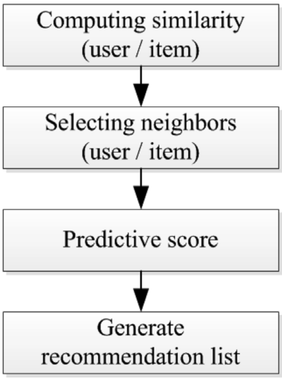

Figure 1 – Trust Transfer Group

Trust networks can be represented as a directed graph (see Fig. 1), where nodes represent entities, and edges represent trust. According to the form of trust value, trust networks can be divided into two categories, binary trust networks and non-binary trust networks. Binary trust networks only take on the trust values 0 (distrust) and 1 (trust); all of the edge weights are set as 1, which can be omitted, as shown in Fig. 2.

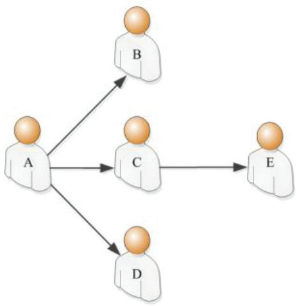

Figure 2 – Trust Transfer Group

Epinions is a typical binary trust network. Trust ratings of non-binary trust network sets values within a certain range to show degree of trust. The value range is 1-10 for FilmTrust and 0-3 for Orkut. The system can provide a rating interface between users, and let user explicitly gives evaluation of other users and obtain the trust network. This belongs to the explicit trust network. Or the trust network can also be generated by analyzing other data such as user ratings, which belongs to implicit trust network (Herrmannova D., 2015).

2.2. Categories of Trust Measurement

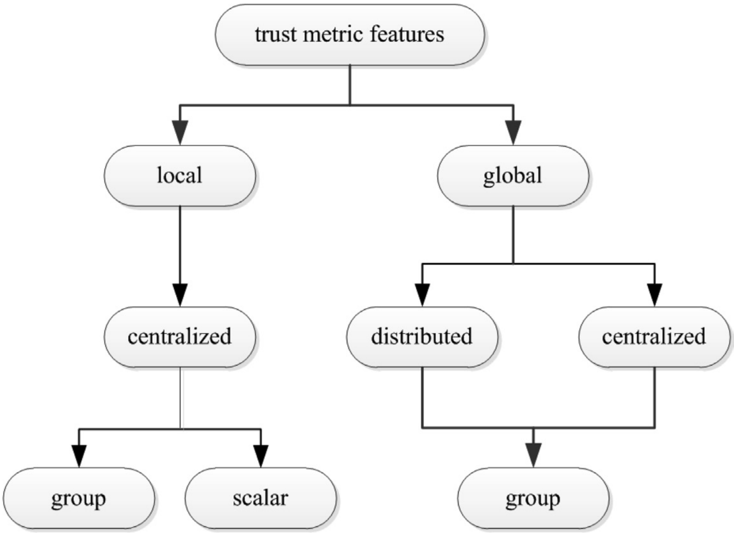

Figure 3 – Trust Metric Classification

The development of the Internet has led to the rapid growth of information, making it difficult for people to quickly find the interest and high-quality content. Yet at the same time the Internet makes the world smaller, and enables people who do not know each other in real life to exchange freely, such as discussing a topic intensely in the forum, share experiences of using an e-commerce commodity, etc. If user A thinks user B's comment is valuable, A builds trust in B, and then the system will give priority to recommending projects that B gives a great evaluation or filter projects that B gives a bad evaluation. This can reduce the project space that the system may recommend to A, decrease calculation and bring A better user experience. Since there are so many Internet users, users cannot determine whether to establish a relationship of trust based on each user's performance. Therefore, the establishment of a trust network has very important significance. When user A has no direct relationship of trust with user B, the trust network can be applied to measure A's indirect credibility of B. How to measure a user's credibility is a research hotspot in trust networks (Guillemin F M, Mazumdar R R., 2015). Trust metrics can be divided into two categories, global trust and local trust, as shown in Fig. 3.

Global trust, global trust depends on the entire trust network and has a global value. For a given target user, any other user has the same credibility on the target user. The global trust value can be calculated by distributed or centralized metrics. Distributed metrics apportions credibility computing to each node in a trust network. Although it has reduced the single node (server) computing amount of centralized metrics, it needs additional storage space to store trust information in other nodes. In addition, distributed metrics computing depends on the processing time of each node in the trust transfer process. Most systems use centralized metrics. According to different algorithms, global trust can be divided into statistical technique and the PageRank-like algorithm. The Feedback Forum in eBay employs the statistical technique to measure the credibility, sum up positive, neutral and negative evaluations obtained by users; user levels of trust are acquired by subtract positive reviews from negative reviews; in order to reflect user recent behavior, three time periods are used to sum up the credibility of users, which are the past six months, one month and one week. This is a relatively simple statistical method. A weighted average function can also be used to take evaluators' credibility and time of reviews as weights. The PageRank-like algorithm follows PageRank's idea, the number of being trusted by other users and the credibility of these users themselves have determined the global trust value of the target users. EigenTrust is an algorithm used by the P2P system to calculate the global trust value. P2P's resource sharing is anonymous; some nodes may publish unverified resources, and the spread of these resources will affect the quality of the entire network. The main idea of the EigenTrust is transitive trust, A trusts B, so A probably trusts who B trusts. A global trust value is endowed based on the historical behavior of the junction uploaded files. First, the local trust value of each node is computed. If node A downloads files uploaded by node B, then A's local trust value of B is satisfactory downloads minus unsatisfactory downloads, and the trust value is normalized; if A and B have no direct interactive behavior, then A's trust value of B is computed on the basis of the entire network. The similar method is followed to finally gain the converged global trust value by carrying out continuous iterations of other nodes' local trust values for B. Advogato is a communication platform for open-source software developers created by Raph Levien, and also a research trial platform for both trust metrics and social networking technologies. Advogato divides users into three groups, entry level, midrange and high end, giving these users different access control. Give some authoritative initial nodes (seed nodes) and predict the global trust value of other nodes in accordance with these nodes. Advogato uses the network flow model to perform a breadth-first search starting from the seed nodes, and compute the shortest path to each node in the network. Assign capacity for each node and its value is inversely proportional to the shortest path. By setting the threshold, respectively calculate the maximum network flow from the above three tiers, so if calculating from the entry level, only consider entry-level users. As per the three-tier results, finally determine the user level that the node belongs to (Scales B J, Turner-Rahman L, Hao F., 2015).

Local trust, Under normal circumstances, different users have different credibility levels of the same user, possibly because of diverse interests and opinions and areas of decision-making of users who send signals of trust. Different from global trust, the local credibility depends only on part of trust networks, which well reflects the individualized characteristic of users. Massa proposed a simple trust transfer model that predicts the indirect credibility from source node to destination node is $(d-n+1)/d$, where d represents the maximum transfer distance, n is the shortest path from source node to destination node. The greater the user distance, the more serious trust attenuation. Similarly, Appleseed uses the group mechanism, but the difference is, Appleseed calculates the credibility based on the spreading activation mechanism; the trust value is related to the source node and it belongs to local trust. TidalTrust presets source node A and target node B. It performs a breadth-first search to record the trust threshold max that each edge must meet. Once the shortest path from A to B is found and set as depthmin, continue to look for the path length, which is also the other path of depthmin. Eventually trust (B) is computed based on all paths in which each edge must meet the trust threshold. MoleTrust is very similar to TidalTrust, but it presets the trust transfer distance dist and trust threshold max. MoleTrust is divided into two steps, First, remove the rings existing in directed acyclic graphs in the trust network, because the presence of rings would make the same node accessed repeatedly, while so many nodes in the trust network will seriously affect efficiency. Afterwards, perform a breadth-first search; only consider the shortest path to source node does not exceed dist node, followed by calculation of the credibility between source node and access nodes (Li X, Gui X., 2009, Wang Y, Xiang Y, Zhou W., 2012). Trust (B) from source node A to destination node B is defined as the trust weighted average of all users who trust B (weights≥max).

3. The Overall Framework and Basic Norms of Trusted User Rating Behavior

3.1. Trust Management Based on Different Demand Predictions

Since evaluation of user rating behavior trust is based on the behavioral evidence of past exchanges, and we need the future credibility of user rating behavior, it is therefore necessary to scientifically predict future user behavior credibility. Meanwhile, service providers can provide more detailed, more specific and more flexible prediction requirements targeting at different needs of trust in user performance and safety. Such requirements can realize configurable prediction strategies of user rating behavior trust that meet different needs. Since the Bayesian network model can on the one hand naturally and visually represent the causal knowledge of user rating behavior trust prediction by using directed graphs. On the one hand, it can integrate the statistical data of past user rating behavior in the form of conditional probability into the model, so the Bayesian network will be able to seamlessly combine priori knowledge of user rating behavior with posteriori data, and reach the prediction effects of fine granularity that meets different combinations of needs.

1. The Bayesian network model based on trust prediction of user rating behavior, A Bayesian network model based on trust prediction of user rating behavior is a directed acyclic graph (see Figure 4), which is composed of nodes that represent variables and directed edges that connect these nodes. Variable nodes comprise the overall trust T of these user rating behavior to be predicted and trust properties after decomposition, such as user efficiency (performance) attribute P and user security attribute S. Directed edges between nodes represent the mutual relation between nodes; the parent node points to their offspring node; parent node is the overall trust T of user rating behavior and leaf nodes are various trust attributes of user rating behavior.

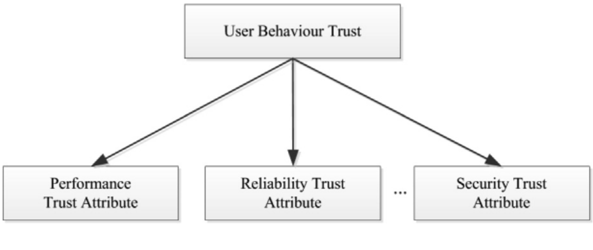

Figure 4 – The Bayesian Network Model of Prediction

2. Data structures of user rating behavior trust prediction, In order to effectively predict user rating behavior trust, the user rating behavior trust T, performance attribute P and security attribute S are divided into L levels of trust. After each contact, the total count of running n plus 1; in the range where the node behavior trust evaluation value falls on, the count of corresponding levels adds 1, and the others remain unchanged. In order to meet predictions of various requirements, we have to save the times of a node falling on two or more different ranges at the same time, which is mainly used to compute prediction problems of user rating behavior trust under multiple trust attribute conditions. The times of a node falling on two or more different ranges at the same time are stored in double dimensional array, while the times of a node falling on three or four different ranges at the same time are stored in three-dimensional array or four-dimensional array. The name of the array represents different nodes, and the subscript of the array represents different range of the credibility. We use Ti, Pi and Si($1 \le i \le L$) to represent the times that overall trust, performance attribute and safety attribute values in the contact history with predictive user falling on Ti, Pi and Si; p(Ti),p(Pi),p(Si) are used to show their respective probabilities (Zhang H, Chen L, Zhang L., 2010, Huanguo Z, Jie L, Gang J., 2006).
3. Calculate the priori data of user rating behavior trust prediction, the priori probability of user rating behavior trust is computed by priori probability of user rating behavior trust, as shown in Formula (1),

$$\mathrm{p}\left(T_i\right)=\frac{\left|T_i\right|}{n}, 1 \le i \le L \tag{1}$$

and,

$$\sum_{i=1}^{L} \mathrm{p}\left(T_i\right)=1 \tag{2}$$

Priori probability of user rating behavior attributes is computed by Formula (3). Here security attribute is used as an example; the calculation method of other trust attributes is similar,

$$\mathrm{p}\left(S_i\right)=\frac{\left|S_i\right|}{n}, 1 \le i \le L \tag{3}$$

and,

$$\sum_{i=1}^{L} \mathrm{p}\left(S_i\right)=1 \tag{4}$$

Conditional probability table of nodes, in addition to calculating a priori probability, it must also calculate the conditional probability of each node. For the leaf nodes, each leaf node has a conditional probability table. The conditional probability of $\mathrm{p}\left(S_i / T_j\right)$ is computed as an example. It means that the probability of the security attribute node in the security scope S_i when the user root node is in the trust range of T_j. It is acquired by using Formula (5).

$$\mathrm{p}\left(S_i / T_j\right)=\frac{\mathrm{p}\left(S_i,T_j\right)}{\mathrm{p}\left(T_j\right)}=\frac{\left|S_i \bigcap T_j\right| / n}{\left|T_j\right| / n}=\frac{\left|S_i \bigcap T_j\right|}{\left|T_j\right|} \tag{5}$$

Prediction of user trust that meets a combination of different security and performance of conditions, by using the Bayesian formula, we can also predict the user credibility probability at different combinations of security and performance. For example, we still assume that L=5, which is high trust (credibility 1) trust (credibility 2), relative trust (credibility 3), basic trust (credibility 4) and distrust (credibility 5), and then we use p (T1/P3,S2) to solve the probability of high trust (credibility 1) when the trust attribute is relative trust (credibility 3) and trust (Trust Level 2). Under the condition of double trust attribute, the user rating behavior trust is computed as Formula (6).

$$\begin{aligned}\mathrm{p}\left(T_i / P_j,S_k\right)&=\frac{\mathrm{p}\left(P_j,S_k / T_i\right)\mathrm{p}\left(T_i\right)}{\mathrm{p}\left(P_j,S_k\right)}=\frac{\mathrm{p}\left(P_j,S_k,T_i\right)}{\mathrm{p}\left(P_j,S_k\right)}\\&=\frac{\left|P_j \bigcap S_k \bigcap T_i\right|}{n} / \frac{\left|P_j \bigcap S_k\right|}{n}=\frac{\left|P_j \bigcap S_k \bigcap T_i\right|}{\left|P_j \bigcap S_k\right|}\end{aligned} \tag{6}$$

3.2. The Overall Structure of User Rating Behavior Trust

Research on user behavior trust includes assessment, prediction and control of user behavior trust, in which evaluation of user behavior trust is the basis, and control of user behavior trust is the goal. The overall structure is shown in Fig. 5

3.3. Basic Norms for User Rating Behavior Trust

According to the basic requirements of trust networks, we can find the basic norms for user rating behavior trust. With these norms we can conduct more detailed studies. These norms include:

1. Objectivity of trust assessment. Trust is borrowed from social science. Excessive subjectivity will affect the credibility of trust assessment, and assessment should combine subjectivity and objectivity, which means that evaluation of trust assessment is subjective, but the content must be objective and take into account subjective and objective characteristics of trust.
2. Subjective consistency. When the user behavior trust assessment has many subjective parameters, subjective consistency checks are needed to ensure that the assessment results are scientific and rational.
3. Scale of trust assessment. User rating behavior trust evaluation should be based on a large number of long-term behavior of the user. Only in this way can the evaluation results be stable and representative “personality characteristics”, and can serve as the basis of our control, and stress the social trust feature that “time will tell”.

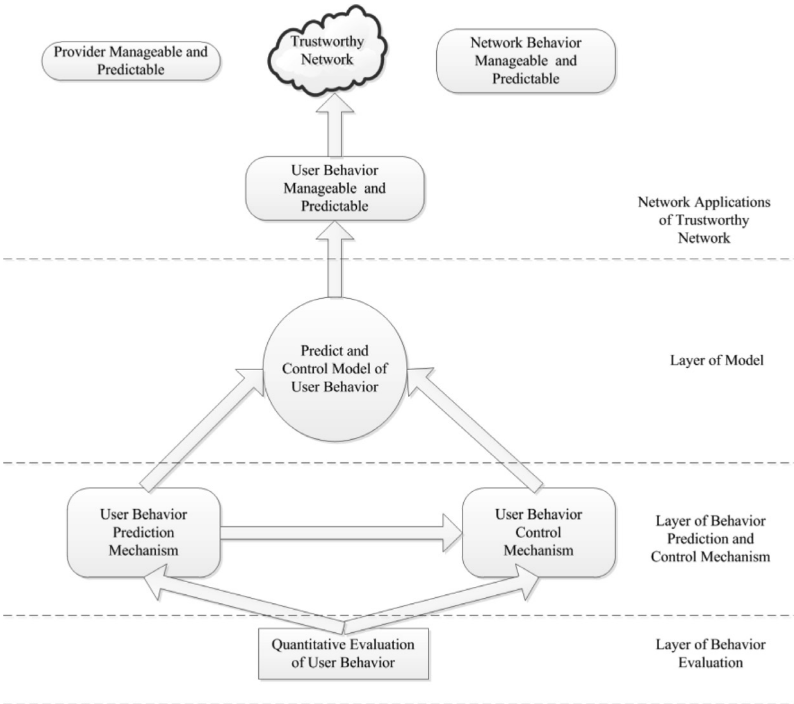

Figure 5 – The Overall Structure of the Research on User Behavior Trust

4. Assessment considers the value of behavior. It is to prevent malicious users from low-value access in exchange of high trust and use high trust to conduct high-value fraudulent acts.
5. Time characteristics of trust assessment. Trust assessment should consider time characteristics such as the importance of user recent behavior and attenuating property of long-term behavior.
6. Anti-deception of trust assessment. Prevent malicious users from cheating by using few times, low-value access in exchange for high level of trust. Usually a conservative method that "slowly increases" trust value is taken to guard against fraud.
7. Deceive punishment of trust assessment. We should not only prevent deceptions, but also punish deceptions that have occurred. Usually we "quick drop" the trust value significantly to punish deceptions.
8. Scalability of methods. This contradicts with the scale requirement of user rating behavior. User rating behavioral evidence in trust networks is huge data, so the scalability problem should be solved.
9. Trust information sharing. Trust information sharing can not only accelerate the trust evaluation speed of unfamiliar users, but also enhance the credibility of trust assessment. Hence, it is necessary for different service providers to

share and exchange trust information to mainly solve difficult trust information sharing brought about by subjective trust.

10. Normalization of behavioral evidence. The size, directivity, monotonicity, meaning of various behavioral evidence are different, so unified standardization processing is required.
11. Effect control and attribute compromising. User behavior control should be initiative and foresighted, rather than preventing act of sabotage from occurring until the wrongful act happens. The basic idea is oriented at prevention and supplemented by monitoring, which can take into account both the control effect and performance.
12. Risk prevention. Trust and risk are a pair of opposites. A risk analysis is required on the basis of trust. Trust assess credibility requires different service providers to share and exchange trust information to mainly solve difficult trust information sharing brought about by subjective trust.

4. Application Examples and Comparative Analysis

In the electronic resources database service subscribed by the school, the service provider is the electronic digital resource provider (database provider), and the user is the school that subscribes database resources. The behavior trust level is set to comprise five levels, which are high trust, trust, relative trust, basic trust and distrust, and the user level probabilities Pti corresponding to these five trust levels are 0.1, 0.7, 0.12, 0.04, and 0.04, signifying that there are relatively great probabilities of trust. Parameter factors αi of the game analysis are 0.7, 0.95, 0.9, 0.85, 0.87, and 0.95, and the assumed values for other parameters are given in Example 2-8 in Table 1, where s_loss_acc_dec means the average loss that the service provider may suffer when accepting access and the user is deceptive; s_loss_nacc_ndec represents the average loss that the service provider may suffer when declining to accept access and the user is not deceptive; s_income_acc_ndec means the normal average income that the service provider may obtain when accepting access and the user is not deceptive; u_income_acc ndec represents the average income that the user obtains when the service provider accepts access and the user is not deceptive; u_income_acc_dec is excess income that the user obtains when the service provider accepts access and the user is deceptive; u_cost is the cost for the user to cheat; u_pun means the punishment that the user suffers for cheating. s_acc_p is the acceptance probability of mixed strategy Nash equilibrium of the database provider; u_dec p is the deception probability of mixed strategy Nash equilibrium of the user. The concrete results are shown in Lines 9 and 10 in Table 1.

Trust level	S_loss_ acc_dec	S_loss_ nacc_ ndec	S_income_ acc_ndec	U_income_ acc_ndec	U_income_ acc_dec	U_ cost	U_ pun	S_ acc_ p	U_ dec_ p
1	1000.0	100.0	100.0	300.0	830.0	86.0	740.0	96	17
2	700.0	95.0	95.0	255.0	747.0	86.0	643.8	83	21
3	490.0	90.3	90.3	216.8	672.3	86.0	560.1	77	27
4	343.0	85.7	85.7	184.2	605.1	86.0	487.3	73	33
5	240.1	81.5	81.5	156.6	544.6	86.0	423.9	71	40

Table 1 – The Value of The Initial Value and the Calculated Results of the Instance Parameters

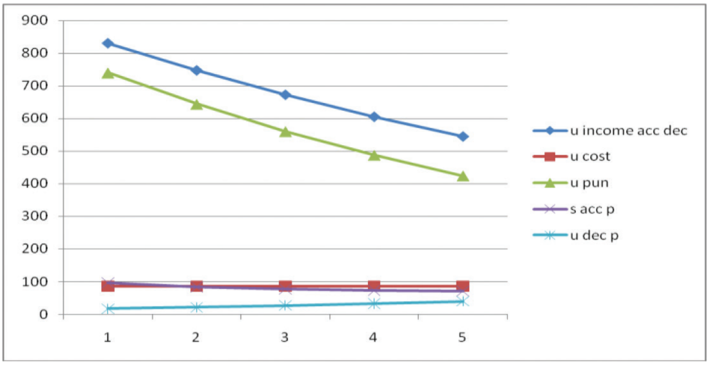

Figure 6 – The Probability of A Hybrid Game With A Database and A User Trust Level

Most of the access control now is mainly focused on the identities or roles. A number of other trust-related access control is mainly based on trust assessment itself, while neglecting to take combined control over behavior trust evaluation, prediction and game-theoretic control. As for user rating behavior in this paper, its access control strategy has the following advantages compared to other access control strategies based on identities, roles and trust assessment, (1) access control based on user identity or role is mainly grounded upon relatively static identity and role, whereas control over user behavior trust in this paper is to make dynamic control decisions based on user behavior; (2) control decisions based on trust assessment itself is only based on past user trust, which cannot explain the future trend of user rating behavior, so there is a lack of necessary trust prediction; (3) prediction is a probability problem. When making decisions, we cannot just depend on the probability but should explicitly accept or reject. As a consequence, we should use some mechanisms to make decisions; because the user rating behavior involves people, the game theory is the most appropriate for analyzing success or failure. In this case, examples of papers can better gear to real circumstances during applications. Relevant data results in the above examples are summarized in Figure 6. From this example we can see that u_income_acc_dec and u_punish decline with a drop of the trust level. While the cost for users to cheat stays unchanged, with lower trust levels of users, s_acc p also lessens whilst u_dec p increases, which is consistent with the conclusions drawn in this paper. It should be noted that in order to clearly see the computational results trend in the same graph, the drawing percentage is magnified 500 times.

5. Conclusion

With the deepening trust network research, user behavior trust studies have grabbed more and more attention. This paper discusses the definition and characteristics of trust networks, trust in trust networks depends on user performance in the system, and shows the relationship between users of a system; it features differences, transitivity, asymmetry and composition, etc. In addition, the overall framework and basic norms for user behavior trust are proposed and a trust prediction framework for user rating behavior is built. Moreover, this paper explores user behavior trust from such perspectives as assessment, prediction and control of behavioral trust and computes decision-making control conditions for user behavior trust attributes. Through a statistical analysis of experimental data, it has been found that the trust prediction framework of user rating behavior established herein has a number of advantages compared to other access control strategies based on identity, role and trust assessment itself, and gives important practical guidance in practical network applications.

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Research on the Fuzzy Comprehensive Evaluation Algorithm for Power Information System's Security Level

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Abstract: As an artery industry of the country, power is the safeguard of people's daily life, providing important support for the country's economic development. The safety of power information system is facing a certain degree of threats due to the rapid development of various information technologies. For this reason, a reliable evaluation algorithm is needed urgently to assess the security level of the power information system. Fuzzy comprehensive evaluation (FCE) algorithm is no doubt one of the best choices. Information security system grading is a multi-hierarchical evaluation model. Focusing on problems as the index assessment is of low accuracy and hard to be quantified, this model uses FCE algorithm to establish a FCE model to rank the security level of information system. Besides, it also applies fuzzy analytic hierarchy process (FAHP) to determine the weight relations between indexes from all levels in the information system's security level index system, thus introducing the coincident indicator to verify the validity of the matrix. Empirical analysis of the model is conducted through the power information management system. The findings reveal that FCE is more accurate and reliable for the quantization and grading of the factors.

Keywords: Information system; Fuzzy comprehensive evaluation (FCE); Security level

1. Introduction

Power is the foundation of all kinds of economic development and construction. As the most important and essential element of people's daily life and the industry, power plays a vital role in the development of the country and the guarantee of social stability.

The establishment of intelligent power grid can accelerate the exploration of clean energy, adjust and optimize the energy consumption structure. Nowadays most of the countries around the world are building and developing intelligence power grids. Power grids are now becoming automatic and informational. The operation and service mode of power grid will have big changes in the near future. Safety is the foundation for the establishment of intelligent power grid, but it is confronted with many security risks and challenges due to large amount data interaction and the increase of intelligent terminal access modes (Gößling S, Klages M, Haußmann J., 2016). Therefore, further research is urgently needed, and a complete guarantee system for the security of power information network should be established to better develop the intelligent grid and lay a solid foundation for its steady operation.

At present, researches into the security of power information network are high on national grid's list of priorities, among which the evaluation of the security level of power information system is the most urgent event. The safety of power information system is affected by various factors (Laureano, R., Caetano, N., & Cortez, P., 2014), such as the power system itself, the operational methods of the staff, environmental factors and so on. In *Power System's Security and Control Measures*, Han Zhenxiang and Cao Yijia pointed out that power information technology is rapidly developing and merging with varied information communication technologies; the study on power system should not focus merely on the security of several sections, but also put emphasis on the overall security as the power system has been merged and integrated (Reda A, Farahat M, Farag F., 2016). It was reported in *2004 Electric Power Informatization Development Review* that the security level of power network should be strengthened through multiple hierarchies, such as network, application, data and so on. Besides, researchers should underline the following aspects, identification of power information system, anti-virus and anti-attack construction of network security system, and the information system management construction. In *Application Research on the Information Security of Power System*, Pan Minghui illustrated the main underlying safety hazard confronting the power information system, and provided different prevention measures accordingly. In *System Security Engineering Capability Maturity Model*, the researcher presented a method to evaluate the security engineering of power information system. First, discussions should be conducted by experts and electric power enterprise users to define the evaluation system influencing power information system's security. Then, evaluations of power information's system security engineering should be carried out. In *Information System Security Engineering*, Guan Yizhang designed a security evaluation model based on the System Security Engineering Capability Maturity Model (SSE-CMM), introducing the required properties which are the guarantee for the establishment of system security engineering and the main evaluation indicators of system security engineering. In *SSE-MM-based Power Information Security Engineering Evaluation*, Li Zhiming evaluated a province's security level of its power information system based on SSE-CMM power information system security evaluation model. In *Information Security Level Evaluation of Power System Based on Fuzzy Comprehensive Evaluation Method*, Cong Lin and Li Zhiming et al. assessed the power information system's security level based on SSE-CMM according to certain procedures and FCE. From the perspective of risks, KroppT analyzed the probability of risks and the threats confronting the power information system in *Security Enhancements for Utility Information Architectures*.

In conclusion, researchers have conducted many studies and analysis of power information system's security, and proposed various solutions and ideas for further studies and references. Since new security troubles are emerging continuously, the safety precautions for power system should be improved and modified accordingly. Hence, the technological standard will not be monotonous. State Grid Corporation of China (SGCC) has held many conferences on information security, aiming at improving the independent innovation capability of information security core technology to find a new method to solve the safety problems of power information system. This method should be equipped with simple theories, convenient model, and easy-realizable assessment; it should be able to help current power enterprises solve the existing safety problems of power information system from macro perspective.

2. Risk Assessment Analysis of Power Information Security

According to the risk assessment standard of information security, the security properties of information include confidentiality, integrality and usability; assessment conducted to evaluate these three security properties of information is called Information Security Risk Assessment (Zeng F, Dong Y, Tang J., 2015). During this assessment, the main evaluation contents are as following, to analyze the possibility of the potential security events that could be caused by information assets, deficiencies of the asset and the risk; to verify the influence of security events on the organization or the system; to define the underlying risk of the information system and the levels of the risk (Balamurugan R., 2015).

Information security has some essential properties as decisive supportability, comparative analyticity, and hypothetical premise and so on. The target of information security risk assessment is to identify the existing and underlying risks confronting the system through the evaluation of security events, which can facilitate the establishment of highly efficient information system and provide a foundation for security strategy. Meanwhile, it can help to enhance the system's reliability and network products' competitiveness (Ekinci S, Demiroren A., 2015).

2.1. Information Security Evaluation Mode

Most of the typical information security models are built according to the related risk assessment standard for information security. They are the foundation of information security risk evaluation, supporting the continuous development of information security models.

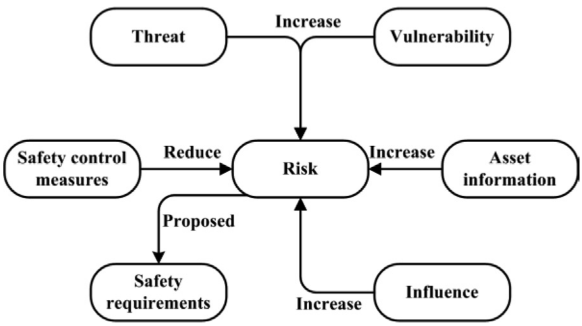

Figure 1 – Information Security Risk Assessment

The information that should be protected by information security is defined as an asset in the international standard ISO/IEC 17799, 2005 *Information Security Technology-Security Engineering-Information Security Management Practice*. It is very important to all kinds of organizations since the modern organizations and enterprises depend more and more heavily on information. The model is presented in Figure 1.

Above are the typical risk assessment models in the information security standard. The interrelationship among various factors of information security risks can be built through the establishment of information security risk assessment model. Then, the risk factors existing in the system can be analyzed, and the abnormal or harmful factors occurring in the interaction between the system and the external environment can be discovered. This way, the qualitative analysis of the system's deficiencies and security threats is finished, and an indication system of risk assessment can be established (Salehizadeh M R, Soltaniyan S., 2016, Kyriakopoulos G L, Arabatzis G., 2016).

2.2. Identification of Information Security's Risk Factors

Correct recognition of risks is requirement of risk evaluation. In the information security area, the research objects include information system, vulnerability of information assets, and the underlying risks. In general, the information system is diversified, flexible and complex. Different information systems have different structures due to their varied business environment. Therefore, the risk factors of information system are also quite flexible. The information security's risk evaluation is generally conducted based on the risk factors of information system. The risk factors are acquired and built upon the recognition of assets, threats and vulnerabilities. Hence, the first step of information security evaluation is to identify the assets, threats and vulnerabilities based on the requirements and functions of the information system (Ekinci S, Demiroren A., 2015).

Asset Identification, the cost of an information system is determined by its assets; correct recognition of assets is the foundation of risk evaluation. The assets of information security include data, software, hardware, devices, services, and documents (Young L A, Yang F, Woodworth D, et al., 2016).

Vulnerability Identification, this kind of identification is to find out the vulnerabilities hiding in the information assets through various methods, such as technological detection, experiments and designs; the detected vulnerabilities will be classified into some categories. For this reason, the identification system should adopt experts' experience and use objective statistical methods.

Threat Identification, threats refer to the potential possibilities of damages to the organization's assets caused by unexpected events. Generally, threats can only be turned into real damages by utilizing the vulnerabilities of the enterprise, system, application or its services. Therefore, the identification of threats is closely related to the identification of assets and vulnerabilities (Alawieh A, Elvington A, Zhu H., 2015).

The identification of risk factors is rather complicated, and it runs through the entire life cycle of the information system. For this reason, the identification of risk factors can be totally clear and completely accurate. It should be carried out with some commonly used qualitative and fuzzy recognition methods, such as risk enumeration, scene analysis, and questionnaire (Liu Z L, Tao Y P, Zhang X L., 2016).

3. Evaluation of Power Information System's Security Level

3.1. Fuzzy Comprehensive Evaluation Algorithm for Power Information System Security

In this study, the index weight computing method of the power information system is designed to calculate its index weight. Then, the fuzzy comprehensive evaluation model is established to assess the security level of power information system. This model is proposed based on fuzzy mathematics, aiming at using the calculation method of matrix theory and statistics to process the comprehensive evaluation problem connecting with multiple factors and multi-hierarchical system (Giner E, Díaz-Álvarez J, Marco M, et al., 2015). FCE model uses the maximum subordination principle and its fuzzy transformation principle to comprehensively evaluate all the influence factors of the evaluation object. This model quantifies the qualitative index to obtain a comprehensive evaluation of power information system's security level; detailed procedures are as following (Pilotto E, Guidolin F, Convento E., 2015).

Step 1, to establish the factor set $U = \{u_1, u_2 \ldots\ldots, u_n\}$ for the power information system's security evaluation; this factor set is formed by all the security indexes of the object.

Step 2, to determine the power information system's judgement set $V = \{v_1, v_2 \ldots\ldots, v_m\}$; namely, the set of all the comments.

Step 3, to build the judgement matrix and conduct single factor judgement. First, judge every factor $a_i = (i = 1, \ldots\ldots, n)$ of the lower hierarchies to obtain a fuzzy set $(r_{i1}, r_{i2} \ldots\ldots, r_{im})$ that corresponds with ***V***, which is actually the procedure to build a fuzzy mapping from ***U*** to ***V***. According to this fuzzy mapping, a fuzzy judgement matrix can be established,

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix} \tag{1}$$

Step 4, First-grade FCE; to establish the fuzzy set of upper hierarchical factors based on the fuzzy judgement matrix of Step 3 and the weight of each index.

$$B_i = (l_{i1}, l_{i2}, \ldots\ldots, l_{im}) = (\sum_{i=1}^{n} w_i \cdot r_{i1}, \sum_{i=1}^{n} w_i \cdot r_{i2}, \ldots, \sum_{i=1}^{n} w_i \cdot r_{im}) \tag{2}$$

In Equation (2), w_i stands for the weight allocation of each factor; it should satisfy the condition of $\sum_{i=1}^{n} w_i = 1$.

Step5, Second-grade FCE. The evaluation results (see Equation (3)) of the ultimate target hierarchy can be achieved in accordance with the evaluation results of Step 4.

$$B_i = (\sum_{i=1}^{s} c_i \cdot l_{i1}, \sum_{i=1}^{s} c_i \cdot l_{i2}, \ldots, \sum_{i=1}^{s} c_i \cdot l_{im}) \tag{3}$$

In this equation, c_i refers to the weight allocation of each factor in middle hierarchies; it should satisfy the condition of $\sum_{i=1}^{s} c_i = 1$.

First class index name	First class index weight	Two stage index	Two stage index weight
Hardware security	0.17	Computer security	0.33
		Network equipment safety	0.30
		Line safety	0.19
		Media security	0.18
Network security	0.23	Firewall	0.32
		Intrusion detection	0.25
		Antivirus	0.22
		Communication encryption	0.21
Information security	0.26	Confidentiality / integrity policy	0.30
		Data encryption	0.22
		Access control	0.25
		Data backup	0.23
Software security	0.34	Operating system security	0.29
		Database system security	0.38
		Application software security	0.33

Table 1 – Power Information System Security Evaluation Index Weight

Step 6, to define power information system's security level according to the above evaluation results and the maximum subordination principle.

3.2. Evaluation of Power Information System's Security Level Based on FCE

The system will be evaluated with the quantitative model for the evaluation of power information system proposed as above; this evaluation takes office automation as example (Asiedu L, Oduro F, Adebanji A O., 2016). The established hierarchical index system is the index set; the weight of each index is calculated through FAHP (see details in Table 1).

The evaluation level of the office automation system is determined as ***V***={Excellent, Good, Medium, Qualified, Unqualified}. The judgement matrix R is the reflection of the fuzzy relation between factor set ***U*** (evaluation indexes) and evaluation set ***V*** (evaluation levels) (Ravi A T, Chitra S., 2015). The first procedure for determining the subordinate relation is to calculate the index's threshold $(v_1, v_2, v_3, v_4, v_5)$ according to the expert experience method. Then, the subordinate relation can be obtained by comparing the index value with its threshold (see Figure 2).

The above index judgement method has some deficiencies during the evaluation process due to the subjectivity of people. In other words, it doesn't take evaluation's fuzziness into consideration. This kind of subjectivity can impose direct influence on the evaluation results of different populations, impossible to ensure the authenticity and objectivity of the evaluation results. Therefore, the evaluation results lack of comparability (Priyadarsini M J P, Murugesan K, Inbathini S R., 2015).

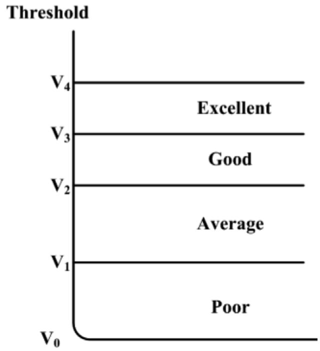

Figure 2 – Index Evaluation

3.3. Comprehensive Evaluation

First, use Equation (2) to obtain the first-grade comprehensive evaluation of an index; then, apply Equation (3) to conduct the second-grade comprehensive evaluation; finally, integrate the comprehensive results of all the indexes.

The first-grade comprehensive evaluation results,

Hardware security evaluation, $B_1 = w_1 \times R_1 = [0.4980 \;\; 0.3120 \;\; 0.1045 \;\; 0.0855 \;\; 0]$

Network security evaluation, $B_2 = w_2 \times R_2 = [0.4814 \;\; 0.2986 \;\; 0.1716 \;\; 0.0484 \;\; 0]$

Information security evaluation, $B_3 = w_3 \times R_3 = [0.5012 \;\; 0.2688 \;\; 0.1012 \;\; 0.1288 \;\; 0]$

Software security evaluation, $B_4 = w_4 \times R_4 = [0.6684 \;\; 0.3316 \;\; 0 \;\; 0 \;\; 0]$

The second-grade comprehensive evaluation results,

$$B = w \times \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = [0.5530 \;\; 0.3044 \;\; 0.0835 \;\; 0.0591 \;\; 0]$$

According to the above findings, the membership degree making this office automation information system's security level to be "Unqualified" is 0; 0.0592 for "Qualified", 0.0835 for "Medium", 0.3 044 for "Good", and 0.5530 for "Excellent". Based on the maximum subordination principle, the security level of this office automation information system is determined as "Excellent".

4. Application Example and Analysis

The power information system is mainly applied to manage power charges, electrical projects, and power information maintenance, etc. The objective aspect (objective aspect refers to the encroaching consequences caused by the specific encroaching behaviors and patterns of the grading objective) of encroachment on power information system can be explained as following, the legal interests of power enterprises, legal persons and other organizations might be affected or damaged when the information system is invaded, revised, aggrandized, or deleted (the patterns of various unknown encroachments include loss, destruction, damage, etc). The detailed harmful consequences for organizations include, having bad effects on organizations' normal work; creating certain level of anxiety in the society; resulting in bad influence; leading to legal disputes, etc. The damage level of the injured party when the information system is encroached is classified into 5 grades.

First, the evaluation result of each index $T_{ij}(i, j = 1,2,3,4)$ is shown in Table 2.

	Factor	**Information system security rank matrix**				
		Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
T_1	T_{11}	0.1	0.5	0.4	0	0
	T_{12}	0.2	0.5	0.3	0	0
	T_{13}	0.1	0.6	0.3	0	0
	T_{14}	0.2	0.4	0.4	0	0
T_2	T_{21}	0.2	0.7	0.1	0	0
	T_{22}	0.2	0.4	0.4	0	0
	T_{23}	0.1	0.6	0.3	0	0
	T_{24}	0.2	0.4	0.4	0	0

Table 2 – Information System Security Rank

Plug numbers into $\lambda_{\max} = \sum_{i=1}^{k} \frac{(\lambda W)_i}{nW_i}$ and the maximum characteristic root of this judgement matrix will be $\lambda_{\max} = 5.608$, in which λ is the quantitative grading coefficient determined by expert investigation method. Normalize vector W in accordance with

$w_i = \frac{\overline{w_i}}{\sum_{i=1}^{k} \overline{w_i}}$ to get the corresponding feature vector. Conduct the consistency test on the obtained paired comparison matrix; the test result reveals that it satisfies consistency requirements. Hence, feature vector W can be used as the weight vector of the evaluation. Calculate the weight vector of each index accordingly; the results are listed below,

$$W_1 = (0.44, 0.28, 0.10, 0.18) \qquad W_2 = (0.41, 0.08, 0.40, 0.12)$$

The equation for fuzzy comprehensive evaluation is as following,

$$R_i = W_i \otimes R^{(i)} = (W_1^{(i)}, W_2^{(i)}, W_3^{(i)}, W_4^{(i)}) \otimes \begin{pmatrix} r^{(i)}{}_{11} & \cdots & r^{(i)}{}_{15} \\ \vdots & \ddots & \vdots \\ r^{(i)}{}_{41} & \cdots & r^{(i)}{}_{45} \end{pmatrix} \tag{4}$$

According to Equation (4), carry out the above-mentioned matrix calculation using fuzzy operators; then, the evaluation results of this grade are achieved. The fuzzy operators ($\otimes$, $\oplus$) used in this study are $a \otimes b = ab, a \oplus b = a + b - ab$. For example, conduct fuzzy compositional on W_1 and $R^{(1)}$ to obtain the following result,

$$R_i = W_i \otimes R^{(i)} = (0.44, 0.28, 0.10, 0.18) \otimes \begin{pmatrix} 0.1 & 0.5 & 0.4 & 0 & 0 \\ 0.2 & 0.5 & 0.3 & 0 & 0 \\ 0.1 & 0.6 & 0.3 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 \end{pmatrix} = (0.1387, 0.4184, 0.3206, 0, 0)$$

As $\sum_{j=1}^{4} r_{ij} \neq 1$, normalization process should be conducted,

$$\boldsymbol{R_1} = (0.1580,\ 0.4784, 0.3653, 0, 0)$$

Based on the maximum subordination principle, the business information security protection of the power information system is determined as Level 2 according to the comprehensive evaluation. In respect to the system service's security level, same method is applied to conduct the fuzzy comprehensive evaluation for service security of the power information system. The calculated result is $\boldsymbol{R_2}$=(0.1752,0.5711,0.2536,0,0). According to the maximum subordination principle, the security level of the power information system's service is also rated as Level 2. The higher level of business information's security level protection and the system service's security level protection is Level 2. Therefore, the security level protection of power information system is defined as Level 2. According to the maximum subordination principle, the business information security level protection of power information system is defined as Level 2, which indicates that the comprehensive protective capacity of this system is good and meets the country's security level grading requirements of the related information system. In brief, the overall performance of this system is quite satisfying in respect to all the indexes.

5. Conclusion

The grading of information system's security level aims at classifying the information system into different grades, and hence to provide corresponding protection for the proprietary or public information of the national security, legal persons, organizations and the citizens, as well as protecting the system used to store, transmit or process this kind of information. The grading of information system's security level is the primary and critical process of the security protection work for information system; it is also the information foundation for other work, such as to put the information system on records, to develop or rectify the system, to conduct grading evaluation, to supervise and examine the system.

In this study, fuzzy mathematical method is applied to establish a fuzzy comprehensive evaluation model for the grading of information system's security level. In respect to the quantification and grading of factors, the results reveal that the fuzzy comprehensive evaluation method is more accurate and reliable. The final grading values calculated with this method can reflect both the relative levels of different grades and the absolute levels of various situations, proving reliable scientific support for the improvement of information system's security level grading. The fuzzy comprehensive evaluation model is established to grade the security level of the system via empirical analysis. The grading results are reasonable, convenient, effective and intuitive, presenting the grading of the information system's security level a quantifiable and scientific mathematic model.

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The Modeling and Simulation of Flow Shop Scheduling Problem Based on Adaptive Genetic Algorithm

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Abstract: Flow shop scheduling problem (FSP) is also known as permutation flow shop scheduling. It is a simplified model for many practical flow line production scheduling problems, a typical NP-hard problem and also a typical scheduling problem of the widest interest. Therefore, FSP research is of important theoretical significance and engineering value. It has a wide range of applications in either discrete manufacturing industry or process industry and has certain representativeness.

Keywords*:* Flow shop scheduling problem; adaptive genetic algorithm; modeling, simulation

1. Introduction

In 1960s, Professor Holland and his students from the University of Michigan, inspired by the biological simulation technology, proposed a genetic algorithm based on the genetic and evolutionary mechanisms for complex systems. This technology is mainly used to solve all kinds of problems in scientific research and engineering practice(Pan Z L, Chen L, Zhang G Z., 2016). In 1967, Professor Holland's student Bagley first proposed "Algorithm Genetic" in his doctoral thesis, which is the embryonic form of genetic algorithm(Du L, Xu Y, Liu J., 2015). In 1994, M Patnaik and L M Srinivas were inspired by the adaptive ability of the natural environment of the natural environment, so the adaptive genetic algorithm was proposed. Compared with the general genetic algorithm, the adaptive genetic algorithm is no longer a fixed value of the policy parameters.It can be adjusted according to the fitness of the population, and improve the overall performance of the algorithm(Xu Z, Zou Y, Kong X., 2015).

Flow Shop scheduling probes into the flow shop process of n jobs on m machines. The processing sequence of each part on each machine is the same. Meanwhile, it is appointed that each job can only be operated once on each machine. Each machine can only process one job at a certain time (Dash S K., 2015). The required processing time and preparation time of each job on each machine are already known (Sun Y, Li W, Dong D, et al., 2015, Muthubalaji S, Malathi V., 2015, Fiuzy M, Mollania N., 2015). It is required to obtain a certain scheduling scheme, to optimize a certain index.

For the general flow shop scheduling problem, the processing time of each job on each machine can be different (Baughn L B, Onsongo G, Bower M.,2015). Without loss of generality, assume that each job is processed in the sequence from Machines l to m (Sheng L, Jing T W, Dong Y G., 2015). Let the processing sequence matrix of jobs be $S=\left(s_{i,j}\right)_{m\times n}$, where $s_{i,j}$ represents the job number of the jth job on Machine f, then

$$\begin{cases} T_{s_{1,1},1}=t_{s_{1,1},1} \\ T_{s_{1,j},1}=T_{s_{1,j-1},1}+\theta^{1}_{s_{1,j-1},s_{1,j}}+t_{s_{1,j},1}, \quad i=2,\cdots,n \\ T_{s_{j,1},j}=T_{s_{j,1},j-1}+t_{s_{j,1},j}, \quad j=2,\cdots,m \\ T_{s_{j,i},j}=\max\left\{T_{s_{j,j-1},j}+\theta^{j}_{s_{j,i-1},s_{j,i}},T_{s_{j,i},j-1}\right\}+t_{s_{j,i},j}, \quad i=2,\cdots,n;\ j=2,\cdots m \end{cases} \tag{1}$$

$$S^{*}=\arg\left\{f\left(S\right)\right\}=\sum_{i=1}^{n}\max\left\{\left(T_{s_{m,j},m}-D_{s_{m,j}}\right),0\right\}\to\min \tag{2}$$

or

$$S^{*}=\arg\left\{f\left(S\right)=T_{s_{m,n},m}\right\}\to\min \tag{3}$$

Although compared with job shop scheduling, the operation constraint of flow shop is relatively simple, it is still a very complex and difficult combinatorial optimization problem (Tian Y, Ping X L, Bai L L., 2015). NP-hard features and strong engineering background makes it a hot research issue in theoretical cycle and engineering field (Laczmafnska I, Gil J, Stembalska A., 2015).

2. Hypotheses and Classification

For this problem, usually the following hypotheses are made.

- The processing sequence of each job on machines is given;
- Each machine can only process one job synchronously;
- A job cannot be processed on different machines synchronously;
- Operations cannot be scheduled;
- The preparation time of operations has nothing to do with sequence. It is included in the processing time;
- The processing sequence of jobs on each machine is the same and definite. Considering the importance and representativeness of FSP, many scholars designed a number of benchmarks, to test and compare the optimal performances of different methods. Below, a simple introduction is given.

1. The Car class. This class is designed by Carlier. It includes benchmarks of 8 different sizes, named as Carl~Car8 respectively.

2. (2) The Hel class. This class is presented by Heller. It includes 2 benchmarks, named as Hell and Hel2 respectively.
3. The Rec class. This class is presented by Reeves. It includes 21 benchmarks of 7 different sizes.
4. The TD or TA classes. These classes are presented by Tailard et al. They includes 120 benchmarks of 12 different sizes, named as Ta001~Ta120 respectively.

3. Algorithm Design

3.1. Encoding

As genetic algorithm cannot deal with the parameters of production scheduling directly, it is necessary to represent them as chromosomes (Cadavid, J. M., & Gómez, L. F. M., 2015), which are composed of genes in genetic space according to a certain structure, by means of encoding. Flow shop scheduling problem uses job sequence to represent chromosomes, so we adopt decimal encoding. For example, for a 5-job flow scheduling problem, assume that the processing sequence of jobs is, j3, j2, j5, j4, j1, then it can be encoded as,

$$V_i = \begin{bmatrix} 3 & 2 & 5 & 4 & 1 \end{bmatrix} \tag{4}$$

Let c(ji,k) represent the completion time of jobs on Machine k. {j1, j2, ..., jn} represents job scheduling, the completion time for n-job and m-machine flow shop scheduling can be expressed as,

$$c(j_1,1) = t_{j_1 1} \tag{5}$$

$$c(j_1,k) = c(j_1,k-1) + t_{j_1 k}, k = 2,\cdots,m \tag{6}$$

$$c(j_i,1) = c(j_{i-1},1) + t_{j_i 1}, i = 2,\cdots,n \tag{7}$$

$$c(j_i,k) = \max\{c(j_{i-1},k), c(j_i,k-1)\} + t_{j_i k}, i = 2,\cdots,n; k = 2,\cdots,m \tag{8}$$

The maximum flow time is,

$$c_{\max} = c(j_n, m) \tag{9}$$

The scheduling objective is to determine {j1, j2, ..., jn}and make Cmax minimal.

3.2. Selection

In algorithm, a simple method, i.e., roulette universal sampling, was used. It will be explained through a practical example below. Table 1 shows 11 individual fitness, selection probability and cumulative probability.

Individual	1	2	3	4	5	6	7	8	9	10	11
Fitness	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.1
Selection Probability	0.18	0. 16	0.15	0.13	0.11	0.09	0. 07	0.06	0. 03	0.02	0.0
Cumulative Probability	0.18	0. 34	0.49	0.62	0. 73	0.82	0. 89	0.95	0.98	1.00	1.00

Table 1 – Calculation for Selection Probability of Roulette Universal Sampling

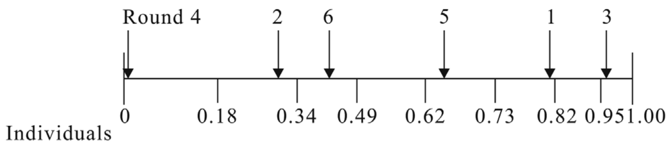

Figure 1 – Roulette Universal Sampling

In order to select mating individuals, it is necessary to select for several rounds. In each round, a uniform random number [0,1] is produced. This random number is used as a selecting pointer to determine individuals to be selected. As shown in Fig. 1, if the random number in Round 1 is 0.81, then the sixth individual is selected. If the random number in Round 2 is 0.32, then the second individual is selected, and so forth. If the random numbers in Round 3, 4, 5 and 6 are 0.96, 0.01, 0.65 and 0.42 respectively, then the 9th, 1st, 5th and 3rd individuals are selected. In this way, the mating population generated through selection is composed of the following individuals, 1, 2, 3, 5, 6 and 9 (see Fig. 1).

3.3. Mutation

This paper adopts mutation operation which changes gene sequence. First of all, a part of genes are selected randomly. Next, the sequence of these genes is reversed.

The specific mutation operation can be summarized as follows.

Step 1, To select a value between 2 and L-1 randomly as the size of mutation block, where L stands for the length of chromosome.

Step 2, To select a position in parent individual Pl to mutate randomly, while the second position is the sum of the first position and the value of mutation block. Genes between these two positions are to be mutated.

Step 3, To reverse the sequence of genes in the mutation block to replace the mutation block obtained from Step 2. New chromosomes are daughter chromosomes.

e.g., If parent chromosomes p1= [2 6 4 12 4 7 13 3 11 5 8 9 1 10] and the mutation position and cross block generated randomly are 3 and 7 respectively, then the daughter chromosomes are [2 6 3 1 7 4 2 1 4 3 11 5 8 9 1 10].

3.4. A Simulation Example

According to the improved genetic algorithm above, we conducted a simulation experiment on the following example. It was a 10-job and 6-machine problem. The processing time matrix T was as follows,

$$T(J_i, j) = \begin{bmatrix} 10 & 20 & 5 & 30 & 15 & 7 \\ 15 & 8 & 12 & 10 & 20 & 11 \\ 20 & 7 & 9 & 5 & 12 & 22 \\ 14 & 6 & 15 & 10 & 9 & 18 \\ 6 & 11 & 5 & 15 & 18 & 20 \\ 13 & 7 & 17 & 10 & 14 & 8 \\ 9 & 13 & 21 & 6 & 10 & 11 \\ 5 & 14 & 7 & 21 & 9 & 10 \\ 10 & 9 & 20 & 15 & 30 & 16 \\ 5 & 14 & 21 & 9 & 18 & 24 \end{bmatrix} \qquad (10)$$

Parameters used in the genetic algorithm were as follows,

pm =0.01, p'm=0.90, pc= 0.85, N=20, K= 10. The population size was 50.

Likewise, for simple genetic algorithm, we simulated with the following parameters,

p_m =0.01, p'_m=0.90, p_c= 0.85. The population size was 50. The end condition was a continuous evolution of 500.

For two genetic algorithms, we considered the following performance indexes,

$$\text{Optimal rate } (\%) = \frac{\text{Times of obtaining optimal solution}}{\text{Total times of solution}} * 100\% \qquad (11)$$

We ran two algorithms 50 times respectively. The resulting optimal rate of the improved genetic algorithm was 88%, while the optimal rate of simple genetic algorithm was only 63%. Meanwhile, we compared their performance in the evolutionary process of algorithms (see Fig. 2).

3.5. Hybrid Flow Shop Scheduling

Hybrid flow shop problem can be described as, there are multiple jobs to be processed. The processing routes of all jobs are the same. They all need to go through several processes in turn. At least one of the processes has multiple parallel machines. The problem to be solved is to determine the allocation of parallel machines, as well as the processing sequence of jobs on the same machine. The objective is to minimize the maximum flow time.

Hybrid flow shop (HFSP) was an extension of the general flow shop scheduling problem, but more complex (Wittrock, 1988). It was characterized by parallel machines in some processes. The shop structure is shown in Fig. 3. Hybrid flow shop is quite common in process industry, such as chemical engineering, steel and pharmacy, etc. It is known as flexible flow line.

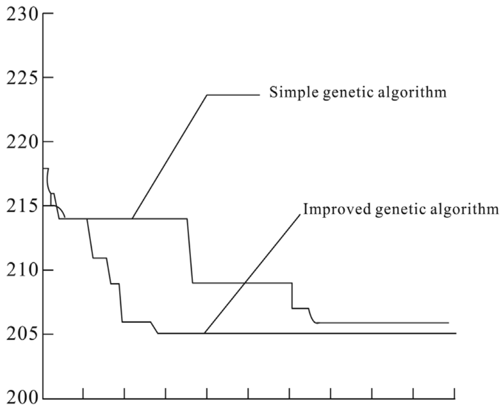

Figure 2 – The variation curve of objective function

The general flow shop problem with three jobs has been proved to be a NP-complete problem. While hybrid flow shop problem with N jobs and S processes, in which each operation has Mi parallel machines (1≤i≤S), is obviously more complex than the general flow shop problem. Shaukat (1991) presented branch-bound algorithm and Wittrock (1988) presented heuristic algorithm. These two approximation algorithms can only solve small-size problems.

In most cases, it is difficult to solve such problems with mathematical methods. However, it is often effective to combine mathematical calculation with intelligent algorithm. This paper solves the minimization of maximum flow time in hybrid flow shop scheduling, using genetic algorithm. As genetic algorithm has strong global search ability, it shows distinct advantages in solving such kind of NP-complete problems. Application results show that hybrid flow shop scheduling based on genetic algorithm presented in this paper is effective (see Fig. 3).

3.6. Genetic Algorithm Encoding for Hybrid Flow Shop Scheduling Problems

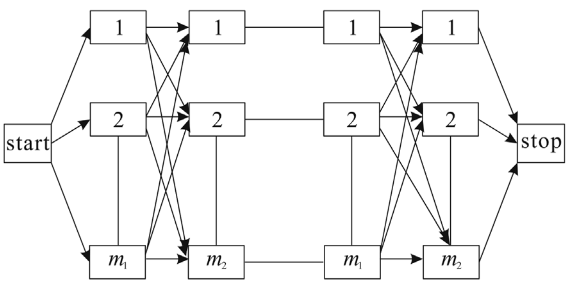

Figure 3 – The Shop Structure of Hybrid Flow Shop Scheduling

This paper proposes an encoding method for hybrid flow shop scheduling problems, which can solve constraints between processes quite well and make each generated chromosome correspond to a feasible scheduling. Besides, no non-constant solutions will be generated in genetic operation.

Suppose W jobs are to be processed. Each job must go through S operations in turn. The number of parallel machines in each operation is Mi, 1≤i≤S. Among all operations, at least one has parallel machine(s), i.e., at least one Mi is greater than 1. Below, an S*N dimension random matrix is built,

$$A_{S\times N}=\begin{bmatrix} a_{11} & \cdots & a_{1N} \\ \cdots & \cdots & \cdots \\ a_{S1} & \cdots & a_{SN} \end{bmatrix} \tag{12}$$

Where matrix element a1j is a random real number in interval (1, Mi + 1), showing that the ith operation of Job j is processed on the Int(a1j)th parallel machine, where function Int (x) means rounding off the real number x. Obviously, Int (a1j)=Int (a1k) may occur. j≠k, indicating that many jobs process the same operation on the same machine. At this moment, if it is the first operation (i=1), then process the job according to the ascending sequence of a1j. If it is not the first operation (i>1),then determine the processing sequence according to the completion time of the previous operation of each job. First completed jobs in each operation are to be processed first. If the completion time is the same, then process according to the ascending sequence of a1j, as well.

According to the foregoing encoding matrix, chromosomes can be determined. Chromosomes are composed of S segments, each including N genes. That is, each line in the random matrix forms a segment. Segments are separated with an identifier "0", to represent different operations. Therefore, the length of chromosomes is S*N+N-1. Chromosome can be represented as,

$$Ind_k=\left[a_{11},a_{12},\cdots\cdots a_{1N},0,a_{21},\cdots\cdots a_{2N},0,\cdots\cdots,0,a_{S1},a_{S2},\cdots\cdots,a_{SN}\right] \tag{13}$$

For example, for hybrid flow shop scheduling problem with 3 jobs and 3 operations, in which the numbers of parallel machines in each operation are 3, 2 and 2 respectively, we label each machine as shown in Fig. 4, where Machine 4 stands for the first parallel machine in Operation 2, Machine 5 stands for the second parallel machine in Operation 2, Machine 6 stands for the first parallel machine in Operation 3 and Machine 7 stands for the second parallel machine in Operation 3 (see Fig. 4).

Suppose that a random matrix is generated as follows,

$$A=\begin{bmatrix} 2.1 & 2.4 & 1.9 \\ 1.6 & 2.1 & 2.3 \\ 1.1 & 2.4 & 1.2 \end{bmatrix} \tag{14}$$

Round off all elements of the matrix and obtain the correspondence between each job and machine, according to the numbering rule of parallel machines in each foregoing operation, 3 elements in Line 1 of the matrix mean that the 1st operation of Job 1 is processed on

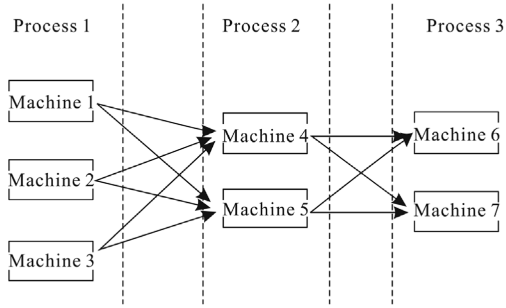

Figure 4 – An Example of Hybrid Flow Shop

Machine 2. Operation 2 is processed on the 1st machine in Operation 2, i.e., Machine 4. Operation 3 is processed on the 1st machine in Operation 3, i.e., Machine 6. Line 2 of the matrix means the 2nd operation of Job 2 is processed on Machine 2. Operation 2 is processed on the 2nd machine in Operation 2, i.e., Machine 5. Operation 3 is processed on the 2nd machine in Operation 3, i.e., Machine 7. Line 3 of the matrix means the 1st operation of Job 3 is processed on Machine 1. Operation 2 is processed on the 2nd machine in Operation 2, i.e., Machine 5. Operation 3 is processed on the 1st machine in Operation 3, i.e., Machine 6.

What we get above is the allocation of machines. From the processing routes of 3 jobs, we can see that for Operation 1, both Jobs 1 and 2 are processed on Machine 2. As 2.1<2.4, we should process Job 1 first on Machine 2, and then Job 2. For Machine 5, as it process the 2nd operation of Jobs 2 and 3, we should determine its sequence according to the completion time of the 1st operation of Jobs 2 and 3. If the completion time of the 1st operation of Job 3 is earlier than the 1st operation of Job 2, process Job 3 first, and then Job 2. If they are the same, as 2.1<2.3, we should process Job 2 first, and then Job 3. The treatment of Machine 6 is similar to Machine 5.

According to the above encoding matrix, a chromosome can be obtained as follows,

[2.1, 2.4, 1.9, 0, 1.6, 2.1, 2.3, 0, 1.1, 2.4, 1.2]

4. Modeling and Solution of Dynamic Scheduling Problem

4.1. Description and Objectives of Dynamic Scheduling

In practical production, the external environment of enterprises is ever changing. There are many uncertain factors, such as the insertion of rush orders and machine failures, etc. These uncertain factors make production scheduling essentially a random and dynamic process.

The presentation of dynamic scheduling application in flexible job shop scheduling problem is, a manufacturing system has m processing machines {M1, M2, ...Mm}. It is necessary to process n jobs {J1, J2, ...Jn} on these machines. The operation sequence of all jobs has been set. Each job contains one or more operations. Operations are not one-to-one corresponding to machines. Instead, different machines can process the same operation. The operating time of the same operation on different machines is different. The production environment is changing dynamically. Orders are not continuous, but periodic. Once a dynamic event occurs, the original scheme should be adjusted immediately and the overall stability should be maintained as far as possible, to minimize the differences between the adjusted scheme and the original scheme .

As introduced in 3.1-3.6 above, there are many kinds of dynamic events that may cause the production environment to change. This chapter mainly considers the treatment of two dynamic events, the insertion of rush orders that cause the delivery time to change and machine failures. Three objective functions are set for dynamic scheduling.

1. Optimization. To minimize the maximum completion time, namely:

$$f_1 = \min\left(\max_{1\leq j\leq n}\left(C_j\right)\right) \tag{15}$$

2. Just-in-time. To minimize tardiness time. Tardiness time Tj refers to the difference between the latest completion time of order Cj, and the required delivery date dj. This difference is not negative, namely, $T_j = \max\left(C_j - d_j, 0\right)$
3. Scheduling stability. To minimize differences between scheduling schemes. To maintain the greatest similarity possible between the original scheduling scheme and the rescheduling scheme. Add the start time difference of unmanufactured operations between the original scheduling scheme and the rescheduling scheme.

Where Sjk stands for the start time of Operation k for Job j in the rescheduling scheme. k'j stands for the total number of remaining operations for Job j when rescheduling begins.

From the three optimization objectives above, the following rescheduling objective function is given,

$$f_2 = \min\left(\max_{1\leq j\leq n}\left(T_j\right)\right) \tag{16}$$

Where u1, u2 and u3 are weight settings. u1+u2+u3=1.

4.2. Dynamic Scheduling Strategies

1. To optimize scheduling with rolling window

When scheduling with rolling window, first of all, determine three basic operating windows, i.e., completed window, rolling window and to-be-processed window. The completed window is used to store all completed jobs. To-be-processed is used to store jobs that have not yet been scheduled. The rolling window is a scheduling window for processing, whose main task is to choose a certain number of jobs from to-be-processed window, put them into the rolling window to complete scheduling and process these scheduled jobs according to the results of scheduling.

According to two dynamic events, i.e., the insertion of rush orders and machine failures, this chapter designs update methods for two kinds of rolling windows respectively. When a rush order is inserted, this order will be updated and integrated into the rolling window. The steps are as follows.

Step 1, To add orders on the job branch and machine branch to the rolling window, beginning from rush orders.

Step 2, To delete updated, repeated and unchanged orders.

Step 3, To schedule and sort orders by start time. When a machine fails, jobs on the machine will be updated to the rolling window. The steps are as follows,

Step 1, The initial rolling window contains all jobs on the failing machine.

Step 2, To delete updated, repeated and unaffected orders.

Step 3, If the failing machine is recovered, the rolling window contains all jobs that can be processed on this machine, excluding jobs that have been completed or are being completed. Then execute Step 2. Otherwise, execute Step 4.

Step4, To schedule and sort orders by start time.

2. To combine event-driven and cycle-driven scheduling

From the introduction of dynamic scheduling strategies in Section 2.2.2, we know cycle-driven scheduling strategy increases the stability of production system. It is widely used in practical production scheduling, but it can't deal with emergencies in a timely manner. Event-driven scheduling can handle dynamic events during production in time, but it can't foresee future events and lacks an overall concept. So this paper takes their advantages into overall account and considers combining event-driven and cycle-driven scheduling. Their combination can not only maintain the stability of manufacturing system, but also respond to dynamic or abnormal events.

4.3. The Design of Improved Genetic Algorithm for Dynamic Scheduling

The previous chapter has applied improved genetic algorithm in the general flexible shop scheduling problem and verified the efficiency of the algorithm. Therefore, the improved genetic algorithm is applied in treating the flexible shop problem again. But as when dynamic scheduling begins, which is quite different from initial scheduling, some machines or jobs are being processed and cannot stop or move, it is necessary to adjust the improved genetic algorithm, to meet the requirements of dynamic scheduling.

1. Chromosome encoding and generation of initial solution

Dynamic flexible job scheduling contains the bi-layer chromosome encoding structure proposed in Section 4.2, which ensures that the generated encoding structure conforms to the scheduling problem. The initial solution of rescheduling is generated randomly according to the actual situation of dynamic events. In this way, the response speed to emergencies can be improved.

2. Machines can be corrected with time

In the process of static scheduling, the possible start time of all machines is zero. However, when dynamic scheduling begins, machines cannot necessarily accept scheduling task immediately. There are three states of machines, idle, processing and fail. When the device is idle and standby, it is unnecessary to correct the available time of machines. The start time of rescheduling is zero. When the device is processing, the completion time of the operation by this machine is used as the start time of rescheduling. When the device fails and can't work normally, we can predict the possible troubleshooting time of machine according to experience first, and then set the available time of machine according to the predicted time. If it is impossible to predict the recovery time, then delete the serial number of this machine temporarily. In the same rolling scheduling window, the available time of different machines may be different. They should be corrected one by one.

3. The design of genetic operation

Genetic operation is a key operation for the genetic algorithm to produce a new generation of population. For dynamic scheduling, rescheduling should not only guarantee the rapid generation of a new adaptive population, but also guarantee the hereditability of well-adapted individuals in the population. The selecting operation uses the best individual preservation method in Section 3.2. Crossover and mutation follow the crossover and mutation methods and steps in Section 4.2.

4. The number of iterations

The rescheduling of dynamic shop requires getting a satisfactory solution as soon as possible. Therefore, the adaptability of solution is used as the end condition of algorithm. Reducing the number of iterations as appropriate can save time and recover production sooner.

4.4. Experimental Results and Analysis

In the simulation experiment, an 8*5 flexible shop scheduling problem was designed, as an instance of dynamic scheduling, as shown in Tab. 2. Two kinds of dynamic events, machine failures and the insertion of rush orders were added and dynamic scheduling was simulated. The parameter setting of the improved genetic algorithm was as follows, the population size N=60, the number of iterations was G=100. The simulation experiment was conducted for 20 times successively.

1. The initial scheduling scheme

The scheduling problem shown in Tab. 2 below is optimized and solved, using the improved algorithm. The initial scheduling scheme generated in the static experiment is shown in Fig. 5 above. The maximum completion time is 30. In the future, dynamic scheduling will be conducted on the basis of this scheduling scheme.

Workpiece	**Process**	**Processing time**				
		M_1	M_2	M_3	M_4	M_5
J_1	O_{11}	5	3	#	#	#
	O_{12}	#	7	#	#	#
J_2	O_{21}	#	#	6	#	#
	O_{22}	#	#	#	3	4
J_3	O_{31}	#	4	6	#	#
	O_{32}	7	#	#	#	#
J_4	O_{33}	#	#	#	7	#
	O_{41}	#	#	#	#	10
	O_{51}	#	#	#	5	#
J_5	O_{52}	4	5	8	#	#
	O_{53}	#	#	#	6	5
	O_{54}	#	3	#	#	4
	O_{61}	#	2	6	#	#
J_6	O_{62}	#	#	8	#	#
J_7	O_{71}	#	#	3	8	#
	O_{72}	#	#	#	7	4
	O_{81}	3	#	5	#	#
J_8	O_{82}	#	#	#	9	6
	O_{83}	#	#	7	#	#
	O_{84}	#	3	#	#	#

Table 2 – The Processing Time of Corresponding Operations of Jobs (unit, min)

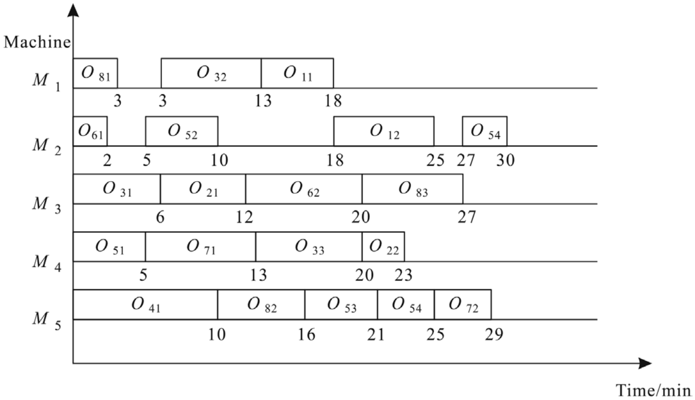

Figure 5 – The Gantt Chart of Initial Scheduling

2. Rescheduling when the machine fails

Workpiece	Process	Processing time			
		M_1	M_2	M_3	M_4
J_1	O_{11}	5	3	#	#
	O_{12}	#	7	#	#
J_2	O_{22}	#	#	#	#
J_3	O_{33}	#	#	#	#
J_5	O_{53}	#	#	#	#
	O_{54}	#	3	#	#
J_6	O_{62}	#	#	#	#
J_7	O_{72}	#	#	#	#
	O_{82}	#	#	#	#
J_8	O_{83}	#	#	#	#
	O_{84}	#	3	#	#

Table 3 – Data Sheet of Rescheduling

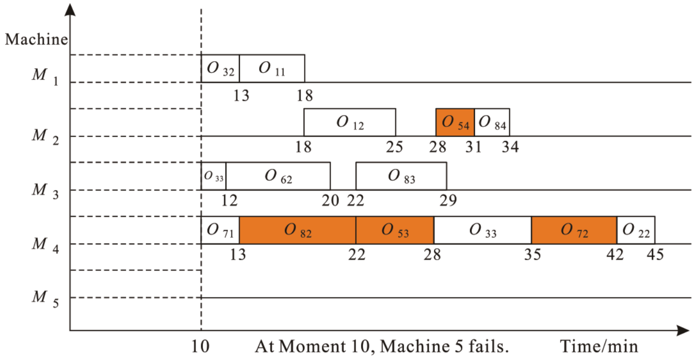

Figure 6 – The Gantt Chart of Rescheduling for Machine Failures

In actual production, first of all, production follows the initial scheduling scheme. When production goes to Time 10, Machine 5 will be damaged and cannot work normally. Besides, the recovery time of failures is uncertain. The subsequent processing tasks on Machine 5 are suspended and transferred to another idle machine for processing. Rescheduling begins. The start time of rescheduling is Time 10. Job J2, J3 and J7 are being processed and cannot stop, so they are not rescheduled. The data to be rescheduled are shown in Tab. 3. above. The rescheduling scheme is shown in Fig. 6 below. Operations O82, O72 and O53 are processed on Machine 4. Operation O54 is processed on Machine 2.

3. Experimental analysis

A scheduling simulation experiment was conducted to simulate two kinds of emergencies, machine failures and rush orders. From the results of scheduling, it can be seen that both of them have achieved satisfactory results. The combination of cycle-driven scheduling and event-driven scheduling, as well as the rolling window technique, is a feasible strategy to solving dynamic scheduling problem. It can divide a dynamic scheduling process into many small static intervals. By optimizing each small interval separately, the overall scheduling scheme is sufficient to cope with sudden disturbance. In the rescheduling scheme, to minimize the maximum completion time is still the most important scheduling objective. But it is also necessary to consider the minimization of tardiness time. There is a wide diversity of dynamic events, but two kinds of dynamic events, machine failures and rush orders are the most typical and representative. Their scheduling strategies can be extended to solve other dynamic scheduling problems.

5. Conclusion

This chapter first expounds on the presentation of dynamic flexible shop scheduling problem, scheduling principle and objective functions, puts forward corresponding improvement scheduling strategies, combines cycle-driven and event-driven scheduling and divides the whole dynamic scheduling process into many small static processes, using the rolling window technique. After that, for each small process, it optimizes their scheduling with the improved genetic algorithm. This chapter analyzes two kinds of events in detail, i.e., the insertion of rush orders and machine failures. Finally, it verifies the algorithm and scheduling strategies, by conducting a simulation experiment on dynamic events, such as machine failures, the suspense of processing and the insertion of rush orders, etc.

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Research on the Design of Intelligent Instrument Performance System Based on the Artificial Intelligence Graphics Algorithm

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Abstract: Objective: In order to improve the intelligent design of the musical instrument performance system. Methods: Establishing intelligent instrument system based on artificial intelligence graphics algorithm. Process: the article introduces the concept and the basic theory of the intelligent instrument playing system, expounds the basic of computer graphics and the principle of music performance prompting system, and establishes the structure model of the intelligent musical instrument playing system. Results and analysis: the paper studied the characteristics of the intelligent instrument system, analyzed the corresponding experimental data, and found that in the musical instrument performance system, only reducing the pitch changes could make the system truly stable. Conclusions: The design of intelligent musical instrument system in this paper can promote the development of the music creation.

Keywords*:* Instrument performance system; music performance prompting system; artificial intelligence graphics algorithm; intelligent design.

1. Introduction

Intelligent instrument performance system is the use of artificial intelligence and graphics algorithm to generate computer animation, the key frame animation is different from the traditional sense, the realization of the system includes the following work: firstly, the 3D hand model is built, then the music analysis and distribution of fingering, finally produce a continuous animation. Playing finger human hand is one of the most complex and sophisticated human structures. Hand animation is part of human animation, many research teams have been working on the research and development of computer simulation and joint animation, professor N.M.T halmann of human and Simulation Center at University of Pennsylvania in the United States, is particularly prominent in the research group of University of Geneva, led by Professor N.I.Badler halmann (Kokalj A., 2003). Both in terms of technology and visual effects, the simulation of human behavior in real life is the most difficult and the most challenging task.

Artificial intelligence is a wide range of cross and frontier science, with the development of electronic computers, artificial intelligence has been applied. Application of artificial intelligence to computer animation and games, on the one hand, it provides a new research method for computer animation (Abreu, A., Rocha, Á., Cota, M. P., & Carvalho, J. V., 2015), on the other hand, computer animation and games have opened up a new area for artificial intelligence, artificial intelligence algorithm can better realize its intelligence, and do not need to consider the limitations of hardware devices on it, it provides a better platform for the study of the theory of artificial intelligence. Music is a kind of sound, and it is also a universal language in the world. It is the thought and emotion of human being. However, skillfully playing an instrument is not an easy thing, it needs to cooperate with flexible finger, people need to learn and practice to master (Cohen E, Lyche T, Riesenfeld R., 1980). We design and develop an intelligent algorithm based musical instrument performance animation system, it provides an effective tool for people to learn to play musical instruments. The system can be selected according to the analysis of the corresponding music playing fingering, at the same time, it analyzes the playing style and music emotion, and finally the performance of computer animation, this not only can help beginners learn to play techniques, but also can be used as entertainment to enjoy, at the same time it also provides a research platform for music research, artificial intelligence research, computer animation research, and the research and development of these fields (Kokalj A., 2003).

2. Materials and Methods

2.1. Basic Computer Graphics

Computer graphics is a discipline that studies how to generate, process and display a graph with a computer. Over the past 20 years, computer graphics has become one of the most important branches of computer science. At least two reasons for this phenomenon. First, the fig. 1 is the most easily acceptable form of information. This is not only because the eyes are the most important organs of human perception, but also because the vast majority of people's brains in the information is about the image of the information. Therefore, in order to form a graphical way of the most natural and most agile. Second, computer graphics itself is very attractive. Human exploration is to promote the scientific development of the largest power (Stollnitz E J, DeRose T D, Salesin D H., 1995). As a result, more and more scholars all over the world have joined the research work in this field, as a result, the scale of the computer graphics conference is increasing, and the results are becoming more and more wonderful, related industries are booming. The judgment and calculation of the intersection of polygon cutting is based on the line clipping of the polygon window, because in the polygon cutting of the intersection is the use of the entity of each edge of the polygon and polygon intersection, that is, line cutting. Line clipping algorithm for polygon window has several effective algorithms. For the convex polygon window of line clipping, a well-known algorithm is proposed by Cyrus and Beck. It can be divided into upper and lower two groups by judging whether the point product of the linear segment of the vector and the edge of the window is greater than zero. Then, the minimum and the maximum points in the lower group are respectively taken, the end of the visible part of the line segment. But it is not significant for the group of concave polygon window, so the Beck Cyrus algorithm is suitable for the line clipping of the convex polygon window (Ferrin T E, Huang C C, Jarvis L E, et al., 1988). Line clipping for general polygon window, some literatures propose an efficient algorithm (called the slope method). First, the algorithm is to select a fixed point on the line or the extension line which is clipped (X_f, Y_f). This fixed point should be left (or under the lowest vertex) of the most left vertex of the polygon window. Then, calculate the slope of the line from the fixed point to the vertices of the polygon:

$$vs_i = \frac{y_i - Y_f}{x_i - X_f} \tag{1}$$

Where $v_i(x_i, y_i)$ is the vertex of the i. This can then determine whether the slope of the straight line is the slope of the two adjacent vertices of the polygon. If, then, the edges of the two adjacent vertices are cut by a straight line or an extension line: Otherwise, do not intersect. If intersection, then calculate the intersection. In this paper, we use the method of fault tangent transformation, which is described below. A polygon window C has n sides, C's vertex is v_i. The coordinates are $(x_i, y_i), i = 1, 2, \cdots, n$; The cutting line is L, and the coordinates of A and B are (x_a, y_a) and (x_b, y_b), as shown in Fig. 1. Below using the case $x_b \geq x_a$ to show that:

$$\Delta x = x_b - x_a \tag{2}$$

$$\Delta y = y_b - y_a \tag{3}$$

And assume that $\Delta x \neq 0$, $\Delta y \neq 0$, or L will be parallel to a coordinate axis, and this situation does not need to cut the cut, make the implementation process more simple (Khalimsky E, Kopperman R, Meyer P R., 1990).

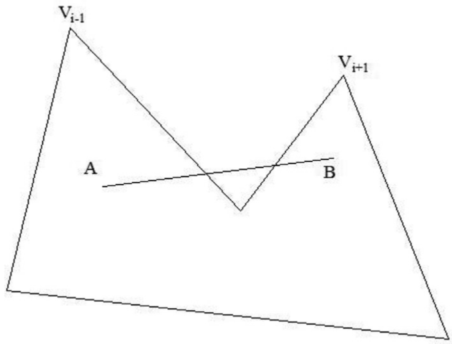


Figure 1 – Polygon Window

In the design of cutting algorithm, the most important consideration is to reduce unnecessary intersection. This method gives a very simple judging condition, and cannot calculate the non effective intersection of the extension line that falls on the window. The non effective intersection of the extension line that falls on the line to be clipped can only be determined after it is calculated to determine its validity (i.e., between the ends of the line). First, the Y and C are applied to the same L, and the L is transformed into a parallel (horizontal) direction of the X axis with the wrong tangent transformation. The matrix of the tangential transformation along the Y axis is $\begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix}$, in the form of a transformation:

$$\begin{cases} x' = x \\ y' = x * d + y \end{cases} \tag{4}$$

Where the x and y represent the coordinates of the wrong tangent transformation (the following are expressed in the form of the transformation of the point or coordinates). It is obvious that the X coordinates of these points have no effect on the coordinates, as shown in Fig 2. The intersection of the L and the Y axis is $I(0, y\ )$, which is:

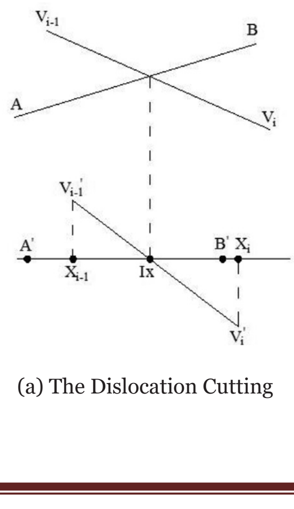
$$y_c = x_a * d + y_a \tag{5}$$

Easy to verify, after the wrong cut, straight AB into a straight line:

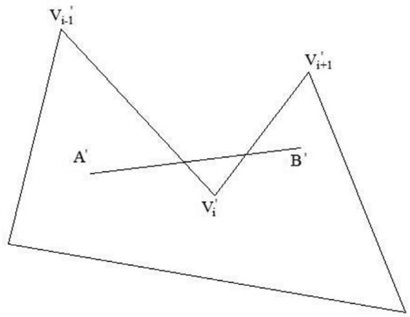
$$y = y_c \tag{6}$$

The error tangent transformation is an affine transformation, which cannot preserve the metric properties of a graph, it can cause a change in the shape of a graph, but the relative relationship between the lines is the same. Because of the C and L to make the wrong cut L into the level, so it is easy to judge and calculate the intersection (Webber B L, Phillips C B, Badler N I., 1993). And the X coordinates of the intersection and the intersection of the transformation are not changed, therefore, after (the wrong cut), it is necessary to carry out the anti-error transformation to the Y coordinates. From the above, the formula of the error is found, the calculation of the error is very small. After the wrong cut, easy to see, the condition of the intersection of an edge of C with the line AB is that the two vertexes after transform $v'_{i-1}(x'_{i-1}, y'_{i-1})$ and $v'_i(x'_i, y'_i)$ are located in the two sides of linear $y = y_c$. Or at least one of the vertices of the transformation is on the line. We first discuss the former case. At this time, the $v'_{i-1}v'_i$ coordinates of the intersection of line $y = y_c$ and line x can be calculated as follows:

$$Ix = x'_{i-1} + \frac{x'_i - x'_{i-1}}{y'_i - y'_{i-1}}(y_c - y'_{i-1}) = x_{i-1} + \frac{x_i - x_{i-1}}{y_i - y_{i-1}}(y_c - y'_{i-1}) \tag{7}$$



(a) The Dislocation Cutting



(b) The Polygon and the Cutting Line (Into Horizontal Line) after the Dislocation Cutting

Figure 2- The Wrong Cut of the Cutting Polygon

The above process can be described as follows:

Calculate $\Delta x, \Delta y, d, y_c, y_a'$ and y_b'; For each v_i, calculate:

$$y_i' = x_i * d + y_i, (i = 1, 2, \cdots, n) \tag{8}$$

Make $y_0' = y_n'$, `that is $j = 1$. For each $i(1 \le i \le n)$, followed by:

$if\ (y_{i-1}' > y_c)\mathrm{AND}(y_i' < y_c)\mathrm{OR}(y_{i-1}' < y_c)\mathrm{AND}(y_i' > y_c)$
then {Using Formula (7) to calculate the x coordinate Ix_j of the intersection point}

As mentioned in the previous section, the new algorithm determines the access of the intersection at the same time. The specific method is to determine the intersection of the intersection based on the parity of the intersection in the line(Kaufman A., 1990), the intersection of odd number is in the point of intersection, the intersection of the number is a point. As the cutting line is transformed into a horizontal line after the wrong cut, so the X coordinates of the points can be determined by the order of the points on the line. If the X coordinates of a point of intersection are obtained, the intersection is found to be located in the extension line of the cutting line and not between the two ends of the line A' and B', the intersection is not inserted into the polygon list, but it is possible to remove the influence of the parity of the other nodes in the line. Our approach is that if the direction of the line is cut from A' to B'.

On the A' side, the extension of the intersection of the line is not preserved but only the cumulative number of effective nodes to maintain the correct order of the right, on the B' side of the extension of the intersection is not cumulative: If the direction of the cutting line is from J_1 to A', the number of points on the

B' side of the extension line is only a total number of points(Tanaka A., 2000).

2.2. Music Performance Tips System Principle

The basic principle of the system of musical performance is to be placed in a row of the keyboard by a row, its role is to tell the player to play what keys at what time, so as to make the music without any knowledge of the background of the play can also play a complete piece of music, the principle block diagram is shown in Fig 3.

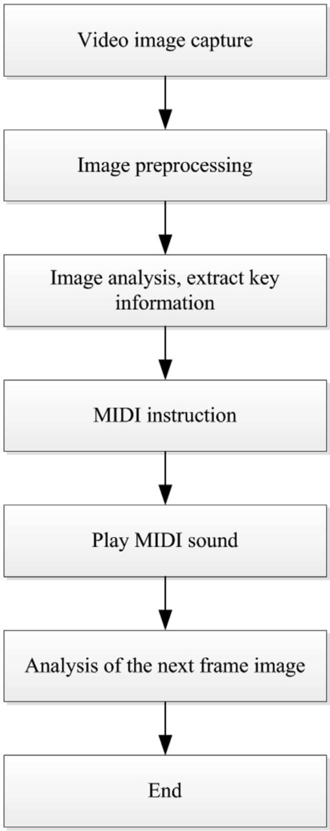


Figure 3 – System Principle and Working Flow Chart

Video image acquisition and image processing: the use of camera equipment to monitor the area of measurement, and the use of VFW for computer to recognize the digital signal. Image preprocessing: the image signal is sharpened, which can improve the visual effect of the image, the image's clarity is higher and it is more advantageous to the computer processing, analysis of various image features. Image analysis, extract key information: the use of background subtraction, the information from the player's hand is separated from the background to form a two value image, so as to extract the position information of the player's hand, and judge the corresponding key information (Morita H, Hashimoto S, Ohteru S., 1991). Prior to this process, the setting of the relevant parameters is required to determine the position of the player's hand. MIDI instruction: the position information of the player's hand is to determine the corresponding key information, MIDI format data generated in real time. Play MIDI sound: MIDI decoder based on the PC MIDI message real-time playback of a specific note. As the music is playing, the playing of the players is very fast, so the real-time performance of the system is very high, in addition, a variety of different color makes the scene there may be interference, so the video based virtual instrument system must have some robustness, to adapt to the changes in the environment. In the design must take into account the following aspects: Accuracy: due to the defects of the camera lens and other factors, the image will be distorted, in the target location, the image distortion should be considered, and the corresponding correction is carried out. In the case of the presence of the image and the interference of the environment, pixel information itself has a 2-3 pixel deviation, which corresponds to the actual size of the measured area, the position deviation (resolution 640 * 480) can be allowed for 1cm, so the process of image processing and identification must be kept in high accuracy to avoid error expansion.

Real time: in the process of performance training, the trainees' reaction speed is high, the trainee wants to play the music file in real time, LED real time real time to complete the corresponding action, the video based virtual instrument system without the keyboard must be trained in real-time detection and tracking, and maintain a high real-time performance. No keyboard virtual instrument system to be able to do the analog video signal each frame or a processing. The maximum operating frequency of the virtual instrument system is 60Hz, and the system must provide 60 times per second. The position coordinates of the training system is the whole performance training system to complete a closed loop operation, taking into account the time required by other systems, and the system must be trained to get the coordinates of the 10ms time. Robustness: although in the case of an ideal experiment or performance training, the ideal image can be obtained from the video based virtual instrument system without keyboard (Rovan J, Hayward V., 2000). But in practice, there are a lot of outside interference is inevitable, such as uneven lighting. Playing the scene is usually light illumination, according to their distribution, the difference of the illumination angle and the light material, the learning board is tested in different degrees of high brightness and dark areas. In addition, the influence of the outside world will make the local dark, or other objects reflect and use flash light will lead to the site immediately appear dark area and instantaneous bright spot. The light spot is reflected by the intensity of the light, and the color is light, if the intensity is large enough, it will be due to the saturation effect of the picture shows that the white light is weak, dark color imaging. These various reasons are caused by the change of illumination conditions and optical brightness is not uniform will reduce the accuracy of the system identification, and even lead to the failure of target identification. Therefore, it is necessary to study the color recognition algorithm which is insensitive to the change of light intensity, and the algorithm that can be adapted to these changes (Friberg A, Bresin R, Sundberg J., 2006).

2.3. The Overall Structure of the Intelligent Instrument Playing System

Intelligent instrument performance system based on intelligent algorithm is shown in Fig. 4, it consists of three parts: virtual space simulator: It contains both the hands and the model of the instrument (such as the piano), and when the instrument is played, the sound of the instrument is made.

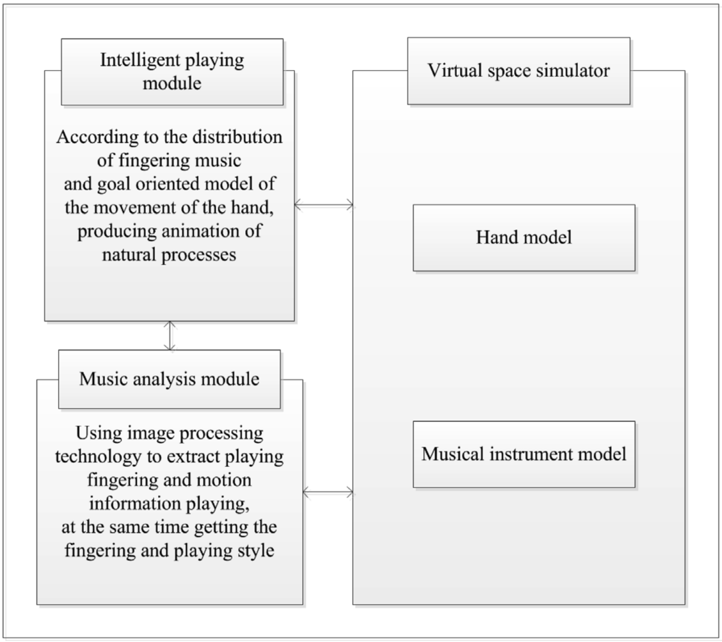


Figure 4 – Performance System Structure of Intelligent Instrument

The establishment of the hand model needs to consider the image, anatomy and robotics, the characteristics of the skeletal muscle model, the spring - damping model, the motion model and the dynamic model are considered, which not only considers the mechanical movement of the bone, but also considers the deformation of the surface, to establish a realistic model of the hands, consider establishing the solid model and the perfect fit for the sounds and movements of the instruments(Ryan J., 1991); Music analysis module: the classical music, the use of video analysis method, using image processing technology to extract playing fingering information and motion information, and access to fingering and playing style; it is also possible to use of intelligent algorithms, the music recognition and analysis.

Analysis of distribution of fingering, playing style and playing music emotion; intelligent module: According to the score distribution method, goal oriented model generation hand movement, the performance of the natural flow of the animation. We know that one of the main evaluation criteria of the animation system is the real sense of motion. The spatial coordinates and motion of the model can be generated by dynamic and kinematic constraints, but if the motion is too mechanical to lose the sense of reality will make the animation to reduce the appreciation (Sloboda J A., 1996).

Thus, the performance of the players is obtained by analyzing methods of key frame data through the video, an intermediate frame is generated by interpolation to generate a realistic performance of the performance, need to take into account the smart algorithm and the movement of the hand model, improve the speed of image analysis and data extraction. Through the intelligent algorithm generates proper distribution of fingering, virtual performer played according to the analysis to obtain the playing style and music emotion attractively. The musical lovers learning to provide very good auxiliary tools, for the creation of music creators provide auxiliary tools. The key to the whole system is based on computer image algorithm combined with intelligent algorithm extracting music playing fingering, capture the playing style and music emotion (Sloboda J A., 1996).

3. Results and Analysis

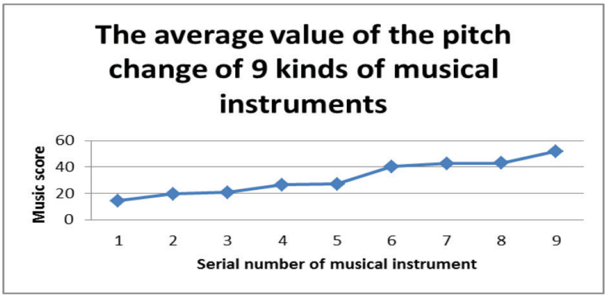


Figure 5- Pitch Statistics of Different Musical Instruments

As shown in Figure 5, number 1 - 9 respectively for the musical instrument Hulusi, Guqin, Guzheng, Pipa, Bamboo flute, Erhu, Flute, Jing Hu and the Suona. The 114 sound high school, there are 4 in the pronunciation of the process did not change, and the remaining 110, are more or less change, there are a lot of high tone, some of the more than 10, and the 228 pitch points are only the highest and lowest part of the change. The positions of these pitches are different from those of the musical instruments, the highest point is usually in the beginning stage of the sound, the lowest in the end stage, the middle stage is high, low pitch, pitch alternation and irregular, these pitches are distributed throughout the entire course of the sound. That is to say, the instrument is played, relatively the most stable tone, the vast majority in the average of 31.83 tones, constantly changing, cannot be truly sustained and stable. The range of variation is 31.83, and it is far greater than that of the 6, why can't you find it? Preliminary analysis, there are two reasons for the change of the pitch is very fast, some shorter than the 0.1 seconds of the pitch of a person's ear: Two is the change is progressive or decreasing, not suddenly changed, a lot of instantaneous change is less than 6(Paradiso J, Sparacino F., 1997).

4. Conclusions

This paper introduced the design and implementation of intelligent instrument system on the basis of computer graphics, described the principle of music performance prompting system, and comprehensively used the knowledge of artificial intelligence, computer animation, AI graphics, robotics, music design, and so on. The musical score analysis of the musical instrument performance system mainly uses the intelligent robot method and computer graphics analysis method, so as to realize the natural and fluent intelligent performance. In a word, the system design in this paper can improve the overall design level of the musical instrument performance system.

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Research on Gesture Driving Virtual Performance System Based on Graphics Behavior

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Abstract: Based on the vision, the technology of gesture recognition is an important part of a new generation of human computer interaction, which enables the computer to understand the gestures by the camera and makes the corresponding response. This paper proposes a combination of natural human computer interaction technology and music performance, and makes use of gestures to play music in the virtual environment, which has a certain practicality and scalability. Firstly, this thesis analyzes and compares several common computer gesture recognition technology, and chooses the suitable gesture driving technology as the key point. Then, in view of the problem of the distance between human and machine in the process of gesture recognition, the corresponding solution method is given. Based on computer vision, this paper uses stereo distance measurement method to screen suitable distance between human and machine, and gives the derivation process of distance measurement formula. The realization of gesture recognition technology needs to use the operation of gesture modeling to achieve real-time recognition of user gestures. In addition, this paper realizes a musical virtual performance system on the basis of the gesture recognition technology. This thesis uses monocular camera to obtain the gesture information of the operator, classifies the features of the gesture segmentation and gesture model, and simulates the action of playing music in the environment of three-dimensional, and makes use of the results of gesture recognition to drive the target program to play the sound that the operator needs.

***Keywords**:* Gesture recognition; computer vision; human computer interaction; gesture tracking.

1. Introduction

Human computer interaction technology means that human carries on the interaction activities with computer. This technology is increasingly becoming an important part of people's life, especially the computer and information technology, intelligent technology, biotechnology and other technical fields. Virtual technology is an advanced human computer interaction technology (Craig S C., 2015), it is a kind of advanced human computer interaction technology, which can effectively simulate the behavior of human in real world. It is the collection of the artificial intelligence, computer graphics, man-machine interface (Birman D, Gardner J L., 2016), network technology and other technologies. Virtual technology is a technology that has great significance, which emphasizes the users as the center, uses the computer control technology that conforms to the natural communication, and provides a natural and effective man-machine communication interface for users, which has a great effect on people's daily life. In traditional music, people usually get wonderful music by playing various musical instruments. However, many people are unable to get their favorite musical instruments to complete performance because of the economy, playing skills, the variety of musical instruments and other reasons. This paper proposes the combination of computer gesture driving technology and the process of the musical performance, users just need to enter the virtual scene (Kikot, T., Fernandes, S., & Costa, G., 2015), move the hands left and right to simulate plucking the strings, thus play the basic scales of all tones (Zhao M, Hu S, Srinivasan R., 2015). These basic scales can be coherent in beautiful music without directly contacting with all kinds of musical instruments. This method not only satisfies the needs of the majority of music fans (Sun S W, Kuo C H, Chang P C., 2016), but also solves the inconvenience that caused by playing various musical instruments, and it has high practical significance, which can be applied to some places of entertainment, music institute, music museum and so on. Computer gesture recognition technology currently has great usability and superiority in the field of music digital and virtual performance. The application of gesture recognition technology can realize the virtual music and make more music fans to engage in music performance and research (Zou H, Hu Y, Zhu X., 2015).

2. Description and Method of Problem

2.1. Definition and Classification of Gesture

Gesture recognition is an important research content in natural man computer interaction technology (Orona H M O, Maldonado G S, Martínez N P S., 2015). Due to the gesture has diversity, ambiguity, the differences in time and space, and the impact of the different cultural background, the definition of the gesture are not identical (Fiorentino M, Uva A E, Monno G., 2015). In this paper, the gesture is defined as: gesture is the combination of hand and arm so as to generate the various postures and movements, it includes dynamic gestures (refers to the action, consists of a series of postures) and static gestures (refers to gestures, a single hand). Dynamic gestures correspond to a trajectory in the model parameter space, it is also the trajectory of the hand movement, which needs to use the spatial characteristics that vary with time to express (Tomori Z, Keša P, Nikorovič M., 2015). The static gestures correspond to a point in space, which emphasizes the significance of the transfer by the hand (RusÁ¡ k Z Á, Cimen I, HorvÁ¡ th I., 2015).

Under normal circumstances, gestures can be divided into the following categories:

1. Interactive gestures and operational gestures. The movement of the former represents a specific information (such as the orchestra conductor), which is perceived by the visual perception; the latter does not express any information.
2. Autonomous and non-autonomous gestures, the latter is used to cooperate with voice to enhance or add some information (such as the speaker uses gesture description, spatial structure and other information).
3. Centrifugal gesture and gesture. The former directly for the speaker, which has a clear intention to communicate, the latter just to reflect the feelings of the speaker and the heart of the desire (Rader N V, Zukow-Goldring P., 2015).

All kinds of visible gestures are quite complex. In this paper, according to the specific characteristics of gesture virtual performance, it needs to move the hand to a specific place (Franch M, Silva C, Lopes G., 2015), and uses virtual performance of gesture classification as a gesture of communication type of imitation gesture.

Using computer to recognize and interpret different gesture input is a key premise for the realization of the application of gesture in human-computer interaction.

2.2. Stereo Distance Measurement of Computer Vision

When the gesture recognition technology based on computer vision is applied to virtual performance, the relative size of human in the virtual scene can change with the change of the position of the operator. Considering the actual virtual performance process, the action of the performance and the distance between people and music has a great relationship (Hurter C., 2015). In addition, in the case of the operator's distance from the camera's position is far from the normal range, if the gesture recognition system is still required to complete a series of operations (Nourinia R, Kanavi M R, Kaharkaboudi A., 2015), such as manual tracking, goal-driven, and so on, it will greatly reduce the efficiency of gesture recognition algorithm, and the real-time and availability of the system (Nan L, Chunlong Z, Ziwen C., 2015). Therefore, after the operator enters the visual range of the camera, the distance between the position and the camera can be measured in real time, and the result of the segmentation result is removed by a certain method in order to improve the accuracy of the system (Changyi X, Lihua Z, Minzan L., 2015).

2.2.1. View and Focus

The focal distance and the visual angle of the camera is the key information in the video image processing. In the use of the camera, the use of a zoom lens can make a bigger scene in the distance. The angle of the shooting range is defined as the angle of view. As shown in Fig. 1. Under normal circumstances, camera shooting angle, that is the size of the angle between the two ends of the diagonal and the camera. The focal distance has a certain relationship with this angle of view. In the case of a certain picture size, the angle of view increases, while the focus distance will be shorter; in contrast, the angle of view is changed, and the focus distance will be longer, as shown in Fig. 2.

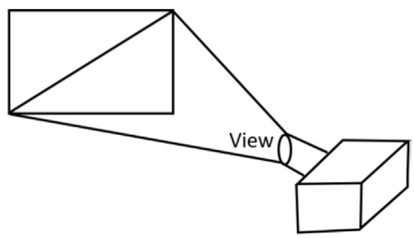

Figure 1 – Camera Perspective

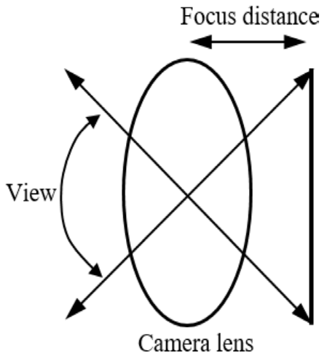

Figure 2 – Camera Focus Distance

2.2.2. *Stereo Vision Model*

Assuming two cameras placed horizontally, the distance between the lenses is b, the focus distance is f, xl and xr are the projection of any point on the left and right. As shown below fig. 3.

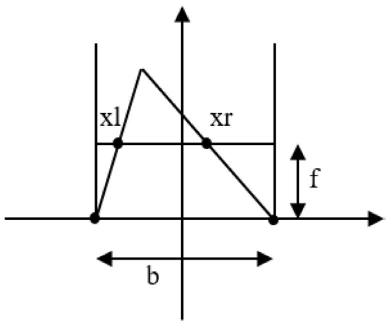

Figure 3 – Schematic Diagram of Image Projection

By the principle of similar triangles can be drawn:

$$b : Z = \left(\left|x_l\right| + \left|x_r\right|\right) : Z - f \tag{1}$$

For X, Y, with the same way, we can get the formula (2) to (4), so as to calculate three dimensional coordinates.

$$X = \frac{x_l + x_r}{2} \times \frac{b}{x_r - x_l} \tag{2}$$

$$Y = \frac{y_l \times b}{x_r - x_l} \tag{3}$$

$$Z = \frac{f \times b}{x_r - x_l} \tag{4}$$

2.2.3. Coordinate Transformation

In the actual situation, the coordinate of Point P in the image plane is represented by pixel coordinates, so it is necessary to transform it and take the coordinate into the formula to calculate. Transformation methods are as follows: set the pixel coordinate of the image is P(u, v).The relationship between pixel coordinates and image coordinates of image points such as formula (5):

$$\begin{cases} x = \dfrac{u - u_0}{dx} \\ y = \dfrac{v - v_0}{dy} \end{cases} \tag{5}$$

In the formula, dx and dy are the number of pixels in the image plane distance, also known as the proportional coefficient. (u_o, v_o) is the intersection of the optical axis of the camera and the image plane.

2.3. Constitution of Virtual Reality System

Generally speaking, the construction of a perfect virtual reality system requires the division of hardware and software of the whole. In hardware, such as the tracking system that can check the position information of the operator’s head, hand, body and so on; feedback system that can provide force and tactile perception; audio system; Image generation and display system that can produce a three-dimensional image. In software, there is a software support environment; there is a set of tools that can generate virtual objects and virtual objects; it is capable of receiving all kinds of functions of high performance sensor information, it can generate and display the function of the stereoscopic graphics.

From the point of view of system, the virtual reality system mainly includes: VR scene observation system, VR scene generation and acceleration display system, high performance computer processing system, audio system, tracking system, tactile and force feedback system. As shown in Fig. 4.

The interaction between human and the virtual world is a reflection of the response of the related objects in the virtual world, so it is called the interaction between human and virtual world. There are three main ways of interaction in virtual reality technology.

1. Control. In the virtual space, the main advantage is to interact with objects in space and manipulate them. So that we can help people understand the reality of the real world in a virtual environment and how the world works.
2. Roaming. Roaming describes how to move from one position to another. The real world’s roaming includes the road, driving, flying, gliding. In the virtual world of virtual reality, the method of roaming is infinite. Roaming consists of

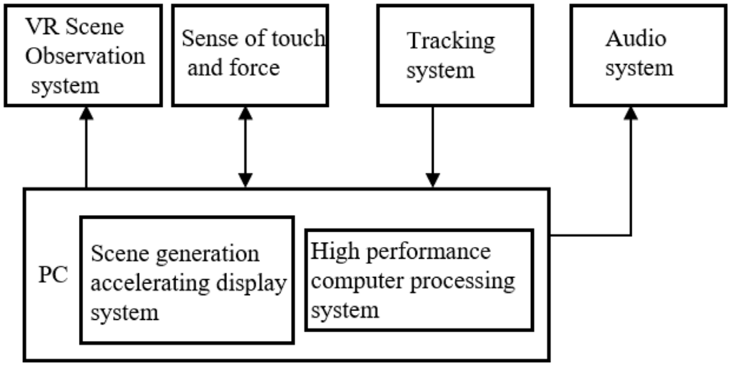

Figure 4 – Sketch Map of Virtual Reality System

two separate parts: travel and find the way. In fact, let the user experience in the virtual world, travel around the virtual world.

3. Communication. That is, the participants can communicate with the virtual objects in the virtual world, and some virtual world use the existing communication technology, such as hearing, touch, vision, and so on, even synchronous communication and asynchronous communication. For example, in synchronous communications, different participants in the same virtual world can communicate in real time.

The development of virtual reality technology has achieved considerable results. The virtual reality technology is being popularized to the market. With the development of science and technology, multi-dimensional information space is gradually able to provide the application environment for virtual reality system, and the virtual reality technology will become the most popular method and tool for human to understand the world and transform the world.

3. Gesture Recognition

3.1. Tracking of Gesture Recognition

Gesture recognition and tracking is a hot research topic at present. Because of the different research purposes, different processing techniques are produced in different aspects. Gesture is a natural and intuitive communication mode. In the daily communication, or in the activities of human computer interaction, gesture is supposed to have a very important role. However, because of the 20 joints of the human hand, the gesture is very complex, so it is a very difficult task for the recognition and tracking of hand.

3.1.1. Gesture Input

In the application system, the input of gesture is the precondition of the gesture recognition and tracking. There are two types of gesture input: one is gesture input based on the data glove, the other is gesture input based on the visual.

1. Gesture input based on data glove. According to the data glove worn on the hand, using the sensor to measure the distortion of the fingers and the hand to achieve the gesture input. It requires that the virtual object can not only track the movement of the hand, but also facilitate the movement of the user's hand and determine the position of the user's hand, the position of the user, the bending angle of the fingers.
2. Gesture input based on vision. That is the video capture, image processing, and pattern recognition and so on. It is characterized by large amount of data, complex processing methods, and is not suitable for real-time recognition. However, the limitations of the user can be very good to make up for the shortcomings of the data glove input.

3.1.2. Gesture Recognition

According to the input type of gesture, we divide the gesture recognition into the gesture recognition based on data glove and the gesture recognition based on visual gesture input. In addition, gesture recognition is divided into static gesture recognition and dynamic gesture recognition and tracking. The static gesture recognition and tracking is an emphasis on the transfer of a certain meaning through the hand. According to the visual 2D gesture recognition and tracking, segmenting the hand region through color or motion, then carries on the feature extraction processing and so on. Different from the static gesture recognition and tracking, the dynamic identification and tracking is emphasized by the motion tracking of the trajectory of the hand, and the vast majority of dynamic gestures are modeled as a trajectory in the parameter space. Compared with the static gesture recognition and tracking, dynamic gesture recognition and tracking is very difficult. In the dynamic gesture recognition and tracking, foreign research is relatively large, many of which are based on the visual recognition and tracking.

3.1.3. Gesture Tracking and Recognition in this Paper

In the early stage of gesture recognition, we first need to determine the way of gesture modeling. The potential model is very important for gesture recognition system, especially for determining the scope of identification, the selection of the model depends on the specific application. At present, almost all of the gesture modeling methods can be classified into two major categories: gesture modeling based on 3D model and gesture modeling based on the table view.

Gesture modeling method based on the 3D model takes into account the intermediate media (including the palm and arm). In implementation, the two step process is generally followed: Firstly, the motion and pose of the palm and arm are modeled, and then the model parameters are estimated from the motion and attitude parameters. Based on the idea of the model, the model is built on the surface of the palm (arm) image, and it is modeled by analyzing the apparent features of gesture in the image sequence. In principle, the gesture model based on 3D hand (arm) model is suitable for all gesture modeling, however, it lacks of efficiency, and estimation of model parameters is not reliable. So as to lead to the error of the result of the final modeling. On the other hand, although the gesture model lacks of generality, but it is simple, efficient, and low computational complexity, which is easy to achieve real-time results. At present, most of the gesture recognition system is based on the concept of the table gesture model.

To sum up, in this paper, the research of gesture driven virtual performance technology is the main input of the music is playing a copy of the gesture. The model is relatively simple, the diversity of gesture modeling is not high, and because of the characteristics of the interaction, it is needed to have a relatively high real-time performance, which is consistent with the characteristics of gesture modeling based on the table view.

After determining the gesture model, the gesture segmentation is needed. The position of the gesture region is obtained from the continuous video stream data, so as to realize the feature extraction of gesture model, and the function of the target is realized by different extraction results. Gesture segmentation is one of the key technologies in the gesture recognition system, which directly affects the recognition rate of the system. At present, most of the segmentation techniques need to be constrained by the background, users and video capture.

It is greatly influenced by the complexity of the background and the change of illumination, and it can be improved in these aspects. In this paper, we chooses a more practical method to meet the practical needs of the solution.

3.2. Design and Implementation of Virtual Playing System

3.2.1. System Sound

As a music system, the sound of the show is very important. Sound is a kind of energy wave, also has the frequency and the amplitude. For the waveform, the size of the sound depends on the amplitude of the wave, the amplitude of is large, the sound becomes large, and the amplitude is small, the sound becomes small. And the height of the sound depends on the frequency, the frequency is high, the voice is sharp; the frequency is low, the voice is relatively flat.

In this paper, the development components of the Microsoft DirectShow is used to control the majority of the interface between the windows and the media.

Some functions in the system unit can be invoked to control the sound frequency, and the sound card on the computer will deal with the digital audio data through the buffer, processing, diversion and other operations, then through the audio interface to transmit the analog signal to the sound of the horn, so that it sounds.

3.2.2. System Architecture

The realization of virtual music playing system can be divided into four modules, which are video initialization, distance measurement, gesture recognition, goal-driven.

The video initialization module completes the initialization of the video capture device, and records the background information of whether the operator entering the front of the camera. Gesture recognition module is the key, including the color space conversion, color extraction, edge tracking, etc. Then, measuring the distance between the operator and the camera, adjusting the distance between the operator and the machine. Too far or too near will affect the recognition rate and success rate of sound.

3.2.3. Goal Driven

Goal-driven module is the last function module in the system. Goal-driven module based on gesture recognition to operate the output of the left and right hand of the space position to drive the music.

Through the method of this paper, we realize each module of the system. Gesture recognition technology based on computer vision makes use of the results of gesture recognition, drives the target program to play the sound that operator needs.

4. Conclusions

This thesis focuses on the research of computer gesture recognition technology, based on the computer vision, applies the natural gesture recognition technology to the virtual performance, which not only has important significance in theory but also in practice. In theory, this paper discusses several key issues in the technology of natural gesture recognition: Natural gesture modeling and gesture segmentation. After analyzing and comparing various types of gesture models, the gesture recognition method on the basis of computer vision is chosen as the focus of this paper according to the actual needs. The original human body position information is obtained by using background subtraction in the video stream data that captured from monocular camera. In the process of gesture segmentation and recognition, this thesis analyzes the method and availability of stereo distance measurement method, and researches two cases：Camera toward and camera tilt，and respectively gives the inference formulas of distance measurement, which can improve the accuracy and efficiency of gesture recognition, then makes use of the results of gesture recognition to drive the target program to play the sound that operator needs. From the point of view of the research and the application, in order to really improve the real-time recognition of gestures and the practicality of the system, and achieve the stability and accuracy of the system in the practical application scene, it is necessary to rely on the recognition algorithm which has better performance and higher efficiency. This is also the future research direction of the virtual performance system of gesture driving.

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The Energy-balance Algorithm Based on Polling and Backoff Mechanism for Wireless SHM System

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Abstract: The structural health monitoring technology has already been widely used in monitoring fields. Among various SHM technologies, the wireless SHM system caused public concerns with its advantages such as low-power, no cabling. This paper focused on the problem of energy imbalance in wireless SHM network and proposed a new energy-balance algorithm. In this algorithm, an energy consumption model was introduced for the data transfer process to describe the relation among factors. And then, the sleeping scheduling mechanism was adopted to reduce the energy consumption of the whole network. Based on analysis result of the energy consumption model, we divided the SHM network into several secondary nets. At this point, the polling and backoff scheduling mechanism was introduced to balance the energy consumption of each node effectively. The MATLAB simulations have proved that the algorithm could balance the energy consumption among nodes in wireless network effectively, and the lifetime of the whole system could be extended significantly.

***Keywords**:* Wireless sensor network; Energy consumption model; Energy balance algorithm

1. Introduction

With the development of the large-span structure and ultra-high-rise building, the application of the wireless structural health monitoring has already been valued by people more and more (Sohn H., Park G., Wait J. R, Limback N. P, Farrar C. R., 2004). Most of the wireless SHM systems used batteries as the energy source for the data acquisition nodes. And, more remarkable, the batteries usually would be difficult to or even cannot be replaced by the new ones when the nodes were installed on the huge target. So it used to be obviously that the wireless SHM system was sensitive to the energy consumption--either the single node or the whole network (A. Sidra, F. Farrah, and S. Shahzad., 2009).

To avoid the problem, researchers used multiple approaches to reduce the consumption of the node itself such as adopted the low-power chips, modified hardware design. Further, people proposed many improved network communication protocols which could reduce the energy consumption of the nodes by controlling the operating frequency (Zapata, B. C., Niñirola, A. H., Fernández-Alemán, J. L., & Toval, A., 2014). But various factors caused that the data throughput of each node was random and was not relatively homogeneous which might lead to large differences of the energy consumption among each node, a small number of nodes might be exhausted while the others could still keep operating for a long time. At this point, the working life of the whole network was not extended effectively. In other words, the protocols needed a proper energy consumption balancing algorithm.

Based on the previous researches this paper built the model for energy consumption of nodes in the whole network and suggested a new energy balance algorithm for wireless SHM network. Through the analysis of the model, the algorithm divided the every subnet of the network into several secondary net. And by the reasonable sleeping scheduling, the algorithm set up the backoff mechanism for node.

2. The Model for Energy Consumption

In most applications of the wireless SHM system, the monitoring modes usually could be classified into centralized monitoring and sampling monitoring. The centralized monitoring was used to analyze the target structure comprehensively and would drive all nodes work at full power. More often, the wireless SHM system would work in the sampling monitoring mode (Wu Shiming ,Lin Cungang , Zhang Zhongmiao, Li Zongliang., 2011). In this mode, the network only gathered the data intermittently from the key area at most of time. In this paper, we discussed the energy consumption balancing for the sampling monitoring mode mainly.

To analysis the process of energy consumption while the data was transmitted, we gave the basic model as the fig. 1.

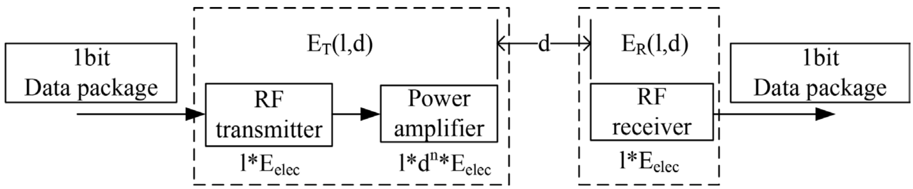

Figure 1 – The Basic Model for the Energy Consumption During Communication

Suppose d as the communication distance between two nodes, and the critical value of the communication distance was d_o (it could be agreed that when $d<d_o$, there should be a relay node to complete the data transmission). When $d<d_o$, the energy consumption would be proportional to d_2. In that case, the communication between nodes conformed to the free-space channel model. When $d<d_o$, the energy consumption would be proportional to d_4. And at this moment, the model adopted the multipath fading channel transmitting model. So, we could describe the relation within different energy consumption by the following formula (1) (2):

$$E_T(l,d) = E_{T-elec}(l) + E_{T-amp}(l,d) = \begin{cases} lE_{elec} + l\varepsilon_{fs} d^2, d < d_o \\ lE_{elec} + l\varepsilon_{amp} d^4, d \geq d_o \end{cases} \quad (1)$$

$$E_R(l) = E_{R-elec}(l) = lE_{elec} \quad (2)$$

The symbol lE_{elec} represented the necessary energy consumption which was keeping the send and receive circle operating and depended on some factors such as the encoding and modulation method of digital signal and the filter. The symbol $E_{T\text{-}elec}(l)$ expressed the energy consumption when the node tried to send a l bits data package and the symbol $E_{T\text{-}amp}(l,d)$ meant the energy consumption of power amplifier which related to both the length of data package and the transmitting distance. The constants ε_{fs} and ε_{amp} depended on the kind of channel model.

To analyze the formula (1) (2) for further, we assumed 6that there were N nodes distributed uniformly in the circle area and the gateway was at the center of the network. Then, the network structure was shown as the fig. 2.

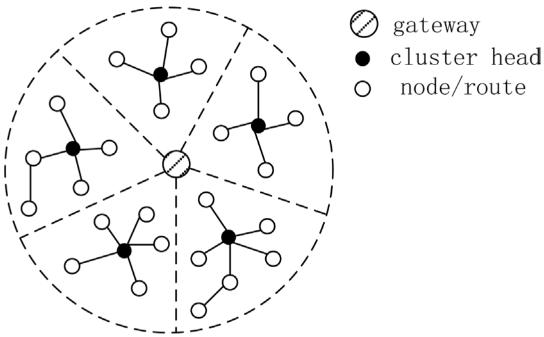

Figure 2 – The Network Structure

Based on this structure, we might suppose further that when the energy consumption was balanced (if possible) so the whole area could be divided into k subnets. Immediately, we could know that the average number of nodes in each subnet was N/k. Defined the symbol d_i as the distance between the node i and the cluster head in subnet and the symbol ρ was the density of the nodes. The expectation of the transmitting distance within the nodes from the same subnet could be described as:

$$E[d_{toCH}] = \iint d_i \rho dr d\theta \tag{3}$$

When the nodes began to transmit a frame of data package, it could send the package to the gateway directly or send to the cluster head. The distance between node and gateway determined the transmitting path. Through the free-space channel model we could obtain the energy consumption when node trying to send a frame of l bit data package to gateway or cluster head (Seema Bandyopadhyay and Edward J. Coyle., 2003).

$$E_{mon-CH} = lE_{elec} + l\varepsilon_{fs} d^2_{toCH} \tag{4}$$

To obtain the value of d^2_{toCH}, let's suppose further that the cluster head was center in the subnet. The symbol r' denoted the distance between the node and the gateway. The area of the monitoring region could be calculated as:

$$s = \pi r'^2 = k\pi r^2 \tag{5}$$

For now, the average radius of the subnet was:

$$r = \sqrt{s / k\pi} \tag{6}$$

To simplify the calculation process, using the $E[d_{toCH}]$ replace the d_{toCH} approximately was entirely reasonable. In that case, given that $\rho = (1/(s/k))$, the formula (4) could be changed as:

$$E_{mon-CH} = lE_{elec} + l\varepsilon_{fs}\frac{s}{k} \tag{7}$$

From the equation above we could get the conclusion: given the energy consumption of the RF circle was constant, the energy consumption of the node would be related to the number of the subnets k. Or rather, this relation was negative correlation.

3. Sleeping Scheduling Mechanism

In the application of the wireless SHM system excessive amount of working nodes would over-take the channel and might bring data collisions. And on the other hand, the most straightforward way to save energy was to put the device to sleep. In view of this point, under the sampling monitoring mode this paper introduced the sleeping scheduling mechanism for the subnets based on the model of energy consumption.

When the wireless SHM system working under the sampling monitoring mode, we only required the nodes keep working in turns in key areas. That is, the node would suspend to sleep when its operation cycle ended (Ming-Feng Wu, Chih-Yu Wen., 2012, Y.-H. Lee, Y.-S. Chen and L.-F. Chen., 2009). As the difference of monitoring areas in each data acquisition cycle, every node might be waked up and began to work or be put to sleep at any time which depended on the gateway. In the energy balance view, of course, there was a significant factor when the gateway arranging the work – the residual energy of each node. At the beginning of monitoring circle, the nodes should submit the feedback about their residual energy to their cluster heads or the gateway. For the gateway, it would choose the key monitoring areas firstly; and then the gateway would determine the work sequences for all the nodes based on their area and residual energy; after that, it would notify the scheduling order to all the nodes directly or via cluster heads and routes. The operation state would convert follow the rule in fig. 3.

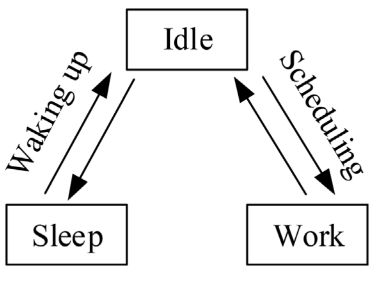

Figure 3 – The Process of the State Transition

Under this mechanism, the residual energy of the nodes depended on the task assignment from the gateway. But in most conditions, for various reasons, the energy consumption could not be balance. For further realization of the energy balance, we designed the improved energy balancing algorithm for the wireless SHM network.

4. The Improved Energy Balancing Algorithm

As the previously stated, the nodes would submit the feedback about their residual energy to the cluster head or the gateway. The initial energy of the node was certain to the gateway when the wireless network was just formed. And soon, we could know the residual energy of the node Ei could be expressed as:

$$E_l = E_{\mathrm{o}} - E_{mon-CH} \tag{8}$$

In the equation (8) the E_o was the initial energy which depended on the battery. And the symbol $E_{mon\text{-}CH}$ meant the energy expended by node. More specifically, the $E_{mon\text{-}CH}$ contained the energy expended when the node was transmitting or receiving data, detecting the channel quality, processing information and so on.

Based on the conclusion in chapter 3, the improved energy balancing algorithm contained two parts: the division of secondary nets in polling scheduling and the backoff mechanism.

4.1. The Division of Secondary Nets in Polling Scheduling

From the equation (7) we had already obtained the conclusion that the relation between the amount and the energy consumption of the nodes relation was negative correlation. And based on the sleeping scheduling mechanism, we introduced the polling scheduling. Under this mechanism we divided the subnets into secondary nets (Yang Liu, Changchuan Yin, Jing Gao, Xiaohui Sun.,2013). By this method the amount of the subnets was expanded as the fig 4.

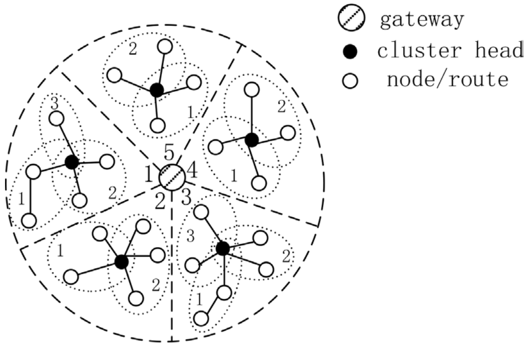

Figure 4 – The Division of the Secondary Subnets

As it was shown in fig 4, we supposed that there were 5 subnets in the gateway-centered network and all the subnets are cluster heads-centered. To this network, we divided the

5 subnets into secondary nets as the fig 4. Take subnet 1 for example, the subnet was divided into 3 secondary nets 1-1, 1-2 and 1-3. Then at certain circle, under the sampling monitoring model in the subnet 1 we might activate the nodes in secondary net 1-1, and the nodes in 2-2 and 2-3 would be put to sleep.

The secondary nets were divided by cluster heads or by the gateway based on the consideration of the residual energy of nodes in the subnets. For instant, assuming the nodes in fig 4 were working under the sampling monitoring model and each monitoring circle was divided into 3 rounds. Then the nodes which need to complete the sampling monitoring were:

1st round: 1-1, 2-1, 3-1, 4-1, 5-1

2nd round: 1-2, 2-2, 3-2, 4-2, 5-2

3rd round: 1-3, 3-3

The secondary nets were proposed to make the nodes be more effectively to manage. That is, in the network, the nodes would work in units of secondary nets. And once the gateway found that the tendency of residual energy of any subnets or secondary nets was becoming unbalance (Ning Jin, Kaiji Chen, Tao Gu., 2012), it would adjust the polling rule for the upper net – by the way of backoff.

4.2. The Backoff Mechanism

In particular, the gateway could "expel" the nodes whose residual energy was low for several backoff periods. When the count of backoff was satisfied, the expelled nodes might be allowed to execute the data acquisition task again. It was worth to point out that if all nodes from the same secondary nets were expelled, these secondary nets would also be cut temporarily (Seok-Won Kang, Jae-Ryong Cha, Jae-Hyun KimA., 2010, Shiming W, Cungang L, Zhongmiao Z, et al., 2011).

The key point of this mechanism was to calculate the number of sleeping periods precisely in the condition of imbalance energy consumption (Nasir Q, Albalt M., 2008). According to the formula (7), we could get the total energy consumption of all nodes from the *N* nodes network in every monitoring circle:

$$\sum_{i=1}^{N} E_i = \sum_{i=1}^{N} l_i (E_{elec} + l\varepsilon_{fs}\frac{s}{k}) \tag{9}$$

And the average energy consumption of each node in a monitoring circle was:

$$\overline{E_N} = \frac{\sum_{i=1}^{N} E_i}{N} \tag{10}$$

If the gateway hadn't expelled any node from the working network, we could calculate the average energy consumption of each node after *t* monitoring circle as:

$$\overline{E_l} = E_0 - t\overline{E_N} \tag{11}$$

After the adjustment from the gateway, assuming that there were m nodes were expelled and there were n secondary nets was cut accordingly, the total energy consumption of all nodes from the *N*-*m* nodes network was:

$$\sum_{i=1}^{N-n} E_i = \sum_{i=1}^{N-n} l_i (E_{elec} + l\varepsilon_{fs} \frac{s}{k-m}) \tag{12}$$

Then, the average energy consumption of the *N*-*m* nodes was:

$$\overline{E_N}' = \frac{\sum_{i=1}^{N-n} E_i}{N-n} \tag{13}$$

Finally, we defined the average residual energy of the nodes which were expelled was E_l', so the backoff periods could be yielded as:

$$t' = \frac{\overline{E_l} - E_l'}{\overline{E_N}'} \tag{14}$$

From the above formulas we could deduce the conclusion: when the residual energy of the node was lower than the average level, the node might be expelled for about t' periods.

5. Simulation & Analysis

This paper supposed the wireless SHM system were monitoring the area of radius 1000m and the gateway could be considered to be at the center of the monitoring area. In this wireless network there were total 120 nodes in 8 subnets (without secondary nets). The detailed parameters for simulation were shown in table 1:

Simulation parameters	Value	Instruction
l	10000*bit*	Amount of data in single transmission
E_{elec}	50*njb*$^{-1}$	Energy consumption of RF for 1 bit data
ε_{fs}	10*pjm*$^{-1}$	Parameter of free space channel model

Table 1 – The Detailed Parameters for Simulation

The MATLAB simulation comparison result of both the wireless SHM system with and without polling scheduling was shown as fig. 5.

We could see the relation between the survival amount of nodes and the monitoring rounds from the fig 5. Obviously, the nodes worked under the polling scheduling mechanism could survive much longer. And the energy imbalance resulted from the different workload among nodes which were in different monitoring areas was restrained

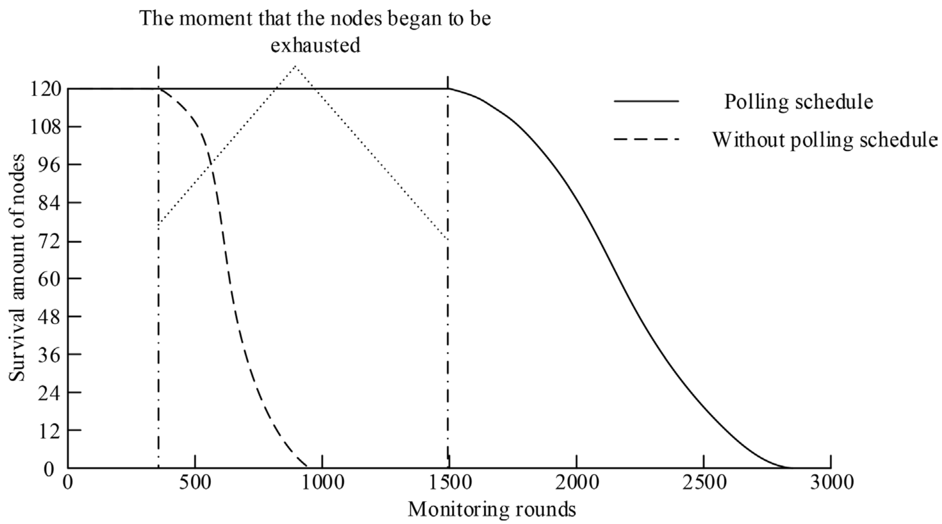

Figure 5 – The Simulation Comparison Result

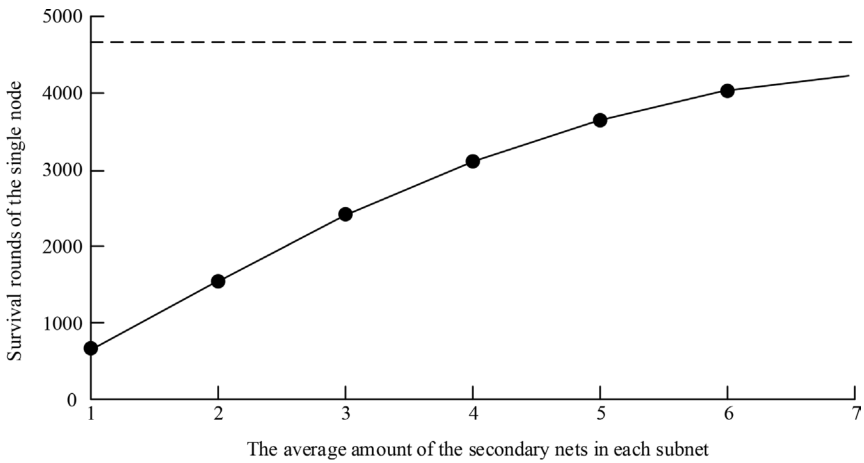

Figure 6 – The Relation Between the Average Amount of the Secondary Nets in Each Subnet and the survival Rounds of Single Node

effectively. Furthermore, the simulation comparison result had pointed out clearly that the moment that the first node was expelled had been delayed greatly.

And also, we shouldn't ignore the point that the amount of the secondary nets could determine the global energy consumption significantly. To prove this conclusion, we changed the average amount of the secondary nets in each subnet which meant that we changed the value of k in formula (6) and simulated again to the survival rounds of single nodes. The result was described as fig. 6.

The simulation result showed that to the single node, the more secondary nets were divided into, the longer time that the node could work. The reason of the result was intuitive: under the polling scheduling mechanism the amount of the secondary nets in a certain subnet would affect the assignment of the monitoring task to nodes. Once the amount of secondary nets was larger, the tasks among each node would tend to be more average. But it was worth mentioning that in the practical application, the amount of the secondary nets should be divided by the importance of the monitoring area.

It could also be learnt from the fig 6 that with the increasing of the amount of secondary nets, the survival rounds of single node began to be converged. This result total conform the formula (7) as the following equation showed:

$$\lim_{k\to\infty} E_{mon-CH} = \lim_{k\to\infty}\left(lE_{elec} + l\varepsilon_{fs}\frac{s}{k} \right) = lE_{elec} \tag{15}$$

From the formula (14) we might predict that assuming the subnets and the secondary nets were divided perfectly ideally, the energy consumption of the single node would tend to approach the limit lE_{elec}.

To further analyze the effect of the "expelling" method under the polling scheduling mechanism, we modified the parameter E_{elec} for some of nodes which would result those nodes consumed energy much faster. Of course, this would lead to energy imbalance To further analyze the effect of the "expelling" method under the polling scheduling mechanism, we modified the parameter Eelec for some of nodes which would result those nodes consumed energy much faster. Of course, this would lead to energy imbalance aggravated. The simulation result was shown in fig. 7.

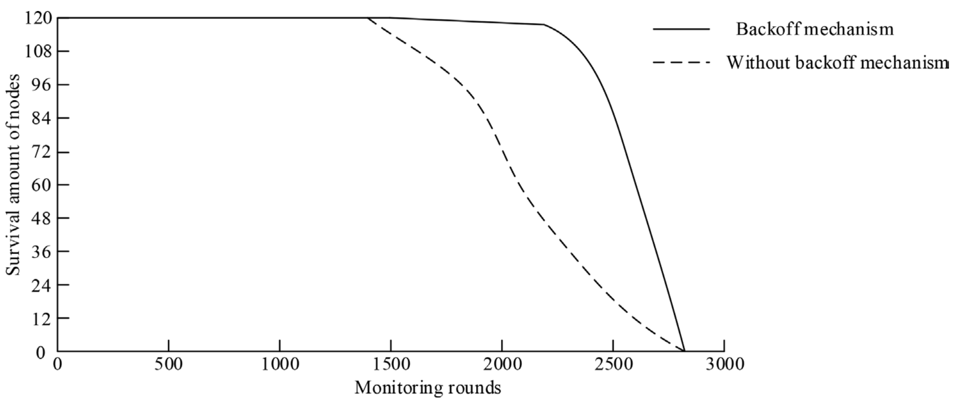

Figure 7 – The Comparison Result Between the Network With and Without The Backoff Mechanism

From the fig 7 we could get the conclusion that though energy of all nodes in the network would be exhausted nearly at the same time, the network with the backoff mechanism still showed the satisfactory effect on energy balancing to each node. The emergence of the exhausted nodes was concentrated after about 2350 monitoring rounds compared with the other network at about 1550 monitoring rounds.

6. Conclusion

This paper proposed an energy balance algorithm for wireless SHM system to solve the energy imbalance among different nodes. Through the positive research, we get the following conclusion:

1. During data transfer process, given the energy consumption of the RF circle was constant, there is a negative correlation between the energy consumption of the node and the number of the subnets.
2. By setting the secondary subnets, the gateway was allowed to “expel” any nodes which were classified as imbalance for several periods. And based on the energy consumption model, the backoff period was calculated accurately.
3. The simulation comparison results proved that the nodes in SHM system which applied the energy balance algorithm would be exhausted nearly at the same time. And benefited from the proposed energy balance algorithm, the working life of the wireless SHM system could be extended.

Though the encouraging simulation result had proved the validity, but it should be noted that the algorithm didn’t consider that in some cases there would be a few nodes work as both the route and data acquisition node. Those nodes might become the hotspots of energy consumption which would be another source of energy imbalance. In future work, we would focus on the problem and improve the algorithm further.

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A Data Fusion Method of WSNs Based On Glowworm Swarm Algorithm Optimized BP Neural Networks

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Abstract: To improve the data transmission efficiency of wireless sensor networks (WSNs), and reduce the data traffic and the energy consumption of the sensing nodes in the network, a data fusion algorithm for WSNs is proposed based on glowworm swarm algorithm optimized back propagation (GSO-BP) neural network (NN). The clustering routing protocol, leach, of sensor network is integrated, and the cluster heads and the nodes in WSNs are considered as the neurons in BP NN. The optimized weights and thresholds of BP networks are used to effectively extract a small number of features in the raw data of sensing nodes. The extracted features are fused and sent to the Sink. It compared GSO-BP method with the leach clustering algorithm, BPNNs, and PSO-BP algorithm in terms of four aspects, including average energy consumption changes of nodes, the changes of alive node number, the number of data packages received by the Sink, and the terminal to terminal transmission delay. Experimental results showed that the proposed algorithm can efficiently reduce the transmission traffic of networks and the energy consumption of sensing nodes, improving the data fusion efficiency and extending the network lifetime.

***Keywords**:* Wireless sensing networks; data fusion; glowworm swarm algorithm optimization (GSO); back propagation neural networks (BPNNS); swarm intelligence

1. Introduction

The Internet of things is called the third wave of the world information industry, following the computer and the Internet technology (H. S. Ning, H. Liu, L. T. Yang., 2013). Wireless sensing network is the main carrier and the key technology of application layer of Internet of things (J. M. Liang, J. J. Chen, H. H. Cheng, Y. C. Tseng., 2013). In the key information collection process of the fundamental factors of Internet of things, different methods have different collection efficiency (S. Balasubramaniam, J. Kangasharju., 2013). The common method is to directly send the data collected by sensors to the Sink, then store them in databases through gateway nodes (Ma, Zhenghua, S. Lei, J. Zhuqing., 2013). Due to the big quantity of data, much energy is consumed, and the data collection capacity is very low. Therefore, the data collected by source nodes are firstly fused. By fusing the raw data of each node (Mora, A. D., & Fonseca, J. M., 2014), the data collection accuracy and efficiency are improved. In this study, a new data fusion model based on swarm intelligence is established. The network energy consumption under different fusion strength is theoretically calculated. Moreover, the network energy consumption and the network running status using different fusion algorithms are analyzed.

Many studies on data fusion in WSNs have been carried out. Zhang proposed a data fusion in WSNs based on Bayes sequential estimation. The results showed that this method has low energy consumption and transmission delay (Zhang Shukui, Cui Zhi-ming, Gong Shengrong., 2009). Tang proposed a Layer-cluster data fusion method based on information entropy, in which the cluster head nodes were periodically selected and the node data within a cluster were fused, significantly reducing the node energy consumption and extending the network lifetime (Tang Chen, Wang Ruchuan, Huang Haiping., 2008). Lin suggested a two-pass data fusion algorithm to control redundant data and reduce data traffic, improving the network efficiency (Lin Wei, Zhu Qilong., 2010). Sun developed a data fusion method based on NN, improving the network efficiency and reducing node energy consumption (Sun Lingyi, Huang Xianxiang, Cai We., 2011).

In this study, it summarized the previous studies, and suggest using the weights and thresholds of the GSO optimized BPNNs in the data fusion of WSNs. In this method, a small number of features in the raw data collected by the sensing nodes in WSNs are efficiently extracted and then sent to the Sink, improving the data collection efficiency and extending network lifetime.

2. The Application of BP in WSNs Data Fusion

A reference to the proposed algorithm Back Propagation Networks Data Aggregation (BPNDA) by Sun (Sun Lingyi, Huang Xianxiang, Cai We., 2011), the monitoring region of WSNs is firstly clustered so that the cluster head sensor in each region receives the data detected by the sensor nodes in this region. The sensor nodes collected the signal data and pretreated it, extracted the useful feature information, and then send to the cluster head node. The algorithm is called Back Propagation Neural Networks Data Fusion (BPNNs DF) and used between the cluster head node and member nodes. The model structure of BPNNs DF algorithm is shown in Fig. 1.

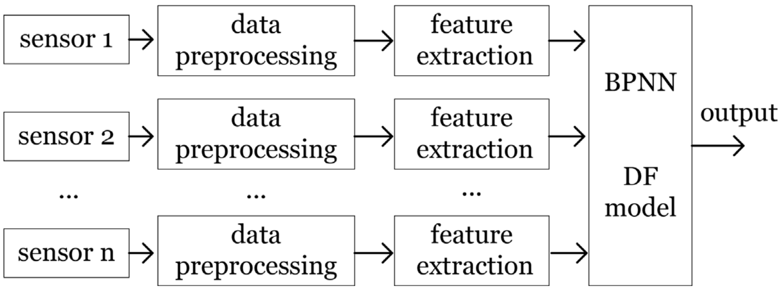

Figure 1 – BPNNs-DF Model Structure

The algorithm reduces the redundant data, but the convergence speed of the traditional BPNN algorithm is slow, it is easy to get trapped in local optima. Moreover, the layout and the parameters of BPNN are often empirical, which limits the further development of BPNN in data fusion field. GSO is a kind of high efficiency swarm intelligence optimization algorithm. It has high convergence speed and is parallelizable. It has been applied in polynomial calculation, combinatorial optimization and other practical problems. It is able to improve algorithm convergence speed, the data collection efficiency and finally extend the network lifetime by using GSO to optimize the structure and parameters in BPNN.

3. GSO Algorithm

With the development of intelligent computing technology, the scientists proposed a lot of swarm intelligence algorithms based on the research of nature. These algorithms are parallel, adaptive, fault tolerance and strong robustness. Dr. Yang X.S abstractly extracted the lighting behavior of glowworms, and proposed GSO algorithm (Yang X S, Deb S., 2010). In GSO, parameters are defined as follows:

Parameter	Description
i	glowworm (i)
(xi(k),yi(k),zi(k))	current position
f(xi(k),yi(k),zi(k))	objective function value
λ	fluorescein value
w	fluorescein update rate
γ	intensity absorption coefficient
r_s	sensing range

Table 1 – Parameters Define for GSO

The GSO is mainly composed of four parts, including initialization, fluorescein update, flying position update and firefly decision domain update (Yuan jijun., 2012). Glowworm *i* will transmit relevant information when flying, the decision range is determined according to eq. (1) (Lü Ming., 2014,Li Song, Liu Li-jun, Zhai Man., 2012,Chen Qiuhong, Guo Meng., 2014).

$$r_d^i(k+1)=\min\left\{r_q,\max\left[0,r_d^i(k)+\beta(m_i-|M_i(k)|)\right]\right\} \tag{1}$$

where $r_d^i(k)$ represents the decision range of glowworm *i* in the *k-th* iteration, and satisfies $c(j_1,1)=t_{j_1 1}$; r_q is the sensing range of glowworms; m_i is the threshold of the number of glowworm's neighbors; β represents the changing speed of the neighborhood; $M_i(k)$ stands for the neighborhood set of glowworm *i* in the *k-th* iteration.

$M_i(k)$ is determined by eq. (2):

$$M_i(k)=\left\{j:\sqrt{\left(x_j(k)-x_i(k)\right)^2+\left(y_j(k)-y_i(k)\right)^2+\left(z_j(k)-z_i(k)\right)^2}<r_d^i;l_i(k)<l_j(k)\right\} \tag{2}$$

where $x_i(k)$, $y_i(k)$ and $z_i(k)$ are the position of firefly *i* in the *k-th* iteration, the position is a three-dimensional coordinate, represented by a triple; $l_i(k)$ stands for the fluorescein value of glowworm *i* in the *k-th* iteration; the probability that firefly *i* moves to its neighbor glowworm j in the *k-th* iteration is represented by $p_{ij}(k)$, and given by (3) (Lü Ming., 2014).

$$p_{ij}(k) = \frac{l_j(k) - l_i(k)}{\sum_{n \subset M_i(k)} l_n(k) - l_i(k)} \tag{3}$$

The position of glowworm *i* after movement is given by (4):

$$\begin{cases} x_i(k+1) = x_i(k) + S(\dfrac{x_j(k) - x_i(k)}{\left|x_j(k) - x_i(k)\right|}) \\ y_i(k+1) = z_i(k) + S(\dfrac{y_j(k) - y_i(k)}{\left|y_j(k) - y_i(k)\right|}) \\ z_i(k+1) = z_i(k) + S(\dfrac{z_j(k) - z_i(k)}{\left|z_j(k) - z_i(k)\right|}) \end{cases} \tag{4}$$

Wher *S* represents the movement step.

The fluorescein value is updated according to (5) after glowworm *i* moves to a new position.

$$l_i(k) = (1-\lambda)l_i(k-1) + \omega f(x_i(k), y_i(k), z_i(k)) \tag{5}$$

Where $l_i(k)$ represents the fluorescein value of glowworm i in the k-th iteration; $\lambda \in (0,1)$ represents the fluorescein volatilization, w is constant, represents the update rate of fluorescein.

4. Design of WSNs Data Fusion Based on GSO-BP

The main steps of data fusion in WSNs are including: the GSO-BP algorithm collected the sensor data in monitored region firstly, preprocessed, quantized, coded and normalized the collected data, and then the data is divided into training set and test set. GSO performs iteration and optimization for the initial thresholds and weights of BPNNs. It constructs optimal WSNs data fusion model, and then applied this fusion model to the WSNs to improve the network fusion accuracy and extend the network lifetime. It used the GSO-BP algorithm to carry out extensive training on the training set, and output the fusion dada by the trained model on the test data set. The mathematical model of WSNs data fusion based on GSO-BP is shown in Fig. 2.

The concrete implementation steps of GSO-BP algorithm is as follows (Lü Ming., 2014):

Step 1: Population initialization: Number the individuals.

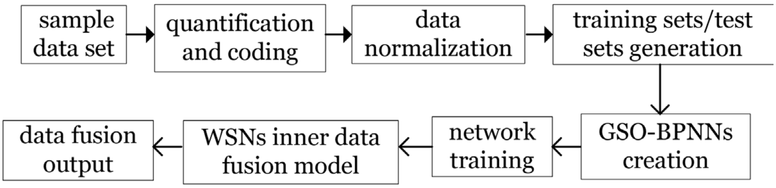

Figure 2 – Mathematical Model of WSNs Data Fusion

Step 2: Fitness function: Train the initial weights and thresholds of the BPNNs, where the fitness value D is given by (6):

$$D = k(\sum_{i=1}^{n} |Q_i - V_i|) \tag{6}$$

Where *K* is a constant number; *n* is the number of network nodes; *Qi* is the expected output value of node *i*; *Vi* is the predicted output value of node *i*.

Step 3: Fluorescein update operation, compute the fluorescein value of glowworm *i* according to (6).

Step 4: Position update operation: Update the position according to (4), and use (6) to compute the objective function value at the new position after updating. Finally, update the global optimum.

Step 5: Decision domain update: After position updating, glowworm *i* dynamically update its decision radius according to the density of neighborhoods.

Step 6: Optimize the BPNNs, and output the optimal results. When the training error satisfies a predefined constraint, the training of optimized BPNN finishes. Input the data to be predicted into the trained BPNN, the data fusion of WSNs will be output.

5. Simulated Test and Analysis

The node parameters in the simulated experiment are shown in Table 2. The simulation environment was Matlab programming, with 2012a edition. We analyzed node energy consumption according to the energy model of node sensing. We defined the node energy consumption equation of data package sending (Li Song, Liu Li-jun, Zhai Man., 2012): $E_{send} = E_{trans} \times s + E_{amp} \times d^2$, where E_{send} represents the energy consumed by sending 1 bit of data; s represents the volume of data package sent; E_{amp} stands for the circuit loss after amplifying signals; *d* is the transmission distance between sensing nodes. The energy consumption equation of receiving signals is: $E_{receive} = E_{rec} \times r$, where E_{rec} represents the energy consumed by receiving 1 bit of data; *r* represents the number of data packages sent by the node. Glowworm parameters settings are (Chen Qiuhong, Guo Meng., 2014): the number of fireflies is 50; the initial fluorescein value is l_0=5; the intensity absorption coefficient is γ =1.0; the maximum attraction is β =1.0; sensing range is r_s=5; step factor is α =0.03; iteration number is max D=100.

Parameter	**Value**
Network scale	100m×100m
No. of nodes	100
Initial energy	0.5 J
Transmission range	30 m
Energy consumption of transmission	50 nJ/bit
Energy consumption of receiving	30 nJ/bit
Data package volume	80 bytes
Simulation time	2000s

Table 2 – Parameters for Simulation Experiment

In the data transmission of WSNs, the leach algorithm first performs clustering, then the within-cluster nodes send data to the cluster head. The cluster head sends data to the Sink (Wan chuanfei, Du shangfeng., 2011). Based on the fact that the connection way of cluster head node and the member nodes is similar to NN, the BPNN method utilizes the transmission way of NN algorithm to transmit data (Sun Lingyi, Huang Xianxiang, Cai We., 2011). The PSO-BP (Particle swarm optimization algorithm-back propagation) algorithm optimizes BPNN, but it has some drawbacks (Chen Qiuhong, Guo Meng., 2014). In this study, the BPNN is improved by data fusion, and the network data fusion efficiency is improved.

It compared the leach clustering algorithm, BPNNs, PSO-BP and GSO-BP algorithm in terms of four aspects, including average energy consumption changes of nodes, the changes of the number of living nodes, the number of data packages received by the Sink, and the terminal to terminal transmission delay. The detailed study and comparison results are as follows.

GSO-BP parameters were set according to the introduction of simulated experimental environment. The evolution process of fitness value in GSO-BP is shown in Figure 3. It can be seen from Fig. 3 that with the increasing of generation number, the algorithm converged relatively fast.

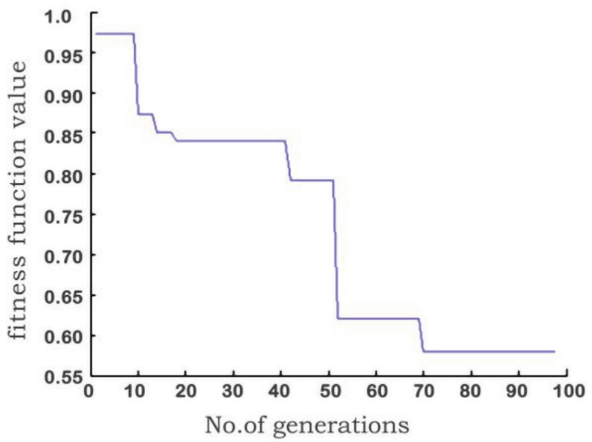

Figure 3 – Evolution Process of Fitness Value in GSO-BP

5.1. No. of Living Nodes

Network lifetime is a key factor in WSNs. Extending network lifetime means extending the life of a network and increasing the work time of the network, which is very important for WSNs. Figure 4 shows the number of living sensing nodes of leach clustering algorithm, BPNNs, PSO-BP and GSO-BP algorithm, with the variation of network polling times.

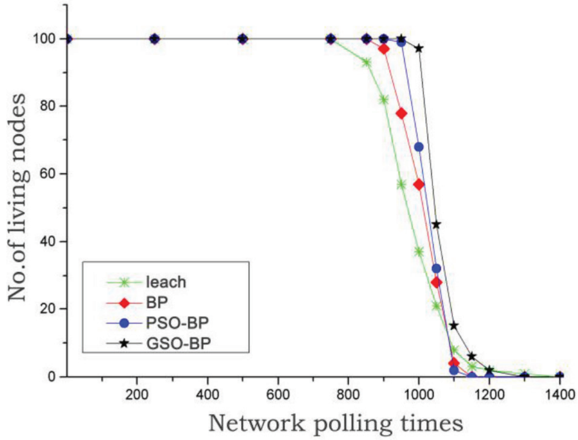

Figure 4 – No. of Living Sensing Nodes with the Variation of Network Polling Times

It can be seen from Fig. 4 that when the network polling time is about 800, the living node number of leach clustering algorithm decreases. When the network polling time is about 850, the living node number of BP decreases, and 900 for PSO-BP, 950 for GSO-BP. From the 900th to 1200th polling, the living node numbers of four algorithms are all decreasing, until all the energy of the network is consumed and the network dies. However, the algorithm proposed in this study consumes the lowest energy, and the network life of this method is the longest. The corresponding fusion accuracy is the highest.

5.2. Number of Received Data Package by the Sink

By comparing the number of data package received by the Sink node, it can know how significant the data fusion in WSNs data transmission. Data fusion enables the Sink node to receive more data, reasonably reducing the redundant data between sensing nodes and reducing the data transmitted. It extends the network lifetime and increases the number of data packages received by the Sink node. Figure 5 shows the number of data packages received by the Sink node using the 4 different algorithms.

It is clear that with the increasing of network polling time, the number of data packages received by the Sink using the 4 algorithms all increases. When the polling time reaches 800, the numbers of data package received by the Sink of the 4 algorithms begin to show big differences. Among the four algorithms, the leach clustering algorithm has the lowest increasing rate of received data package number, followed by BP, PSO-BP, and

GSO-BP which has the highest increasing rate. This is consistent with the lifetime shown in Fig. 4. Because the numbers of living nodes of the four algorithms decrease after 800 times of polling, which causes the increasing rate of data package received by the Sink to decrease.

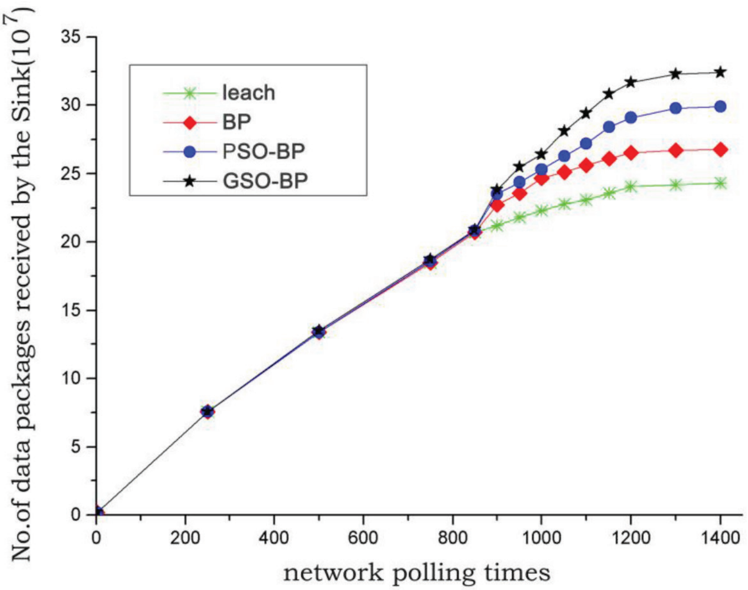

Figure 5 – No. of Data Packages Received by the Sink

5.3. Comparison of Average Node Energy Consumption

In the simulated experiment process, the Sink does not consider energy consumption problem. It is set to 50J, and its position is located at the center with a transmission distance of 30m. By analyzing the average energy consumption of nodes, we can further know the network energy consumption and the advantages of each algorithm. The comparison of the average energy consumption of the four algorithms is shown in Fig. 6.

In Fig. 6, with the increasing of network polling times, the order of the node residual energy of the four algorithm is leach clustering < BP < PSO-BP <GSO-BP. Meanwhile, it is clear that the order is consistent with the lifetime shown in Fig. 4. Therefore, the proposed algorithm can achieve a high accuracy of fusion, increasing the number of data packages received by the Sink.

5.4. Average Terminal to Terminal Delay (ATTD)

To better demonstrate the advantages of the proposed method, we compared the ATTD of the four algorithms. The results are shown in Figure 7.

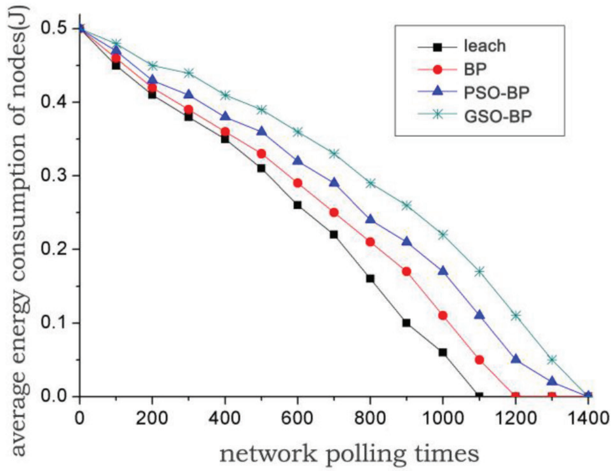

Figure 6 – Average Energy Consumption of the Four Algorithms

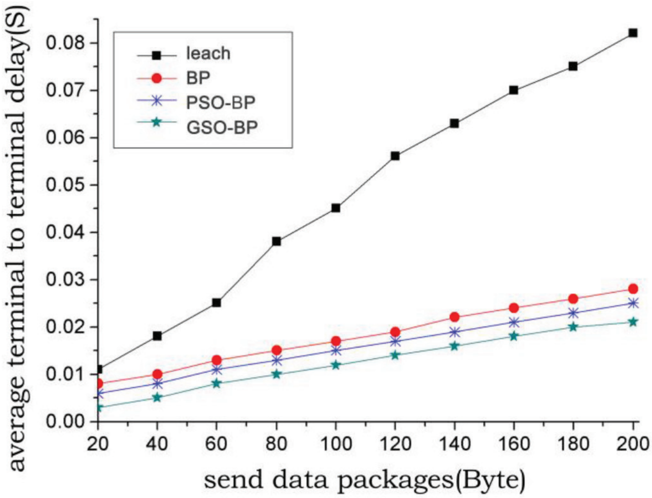

Figure 7 – ATTD of Four Algorithms

In Fig. 7, the ATTD of leach clustering is longer than the three other algorithms. Moreover, with the increasing of received data packages, the increasing rate of the ATTD of leach clustering is the largest, while the increasing rates of the other three algorithms are relatively small. The ATTD of the proposed GSO-BP algorithm is the smallest. This is because the data are fused in the process of transmission, which removes the redundant signals between sensing nodes and shortening the transmitted data between terminal node and the Sink node, extending the network lifetime.

Although all the performance parameters of the WSNs data fusion based on GSO-BP are satisfactory, the algorithm consumes much time. Therefore we repeated the simulation experiment for 100 times, and we calculated average simulation time. The consumed simulation time of the four algorithms are shown in Table 3.

Algorithm	**Simulation time(S)**
Leach	8.61
BPNNs	2.84
PSO-BP	7.05
GSO-BP	5.67

Table 3 – Simulation Time of Different Algorithms

It can be seen from Table 3 that although the consumed time of the proposed algorithm is relatively long, it is still acceptable. The proposed data fusion algorithm has a relatively high fusion efficiency, improving the data fusion efficiency of WSNs, reducing the energy consumption, and extending the network lifetime.

6. Conclusion

Data fusion is a key technology of WSNs and has been a hot research topic for scholars. In this study, a data fusion algorithm for WSNs is proposed based on GSO-BPNN. By using GSO-BPNN between the cluster head node and member nodes, our experimental analysis demonstrated that the proposed method can effectively reduce the network transmission traffic and the energy consumption of sensing nodes, improving the fusion efficiency and extending the network lifetime. However the simulation time is relatively long, and the convergence time of the algorithm is also relatively long. Artificial intelligence is continuously developing, and many swarm intelligence algorithms have appeared, such as bat algorithm, leapfrog algorithm (Liu Changping, Ye Chunming., 2011), etc. The future work includes using new swarm intelligence algorithms in WSNs data fusion to improve the network efficiency.

Acknowledgements

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Investigation of Tree Trunk Extraction Algorithms Based on Least Squares Using A 2D Laser Scanner

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Abstract: Feature extraction of tree trunk including diameter and center location plays an important role in remote sensing applications and agricultural and forestry automation. 2D laser scanner has been proven to be a feasible tool for tree trunk detection, which can rapidly provide numerous reliable distance data between the object to the scanner. Various tree trunk extraction algorithms emerged as demand in past decades. Among them circle fitting algorithms based on Least Squares are representative and commonly used. In this research, a tree trunk feature extraction system using a latest 2D laser scanner (SICK LMS511 PRO) was developed to compare three representative algorithms based on Least Squares (KASA, MLS, and AI) in tree trunk diameter and distance extraction at different angular resolutions, evaluated by time consuming, stability and accuracy. The time consumed by three algorithms ranged from 94 to 109 ms. KASA and MLS displayed better stability and accuracy while AI performed unstably and gave poor accuracy in diameter extraction. 0.333° was the best angular resolution for SICK LMS511 PRO to extract tree feature by KASA and MLS.

Keywords*:* Tree trunk; diameter and distance extraction; least squares; angular resolution; stability and accuracy; 2D laser scanner; agriculture and forestry

1. Introduction

Active laser scanning (Lee K H, Ehsani R, and Castle W S., 2010) has been applied to labor-intensive industries like agriculture and forestry in order to save time and labor force. Active laser scanning is a non-contact technology that measures the distance from a laser scanner to an object by emitting and receiving a pulsed laser beam. The distance measurement is essentially based on time of flight principle, the difference of phase or the frequency shift between emitted and received beam. A 2D laser scanner radially scans the surrounding perimeter on a single plane using a laser beam and the position of an object is given in the form of distance and angular. A 3D laser scanner scans surrounding using a laser rectangular matrix instead of a beam so a 3D point cloud could be obtained per scan. Thereinto, 2D laser scanning has been proven to be a feasible and promising method for rapidly collecting numerous reliable information of target (e.g. tree trunk) and widely used in precision targeted spray, remote sensing applications, and forestry automation. Kang et al. (Kang F, Li W, Pierce F J, and Zhang Q., 2014, Kang F, Wang H, Pierce F J, Zhang Q, and Wang S., 2012) developed a scanning laser-based trunk detection system using a 2D laser scanner to recognize grapevine trunks and posts and trigger a multi-nozzle trailer sprayer to spray a barrier of chemical on the trunks aiming to stop cutworms. Following the same line of work, Kang *et al*. (Kang F, Wang H, Pierce F J, Zhang Q, and Wang S., 2012) developed a grapevine sucker detection system for vine-specific based sucker targeted spray in vineyards. The same 2D laser scanner was used to detect grapevine trunks and trigger a CCD camera for imaging the suckers. Meanwhile, the distance from the trunk to the scanner measured by the scanner was adopted to calculate the actual 2D dimensions of the suckers. Jutila *et al*. (Jutila J, Kannas K, and Visala A., 2007) measured tree diameter and location using a 2D laser scanner mounted on a mobile ATV platform in a pine forest and concluded that the scanner suited adequately well for the tree measurement purpose. The high scanning frequency of 38 Hz enabled accurate measurements onboard a mobile platform with the error of *ca*. 4% in tree diameter calculations. Zheng et al. (Zheng Y, Liu J, Wang D, and Yang R., 2012) proposed that repeated operations were needed in the progress of aligning the harvesting head of a logging harvester to capture a trunk, which led to time consuming and fuel losses. A feasibility research using a 2D laser scanner and an inertial sensor was conducted to measure the diameter and center of tree trunk in order to determine the location of tree trunk near the harvesting head for operation efficiency improvement and costs reduction.

In the reports mentioned above, it is noted that the features of tree trunk needed to be extracted by a 2D laser scanner are diameter and center location (or the distance from the tree trunk center to the scanner). Multifarious tree trunk extraction algorithms based on 2D laser scanning emerged as demand in the past decades including circle fitting based Least Squares (Kanatani K and Rangarajan P., 2011), Cosine Theorem (Lee K H, Ehsani R, and Schueller J K., 2007), Inscribed Angle Variance (Xavier J, Pacheco M, Castro D, Ruano A, and Nunes U., 2007), and Conjugate gradient (Zheng Y, Liu J, Zhang S, and Ge T., 2014). Among them circle fitting based on Least Squares is representative and commonly used. Besides, the 2D laser scanners used in previous researches can be categorized into two kinds. One was Hokuyo scanners such as URG-30LX and URG-40LX-01 (Kang F, Pierce F J, Walsh D B, Zhang Q, and Wang S., 2011, Kang F, Wang H, Pierce F J, Zhang Q, and Wang S., 2012), another was SICK scanners including LMS 221 (Ringdahl O, Hohnloser P, Hellström T, Holmgren J, and Lindroos O., 2013) and 291 (Zheng Y, Liu J, Wang D, and Yang R., 2012, Zheng Y, Liu J, Zhang S, and Ge T., 2014). Hokuyo scanners only have single angular resolution and are suggested to be indoors used, which retard their application in agricultural and forestry environments; SICK provides several models for outdoor use and there are multiple angular resolution options available for these scanners. SICK LMS511 PRO is the upgraded product of LMS 221 and 291 and so far researches on tree trunk extraction using LMS511 PRO are barely reported. Under this premise, the goal of this research was to develop a tree trunk detection system using the 2D laser scanner (SICK LMS511 PRO) in order to compare the performance of representative circle fitting algorithms based on Least Squares in tree trunk features extraction (diameter and distance) at different angular resolution evaluated by time-consuming, stability and accuracy. The ultimate goal was to figure out reasonable tree trunk identification algorithm and laser scanner configuration for feeding target information including tree trunk diameter and distance to the previously developed precision barrier targeted sprayer (Kang F, Pierce F J, Walsh D B, Zhang Q, and Wang S., 2011) to precisely apply barrier treatment on tree trunks of planted forest and urban roadside trees.

2. Materials and Methods

2.1. System Hardware

Figure 1 shows the hardware components of the tree trunk detection system. The primary detection device was a 2D laser scanner (LMS511 PRO, SICK AG, Inc., Waldkirch, Germany) installed on a tripod. The scanner is a noncontact optical device that radially scans in a plane and measures the distance to an object using a pulsed laser beam of 905 nm with laser class 1 eye-safety. The measurement is based on the time-of-flight (TOF) principle (Hebert M., 2000). A pulsed laser beam is emitted by the laser source in the scanner and partially reflected when it hits an object. The flight time of the impulse during this process is directly proportional to the distance between the scanner and the object. Then the distance of laser scanner from the obstacle can be figured out (Haken H., 1984). The specifications of the laser scanner are shown in Table 1. In this research, the scanner communicated with the computer via Ethernet. The Client/Server (C/S) communication mode was used for data transmission. The laser scanner played as the server while the client was a laptop PC (Dell E5400, Intel(R) Core(TM) 2 Duo CPU P8700 @ 2.53GHz, 3.45GB RAM). The system was powered by a 24V DC lithium battery. The laser scanner was installed on a tripod via a "[" type holder. A high luminance laser probe (650 nm, 200 mW line laser device, S&D Laser AG, Inc., Guangdong, China) was mounted on the top of the holder for helping determine the scanned position on a tree trunk because of the invisibility of the laser beam (905 nm) emitted by the laser scanner (Oliveira, J. A., Ferreira, J., Figueiredo, M., Dias, L., & Pereira, G., 2014). A visible red cross-beam could be projected on the tree trunk by the laser probe. The scanned position of the tree trunk can be determined by calibrating the geometric projection relationship between the laser scanner and the probe. The laser probe was powered by a couple of AA batteries. A protractor was fixed on the holder right beneath the probe for measuring the actual angle of the scanned tree trunk in the field of view of the laser scanner (Fig. 1).

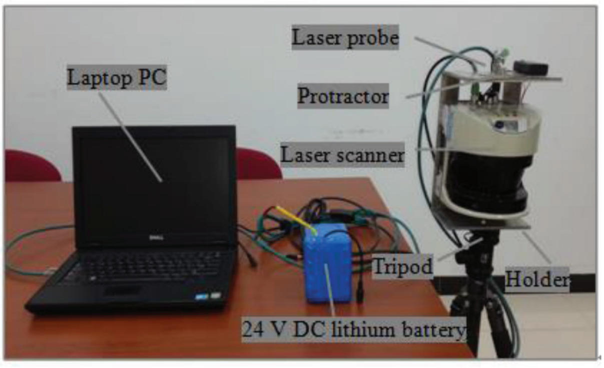


Figure 1 – Hardware Components of the Tree Trunk Detection System

Model	**LMS511 PRO**
Max range with 10% reflectivity	26 m
Field of view	190°
Angular resolution	0.167°, 0.25°, 0.333°, 0.5°, 0.667°
Scanning frequency	25, 35, 50, 75, 100 Hz
Systematic error with 10% reflectivity	± 25 mm (1 to 10 m); ± 35 mm (10 to 20 m)
Statistical error with 10% reflectivity	± 7 mm (1 to 10 m); ± 9 mm (10 to 20 m)
Operating voltage	24 V DC ± 20%
Data interface	Serial (RS-232, RS-422), Ethernet, CAN bus, USB

Table 1 – Specifications of the SICK LMS511 PRO Laser Scanner

2.2. System Software

There is a vendor-provided configuration software named SOPAS®, which can configure the laser scanner such as angular resolution setting, single and multiple measurement, and displaying the scan points after coordinate transformation. But it has no functions of filtering, clustering and fitting the data. Its role in this research was to assist the experimental software which was the main software used in the experiment. The experimental software was developed in Visual C 6.0 using MFC framework. The interface of the software is shown in Figure 2. It was divided into display area, software setting area, parameter configuration area, data acquisition area, and algorithm area. Users can set up the laser scanner's angular resolution, maximum measurement distance, the start and end scan angle in parameter configuration area and conduct single or multiple measurements in data acquisition area. The scan points can be displayed in the display area as black solid points. The extraction results of tree trunks will be demonstrated in the display area as different color solid hollow circles according to the algorithms (Fig. 2).

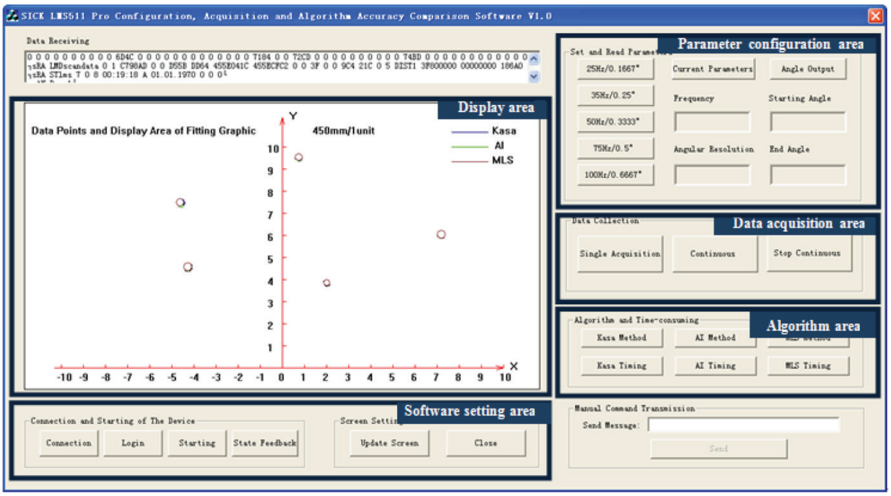


Figure 2 – Interface of the Experimental Software

2.3. Algorithm Principle

After a complete scan from the first to the last step, the laser scanner provides a frame of data. A set of point cloud data S^P consisting of numerous data points can be obtained after removing the head and end of the frame. Each data point includes the distance and measurement angle between the first and the current step allowing a counterclockwise order, which is in polar form as follows:

$$S^P = \left\{ S_i^P = (\theta_i, d_i)^T \,|_{S_i^P \in P} ; i=0,1,\ldots,n_s ; 0 \le n_s \le 180 \right\} \tag{1}$$

where θ_i and d_i are the measurement angle and the distance in polar coordinates (P), respectively. n_s is the number of data points recorded. The data points with the distance more than 5 m were eliminated in order to avoid unexpected noise. The data points after distance filtering are needed coordinate transformation before further processing, as shown in Equation (2).

$$\begin{bmatrix} X_i^V \\ Y_i^V \end{bmatrix} = \begin{bmatrix} d_i \cos\theta_i \\ d_i \sin\theta_i \end{bmatrix} \tag{2}$$

where V is the Cartesian coordinates whose origin is the light source of the laser scanner. $(x_i^V, y_i^V)^T$ is the point in V coordinates (Kise M, Zhang Q, and Noguchi N., 2005). The points fulfilling the following condition (Equation (3)) are assumed belonging to the same tree trunk and assigned to a cluster and marked.

$$\| d_i - d_{i-1} \| < \Delta D_{\max} \tag{3}$$

where ΔD_{max} is the distance threshold (0.4 m was used in this research) (Jutila J, Kannas K, and Visala A., 2007). Based upon the fact that the cross-section of the tree trunk is approximate circular, it was called trunk circle (TC) here. TC in the Cartesian coordinates was described as:

$$(x-a)^2 + (y-b)^2 = r^2 \tag{4}$$

So our basic problem for extracting aforementioned features is to determine the values for the center (a, b) and the radius r for the best fitting circle to the TC according to the clustered points. Three representative circle fitting algorithms based on Least Squares including Kasa's method (KASA), Modified Least Squares method (MLS) and Average of Intersections (AI) were used to accomplish this goal.

In KASA (Kasa I., 1976), a reasonable fit of a TC to the points in the same cluster is given by summing the squares of the distances from the points to the TC as follows:

$$SSK(a_K, b_K, r_K) = \sum_{i=1}^{n} \left[r_K^2 - (x_i - a_K)^2 - (y_i - b_K)^2 \right]^2 \tag{5}$$

where SSK is the KASA's square error function, (a_K, b_K) and r_K are the extracted TC's center coordinate and radius, respectively. n is the number of points in the same cluster.

Estimated values of (a_K, b_K) and r_K were obtained by satisfying Equation (6) to minimize SSK. The estimated (a_K, b_K) and r_K were treated as the TC's center and radius extracted by KASA, respectively.

$$\frac{\partial SSK}{\partial a_K} = 0, \quad \frac{\partial SSK}{\partial b_K}=0, \quad \frac{\partial SSK}{\partial r_K}=0 \tag{6}$$

The idea of Reduced Least Squares (RLS) Method (Gander W, Golub G H, and Strebel R., 1996) is to find out one point by minimizing the sum of the distances between the points and the midperpendicular of any two points data as described in Equation (7). The determined point will be considered as the fitting circle's center.

$$SSR(a,b) = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{(aX_{ji}+bY_{ji}-0.5(Y_{ji}^{(2)}+X_{ji}^{(2)}))^2}{X_{ji}^2+Y_{ji}^2} \tag{7}$$

where SSR is the RLS's error function. $X_{ji} = x_j - x_i$, $Y_{ji} = y_j - y_i$, $v_{i-1}^{'}(x_{i-1}^{'}, y_{i-1}^{'})$, $Y_{ji}^{(2)} = y_j^{\,2} - y_i^{\,2}$, $X_{ji}^2 = (x_j - x_i)^2$, $Y_{ji}^2 = (y_j - y_i)^2$. Although the algorithm is theoretically possible, it is noted that the denominator ($X_{ji}^2 + Y_{ji}^2$) will be quite small when the two points (x_i, y_i) and (x_j, y_j) are close enough, which will lead to considerable error. By noting this, Umbach and Jones proved that SSR(a, b) will also reach the minimum as long as minimizing the sum of the numerator of Equation (7) and proposed a Modified Least Squares method (MLS) (Umbach D and Jones K N., 2003) which was used for tree trunk extraction in this research as defined:

$$SSM(a_M, b_M) = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} (a_M X_{ji}+b_M Y_{ji}-0.5(Y_{ji}^{(2)}+X_{ji}^{(2)}))^2 \tag{8}$$

where SSM is the MLS's error function. (a_M, b_M) are the TC's center determined by MLS. The values of (a_M, b_M) can be obtained by simultaneously equaling the partial differentials ($\frac{\partial SSM}{\partial a_M}$ and $\frac{\partial SSM}{\partial b_M}$) to zero. The TC's radius r_M can be calculated as follows:

$$r_M = \sum_{i=1}^{n} \sqrt{(x_i-a_M)^2+(y_i-b_M)^2} \;/\; n \tag{9}$$

To obtain a value for the TC's center, it is noted that any three points can determine the center of this circle with the assumption that all scan points were on the circle. Unfortunately, it is basically impossible because the occurrence of measurement error. Each triplet would produce an estimate for the center. There are totally $y_b^{'}$ estimates. The value of the TC's center could be determined by average all of these estimates as follows:

$$a_A = \frac{\sum_{i=1}^{c_n^3} a_i}{c_n^3}, \quad b_A = \frac{\sum_{i=1}^{c_n^3} b_i}{c_n^3} \tag{10}$$

It is referred as the Average of Intersections method (AI) (Liu W and Dori D., 1998) with resulting values of a, b and r labeled as a_A, b_A and r_A. r_A can be produced by using a_A and b_A in Equation (9).

2.4. Experimental Methods

2.4.1. Preheating Experiment of Laser Scanner

Lee and Ehsani (Lee K H and Ehsani R., 2008) proposed that the average distance data measured by LMS200 laser scanner (SICK AG, Inc., Waldkirch, Germany) at an intended distance decreased with run time until about 53 min, and then stayed at a constant level. As the upgrading product of LMS200, a preheating experiment was designed for LMS 511 PRO to determine its preheating time for achieving a stable distance measurement. The LMS 511 Pro was set to horizontally and continuously scan a fixed object (a sheet of white paper) at an intended distance of 2 m. The angular resolution was set to 0.167°, 0.333°, and 0.667°. The scanning frequency was 25, 50, and 100 Hz, respectively. The run time was one hour for each scanning frequency. The results demonstrated that the measured distance data fluctuated very slightly and the error ranged from 1 to 8 mm at the distance of 2 m with the percentage error no more than 0.4% during the whole runtime. Based on this conclusion and taking into account the startup of the scanner, a preheating time of 10 min was given in the following experiments.

2.4.2. Geometric Projection Relationship Calibration

There were manufacturing and installation errors when mounting the laser scanner and probe on the holder. A geometric projection relationship calibration between the laser scanner and the probe was conducted to determine the scanned position on the tree trunk using the probe, as shown in Fig. 3. There were two unknown parameters need to be determined. One is the pitch angle of the probe (α), the other is the vertical distance between the laser scanning plane and the probe (Δk). The horizontal line was defined as 0° and counterclockwise as positive value for the pitch angle. The calibration experiment was conducted in lab. The scanner mounted on the tripod was leveled by a level bar. A white cardboard was horizontally installed on another tripod and placed two intended distances from the scanner ($l1$ = 1 m and $l2$ = 2 m). It is hard to determine the true distance between the scanner and the cardboard because the laser beam detector, which is the true reference point of the scanner, is sealed inside the case of the scanner. Therefore, a new reference point was adopted on the top of the scanner housing according to the scanner's dimensions. It was on the center line of the scanner at a distance of 93 mm from the scanner's backboard. SOPAS was used to collect and display the data. After the preheating time, the cardboard was moved downwards at each intended distance when the scanner continuously scanned it until the scanning plane coincided with the bottom edge of the cardboard. Then the distance between the bottom edge of the cardboard and the cross-beam on the cardboard emitted by the probe (S) was recorded. This operation was repeated five times and the average was adopted for each intended distance ($l1$ and $l2$). Equation (11) was used to calculate α and Δk as follows:

$$\begin{cases} l_1 \tan\alpha + \Delta k = S_1 \\ l_2 \tan\alpha + \Delta k = S_2 \end{cases} \tag{11}$$

where S1 and S2 are the distances between the bottom edge of the cardboard and the cross-beam of the probe at l1 and l2, respectively. The values for α and Δk in this research was 5.346° and 210 mm, respectively.

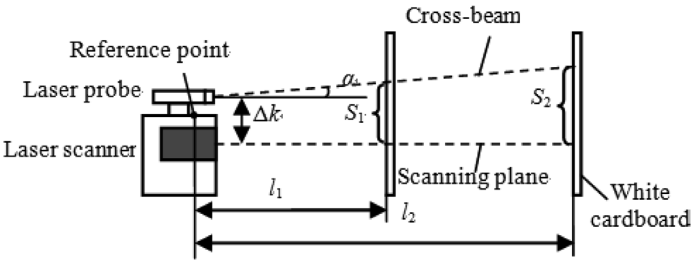
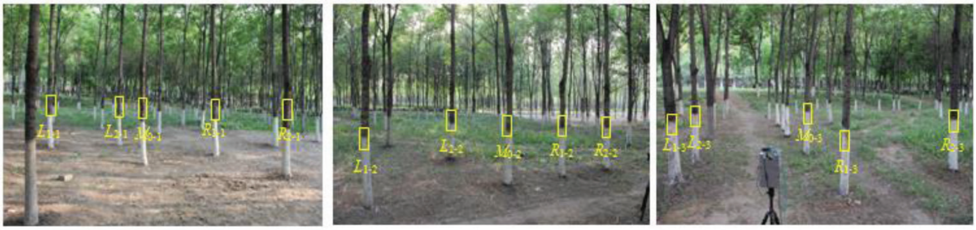


Figure 3 – Schematic Diagram of Geometric Projection Relationship Calibration

2.4.3. Comparative Experiment of Three Algorithms at Different Angular Resolutions

A comparative experiment of three algorithms was conducted to evaluate their performance of tree trunk features extraction at different angular resolutions. The experiment was conducted at Dongsheng Bajia Country Park in Beijing, China (116.3468° N; 40.0256° E). Three plots were randomly chosen in a planted forest taking up an area of 25 m by 25 m which was planted in 2007. There were five trees in each plot whose cultivar is Chinese Ash, as shown in Fig. 4. There were totally fifteen trees for the experiment. The inter row spacing was 2 m and intra row spacing was 1.5 m. The diameter at breast height (DBH) varied from 110 to 178 mm with a mean of 135 mm. The average tree height was ca. 9 m. The distance data more than 5 m was eliminated for avoiding background interference in the field of view of the scanner. The whole measurement system was leveled before experiment so no inertial sensors were needed. The leveling operation was consisted of two steps. First was to level the tripod relied on its built-in leveling bubble. Second was to level the scanner using a level bar. Above operations guaranteed the scanning plane of the scanner was absolutely horizontal no matter how the scanner was rotated during the experiment.

Five angular resolutions of the scanner including 0.167°, 0.25°, 0.333°, 0.5°, and 0.667° were used for data collection. The corresponding scan frequencies were 25, 35, 50, 75, and 100 Hz, respectively. Three repetitions were conducted at each angular resolution. The experimental software developed in Visual C was used as the software tool to acquire and extract the TC's features (diameter and distance). All data were saved as text files for offline analysis and processing. The actual values of the tree trunk diameter and distance from the center of TC to the scanner were measured manually (Fig. 5). The probe was rotated horizontally to ensure its cross-beam was projected on the middle of the trunk side scanned by the scanner (Fig. 5a). The position at a distance S downwards from the



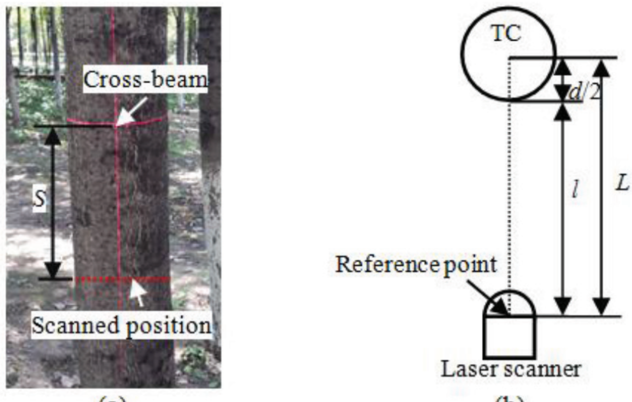
(a) (b) (c)

Figure 4 – Plots for the comparative experiments of three algorithms: (a) Plot 1, (b) Plot 2, and (c) Plot 3. Five trees were selected in each plot whose cultivar is Chinese Ash. Tree labeling followed a format as Ωn-p: Ω including L, M, and R means trees left, middle and right in the field of view of the laser scanner, respectively; n means n:th tree in Ω; p including 1, 2, and 3 means plot 1, 2, and 3.

cross-beam was determined as the actual scanned position of the trunk. The value of S was given by Equation (12).

$$S = l \tan \alpha + \Delta k \tag{12}$$

where l is the horizontal distance from the cross-beam on the trunk to the reference point of the scanner (Fig. 5b). It was measured manually by a tape. The actual diameter of the scanned position of the trunk (d) was measured at three different circumferencial directions by a caliper and averaged. The actual diameter of all trees in three plots ranged from 110 to 178 mm with a mean of 133 mm. The actual distance between the TC's center to the reference point of the scanner (L) was obtained by summing the TC's radius d/2 and the distance l (Fig. 5b).



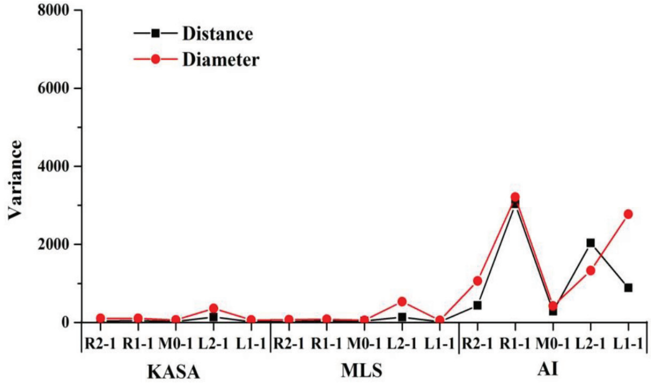
(a) (b)

Figure 5 – (a) Determination of the Scanned Position of the Tree Trunk Using the Cross-Beam Emitted By The Probe. (B) The Schematic Diagram of Distance Measurement Between the TC's Center and the Laser Scanner From Top View

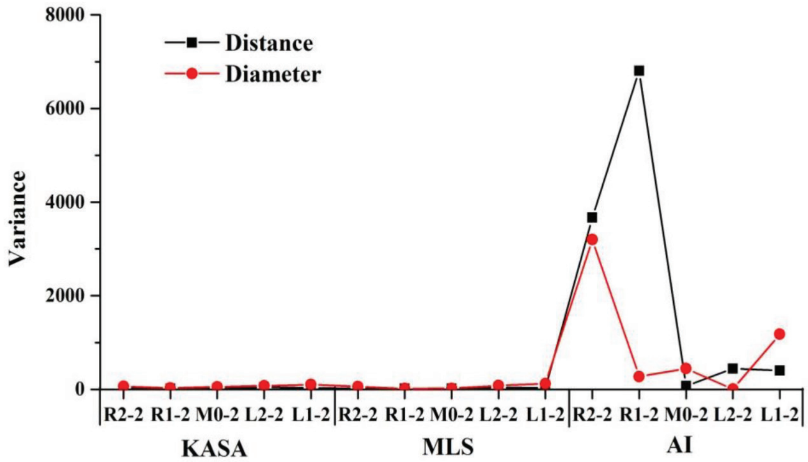
3. Results and Discussion

The accuracies of tree trunk features extraction by the three algorithms were evaluated by comparing the extracted data to the actual data. The experiment involved two independent variables which were the angular resolution and algorithm. The results of time consuming by three algorithms at all angular resolutions showed that the most time consuming part was the clustering which related to the number of trunks needed to be extracted in the field of view. It ranged from 63 to 78 ms. The angular resolutions and algorithms had minor influence on time consuming. There were five trunks in each plot for extraction, so the consumed time of the whole data processing differed very little, which ranged from 94 to 109 ms. Therefore, the factor of time consuming weighed less in the algorithm evaluation. Fitting stability and accuracy were used to evaluate the performance of the three algorithms at different angular resolution in order to figure out the optimal combination of algorithm and angular resolution for LMS511 PRO. The fitting stability was evaluated as variance while the accuracy was evaluated as absolute error and absolute percentage error.

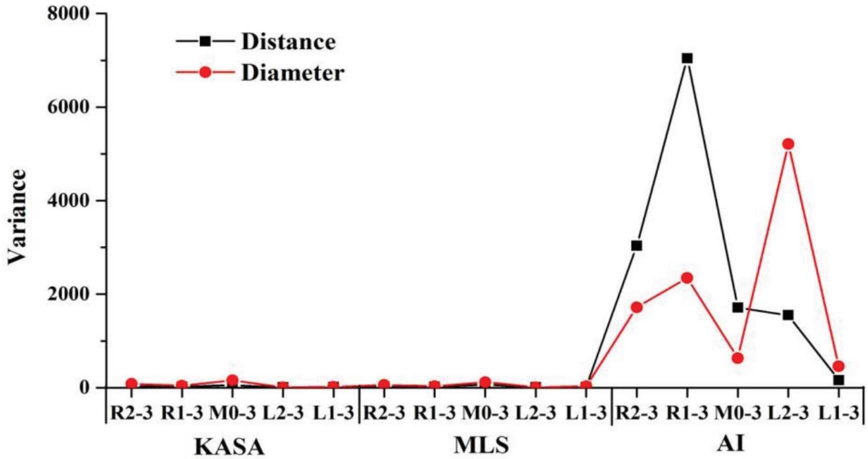
Fig. 6 shows that the comparison of the fitting stability of three algorithms (KASA, MLS, and AI) for diameter and distance extraction at different angular resolution in three plots. The variance of the extraction results of three measurements by each algorithm and at each angular resolution was calculated. The variance of KASA both on diameter and distance in three plots at all angular resolutions differed little. The values of standard deviation were 84.82 for diameter and 31.86 for distance, respectively. MLS performed very similar to KASA with 127.71 for diameter and 31.63 for distance. Higher variance occurred when extracting trunk L2-1's diameter (132 mm) by both KASA and MLS in plot 1, which was 361.24 and 534.20, respectively. It was because the distance of L2-1 to the scanner was longest (4.78 m). Fewer points (less than 5 points) were projected to L2-1 when the angular resolution was set to the lowest one (0.667°/100 Hz) leading to the increasement of fitting error (Fig. 6a). AI got highest variance both on diameter and distance in the three algorithms at all angular resolutions in three plots ranging from 6.39 to 5211.92 with an average of 1617.47 on diameter and from 74.79 to 7045.89 with an average of 2105.21 on distance. It was analyzed that AI has a strict requirement of the distribution of scanning points. The center of fitting TC would be far away from its actual position if any three points were almost collinear. To sum up, KASA performed most stable both on diameter and distance extraction at all algorithms, next came the MLS and AI got the worst stability.



(a)



(b)



(c)

Figure 6 – Fitting Stability of Tree Trunk Diameter and Distance Extractions by Three Algorithms (KASA, MLS, and AI) at all Angular Resolutions in (a) Plot 1, (b) Plot 2, and (c) Plot 3

Table 2 illustrated the mean absolute error, absolute percentage error and standard deviation (SD) for extracting tree trunk features (diameter and distance) by KASA, MLS, and AI at all angular resolutions. KASA and MLS gave better accuracies in diameter extraction with the mean absolute errors of 18 and 19 mm and the SD of 18 and 18 mm, respectively. The absolute percentage errors by KASA and MLS were 13.7% and 14.6%, respectively. AI showed worse accuracy and stability than KASA and MLS with 48 mm mean absolute error and 33 mm SD leading to a higher absolute percentage error of 37.1%. Thirteen of fifteen trees (87%) were overestimated in diameter by all three algorithms. It was explained in Fig. 7. Because of the scanning mechanism used for our specific application, only the side of a tree trunk facing to the laser scanner can be scanned. The obtained scan data per trunk fluctuated and shaped like a rough arc not a circle due to the subcentimetre-level roughness of the bark on the tree trunk. The center of the extracted TC was resulted in radially away from its actual position, which led to larger estimated diameter. Proper filtering (Jutila J, Kannas K, and Visala A., 2007) and convex hull method (Lee K H and Ehsani R., 2009) could be used to smooth the fluctuation and shape the scan data to a well-behaved arc. In addition, although the laser beam can travel to quite a long distance in a straight line and maintain a narrow beam width, the beam width is still distance-dependently increasing as follows:

$$Width_{Beam} = Dis \times 0.0046 + 13 \tag{13}$$

where WidthBeam is the beam width in millimeter. Dis is the distance from the laser scanner to the object in millimeter. A beam will be registered by the laser scanner as long as its reflectivity is more than 10%. It means the center of the outermost beams actually be outside the trunk, which was also contributable to the overestimation of TC diameter. It was expected to be improved by beam width compensation (Kise M, Zhang Q, and Noguchi N., 2005). Diameter overestimation is acceptable for precision barrier targeted application. Due to the diameter overestimation, the distance was overestimated as well by the three algorithms because that the TC's distance is determined by its center (Fig. 7). The mean absolute error of KASA, MLS, and AI was 23, 27, and 27 mm with the SD of 47, 47, and 58 mm, respectively. Although higher absolute error was given in distance extraction than in diameter extraction, lower absolute percentage error (0.6% for KASA, 0.8% for MLS, and 0.9% for AI, respectively) was achieved because of the higher value of tree trunk's distance than of its diameter.

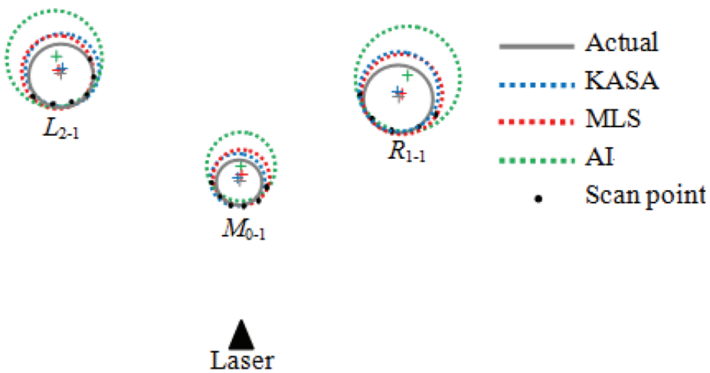


Figure 7 – Schematic Diagram of Diameter Overestimation in Plot 1. The Tree Trunk Samples Were L2-1, M0-1, and R1-1. Their Diameters Were 132, 121, and 150 mm, Respectively. The Corresponding Distances to the Laser Scanner Were 4.78, 2.13, and 4.14 m, Respectively

Feature	Algorithm	Absolute error (mm)		Absolute percentage error (%)	
		Mean	Standard Deviation	Mean	Standard deviation
Diameter	KASA	18	18	13.7	14.2
	MLS	19	18	14.6	13.8
	AI	48	33	37.1	26.4
Distance	KASA	23	47	0.6	1.5
	MLS	27	47	0.8	1.6
	AI	27	58	0.9	1.9

Table 2 – Mean Absolute Error, Absolute Percentage Error and Standard Deviation (SD) for Extracting Tree Trunk Features (Diameter and Distance) by KASA, MLS, and AI at all Angular Resolutions

There are several angular resolution options (0.167°, 0.25°, 0.333°, 0.5°, and 0.667°) to be chosen when measurement operations are conducted using the laser scanner in agriculture and forestry for tree trunk measurement. The stability and accuracy of extracting tree trunk features (diameter and distance) by KASA and MLS were compared based on the angular resolution aiming to find out optimal angular resolution for both algorithms. AI was excluded because of its poor stability and accuracy in diameter extraction. The variance in diameter extraction by KASA and MLS significantly increased with the aggrandizement of the angular resolution (Fig. 8). The smaller the angular resolution was, the more stable the diameter extraction was achieved by both algorithms. Worst stability occurred at the angular resolution of 0.667° because fewer laser beams hit the tree trunk leading to serious problem in diameter extraction, especially for smaller trees in further distance. Even only two scan points were obtained when detecting L2-2 (132 mm in diameter and 4.75 m in distance). Both algorithms failed to conduct the circle fitting. Due to the relationship between the diameter and distance of tree trunk, the variance of distance extraction by KASA and MLS displayed similar to but gentler layout than the diameter extraction as the angular resolution increasing (Fig. 8). Best and worst stability occurred at the angular resolution of 0.167° and 0.667°, respectively. In contrast, better stability was achieved in distance extraction than in diameter extraction.

The results of comparison of the accuracy of tree trunk diameter and distance extraction by both algorithms based on the angular resolution showed that the changing trend of the accuracies were not very identical to the stability mentioned above no matter diameter or distance extraction as the angular resolution increasing, as shown in Fig. 9. The absolute error in diameter at 0.167° and 0.25° was ca. 21 mm, 22 mm and went slightly higher at 0.5° and 0.667° (ca. 25 mm). It is easy to understand that fewer scan points were collected at larger angular resolutions (i.e. 0.5° and 0.667°), which led to poor circle fitting results. At smaller angular resolutions (i.e. 0.167° and 0.25°), theoretically more scan points could be obtained for each tree trunk. Better circle fitting and lower absolute error should be resulted in by both algorithms. However, it was not the case at all. Due to the irregular bark of the tree trunk, more unexpected fluctuant noise and outliers would

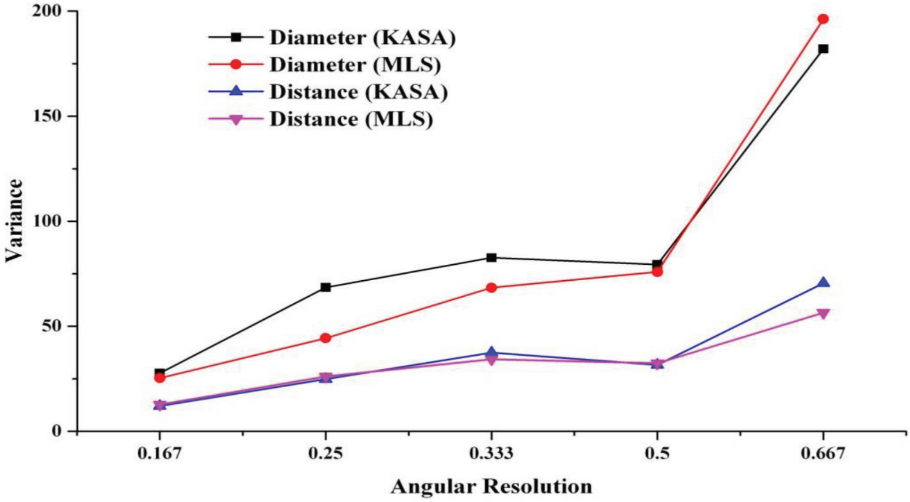


Figure 8 – Stability of Tree Trunk Diameter and Distance Extraction by KASA and MLS Based on the Angular Resolutions Including 0.167°, 0.25°, 0.333°, 0.5°, and 0.667° Evaluated as Variance

be introduced into circle fitting leading to worse accuracy in diameter extraction, hence to distance. Best accuracy occurred at 0.333° with the lowest absolute error of 18 mm.

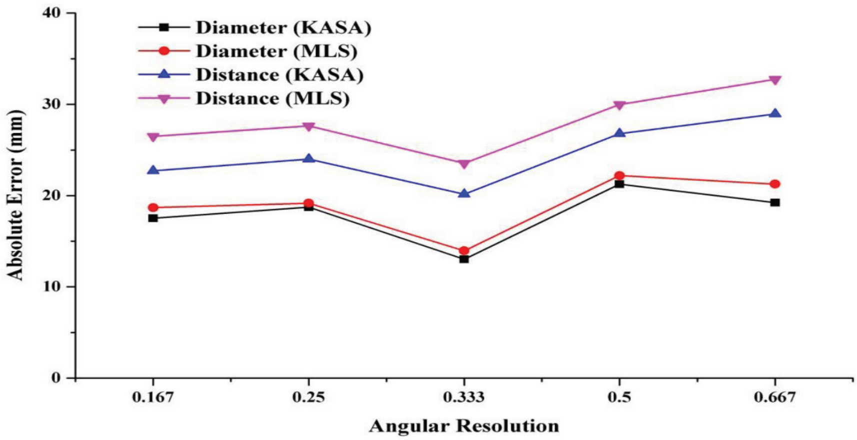


Figure 9 – Accuracy of Tree Trunk Diameter and Distance Extraction by KASA and MLS Based on the Angular Resolutions Including 0.167°, 0.25°, 0.333°, 0.5°, and 0.667° Evaluated as Absolute Error

Based on aforementioned analysis and discussion, it can be concluded that KASA and MLS performed more stable and accurate in tree trunk diameter and distance extraction. The optimal angular resolution of the laser scanner (SICK LMS511 PRO) for KASA and MLS was 0.333°.

4. Conclusions

A tree trunk measurement system using 2D laser scanner was developed for comparing three algorithms based on Least Squares (KASA, MLS, and AI). The laser scanner could output stable distance data as time elapsing and did not require long preheating time. The most time consuming part in tree trunk features extraction was the clustering which related to the number of trunks in the field of view of the scanner. The consumed times of the whole data processing by three algorithms at all angular resolution differed slightly, ranged from 94 to 109 ms based on a specific hardware configuration. KASA and MLS indicated better stability comparing to AI at all angular resolutions. The same phenomenon occurred when comparing the accuracies of diameter and distance extraction. The stability by KASA and MLS in diameter and distance extraction reduced with aggrandizing the angular resolution. The accuracy did not exactly follow the trend and best accuracy was achieved at 0.333° with the absolute error of 18 mm. To sum up, KASA and MLS performed more stable and accurate in tree trunk diameter and distance extraction. The angular resolution of 0.333° was optimal for tree trunk features extraction by KASA and MLS using SICK LMS511 PRO. The information could be a guidance for users to configure the equipment according to their application in agriculture and forestry.

Acknowledgment

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Power Characteristics of Electromagnetic Wave Propagation Along Arched Tunnel Walls

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Abstract: In order to conduct wireless microwave power charging technology in coal mine tunnels, it is extremely necessary to know the power characteristics of wireless electromagnetic wave along the tunnel wall. In this paper, we presents the experimental results of narrowband wireless electromagnetic wave propagation measurements, and proposed the statistical model of the power characteristics at 2.4GHz in real arched mine tunnels. Two standard half-wave dipole antennas were used to perform the field experiments in straight and curved tunnels. Results show that 10 meters distance belongs to the free space propagation zone. The path loss exponents highly rely on the location of the receiver and antenna polarizations. To obtain more power, The locations of the receiver should be matched with the corresponding polarizations. What's more, free space model and multi-mode model were compared, it was proved that the free space model can well be used for representing the power characteristic.

Keywords: Radio propagation, narrowband measurements, mine tunnel, path loss

1. Introduction

In recent years, wireless charging techniques have become a hot topic. Some researchers are concentrating their mind on charging the wireless sensor nodes, which are deployed in harsh environment and not easily be replaced batteries (M.R.A. Khandaker, W. Kai-Kit., 2015,S. Kim, R. Vyas., 2014,D. Enjie, X. Hui., 2014). Wireless charging is always based on three techniques. They are inductive coupling, magnetic resonance coupling, and microwave power transfer, respectively. During the wireless charging process, in order to obtain the best performance, transmitter and receivers are both require alignment and calibration of coils for the inductive and magnetic-resonance coupling, inductive and magnetic-resonance coupling require alignment and calibration of coils at transmitters and receivers (S. Yoshida, T. Noji., 2013). However, microwave power transfer is not restricted by the aforementioned three factors, and easier to act in mine tunnel environment. The-state-of-the-art monitoring system based on wireless sensors in coal mine (Laureano, R., Caetano, N., & Cortez, P., 2014), sensors are mainly distributed along tunnel walls. To charge the sensor nodes along the route in coal mine tunnel, the majority of the transmitters, which locate at the center of the tunnel, moves towards the direction of the tunnel axial, and charge the sensor nodes along the route. In order to achieve the maximum wave transmission efficiency and design reasonable antenna for transmitters and receivers, it is necessary to ascertain the power characteristics of the electromagnetic wave along tunnel walls.

Most of the sensor nodes in mine tunnels operate on 2.4GHz. Considering the actual situation, the charging distance is assumed to be 10 meters. 10 meters distance belongs to the near region at 2.4GHz (K. Huang, V.K.N. Lau., 2014, K. Guan, Z. Zhong., 2013, Y. P. Zhang, Y. H. wang., 1998, V. Malo Machado, J.A. Brandao Faria., 2015). In the near region, free space model is adopted to explain the wave propagation characteristics, while others researchers interpret the wave propagation characteristics with multi-mode model(J. M. Molina-Garcia-Pardo, M. Lienard., 2008). Guan ke et al. (V. Malo Machado, J.A. Brandao Faria., 2015, S. Zhi, I.F. Akyildiz., 2010)further classified the near region into two parts, free space zone that near the transmitting antenna and the following multi-mode zone, and proposed the formula to calculate the Demarcation Point. Although various propagation models are proposed, most of them are based on the rectangular tunnel and hypothesis. What's more, most scholars focus on the propagation characteristics in large distances. However, the propagation characteristics along the tunnel walls in short distance are rarely mentioned and not efficiently studied in the-state-of-the-art research work. For the arched tunnels, locations where the sensor nodes at (A, B and C in fig. 2) are closer to circular waveguide situation. J.M. Molina-Garcia-Pardo et al.(V. Malo Machado, J.A. Brandao Faria., 2015) utilize the rectangular tunnel to approximate the arched tunnel. The results show a high consistency between the measured data and the simulations results. However, there is a big deviation for the two results, when the antennas are close to tunnel walls.

In the last decade, researchers always use field experiment-based method to do the research work on power characteristics of power characteristics of electromagnetic wave propagation in coal mine (K. Guan, Z. Zhang., 2013, M. Boutin, A. Benzakour., 2008). Chahé Nerguizian et al.(K. Guan, Z. Zhang., 2013)analyze the path loss along different route in the coal mine tunnel with narrowband measurements method. He indicated that the received power showed a greater variability when the antenna is close to the tunnel walls, but did not give a concrete analysis. Ruisi He et al. (C. Nerguizian, C. L. Despins., 2005) deploy the received antenna 0.25 meters away from the tunnel walls, and arrange the transmit antenna on the locomotive travelling along rails, during their experiment. They analyze the path loss of coal mine tunnel with more than 200 meters long, but the tunnel within 10 meters is not taken into consideration. Youssef Rissafi et al.(H. Ruisi, Z. Zhangdui., 2013) show that the random lognormal distribution can be used to depict the path loss for the ultra wide band electromagnetic wave in coal mine tunnel. However, the path loss in different locations is not analyzed in-depth.

Due to propagation loss between the transmitter and receiver antenna, rather than the channel-impulse-response (CIR) and delay spread, is the main reason to obtain the maximum charging efficiency. Consequently, we also use the field experiment-based method to carry out the power characteristic analysis along 10 meters tunnel walls.

2. Setup of the Measurement System

2.1. The Environment Description

As shown in Fig. 2, the experimental measurements are implemented in the typical arched tunnel, where locates in Guozhuang Mine, in the city of Tengzhou, Shandong Province. The tunnel is 400 meters long, and includes two parts, the Light-Of-Sight (LOS) part and the Non-Light-Of-Sight (NLOS) part. The skeleton map is shown in Fig. 1. The arched tunnel was the classical D section, as shown in Fig. 2. The specific value of the width (W), the side height (SH) and the maximum height (MH) are listed in Table 1.

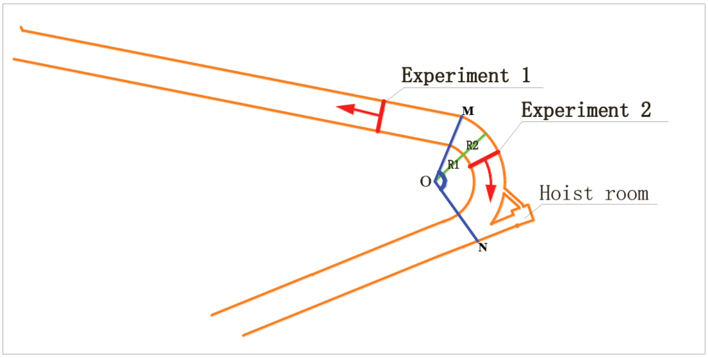


Figure 1 - Skeleton map of the Tunnel

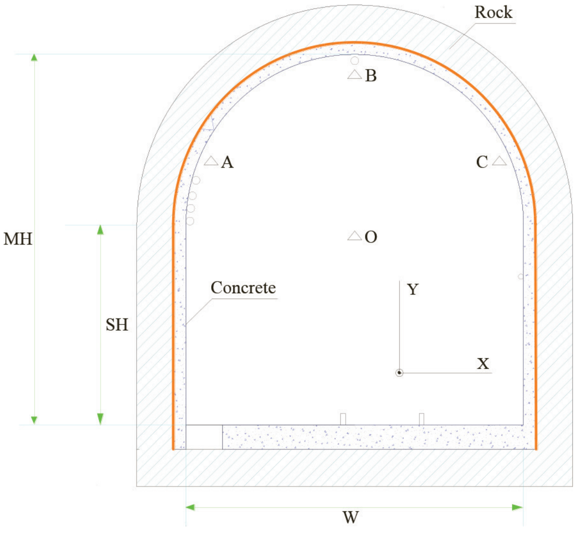


Figure 2 – Section of the Tunnel

	Width	Maximum height	Side height
Experiment 1	2.70	2.65	1.20
Experiment 2	3.70	3.15	1.60

Table 1 – Width, Maximum Height, and Side Height of the Experimental Tunnel (m)

The tunnel was drilled through the sand rock, and was reinforced by the concrete (about 10 cm thicknesses), seen in Fig. 2. The iron wire meshes (with size of 0.2cm*10cm) were also embedded between the concrete and the rock to make the tunnel much stronger. As shown in Fig. 2, we used the orange bold line to indicate the location of the iron wire meshes. One side of the tunnel, 4 electricity cables (600V, 60Hz), with 5 cm distance to each other, were equipped on the wall. It is about 1.4 m from the ground to the lowest cable. On the other side of the tunnel, 1.2 m above the ground, one water pipe, with 5cm diameter, was installed on the wall. What's more, there is a drainage channel at the cables side, with width of 30cm and depth of 20cm, separately. Two rails were laid 10 cm off the center of the tunnel ground. On the roof of the tunnel, there was another cable (10 cm to the top) for the floodlight.

2.2. Measurement Setup

As shown in Fig. 3, two standard half-wave dipole antennas working on 2.4GHz were adopted in our experiments. The transmitting antenna was connected with the microwave signal source (R&S-SMB100A) by a 2m long low-loss RF cable (goreXN3449, 0.4dB/m at 2.4GHz). The output power of the signal source was set to 16dBm. Receiving antenna was connected with a spectrum analyzer (GSP-830E) by a 5m long cable (goreXN3449), and the PC was connected to the spectrum analyzer for recording the data. This narrowband experiment system was calibrated with 120-dB dynamic range.

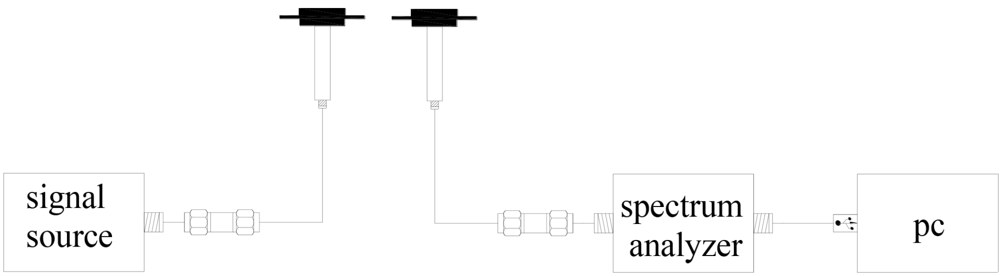


Figure 3 – The Whole Test System

2.3. Measurement Procedure

In order to bring convenience to the subsequent data analysis, here we defined the corresponding axis.. Z axis, X axis, and Y axis are defined as the longitudinal direction, the width, and the height of the tunnel, respectively. The coordinate origin is defined at the center of the tunnel ground. The initial Z coordinates of the transmitting antenna was set to 0 in our experiments.

To make sure the insertion loss to be the least level (K. Guan, Z. Zhong., 2013), we placed the transmitting antenna in the tunnel center (seen in Fig. 2, marked with O). The receiving antenna was placed at the following three locations A, B and C, successively, as shown in Fig. 2. The reason why we choose the three locations is that the coal mine monitoring system always chooses them as the optimum place to deploy the wireless sensors. At the beginning of the measurement, receiving and transmitting antenna were on the same cross-section. That is to say the initial Z coordinates of locations A, B, C and O are 0. The initial information of the two experiments was shown in Table 2. During the experimental measurement, the transmitting antenna was moved towards the arrow direction, as shown in Fig.1. We collect the experimental data every 0.2 meters along the 10 meters tunnel. Received powers on the location A, B, and C were measured with X (horizontal) and Y (vertical) antenna polarization.

	Experiment 1	**Experiment 2**
Height of O	1.60	1.60
Height of A	2.20	2.30
Height of B	2.55	2.95
Height of C	2.20	2.40
$_{d}$OA	1.17	1.46
d_{OB}	1.00	1.40
d_{OC}	1.17	1.46

Table 2 – The Initial Information of the Two Experiments (m)

3. Results and Analysis

3.1. Path Loss Model

The state-of-the-art models based on the theoretical analysis are mostly derived in rectangular tunnels. To use these models, the arched tunnel should be approximated as the rectangular tunnel by equivalent cross-sectional area (V. Malo Machado, J.A. Brandao Faria., 2015). Consequently, we also use the same way to approximate the arched tunnel as the rectangular tunnel. In the near region of the antenna (less than 10 meters), the free space model and multi-mode model are usually adopted to describe the path loss.

The random lognormal (normal in dB) distribution is utilized to describe the path loss at any location in the gallery (H. Ruisi, Z. Zhangdui., 2013, Y. Rissafi, L. Talbi., 2012). The mathematical model is as follows:

$$PL_{dB}(d) = PL_{dB}(d_0) + 10n\log_{10}(\frac{d}{d_0}) + X_{\sigma} \tag{1}$$

Where $PL_{dB}(d_0)$ is the path loss at the reference distance d_0, d_0 is usually set to be 1 m. n is the path loss exponent. X_σ is a zero-mean Gaussian distributed random variable in dB with the standard deviation σ_{dB}.

Using the modal theory (M.R.A. Khandaker, W. Kai-Kit., 2015), the losses of horizontally and vertically polarized E_{mn} modes can be described by.

$$a(m,n)^h = 4.343\lambda^2\left(\frac{m^2\varepsilon_v}{W^3\sqrt{\varepsilon_v - 1}} + \frac{n^2}{H^3\sqrt{\varepsilon_h - 1}}\right) \tag{2}$$

$$a(m,n)^v = 4.343\lambda^2\left(\frac{m^2}{W^3\sqrt{\varepsilon_v - 1}} + \frac{n^2\varepsilon_h}{H^3\sqrt{\varepsilon_h - 1}}\right) \tag{3}$$

Where ε_v and ε_h represent the relative permittivity for vertical and horizontal walls. m and n are the propagation modes. W and H represent the width and height of the tunnel, respectively. The total loss can be calculated with formula (4), when considering both the vertical and horizontal polarizations at the same time.

$$L_{mn}^{v/h}(dB) = 10\lg\left[\sum_{i=1}^{m}\sum_{j=1}^{n}\times\cdots \sqrt{10^{2a(i,j)^h|z_r - z_t|} + 10^{2a(i,j)^v|z_r - z_t|}}\right] \tag{4}$$

3.1. Data Analysis

In this section, we divide the experiment measurement results into two scenarios: the straight tunnel and the curved tunnel. In addition, the power characteristics for the corresponding scenarios is analysed.

3.2.1. Power Characteristics in Straight Tunnel

The Experiment 1 was conducted in the straight tunnel. On the three different locations A, B and C, the measured data, the simulation data of model (1) and model (4) are shown in Fig.4. All the measurement data are under X antenna polarization. Fig.5 illustrates the case of Y polarization at these locations. What's more, for comparison, the free space models under X polarization are added in Fig.5. In the actual wireless charging application, we focus on the average power within 10 meters. So the influence of X_σ is ignored when simulating the formula (1). Seen in Table 1, d0 is set to be d_{OA}, d_{OB} and d_{OC}, respectively. The formula (4) is based on the rectangular tunnel, hence the arched tunnel adopted in Experiment 1 is approximated as a rectangular tunnel with the size of 2.7 m* 2.4 m (width * height). The value(S. Zhi, I.F. Akyildiz., 2010) of ε_v and ε_h are set to be 5-0.1*j in formula (2) and (3).

The path loss exponents n obtained when simulating the formula (1) are shown in Table 3. As shown that, the values of n are bigger than that in free space (n = 2) except the Y polarization on the location B. It means that the attenuation speed of microwaves along the tunnel walls is faster than that in free space in most cases.

	X Polarization	Y Polarization
Location A	-2.587	-3.786
Location B	-2.373	-1.139
Location C	-2.749	-2.319

Table 3 – Path Loss Exponent N at the Three Locations Under X and Y Polarization

As shown in Fig.4 and 5, the free space model can accurately predict the path loss. The multi-mode model does not work very well. Here, we utilize the mean error (ME) and root mean square error (RMSE) to calculate the difference between the measurements and the predictions. As shown in Table 4, the FX and the FY denote the free space model under X and Y polarization, respectively. The MX and the MY represent the multi-mode model under X and Y polarization, respectively. It also can be seen from the ME and RMSE that in the very near region, at least within 10 meters from the transmitting antenna, the power characteristics of microwaves along arched tunnel walls can be well described by the free space model.

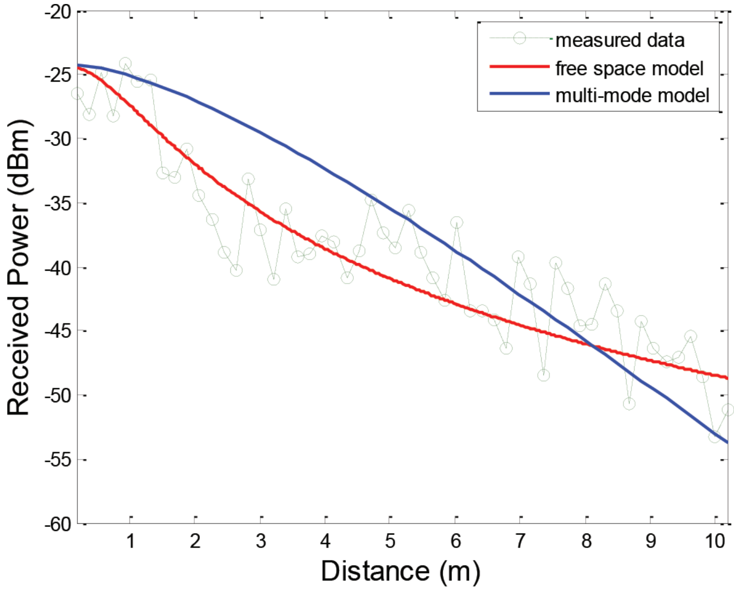
Comparing the X and Y polarization of free space model at the same location, as shown in Fig.5. Clearly, we can see that the received power under X polarization outperform the received power under Y polarization at the location A and C. In other words, the model with X polarization can be better utilized to predict the actual received power at the location A and C. At the location B, X polarization is dominating.

		Location A	Location B	Location C
ME	FX	0.4795	-1.338	0.5373
	FY	1.8268	-0.0448	-1.0423
	MX	71.3743	48.6066	73.3891
	MY	60.5962	50.3233	58.884
RMSE	FX	4.4446	3.8267	5.3057
	FY	4.8621	2.6674	4.8093
	MX	16.3679	10.8975	17.017
	MY	15.2505	6.647	9.8617

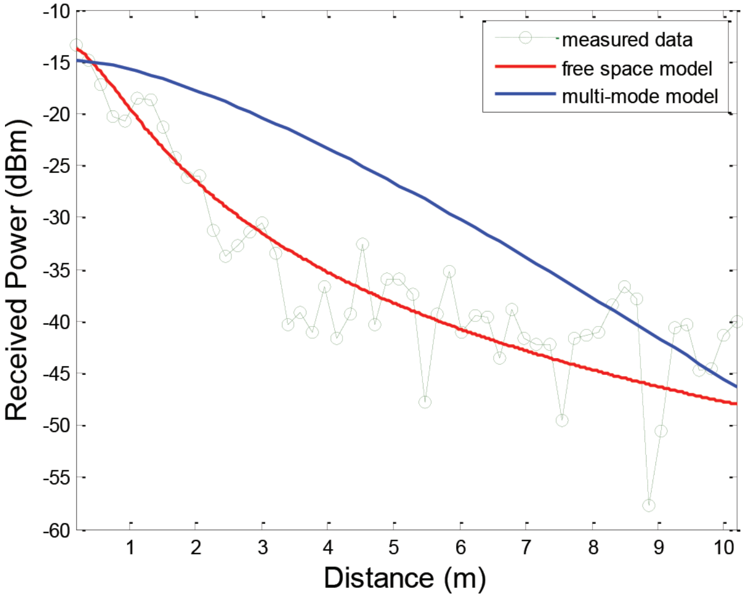
Table 4 – ME and RMSE Between Measurements and Simulation

3.2.2. Power Characteristics in Curved Tunnel

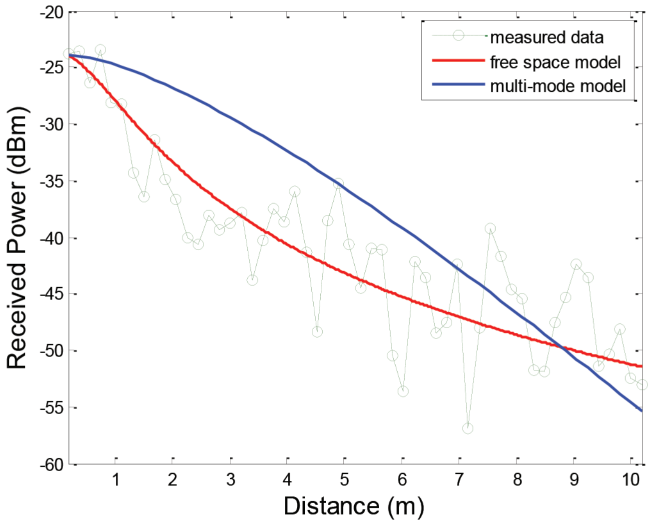
The Experiment 2 is implemented in the curved tunnel, as shown in Fig.1. The bending angle $\angle MON$ is about 120 degree. The inner curve radius R1 is about 18 meters, and the outer curve radius R2 is about 21.7 meters. For 10 meters distances, both the inner tunnel wall and the outer wall are belongs to the LOS area. Fig.6 and 7 show the measured data under X and Y polarizations, respectively. The simulations of corresponding model (1) and (4) are also plotted in the figures.



(a) location A

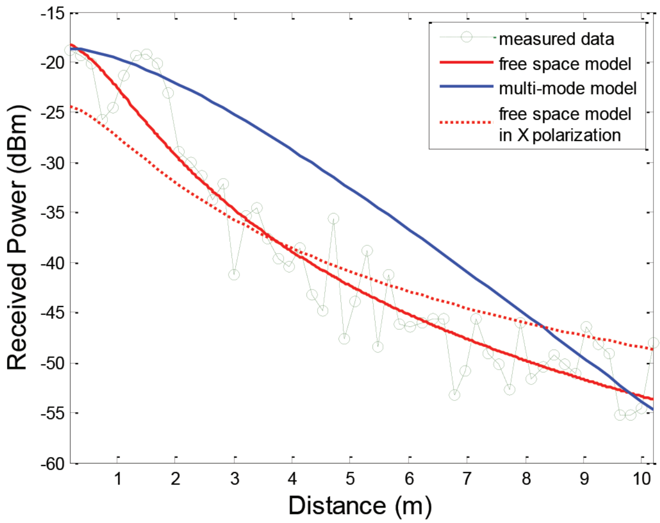


(b) Location B

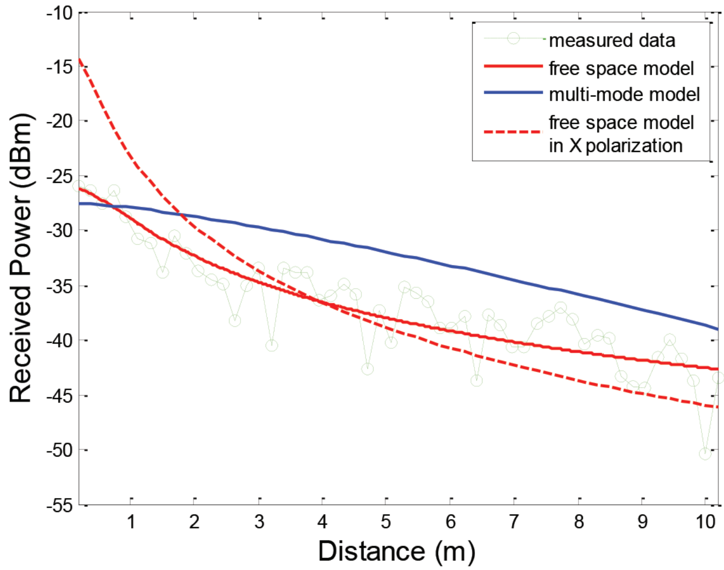


(c) location C

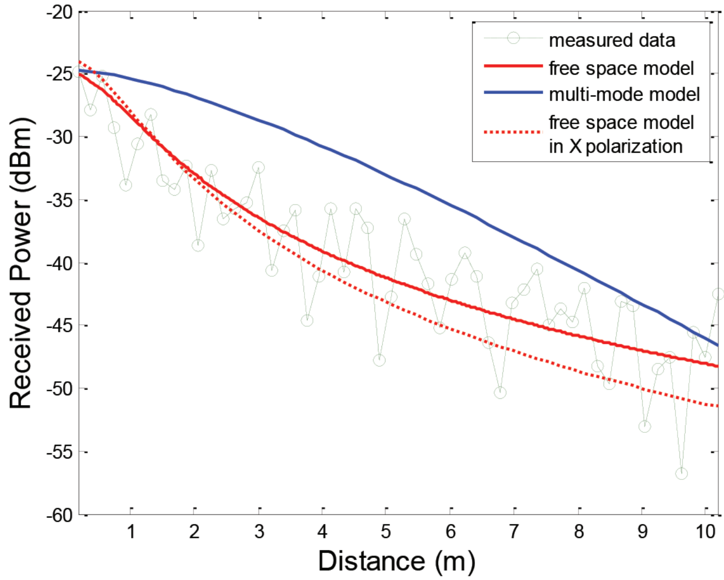
Figure 4 – Received and Simulated Power At Three Locations Under X Polarization



(a) location A

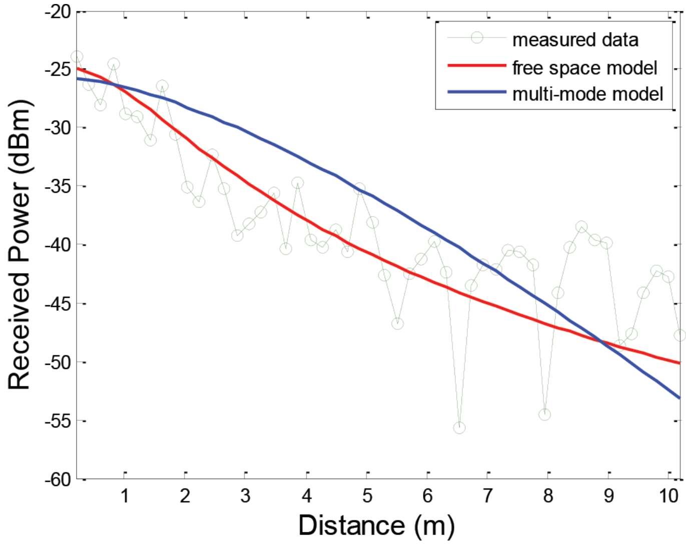


(b) location B

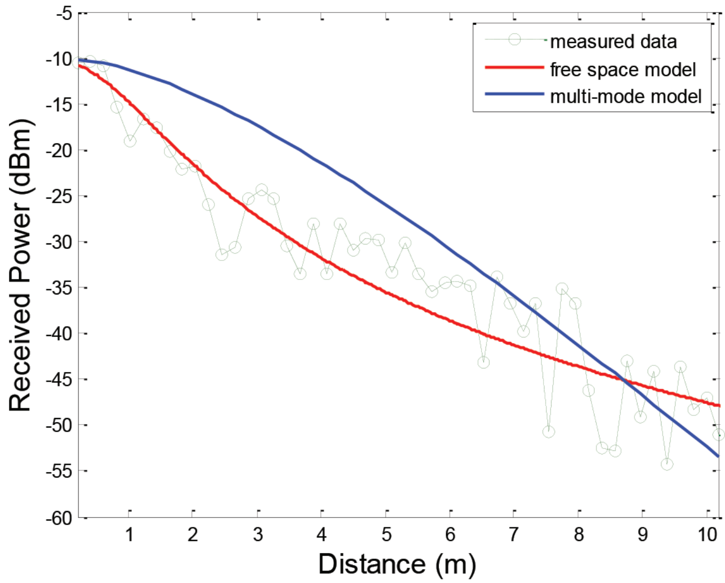


(c) location C

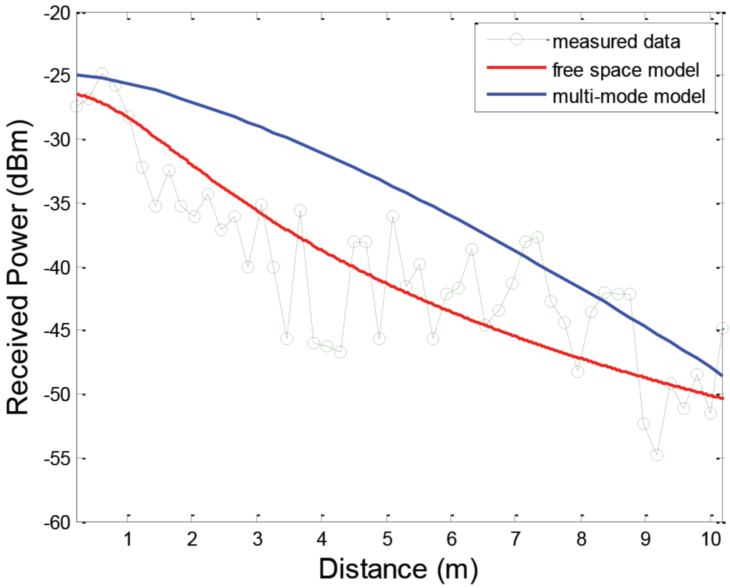
Figure 5 – Received and Simulated Power At Three Locations Under Y Polarization



(a) location A

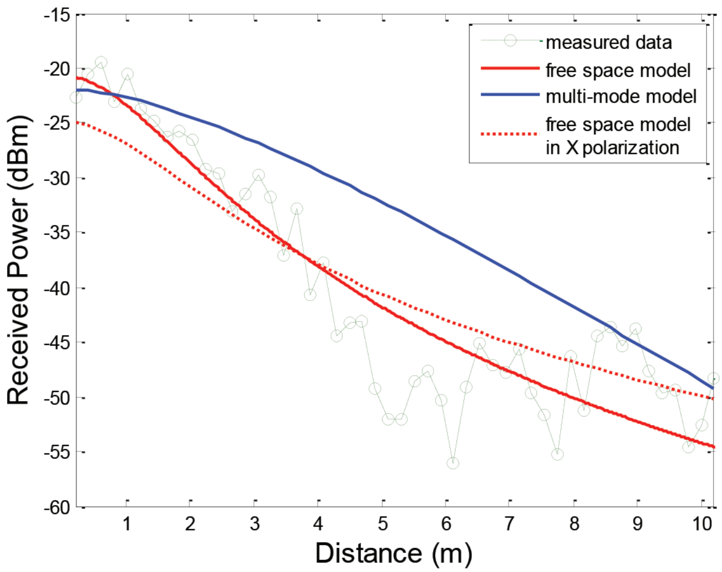


(b) location B

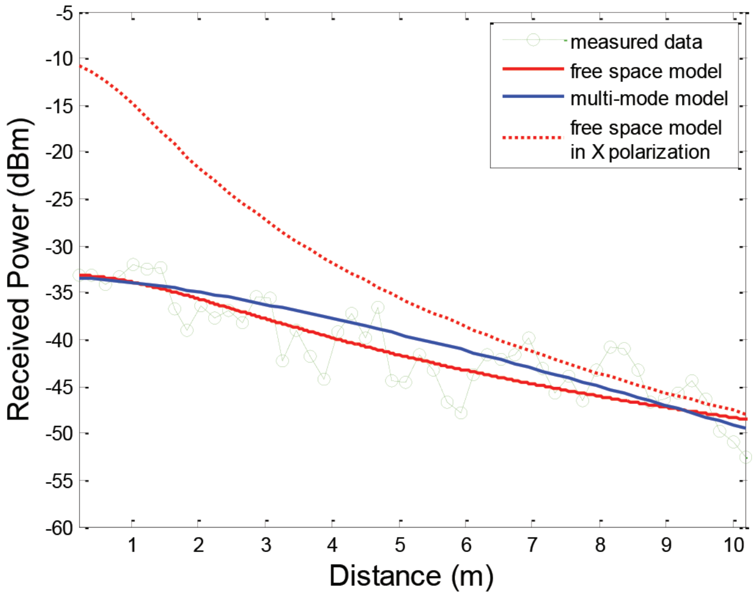


(c) location C

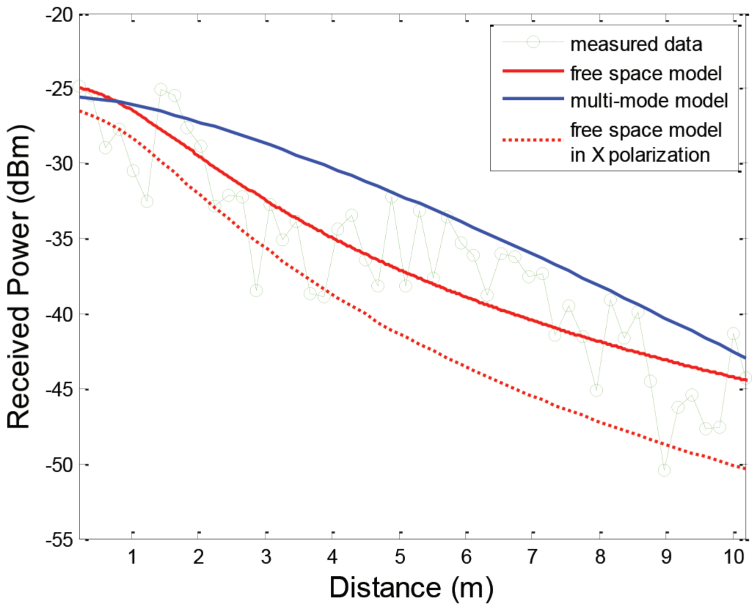
Figure 6 – Received and Simulated Power At Three Locations Under X Polarization



(a) location A



(b) location B



(c) location C

Figure 7 – Received and Simulated Power At Three Locations Under Y Polarization

The path loss exponents n acquired when simulating the formula (1) in Experiment 2 are shown in Table 5. The mean error (ME), root mean square error (RMSE) between the measurements and the predictions in curved tunnel are shown in Table 6. It can be seen from Fig.6 and 7 that the free space model fitted the measured data more well than the multi-mode model. Table 6 show that whether ME or RMSE, the free space model behaves well than the multi-mode model in both X and Y polarization at any locations.

Similar to the straight tunnel, comparing the free space model in X and Y polarizations in fig.7, the received powers under Y polarization outperform the case of X polarization at the location A and C. But at the location B, X polarization is far better than Y polarization. Location A is in the inner wall and location C the outer wall. It can be seen from the Table 5 that the path loss exponent |n| of location A is a little bigger than that of location C. That's to say, the attenuation of microwaves along inner bending wall is bigger than that of the outer wall.

Comparing the Experiment 1 and 2, the path loss exponent |n| of experiment 2 are bigger. In other words, the attenuation of the microwave in curved tunnel is bigger than that in straight tunnel. Besides the curved factor, the larger dimension of the tunnel is another reason. The path loss exponent n of Y polarization at location B is still an exception. Its absolute value is also less than 2 as in the straight tunnel.

	X Polarization	**Y Polarization**
Location A	-3.579	-4.395
Location B	-4.149	-1.592
Location C	-3.111	-2.536

Table 5 – Summary of Path Loss Exponents N At Three Locations under X and Y Polarization

		Location A	**Location B**	**Location C**
ME	FX	-0.5276	-0.5279	0.7365
	FY	0.0094	4.1339	0.2193
	MX	71.3508	74.5769	65.9763
	MY	52.7761	42.7568	51.5595
RMSE	FX	4.4802	4.2141	5.2002
	FY	4.3877	4.3053	3.9582
	MX	13.9418	24.5631	13.9839
	MY	18.7251	9.1414	11.7307

Table 6 – ME and RMSE Between Measurements and Simulation

4. Conclusions

In this paper, we explore the power characteristics along tunnel walls in short distance to study the wave transmission efficiency. The experiments were performed in two tunnel scenarios: the straight tunnel and the curved tunnels. The transmitting antenna was placed in the middle of the tunnel and the receiving antenna was placed on the tunnel walls. We measured the received power under X polarization and Y polarization, respectively. The results show that the path loss follows the free space model. On the side walls (locations A and C) in both straight and curved tunnels, antennas working on Y polarization can gain more power. But on the top of tunnels (location B), the optimum results could be obtained on X polarization. What's more, in curved tunnel, the microwave attenuation along the inner side wall is greater than that along the outside wall.

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A Clustering Method for High-dimensional Data Analysis in Stock Market

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Abstract: This paper mainly studies cluster analysis in time sequence of stock returns. Since main cluster objects are a group of high-dimensional time sequence data, as one datum, each time sequence can be taken as one data point in a group of time sequence, it cannot be divided. We put forward a time sequence clustering algorithm based on combination between independent component analysis and the improved k-means algorithm. This algorithm uses independent component analysis for feature extraction on time sequence data. Then, the improved k-means algorithm is used to complete clustering analysis on time sequence feature data to obtain a new feature-based time sequence clustering method. This method is applied for financial data mining to cluster 40 stocks and the deep causes behind stock data affecting stock market tendency are analyzed. The experimental results show that this method can effectively solve redundancy in financial time sequence and reflect some important features in financial market.

Keywords*:* Stock; clustering; ICA, K-Mean; time series.

1. Introduction

Recently, security markets constantly expand and listed companies rapidly are increasing rapidly. If investors have thousands of stocks, they cannot possibly analyze each stock. They can only study stocks in classification and then invest on the basis of selecting appropriate investment portfolio. Clustering analysis is an effective way to direct security investment. It can reveal the similarity degree of a group of stocks, assist investors to correctly understand and grasp overall features and development tendency in stocks so as to determine investment scope and select favorable opportunity to reasonably invest. There are two types of data in security market systems: stock quotation data and customer transaction data (Yu LeAn, Wang Shouyang.,2009). Stock quotation data is generated in transaction which mainly contains opening price, closing price, trading volume, etc. But stock analysts and investors pay the most attentions to stock price change because stock price change contains long-term tendency of stocks. Stock price is a group of data based on time sequence ranking so it is called time sequence data. This kind of data is continuous within certain time segment and there has certain law and relationship in its internal part. In terms of data mining category, two important features of stock price to form time sequence are huge data and high dimension (Tong S, Koller D., 2002). Meanwhile, there are other features such as periodicity, randomness and trend in time sequence of stock price.

ICA can be seen as the expansion of PCA and factor analysis. However, as a more powerful technology, ICA can still find out internal factor source to support observation data when classical methods are completely ineffective (Nanda S.R., Mahanty B., Tiwari M.K., 2010). For the clustering analysis in time sequence data of stock returns, this paper proposes a time sequence clustering algorithm based on combination between ICA and the improved k-means algorithm (Cadavid, J. M., & Gómez, L. F. M., 2015). Its basic thought is to apply ICA to perform feature extraction on time sequence data at first and then use common division clustering algorithm to complete clustering analysis on time sequence feature data. Based on maximum likelihood estimation adaptive algorithm of fixed step ICA, by one-dimensional search to introduce step correction method, disorder error of new algorithm on convergence speed and stable state can reach the best joint, it has the perfect time-varying system tracking ability. The simulation results prove that the algorithm in this paper can effectively improve ICA adaptability and more correctly complete blind source separation. On this basis, the algorithm is used on stock data in strong time variation in order to verify its effectiveness and feasibility.

2. Time Series Clustering Analysis Method Based on ICA

Since the random variables $s_1(t)$, $s_2(t)$,..., $s_n(t)$ are statistically independent each other, they are linearly independent. Therefore, these independent n random variables can compose a linear space. $s_1(t)$, $s_2(t)$,..., $s_n(t)$ is a group of base of the linear space (Bai Yaohui, Dang Jianwu., 2014). A is the parameter matrix of observation variable $x(t)$ under the coordinates of this base. Then, from the perspective of vectors, base and coordinates of the linear space, the similarity relation between the line vectors of A reflect certain similarity relation among the components $x_1(t)$, $x_2(t)$,..., $x_m(t)$ of $x(t)$. Thus, if A is known, we can perform clustering on matrix A to complete the clustering task on observation variables $x_1(t)$, $x_2(t)$,..., $x_m(t)$. Since the variable dimension of A is n , which is independent of time t, it can greatly reduce the dimension of time series data. It demonstrates that independent component analysis (ICA) is reasonable and effective on feature extraction and dimensionality reduction for time series data.

In basic ICA model, there exists necessary mixing element or uncertainty. For the samples data of each group of observation variables $x_1(t)$, $x_2(t)$,..., $x_m(t)$, we adopt ICA algorithm to estimate mixed matrix $\hat{A}$ and the results may be different each other. The follows will discuss if it cause influence to the line vectors in the mixed matrix.

For $x_1(t)$, $x_2(t)$,..., $x_m(t)$, $\hat{A}$, also with restored independent component $\hat{s}_1(t)$, $\hat{s}_2(t)$,..., $\hat{s}_n(t)$ acquired by ICA algorithm satisfy the following equation:

$$x(t) = \hat{A}\hat{s}(t) \tag{1}$$

The restored independent component and real independent component have the relation as:

(2)

From equation 1 and 2 we have

$$x(t) = As(t) = AP^T diag(\frac{1}{\alpha_1}, \frac{1}{\alpha_2}, ..., \frac{1}{\alpha_n}) diag(\alpha_1, \alpha_2, ..., \alpha_n) Ps(t)$$
$$= AP^T diag(\frac{1}{\alpha_1}, \frac{1}{\alpha_2}, ..., \frac{1}{\alpha_n}) \hat{s}(t) \quad (3)$$

Since $\{\hat{s}_1(t), \hat{s}_2(t), ..., \hat{s}_n(t)\}$ are statistically independent each other, by equation 1 and 4 we have

$$\hat{A} = AP^T diag(\frac{1}{\alpha_1}, \frac{1}{\alpha_2}, ..., \frac{1}{\alpha_n}) \quad (4)$$

From equation 5, we can know that the estimated mixed matrix $\hat{A}$ is acquired by rank transformation of A. For mixed A, it will not change the similarity relation among the vector groups of A, by changing the sequence of two rows or each row multiplying nonzero constant. Since A is parameter matrix of $x_1(t)$, $x_2(t)$,..., $x_m(t)$ under the base $s_1(t)$, $s_2(t)$,..., $s_n(t)$, and its parameter matrix is $\hat{A}$, the similarity relation of $x_1(t)$, $x_2(t)$,..., $x_m(t)$ will keep unchanged between the lines of parameter matrix, under two groups of base. Similarly, though the mixed matrice estimate by ICA algorithm have difference each other, it will not influence the similarity to line vector of the mixed matrix.

In actual application, though A is unknown, by the above discuss and equation 5, the similarity relation among the lines of $\hat{A}$ can reflect the similarity relation among $x_1(t)$, $x_2(t)$,..., $x_m(t)$. Therefore, we can performing clustering on the vector group constituted by line vectors to complete the clustering task on $x_1(t)$, $x_2(t)$,..., $x_m(t)$.

3. Improved Clustering Mixed Algorithm

For original time series data we can adopt ICA algorithm to extract static feature data first. Then we use the improved k-mean algorithm to make clustering for extracted static feature data (Aghabozorgi Saeed, Teh Ying Wah., 2014). Then we complete the clustering on original time series data, as the new time series clustering method based on ICA in this paper.

As mentioned above, the time series clustering analysis base on ICA should first perform feature extraction with ICA algorithm on time series data (Donoho D L., 2000, Yu H, Yang J., 2001). Independent component is exactly the cause that hides behind the phenomenon so its weight denotes the feature of time series (Prasanna S., Maran Ezhil., 2015). We propose an analysis method using its weight clustering to replace the time series clustering, which reduce the computation greatly. Therefore, we adopt classic FastICA algorithm to extract the features and acquire the mixed matrix. The detailed procedures are:

Step 1: Observation data centralization and whitening and obtain $z(t)$;

Step 2: Give initial value of $w_i \in R^n$, $i = 1,2,...,n$. Its norm is 1 as the orthogonal matrix W;

Step 3: For each $i = 1,2,...,n$, let $w_i \leftarrow E\{zg(w_i^T z)\} - E\{g^t(w_i^T z)\}w_i$. g is nonlinear function by Gauss selection of data;

Step 4: Symmetrically orthogonalize matrix W: $W \leftarrow (WW^T)^{\frac{1}{2}} W$;

Step 5: If it is not convergent, returen to setp 3.

K-means is a popular algorithm in clustering analysis algorithms. An important defect of this algorithm is it is too sensitive to the initial clustering center. We put forward an improved k-means algorithm to make clustering on mixed matrix. This method adopts hierarchical algorithms to acquire a group of clustering center, which optimizes the choice of initial clustering center (Rauber A, Merkl D, Dittenbach M., 2012, Jackson Q, Landgrebe D., 2001, Shuman D, Narang S K, Frossard P, et al., 2013).

The detailed procedures are:

Input: clustering number k and the data matrix containing n objects.

Output: k sets keeping the minimum squared error criterion.

Step1: initialization. $R_0 = \{w_i, i = 1,...,n\}$; $P_0 = P(W)$; $t = 0$, $P(W)$ denotes the neighbour matrix deduced from W;

Step 2: repeat the following procedures. $t = t + 1$; combine two classic sets that are close to R_{t+1} to get R_t; adopt matrix updating algorithm in complete connection algorithm to get the neighbour matrix P_t;

Step 3: Repeat step 2 until the clustering R_{n-k} is formed, that is, all vectors are merged to k clusters;

Step4: Compute the center of above k clusters as the initial clustering center of improved k-means algorithm;

Step 5: Using acquired clustering center to adopt k-means algorithm twice, to cluster the mixed matrix;

In a word, the FastICA, together with improved k-mean clustering algorithm, makes up the time series clustering method based on ICA in this paper.

4. Algorithm Implementation and Analysis

Because of large scale and good fluidity in Shanghai security market, this paper selects 10 stocks from 50 Shanghai stock indexes to perform independent component analysis. They are respectively from 600053 Zhongjiang Estate, 600234 Shanshui Culture, 600283 Qianjiang Water Conservancy, 600776 Dongfang Communication, 600101 Mingxing Power, 600839 Sichuan Changhong, 600160 Juhua Stock, 600680 Shanghai Putian, 600754 Jinjiang Stock and 600238 Hainan Yedao. We extract each stock from sina.net financial sector as of May 1, 2015, the previous 500 stock closing price data and compute the daily rate of return to construct the time series database of the rate of return. A 10*500 data matrix refers to the historical data of daily return in 10 stocks. After it is input in calculating project of variable step size ICA maximum likelihood estimation adaptive algorithm based on one-dimensional search, after the data is performed centralization, whitening, dimension-reduction and ICA analysis. Then we can get 10*7 mixing matrix, 7*10 separation matrix and 7* 500 independent component matrix. Fig.3 depicts its original data figure and fig.4 depicts the tendency of various independent elements after analysis.

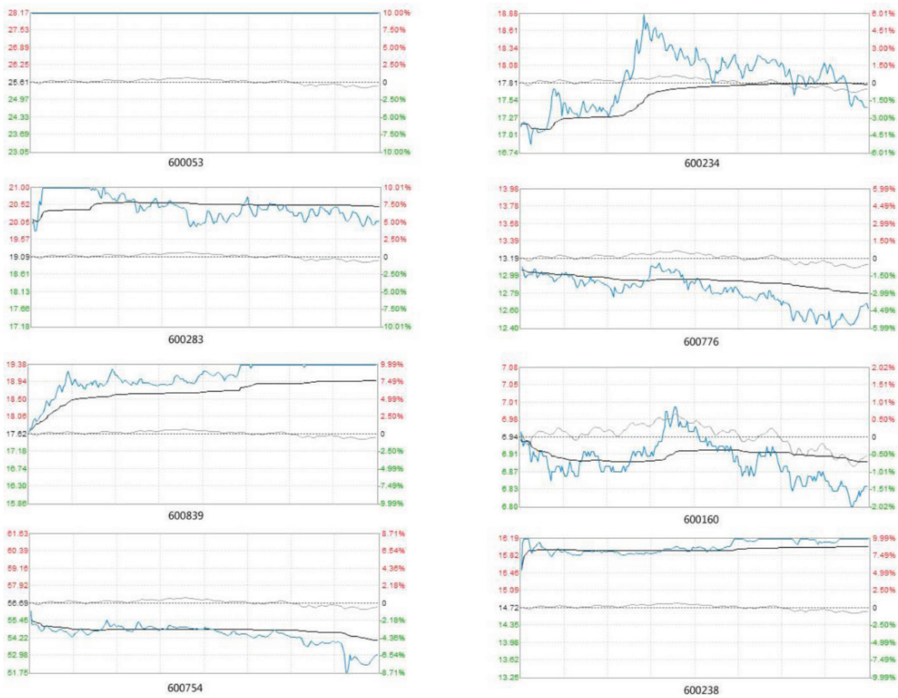

Figure 1 – Stock Movements

Because determining time series model is applied to analyze, determining time series model considers that change form of time series is caused by stack and convection of four parts including long-term tendency, season variation, cyclic variation and irregular variation. Through the analysis of fig.5, we obtain the first independent element and the fourth independent element reflect circulation movement of original stock sequence; the second independent element and the third independent element reflect long-term tendency of original stock sequence; the fifth independent element and the eighth independent element reflect seasons variation of original stock sequence; the sixth independent element and the seventh independent element reflect irregular variation of original stock sequence. Factors that affecting stock market are very complicated and their variation is caused by a series of factors' comprehensive actions. Therefore, due to prior knowledge difference of above factors, there may have different explanations. After above deep-level factors affecting stock market are obtained, they can provide

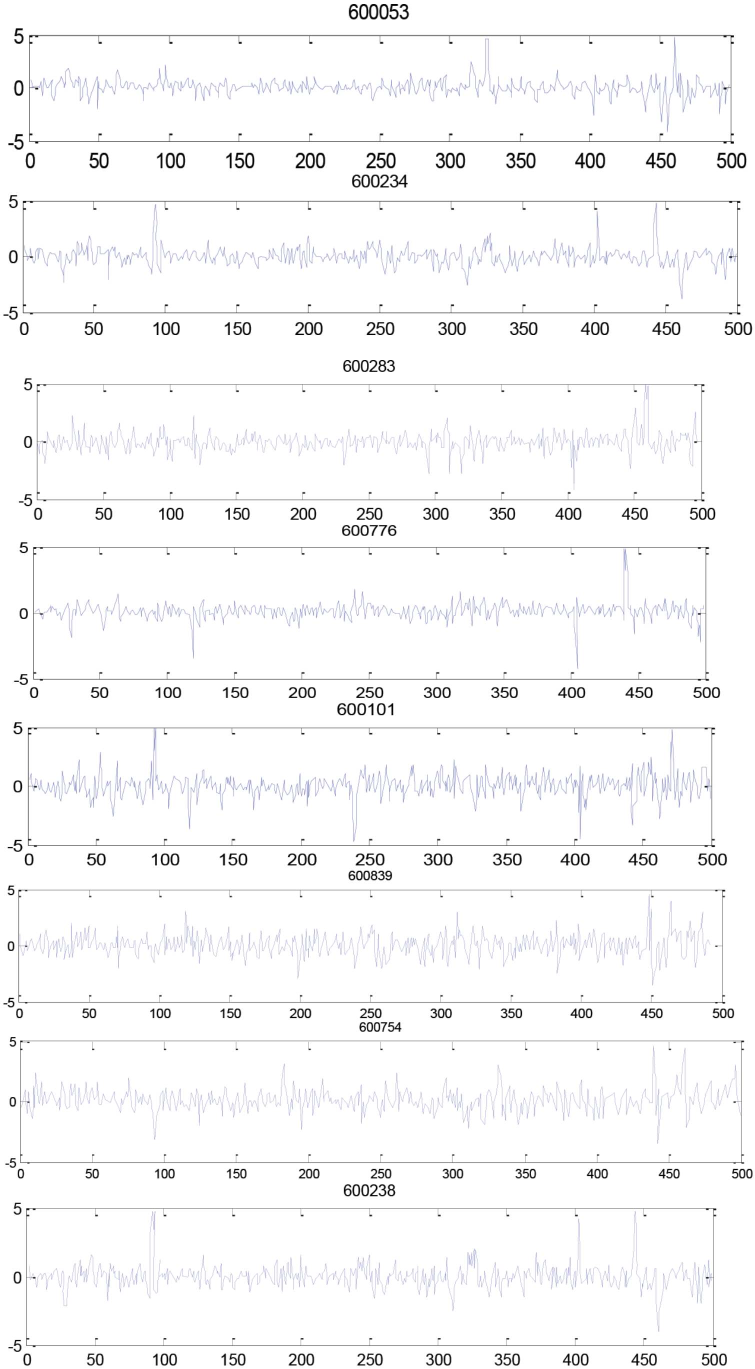

Figure 2 – Independent Components

references for related departments to formulate policies for stock market to develop healthily and orderly.

To better describe the performance of four clustering methods, we adopt multiple attribute decision method to provide evaluation. The evaluation results are shown in table 1 and 2. ICA-k-mean can automatically estimates clustering number, so its corresponding index value is set as 1. Since given time series data set spectral clustering cannot automatically estimate the clustering number well, its index value is set as 0.8.

	Stability	Clustering result	Running time	Estimating clustering number automatically	Evaluation result
ICA-k-mean standard 0-1 value	0.0012	0.9190	0.3442	1	1.3736
	1	0	0.9961	1	
ICA-Spectral standard 0-1 value	0.0021	0.9268	0.3340	0	0.4080
	0	0.2507	1	0	
Spectral clustering standard 0-1 value	0.0015	0.9571	0.4108	0.8	1.3187
	0.0067	1	0.9298	0.8	
k-mean standard 0-1 value	0.0019	0.9188	1.3148	0	0.1704
	0.2212	0.7836	0	0	

Table 1 – Clustering Results Comparison of Four Clustering Methods on Stock Dataset (Repeated Time:30)

	Stability	Clustering result	Running time	Estimating clustering number automatically	Evaluation result
ICA-k-mean standard 0-1 value	0.0012	0.9155	0.3286	1	1.3717
	1	0	0.9990	1	
ICA-Spectral standard 0-1 value	0.0027	0.9303	0.3276	0	0.4280
	0	0.3566	1	0	
Spectral clustering standard 0-1 value	0.0015	0.9570	0.4098	0.8	1.3283
	0.8	1	0.9184	0.8	
k-mean standard 0-1 value	0.0021	0.9489	1.3353	0	0.1826
	0.4	0.8048	0	0	

Table 2 – Clustering Results Comparison of four Clustering Methods on Stock Dataset (Repeated Time:100)

Table 1 refers to each index value and evaluation results when the repetition times of k-mean average is 40. Table 2 is each index value and evaluation result when the repetition times of k-mean value is 100. The first line and the first column refer to related index. The second and fifth columns refer to corresponding index values of four clustering methods and the normalized index value after standard 0-1 transformation. The sixth column refers to utilize eigenvector to determine various indexes weight at first and then the obtained evaluation results of clustering methods through weights. Since the focus in this paper is to automatically estimate clustering quantity of time series data set and perform dimension reduction on time series data set. Thus, importance degrees of four indexes from big to small are automatic estimation clustering quantity, operating time, clustering results and clustering results stability. Eigenvector is used to determine attribute importance matrix of various index weights. Attribute importance matrix in this paper according to four indexes importance is shown as table 3.

	Stability	**Result**	**Running time**	**Estimating clustering number automaticlly**
Stability	1	3	5	7
Result	1/3	1	2	4
Running time	1/5	1/2	1	2
Estimating clustering number automaticlly	1/7	1/4	1/2	1

Table 3 – Attribute Importance Matrix

From table 1 and table 2 we can see, the independent element analysis-based time series multi-channel normalized cutting spectrum cluster is more appropriate for clustering in time series data from automatic estimation clustering quantity, clustering results quality during algorithm operation and clustering results stability.

5. Conclusion

For the redundancy in high-dimensional financial data mining, this paper proposes ICA-based time sequence clustering analysis. At first, due to defects of k-means algorithm initial clustering center selection, this paper utilizes hierarchical clustering algorithm to optimally select initial clustering center and proposes the improved k-means algorithm. Then, the improved k-means algorithm is combined with the fixed point algorithm in ICA to obtain the ICA-based time sequence clustering analysis method in this paper. Finally, this method is applied in financial data mining to cluster stock data and analyze fluctuation characteristics in stock market. The simulation results show this method can effectively solve the problem of redundancy in financial time sequence and reflect some important features in financial market.

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Financial Crisis Short Term Forecasting Method Using Artificial Intelligence based Classification Algorithm

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Abstract: This paper aims to solve the problem of financial crisis short term forecasting, which is a key step for modern society development. In the proposed framework of the financial crisis short term forecasting system, high dimension financial data are extracted from the financial database. Then, in order to reduce time complexity, we design an index system to map high dimension financial data to a low dimension space. Particularly, four factors are utilized to represent the financial position of modern enterprises, that is, a) Profitability, b) Solvency, c) Operating capacity, and d) Composition of capital. Afterwards, the financial crisis short term forecasting algorithm is presented by integrating particle swarm optimization and support vector machine together. Experimental results demonstrate that compared with other methods, the proposed algorithm is able to achieve high accuracy of financial crisis short term forecasting. Particularly, the proposed financial crisis short term forecasting algorithm can not only boost enterprises' subsistence and development, but also promote the benefits of investors. The main innovations of this paper lie in that a) we develop a hybrid particle swarm optimization and support vector machine model to forecast short term financial crisis and b) we build up an appropriate financial evaluation index system to cover all influences of enterprise financial crisis.

***Keywords**:* Financial crisis, short term forecasting, artificial intelligence, particle swarm optimization, support vector machine.

1. Introduction

In modern economic globalization process, with the rapid development of the capital markets, business competition has been more and fiercer. In modern society, each company may encounter financial crisis (Cao Wei, Cao Longbing, 2015; Audrino Francesco, 2014). If the company manager cannot tackle these problems in time, company will go into the bankruptcy state. Although we cannot completely avoid each company to be far from the financial crisis, we should forecast short term financial crisis for all companies (Kunze Frederik, Kramer Jens, 2014). As is well known that predicting the financial crisis refers to an important task in manager's daily work. If the financial crisis cannot be solved in time, the manager will lose the capability to tackle it and then go into the bankruptcy (Berger T, Missong M, Financial Crisis, 2014; De Sousa Gabriel

Vtor Manuel, 2014). Hence, forecasting the corporate financial crisis has important theoretical and practical significance.

In the capital market, company can collect the low cost fund from capital market and boost enterprise development. The investor should fully utilize capital market operation to achieve higher reward. Modern company is faced with the gradually dangerous marketplace environment (Metescu Ana-Maria. et al, 2013; Halbleib Roxana, Pohlmeier Winfried, 2012). Financial crisis not only affects enterprises' subsistence and development, but also influences the benefits of investors. With rapid development of capital market and the reform of market economy system, the complexity and uncertainty in economic field have been increasingly evident(Svetlova Ekaterina, 2012). Furthermore, financial crisis happens frequently, meanwhile, bankruptcy occurs in enterprises as well (Zaleskiewicz Tomasz, 2011). In this paper, we focus on the problem of financial crisis short term forecasting by a hybrid PSO-SVM model.

For the problem of financial crisis forecasting, existing methods are listed as follows. Chen et al. used Adaptive Markov chain Monte Carlo method to forecast financial risk via a computational Bayesian framework (Chen Cathy W S. 2012). Chen et al. utilized Z-Score value to measure multinomial financial crisis index for financial crisis forecasting, and exploited Grey Markov forecasting for performance valuation (Chen Li-Hui, Guo Tsuei-Yang, 2011). Yu et al. proposed a multiscale neural network learning paradigm to forecast financial crisis events for short term purposes (Yu Lean. et al, 2010). Cipollini et al. exploited principal components analysis to achieve vulnerability indicators to forecast financial crisis (Cipollini A, Kapetanios G, 2009). Hajek et al. proposed a novel framework using Latent Semantic Indexing to forecast financial crisis, and this work assume that equity markets can forecast even sharp changes in monetary policy during a quarter ahead of such a change (Hajek Petr. et al, 2009). Oh et al. establish an alarm zone in the daily financial condition indicator, which is utilized to forecast a potential financial crisis with high accuracy. Particularly, this paper is able to provide an early warning signal via neural networks and nonlinear programming (Oh KJ. et al, 2005).

Different from the above research work, we proposed a novel financial crisis short term forecasting method based on a hybrid particle swarm optimization and support vector machine model. In particularly, in our work, to improve the performance of particle swarm optimization we provide a high inertia weight to build up a new searching space, and inertia weight decreases with paths varying for different particle number.

2. Framework of the Financial Crisis Short Term Forecasting System

In this section, we will discuss the design of financial crisis short term forecasting system. Framework of the financial crisis short term forecasting system is illustrated in Fig. 1. The proposed financial crisis short term forecasting system extracts high dimension financial data from the financial database. Afterwards, to reduce the time cost of the financial crisis short term forecasting task, we proposed an index system to map high dimension financial data to a low dimension space. Afterwards training dataset and testing dataset are built up based on the low dimension experiment data (Oliveira, J. A., Ferreira, J., Figueiredo, M., Dias, L., & Pereira, G., 2014). Next, we utilize Particle Swarm Optimization to optimize parameters of SVM, and then training dataset is exploited to train a SVM classifier. In the end, financial crisis forecasting results can be gained for a given testing sample.

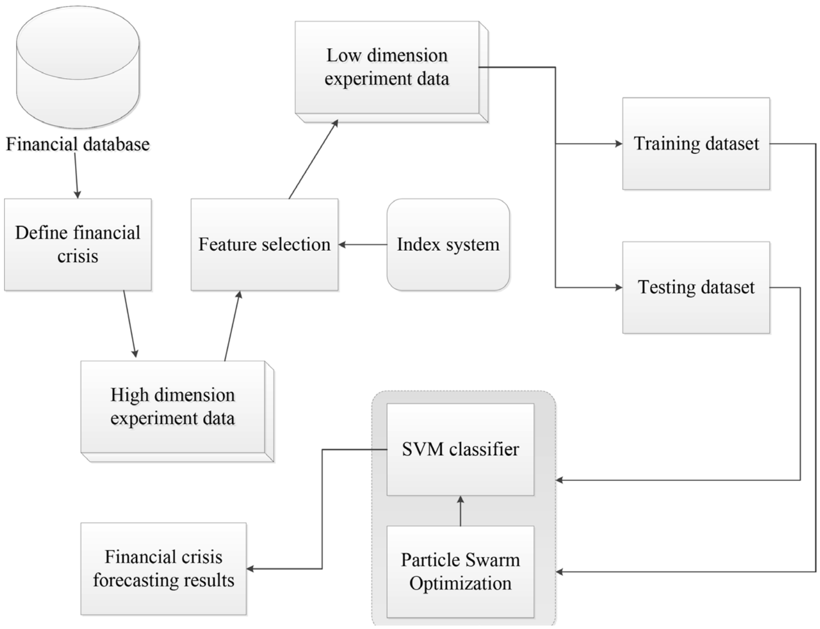

Figure 1 – Framework of the Financial Crisis Short Term Forecasting System

To carry out the financial crisis prediction, we should build a reasonable index system in advance (shown in Fig. 2). Moreover, high quality index system is able to help us to find the reasons of financial crisis. If the financial crisis can be precisely forecasted, management method of companies can be significantly improved. Based on the above analysis, we should make clear the principle of enterprise financial crisis evaluation

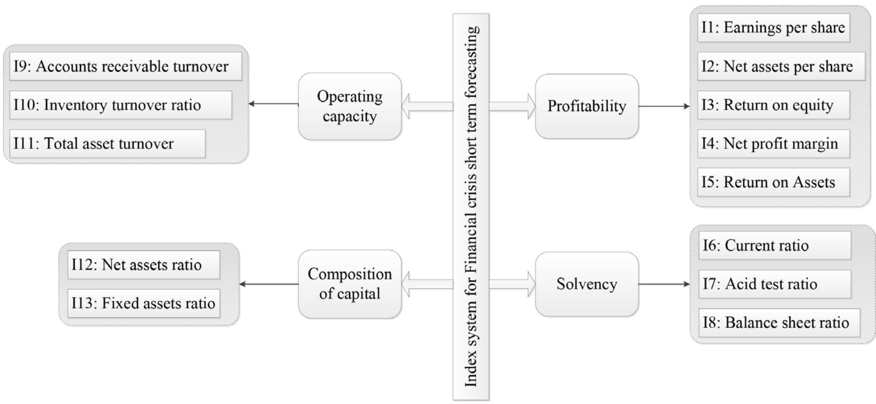

Figure 2 – Index System for Financial Crisis Short Term Forecasting

index system construction, and then choose appropriate financial evaluation index system to cover all influences of enterprise financial crisis.

As is shown in Fig. 2, the factors that affect the financial position of the enterprise are classified into four aspects: 1) Profitability, 2) Solvency, 3) Operating capacity, and 4) Composition of capital. Furthermore, the proposed index system also contains special characteristics of the global economic environments.

3. The Proposed Financial Crisis Short Term Forecasting Method

The main idea of this paper is that we introduce an artificial intelligence based classification algorithm (that is, support vector machine) to forecast short term financial crisis. As is well known that support vector machine based on statistical learning theory has been widely utilized in many applications of machine learning, and SVM is able to solve the classification problem with high accuracy and good generalization capability (Garcia Nieto P J. et al, 2016; Garcia Nieto P J. et al, 2015; Garcia-Gonzalo E. et al, 2015; Hsieh Ching-Tang, Hu Chia-Shing, 2014). In order to an optimal SVM prediction model, it is very crucial to select a kernel function and parameters to gain a soft margin. Parameters of SVM classifier greatly affect performance of classification accuracy (Sudheer Ch. et al, 2014; Selakov A. et al, 2014; Liu Baoling. et al, 2013).

In this section, we utilize particle swarm optimization to SVM parameters. Particle swarm optimization is designed to be initialized with a population of random solutions, which are named as particles (Wang Wen-chuan. et al, 2013). In particular, each particle goes in the search space at a velocity which is dynamically updated according to its own and neighbors' historical behavior. Different from the genetic algorithm, particle swarm optimization is more effective (Subasi Abdulhamit, 2013). Therefore, this paper adopts particle swarm optimization to optimize the SVM parameters.

SVM is designed to nonlinearly map the training data to a high dimensional feature space, and utilize a linear regression model in the feature space. In support vector machine, the key task is to optimize the following equation.

$$\min J(w,\xi) = \frac{1}{2} w^t w + \frac{\gamma}{2} \sum_{i=1}^{l} \xi_i^2 \tag{1}$$

$$y_i = w^T \varphi(x_i) + b + \xi_i, i \in \{1,2,\cdots,l\} \tag{2}$$

where $\varphi(x_i)$ denotes a high dimensional feature space and parameter ξ is error vector. Moreover, parameter w and b are used to seek the classification boundary, ξ_i refers to a slack variable, and parameter γ is value of penalty for mis-classification. Then, the level of financial crisis short term is gained by solving the following equation.

$$f(x) = wx + b = \left[\sum_{i=1}^{Ns} y_i \alpha_i \varphi(x_i) \varphi(x) \right] + b \tag{3}$$

However, classification accuracy of SVM is significantly affected by parameter estimation. Hence, in this paper, we introduce particle swarm optimization to optimize parameters of SVM. In particle swarm optimization, each solution is defined as a particle which is used to obtain the best position. In particular, for each iteration, PSO aims to search for two best solutions: 1) $pbest$ and 2) $\Delta y \neq 0$. $pbest$ is defined as the fitness in the current iteration, and $gbest$ means the global best solution.

$$\begin{aligned} v_i^d(N+1) &= v_i^d(N) + c_1 \cdot rand1_i^d \cdot (pbest_i^d(N) - x_i^d(N)) \\ &\quad + c_2 \cdot rand2_i^d \cdot (gbest^d(N) - x_i^d(N)) \end{aligned} \tag{4}$$

$$x_i^d(N+1) = x_i^d(N) + v_i^d(N+1) \tag{5}$$

where $v_i^d(N)$ is the current velocity, d means the d^{th} particle, i refers to the i^{th} variable, and $rand2_i^d$ means iteration number. $rand1_i^d$ and $rand2_i^d$ are random numbers in the range [0,1]. Furthermore, c_1 and c_1 denote acceleration degrees. In order to avoid premature convergence, weighting factors are defined as follows.

$$\begin{aligned} v_i^d(N+1) &= \omega \cdot v_i^d(N) + c_1 \cdot rand1_i^d \cdot (pbest_i^d(N) - x_i^d(N)) \\ &\quad + c_2 \cdot rand2_i^d \cdot (gbest^d(N) - x_i^d(N)) \end{aligned} \tag{6}$$

where parameter w refers to a weighting factor.

Afterwards, the proposed financial crisis short term forecasting algorithm based on a hybrid particle swarm optimization and support vector machine model is illustrated as follows.

Algorithm: Financial crisis short term forecasting algorithm.

Input: Parameter of financial crisis short term forecasting algorithm.

Output: Financial crisis short term forecasting results.

Step 1: Designing a function to estimate initial dynamic inertia weight:

$$\bar{\gamma} = \left(\frac{i_{\max} - i_{cur}}{i_{\max}} \right)^n \cdot (\gamma_{ini} - \gamma_{fin}) + \gamma_{fin} \tag{7}$$

Step 2: Calculating inertia weight:

$$\gamma^* = (d)^r \cdot \gamma_{ini}, d \in [0.1,1] \tag{8}$$

Step 3: If $f(P_{gd-new})$ is lower than $f(P_{gd-old})$

Step 4: Set $r = r - 1$

Step 5: Else set $r = r + 1$

Step 6: Computing stochastically initialization population, velocity, and fitness value for each particle.

Step 7: Initializing position of $gbest$ and $pbest$.

Step 8: Initializing position of $lbest$ using the best particle in the initialized population.

Step 9: End If.

Step 10: While max endgen for a generation is not satisfied then.

Step 11: $k = k + 1$

Step 12: Producing a swarm for the next generation and then evaluate it.

Step 13: End while.

Step 14: Using the above improved PSO to optimize parameters of SVM.

Step 15: Output the level of financial crisis by the SVM classifier.

4. Experiment

As is well known that Quoted company is defined as the company that has a wide influence on the business in modern economic society. From the point of view of enterprise management, quoted company with its accounting information is able to enhance management quality and then promote enterprises' social responsibility. In general, financial crisis short term forecasting is crucial for modern society management. To make performance comparison, standard support vector regression (SVR) and standard SVM classifier are used to compare with our method.

At first, weight of each index is calculated by the Analytic Hierarchy Process (AHP) (shown in Fig. 3).

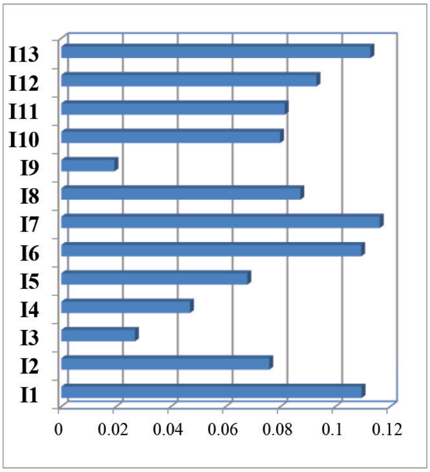

Figure 3 – Index Weight of the Proposed Index System.

Next, we collect financial data from several quoted companies to build up a dataset, and compare our proposed with support vector regression and support vector machine. Error rates of financial crisis short term forecasting with different algorithms are listed in Table. 1 as follows.

No. of quoted company	SVR (%)	SVM (%)	Our algorithm (%)
1	12.12	11.47	2.49
2	7.32	6.56	4.43
3	8.20	8.08	3.25
4	5.79	4.78	2.06
5	11.35	10.80	2.29
6	10.74	9.78	3.04
7	6.12	5.18	4.96
8	6.98	5.85	1.51
9	9.93	9.29	1.06
10	0.47	0.42	4.13
Average	7.9	7.22	2.92

Table 1 – Error rates of Financial Crisis Short Term Forecasting with Different Algorithms.

Table.1 demonstrates that the average error rate of our algorithm is 2.92%, and our algorithm obviously performs better than SVR and SVM. Next, we take quoted company 1 and 2 as examples to show forecasting values and error rates for different algorithm. In particularly, financial data in 100 days are extracted from quoted company 1 and 2 are used as testing dataset.

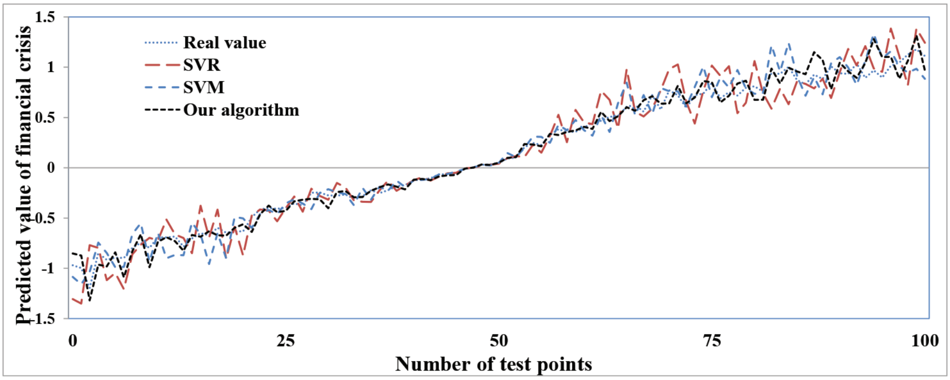

Figure 4 – Forecasting Value of Different Algorithms for Company 1.

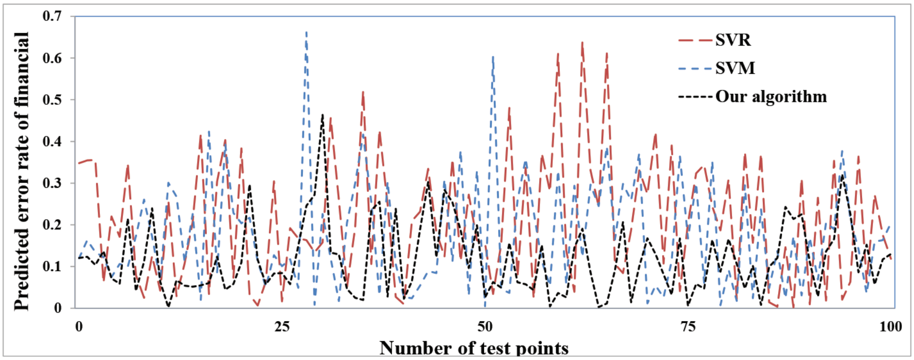

Figure 5 – Forecasting Error Rate of different Algorithms for Company 1.

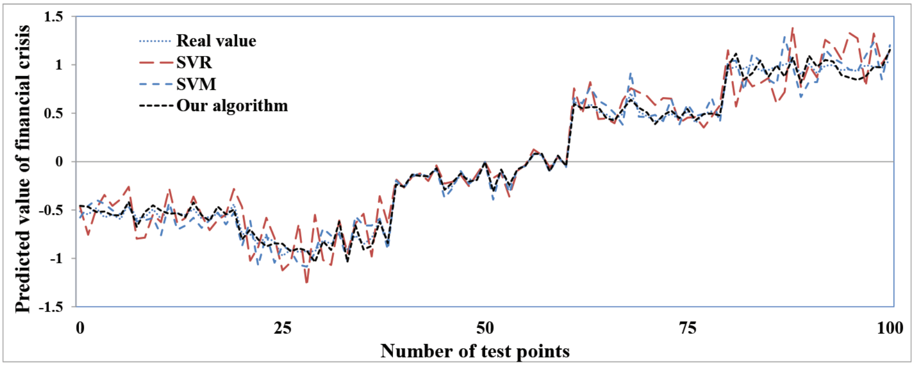

Figure 6 – Forecasting Value of Different Algorithms for Company 2.

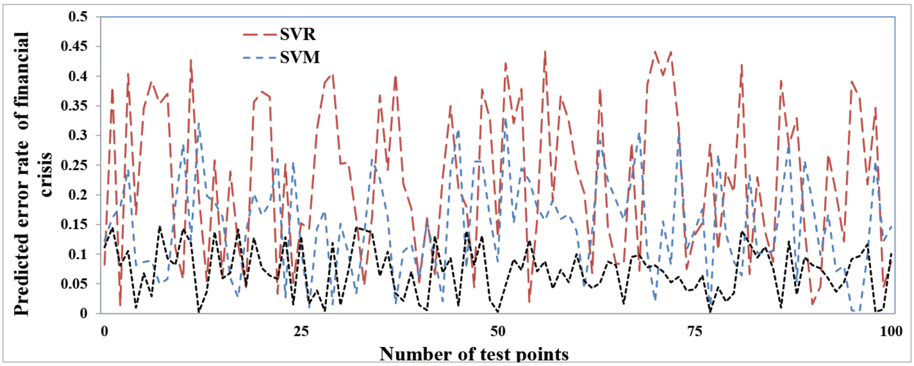

Figure 7 – Forecasting Error Rate of Different Algorithms for Company 2.

Combining the experimental results in Fig. 4 to Fig. 7, we can see that the forecasting values of our proposed is much closer to real values than SVR and SVM, and forecasting error rates of our proposed method are much lower than other algorithm. The reasons lie in the following aspects: 1) We convert the financial crisis short term prediction problem to an artificial intelligence based classification problem, 2) In order to promote the performance of particle swarm optimization we design a high inertia weight to construct a new searching space, 3) For various values of particle number, inertia weight decreases with paths varying, and 4) final inertia weight is gained if at the max number of iterations is reached.

5. Conclusion

This paper aims to tackle the financial crisis short term forecasting problem. An index system is provided to map high dimension financial data to a low dimension space, and four factors are included: a) Profitability, b) Solvency, c) Operating capacity, and d) Composition of capital. The main innovation of this paper is that short term financial crisis is predicted by integrating particle swarm optimization and support vector machine together. Finally, experimental results prove the effectiveness of our proposed algorithm.

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Three Dimensional Weld Pool Surface Reconstruction based on Shape from Shading Algorithm

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Abstract: In this paper, we concentrate on the problem of three dimensional weld pool surface reconstruction, which is a key step in welding product producing. Firstly, the monitoring system for three dimensional weld pool surface reconstruction is given. In this monitoring system, a laser generator is installed to generate a dot matrix structure light pattern, and then the laser pattern is projected to the area to cover all weld pool regions. Secondly, a graph cut based shape from shading algorithm is proposed to tackle the three dimensional weld pool surface reconstruction problem. Experimental results demonstrate that the proposed 3D weld pool surface reconstruction algorithm can achieve high quality of 3D weld pool surface reconstruction. In particular, this work is able to promote the effectiveness of welding product generation, and significantly relieve burdens of skilled welders. The main innovations of this paper are that we define the reflection pattern which is deformed through specular liquid weld pool, and then utilize reflection pattern to reconstruct the 3D weld pool surface.

Keywords: Weld pool, surface reconstruction, shape from shading, graph cut, reflection pattern.

1. Introduction

In recent years, welding product producing requires the mode of automation and intelligent, and this process also requires precise control of weld penetration with wide utilization of welding robot (Chen Dongsheng. et al, 2015; Pang Shengyong, et al, 2015;). Particularly, several skilled welders find that the surface of weld pool adopting eyes and select weld parameters through the penetration state information, but this method is not effective (Zhang Wei Jie. et al, 2015; Wang Zhenzhou. 2015). Hence, in this paper, we use several the vision sensors to obtain 3D topography information to compute the optimal parameters of the weld pool surface reconstruction. 3D weld pool surface reconstruction is a key problem in producing intelligent welding machines, and this process is able to obtain optimal welding parameters, such as welding current, speed, arc length, etc. (Frolov V. Ya., Toropchin A. I. 2015; Liu Y. K., Zhang W. J., Zhang Y. M. 2015; Wang Xinxin. et al, 2015).

Shading is defined as a spatial pattern of light reflected from an object, which is able to carry detailed information about 3D shape and plays an important role for its perception (Velásquez, E., Cardona, A., & Peña, A., 2014). As is well known that painters have exploited shading for many years to generate highly realistic 2D depictions of complex 3D objects(Schofield Andrew J. Allen Harriet A. 2015). But shading is still an ambiguous cue of relief, which used the same 3D shape from various directions, and the various 3D shapes are able to generate the same shading.

Shape from shading (SFS) refers to the problem of calculating surface normal from one image, and many simple assumptions have been proposed, for example, smooth surfaces, uniform albedo and so on. Shape from shading denotes the process of calculating the 3D shape from an image of a surface (Giesel Martin, Bartov Jenny, Zaidi Qasim, 2015). Shape from shading only requires simple equipment's and has widespread compatibility. In recent years the shape from shading technology develops rapidly, and it is a key issue in 3D weld pool surface shape reconstruction (Qadri Muhammad A. J. et al, 2014).

Recently, related studies about shape from shading are listed as follows. Movafeghi et al. utilized the shape-from-shading algorithm to process the Lorestan plate's X-ray image, and then the 3D image is reconstructed by weighed integration of the original image and the three-dimensional image (Movafeghi A. Yahaghi E. Mohmmadzadeh N. 2015). Abada et al. proposed a method of solving the ambiguity based on the singular points for the shape from shading ambiguity problem (Abada Lyes, Aouat Saliha, 2015). Goncalves et al. proposed two improvements to the state of the art methods for perspective shape from shading in Near-Lighting Endoscopes (Goncalves Nuno. et al, 2015). Egan et al. studied on influences of smooth occlusions and directions of illumination on the visual perception of three dimensional shape from shading (Egan Eric J. L., Todd James T. 2015). Todorovic et al. conducted an experiment with perspective line drawings of different 3D shapes, and judged their depth extent and direction of illumination (Todorovic Dejan, 2014).

Different from the above works, in this paper, we propose a novel graph cut based shape from shading algorithm to reconstruct the 3D weld pool surface, and we define the reflection pattern which is deformed through specular liquid weld pool.

2. Monitoring System for Three Dimensional Weld Pool Surface Reconstruction

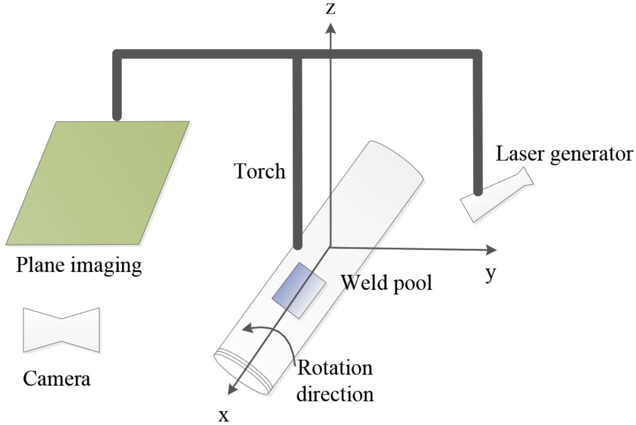

Figure 1 – Monitoring System for Three Dimensional Weld Pool Surface Reconstruction.

The configuration of the monitoring system in three dimensional 3D rectangular coordinate systems is illustrated in Fig. 1. In this monitoring system, a laser generator is utilized to produce a dot matrix structure light pattern, and then the laser pattern is projected onto the area by the torch electrode to cover all weld pool regions. Particularly, the liquid weld pool is able to reflect the incident laser pattern when the surface of the solid base metal is built up. Hence, in can be controlled that only the dots projected on the weld pool are reflected.

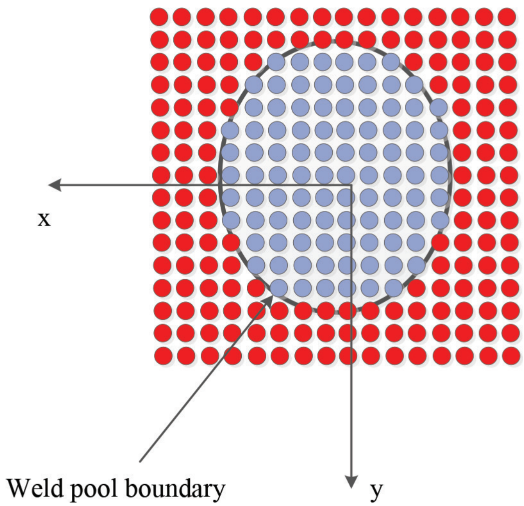

Figure 2 – Projection Pattern of the Weld Pool

We develop an imaging plane by a sheet of glass with a distance of 95 mm from the electrode, and the reflected dots are intercepted by the imaging plane. In order to gain the reflection pattern, a camera is installed on imaging plane. The design of projection pattern is a key issue in our work, and projection pattern of the weld pool is provided in Fig. 2.

As is shown in Fig. 2, the laser dot position is able to be detected by its row and column numbers in both projection pattern and reflection pattern. Moreover, we can see that reflection patterns can be deformed by the weld pool. Therefore, the reflection pattern is made up of the geometry of the 3D weld pool surface, and it is very important for weld pool 3D reconstruction. To fully utilize the reflection pattern to compute the 3D weld pool surface, each dot in the reflection pattern is required to be mapped to the incident laser ray. Afterwards, we propose an effective pattern recognition algorithm by discovering the reflection pattern from the captured image and then integrating the projection and reflection pattern using the map of each laser dot.

3. The Proposed Algorithm Based on Shape From Shading

In our proposed algorithm, each dot may contain fake dots and reflected laser dots. Assume that I refers to all the pixels in the image, and set of all dark pixels is defined as,

$$D = \{ g(x,y) = 0(x,y) \in I \} \tag{1}$$

where for each dot $D_i, i \in \{1,2,\cdots,N\}$, and N refers to the number of dots. The following conditions should be satisfied.

$$\bigcup_{i=1}^{N} D_i = D \tag{2}$$

$$D_i \bigcap D_j = \phi \tag{3}$$

Shape from shading denotes a technology of discovering the three dimensional information via variation of shading on the image. The inverse problem of correcting surface shape is implemented by shapes from the shading problem. Therefore, the correlation is defined as follows.

$$I = R(p,q) \tag{4}$$

where $R(p,q)$ means the reflectance map of the weld pool surface point (x,y), and the following condition should be satisfied.

$$p = p(x,y) = \frac{\partial z}{\partial x} \tag{5}$$

$$q = q(x,y) = \frac{\partial z}{\partial y} \tag{6}$$

where parameter z denote the depth of weld pool surface.

Afterwards, we define a reflectance function $R(p,q,v)$, where the symbol v denotes a unit viewing direction vector. Image brightness from weld pool surface orientation is computed by the following equation.

$$I_{i,j} = R\left(p(i,j), q(i,j), V_{ij}\right) \tag{7}$$

The innovation of this paper lies in that we introduce graph cuts in shape from shading algorithm. Particularly, we use graph cut algorithm to solve the energy minimization problem, and the general energy function is proposed to tackle the shape from shading problem. The energy function is defined as follows.

$$E(\chi) = \sum_{p} R_p(\chi_p) + \sum_{(p,q)\in N} V_{pq}(\chi_p, \chi_q) \tag{8}$$

$$R_p(\chi_p) = \begin{cases} 0, \textit{if } \chi_p \textit{ is a concave case} \\ \infty, \quad \textit{otherwise} \end{cases} \tag{9}$$

$$V_{pq}(\chi_p, \chi_q) = \left\| \overrightarrow{n_p}(\chi_p), \overrightarrow{n_q}(\chi_q) \right\| \tag{10}$$

Graph cut in our proposed 3D weld pool surface reconstruction should satisfy the following conditions:

$$V_{pq}(\alpha,\beta)=0 \Leftrightarrow \alpha=\beta \tag{11}$$

$$V_{pq}(\alpha,\beta)=V_{pq}(\beta,\alpha)\geq 0 \tag{12}$$

$$V_{pq}(\alpha,\beta)\leq V_{pq}(\alpha,\delta)+V_{pq}(\delta,\beta) \tag{13}$$

Using the above graph cut based shape from shading algorithm, a structured light laser pattern, dot matrix, can be projected to the weld pool surface, and then the specular reflection is intercepted and imaged by an imaging plane. Furthermore, we define reflection pattern which is deformed through specular liquid weld pool. Finally, reflection pattern which is obtained by our proposed graph cut based shape from shading algorithm is utilized to reconstruct the 3D weld pool surface.

4. Experiment

To make performance evaluation, we design and implement an experiment in this section. Parameters of this experiment are illustrated in Table.1. The welding process is developed using direct current electrode negative GTAW, and the weld pool rotates in the welding process when torch orientation, imaging plane, laser projector, and camera are in the still state. Particularly, rotation speed and the distance from the tungsten tip to the pipe surface are managed through rotation speed and arc length.

Parameter category	Parameter name	Value
Welding parameters	Welding current (A)	55-80
	Welding speed (mm/s)	1.5
	Electrode extension (mm)	3.5
	arc length	3-6
	Electrode diameter (mm)	2.45
	Argon Shielding gas	100%
	Flow rate of shielding gas (L/min)	11.8
Monitoring parameters	Pattern projection angle	38
	Imaging plane to electrode (IPE) distance (mm)	70-100
	Laser to electrode distance (mm)	22-26
Camera parameters	Frame rate (FPS)	25
	Shutter speed (ms)	3-7

Table 1 – Parameters of This Experiment

Performance evaluation criteria used in this experiment is given as follows.

(1) Noise reduction (denoted as NR) is defined as follows.

$$NR = \frac{N_{nonNR}}{N_{NR}} \tag{14}$$

where N_{nonNR} and N_{NR} refers to numbers of reflected dots and fakes dots without and with the noise pruning process respectively.

(2) Pattern recognition (dented as PR) rate is defined as follows.

$$R_{PR} = \frac{N_{iPR}}{N_{PR}} \tag{15}$$

where N_{PR} means the real number of reflected dots in the host image, and the symbol N_{iPR} refers to the dots which is detected by the proposed algorithm.

In the following part, we will show the noise reduction rate using the proposed algorithm under different settings.

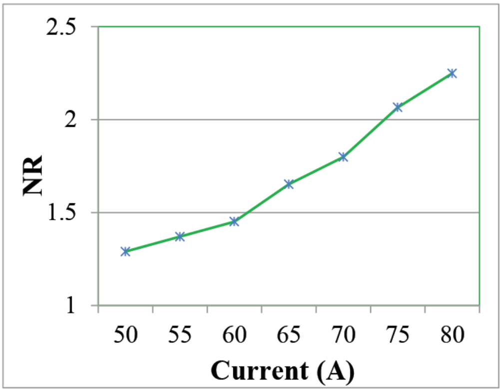

Figure 3 – Noise Reduction Rate for Different Current

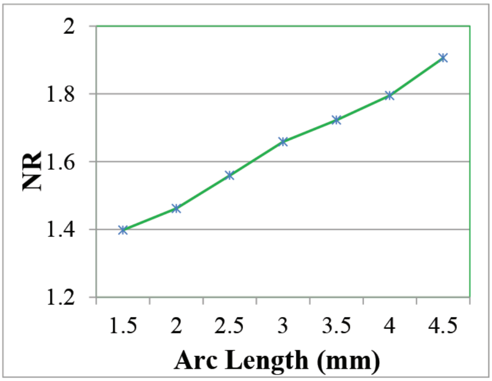

Figure 4 – Noise Reduction Rate for Different Arc Length

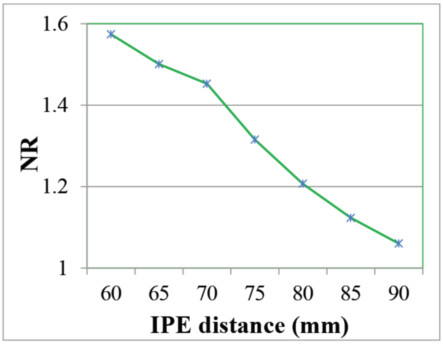

Figure 5 – Noise Reduction Rate for Different IPE Distance

We can find that from Fig.3 to Fig. 5, the average value of NR rate increases continuously with the current and arc length increasing. However, with the IPE distance increasing, NR rate decreases rapidly. With the current increasing, arc radiation density increases as well and density more impulse noise appears in images. On the other hand, by decreasing the arc length, it will affect the success ratio of reflection pattern recognition. Furthermore, through increasing the IPE distance, the images are less interfered from the arc radiation.

Next, we provide the pattern recognition rate of our algorithm under different settings.

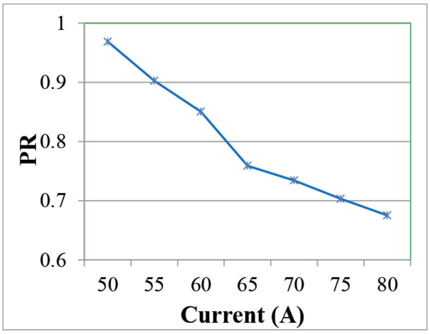

Figure 6 – Pattern Recognition Rate for Different Current

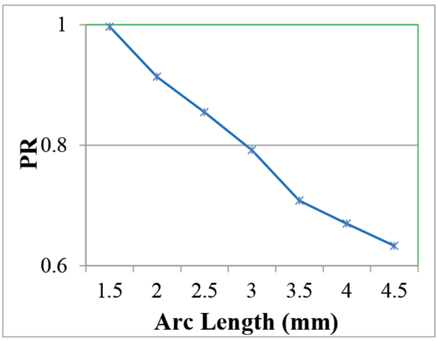

Figure 7 – Pattern Recognition Rate for Different Arc Length

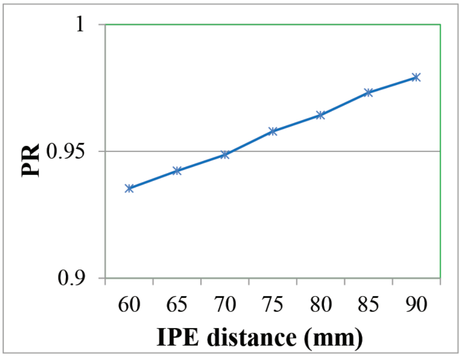

Figure 8 – Pattern Recognition Rate for Different IPE Distance

It can be seen from Fig. 6 to Fig.8 that interference from the arc radiation also can influence the affects the pattern recognition rate. The reason lies in that aforementioned significance differences for the three parameters, and the increase degree of pattern recognition rate caused by current augmentation is higher than that generated by the increase of the arc length and decrease of the IPE distance.

From all the experimental results above, it can be observed that our 3D weld pool surface reconstruction algorithm has the ability to gain high quality of 3D weld pool surface reconstruction even when various disturbances happen.

5. Conclusion

This paper focuses on the problem of three dimensional weld pool surface reconstruction. In the 3D weld pool surface reconstruction monitoring system, a laser generator is installed to generate a dot matrix structure light pattern, and then the laser pattern is projected to the area to cover all weld pool regions. Afterwards, we proposed a graph cut based shape from shading algorithm reconstruct 3D weld pool surface. In the end, experimental results prove the effectiveness of the proposed algorithm.

Acknowledgements

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Personal Portrait Rendering Method Based on Feature Discovery

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Abstract: In the process of non-realistic rendering, the feature extraction and cartoon style painting of the characters have been the focus of research. The feature extraction mainly focuses on the image processing and edge extraction in current study. Therefore, this paper mainly studies feature discovery-based facial portrait rendering method in cartoon style. For cartoon features, it adopts bilateral filtering to abstract input images so contrast ratio in high contrast region is higher and contrast ratio in low contrast region is lower. Then the abstracted image is quantitatively processed to simulate coloring style of cartoon and the technology is applied to extract edge line so as to improve cartoon visibility. Due to obvious transition discontinuity between quantification intervals during images quantification treatment, color soft quantum method is also used to improve the quantification effect. The intensity gradient function is introduced so there appears obvious boundary only in large intensity gradient. In low gradient region, the boundary is extended to larger regions to obtain quantification effect picture in bright color and transition continuity of quantification interval. The experiments show the rendering effects achieved by our method are rich in line modeling and prominent in feature extraction, which well restores the inherent nature of the characters of the portrait.

Keywords: Portrait rendering; feature; abstracted image; quantification; edge information

1. Introduction

Recently, with development of non-realistic rendering technique, researchers apply geometric modeling and image processing methods to simulate rendering many artistic styles such as watercolor, landscape painting, oil painting, etc. As a fashionable visual culture, caricature transmits abundant and pluralistic culture information and it has attracted many graphics researchers who devote themselves to rendering caricature in cartoon style (O'Regan D., Kokaram A.C. 2009). Recently, many researchers have performed related studies on facial portrait style transformation. Yang (Yang Ming, Lin Shu, Luo Ping. 2010) put forward a multi-grade free shape-based deformation algorithm and then put forward an energy minimization method. Czúni (Czúni Lászió, Hanis Attila, Kovács Levente. 2004) proposed a template-based exaggerating portrait generation system. put forward a sample-based method to operate computers to learn painters' drawing style and features exaggeration technique in amounts of training materials. GeethaRamani (GeethaRamani R. Nivas I Arun. 2014) proposed feature deformation-based cartoon facial portrait generation algorithm and accumulated facial contour information and facial texture information to get facial illustration painting. They applied operators to extract facial contour information to perform binary procession on image in order to obtain facial texture information. Chen (Chen Ting-Yen, Klette Reinhard. 2014) used binaryzation, corrosion and closing operation methods to separate hair, apply skin color model to respectively detect feature point of five sense organs on face, use three-time spline curve to fit the marked feature points and finally fuse hair with the features of five sense organs on face to obtain human face portrait. Experiment results show that this method will generate satisfactory effect. By the research of above literatures we find that single image segments cannot approach the expected effects generally, so it needs to integrate all segmentation algorithms to complete the feature extraction.

Due to the cartoon features, this paper adopts bilateral filtering to perform abstraction treatment on input image so that contrast ratio in contrast regions is higher and contrast ratio in low contrast regions is lower. Then, the images after abstraction treatment are performed quantification procession to simulate coloring style in cartoon. Then, filter is used to extract edge line of image after abstraction to further improve cartoon. Finally, the images after quantification are fused with the extracted edge image to obtain effect drawing of cartoon style in bright color, high visibility and fewer details.

2. Overall Process

Holger Winnemoller (Winnemoller H., Olsen S. C Gooch B. 2006) proposed a new abstract style method: through inputting a face image, face image is converted from RGB color space to CIE-Lab color space. Then, CIE-Lab color space image is performed iterative adaptive bilateral filtering and image is performed edge detection and brightness quantification. Finally, the edge detection result image is synthesized with brightness quantification image and the synthesis image is performed IBW sharpening (Laureano, R., Caetano, N., & Cortez, P., 2014). Thus, there are three parts in portrait rendering algorithm for cartoon style in this paper: The first part performs abstraction processing on input image to enhance contrast degree of image. The second part performs soft quantification processing on images after abstraction to reach simulation of better cartoon coloring style. The third part applies filter to extract edge line of images after abstraction to fuse the obtained contour image with color quantification image.

Finally, the effect drawing of cartoon style in bright color, high visibility and fewer details can be obtained. The algorithm process is shown as fig. 1:

3. Portrait Cartoon Rendering Method Based on Feature Discovery

3.1. Image Abstraction

A bilateral filter (Zou Dan, Qian WenHua, Xu Jin. 2013) can effectively keep edge and eliminate noise. Rather than common Gaussian/ convolution low-pass filter which only considers position influence on center pixel, a bilateral filter also considers similarity

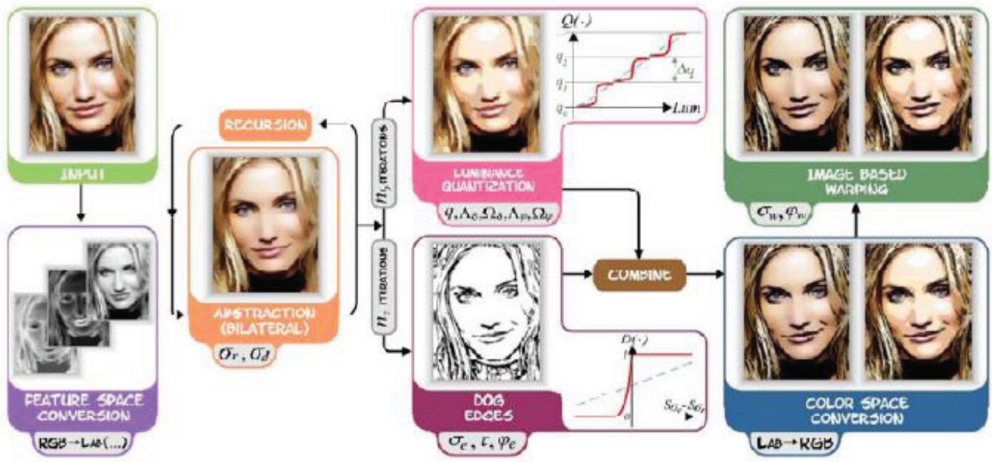


Figure 1 – Flow of Rendering Process

3. Portrait Cartoon Rendering Method Based on Feature Discovery

3.1. Image Abstraction

A bilateral filter (Zou Dan, Qian WenHua, Xu Jin. 2013) can effectively keep edge and eliminate noise. Rather than common Gaussian/ convolution low-pass filter which only considers position influence on center pixel, a bilateral filter also considers similarity degree effect between pixel in convolution nuclear and center pixel. According to similarity degree between position effect and pixel value to generate two different weight tables, a bilateral filter considers these two weights during calculating center pixel to make bilateral low-pass filter.

Compared to Gauss filter, the bilateral filter can better save the edge information of images. Its theory is the product of one Gauss function associated with space distance and another Gauss function associated with grey distance.

The zero mean additive Gauss noise image model is:

$$g(x,y) = f(x,y) + n(x,y) \tag{1}$$

In equation 1, f is noise free image, n the noise obeying zero mean Gauss distribution, and g is noise image. $g(x,y)$ denotes the pixel value of image g at position (x, y). Noise n is to be filtered to establish noise free image f. The bilateral filter adopts local weighted average method to restore the pixel value of original image:

$$f = \frac{\sum_{(i,j)\in Ss,y} w(i,j)g(i,j)}{\sum_{(i,j)\in Ss,y} w(i,j)} \tag{2}$$

In above equation, Ss, y denote the area of center node with the size of $(2N+1)*(2N+1)$. Actually, the right side of the equation is the weight average of light value neighboured to the center pixel point. Each pixel point $M_i(k)$ is composed of two parts of factors, that is, the following space distance and grey distance.

Space distance is the Euclidean distance from current object point to center point (Ross A. 2015). The mathematical formation of space region is:

$$e^{-\frac{\{x_i-y_c)^2+\{y_i-y_c)^2\}}{z\sigma^2}} \tag{3}$$

(x_i, y_i) is the position of current point, (x_c, y_c) is the position of center point and sigma is standard deviation of space region.

Grey distance is the absolute difference between current object grey and center point. The range Gauss function and its mathematical formation is:

$$e^{-\frac{\{gray(x_i y_i)-gray(x_c y_c)^2\}}{z\sigma^2}} \tag{4}$$

$gray(x_i, y_i)$ is the grey value of current point, $gray(x_c, y_c)$ is the grey value of center point and sigma is standard deviation of range .v

Bilateral filtering can produce better abstraction effect image, making the contrast of image regions with high contrast degree higher, and low contrast regions contrast degree lower, which simplifies the scene information.

3.2. Subtitle

During quantification processing on input images, input images need to be converted from space to space in order to separate the brightness channel to be quantified. Brightness channel after quantification is fused from space to space to obtain quantification image. The quantification image is overlapped with the extracted edge line in style and color is converted from space to space. The effect drawing in cartoon style is finally obtained.

$$Quantized(\hat{x}, q, \varphi) = q_{nearest} + \frac{\Delta q}{2}\tanh(\varphi g(\hat{x}) - q_{nearest})/2 \tag{5}$$

$Quantized(.)$ is quantized effect drawing, q is quantization level, Δq controls the width of quantization range, $q_{nearest}$ is the edge information that is the nearest to $f(\hat{x})$ and φ is the parameter that controls the transition sharp degree between two quantization range.

When $NR = \frac{N_{nonN}}{N_{NR}}$ is big enough, the uncontinuity among the quantization range is not obvious. But if sharpening parameters φ is fixed, it will destroy the elation between sharpening degree of quantization and input images, and it will also cause many obvious transition or edge information in big smoothing area. Winnemoller set that the parameter φ is the light gradient function of abstracted image, as is depicted by equation 6. Then, only at the place that has big light gradient, the obvious quantum level boundary can emerge; at the place with low gradient, the quantum level boundary will be extended to bigger area. By definition of sharpening range [$\Lambda_\varphi, \Omega_\varphi$] and gradient degree range [$\Lambda_\delta, \Omega_\delta$], we can make a comprise a the reduce of color change and deepening of quantum boundary. First we compute the light gradient of pixels and specify the value to [$\Lambda_\delta, \Omega_\delta$]. Then the value of φ will be generated by linear exchange as shown in equation 6.

$$\varphi = grand\frac{\Omega_\varphi - \Lambda_\varphi}{\Omega_\delta - \Lambda_\delta} + \Lambda_\varphi \tag{6}$$

3.3. Edge Extraction

After image abstraction, the contour lines in images are not obvious but the obvious contour lines are basic features of rendering effect drawing in cartoon style. FDOG filter (Kass Michael, Pesare Davide. 2011) and images after abstraction in this paper are performed edge line extraction. Therefore, some details in images are ignored and continuity and smoothness of the extracted lines are better. The specific steps are:

Step 1: input a image acquired by photography. It is preprocessed by the improved method to get image $l_m(x)$;

Step 2: Establish edge vector $t(x)$ according to $l_m(x)$, recorded as edge tangent flow. The gradient of $t(x)$ perpendicular to image $g(x) = \nabla I(x)$. $X = (x, y)$ is the pixel point coordinate of $l_m(x)$;

To keep the sides with stronger directions and the sides with weaken direction to follow the direction of the neighbour sides with stronger direction, we define the following filter to protect the sharps and sides of weaken direction are not influenced by Independent vector:

$$t_{new}(x) = \frac{1}{k}\sum\nolimits_{y\in\Omega x}\phi(x,y)t^{cur}(y)\omega_s(x,y)\omega_m(x,y)\omega_d(x,y) \tag{7}$$

Ωx is the neigobourhood of x and k is normalized factor of the vector. For space weight function ω_x we adopt a filter frame with that is symmetric by radius and its radius is r. We have the following relations:

$$\omega_s(x,y) = \begin{cases} 1, & if\ ||X - Y|| < r \\ 0, & otherwise \end{cases} \tag{8}$$

The other weight functions ω_m and ω_d are also important. We call ω_m as amplitude weight function. Its definition is :

$$\omega_m(x,y) = \frac{1}{2}(1 + \tanh[\eta(\hat{e}(y) - \hat{e}(x))]) \qquad (9)$$

$\hat{e}(Z)$ denotes the gradient size after normalization, and η controls the descending rate. We may fined that ω_m is monotone increasing. If the gradient amplitude of y is bigger than x, the weight of y will be larger, which ensures the leading edge direction. We let $\eta = 1$ in this paper. The acquired $F(s)$ is integrated along the edge $c_x(s)$ to enhance the edge of lines, so we can acquire the line-widened edge images:

$$H(x) = \int_{-S}^{S} G_{\sigma m}(s)F(s)ds \qquad (10)$$

4. Experimental Results and Analysis

In people aged 23-26 years, differences in migration rates by socioeconomic background are similar to those in the age group 19-22 years, whereas the variation is even larger for secondary or higher educated persons.

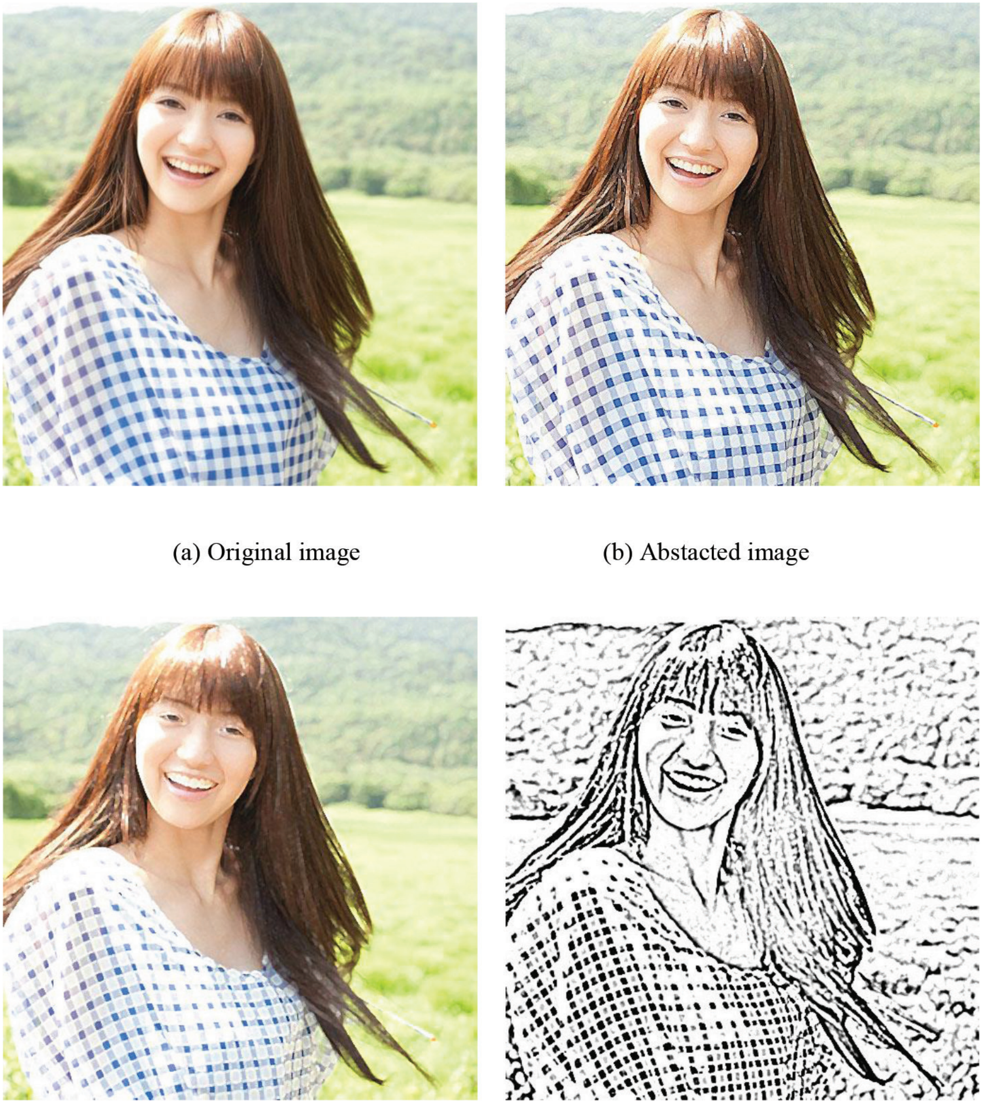
The effect drawings of abstracted figures are shown in figure 2. By the comparison of above figures we can find that the bilateral filter can generate better abstracted impression drawing, which makes the contrast ratio of high contrast region in original figure higher, and contrast ratio of low contrast region lower, simplifying the scene information.

(a) Original image (b) Impression drawing after 4 times of iteration

Figure 2 – Abstracted Processing Effects

Figure 3 (a), (b) and (c) are the effect drawings with bilateral filter whose iteration number is 8, and soft quantization level is 8, 10, and 12 respectively. (d) is processed by uniform quantization. From the analysis on experimental results comparison, it is found that when the quantization level is 12, there are many transition or edge information in the smoothing area of image. By the analysis of (a), (b) and (c), we find during the uniform quantization process, the transition in the quantization of image is obviously discontinuous. As we know after quantities of analysis and comparison, when selected quantization level is large, there are many transitions or edge information in smoothing shaded area of the quantized figure; when adopting uniform quantization process, the quantization range of effect drawing has obvious discontinuous transition.

After the abstracted quantization processing and contour extraction, we overlap the extracted contour line with quantized image, and the color space of acquired image is converted from space to RGB space. So we can obtain the final portrait rendering images with cartoon style.



(a) Original image

(b) Abstacted image

(c) Quantification effect

(d) Edge effect

Figure 3 – Experiments Analysis

5. Conclusion

This paper studies the non-realistic rendering technique of portrait cartoon. Then it proposes an automatically generated cartoon algorithm without users' participation and drawing technique. At first, a bilateral filter is applied to perform abstraction treatment on images so that contrast ratio in high contrast region is higher while the contrast ratio in low contrast region is lower. Then, abstraction images are performed soft quantum treatment in order to reduce transition discontinuity between quantification intervals and simulate coloring style in cartoon. The filter is used again to extract edge line of images after abstraction. The extracted contour line has better continuity and smoothness to pave a way for further improving cartoon visibility. Finally, the images after quantification are fused with the extracted edge image to obtain effect drawing of cartoon style in high visibility and less details. The experiment shows that this method can obtain the portrait drawing of cartoon style with better effect.

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Heterogeneous Database Synchronization Mechanism Based on ETL and XML

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Abstract: To solve the local problem in data source of structurized relational database, this paper analyzes the key influencing factors and proposes a novel mechanism based on improved ETL and XML for DDB. The new mechanism adopts transaction processing of SQL Server and ETL technology of data warehouse to establish an intermediate layer, extracting the incremental data needed to be transferred to be saved to the data warehouse. Then the data are compressed, transferred and decompressed. The upload and download of data adopt XML technology. The XML Schema documents are converted from storage data to XML to create new XML files for upload. Then it maps XML files to corresponding tables of the object server to realize the data download, so it has stronger advantage compared to SQL Server copy. The improved ETL technology can also relieve the carrying pressure of servers to reduce the load of network. The advantage of XML for synchronization is efficient and reliable, which is suitable for mass data processing and it can be extended for synchronization of heterogeneous databases. The experimental analysis show the new mechanism is easy to be realized with higher efficiency and augmentability.

***Keywords**:* Database synchronization, ETL, XML, heterogeneous database, SQL.

1. Introduction

With the rapid development of network application, people's requirement to obtain accuracy and betimes of information becomes higher and higher. At present, database system is the most convenient and efficient means to store data and search information and most companies store information in database. Current database system tendency is developing from minimization to maximization, and from centralization to distribution. In distributed database system, most data is stored in dispersion in different nodes of the same network. Data consistency and integrity in maintaining distributed database will also exist if synchronous update of various nodes database system information will be realized. Under this background, data synchronous study in distributed database system will become hot subject (Santos Ricardo Jorge, Bernardino Jorge. 2009).

In terms of heterogeneous data conversion, large software manufacturers develop corresponding API or components such as ODBC, OLE DB, ADO, etc, and many commercial database manufacturers develop special data conversion tools (Duan Cheng, Wang ZengPing, Wu KeHe. 2010). Common tools are DTS in SQLServer2000, SQL*Loader in

Oraele and Data Pipline in power Builder so heterogeneous data access and transformation are realized to some extent (Carvalho, A. A., Araújo, I., & Fonseca, A., 2015). However, the generality of these conversion tools is very poor and it relies on specific platform, lacks expansibility and cannot realize flexible addition of data source. Domestic study on heterogeneous data source integration also makes progress. Database and multi-media institute in Huazhong University of Science and Technology studied OLE/DB access-based ETL tool:DM3 (Poess Meikel, Rabl Tilmann, Jacobsen Hans-Arno. 2014). DM3 system adopts object-oriented method to realize LE DB access and DTS access through COM technology so it has perfect expansibility. Galaxy system in Southeast University (Rahman Nayem., 2008) comprehensively analyzes and studies integration, conversion and query optimization of various heterogeneous data source such as database system, web file, text, etc. The software Fangzheng Yichang Info Hub (Choi Mi-Young, Cho, Eun-Ae, Park Dae. 2010) which was developed by EC-Founder company adopts XML technology to provide secure and dependent message transmission for terminal node and successfully realize cross-regional and cross-department integration of information resources.

Based on deep studying communication program, data replication, XML and data warehouse in data synchronization, this paper designs a new mechanism which adopts SQL Server transaction processing, ETL technology in data warehouse and XML technology to realize data synchronization. New synchronous mechanism firstly utilizes SQL Server transaction processing and ETL technology of data warehouse to construct an interlayer or data acquisition system. This system extracts the needed transmitting incremental data to store in data warehouse and performs data processing such as compression, transmission and decompression. Uploading and downloading of data is realized by XML technology. The firstly realized storage data is converted in file and then generate XML file to upload. Then, XML file is mapped to the target server table to realize data download. ETL and XML-based synchronous mechanism is mainly and deeply analyzed from unstable networked environment too large data quantity and introduces new technology to guarantee data integrity and consistency. The new mechanism has stronger advantage in comparison to SQL Server duplication. The introduced ETL technology can effectively relieve server carrying pressure and reduce the network load.

2. Synchronous Scheme Study of Heterogeneous Database

2.1. ETL Mechanism

ETL is respectively the acronym of Extract, Transform and Loading. Extract refers that data is read from variously original business system database and this is the precondition of all jobs. Transform is to transform the extracted data according to the previously designed rules and process redundant and ambiguous data so that originally hydrogenous data format can be unified. Loading is that all data after transformation will be incrementally or totally introduced to the target database. The framework integrates much dispersed, and heterogeneous original data to realize centralized management of heterogeneous data source (Shao Xiongkai, Ke Qiang, Jiang Jiang. 2009). Actually, it realized centralized storage of heterogeneous data. ETL tool finally obtains unified and complete data warehouse through a series of extraction, transformation and loading. Originally dispersed application system still independently operates while originally heterogeneous data source still provides data service for respective application systems.

2.2. XML Technology

There are totally four layers from up to down. The Basic service function of each layer is described as:

1. Information source layer. It is at the bottom layer which mainly collects data in system. These data is made up by variously different database and files.
2. XML intermediate layer. It is about conversion and unification of data to match data at the bottom layer and the defined XML format file.
3. Interface layer. It is about data distribution. Specifically, according to specific protocol, protocol model and different application requirements of this layer, data will be distributed according to certain format for other interlayers to access.

3. Data Synchronization Mechanism Based on ETL and XML

3.1. Overall Design

Due to our system, we offer transaction processing mechanism, adopt tool to perform incremental extraction on the observed data and then store to data warehouse in order for successive transmission. Data transmission will transmit to other sites in network after certain conversion. The computer which receives data will inversely converse on data.

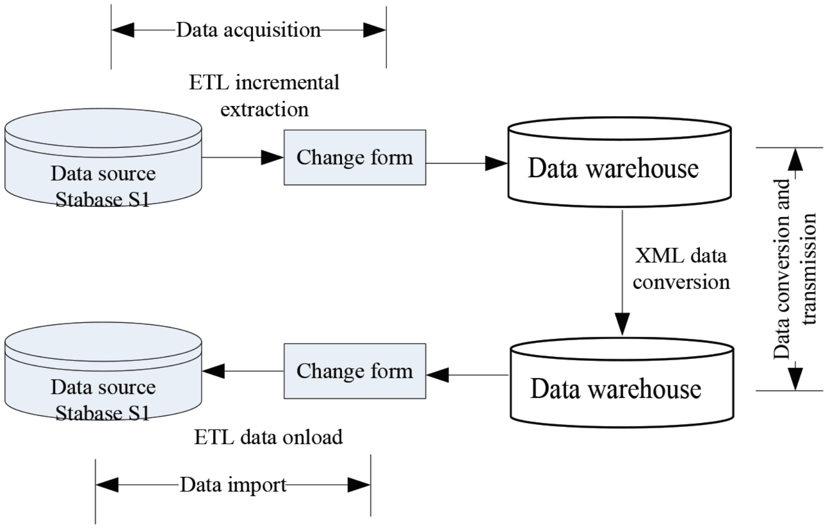

Figure1 – Overall Flow of Data Synchronization

From fig. 1, we can see that this data processing method process in many details on original synchrnous mechanism basis.

3.2. Improved ETL Mechanism

From the improved ELT structure, the most essential is E-L process. L locates in the front of T. It is not simply replicate complete data source to data warehouse terminal but to take data source as a local mode of distributed database and deploy its local concept figure in data warehouse. In this way, data warehouse becomes the global mode of the whole distributed environment. ETL engine is deployed on data warehouse and completes data conversion with global concept mode. E-L process fully uses data transparency, distributing transparency, replicating transparency, and slicing transparency in the distributed database to be completed by distributed database management system. In the whole environment, all data source server and data warehouse server are one node or site in distributed database to complete data migration, query optimization and transaction control by distributed data management system.

From distributed database definition, the distributed database is made up by global database and practically various local database so each ETL query and loading process are divided into global processing and local processing. Taking a complex query as an example, in terms of ETL engine, it only sees data warehouse in global relationship and completes this query in global relationship. In practice, during querying execution, what finally involves is physical relationship query in specific field. According to networked transmission price, local I/O price and CPU usage price, optimization processing of query in database bottom optimizes and processes the smallest price in query execution strategy or seeking relatively optimized operation steps. In addition, transaction control of ETL engine also relies on distributed transaction management in order to guarantee correct execution and execution results effectiveness of transaction (see fig. 2).

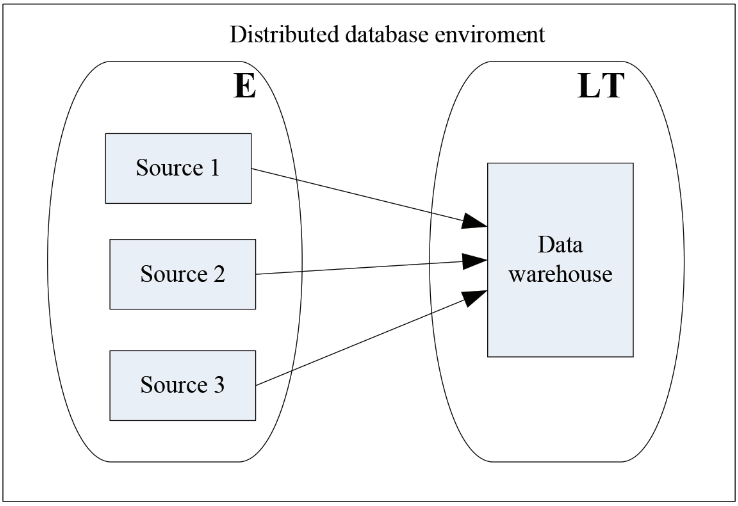

Figure 2 – Process of Improved ETL

In order to realize synchronization of data between two servers, S1 and S2, it needs not only realize incremental extraction of data updating through ETL technology but also realizes mutual verification and data conversion of all table updating and corresponding XML document in database. XML data synchronization-based data flow diagram is shown as following fig. 3.

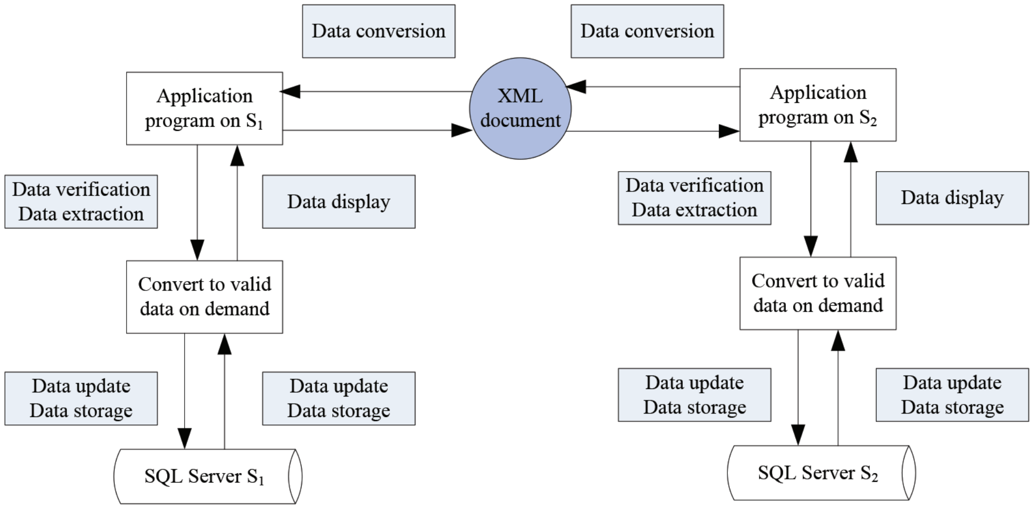

Figure 3 – Data Flowchart Base on XML Data Data Synchronization

The specific procedures are:

1. To analyze system database, to utilize XML Schema describes all relationship between all table structure and table in database to generate corresponding XML document.
2. Adopt XML Schema maps structure and relationship of table in server S1 database to corresponding XML document.
3. XML documents described by XML Schema are mapped to server database.

There are two parts for relational mode mapping on XML document:

To get XML Schema, first according to relational database system to solve relational mode and then reconstruct directed graph, the mapping of the mapping structure which is generated by directed graph and the directed graph is XML Schema.

4. Test and Results Analysis

4.1. The Improved ETL Algorithm Performance Test

This experiment tests heterogeneous data source on the tools from two servers with same allocation. Data source table is a field table with thousands of data quantity and loads to data warehouse after this process. All conversion is the basic mathematical calculation. The test results of this tool under different database types are shown as table 1.

Type of extraction database	**Type of data warehouse**	**Execution time(s)**	**Execution efficiency (million pieces/s)**
Oracle 10i	Oracle 10i	~21	~6.9
SQL server2005	Oracle 10i	~86	~1.8
DB@	Oracle 10i	~39	~3.76

Table 1 - Test Results of Improved ETL Tool with Different Data Sources

After analysis, the executing efficiency of the tool under synchronization between data source and data target is the highest. This is the results to utilize distributed database optimization mechanism.

The current four tools such as Oracle Warehouse Builder, Data Integrator, Information are performed comparatively testing. The experiment results under synchronous database between database and data warehouse.

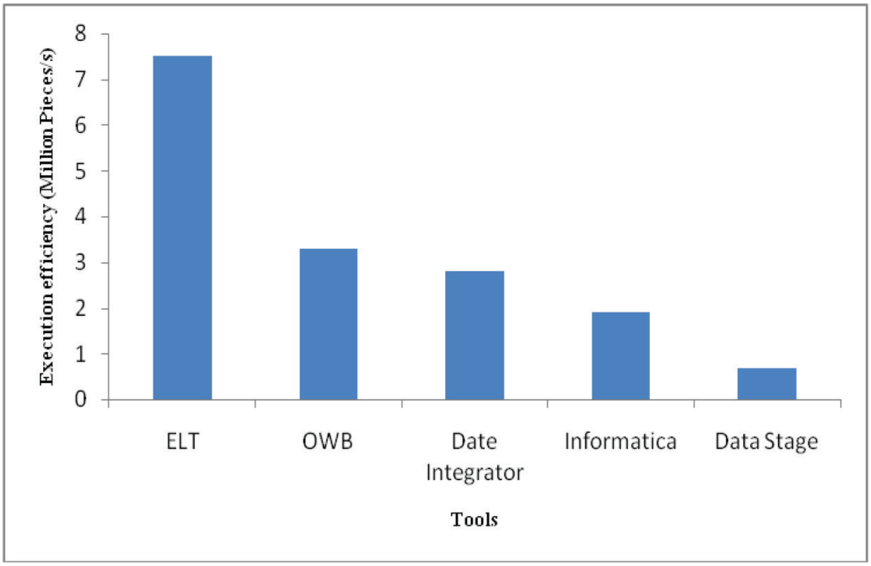

Figure 4 – Performance Comparison Result

From column graph, executing efficiency of is Oracle Warehouse Builder, Data Integrator. The efficiency of Data Stage is very low and consuming time of the same data quantity is near 10 times. The realized tool of this study is superior to these tools on performance and the executing efficiency is about 60 thousand per second. Above data is tested on two PC servers with 4.3.GHZ processor and 2 GB memory, even though the data may be different in different database products. On this basis, SQL language displays perfect performance on large data quantity under ETL pressure test.

4.2. XML Data File Test and Results Analysis

Meanwhile, two tables, test1 and test2 are established in simulating PMIS base. These two designed tables and two test main table fragments of data center are the same in field number and type but the field length is longer than test table. Meanwhile, test1 and test2 do not have any constraints so they can test programs to observe whether mode mapping file can play a part in restricting and checking in different input situations. After XML document file is established according to data center according to association table information, towards above 5 test constraints, this chapter respectively designed simulating test data. Its test results and abnormality without passing check are shown as table 2.

From test results, model mapping document in target database to combine document can effectively verify field length and various constraint information in database system. Before data loading, it provides strict data check for XML data file and provide highly dependable guarantee for power data conversion so it completely matches project requirement.

Constraint	Test records	Abnormal prompt
Null	(pass,1,2,z,m)(2,pass,1) (111,1,2,z,m)(1111,1) (pass,1,2,z,m)(2,pass,1)	Evc-complex-ype.2.4.a: Invalid content was found starting with element 'subfor'. One of '{subid}' is expected.
Unique	(1111,1,2,x,m)(2,1111,1) (pass,1,2,z,m)(2,pass,1) (1111,1,2,z,m)(2,1111,1) (pass,1,z,m)(2,pass,1)	Duplicate unique value {z} declared for indetity constraint of element "test"
Data value range	(1111,x,m)(2,1111,1)	Eve-minExclusive-valid: Value 'I' is not facet-valid with respect to minExclusive '8' for type '#AnonType_number' contesttest
Main foreign key	(pass,1,z,m) (2,pass,1) (1111,1,2,x,m)(2,2222,1) (pass,1,2,z,m) (2,pass,1)	Key 'surbref' with value '2222' not found for identity constraint of element 'test'
Field length	(youthinkyoucan pass,12,z,m) (youthinkyoucan pass,1)	Eve-maxLength-valid: Value 'you thinkyouccanpass' woth length='18' is not facet-valid with respect to maxLength '8' for type '#anonType_id contesttest'

Table 2 – Test Results of Document Verification Constraint

5. Conclusion

This paper takes database synchronization of network information management system as background, integrating its practical network and software, and analyzes the practical requirement of new synchronous mechanism and proposes feasible data synchronization scheme. The new mechanism learns the lesson that previous SQL Server loses data during replicating and transmitting data, introduces ETL processing incremental extraction to obtain data updating and transmits after data conversion. ETL and XML-based synchronous mechanism compares to the improved application of SQL Server replication on data consistency, data integration, synchronous efficiency, security, etc. The results show that the proposed scheme in this paper is efficient and reliable.

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Chip Stacking Thermal Placement Optimization Algorithm based on Intelligent Computing

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Abstract: The thermal placement optimization of encapsulation chip stacking is investigated. The goal is to reduce the highest temperature of the chip and make the temperature field more uniform. Firstly chip stacking placement model is investigated. Then an improved simulated annealing particle swarm optimization algorithm is put forward to optimize three-dimensional chip thermal placement. The simulation results show that the proposed optimization scheme can make temperature distribution more uniform and the highest temperature is decreased obviously. This algorithm can be used to guide thermal placement design of chip stacking.

***Keywords**:* Chip stacking thermal placement, Simulated annealing, Particle swarm optimization.

1. Introduction

The overheating of electronic equipment is one of the main reasons for the failure of electronic products, which severely limits the improvement of the performance and reliability of electronic products, and also reduces the working life of the equipment. When using package stack, due to the limited cooling area with accumulated heat, the heat density increases significantly and heat dissipation problem is more serious(YANG Bang-chao. et al, 2002; XU Ning. et al, 2005). Thermal placement optimization means that the chip position on substrate is optimized in the thermal design phase, making substrate get optimal heat dissipation placement scheme. If we want to solve the heat dissipation analysis of chip stacking, three-dimensional multi-layer thermal placement optimization problem of chip stacking is particularly important. Chip stacking mainly relies on multi-layer device interconnection technology to stack multiple devices, so as to achieve the goal of narrowing the substrate. Multi-layer device interconnection technology is connection type between the solder ball. Bump connection is the main wielding form of three-dimensional stack and the wielding mainly solves reliable connection between convex points, at the same time it ensures that deformation of solder ball is not too big. Besides, there is no residual impurity on the welding surface. Such phenomenon does not exist in the two-dimensional SMT assembly process, this problem is the new topic in device stereoscopic stacking assembly process and is a key problem need to study(YAN De-jin. et al, 2007; Yating Yu, Pingan Du. 2008; Ying Liang, Chunyue Huang, Dejin Yan, Tianming Li. 2009). The generated new problem by stack placement includes the following facts. The cooling area does not increase, but emitted heat increases, so that the heat density increases. After multi-device packaging, heat sources are connected with each other, then thermal coupling is enhanced and thermal dissipation is more serious(Jincai Wu, Wei Yan, Hongyan Huang. 2011). Thermal resistance of chip stacking is divided into external heat impedance and inner heat impedance. The external heat impedance is heat impedance between assembled outside shell and the environment, which mainly is heat convection. It can be solved by good heat dissipation measures (Gasca-Hurtado, G. P., Peña, A., Gómez-Álvarez, M. C., Plascencia-Osuna, Ó. A., & Calvo-Manzano, J. A., 2015). Internal heat impedance is heat impedance between device temperature and outside shell, which is mainly thermal conduction. Total thermal impedance is the sum of inner heat impedance, contact heat impedance and external heat impedance, which is related to packaging form, installation technology, environmental condition and the heat dissipation area(Bongki Lee, Byunggyu Ahn, Jaehwan Kim, Minbeom Kim and Jongwha Chong. 2012). In practical design, a variety of means are integrated. Placement optimization problems were often encountered in industrial design. For the optimization problem, since the 1980s, a variety of intelligent optimization algorithm has been proposed, which provides a new thought and is widely applied in various fields such as science, economic and engineering(J. Xie and M. Swaminathan. 2010). Thermal placement algorithms mainly use the genetic algorithm, simulated annealing algorithm, ant colony algorithm, particle swarm optimization algorithm and the relevant improved algorithms(J. Xie and Madhavan Swaminathan. 2011; Tohru Suwa, Hamid Hadim.2007; Cahlon B, Schochetman I E, Shillor M. 1993; Carson Flynn, Young-Cheol Kim. 2004; D. S. Knysh and V. M. Kureichik.2 010). These algorithm optimization results are better than the result of the initial random distribution in a certain extent. But these optimization algorithms have various defects. Particle swarm algorithm is easy to fall into local optimum, which leads to big error when the discrete variable is made to be integer. Simulated annealing algorithm is sensitive to parameters setting and the execution time is too long. In terms of three-dimensional chip stacking, only Liang Ying and other scholars used genetic algorithm for simple three-dimensional thermal layout research in China(Liangying, Chun-yue huang, Yan Dejin, Tian-ming Li. 2007; Chen H, Zhu Y, Hu K. 2010; Jianguo JIANG, Qian SU. 2013; Du Bing, Yin Jing-hua, Liu Xiao-wei. 2007). There are very few researches on the three-dimensional chip stacking thermal layout optimization, so three-dimensional chip stacking thermal layout optimization still needs further research.

In the next section, chip stacking placement model is investigated. In section 3, chip stacking thermal placement optimization algorithm is put forward. In section 4, one experiment is done to test the performance of proposed thermal placement optimization algorithm. At last, some conclusions are given.

2. Chip Stacking Placement Model

Supposing on the substrate of chip stacking, there are n number of BGA encapsulation chips. They are arranged in M rows and n columns evenly. There is a total number of $M \cdot N$ positions. Each location can be stacked with K layer of chips at most. Assuming size and direction of each chip does not change. n number of chip stacking has the following two kinds of extreme cases.

For n number of layer, n number of chips are stacked in the same position, $K=n$. For the situation of one layer, there are $M \cdot N$ number of chips corresponding to $M \cdot N$ number of positions. Under this situation $K=1$, $M \cdot N \geq n$. The range of K is $1 \leq K \leq N$, $K \in N^+$. n number of chips are marked as 1, 2, ..., n. If serial number exists, there is a component in this place. If serial number does not exist, there is no component in this place. There are n number of chips and $M \cdot N$ number of positions. The scheme can be expressed by n number of $M \cdot N$ matrix labeled as A_{ij}.

$$A = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1N} \\ A_{21} & A_{22} & \dots & A_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ A_{M1} & A_{M2} & \dots & A_{MN} \end{bmatrix} \tag{1}$$

$A_{ij} = a_1^{ij}, a_2^{ij}, \cdots, a_n^{ij}$. For $a_1^{ij}, a_2^{ij}, \cdots, a_n^{ij}$, if the previous element is zero, all the back positions have no chip. So the sequence $a_1^{ij}, a_2^{ij}, \cdots, a_n^{ij}$ can be compressed appropriately. Record the number of non-zero and the value of non-zero element in $a_1^{ij}, a_2^{ij}, \cdots, a_n^{ij}$. T_{ij} is the number of element that is not zero in A_{ij}. Q_{ij} represents the value of element that is not zero in A_{ij}. Sequence *T*, *Q* describes placement of chip stacking. T represents division sequence which records the number of layer of stacked chip in each position. *Q* represents ordered sequence, which records the non zero value in each layer. Matrix *A* describes placement of chip stacking, *T* and *Q* represents simplification of matrix *A*, so that sequence *T* and *Q* can be used to describe chip stacking placement model. When calculating the temperature of any point on the chip, not only we should consider the heat impact produced by the adjacent chip, but also we should consider heat from other chips. The internal and external heat distribution equations are as follows(Lall B S, Kabir Ortega A. 1997). $T = c_1 I_0(mD^+) + t^+ / 2B_i$, $0 \leq D^+ < 1$. $T = c_4 K_0(mD^+)$, $D^+ \geq 1$.

T represents dimensionless temperature. D represents distance variable, D^+ represents dimensionless distance *D/R*, *k* represents coefficient of thermal conductivity, *h* represents heat transfer coefficient, *t* represents thickness of chip, t^+ represents dimensionless chip thickness *t/R*, B_i represents Biot number, $m = R\sqrt{2h/kt}$. I_0 and I_1 represents the first kind of 0 and 1 order Bessel function respectively. K_0 and K_0 represents the second kind of 0 order and 1 order Bessel function respectively.

$$c_1 = \frac{-t^+ / 2B_i}{I_0(m) + K_0(x) I_1(m) / K_1(m)}, c_4 = -c \frac{I_1(m)}{K_1(m)} \tag{2}$$

The area of circle is approximately equal to the area of the chip, assuming the area of circle is the same as the area of the chip, so radius of the circle is $R = \sqrt{WH / \pi}$. W represents the width of chip and H represents height of the chip. To simplify the calculation, the temperature of the chip center is used to represent the chip temperature. Then $I_0 = 1$, $D^+ = 0$. $T_{\max} = c_1 + t^+ / 2B_i$. T_{io} represents temperature of each module and T_{ji} represents contribution temperature of chip j to chip i. Temperature of each chip is $T_i = T_{io} + \sum_{j \neq i}^{M} T_{ji}$.

To reduce the complexity of the solution, the surface temperature of the chip is obtained by using the polynomial approximation. $T_{io} = 12.5 \cdot [1 + 6.31 \cdot (A_i / A_{\max})^{-2.87}]^{-0.5}$. $T_{ji} = 0.02 \cdot A_i / A_{\max} \cdot [1 + 6.82 \cdot (D_{ji} / R_i)^{-0.55}]^{-1.5}$. A represents area of heat transfer and $A_{\max}$ represents the contribution rate of chip j to chip i.

3. Chip Stacking Thermal Placement Optimization Algorithm Design

Chip stacking placement problem model is established, which uses a sequence X represents a placement scheme. In the optimization algorothm, sequence X is taken as optimization parameters. p_i represents optimal solution of particle itself at present and p_g represents optimal solution of the whole swarm at present. The standard particle swarm optimization can be described as follows.

$$v_i(k+1) = wv_i(k) + c_1 r_1 (p_i - x_i(k)) + c_2 r_2 (p_g - x_i(k)) \quad (3)$$

$$x_i(k+1) = x_i(k) + v_i(k+1) \quad (4)$$

$$p_i(k+1) = \begin{cases} x_i(k+1), & f(p_i(k)) > f(x_i(k+1)) \\ p_i(k), & otherwise \end{cases} \quad (5)$$

$$p_g(k+1) = \begin{cases} p_i(k+1), & f(p_g(k)) > f(p_i(k+1)) \\ p_g(k), & otherwise \end{cases} \quad (6)$$

x_i represents current position of the i-th particle, v_i represents current speed of the i-th particle and p_i represents the best position of individual. p_g represents the experienced best position of the whole particles. w is used to control searching range of the algorithm. c_1 and c_2 belongs to [0,2]. r_1 and r_2 are two independent random variables which obey $U(0,1)$ distribution. In the proposed particle swarm optimization algorithm, the modified p_i is

$$p_i(k+1) = \begin{cases} x_i(k+1), & \min(1, \exp(\frac{f(p_i(k)) > f(x_i(k+1))}{T})) > r \\ p_i(k), & otherwise \end{cases} \quad (7)$$

Position and speed update equation is equivalent to formula (3) and (4). In order to ensure p_g is the experienced best position of the whole particles, particle swarm optimization and simulated annealing algorithm can be combined. When the basic paricle swarm algorithm converges to p_g, p_g is taken as initial point of simulated annealing algorithm for further searching. According to Metropolis criterion, the new solution y is accepted. If a new solution y makes $f(y) < f(p_g)$, it means that solution solved by basic particle swarm algorithm is not optimal. At this time, y can be used to replace a particle in the particle swarm randomly. Then improved particle swarm algorithm is used for further evolution. If there is no such solution y, p_g is the global optimal solution. The process of proposed optimization algorithm is as follows. Step1. set the parameters. The parameters of simulated annealing algorithm includes initial temperature t_0, Markov chain length function L_k, temperature attenuation function and neighborhood function. The parameters of particle swarm optimization includes swarm scale m, the maximum speed $V_{\max}$, inertia weight w, c_1, c_2, the maximum evolution generation $T_{\max}$, current evolution generation $t=1$, m number of random particles $\{x_1, x_2, \ldots, x_m\}$ and initial speed and position of each particle. Step2. Initialize the whole swarm. m number of particles are generated randomly in the d dimensional searching space including initial position and initial speed. Position and speed of each particle is updated according to formula (3) and formula (4). p_i is updated according to formula (7). The individual best position with the smallest fitness value is taken as global best position $gbest$. Step3. According to dynamic adaptive particle swarm algorithm, global best position $gbest$ is obtained. Step4. Take $gbest$ as initial point and simulated annealing algorithm is used for further searching. If a solution y better than $gbest$ is obtained, turn to step 5. Otherwise, turn to step 6.

(a) set initial position $y = p_g$, , initial temperature t_0, Markov chain length L_0. (b) execute the following steps for $L_k^{'}$ times repeatedly.

(1) generate a new solution $y^{'}$ in the neighbourhood of y. (2) According to Metropolis criterion, accept new solution y. If $f(y^{'}) \le f(y)$, $y = y^{'}$. (3) If $f(y) < f(p_g)$, turn to step 5. (c) $k^{'} = k^{'} + 1$, calculate the next temperature $t_k^{'}$ and Markov chain length $L_k^{'}$.(d) If it does not meets termination criterion, turn to step (b). Otherwise, turn to step 6. Step5. y is used to replace one particle i in m number of particles. Its current position x_i and the current best position p_i are y. The corresponding fitness value is $f(y)$. Then turn to step 3. Step 6. The algorithm stops and $gbest$ is solution.

4. Simulation and Analysis

Chips with different power consumption, material and different shapes distributed on the substrate are considered. When three-dimensional chip stacking thermal analysis model is established, the top level chip power is 0.02 watt, 0.03 watt, 0.04 watt, 0.05 watt, 0.06 watt, 0.07 watt, 0.08 watt, 0.09 watt, 0.10 watt, 0.11 watt, 0.12 watt and 0.13 watt. Chip size is $6 \times 6 \times 4$, the unit of which is millimeter. Corresponding chip coding is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. The underlying chip power is 0.06 watt, 0.07 watt, 0.08 watt, 0.09 watt, 0.10 watt, 0.11 watt, 0.12 watt, 0.13 watt, 0.14 watt, 0.15 watt, 0.16 watt and 0.17 watt. The underlying chip size is $8 \times 8 \times 4$. The corresponding coding is 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24. The boundary conditions are set as follows. Convective heat transfer coefficient is $10W / m^2 \times k$, initial temperature is $25^{\circ}C$, convection boundary conditions are taken as area load imposed on the chip surface, the temperature is taken as freedom degree constraints imposed at the boundaries of known temperature, heat production rate is taken as body load imposed on the unit and chip power divided by its volume is the value of heat production rate. After optimization the top level chip is 10, 8, 3, 9, 6, 1, 2, 5, 11, 4, 7, and 12. The underlying chip is 16, 19, 18, 15, 22, 23, 24, 21, 13,17, 20 and 14.Based on thermal overlapping model, three-dimensional chip stacking placement optimization algorithm is simulated under MATLAB environment. 24 numberof chips are optimized by 130 generation of optimization operation. The optimal solution corresponding to randomly generated initial placement is 112. After

130 generation of optimization iteration, the optimal value converges to 110 or so.The highest temperature before optimization is 141.15 centigrade degree and the lowest temperature before optimization is 48.22 centigrade degree. Temperature difference before optimization is 92.93 centigrade degree. This placement is easy to cause burning of individual components on the substrate due to the high temperature, which affects the reliability of the whole equipment. After optimization, the highest temperature is 122.67 centigrade degree and the lowest temperature is 45.6 centigrade degree. Absolute difference of the highest temperature and the lowest temperature is reduced a lot, which is about 16 centigrade degree. The steady state temperature distribution uniformity. The optimized placement temperature is more uniform and the highest temperature is decreased obviously.

5. Conclusion

In view of the thermal placement optimization problem of chip stacking, thermal overlapping model is combined with the heat conduction formula. The highest temperature value of all chips is taken as evaluation indicator. Improved simulated annealing particle swarm optimization algorithm is used to optimize the chip thermal placement. The simulation results show that the proposed optimization scheme can make temperature distribution more uniform. Besides the highest temperature is decreased obviously.

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Integrated Application of Evaluation of Multimedia Technology in English System Research and Application of Matlab

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Abstract: Multimedia technology is applied extensively in English teaching. With the development of multimedia technology, the application also becomes a breakthrough. In the higher vocational English teaching, teachers design the course on the premise of paying attention to the multimedia. The application of multimedia technology should also expand the meaning in breadth and depth. The author analyzes the key of multimedia technology based on multimedia English teaching model and utilization of the experiment teaching method. He combines the Matlab software and fuzzy comprehensive evaluation method to verify the significant effect exerted on multimedia technology in English teaching. The studies show that the designed teaching model can effectively serve the higher vocational English teaching.

Keywords: Multimedia technology, higher vocational english, teaching design, teaching experiment, comprehensive assessment, matlab.

1. Introduction

English teaching is a language teaching, which guides language learning to pay attention to five skill trainings including listening, speaking, reading, writing and translating, needs a comprehensive range of stimulating learners, and leads students into language teaching environment. The traditional English listening teaching has introduced the recorder and other electronic equipment and has actually formed the prototype of the multimedia teaching. However, at present, with rapid development of multimedia technology, English teaching has become better. This paper studies the key technologies of multimedia technology in order to verify the multimedia technology in the higher vocational English teaching by designing a teaching model and a teaching experiment.

A lot of people have made efforts to study multimedia technology and its application in teaching. Among them: (He Gaoda et al. 2007) studies the multimedia assisted college English teaching and learning environment. This paper discusses the multimedia assisted college English teaching and learning environment adaptation strategy, resource development, teaching mode as well as issues about management and evaluation, etc. (Zhang Zhihua et al. 2011) used the factor analysis in multivariate statistical analysis, and satisfied with the college English multimedia teaching process to carry on the empirical analysis. (Jiang Baiqiang 2013) pointed out that the multimedia teaching with its unique function, which can satisfy the requirements of the new curriculum reform, makes the English classroom full of vigor. (Wang Yongguo et al. 2014) put forward an ARM11 processor system of multimedia teaching network central controller, wherein the PC software frame of wireless network was used to control the total power of multimedia classroom start-stop, and a computer switch machine switched machine (Martins, J., Gonçalves, R., Santos, V., Cota, M. P., Oliveira, T., & Branco, F., 2015), projector and screen to control the sunrises. (Li Jiang, et al. 2015) analyzed the multimedia theory knowledge teaching and the teaching software tools, wherein three aspects were created to study the concrete application of the Mind Dimensional Mapping and summarize the Application Methods and Skills in order to promote the reform of course teaching and the improvement of teaching quality.

The scholar's study is roughly divided into three categories including teaching evaluation, multimedia technology and application, but did not establish contact with the teaching experiment. Through odds in this paper, as well as the corresponding multimedia technology combined with specific teaching design model, and with the help of mathematical model, a comprehensive evaluation of teaching effect could achieve better results, but also can reveal more multimedia technologies applied in higher vocational English teaching in the original.

2. Multimedia English Teaching Design Model

Multimedia technology (multi-media technology, MMT) refers to the utilization of computer technology (Kingsley K V, Boone R., 2008) with the purpose of integrating the image information and interactive interface technologies, which has three basic characteristics (Boll S F., 1079) including multidimensionality, integration and interactivity. The MMT has shown above three characteristics, made its application increasingly wide, including its significant application in teaching. This study aims to design the multimedia English teaching system so as to realize efficient vivid classroom English teaching.

2.1. Multimedia Technology

Key technologies of MMT mainly include audio processing technology (Tian Ping, Tian Feng. 2015), video processing technology (Gorzałczany M B., 1987), image processing technology (Yi Zhun. 2014), animation techniques (Zhang Zhun, 2013) and Flash technology. APT technology involves implementation application of Cool Edit Pro software, the application of VPT technology Corel VideoStudio software, the realization of the IPT technology application of Photoshop software, and the application of CPT technology Animator Pro software.

Objective APT audio processing audio is split and includes audio noise reduction and sound landscaping, wherein noise reduction processing is the key aspect in Cool Edit Pro software application. Expressions with impatient voice model can be written in the form as shown in formula (1), which is the formula about pure speech, noise, and impatient voice for the band, and it aims to filter out noise by filtration or possible way reduction.

$$y(n) = s(n) + d(n) \tag{1}$$

In this study, adaptive noise canceller with impatient voice is taken as a filter for noise reduction, wherein the principle of the filter (Tian Ping, Tian Feng, 2015) is shown in Fig.1:

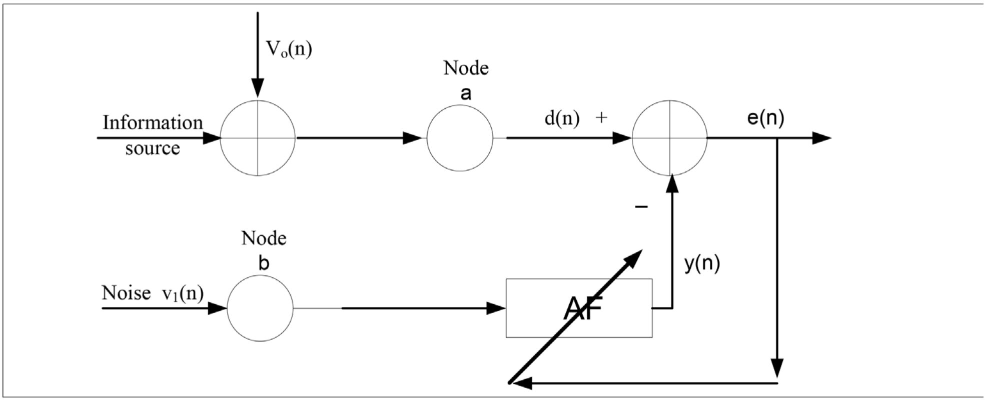

Figure 1 – Principle Diagram of Audio Noise Filter (Lun Shuxian. et al, 2003)

Fig. 1 shows that not only the signal of the sensor is received, but a noise field is also received, while original input is an interference signal. As a superposition, due to the reference input and the related signal not related to as well as the end of the original input into the adaptive filter's side, the end of the reference input to the adaptive filter's side, and control of adaptive filter AF reception error, the output becomes closer to the source output so as to realize the noise reduction.

The purpose of the application of VPT video is to complete video footage clips, addition of synthetic and subtitles and realization of screen display conversion. Due to the larger storage space required by the video file, it is necessary to adopt reasonable video compression technology. Video compression usually involves sampling, pretreatment, inter-frame prediction, transformation, quantization and entropy coding and packaging of a few steps, as shown in Fig. 2 Video Compression Coding Block Diagram (Lv Ning, Liu Ying. 2015).

IPT was applied to the multimedia image cropping and effects of addition and application of CPT two-dimensional animation courseware, and application of teaching courseware, wherein most of the contents were presented finally by Flash preferentially.

2.2. Establishment of Teaching Design Model

Teaching projection is the necessary link of practical teaching channel. By the TP, the relationship between the elements of teaching system and the demand (He Kekang. et al, 2002) in the process of teaching will be determined in order to guide practical teaching. TP model for an ideal teaching theory construction describes the structure of teaching and learning activities or stable relationship among the elements in the process of

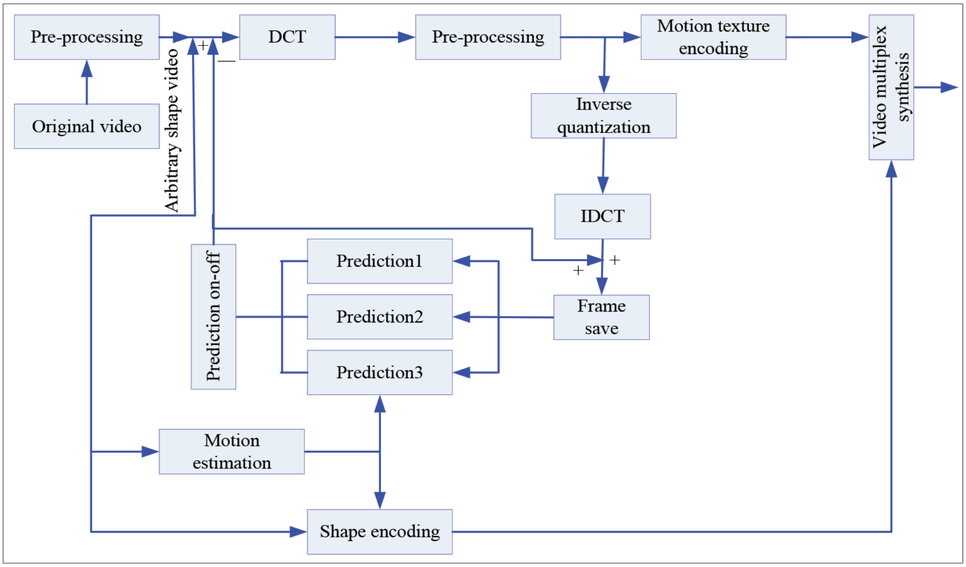

Figure 2 – Video Compression Coding Block Diagram

simplification form, and also reflects or represents theories in the activities of teaching forms. As shown in Fig. 3, this article builds higher vocational English teaching design model based on multimedia technology.

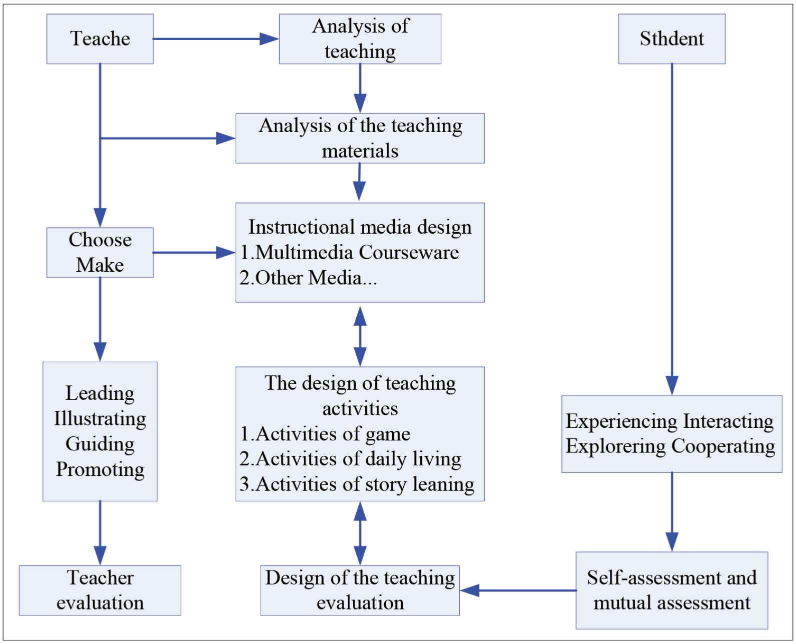

Figure 3 – Design Model of Higher Vocational English Teaching Based on Multimedia Technology

3. Teaching Experimental Design and Comprehensive Evaluation Model

3.1. Teaching Experiment Design

In the experiment, 412 students were selected to undergo the questionnaire survey. The students were asked to make an evaluation of the course according to the actual situation. 412 questionnaires were sent and 400 valid questionnaires were collected. From September 8, 2014 to the date when the class was started, the experimental class teaching materials were selected from the English original movie "Forrest Gump". In this study, the teaching experiment verifies the effect of the application of multimedia in English Teaching at vocational colleges through comparison between English listening and speaking teaching effect. The independent variable of this experiment is a multimedia assisted English teaching method, while the six target variables include teaching (Instructional), Science (Scientificity), technology (Technicality), art (Artistry), learning (Learnability) and teaching activity (Organization). The teaching stage is divided into five stages, as shown in Table 1.

Stage of teaching	**New multimedia elements**	**Form of multimedia art**	**Stage teaching output**
First stage	dialogue sound	Video audio clips	scores of classroom test and student reviews
Second stage	background sound	Video audio clips	scores of classroom test and student reviews
Third stage	picture	PPT	scores of classroom test and student reviews
Fourth stage	video	Video clip	scores of classroom test and student reviews
Fifth stage	text	E-text	scores of classroom test and student reviews

Table 1 – Teaching Design Scheme

According to the basic experimental teaching plan as shown in Table 1, the specific implementation process of this experiment is as follows:

- Remove the background sound of pure English dialogue. Play it for two times, and then ask the students to complete the self evaluation and join the exam.
- Play an English dialogue with a background sound. Play it for two times, and then ask the students to complete the self evaluation and join the exam.
- The background sound is played on the English dialogue, and the PPT synchronization is used to present the information of the scene. Play it for two times, and then ask the students to complete the self evaluation and join the exam.
- Play the background sound of the English dialogue, and synchronize the video clip. Play it for two times, and then ask the students to complete the self evaluation and join the exam.

- Use E-text to give the scene at first, and then play the listening teaching material, for the superposition of the background sound of English dialogue, and then synchronize video clips. Play it for two times, and then ask the students to complete the self evaluation and join the exam of following class.

3.2. Construction of Evaluation Index System

When the multimedia technology is applied into English teaching, it will exert a positive impact on the teaching effect. In order to measure this effect quantitatively, it is necessary to construct evaluation index system and evaluation model.

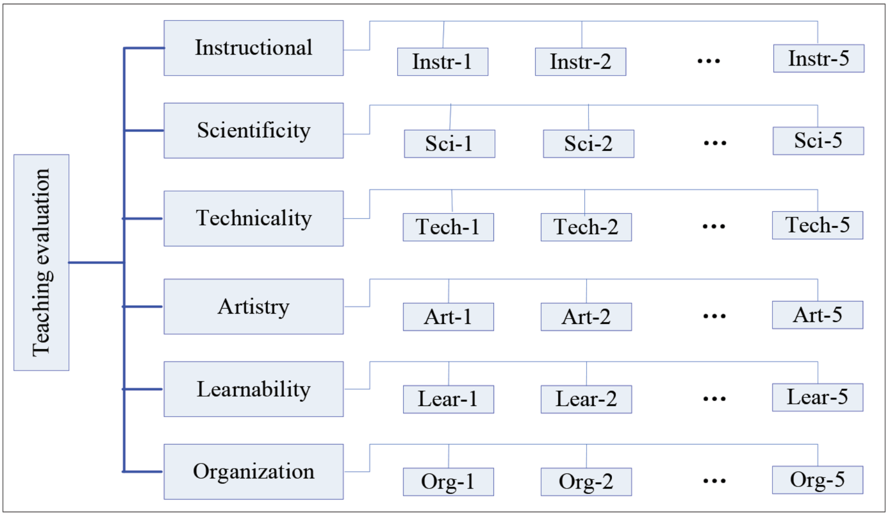

Figure 4 – Evaluation Index System of Multimedia English Teaching

This research designs the index system of the evaluation criteria of the (Instructional), Scientificity (Organization), Technicality (Artistry), Learning (Learnability) and teaching activities. Indexes of the instructional guidelines include Instr-1-target, Instr-2-teaching mode, Instr-3-material selection of rationality and scientific nature, Instr-5-English teaching design and scientific nature, Instr-4-English language teaching and learning, Art-1-standards, scientificity standards, Sci-1-standards, artistry standards, Sci-2-standards, Tech-5-English language environment, Sci-4-, Sci-3-standards, Sci-5-standards, Tech-4-standards, Tech-1-standards, Technicality quality, Tech-2-, and Tech-3-. Teaching contents and Art-3- layout design are concise and beautiful. Art-4- voice music and audio are clear and Art-5- performance of the novel plot is lively and interesting; Learnability guidelines have a lot of Lear-1-information resources, Lear-2- training aims to train students to listen to the said contains in a targeted manner, and the implementation of personalized teaching and Org-5- classroom organization and management requires orderly and proper allocation of teaching time and adjustment of the classroom atmosphere with reading and writing translation in the basic skills, Lear-3- with learning has an evaluation function which can timely feedback learning effect, Lear-4- indicates appropriate abundant cultural import and Lear-5- indicates cultivation of learners' autonomous learning ability of innovation ability; Organization criteria indicators have Org-1-instruction focus and disperse the difficulties of explaining the profound things in a simple way, Org-2-multi angle explanation of inspiration questions can stimulate the students' enthusiasm, Org-3- plays the guiding role of teachers to enhance their abilities and interactivity, and Org-4- includes teaching contents and methods. Through the above criteria and indicators, the index evaluation system can be obtained as shown in Fig. 4.

3.3. Fuzzy Comprehensive Evaluation Model

In this study, the integration of multimedia technology in Higher Vocational English teaching evaluation system is a two-level fuzzy multi-objective decision-making system, and the model construction and application of the following steps are as follows (Gorzałczany M B. 1987).

STEP1: The factor set $U=\{x_1,x_2,\cdots,x_n\}$ is divided into six sub factors according to the six criteria $u_1,u_2,\cdots,u_6$.$u_i=\{x_{i1},x_{i2},\cdots,x_{i5}\}$, which satisfies $u_1 \cup u_1 \cup \cdots \cup u_s = U$ and $u_i \cap u_j = \varnothing,(i \neq j)$.

STEP2: For each sub factor set u_i, a fuzzy multi-objective decision is made. A comment set $V=\{y_1,y_2,\cdots,y_m\}$ is set up. The factors in the V are assigned to be weighed as $A_i=\{a_{i1},a_{i2},\cdots,a_{im}\}$. R_i is set as a single factor evaluation matrix, while you can then get a grade evaluation vector: $B_i = A_i \circ R_i = (b_{i1},b_{i2},\cdots,b_{im}),(i=1,2,\cdots,s)$.

STEP3: Every u_i is regarded as a factor, wherein $K=\{u_1,u_2,\cdots,u_s\}$, K is composed of a factor set, and the single factor evaluation matrix is made up of the first order evaluation vector:

$$R=\begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_s \end{bmatrix}=\begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1m} \\ b_{21} & b_{22} & \cdots & b_{2m} \\ \vdots & \vdots & & \vdots \\ b_{s1} & b_{s2} & \cdots & b_{sm} \end{bmatrix}$$

u_i refers to a part of the upper part of the formula U , which can reflect the certain attributes, and can give the weight distribution $A=(a_1,a_2,\cdots,a_s)$ according to their importance, so it can get the two level fuzzy multi-objective decision $B=A\circ R=(b_1,b_2,\cdots,b_m)$.

In order to determine the weight of each factor, in this paper, the fuzzy analytic hierarchy process (Fuzzy Analytic Hierarchy Process, FAHP) is used to determine the weights.

Programming proposed by the author adopts Matlab rich function, matrix operation and control functions, and explores its application in analytic hierarchy process (AHP) analysis. By multi-layer loop structure, the realization of multiple level inputs and generates the judgment matrix through the calculation of characteristic values of them, wherein a part of the program is used to generate the judgment matrix as follows:

```
for a=1:mp
for b=1:mp
A(b,b)=1;
```

```
if a fprintf('Line %i, Row %i\n',[a;b]);
A(a,b)=input('Please input the value: ');
A(b,a)=1/A(a,b);
end
end
Generated hierarchy total sorting weight matrix of the part program is as follows:
for r=p-1:1
v=['vect=vect*vector' int2str(r)];
evalc(v)
end
fprintf('The final judging vector is:')
fprintf('\n%.4f',vect)
[m,maxpl]=max(vect);
fprintf('\n\nThe Scheme %i is the best solution.\n\n',maxpl)
```

Among them, the mp indicates the number of indexes within the layer, layer number of p is taken as an index, which is specified by the user at the beginning of the program; Vect indicates the null matrix initially assigned by the judgment of the vector loop generated after the first index layer; M indicates the maximum vect vector, and maxpl records the location of the maximum value.

The factor set is still $U=\{x_1,x_2,\cdots,x_n\}$. In the two factors of comparative judgment, the triangular fuzzy number is shown in a quantificational manner. In other words, when the factor x_i is significantly more important than the factor x_j, the triangular fuzzy number $a_{ij}=(L,5,P)$ is used for representation. Here, L,P are expanded to represent the fuzzy degree of judgment, the bigger $P-L$ is, the higher the fuzzy degree is, while when $P-L=0$, sentences are not vague. When $\frac{n(n-1)}{2}$ fuzzy judgments are made, the fuzzy judgment matrix $A=(a_{ij})_{m\times n}$ can be obtained by the triangular fuzzy array. The definition x_i of "fuzzy judgment" (2) is defined as the "fuzzy comprehensive judgment" (3), and the definition x_i of factors and other factors, such as the "comprehensive importance" (5) is shown by the factor of the weight vector of the factors to be normalized. In the above formulas (2) - (6), $\oplus$ indicates the general addition and $\oplus$ indicates the generalized multiplication.

$$m(x_i)=a_{i1}\oplus a_{i2}\oplus\cdots\oplus a_{in}=\sum_{j=1}^{n}\oplus a_{ij},(i=1,2,\cdots,n) \tag{2}$$

$$m(X)=m(x_1)\oplus m(x_2)\oplus\cdots\oplus m(x_n)=\sum_{i=1}^{n}\oplus m(x_i) \tag{3}$$

$$S_i=m(x_i)\otimes m(X)^{-1} \tag{4}$$

$$d(x_i)=K(S_i\geq S_1,S_2,\cdots,S_n)=\min_{k=1,2,\cdots,n,(k\neq i)}K(S_i\geq S_k) \tag{5}$$

$$W(d(x_1),d(x_1),\cdots,d(x_1)) \tag{6}$$

4. Empirical Evaluation

FAHP method is used to determine the weight of each index, while the results are shown in Table 2.

Statistical results can be obtained through investigation. Students deem multimedia teaching to be excellent and good, wherein the numbers of qualified and the unqualified respectively account for 30%, 35%, 26% and 35%. Hence, it can be used as shown in formula (7) of type of fuzzy sets, as follows:

		Secondary indexes		Guidelines layer		Secondary indexes	
Name	**Weight**	**Name**	**Weight**	**Name**	**Weight**	**Name**	**Weight**
		Instr-1	0.20			Art-1	0.20
		Instr-2	0.22			Art-2	0.24
Instructional	0.20	Instr-3	0.20	Artistry	0.10	Art-3	0.22
		Instr-4	0.22			Art-4	0.16
		Instr-5	0.16			Art-5	0.18
		Sci-1	0.18			Lear-1	0.18
		Sci-2	0.24			Lear-2	0.24
Scientificity	0.15	Sci-3	0.22	Learnability	0.20	Lear-3	0.20
		Sci-4	0.20			Lear-4	0.16
		Sci-5	0.16			Lear-5	0.22
		Tech-1	0.25			Org-1	0.22
		Tech-2	0.22			Org-2	0.24
Technicality	0.15	Tech-3	0.22	Organization	0.20	Org-3	0.20
		Tech-4	0.17			Org-4	0.18
		Tech-5	0.14			Org-5	0.16

Table 2 – Weight of Index of Each Layer to Determine Results List

$$T_1 = \{0.30, 0.35, 0.26, 0.09\} \quad (7)$$

According to this way, and based on the top of the other four factors of fuzzy set judgment as a result, the instructional fuzzy evaluation matrix is obtained as shown in formula (8).

$$V_1 = \begin{bmatrix} 0.30 & 0.35 & 0.26 & 0.09 \\ 0.16 & 0.40 & 0.36 & 0.08 \\ 0.41 & 0.38 & 0.14 & 0.07 \\ 0.18 & 0.33 & 0.41 & 0.08 \\ 0.20 & 0.35 & 0.28 & 0.17 \end{bmatrix} \quad (8)$$

Then reuse is shown in table 2 ~ Instr Instr - 1-5 of weight coefficient, and the weighted average can be as shown in formula (9) of type indicator of Instructional evaluation class level.

$$R_1 = \begin{bmatrix} 0.20 \\ 0.22 \\ 0.20 \\ 0.22 \\ 0.16 \end{bmatrix}^T \cdot \begin{bmatrix} 0.30 & 0.35 & 0.26 & 0.09 \\ 0.16 & 0.40 & 0.36 & 0.08 \\ 0.41 & 0.38 & 0.14 & 0.07 \\ 0.18 & 0.33 & 0.41 & 0.08 \\ 0.20 & 0.35 & 0.28 & 0.17 \end{bmatrix} = \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \end{bmatrix} \tag{9}$$

As shown in formula (9), the calculation method can be successively Scientificity, Technicality and Artistry, Learnability and Organization level evaluation level. Formula (10) is obtained as shown in the evaluation matrix:

$$S = \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \\ 0.27 & 0.33 & 0.29 & 0.11 \\ 0.30 & 0.32 & 0.28 & 0.10 \\ 0.27 & 0.31 & 0.27 & 0.15 \\ 0.26 & 0.30 & 0.30 & 0.15 \\ 0.28 & 0.31 & 0.29 & 0.12 \end{bmatrix} \tag{10}$$

Then it is reused as shown in Table 2 of Scientificity, Technicality and Artistry, Learnability and Organization of weight coefficient, and weighted average, while the comprehensive evaluation results are obtained:

$$F = \begin{bmatrix} 0.20 \\ 0.15 \\ 0.15 \\ 0.10 \\ 0.20 \\ 0.20 \end{bmatrix}^T \cdot \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \\ 0.27 & 0.33 & 0.29 & 0.11 \\ 0.30 & 0.32 & 0.28 & 0.10 \\ 0.27 & 0.31 & 0.27 & 0.15 \\ 0.26 & 0.30 & 0.30 & 0.14 \\ 0.28 & 0.31 & 0.29 & 0.12 \end{bmatrix} = \begin{bmatrix} 0.27 & 0.32 & 0.29 & 0.12 \end{bmatrix} \tag{11}$$

The formula (11) shows application of the multimedia technology in higher vocational English teaching, wherein comprehensive evaluation results: a great degree of 27%, a good degree of 32%, the qualified degree of 29%, and unqualified degree of 12%. Therefore, the multimedia technology in the higher vocational English teaching plays a certain positive role, and can effectively improve the teaching quality.

5. Conclusion

Multimedia technology is applied more and more extensively in various branches of teaching. Through the analysis of multimedia technology applied in the curriculum design, keys in the technologies of its application are mainly audio processing, video processing, image processing, and animation production. All the implementations of the technology have a corresponding kind of software to support. However, there are still some shortcomings in technical support software algorithm design, which still need to be further developed. Therefore, the trend of the development of the multimedia technology lies in its support for software algorithm design and hardware performance boost. Multimedia technology application in English teaching shall not only depend on the technology of advanced degree, but shall also rely on the rationality of the design of curriculum and teachers' abundant knowledge. In this paper, according to the investigation on the higher vocational English teaching design and through the experiment design and experimental results, the author combines the Matlab software and the fuzzy comprehensive evaluation model for teaching effects. Finally, the result shows that the design of this study is based on the multimedia technology in higher vocational English teaching. The design has a good practical effect and can be used in a certain scope. If it is applied in teaching of other subjects, designing and adjustment will also be required.

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Research on Cooperation in Business Competition Based on Computer Game

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Abstract: This paper analyzes the traditional game theory model based on a lot of game theories in order to solve the complex relationship between competition and cooperation businesses. The theory was improved in combination with computer game on this basis. Businesses S-S, S-C competition cooperation machine game models were established. Based on the Industrial and Commercial Bank of China among the state-owned commercial banks, the actual situation of the Agricultural Bank of China and China Construction Bank was analyzed from the game machine and certain aspects of co-production. Meanwhile, the paper puts forward the necessity of state-owned commercial bank competition cooperation mode. Cooperation mode is the inevitable choice of profit maximization based on the merchants' difference and contrast. It aims to provide a reference for business development strategy in the future.

Keywords: Computer game, benefit maximization, state-owned commercial bank, competition and cooperation.

1. Introduction

With the rapid development of computer technology, the computer game (the game) machine has become a vibrant research field. Computer game is the weight of artificial intelligence research direction. At present, the most sophisticated computer game in the world is the chess computer game technology (Cachon G. P, Netessine S., 2006). After a magnificent "fight", "blue" computers have left an indelible impression to mankind. This paper learns a lesson from the game of chess machine practice for many years. The chess game assessment, research and other core game-tree search technologies were applied for competitive and cooperative relations of businesses (C. Politis., 2009). It has achieved remarkable results.

With respect to application of game theory in economic field, many people have made efforts, and made certain achievements. For example: (Xu Ying. 2008) studied the manufacturers and suppliers in the study of the supply chain of game theory, wherein game theory was used to research vendors offer and objective evaluation of suppliers; (Yang Hong & Chen Yi. 2009) made a detailed study for competition and cooperation between suppliers and retailers, used game theory to study distribution supply chain relationships with the value-added supply chain as the center, and established a new supply chain competitive partnership to expand Game Theory; (Zhao Haiqi et al. 2004) proposed the analysis based on using game theory to business game, wherein final results showed that the competition and cooperation between the coexistence of commercial games were cofigurative; (Li Yannan. 2007) used game theory to analyze the issue of choice of cooperation and competition between suppliers and retailers in the face of interests of the supply chain between suppliers and retailers (Runa, A. I. D. N. F., & Miranda, G. L., 2015), and used game dynamic model to study the condition of individual rationality under inefficient non-cooperative mode. Finally, game theory gave a strategic cooperation model between suppliers and retailers.

In this paper, further studies about the application of game theory in the economic structure were expanded based on previous studies. As for state-owned commercial banks by the three businesses, for example, it is necessary to conduct rational and scientific analysis of the relationship between competition and cooperation. Through literature research, game model and other methods in the future development trend of the three businesses, a systematic study was carried out. Its purpose is to promote the healthy development of business enterprises so as to provide a theoretical support (Gnyawali. D. He. J, and Madhavan. R., 2006).

2. Construction Competition Game Model of Machinery Business Cooperation

Most of our businesses are able to operate the whole business, but in comparison with foreign countries, China's business relations still have many shortcomings. For state-owned commercial banks, the competition among businesses is relatively mature, and the first competitive-cooperative game model as follows aims to analyze aspects of the production of state-owned commercial banks.

3. Cournot Model

If there are two businesses in the market, their production and supply processes will be exactly the same. In the face of the same market conditions, the demand is very understanding between each other. In other words, both of them rely on each other's decision to finalize the decision-making objectives of the business, while the two sides without contact with each other aim to get the maximum profit (Kreycik C E, Couture T D, Cory K S., 2011). Such model is the Cournot model proposed by the French economist in the middle of 19th Century.

If you make two businesses to produce products, then sales market demand function will be:

$$p = p(Q) = a - bQ = a - b\sum_{i=1}^{2} q_i \tag{1}$$

Among them, the total sales Q, a, b were constants.

Business benefit function:

$$u_i(q_1, q_2) = q_i \tag{2}$$

$$p(Q) = q_i(a - b\sum_{i=1}^{2} q_i) \tag{3}$$

As for businesses in the process of decision making, a Sales Production business is fixed and the other businesses with the purpose of obtaining the maximum benefit by partial derivatives can be calculated (Mariani. M., 2007), while optimal sales of two businesses can be obtained.

4. Improvement of Traditional Game Model and Establishment of Machine Model of Game

With the rapid economic development, the original game model is unable to meet current business needs any longer (R. Zhang, F. Gao, Y. C. Liang., 2010), so the model was improved in this article.

At first, the number of businesses has been amended. Production businesses are represented by the number of users. To simplify the calculations, herein three state-owned commercial banks including the Industrial and Commercial Bank of China, Agricultural Bank of China, and China Construction Bank are selected. Respectively corresponding users were q_1, q_2, q_3, which indicate the output of state-owned industrial and commercial bank of the three state-owned commercial banks (Joel Bleeke, David Ernst., 2009). Hence, the total number of users in the market is as follows:

$$Q = \sum_{i=1}^{3} q_i \tag{4}$$

Secondly, the cost to improve the business: if the business of operating costs in fixed costs is c_1, the marginal cost is c_2.Then i business operator cost is as follows:

$$JC(q_i) = c_1 + c_2 q_i \tag{5}$$

Marginal cost and fixed cost are constant.

If the needs of three state-owned commercial banks are the same, then the demand function is as follows:

$$\begin{aligned} p &= p(Q) \\ &= a - bQ \\ &= a - b\sum_{i=1}^{3} q_i \end{aligned} \tag{6}$$

With the order revenue function for businesses of $u_i(q_1, q_2, q_3)$, revenue of the corresponding first merchants will be as follows:

$$u_i(q_1,q_2,q_3)=q_i(a-b\sum_{i=1}^{3}q_i)-c_1-c_2q_i \tag{7}$$

Wherein, values of a,b,c_1,c_2 are constant.

1. Improved game model in competitive state:

When q_1,q_2 are determined and q_3 stays at the third stage of the optimum conditions, $\frac{\partial u_3}{\partial q_3}$ is:

$$a-bq_1-bq_2-2bq_3-c_2=0 \tag{8}$$

So:

$$q_{3ss}=\frac{a-bq_1-bq_2-c_2}{2b} \tag{9}$$

In fact, the function involves China Construction Bank, Industrial and Commercial Bank of China, and Agricultural Bank of China, while the number of users indicates the inverse function (Xu Ying., 2008). Among them, the production q_{3ss} forecast of the Agricultural Bank of China, and Construction Bank of China is:

$$\begin{aligned} u_2 &= q_2(a-b\sum_{i=1}^{3}q_i)-c_1-c_2q_2 \\ &= \frac{q_3(a-bq_1-bq_2-c_3)}{2b} \end{aligned} \tag{10}$$

When ICBC China determines the optimal conditions for businesses at the second stage:

$$\frac{\partial u_2}{\partial q_2}=0 \tag{11}$$

So:

$$q_{2ss}=\frac{a-bq_1-c_2}{2b} \tag{12}$$

Forecast of Industrial and Commercial Bank of China, Agricultural Bank of China and China Construction Bank:

$$\begin{aligned} u_1 &= q_1(a-b\sum_{i=1}^{3}q_i)-c_1-c_2q_1 \\ &= \frac{q_1(a-bq_1-c_2)}{4b}-c_1 \end{aligned} \tag{13}$$

Commercial Bank of China at the first stage of the optimal conditions:

$$\frac{\partial u_1}{\partial q_1} = 0 \tag{14}$$

Through calculation:

$$q_{1ss}{}^{*} = \frac{a - c_2}{2b} \tag{15}$$

When above values are substituted into the equation:

$$q_{2ss}{}^{*} = \frac{a - c_2}{4b} \tag{16}$$

$$q_{3ss}{}^{*} = \frac{a - c_2}{8b} \tag{17}$$

By the formula, you can get sub-game *Stackelberg*, while refining business even balanced competition model number is $(\frac{a-c_2}{2b}, \frac{a-c_2}{4b}, \frac{a-c_2}{8b})$. The ratio of the equilibrium output is 4:2:1. The total output of marketing is as follows:

$$Q_{ss}{}^{*} = \frac{7(a - c_2)}{8b} \tag{18}$$

Earnings of three state-owned commercial banks including the Industrial and Commercial Bank of China, Agricultural Bank of China and China Construction Bank are respectively:

$$u_{1ss}{}^{*} = \frac{(a - c_2)^2}{16b} - c_1 \tag{19}$$

$$u_{2ss}{}^{*} = \frac{(a - c_2)^2}{32b} - c_1 \tag{20}$$

$$u_{3ss}{}^{*} = \frac{(a - c_2)^2}{64b} - c_1 \tag{21}$$

Total income:

$$U_{ss}{}^{*} = \frac{7(a - c_2)^2}{64b} - 3c_1 \tag{22}$$

On the premise of increasing production in the total market for each bank:

$$q_{1ss}^{\ *} > q_{1c}^{\ *},\ q_{2ss}^{\ *} > q_{2c}^{\ *},\ q_{3ss}^{\ *} > q_{3c}^{\ *} \tag{23}$$

$$u_{1ss}^{\ *} = u_{1c}\ ^{*},u_{2ss}^{\ *} < u_{2c}^{\ *},u_{3ss}^{\ *} < u_{3c}^{\ *} \tag{24}$$

Through the above comparison, it can be seen in the improvement $S-S$ of game modes. As for Commercial Bank of China, even if there is no benefit, the proportion of the market share in the peer, as opposed to competitors, appears to be more advantageous. Therefore, the Bank of China should make full use of the advantage to get a bigger share. In addition, since the leading role of Industrial and Commercial Bank of China, the Matthew can be formed easily, so that the vicious cycle of competition is increased.

2. Improved game model in state cooperation

In the competition and cooperation, the control has been carried out to the production, if

$$q_{1ss} = \frac{a-c_2}{3b},\ q_{2ss} = \frac{a-c_2}{5b}, q_{3ss} = \frac{a-c_2}{9b} \tag{25}$$

Respective benefits of them:

$$u_{1ss} = \frac{16(a \quad c\ )}{135} - c_1 \tag{26}$$

$$u_{2ss} = \frac{16(a-c_2)^2}{225b} - c_1 \tag{27}$$

$$u_{3ss} = \frac{16(a-c_2)^2}{405b} - c_1 \tag{28}$$

In comparison with the optimal benefits, the results can be:

$$u_{1ss} > u_{1ss}^{\ *},\ u_{2ss} > u_{2ss}^{\ *},\ u_{3ss} > u_{3ss}\ ^{*} \tag{29}$$

You can find that the three state-owned commercial banks realize the earning increase, which can explain that the three state-owned commercial banks including Commercial Bank of China, Agricultural Bank of China, and China Construction Bank not only join the competition, but also make some cooperation. On this basis, we can make all three parties obtain benefits.

For the above, the model is about the further promotion n . In view of the market there, the sub-game perfect Nash equilibrium quantity is as follows:

$$q_{iss}^{\ *} = \frac{a-c_2}{2^i b},\ i = 1,2,3,\cdots,n \tag{30}$$

Benefit:

$$u_{iss}{}^{*} = \frac{(a-c_2)^2}{2^{i+n}b} - c_1,\ i = 1,2,3\cdots,n \tag{31}$$

3. Improved $S-C$ machines game model in competitive state

If the output of the Industrial and Commercial Bank of China is q_1, the optimum reaction equation for Agricultural Bank of China and China Construction Bank is as follows:

$$\begin{cases} \dfrac{\partial u_2}{\partial q_2} = a - bq_1 - 2bq_2 - bq_3 - c_2 = 0 \\ \dfrac{\partial u_3}{\partial q_3} = a - bq_1 - bq_2 - 2bq_3 - c_2 = 0 \end{cases} \tag{32}$$

Solution is obtained:

$$q_{2sc} = q_{3sc} = \frac{a - bq_1 - c_2}{3b} \tag{33}$$

The best response functions can also be obtained:

$$u_1 = q_i(a - b\sum_{i=1}^{3} q_i - c)_2 - c = \frac{q_1(a - bq_1 - c)_2}{3b} - c \tag{34}$$

If $\frac{\partial u_1}{\partial q_1} = 0$, then:

$$q_{1sc}{}^{*} = \frac{a-c_2}{2b},\ q_{2sc}{}^{*} = q_{3sc}{}^{*} = \frac{a-c_2}{6b} \tag{35}$$

As a result, the son Bo perfect Nash equilibrium of three state-owned commercial banks including Commercial Bank of China, Agricultural Bank of China, and China Construction Bank is as follows:

$$Q_{sc}{}^{*} = \frac{5\left(a-c_2\right)}{6b} \tag{36}$$

The profit function of three state-owned commercial banks including the Industrial and Commercial Bank of China, Agricultural Bank of China, and China Construction bank can be obtained:

$$u_{1sc}{}^{*} = \frac{(a-c_2)^2}{12b} - c_1 \tag{37}$$

$$u_{2sc}{}^{*} = \frac{(a-c_2)^2}{36b} - c_1 \tag{38}$$

$$u_{3sc}{}^{*}=\frac{(a-c_2)^2}{36b}-c_1 \tag{39}$$

You can get the total revenue function:

$$U_{sc}{}^{*}=\frac{5(a-c_2)^2}{36b}-3c_1 \tag{40}$$

(4) Improved $S-C$ machines game model in cooperation state

In the competition and also the cooperation, the control has been carried out on the production, if,

$$q_1=\frac{a-c_2}{3b},q_2=q_3=\frac{a-c_2}{7b} \tag{41}$$

Respective benefits of merchants are as follows:

$$u_{1sc}=\frac{8(a-c_2)^2}{63b}-c_1,\, u_{2sc}=u_{3sc}=\frac{8(a-c_2)^2}{147b}-c_1 \tag{42}$$

The improved machine game models and improved machine game models of the best returns are compared .The result is:

$$u_{1sc}>u_{1sc}{}^{*},u_{2sc}>u_{2sc}{}^{*},u_{3sc}>u_{3sc}{}^{*} \tag{43}$$

Through the above analysis after the game, we can get the three state-owned commercial banks during the collaboration, wherein each of them respectively obtains benefits.

5. Business Competition and Cooperation-Benefit Analysis Based on Game Machine Model of Cooperation

Assuming the merchant benefit analysis, the two businesses employ the trigger mode. If the business A adopts an uncooperative mode, then B will choose the business mode of cooperation. However, if the business A is found to use B uncooperative mode, B businesses in the next decision will be used in the same pattern of non-cooperation. In the actual market, the game usually chooses revenge and cooperation modes. Therefore, this article uses a discount factor of game analysis of state-owned commercial banks in the market competition and cooperation in the aspect of earnings.

6. Business Cooperation Revenue Model

As for state-owned commercial banks in the market including Industrial and Commercial Bank of China, Agricultural Bank of China, and China Construction Bank, the total income of the three businesses is U_a,U_b,U_c. State-owned commercial banks in the discount factor game is σ, wherein the discount factor represents the degree of patience game business, and $0 < \sigma < 1$. Therein the discount factor and yield have a positive correlation. If the state-owned commercial banks have adopted a cooperative mode, the results of five units will be returned. It has been so sustained, while their earnings are as follows:

$$U_a = U_b = U_c = 5 + 5\sigma + 5\sigma^2 + 5\sigma^3 + \cdots + 5\sigma^n = \frac{5}{1-\sigma} \tag{44}$$

7. Business Uncooperative Revenue Model

As for the state-owned commercial banks in the market, the total income of the three businesses: U_{a1}, U_{b1}, U_{c1}. Chinese commercial bank adopts the cooperation model. It is found in the discovery that the Agricultural Bank of China and China Construction Bank adopt the non-cooperative mode. It is found in the discovery that the Agricultural Bank of China and China Construction Bank adopt the non-cooperative mode. Since then, the Chinese commercial banks have lost trust in the other two banks. At this time, own benefits of the three businesses are as follows:

$$U_{a1} = 4 + 3\sigma + 3\sigma^2 + 3\sigma^3 + \cdots + 3\sigma^n = 4 + \frac{3\sigma}{1-\sigma} \tag{45}$$

$$U_{b1} = 6 + 3\sigma + 3\sigma^2 + 3\sigma^3 + \cdots + 3\sigma^n = 6 + \frac{3\sigma}{1-\sigma} \tag{46}$$

$$U_{c1} = 6 + 3\sigma + 3\sigma^2 + 3\sigma^3 + \cdots + 3\sigma^n = 6 + \frac{3\sigma}{1-\sigma} \tag{47}$$

Through the above formula, the following results can be obtained:

①For the $0 < \sigma < 1$, $U_a > U_{a1}$, cooperation model is most profitable for the Commercial Bank of China;

②When $\frac{5}{1-\sigma} > \sigma + \frac{3\sigma}{1-\sigma}$, that is $\sigma > 0.33$. In this case, the Agricultural Bank of China and China Construction Bank cooperation model can get maximum profits. Therefore, taking into account their own interests, the three businesses will be the choice of cooperation.

Through the above analysis, we can summarize the following results. If anyone in the state-owned commercial banks adopts the uncooperative mode, it would motivate other businesses to use the revenge mode. However, when the game discounted earnings satisfy certain conditions, the game can benefit from cooperation businesses. Through the above analysis, we can see from their own business interests that application of the model of cooperation is the inevitable result of future choices.

8. Business Plan Game Mode

In the state-owned commercial banks, if one of the businesses does not use run-balanced output, you can get the business to obtain profits according to the above formula:

$$U = q_1{}^{*''} p^{*'} - q_1{}^{*''} c = q_1{}^{*''} \left(\frac{a+2c}{4} - c \right) > \frac{(a-2c)^2}{8} = U_1{}^{*'} \tag{48}$$

Through the above comparison, we can find that benefits of the business which adopts betrayal cooperation model will exceed that of the cooperative mode. Business in a competitive market formulates a "Cottle" in order to obtain greater benefits and the use of cooperative mode. However, in the game equilibrium analysis, it may also cause problems such as "Cottle paradox".

If U, L, D, R refer to game revenues, merchant armor selects D and U business model, businesses have chosen L and R mode, and businesses appropriately choose A, B. Thereby, two Nash equilibriums are formed, wherein Pareto (D, R, B) weaker (U, L, A) . If you do not use conspiracy between businessmen, the game would be ended. If the business prop chooses A, the merchant A and B would make mutual cooperation, and use a D, R. If it is more than (U, L, A), no benefit would be obtained, otherwise a unit of income would be acquired. Merchant conspiracy analyzes the situation as shown in Table 1 and Table 2.

Classification		**Businesses B**	
		R	**L**
Businesses A	*D*	1, 1, −5	−5, −5, 0
	U	−5, −5, 0	0, 0, 10
Businesses C-*A*			

Table 1 – Business Analysis Table Game Conspiracy

Classification		**Businesses B**	
		R	**L**
Businesses A	*D*	−1, −1, 5	−5, −5, 0
	U	−5, −5, 0	−2, −2, 0
Businesses C-*B*			

Table 2 – Business Analysis Table Game Conspiracy

Currently, the state-owned commercial banks are facing market competition disturbances from various cities and small banks as well as new invaders such as AliPay. However, in order to dominate the market, it is necessary to strengthen competition and cooperation among the state-owned commercial banks. It is possible to effectively control the volatility of the market. If a merchant is contrary, it will cause businesses to enter the vicious cycle, thus weakening the comprehensive competitiveness of state-owned commercial banks. Therefore, in order to achieve effective competition and cooperation model between each other, we need management from the government. State-owned commercial banks enter the market in order to avoid vicious competition among them.

9. Conclusion

In this paper, the business competition and cooperation mode is analyzed based on computer game theory model. The business S-S, S-C competition and cooperation machine game model is used creatively in combination with the characteristics of state-owned commercial banks, which enriches the game of applications.

Game analysis about the Industrial and Commercial Bank of China, Agricultural Bank of China and China Construction Bank among state-owned commercial banks is expanded. Under certain conditions, at the same time of competition with each other, the cooperative mode is used to obtain greater benefits, not only to achieve the benefits of the three businesses, but also to promote the development of state-owned commercial banks which provide the impetus at the same time in mutual competition.

China's state-owned commercial banks form a huge complex service system which changes with information technology. Due to market resource constraints, in order to expand game business of competition and cooperation, competitive cooperation model between state-owned commercial banks becomes an inevitable choice and the inevitable trend of future development. Competitive cooperation model between state-owned commercial banks is an inevitable choice and the inevitable trend of future development as it provides some guidance for the future development of better business.

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Application of Virtual Computer Technology in Digital Library Based on Generalized Evaluation Algorithm of Auxiliary System

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Abstract: In order to analyze application of virtual computer technology in digital library, the weight was topped off during building of a digital library with the virtual computer technology. Earnings obtained by the digital library after application of the virtual computer technology were finally obtained. At last, it is concluded through AHP analysis that application of the virtual computer technology in the digital library can realize digitalization, dynamic development and diversification of resources, and can improve resource types and resource storage. Weights of resource information transfer, system improvement timeliness and system operation simplicity obtained by the algorithm are respectively 0.354, 0.325 and 0.331.

Keywords: Generalized evaluation algorithm of auxiliary system, virtual computer technology, digital library.

1. Introduction

In recent decades since the Reform and Opening Up, the characteristic economic system of our country has been built in a comprehensive manner. With high-speed development of digital science and technology, computer technology has also obtained fast development in our country. In the current world with high degree of informationization, computer technology has been fully applied in different industries of our country, greatly increasing working efficiency of each industry (Guo Mingrui. 2011). By extending the virtual computer technology to the library service field, time and space restrictions of traditional library can be eliminated, and thus application efficiency of libraries can be increased (Leimeister J M, Ebner W, Krcmar H., 2005), and convenience learning manner will also be provided to users. Aiming at this issue, the necessity of applying the virtual computer technology in libraries can be analyzed in details by the generalized evaluation algorithm of auxiliary system.

2. Analysis of Applying Virtual Computer Technology in Digital Library

With network development, the computer technology has obtained great development and has been effectively applied in many service fields, so that service efficiency in each field has been increased obviously (Su Dongchu. 2009). With construction of high informationization, information technology and information network have become inseparable services in our daily life. With respect to library services, traditional libraries and digital libraries are highly restricted by the space, so that users have to waste certain time to obtain book resources. Therefore, it is very necessary to build a digital library service platform based on network technology so as to provide a more convenient and effective library learning platform (Li Yuan. 2009). Fig.1 reflects the necessity to build the digital library service platform.

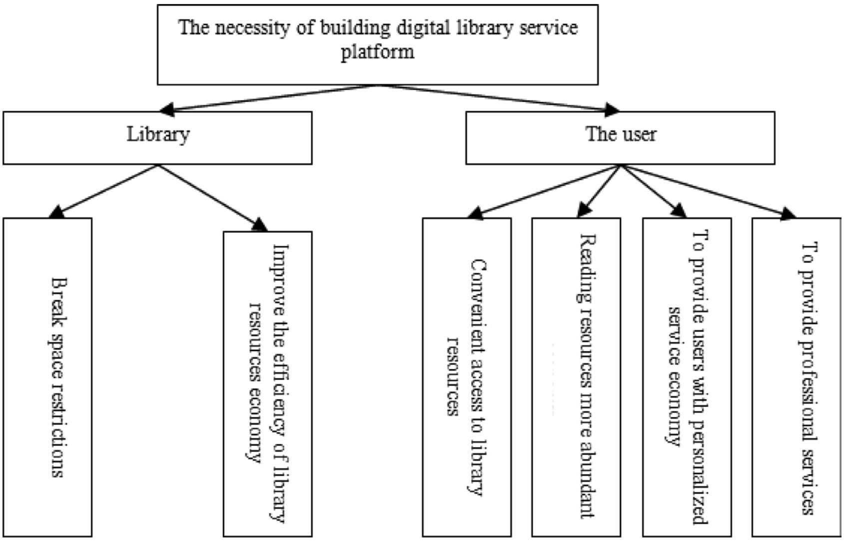

Figure 1 – Necessity of Building Digital Library Service Platform

Building of the digital library service platform will not only benefit the library, but can also provide users with more excellent services. With regard to a library, space restrictions of the library can be broken and utilization efficiency of book resources can be increased by building the digital library service platform (Wang Chenchen. 2011; Li Mei. 2014); in respect to users, resources can be obtained more conveniently, reading resources will become more abundant (Freixo, J., & Rocha, Á., 2014), and users will be provided with more professional and personalized services through potential demand analysis of users by establishing the digital library service platform.

Nevertheless, building of a mobile library service platform is not only an issue about establishing a technical management system. Instead, it is a systematic project which combines users, administrators (Zhang Yumei. 2014; Jiang Huixian, Lin GuangFa. 2005), processes and techniques. Except for the system, a special service platform management mechanism shall also be built, professional personnel shall be assigned to manage and maintain the service platform and the service platform shall be provided with technical and information support. Characteristics of platform management are shown in Fig.2.

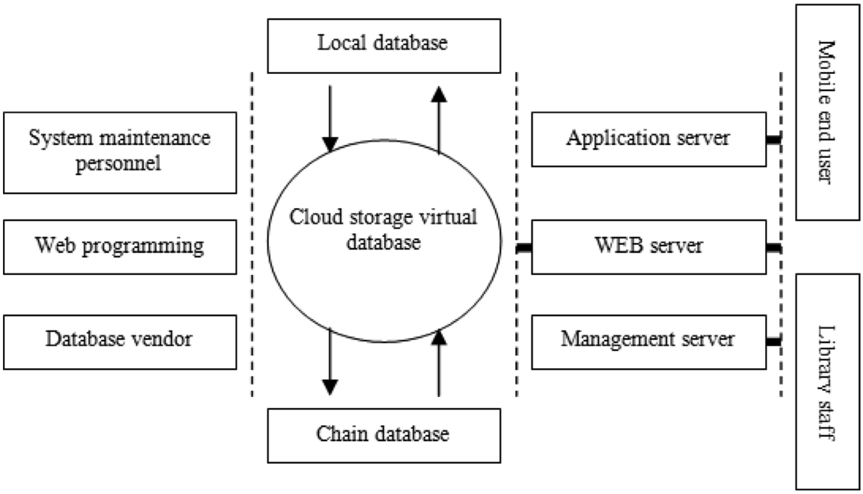

Figure 2 – Diagram of Management Characteristics of Computer Virtual Technology

By establishing cloud storage, cooperative work among databases or other equipment can be realized. A uniform server system can be virtualized by the database virtualization technology in order to realize uniform management and scheduling of heterogeneous databases on various kinds of different nodes. It is feasible to keep on adding new servers and nodes or canceling unnecessary servers and nodes to realize flexible storage management and provide distributed storage cluster services of the mobile library, as shown in Fig. 3.

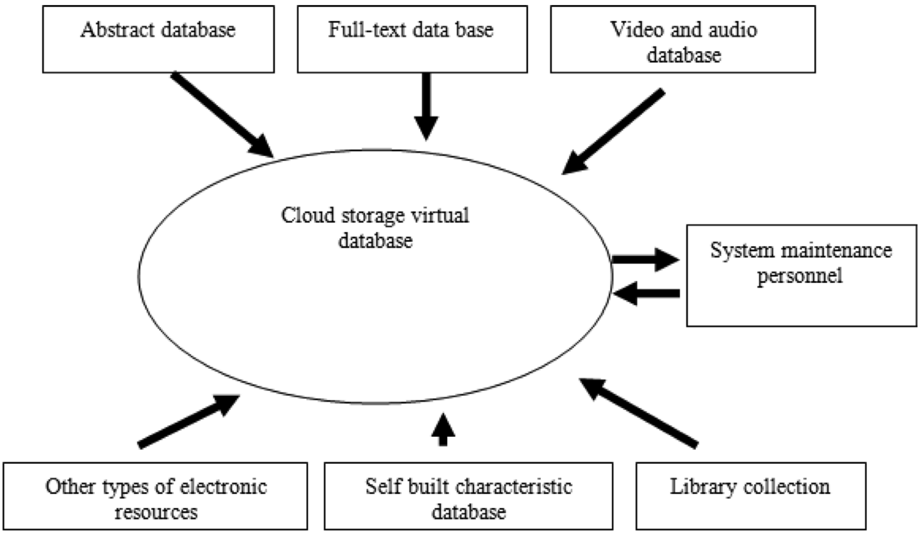

Figure 3 – Computer virtual Cloud Storage Cluster

The computer virtual cloud storage service saves cost in many aspects including data storage, maintenance and management for the mobile library, so that the mobile library only needs to make a small investment in information facilities in order to provide users with data services based on multiple sources, multiple types and heterogeneity. In respect to establishment of links, the mobile library can deploy storage of relevant data in a server of the cloud storage service platform.

3. Weight Analysis of Application of Virtual Computer Technology in Digital Library

3.1. Hierarchical Structure of Application of Virtual Computer Technology in Digital Library

It is found in above analysis that profits will be brought to multiple aspects of the digital library by applying the virtual computer technology into the digital library, including time saving, space decrease and cost reduction, etc. In order to find the application form of virtual computer technology in the digital library, the paper applies AHP analysis to quantify the application of virtual computer technology in the digital library (Hanzl M., 2007; Lin C C, Metters A T., 2006). Relations among a target layer, a criterion layer and a scheme layer are established.

Target layer: application of virtual computer technology in digital library.

Criterion layer: influential factors of scheme, x_1 refers to resource digitalization, x_2 refers to dynamic development and diversification of resources, x_3 refers to improvement of resource types, x_4 refers to improvement of resource storage.

Scheme layer: y_1 refers to information transfer of resources, y_2 refers to timeliness of system improvement, y_3 refers to the hierarchical structure obtained by system operation simplicity, as shown in Fig.4.

3.2. Comparison Matrix of Application of Virtual Computer Technology in Digital Library

According to a lot of experience from experts and with a lot of literatures as reference, pairwise comparison matrixes obtained by setting “1-9”scales are as follows.

Scale a_{ij}	**Definition**
1	Factor i and factor j have equal significance
3	Factor i and factor j are slightly important
5	Factor i and factor j are relatively important
7	Factor i and factor j are very important
9	Factor i and factor j are absolutely important
2,4,6,8	Scale value corresponding to intermediate state between above judgments
Reciprocal	If factor i and factor j are relatively weak, the obtained judgment value is a reciprocal

Table 1 – 1-9 Scale Table

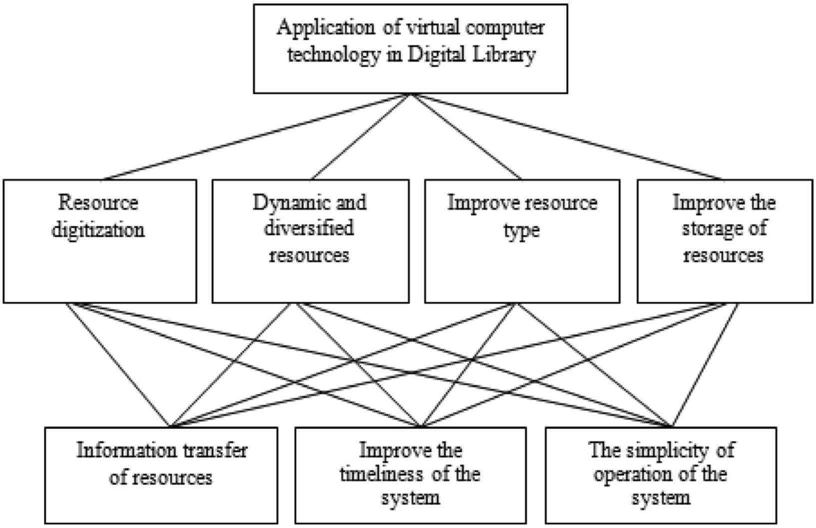

Figure 4 – Hierarchical Structure

G	x_1	x_2	x_3	x_4
x_1	1	1	3	4
x_2	1	1	3	5
x_3	1/3	1/3	1	4
x_4	1/4	1/5	1/4	1

Table 2 – Comparison Matrix

x_1	y_1	y_2	y_3
y_1	1	3	4
y_2	1/3	1	2
y_3	1/4	1/2	1

Table 3 – Comparison of x_1

x_2	y_1	y_2	y_3
y_1	1	4	4
y_2	1/4	1	1/2
y_3	1/4	2	1

Table 4 – Comparison Matrix of x_2

x_3	y_1	y_2	y_3
y_1	1	1/2	1/3
y_2	2	1	1/2
y_3	3	2	1

Table 5 – Comparison Matrix of x_3

x_4	y_1	y_1	y_1
y_1	1	1/3	1/3
y_2	3	1	2
y_3	3	1/2	1

Table 6 – Comparison Matrix of x_4

3.3. Hierarchy Consistency Test of Application of Virtual Computer Technology in Digital Library

According to the formula $CI = (\lambda_{\max} - n)/(n-1)$, the CI was worked out and then analysis consistency was obtained. At last, C consistency was found to be rational, namely that all the judgment matrixes passed the consistency test with application of above theories.

$$C_1 = \begin{Bmatrix} 1 & 3 & 4 \\ 1/2 & 1 & 2 \\ 1/4 & 1/2 & 1 \end{Bmatrix}, C_2 = \begin{Bmatrix} 1 & 4 & 4 \\ 1/4 & 1 & 1/2 \\ 1/4 & 2 & 1 \end{Bmatrix}, C_3 = \begin{Bmatrix} 1 & 1/2 & 1/3 \\ 2 & 1 & 1/2 \\ 3 & 2 & 1 \end{Bmatrix}, C_4 = \begin{Bmatrix} 1 & 1/3 & 1/3 \\ 3 & 1 & 2 \\ 3 & 1/2 & 1 \end{Bmatrix}$$

Corresponding maximum eigenvalue and eigenvector are successively as follows:

$$\lambda_{\max}^{(0)} = \frac{1}{4}\left(\frac{2.277}{0.287} + \frac{2.279}{0.278} + \frac{0.785}{0.236} + \frac{0.638}{0.190}\right) = 4.15$$

$$i^{(0)} = \begin{Bmatrix} 0.289 \\ 0.289 \\ 0.245 \\ 0.191 \end{Bmatrix}$$

$$\lambda^{(1)}{}_{\max} = 3.24, i^{(1)}{}_1 = \begin{Bmatrix} 0.427 \\ 0.241 \\ 0.332 \end{Bmatrix}, \quad \lambda^{(2)}{}_{\max} = 3.34, i^{(1)}{}_2 = \begin{Bmatrix} 0.335 \\ 0.241 \\ 0.424 \end{Bmatrix}$$

$$\lambda^{(3)}{}_{\max} = 3.65, i^{(1)}{}_{3} = \begin{Bmatrix} 0.236 \\ 0.462 \\ 0.302 \end{Bmatrix}, \quad \lambda^{(4)}{}_{\max} = 3.17, i^{(1)}{}_{4} = \begin{Bmatrix} 0.163 \\ 0.438 \\ 0.399 \end{Bmatrix}$$

According to $CI = (\lambda_{\max} - n)/(n-1)$, the *RI* values are obtained, as shown in Table 7.

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Table 7 – RI Value

With regard to the judgment matrix *C*, $\lambda^{(0)}_{\max} = 4.15, RI = 0.91$

$$RI = \frac{4.15-4}{4-1} = 0.053$$

$$CR = \frac{CI}{RI} = \frac{0.053}{0.91} = 0.057 < 0.1$$

Consistency of *C* was rational, so the eigenvector of *C* is the weight vector.

The judgment matrixes C_1, C_2, C_3 and C_4 passed the consistency test with application of above theories. Hence, the calculation results from the target layer to the scheme layer are shown in Fig. 5.

Calculation structure is as follows:

$$i^{(1)} = (i_1^{(1)}, i_2^{(1)}, i_3^{(1)}, i_3^{(1)}) = \begin{Bmatrix} 0.427 & 0.335 & 0.236 & 0.163 \\ 0.241 & 0.241 & 0.462 & 0.438 \\ 0.332 & 0.424 & 0.302 & 0.399 \end{Bmatrix}$$

$$i = i^{(1)} i^{(0)} = \begin{Bmatrix} 0.427 & 0.335 & 0.236 & 0.163 \\ 0.241 & 0.241 & 0.462 & 0.438 \\ 0.332 & 0.424 & 0.302 & 0.399 \end{Bmatrix} \begin{Bmatrix} 0.298 \\ 0.263 \\ 0.219 \\ 0.200 \end{Bmatrix} = \begin{Bmatrix} 0.354 \\ 0.325 \\ 0.321 \end{Bmatrix}$$

3.4. Result Analysis

According to above analysis, we can find that the application of virtual computer technology in a digital library can realize digitalization, dynamic development and diversification of resources, and can improve resource types and resource storage. In

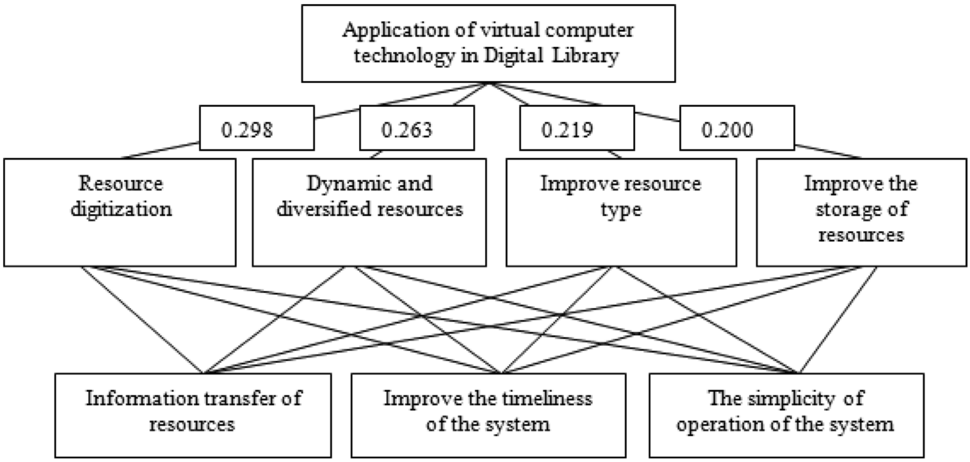

Figure 5 – Calculation Results from Target Layer to Scheme Layer

this way, information transfer of resources of digital library can be realized rapidly, and thus timeliness and simplicity of system operation of the digital library can be improved. Weights occupied by the three aspects are respectively 0.354, 0.325 and 0.331.

4. Conclusion

By researching the application of computer virtual technology in the digital library, the paper finds that the application of virtual computer technology in digital library can bring many benefits to the library and realize resource information transfer, improvement of system timeliness and simplicity of system operation, wherein weights occupied by them are respectively 0.354, 0.325 and 0.331. By analyzing the application of virtual computer technology in resource building of digital library based on the weight results, resources can be collected in a multi-dimensional manner, dynamic development and diversification of resources can be kept and the objective of rapid information transfer of resources can be realized. In addition, the virtual computer storage technology can realize digital processing of resources and improve the storage system of resources in order to improve timeliness and simplicity of the digital library.

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Analysis on Propagation and Development of Foreign Literature in China Based on Time Sequence Model & MATLAB Software

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Abstract: To study the propagation and development of foreign literature in China, this thesis first combines the principle of time sequence model to study the status of foreign literary works propagating in China, and establishes an exponential smoothing forecasting model, which is then modified in combination with computer programming knowledge so as to facilitate programming computation, programming based on Matlab software and solution-finding through program. The sales volume of foreign literary works in China in 2016 is forecast. Finally, the exponential smoothing forecasting model as well as the program in this paper is applied to forecast ten best-sellers of foreign literary works in China in 2016.

Keywords*:* Foreign literary work, principle of time sequence, exponential smoothing forecasting model, sales volume, computer programming.

1. Introduction

With the rapid development in computer technology as well as perfection of various kinds of software, a lot of problems can be computed via computer program so as to achieve more precise result with celerity. This paper combines computer technology for computation and research on propagation of foreign literature in China. Over the recent years, foreign literature has spread extensively across China. There are many ways foreign literature spreads across China. This paper mainly studies the sales volume of foreign literary books in China, which can reflect the status quo and future development trend of foreign literature disseminating in China, thereby providing convenience for publishing houses and relevant departments. This paper first combines the model of time sequence model to study the status quo of foreign literary works propagating in China. In pertinence to the status of foreign literature propagating and developing in China, many predecessors have made great contributions (Belo, A., Castela, G., & Fernandes, S., 2013). Among them:

Zhang Man conducted a study and analysis into the relationship between contemporary Chinese and foreign literatures in *Individualized Characteristics of the Relationship between Cultural Subjective Consciousness and Literature* in 2012, proposing the research methodology of new literary relationships of "cognition of subsistence" and putting forward important conception in pertinence to how to enlarge space and expand the scope of research (Zhang Man., 2012).

Zheng Daili combed foreign literary works in *A Study on Foreign Literature Adapted Chinese Films & Televisions* in 2013, summarizing the discrepancy between and rules of Chinese and foreign literatures, which promotes the development and diversification of Chinese traditional culture and illuminates a development direction of foreign literary adaption based Chinese films in the globalized context (Zheng Daili., 2008).

Ding Helin analyzed the market of literary works in the thesis *A Study on Propagation of Modern Novels* in 2012, noting that the effect of dissemination of modern literary novels can fall into direct macroscopic and macroscopic social effects, and also studied the dissemination and influence of Chinese literary novels overseas(Ding Helin. 2012).

Wen Hongwei proposed a singular and efficacious teaching strategy in the thesis *An Exploration into the Teaching Strategy for Introductory Reading of Foreign Literary Masterpieces in Senior High Philology*, which stimulated student's interest in learning (LaPadula M., 2003, Tait A., 2000). He also raised new insights into introductory reading of foreign masterpieces (Rumble G., 2000), thereby promoting the status quo of foreign literary works propagating in China(Wen Hongwei. 2014, Floyd D L, Casey, Powell D., 2004).

On the base of predecessors' research, this paper builds an exponential smoothing forecasting model, and then combines MATLAB for solution-finding via program (Ludwig-Hardman S, Dunlap J C., 2003). Finally, the exponential smoothing forecasting model as well as the program established in this paper is applied to prognosticate China's ten best-sellers of foreign literary works in 2016. The aim is to make a contribution to China's career of literary and cultural development.

2. Time Sequence Model Based Analysis on Development of Foreign Literary Works in China

2.1. Analysis on the Status Quo of Foreign Literary Works Developing in China

Along with development of society and progress of times, people have higher and higher pursuit for spiritual level (Slavin, R.E., 2008; Slavin,R.E., 2014). Over the recent years, foreign literature has propagated extensively across China. There are a diversity of ways foreign literature disseminates in China. The approach that can best reflect the status quo of foreign literature disseminating in China is definitely the marketability of foreign literary works. The author made a statistics on the status of occupation of foreign literary works in Chinese market in 2013, as shown in Figure 1 as below:

Through Figure 1 it can be seen that, the sales volume of foreign literary works has far outnumbered Chinese ancient literary works (Tait, Alan., 2013,Tait, Alan., 2000), becoming dominant with the second largest sales volume, only second to the sales volume of Chinese contemporary literary works. As people's pursuit for spiritual culture enhances rapidly, the sales volume of foreign literary works is bound to continue rendering a fast-rising tendency, therefore forecasting the sales volume of foreign

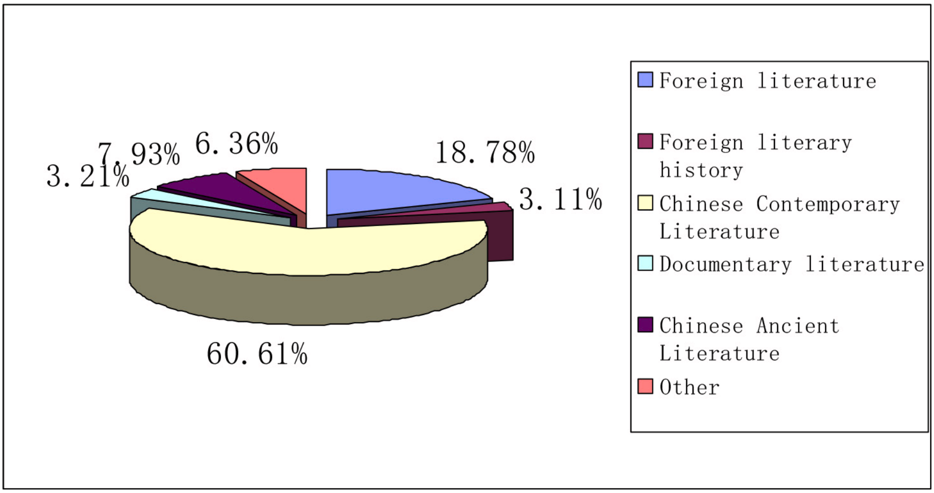

Figure 1 – Status of Occupation of Foreign Literary Works in Chinese Book Market in 2013

literary works will attach vital significance to publishing houses as well as to various industries involved (Tait, Alan., 2013).

2.2. Principal of Time Sequence Model

Mainly combining the method of time sequence, this paper analyzes the data of sales of foreign literary works in China, thereby forecasting the sales volume in 2016, in order for relevant departments to make corresponding countermeasures, depending on the object under investigation.

The time forecasting technique refers to time sequence processing of the forecast object before studying its changing tendency. Common models of time sequence include the following three types:

1. Additive Model

$$y_t = T_t + S_t + C_t + R_t \tag{1}$$

2. Multiplicative Model

$$y_t = T_t \cdot S_t \cdot C_t \cdot R_t \tag{2}$$

3. Hybrid Model

$$\begin{cases} y_t = T_t \cdot S_t + R_t \\ y_t = S_t + T_t \cdot C_t \cdot R_t \end{cases} \tag{3}$$

In Formulas (1) - (3), T_t is long-term tendency term, S_t is season varying tendency term, C_t is cyclical variation tendency term, R_t is random interference term, and y_t is observational record, $E(R_t)=0, E(R_t^2)=\sigma^2$.

2.3. Tendency Moving Average Method

Moving average method mainly combines time sequence data for evolution, so as to reflect the long-term changing tendency of data. When data are considerably subjected to irregular or periodic variations, it is not easy to indicate their development tendency and concrete numerical value. At such moment the moving average method is adopted to remove the influence of these factors. In pertinence to the research object and its characteristics in this paper, it is most reasonable to adopt the tendency moving average method. Its concrete algorithmic process is shown as the following formula:

The formula for once moving average number is as below:

$$M_t^{(1)} = \frac{1}{N}(y_t + y_{t-1} + \cdots y_{t-N+1}) \tag{4}$$

Formula (4) is combined for twice translation to get the following Formula (5):

$$M_t^{(2)} = \frac{1}{N}(M_t^{(1)} + \cdots + M_{t-N+1}^{(1)}) = M_{t-1}^{(2)} + \frac{1}{N}(M_t^{(1)} - M_{t-N}^{(1)}) \tag{5}$$

Next the moving average hysteresis error is employed to establish a straight line tendency forecasting model. Assume time sequence $\{y_t\}$ has the tendency of straight line since a certain time, then set this straight line tendency model as,

$$\hat{y}_{t+T} = a_t + b_t T, \quad T = 1,2\cdots \tag{6}$$

In Formula (6), *t* represents the number of current periods, *T* represents the number of periods from *t* to the forecasting period; a_t denotes the intercept; b_t denotes the slope.

3. Establishment and Solution-Finding of Computer Programming Knowledge Based Exponential Smoothing Forecasting Model

In pertinence to once-moving, it is actually considered that the data over the latest N periods have identical values of influence on the future, namely the same weights of 1/N. The data prior to the *N* periods are considered to make no difference, with a weight of 0. Unlike once-moving, the weights for more-than-once moving average number do not equal 1/N. Moreover, the higher the number of times, the more sophisticated the structure of weights, but the weights on both ends eternally keep minimum, namely symmetric weights. In pertinence to the circumstance in this paper and in general cases, the weight of historical data's influence on the future decrements was taken as time increments. Therefore, the most practical method is to take the weighted average of data within different historical periods as the forecast value. The exponential smoothing forecasting model built in this paper exactly meets this requirement.

3.1. Establishment of Exponential Smoothing Forecasting Model

Assume the time sequence is $y_1, y_2, \cdots y_t$, α denotes weighting coefficient, 0<α<1, then once-smoothing exponential formula is recorded as the following formula:

$$S_t^1 = \alpha y_t + (1-\alpha) S_{t-1}^{(1)} = S_{t-1}^{(1)} + \alpha (y_t - S_{t-1}^{(1)}) \tag{8}$$

Formulas (4) and (8) are combined to derive a recursive formula for moving average number as the following Formula (9):

$$M_t^{(1)} = M_{t-1}^{(1)} + \frac{y_t - y_{t-N}}{N} \tag{9}$$

Take $M_{t-1}^{(1)}$ as the optimum estimate value of y to get,

$$M_t^{(1)} = M_{t-1}^{(1)} + \frac{y_t - M_{t-1}^{(1)}}{N} = \frac{y_t}{N} + \left(1 - \frac{1}{N}\right) M_{t-1}^{(1)} \tag{10}$$

$\alpha = \dfrac{1}{N}$, then substitute S_t for $M_t^{(1)}$ to derive the following Formula (12),

$$S_t^{(1)} = \alpha y_t + (1-\alpha)\left[\alpha y_{t-1} + (1-\alpha) S_{t-2}^{(1)}\right] = \cdots = \alpha \sum_{j=0}^{\infty} (1-\alpha)^j \tag{11}$$

Formula (11) reveals $S_t^{(1)}$ denotes the weighting average of all historical data, and the weighted coefficients are $\alpha, \alpha(1-\alpha), \alpha(1-\alpha)^2 \cdots$; Thus we get:

$$\sum_{j=0}^{\infty} \alpha (1-\alpha)^j = \frac{\alpha}{1-(1-\alpha)} = 1 \tag{13}$$

Since weighted number complies with the rule of exponential change while having the characteristics of smoothing data, it is called exponential smoothing in this paper. The forecast by such smoothing principle is the once-smoothing exponential method. Hence the function for the forecasting model can be written as,

$$\hat{y}_{t+1} = \alpha y_t + (1-\alpha) \hat{y}_t \tag{14}$$

Which actually takes the exponential smoothing value of the t^{th} period as the forecast value of the $(t+1)^{th}$ period.

3.2. Selection of Weighting Coefficient and Determination of Initial Value

Selection weighting coefficient is crucial in the step of exponential smoothing. According to Formula (15), the value of α expresses the proportion of the forecast value to the raw data. The greater the value of α, the larger the proportion of the forecast value, and vice versa. Rewrite Formula (15) into the following form:

$$\hat{y}_{t+1} = \alpha y_t + (1-\alpha)\hat{y}_t \tag{15}$$

Formula (15) reveals a new forecast value can be obtained by modifying the original forecast value in terms of the forecast error. The value of α manifests the amplitude of modification. A smaller value of α indicates a smaller amplitude of modification of the forecast value.

If α=0, the forecast value of the next period equals the observed value of the current period. It is hard to make prediction in pertinence to such extreme situation. So the value of α should range between 0 and 1 according to the concrete requirement of the principle of time sequence. The concrete method of selection may follow the following principle: 1) If the time sequence fluctuates slightly, then the value of α can be smaller, ranging between 0.1 and 0.5. 2) If there is significant tendency of variation with the time sequence, then the value of α can be greater, ranging between 0.6 and 0.9, so that the model has higher sensibility. Actually, in this paper three different values of α are selected as 0.2, 0.5 and 0.8, respectively. The minimum forecast error is determined through computation, thereby the corresponding value of α is to be selected.

In program computation in combination with the above forecast model formula, the initial value $S_0^{(1)}$ also needs to be determined. $S_0^{(1)}$ is artificially provided in combination with real situation. When there are a large number of time sequence data, the initial value has small effect on subsequent forecast values, thus the data of the first period can be selected as the initial value. However, if the initial value of the data of time sequence model is smaller, then the initial value has relatively greater effect on subsequent forecast values. This moment we must study carefully and determine the initial value in the most reasonable way. This paper selects the average of data over the beginning few years in pertinence to determination of the initial value.

3.3. Program Implementation of Model and Result Analysis

The process during which foreign literary works are typified in China is also a process through which to form a political meaning-giving system with Chinese translated foreign literary canons as the object of statement. In the following this paper takes a well-seller *The Unbearable Lightness of Being*, a well-seller over the recent years, as an example, with its historical data of sales volume shown in the following Table 1.

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Sales Volume	17300	18020	21500	17082	20110	20390	22450	25380	24670	28090

Table 1 – Statistic Table of Sales Volume of The Unbearable Lightness of Being over the Recent Decade

Substitute the data of Table 1 into the exponential smoothing forecasting model established in this paper. Compile a program using MATLAB as Figure 2.

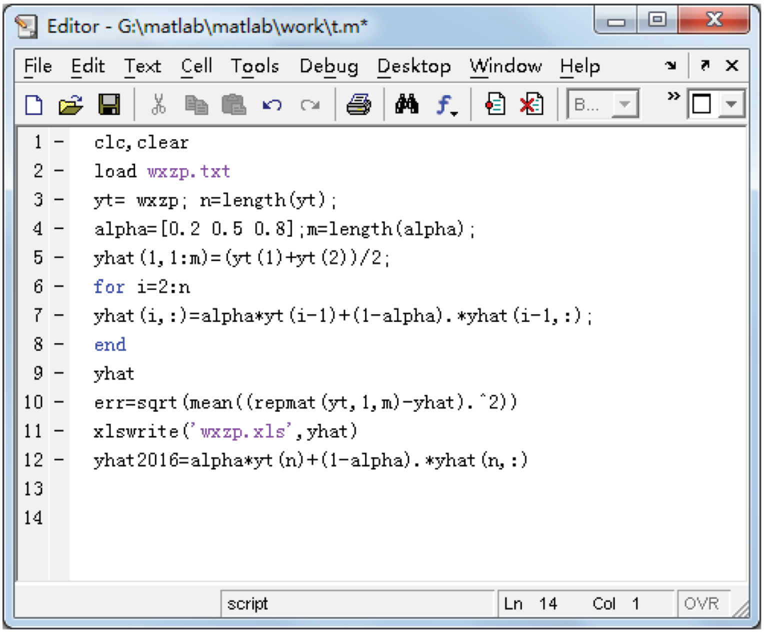

Figure 2 – Program Implementation of Model

The program is associated to compute the data in Table 1 (three different values of α are selected as 0.2, 0.5 and 0.8, respectively), so that the historical result of forecast can be derived as the following Table 2.

Year	t	**Actual sales volume**	**Forecast value** $\alpha = 0.2$	**Forecast value** $\alpha = 0.5$	**Forecast value**
2006	*1*	17300	18223.82	18929.66	16594.679
2007	*2*	18020	18982.268	19717.484	17285.3246
2008	*3*	21500	22648.1	23525.3	20623.445
2009	*4*	17082	18691.1244	16385.56686	17994.1788
2010	*5*	20110	19290.1153	22004.362	23179.39493
2011	*6*	20390	22310.738	21478.826	19558.6997
2012	*7*	22450	23648.83	24564.79	21534.7135
2013	*8*	25380	26735.292	27770.796	24345.2574
2014	*9*	24670	26993.914	23664.2041	25987.378
2015	*10*	28090	29590.006	26944.7707	30736.078
2016	*11*		30359.563	29042.784	31223.085

Table 2 – Forecast Value of Historical Sales Volume of The Unbearable Lightness of Being

Table 2 reveals as the value of α varies, the forecast values differ substantially. Now the annotated error *S* of the forecast values is calculated to determine the value of α. The smaller the annotated error *S*, the more reliable the result of forecast. Calculate the standard deviation of the data in Table 2 to produce the following Table 3.

α	0.2	0.5	0.8
S	4.5029	4.5908	4.8426

Table 3 – Forecast Annotated Error

Consequently, the result of calculation evinces when the value of α is 0.2, the annotated error *S* reaches minimum, which indicates this moment the forecast data are most reliable. It is forecast that the sales volume of the foreign literary work The Unbearable Lightness of Being is $\hat{y}_{2016} = 30359$ in 2016.

Associating the above model and selecting the data of historical sales volume of foreign literary works in China Statistical Yearbook, this paper forecasts the ten best-sellers of foreign literary works and their sales volumes in 2016 as the following Table 4:

Rank	Book ID	Book title	Price	Edition	Sales volume
1	978-720806164-4	The Kite Runner	35	Shanghai People	49210
2	978-720807224-4	Water for Elephants	35	Shanghai People	45356
3	978-753273107-7	The Unbearable Lightness of Being	32	Shanghai Translation	30359
4	978-754423701-7	The Dog of Babel	35	South Sea	29379
5	978-754423821-2	The Book Thief	42	South Sea	28755
6	978-780741365-3	A Diary of Hydrangea	38	Wenhui	24630
7	978-720805003-7	The Da Vinci Code	36	Shanghai People	21016
8	978-750634127-1	Sophies World	38	Author	20053
9	978-720807210-7	A Thousand Splendid Suns	37	Shanghai People	19705
10	978-753872284-0	Chimera’s World	39	Times Literature	19065

Table 4 – TOP10 Best-Sellers of Foreign Literary Works in 2016

4. Conclusion

This paper has established an exponential smoothing forecasting model and performed computer program solution-finding to forecast the sales volumes of foreign literary works in 2016. The established forecast model is not merely limited to solving the practical problem in this paper, but vast scientific researchers are expected to expand the exponential smoothing forecasting model to a broad spectrum of domains and advance China’s growth. The result of forecast indicates the sales volume of the foreign literary work *The Unbearable Lightness of Being* will reach 30359 by 2016, as found in this paper. Also forecast are ten best-sellers of foreign literary works and their sales volumes in 2016. It is expected that the data and results in this paper can help Chinese publishing houses and relevant departments of cultural development to make certain policy-making contributions.

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Optimization Design of Characteristic Landscapes and Application of Virtual Technology in Green Spaces of Small Towns

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Abstract: This papers aims at making good use of existing terrain, personnel structure and resource distribution in small towns to scientifically plan and manage the further development of small towns in China, thus enabling the small towns to develop soundly and orderly. Based on field research, virtual technology was used for simulating the vision, audition and sports etc. in natural environment by means of human-computer interaction to optimize the future small town in line with terrain impression theory, regional image theory, landscape planning principles, city and country impression theory, environmental psychology as well as polysystem theory, with capitalization of economic, environmental and social benefit taken into consideration.

Keywords: Optimization design, landscape image system, small town

1. Introduction

Under international background, hyperinflation is universal in metropolises. Moreover, many intractable social and economic contradictions emerged in the early stage of urbanization in developed countries. In face of the problems amid urban development, the development of rural areas and small towns are gradually drawing more and more attention (Jun Chao., 2014). Currently, with the acceleration of urbanization construction, the economic development in small towns also accelerates. However, it's noticeable that the natural landscapes and cultures are damaged and abandoned amid the rapid development of small cities, which is increasingly serious (Zhang Zhiyun. 2015; Liu Jia., 2012). Therefore, optimizations design for characteristics landscapes of green spaces in small towns has become a remarkable topic.

Developed countries and developing countries are both expected to pay attention to the construction of small towns as the construction of small towns has become an important factor for guaranteeing orderly and sound development of urbanization (Qing Yu., 2010). This shows that construction of small town has become the common experience of national development in all countries. Sound construction of small town can ensure the sound development of a nation (Chen Yingjin., 2012). Therefore, forced by the two trends of small town development both home and abroad, the effective approach for improving the quality of small towns should be found (Freixo, J., & Rocha, Á., 2014), so as to quickly and stably develop small towns in a controllable range, integrate human resources and guide the construction of "small towns with new lifestyle" (Li Mingqi. 2012; Song Yongpeng., 2012).

In recent years, Chinese researchers have achieved significant achievements in virtual reality technology, for instance, training for the operators at nuclear power plant, remote-control mining and VR system etc. (Liu H L, Chen X Y, Zhang Y, et al., 2014). Nowadays, two-dimensional bitmap is mostly commonly used in the software for small town planning and management in China. Vector diagram is used in some comparatively advanced planning and management software. In more advanced software, the planning and management as well as geography information are combined (Geography Information System, GIS) (Yang Wenjuan, et al., 2012). Geography Information System provides sufficient information as well as development and application of two-dimensional information display in hierarchies for planning and management.

2. Research Objectives for Small Town Design and Planning

2.1. The objectives discussed in urban landscape design and planning

A great many of small cities were researched in this paper. Many common landscape elements in small towns are combined to research the prominent problems of the natural landscapes in small cities. Fig. 1 is the diagram of sensorial impression of small towns.

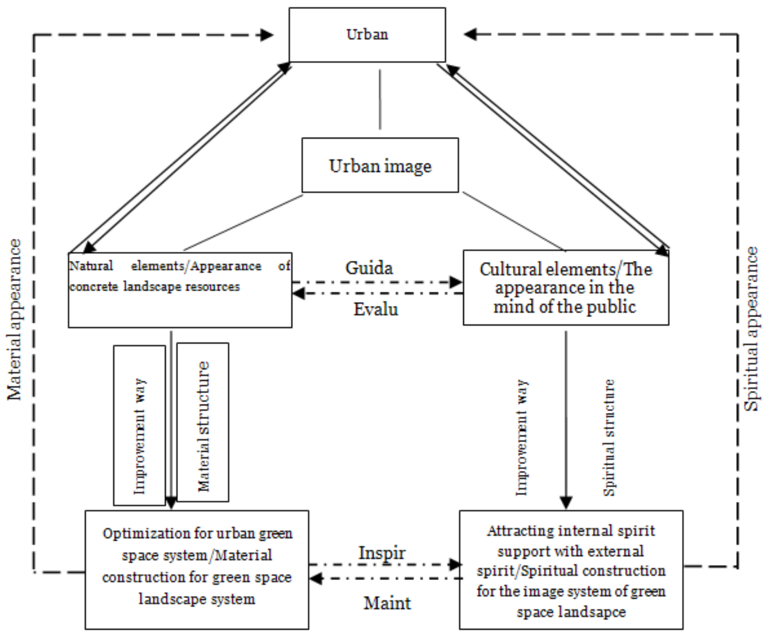

Figure 1 – Diagram of the Appearance of a Small Town

Small towns are closely related to rural areas as they are adjacent to each other. Therefore, the landscapes in the small towns are identical with that in the rural areas to some extent (Xue Lei., 2007). Small towns mostly emphasize on naturality. Similar to rural landscapes, sceneries in small towns are also conversant. Generally, there are not too many high buildings in a small town, so there is abundant internal space to make use of. By considering the elements in all respects, the using space can be divided into different small spaces, so that people will feel very comfortable, and they will not feel compact. Compared with metropolises, small towns are seldom connected to outside world. Hence, small towns are not prone to being affected by external cultures. Moreover, they are enclosed to some extent. As a result, small towns will be provided with intense local features and profound cultural connotation. This shows that small towns will have naturally regional features.

2.3. Theoretical Basis

2.3.1. Landscape Ecology Theory

See the following diagram for the specific expression forms in landscape ecology:

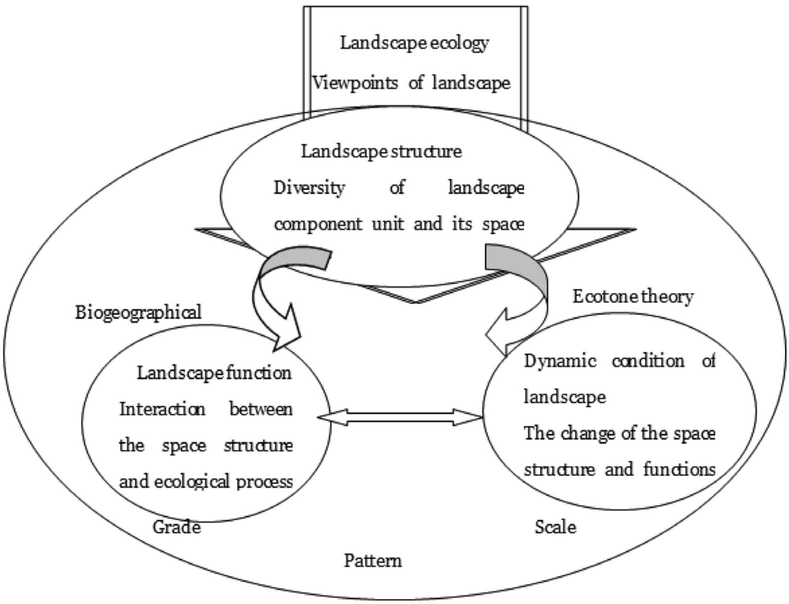

Figure 2 – Diagram of Expression Forms in Landscape Ecology

2.3.2. Theories about Urban Design

Opusculum building, spatial pattern arrangement and mutual connections among open spaces of the buildings are mainly taken into account in the design for small towns. In general, theory about small town design aims at improving people’s livelihood and living environment, which requires providing visual, physiological and psychological touch for people (Li Sumin. 2008; Xue Lei. 2007). This has many actual requirements for architectural style and environmental facilities.

Theories about urban design can provide some guidance for landscape planning and designing for small towns, regulate the environmental design of landscape space in small towns and reinforce regulation and control for the construction of urban green space system. By changing architectural style, environmental facilities and urban space, the towners can be provided with various living environment and excellent spaces for activities.

2.3.3. Theory of Sustainable Development

Researchers want to build an economically prosperous and culturally developed small town which can cater to rural and urban needs amid the development and construction of small towns. Damage to natural landscapes amid urban construction is one of the prominent problems which cause unbalanced ecosystem. Small towns are adjacent to the wide rural areas. Therefore, the urban green space system should be constructed as the case may be, for the purpose of protecting local ecosystem. Local vegetation resources should be used, and the construction should be guided by means of eco-friendly principles and methods. The small town should be designed according to local rivers, lakes, natural terrain as well as plants landscape and community structure in order to realize eco-friendly, scientific and comprehensive functions as well as artistic, economically rational style, thus achieving the perfect combination of small town and urbanization. The unique form and characteristic architectural styles of the town should be protected, aiming at promoting the extension of urban structure and regression to origin.

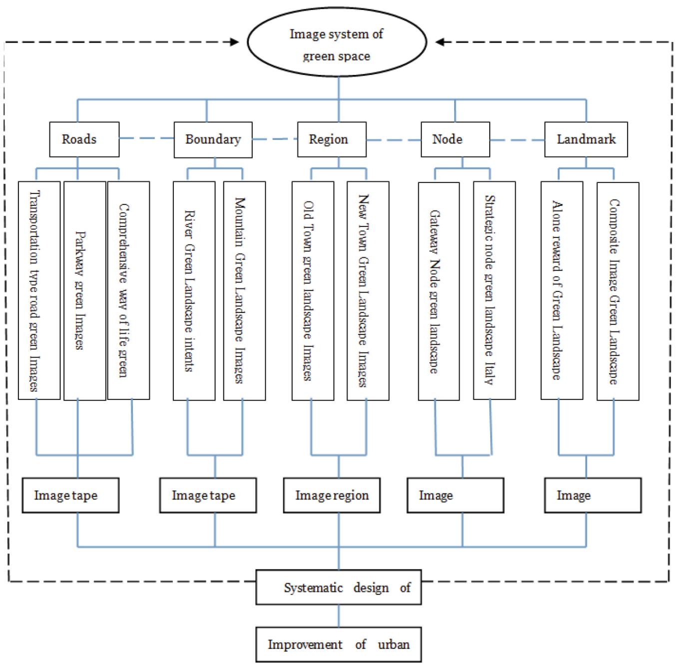

Figure 3 – Diagram of Landscape Image

2.4. Principle for Researching the Landscape Planning and Design of Small Towns

2.4.1. Economical Principles

Many small towns accelerate construction at the cost of sacrificing ecological environment. However, lacking of macro plan for the landscape construction in middle and small towns will deteriorate the ecological environment of small towns. As a result, causing ecologicalization of the landscapes in small towns has become an inevitable trend. How to build a sound small town environment has become a permanent theme for small town development. In general, to promote urban construction, the following respects should be taken into account:

2.4.2. Human-Oriented Principles

Modern landscape planning ought to be designed from a human-oriented perspective to coordinate the relation between environment and human beings at a higher level. The basic goal of small town construction is to cater to human beings' needs. The criterion for evaluating the construction lies in human beings' happiness index. The authentic comfort and convenience in a small town are whether people have the sense of identity, whether it can arouse people's resonance, and whether people have the impulsion of participating in it.

2.4.3. Feature Principles

Owning soul is one of the features of a small town. A small town with soul must have excellent appearance. Moreover, it can promote the development of the small town and improve its popularity. The construction layout of the small town is built in line with landscape appearance and construction principles. See the following picture for the construction layout:

Figure 4 – Construction Layout of Caofeidian Town

3. Case Study—Optimization Design and Application of Virtual Technology to Green Space System of Caofeidian, Tangshan

Located at south Tangshan, Caofeidian is in the middle of circum-Bohai-Sea region. It has wide sea area. Caofeidian District has a long coastline, including 69.5km of deep-water coastline. The port of Caofeidian will not freeze in winter. In addition, there is wide unused land and petroleum etc. on the land. See the following picture for the construction deployment.

Figure 5 – Caofeidian Construction Deployment

3.1. Analysis on Overall Status

Through field investigation on Caofeidian, the researchers have concluded the following points about the overall status of it green space landscape:

- The quantity of greening is small, and the greening efficiency of green space is low.
- Greening development is unbalanced, the green space distributes unevenly.
- Large green space develops insufficiently. The forest land and big trees are particularly few in public green space. The use ratio of public green space is low, which is insufficient to ease heat island effect.
- There is little green space along roads, which cannot reflect the humanized theme style.
- The resource utilization rate of local trees is not enough, and there are not too many exotic trees. The urban green space landscape lacks of personality and features.

3.2 The Concept of Optimization Design

Virtual reality technology is widely applied(Jiang Huixian, Lin GuangFa. 2005; Zhuo Jinwu. 2010; Wang Xiaoyin. 2010; Zhou Yongzheng. 2010). It can be applied to any field that needs saving, management, analysis and understanding complicated data on a computer. Currently, it is mainly applied to engineering field; for instance, manufacturing, vehicle body design and industrial security system etc.

Virtual reality technology has image production and display functions. The system can generate real image information. In addition, this system can also save abundant graphics and text informant.

The lake in Caofeidian New District should be preserved and constructed by building it in to a wetland to make it become a natural gene pool for wild animals and plants as well as a destination for rare international migrant birds, aiming at laying a solid foundation for building green port, green industry and green city.

Figure 6 – Virtual Natural Wetland at Caofeidian

The rivers and lakes in Caofeidian should be protected, and the seafood should be fished rationally, so that people can enjoy the delicious cate while enjoying the beautiful scenery.

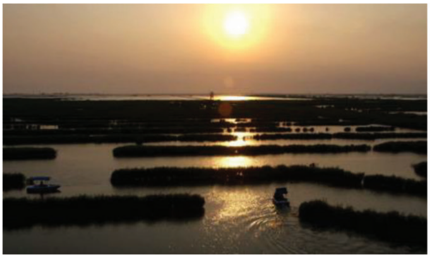

Figure 7 – Virtual Aquatic Product Manufacturing Base at Caofeidian

The name Caofeidian originated from a poignant love story. In early Tang Dynasty, Li Shimin led the troops to go on an eastward expedition across the sea before he became the emperor. They met with stormy waves on the sea, and saved a girl on an island. Li Shimin was attracted by the girl's beauty, so they fell in love with each other soon.


Figure 8 – Virtual Caofeidian Culture

Tangshan City has a time-honored industrial history. As one of the cradles of Chinese modern industry, Tangshan has abundant resources and has produced numerous important energies that the country needs. Also, it provides raw materials for national development. Meanwhile, with the rapid development of surrounding cities, Caofeidian's industrial structure tends to be perfect.


Figure 9 – Virtual Industrial Base at Caofeidian

3.3. Optimization Guiding Thought

1. Integration between humanism history and the environment

   The landscape respects the nature, and pays attention to the sustainable utilization of space. Meanwhile, it also integrates humanism history to the entire landscape optimization and design.
2. The urban spirit and regional culture are sufficiently embodied and comprehended. Caofeidian's spirit and regional features of "learning, innovation, harmony and excellence" are expanded and sublimed amid landscape optimization design, which conveys the inclusiveness and vitality of the city from multiple perspectives and in multiple respects. In this way, urban residents' complex of returning to idyllic life is reflected completely, thus achieving the goal of enabling people to

cherish nature, respect the nature and cultivate their later generations about the nature education view in an unconsciously manner.

3. Environmental optimization of natural ecology

   The greenbelts along the roads should act as the main greening way. The three-dimensional space of characteristic plant is composed of various colors of plants, which creates an intense and characteristic visual impact.

4. Organic integration of scene features

   The features of the regional landscape should be seized while emphasizing the connections to the surrounding areas. The integration between the landscape and the city ought to be taken into account.

4. Conclusion and Prospect

In this paper, the construction of "green landscape image system" is proved, the green space system of the small town is planned, designed and optimized through theoretical research, case study and engineering example. Also, the technical feasibility of "design for green space landscape image system" is verified. The virtual results can be divided into three categories according to immersion: non-immersion, immersion and superposition. They are optimized by using virtual technology. The design for small town concluded in this paper needs to take sufficient account into the space pattern of the buildings as well as the mutual connections among the open spaces in order to realize visual aesthetic impact. A reasonable optimization scheme includes the follows: integration between humanism history and the environment, the organic integration among urban spirit, regional culture, environment optimization for natural ecology and scene features.

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Study on the Influence of Beijing-Tianjin-Langfang Synergic Development on Promoting Urban Spatial Based on Layout Fuzzy Mathematics

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Abstract: As Beijing-Tianjin-Langfang synergic development improves continuously over recent years, studies on promoting urban functions and optimizing space under the framework of Beijing-Tianjin-Langfang synergic development have raised wide attentions. Especially the studies on promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development have received wider and wider attentions. With computer as data processing tool, this paper establishes an evaluation model based on fuzzy comprehensive evaluation with respect to promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development. The analytic hierarchy process (AHP) is employed to determine weights and then the grade of membership of various factors. Finally the model's practicability is verified via a real case. It is evinced that the evaluation system and method established in this paper are effective in addressing practical issues. Scientific basis is offered for the system of research on promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development.

Keywords: Beijing-Tianjin-Langfang synergic development, urban functions, optimizing spatial layout, fuzzy comprehensive judgment, analytic hierarchy

1. Introduction

In the process of Beijing-Tianjin-Langfang synergic development, how to more effectively address the issue of urban spatial layout and development has raised vast attentions. There exist a considerable number of issues on urban development at present such as environmental pollution, traffic problems, degeneration in urban functions, etc., all of which are issues for cities to address at the moment as well as the key points to avoid in future urban construction. A hot issue of research is promoting urban functions and optimizing spatial layout under the framework of Beijing-Tianjin-Langfang synergic development(Wang Chengxi. 2004; Qiu Baoxing., 2009). This requires building an evaluation system for influential degree of Beijing-Tianjin-Langfang synergic development on promoting urban functions and spatial layout. Most studies on the evaluation system for influential degree of promoting urban functions and optimizing space are predominated by theoretical studies, while fewer derive a process from quantitative analysis to qualitative analysis by analyzing relevant data(Yang Linhong. 2010; Yao Shengyong and Pan Haixiao., 2009; Shu Huiqin and Shi Xiaofa., 2008). This paper addresses the qualitative judgment between evaluation indicators by the method of fuzzy mathematical modeling, which provides effective reference and guidance for the evaluation system for promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development, as well as provides scientific guarantee for healthy and fast development in urban construction.

2. Construction of Evaluation Model

Under the background of Beijing-Tianjin-Langfang synergic development being entrenched as national strategic development, the development of Beijing, Tianjin and Langfang appears particularly important and will act a crucial promotive role in Beijing-Tianjin-Langfang synergic development (Feng Weibo., 2006; Zhou Changlin, Meng Ying, et al., 2010). Under the general background of Beijing-Tianjin-Langfang synergic development, promoting urban functions and optimizing spatial layout will be a major issue of research. Under Beijing-Tianjin-Langfang synergic development in future, a layout of international metropolis will emerge. With the continuous development of urban space, the driving force of urban spatial variation lies mainly in clusters of group industries, development trend of economic diversification, industrial orientation, etc., while these influential factors are jointly subjected to policy background (Zhang Xiaoping., 2004). As attentions increases continuously to issues of urban environment, urban transportation (Castela, N., Dias, P., Zacarias, M., & Tribolet, J., 2013), citizen satisfaction, etc., new requirements and goals have been raised with regard to promoting urban functions and optimizing spatial layout under Beijing-Tianjin-Langfang synergic development in future (Li Sumin. 2008; *The Forbidden City,*2008; Anselin L., 1995). Therefore, establishing a reasonable evaluation indicator is of particular importance to realizing reasonable layout of urban space and effective promotion of spatial functions in future.

2.1. Fuzzy Comprehensive Judgment Method

When matters are being evaluated in real life, odds are that they are diversely subjected to many factors at the same time. Thus, comprehensive judgment is in need. But there typically exist some fuzzy influential factors, therefore fuzzy mathematical methods are required to evaluate such fuzzy relations (Yang Lunbiao and Gao Yingyi., 2005).

1. Determination of set of comments

Use X to represent all comments that may emerge, and let n be the number. All comments make up a set of comments.

$$X = \{x_1, x_2, \ldots x_n\}$$

x_i denotes various outcomes that may occur in the result of evaluation. On the base of fuzzy comprehensive judgment, all factors are realized to achieve the most reasonable result of judgment.

2. Determination of set of factors

U is a set of factors:

$$U = \{u_1, u_2, \ldots u_n\}$$

Where u_i are all factors that may affect the result of the judged object.

3. Single-factor fuzzy judgment

The set of factors contains *i* factors u_i (1,2,...,m) which need to be evaluated correspondingly. The set of comments u_i (1,2,...,m) contains *j* elements, the grade of membership of x_j is r_{ij}(j=1,2,...,n), the set of influence judgment for the *i* th element u_i is r_i=(r_{i1}, r_{i2}, ..., r_{in}).

In making judgment on the norm hierarchy, the sets of judgment for indicators on the scheme hierarchy make up a judgment matrix(Zhou Yongzheng. , 2010).

$$R_i = \begin{bmatrix} r_1 \\ r_2 \\ \cdots \\ r_m \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

(4) Fuzzy comprehensive judgment (Zhuo Jinwu., 2010)

In the matrix R_i: the *i*th row of R_i reflects the degree of influence of the *i*th factor on the judged object's membership, the fuzzy comprehensive judgment method is employed to make judgment:

$$A_i = W_i \bullet R_i = (w_{i1}, w_{i2}, \ldots w_{im}) \bullet \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{mi} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (a_{i1}, a_{i2}, \ldots a_{in})$$

$$A = W \bullet R = (W_1, W_2, \ldots W_i) \bullet \left[A_1, A_2, \ldots A_i\right]^T = (a_1, a_2, \ldots a_n)$$

In the formula " • " denotes a specific function operation. A_i is the judgment matrix of the *i*th norm hierarchy evaluation indicator with respect to the comment.

4. Establishment of set of weights (Wang Xiaoyin., 2010; Zhou Yongzheng., 2010)

AHP is employed to determine the weight between different influential factors with respect to different indicators.

$$W = \{W_1, W_2, \ldots, W_i\}$$

$$W_i = \{W_{i1}, W_{i2}, \ldots, W_{im}\}$$

The weight of norm hierarchy is W_i, and the weight of scheme hierarchy is w_{im}. A constraint on the weight of all hierarchies is:

$$\sum_{n=1}^{n} w_i = 1 \,, w_i \geq 0$$

2.2. Evaluation System for Urban Function and Optimizing Spatial Layout Influence

First, relevant influential factors with greater influences are identified under the framework of Beijing-Tianjin-Langfang synergic development. The relevant factors are classified, and their interrelationships are identified. The constitutional factors affecting the evaluation system are divided into two grades: The first-grade indicators are compacted urban space, filled-in development pattern, gorgeous urban environment, and public transportation, the second-grade indicators are urban material spatial structure, urban regional spatial layer, developing progress, developing subject, quality of environment, urban philosophy, adaptive city, and hybrid transportation.

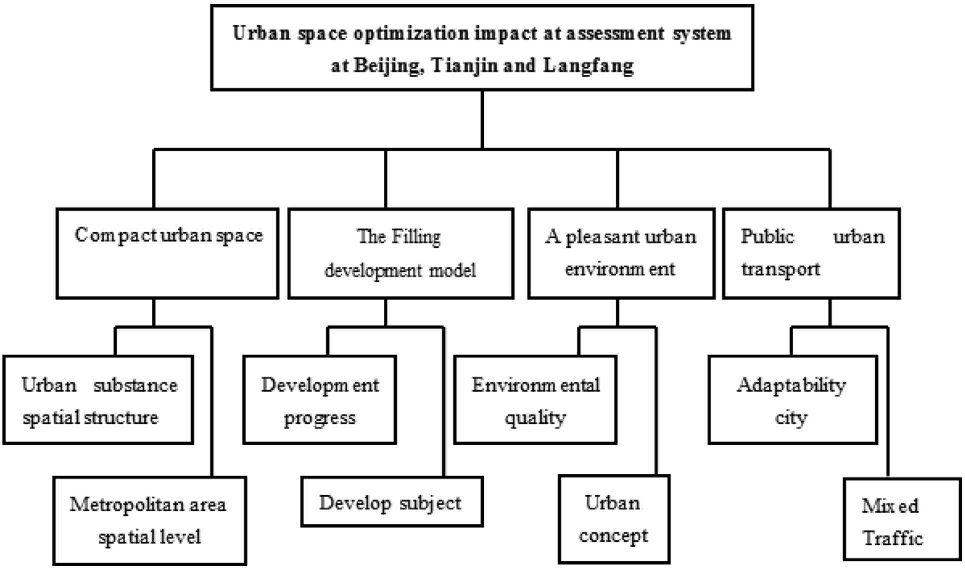

Figure 1 – Fuzzy Comprehensive Judgment Based Classification of Influential Factors

1. Determination of norm hierarchy weights

Key factors influencing the evaluation system mainly fall into the four aspects mentioned above, hence the factors-set objective hierarchy (the evaluation system for promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development), norm hierarchy (compacted urban space, filled-in development pattern, gorgeous urban environment, and public transportation city), attribute hierarchy (urban material spatial structure, urban regional spatial layer, developing progress, developing subject, quality of environment, urban philosophy, adaptive city, and hybrid transportation) for the fuzzy comprehensive judgment are determined as:

$$X = \{x_1, x_2, x_3, x_4, x_5\} = \{\text{ good, better, general, poorer, poor }\}$$

3. Determining Weight by AHP

1. Constructing judgment matrix

It is required that an appropriate decision-making matrix be established on each hierarchy to determine the weight relation and establish a judgment matrix between element relations. By listing the degree of importance between elements on each hierarchy, a comparative matrix $A = (a_{ij})_{n\times n}$ is derived, where $a_{ij} = 1$.

$$r_i = \sum_{j=1}^{n} a_{ij};\ i = 1,2,3,\ldots,n$$

Through mathematical transformation, the comparative matrix is converted into an indirect judgment matrix. The method of transformation is as the following:

$$d_{ij} = \begin{cases} \dfrac{r_i - r_j}{r_{\max} - r_{\min}}(b_m - 1) + 1 & r_i - r_j \geq 0 \\ 1 \Big/ \left[\dfrac{r_j - r_i}{r_{\max} - r_{\min}}(b_m - 1) + 1 \right] & r_i - r_j < 0 \end{cases}$$

The derived indirect judgment matrix has the following nature:

$$\begin{cases} 1/b_m \leq d_{ij} \leq 1 & d_{ij} < 1 \\ 1 \leq d_{ij} \leq b_m & d_{ij} \geq 1 \end{cases} d_{ij}$$

Namely is a scale

$$d_{ij} = 1/d_{ji}$$

The indirect matrix after transformation still has the nature of reciprocity between symmetric elements of the matrix:

When b_m=9, 9 is the scale.

2. Computing relative weight

This paper adopts the square root method to resolve the problem of weights on n elements $A_1, A_2, \ldots, A_n$ among multiple indicators C_k. The latent root of judgment matrix A is determined as $AW = \lambda_{\max} W$. The yielded latent root W undergoing normalization process is taken as the sorting weights on elements $A_1, A_2, ..., A_n$ under indicators C_k. From the equation it can be known that λ_{max} exists solely. Therefore, W can be expressed by positive components. W also exists solely. In order to verify the consistency of the judgment matrix, average eigenvalue difference CI is used to express the indicator of consistency to get (Feng Weibo., 2006):

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

When $CI = 0$, namely when $\lambda_{max} = n$, the judgment matrix is called to have complete consistency, when $CI > 0$, the value of CI is compared with randomness index RI.

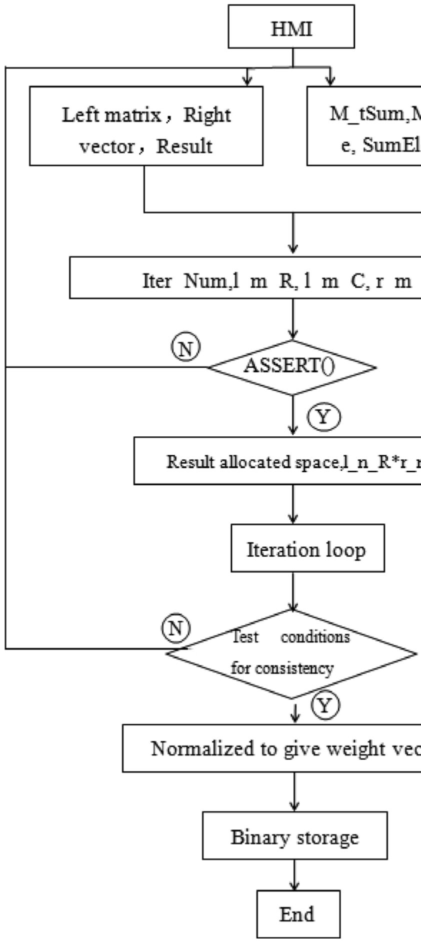

Figure 2 – Processing Flowchart of AHP

When the randomness-to-consistency ratio is:

$$CR = CI / RI \le 0.1$$

The matrix demonstrates good consistency.

When the randomness-to-consistency ratio is:

$$CR = CI / RI > 0.1$$

The matrix does not demonstrate good consistency, and requires continuous modifications until reaching satisfactory consistency.

For 1^{st}~10^{th} matrices, the consistency indices of judgment matrix are shown as Table 1. The computerized processing flowchart using AHP is shown as Figure 2.

Order	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 1 – Table of Consistency Indices for 1st-10th Judgment Matrix

4. Solution in Real Instance

1. Judgment Matrix

With a certain city as an example substituted into the fuzzy comprehensive judgment based fuzzy comprehensive evaluation on the evaluation model of promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development, the above method of determining the judgment matrix can be utilized to figure out the weight of the evaluation model of influential degree. The judgment matrix is shown in the following Table 2:

G	A_1	A_2	A_3	A_4
A_1	1	0	0	0
A_2	2	1	0	0
A_3	2	2	1	0
A_4	2	2	2	1

Table 2 – Judgment Matrix for A_1, A_2, A_3, A_4 Constructing Evaluation Model about G

To determine the matrix constructed with A_1, A_2, A_3, A_4 about G, the following steps are followed:

According to the table, $r_{\max} = 7$, $r_{\min} = 1$, $b_m = 6$, and the model's indirect judgment matrix is:

$$A=\begin{bmatrix} 1 & 3/8 & 3/13 & 1/6 \\ 8/3 & 1 & 3/8 & 3/13 \\ 13/3 & 8/3 & 1 & 3/8 \\ 6 & 13/3 & 8/3 & 1 \end{bmatrix}$$

According to Table 2, the maximum eigenvalue is $\lambda_{\max}=4.0950$, whose weight vector is $w=(0.0761,0.1520,0.2164,0.5556)$. Since $\lambda_{\max}=4.0950>4$, the consistency verification is performed as:

$$CI=\frac{\lambda_{\max}-n}{n-1}=0.0288 \quad RI=0.9$$

$CR<0.10$ which indicates Table 2 can undergo the consistency verification, so the result of A_1, A_2, A_3, A_4 about G is $(0.159,0.184,0.512,0.145)^T$. The result is expressed as below:

First-grade indicator	**Compacted urban space**	**Filled-in development pattern**	**Gorgeous urban environment**	**Public transportation city**
Weight	0.159	0.184	0.512	0.145

Table 3 – Four Ways to Determine Evaluation Weight Coefficient Vector

2. Determining grade of membership R

Give evaluation and score to all factors with 1 point as full score to get the scoring result of influential factors as shown in the following Table 4:

Content of norm hierarchy indicators	**Content of scheme hierarchy indicators**	**Scoring result**				
		Good	**Better**	**General**	**Poorer**	**Poor**
Platform-Type E-Commerce Credibility	Compacted urban space	0.28	0.34	0.22	0.14	0.02
	Filled-in development pattern	0.36	0.35	0.15	0.12	0.02
	Gorgeous urban environment	0.22	0.32	0.23	0.14	0.09
	Public transportation city	0.43	0.39	0.06	0.09	0.03

Table 4 – Statistic Result of Investigation into Membership of Influential Factors

Multiple the 5 judgment grades by 9, 7, 5, 3, 1, respectively, to get the values of evaluation, and stipulate the values as in Table 5.

Qualitative range	***V*>8**	**7.9> *V* >6**	**5.9> *V* >4**	**3.9> *V* >2**	**1.9> *V* >0**
Quantitative range	Good	Better	General	Poorer	Poor

Table 5 – Quantitative Range

Give respective rating evaluation to the four evaluation factors impacting promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development:

$$(0.159, 0.184, 0.512, 0.145)^T$$

$$A = W \times R = \left[0.159, 0.184, 0.512, 0.145\right] \times \begin{bmatrix} 0.28 & 0.34 & 0.22 & 0.14 & 0.02 \\ 0.36 & 0.35 & 0.15 & 0.12 & 0.02 \\ 0.22 & 0.32 & 0.23 & 0.14 & 0.09 \\ 0.43 & 0.39 & 0.06 & 0.09 & 0.03 \\ 0.24 & 0.12 & 0.18 & 0.21 & 0.16 \end{bmatrix} =$$

$$(0.35, 0.22, 0.16, 0.12, 0.15)$$
$$V = 9 \times 0.35 + 7 \times 0.22 + 5 \times 0.16 + 3 \times 0.12 + 1 \times 0.15 = 6.00$$

The overall score of evaluation criteria is obtained as 6.00, belonging to a better grade, which indicates the evaluated city is a better system with certain advantages for promoting urban functions and optimizing spatial layout under the framework of Beijing-Tianjin-Langfang synergic development. By comparing the scores of evaluation of the four influential factors, it can be seen that gorgeous urban environment has the greatest influence on promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development. Therefore, in order to promote urban functions and optimize spatial layout under the framework of Beijing-Tianjin-Langfang synergic development, promotion and perfection should be enhanced in quality of environment, living comfort and convenience of transportation.

5. Conclusion

Under the precondition of computer serving as a processing tool, relevant evaluation indicators for studying and appraising promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development are introduced into the available fuzzy comprehensive evaluation system, thereby a research and evaluation model has been established based on the influence of fuzzy comprehensive evaluation on promoting urban functions and optimizing spatial layout under the framework of Beijing-Tianjin-Langfang synergic development. The method of fuzzy mathematical modeling has addressed the quantitative judgment between the evaluation indicators. The model's practicability has been verified through a real case. The result suggests the evaluation system and method established in this paper are feasible and effective in solving real problems, which lays scientific basis for the research and evaluation system on promoting urban functions and optimizing the influence of spatial layout under the framework of Beijing-Tianjin-Langfang synergic development, and which provides scientific guaranty for healthy and fast development in urban construction.

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Research on the Construction of Computer Interactive Training System of Modern Business English Talents under Economic Promotion Based on Fuzzy Evaluation Model

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Abstract: In the paper, the training system of modern business English talents was analyzed in accordance with fuzzy synthetic evaluation model. Firstly, factors of business talents training under the computer interactive training model were established, including construction goals, promotion of curriculum system reform and teaching mode reform, construction of perfect business English faculties and strengthening of the construction of business English professional training. Secondly, judgment matrix was established for the factor sets, and effective computer network interactive training system for business English talents was found by formulating reasonable computer network interactive training system with a combination of information technology, and finally the obtained associated intervals of computer network interactive training system for business English talents were analyzed via evaluation set.

Keywords: Fuzzy evaluation, economic development, computer network interactive technology, training of business english talents.

1. Introduction

After the reform and opening-up, the development of various industries has been speeding up with the development of comprehensive strength of China (Lun Shuxian. Et al., 2003). In today's diversified society, there is a rapid demand for English due to the characters of industries, which leads to more and more people learning professional and practical English. The training of talents is to serve social progress. From the perspective of economy, the construction of reasonable talent training program is for local economic development, among which the most direct one is to co-cultivate between schools and enterprises, and make full use of resources according to regional features and promote the training of talents from the prospective of plunging into a practice (Hu Shuli., 1994; He Kekang. et al., 2002; Translation and Translating., 2011; Limeng Hua., 2007). English, as a universal language, connects the whole world together. The expression of English makes it possible to achieve common prosperity in terms of culture and economy in the whole world and make other countries know their own local culture and develop import and export trade (Deng Jun. et al., 2012; Sui Xiaobing., 2013; Liu Yongquan, Zhangguo Yan., 2005). Therefore, English is not just a language, it also involves business (Jiménez, D. L., Redchuk, A., Dittmar, E. C., & Vargas, J. P., 2013). To cultivate business English talents, we cannot just focus on the teachings of relevant linguistic language, but also make the economic development a central task and construct talents according to market needs so as to achieve external economic benefits of English and promote regional economic development.

2. The analysis of the Relevance Between Economic Development and the Training of Business English Talents With a Combination of Fuzzy Evaluation Model

Factor sets were established for the establishment of construction goal U_1 for the training of application-oriented talents, promotion of curriculum system reform U_2 and promotion of teaching mode reform U_3, establishment of perfect professional faculties of business English U_4 and strengthening of the professional and practical construction of business English U_5:

$$U = \begin{pmatrix} U_1 & U_2 & U_3 & U_4 \end{pmatrix}$$

Small factor sets were established according to the five major factor sets, as shown in Table 1.

3. Multi-Object fuzzy comprehensive evaluation

(1) Firstly, confirm the factor domain in modeling process:

$$U = \{u_1, u_2, \cdots, u_n\}$$

$$U = \{u_1, u_2, \cdots, u_n\}$$

(2) Confirm the judgment domain:

$$V = \{v_1, v_2, \cdots, v_m\};$$

$$V = \{v_1, v_2, \cdots, v_m\};$$

(3) Confirm the fuzzy judgment matrix $R = (r_{ij})_{n\times m}$:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Establishment of the construction goal U_1 for the training of application-oriented talents	**Promotion of curriculum system reform U_2**	**Promotion of teaching mode reform U_3**	**Establishment of perfect professional faculties of business english U_4**	**Strengthening of the professional and practical construction of business english U_5**
Unit demand for business English talents u_{11}	Update the course contents of vocational high school according to capacity modules u_{21}	Orientation of teaching model u_{31}	Formulate different training programs for different teachers u_{41}	Establish practical teaching focusing on the training of innovative capacity of students u_{51}
Capacity level of business English talents u_{12}	Organize teaching at training center with business scenes u_{22}	Establish module teaching model u_{32}	Teachers should emphasize the combination of theory with practice u_{42}	Highlight training of students' professional and basic skills u_{52}
	Enhance the construction of module courses u_{23}	Transform the teaching content from knowledge-based education to competency-based education u_{33}	Attract enterprise production and management staff related to practice u_{43}	Strengthen the cooperation between school and enterprise and promote order-based training u_{53}
	Based on the reform of subject courses, conduct necessary course integration u_{24}	Use the principles of career English to improve English teaching methods in vocation high schools u_{34}	Emphasize the internal training of teachers at schools u_{43}	
		Create a practical English learning environment for students in scene teaching u_{35}		

Table 1 – The Analysis of Relevance between Economy and Training of Business English Talents

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

Each factor u_i can make a judgment $f(u_i)(i=1,2,\cdots,n)$ and get a fuzzy mapping f from factor domain U to judgment domain V, which is:

$$f: U \to F(U)$$
$$u_i \mapsto f(u_i) = (r_{i1}, r_{i2}, \cdots, r_{im}) \in F(V)$$

$$f: U \to F(U)$$
$$u_i \mapsto f(u_i) = (r_{i1}, r_{i2}, \cdots, r_{im}) \in F(V)$$

Then, find fuzzy relations $R_f \in F(U \times V)$ from fuzzy mapping f, which is:

$$R_f(u_i, v_j) = f(u_i)(v_j) = r_{ij} (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)$$

$$R_f(u_i, v_j) = f(u_i)(v_j) = r_{ij} (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m)$$

(4) Establish weight set, $A = (a_1, a_2, \cdots, a_n) \in F(U)$, satisfy the conditions:

$$\sum_{i=1}^{n} a_i = 1 \quad a_i \geq 0$$

$$\begin{aligned} B &= A \cdot R \\ &= \left(a_1, a_2, a_3, \cdots, a_n\right) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \\ &= \left(b_1, b_2, b_3, \cdots, b_n\right) \end{aligned} \tag{2}$$

Comprehensive judgment: for weight $A = (a_1, a_2, \cdots, a_n) \in F(U)$, use model $M(\wedge, \vee)$ to get max-min compositional operation to obtain the comprehensive judgment as follows:

$$B = A \circ R \quad (\Leftrightarrow b_j = \bigvee_{i=1}^{n} (a_i \wedge r_{ij}), j = 1, 2, \cdots, m)$$

$$B = A \circ R \quad (\Leftrightarrow b_j = \bigvee_{i=1}^{n} (a_i \wedge r_{ij}), j = 1, 2, \cdots, m)$$

The confirmation of the weight $A = (a_1, a_2, \cdots, a_n)$ of judgment domain V is an important link in the modeling process. The main reason is that in the judgment process, it should be identified by establishing fuzzy relations base on the reality.

In this paper, the fuzzy synthetic evaluation model selected during the modeling process was (U, V, R), for the weight $A = (a_1, a_2, \cdots, a_n) \in F(U)$, the fuzzy evaluation matrix was $R = (r_{ij})_{n \times m}$, and the comprehensive judgment process $B = A \circ R = (b_1, b_2, \cdots, b_m) \in F(V)$ was got by applying the model $M(\wedge, \vee)$, in which $b_j = \bigvee_{i=1}^{n} (a_i \wedge r_{ij}) \quad (j = 1, 2, \cdots, m)$.

$$b_j = \bigvee_{i=1}^{n}(a_i \wedge r_{ij}) \quad (j = 1, 2, \cdots, m)$$

From above factors, the evaluation sets were concluded as follows:

$$U_1 = \{u_{11}, u_{12}\}; U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\}; U_3 = \{u_{31}, u_{32}, u_{33}, u_{34}, u_{35}\};$$

$$U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}; U_5 = \{u_{51}, u_{52}, u_{53}\};$$

$$U_1 = \{u_{11}, u_{12}\}; U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\}; U_3 = \{u_{31}, u_{32}, u_{33}, u_{34}, u_{35}\};$$

$$U_4 = \{u_{41}, u_{42}, u_{43}, u_{44}\}; U_5 = \{u_{51}, u_{52}, u_{53}\};$$

In the modeling process, ranking matrixes of the following five aspects were concluded: establishment of construction goal U_1 for the training of application-oriented talents, promotion of curriculum system reform U_2 and promotion of teaching mode reform U_3, establishment of perfect professional faculties of business English U_4 and strengthening of the professional and practical construction of business EnglishU_5.

During the evaluation process, the weight vectors were obtained as follows:

$$\beta = \{\beta_1, \beta_2, \beta_3, \beta_4, \beta_5\} = \{0.3, 0.3, 0.2, 0.1, 0.1\}$$

$$U_i^* = U_i \cdot \beta^T$$

$$U_1^* = 10\,,\; U_2^* = 9.4\,,\; U_3^* = 5.6\,,\; U_4^* = 4\,,\; U_5^* = 4$$

$$\beta = \{\beta_1, \beta_2, \beta_3, \beta_4, \beta_5\} = \{0.3, 0.3, 0.2, 0.1, 0.1\}$$

$$U_i^* = U_i \cdot \beta^T$$

$$U_1^* = 10\,,\; U_2^* = 9.4\,,\; U_3^* = 5.6\,,\; U_4^* = 4\,,\; U_5^* = 4$$

Results after normalization,

$$U_1^* = 0.303\,,\; U_2^* = 0.285\,,\; U_3^* = 0.170\,,\; U_4^* = 0.121\,,\; U_5^* = 121$$

$$U_1^* = 0.303\,,\; U_2^* = 0.285\,,\; U_3^* = 0.170\,,\; U_4^* = 0.121\,,\; U_5^* = 121$$

We got,

$$\bar{A} = (0.2 \quad 0.28 \quad 0.17 \quad 0.12 \quad 0.23)$$

$$\bar{A} = (0.2 \quad 0.28 \quad 0.17 \quad 0.12 \quad 0.23)$$

The construction proportion of Business English training courses, such as construction goals for application-oriented talents, promotion of curriculum system reform, promotion of teaching mode reform, establishment of perfect professional faculties of business English, strengthening of the professional and practical construction of business English and the like, could be analyzed from $\bar{A} = (0.2 \quad 0.28 \quad 0.17 \quad 0.12 \quad 0.23)$.

In the paper, degree of membership of evaluation language was established, as shown in Table 2.

Evaluation methods	**Grade range setting**			
	0-60	**60-80**	**80-90**	**90-100**
Excellent	0	0	0.05	0.95
Good	0	0.05	0.9	0.05
General	0.05	0.9	0.05	0
Bad	0.95	0.05	0	0

Table 2 – Membership of Evaluation Language about Relevance Between Economic Development and Training of Business English Talents

The construction of second-class index is complex. It is judged by the connectivity between Internet economic development and training of business English talents according to the research data, references and cases. And its importance of second-class index is reflected by the grades. In this paper's model second-class index is established by referring to foreign and domestic documents and the fuzzy evaluation value is concluded between the connectivity of economic development and training of business English talents.

Table 3 – was concluded with above indexes.

Single-level fuzzy sets of weight factors concluded in this paper were as follows:

$$U_1^* = \{U_{11}, U_{12}\} = \{0.75, 0.25\} ;$$

$$U_2^* = \{U_{21}, U_{22}, U_{23}, U_{24}\} = \{0.54, 0.1\ 0.24\ 0.14\} ;$$

$$U_3^* = \{U_{31}, U_{32}\} = \{0.4, 0.6\} ;$$

$$U_4^* = \{U_{41}, U_{42}\} = \{0.55, 0.45\} ;$$

$$U_5^* = \{U_{51}, U_{52}\} = \{0.65, 0.35\}$$

$$U_1^* = \{U_{11}, U_{12}\} = \{0.75, 0.25\} ;$$

$$U_2^* = \{U_{21}, U_{22}, U_{23}, U_{24}\} = \{0.54, 0.1\ 0.24\ 0.14\} ;$$

$$U_3^* = \{U_{31}, U_{32}\} = \{0.4, 0.6\} ;$$

$$U_4^* = \{U_{41}, U_{42}\} = \{0.55, 0.45\} ;$$

Each indicator,	**Value**	**Each indicator**	**Value**
Unit demand for business English talents u_{11}	very good	Use the principles of career English to improve English teaching methods of vocation high school u_{34}	good
Capacity level of business English talents u_{12}	general	Create a practical English learning environment for students in scene teaching u_{35}	good
Update the course content of vocational high school according to capacity module u_{21}	very good	Formulate different training programs for different teachers u_{41}	good
Organize teaching at training center with business scenes u_{22}	very good	Teachers should emphasize the combination of theory and practice u_{42}	general
Enhance the construction of module courses u_{23}	general	Attract enterprise management staff related to practice u_{43}	good
Conduct necessary course integration based on reform of subject course, u_{24}	very good	Emphasize the internal training of teachers at school u_{43}	general
Orientation of teaching model u_{31}	general	Establish practical teaching focusing on the training of innovative capacity of students u_{51}	general
Establish module teaching model u_{32}	good	Highlight training of students' professional and basic skills u_{52}	good
Transform teaching content from knowledge-based education to competence-based education u_{33}	general	Strengthen the cooperation between school and enterprise and promote order-based training u_{53}	good

Table 3 – Evaluation Value of Relevance between Economic Development and Training of Business English Talents

$$U_5^* = \{U_{51}, U_{52}\} = \{0.65, 0.35\}$$

Evaluation sets of five factors, which are establishment of construction goal U_1 for the training of application-oriented talents, promotion of curriculum system reform U_2 and promotion of teaching mode reformU_3, establishment of perfect professional faculties of business English U_4 and strengthening of the professional and practical construction of business English U_5, were as follows:

Establishment of construction goals for the training of application-oriented talents:

$$U_1 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Promotion of curriculum system reform:

$$U_2 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Promotion of teaching mode reform:

$$U_3 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Establishment of perfect professional faculties of business English:

$$U_4 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Strengthening of the professional and practical construction of business English:

$$U_5 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

According to the formula,

$$B_i = A_i \cdot R_i$$

Fuzzy evaluation matrixes were concluded after the normalization of B_i.

$$\bar{B} = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{pmatrix} = \begin{pmatrix} 0.07 & 0.26 & 0.14 & 0.41 \\ 0 & 0.16 & 0.74 & 0.54 \\ 0.14 & 0.14 & 0.31 & 0.17 \\ 0.16 & 0.21 & 0.31 & 0.34 \\ 0.11 & 0.32 & 0.26 & 0.31 \end{pmatrix}$$

Evaluation values of relevance were obtained as follows:

$$Z = U^* \cdot B = \begin{pmatrix} 0.38 & 0.23 & 0.11 & 0.10 & 0.18 \end{pmatrix}$$

It can be analyzed through the results of the solution of the model, with the rapid development of economy, education of modern business English talents tends to have a practical and multidisciplinary nature and the setting of courses should also be reformed.

- Practical capacity: due to the difficulty in cooperation between school and enterprise and the characters of English majors, business English has many development potentials. In consideration of the demand of enterprise for business English talents and more recognition achieved by practical experience, so effective training is to recommend them to intern in enterprise or establish professional practical base:

- Multidisciplinary: the measure of business English staff lies in his professional qualities. That is to say, business English born from international business exchanges and business exchanges span from science, engineer, management to law. Therefore, expertise in certain professional knowledge can better serve the exchanges of business English.
- Reform of curriculum system: traditional English teaching system and course setting still focus on English language and literature, the main courses including Basic English, Advanced English, Extensive Reading, Listening Comprehension, Oral English, English Grammar, Translation and Interpretation, English Writing, English and American Literature, Introduction to Linguistics, English Teaching Methodology and Science Tech Translation and so on. And they emphasize the improvement of listening, speaking, reading, writing and translation of students. But the setting framework of business English is English plus certain professional knowledge, which is language skills + business knowledge + humane qualities. Therefore, it is necessary to actively introduce talents teachers with dual degrees in English and business, rely on foreign teachers, especially those with qualification backgrounds of international trade and marketing to enrich teaching body.

4. Research on the reform of educational course system based on computer network interactive technologies

In this paper, with teaching practice and review under the computer network interactive training system of business English as example, it more clearly showed the obvious effects of applying computer network interactive technology into the training of business English talents. Firstly, the automatic grading software was applied. The evaluation and correction advice after the check and correction of the software are as follows in Fig. 1.

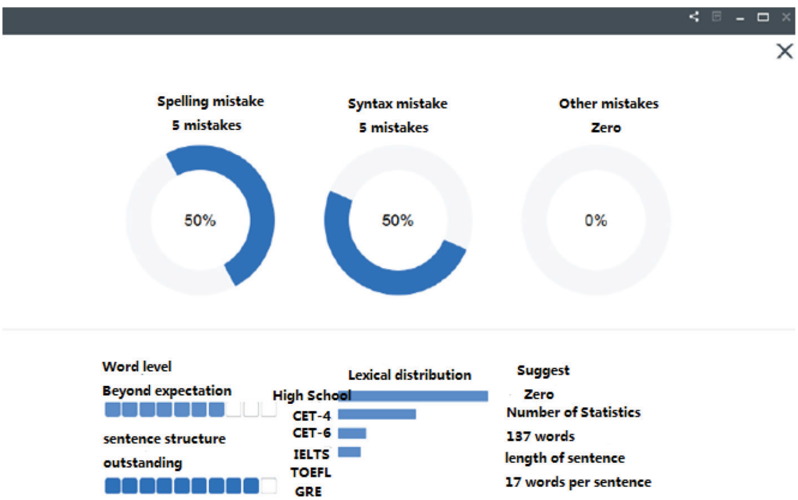

Figure 1 – Interface of Computer Self-test Results on Students' Composition

According to above correction and evaluation, students can correct their work in time. In the meantime, they can find their weaknesses in vocabulary and grammar take immediate remedy measures and take the advice and answer from teachers. Due to the limitations in document organizing and knowledge, some “invisible mistakes” are inevitable in whether self-evaluate or self-correct or peer review or change compositions. Automatic grading software can present the mistakes in details to the students in both vocabulary and grammar, but it is unable to judge whether the main thinking of the composition meets the requirement of the topic and give an accurate judgment of their overall structure and wording ideas. According to constructivism theory, the real progress significance in the study process is much more than the final evaluation index. So the repeat correction function offered by the platform can help us better grasp the development course of us and students.

Repeat correction function of the platform can track course of each correction as shown in Fig.2. Repeat correction can allow the students to grope the pattern of English language usage and mobilize them to sprint towards higher grades and therefore activate their activity on composition.

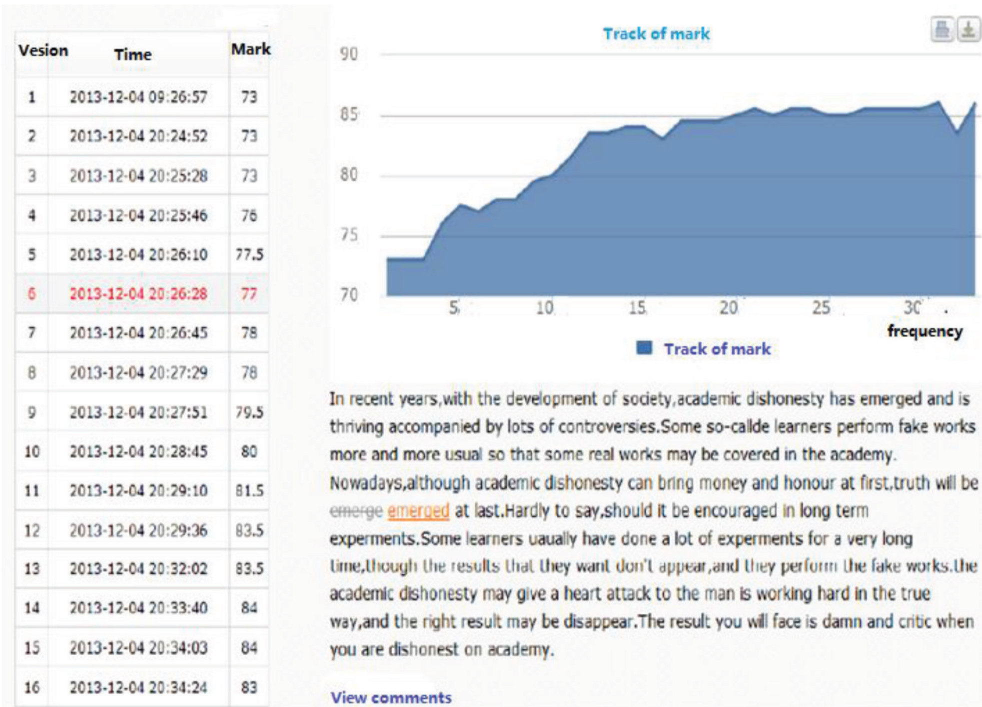

Figure 2 – Interface on Students’ Learning Path on the Cloud-assisted Learning Platform

5. Conclusion

The main reason for the lack of business English talents is the complexity of our country’s English education industry. In this paper, firstly, it offered the computer network interactive training system of business English and authenticates with examples its effective application in the training of business English talents. Secondly, it analyzed the influence of economic development towards the computer network interactive training system of business English with fuzzy evaluation models and concluded the value range of connectivity between 100-90, the evaluation factors connectivity of language membership were higher and the evaluation result of computer interactive system was excellent.

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Research on English Language Teaching Mode of Colleges and Universities with Computer Network Environment Interaction Technology

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Abstract: The integration of computer network and foreign language teaching is quite different from computer-assisted instruction in essence: computer-assisted instruction focuses on assistant function, namely, assisting teachers to improve the teaching effect; while the integration of computer and teaching becomes an organic component of the whole teaching system. The paper carries out a discussion from following aspects based on investigations and surveys on a large number of literatures: through the sound function of "individuation" feature emphasized by Web2.0 computer network environment in terms of the teaching mode: (such as Blog, Wiki, etc.), the communication between teachers and students as well as among students is promoted to a higher level so as to realize the innovation and share of knowledge. The application of computer network environment interaction technology based on Web2.0 into English language teaching mode can construct a kind of new interactive teaching mode between teachers and students.

Keywords: Web2.0, Innovation and share, Pseudo-correlative feedback, teaching mode.

1. Introduction

With the progress of science and technology, the information network technology has changed quickly and traditional English teaching mode has been confronted with urgent requirements for severe challenge and innovation. Only the innovation of such teaching mode can keep pace with social development and changes, otherwise the mode may be abandoned by the society and weed out gradually. However, currently, the development of network technology of WEB2.0 can exactly meet the requirements of new type of English teaching mode (Chen Jianlin., 2011). Under the network environment of Web2.0, the communication mode of information changes completely compared with past days, as a result of which, unilateral interactive communication turns into bilateral one; and any individual can become the subject in cyber world and turn from the person consuming information into the one producing and providing information. The generation of information has changed dramatically, which can in turn lay the foundation for the changes in the field of teaching. However, how to better realize teaching through such platform is the problem that the new type of English teaching mode needs to deal with. The fundamental task for the educators lies in improving the quality of teaching so as to promote students' learning efficiency. According to current teaching form, the educators must exploit and employ brand new teaching design ideas, educational mode and teaching method by learning and applying modern technology as their teaching means and tool (Sui Xiaobing., 2013).

Domestic typical Web2.0 websites include those mostly applying blogs and social networks, especially the blog websites which are of fast development and powerful influence, such as Bokee (www.bokee.com), Sina Blog (www.blog.sina.com.cn), Baidu Post (www.post.baidu.com), etc. With the idea of WEB2.0, the teaching advocates practice, experience, participation, cooperation and interaction, and broadens students' ability to use language so as to formulate an attitude of actively learning language, and allows students to think initiatively and to practice bravely for the purpose of improving their cross-cultural awareness and autonomous learning ability based on the brand new teaching mode (Li Menghua., 2007; Ni Qingquan., 2009). But in order to attain the purpose of laying foundation for the aforesaid networks, excavating users' potential interests and requirements according to search terms is a must; therefore, the paper should make analysis and process on those search terms, namely, it should gather most of the scattered terms to certain categories, which can be regarded as users' potential interests or requirements implied by those search terms. However, the entries recorded by these semantic dictionaries are no doubt of universality without pointing at a specific English teaching field, as a result of which, it remains quite difficult to search (Liu Yi, Li Bo., 2012).

Particularly in the process of English teaching, the existing search and identification of English and Chinese is more complicated. The more intricate text preprocessing contains such treating processes as text denoising, word separation, part-of-speech tagging and word frequency statistics of single texts, etc. (He Yongbin., 2012). Besides, the main statistical models applied in word separation based on statistics include mutual information, neural network model, N-grammar model, maximum entropy model and hidden Markov model, etc. (Deng Juan, Huang Changchao, Li Na., 2012). During the practical operation, it should combine such stipulations as processing speed, storage space and accuracy requirements to ensure what kind of features should the represented text choose. The common text representation mainly includes three types of model: Boole Model, Rate Model and Vector Space Model (VSM) (Qi Denghong, Liang Guojie., 2014). However, these models cannot better solve the problem of the identification of English and Chinese. According to this problem, the paper designs a highly effective interactive network teaching mode of colleges and universities.

2. Feature Selection on Extended Text of Classification of Keywords under Interactive Mode

The specific implementing method is: according to various combinations of dimension and calculation on original data, a dimension can be produced which contains richer meaning. The shortcoming of feature extraction method lies in that the obtained dimension may lose its original real meaning and just contain statistical meaning. Therefore, the method may not be employed in terms of selection on features of textual classification. Screen feature refers to construction of feature subsets by selecting those entries that are usable and can be classified in terms of category from feature syslog

(Castela, N., Dias, P., Zacarias, M., & Tribolet, J., 2013). The specific screen operation lies in: give scores on each entry through selected evaluation function; rank the entries according to scores; and finally select those entries with higher scores to form feature subset. The previous methods of feature selection all adopt one single feature index, which cannot embody the population distribution of features and the rules among them.

The paper puts forward an optimization method of feature selection, which is based on reconstruction. By combining system of selection, it defines an objective function, which is used to ensure the feature subset of the remaining features and through rapacity design and to get the result of the objective function straight pushing-type experimental inference, so as to obtain simplified feature subset. Based on finishing primary feature subset by traditional feature selection approach, another feature subset through precise screen will be obtained by conducting profound feature selection using reconstructed feature selection approach, which can not only avoid the deficiency of single feature index but also promote the efficiency of feature selection approach.

Feature selection approach based on reconstruction idea.

Conducting feature selection mainly wants to obtain as much information on feature set as possible, and then construct all data set through these feature information. If the overall feature set is set as J and selected feature subset as S, we put forward the following objective function:

$$J(S) = \min_{S \subset J} \min_H \left(\left\| X - X(S)H \right\|_F^2 + \mu \left\| H \right\|_F^2 \right)$$

The selected feature set is close to the original data matrix X after linear transformation H through the above objective function. Adding $\mu \left\| H \right\|_F^2$ in the objective function can ensure the overall formula with reversibility during the process of solving the objective function, which can gain a more stable result. If the selected feature set is confirmed, then through the method of obtaining extremum, we can directly obtain the optimal matrix H as follow:

$$H = \arg\min_H \left(\left\| X - X(S)H \right\|_F^2 + \mu \left\| H \right\|_F^2 \right) = \left(X(S)^T X(S) + \mu I \right)^{-1} X(S)^T X$$

The objective function of selecting feature subset becomes like this:

$$I(S) = \min_{S \subset J} \left(\left\| X - X(S)\left(X(S)^T X(S) + \mu I \right)^{-1} X(S)^T X \right\|_F^2 + \mu \left\| H \right\|_F^2 \right)$$
$$= \min_{S \subset J} \left(\left\| X - P_{X(S)}(X) \right\|_F^2 + \mu \left\| H \right\|_F^2 \right)$$

At the same time, it is unnecessary to reconstruct the overall data set in terms of cluster or classification of textual data. Generally speaking, the text is of a large number of noise features, which contain little information and have little impact on similarity calculation among texts. Therefore, in order to get rid of these features, highly effective algorithm must be employed; to further wipe out redundancy by applying minimized objective function; and finally confirm the reconstruction information on forming feature subset. For the purpose of getting rid of redundant useless feature to obtain simplified feature set, it shall be ensured that these useful feature sets can be reconstructed. Through reduction we can obtain the following formula:

$$I(S) = \min_{S \subset J} T_r\left(X^T X - X^T P_X(X)\right)$$

Putting $P_{X(S)}(X) = X(S)\left(X(S)^T X(S) + \mu I\right)^{-1} X(S)^T X$ into the above formula, we can obtain:

$$I(S) = \min_{S \subset J} T_r\left(X^T X - X^T X(S)\left(X(S)^T X(S) + \mu I\right)^{-1} X(S)^T X\right)$$
$$= \min_{S \subset J} T_r\left(\mu X^T \left(X(S) X(S)^T + \mu I\right)^{-1} X\right)$$

The above formula can be used to select the problem of optimal set, which remains a NP problem. It maintains a huge workload to search for globally optimal solution. Thus, we can use greedy algorithm to obtain approximate solution by selecting one feature of minimizing the objective function each time and adding the feature into selected feature set and then obtaining locally optimal solution. If we conduct inverse substitution every time, then it remains a huge computational effort. Therefore, we suggest to calculating the value of the next term through recursion formula. By using Woodubry equation to obtain the following formula:

$$K_{\{S \cup \{f_K\}\}} = \left(X(S) X(S)^T + f_K f_K^T + \mu I\right)^{-1} = \frac{K_S - K_S f_K f_K^T K_S}{\left(1 + f_K^T K_s f_K\right)}$$

The objective function that needs to be calculated is as follow:

$$f_K = \arg\min_{f_K \notin S} T_r\left(X^T \left(\frac{K_S - K_S f_K f_K^T K_S}{1 + f_K^T K_S f_K}\right) X\right)$$
$$= \operatorname{argmin}_{f_K \notin S} T_r\left(\frac{X^T K_S f_K f_K^T K_S X}{1 + f_K^T K_S f_K}\right)$$

Detailed steps.

The detailed steps in this paper on application of feature selection approach based on reconstruction are as follows:

Input: data matrix $X \in R^{n \times d}$; each line refers to a data point and each row refers to a feature. The number of features to be selected is K, and parameter is μ.

Output: feature selection set S.

Steps.

Conduct initial feature selection by applying the aforementioned several feature selection approaches, to obtain initial feature set and update x matrix:

Use greedy algorithm to conduct feature selection set. Initially, $K = -1$, $S = \varnothing$.

Conducting the below step for k times:

(a) $f_K = \operatorname{argmin}_{f_K \notin S} T_r\left(\frac{X^T K f_K f_K^T K X}{1 + f_K^T K f_K}\right)$

(b) Update, $K = K - \frac{K f_K f_K^T K}{1 + f_K^T K f_K}$, $S = S \cup \{f_K\}$

Finally obtain feature selection set S.

For the optimization method of this feature selection, the paper will make a comparison between this method and the feature selection just applying traditional feature selection method so as to verify the effect of the former method in the next chapter.

3. Case study—English Learning Blog

The paper takes English learning blog as an example to demonstrate the promotion of teaching mode. The structure chart of the whole blog is as follow:

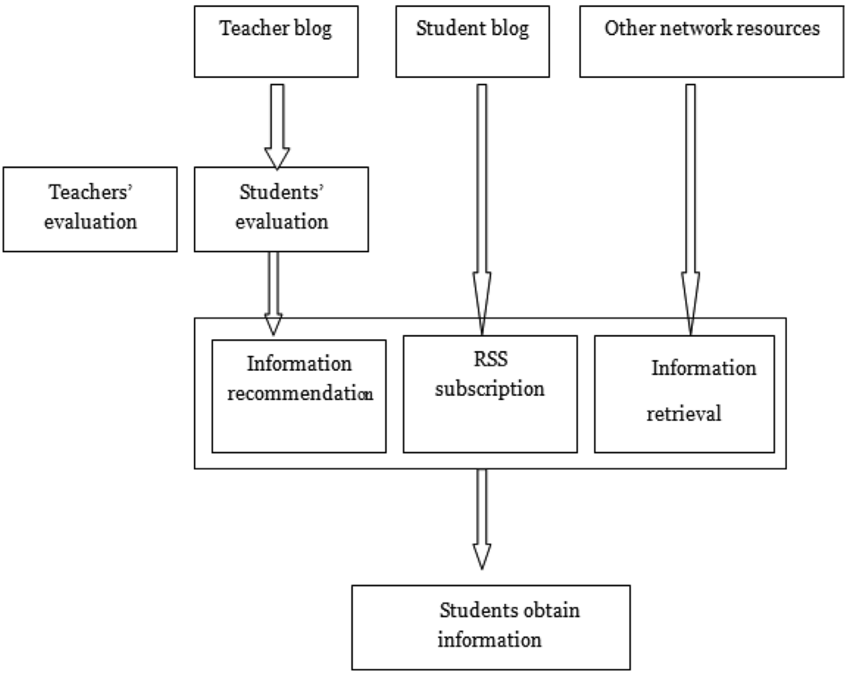

Figure 1 – Structure Chart of Blog

1. User login

Firstly, users should log in after entering into the blog and then can share various learning resources and publish personal comments.

2. Assisted instruction

After success login, users can see the posts published by teachers, whose contents remain the information published by teachers. Teachers can put daily teaching and after-class instruction onto their blog. Teachers can publish relevant teaching notice, arrange students' homework and make comments on students' work via blog, so as to realize the assistant management of classroom teaching.

3. Filtration and recommendation of resources

There is a link column in the content of the posts and on the right side of the page, on which the links of learning resources recommended by teachers are listed. In this era with flush network information, the information online is abundant but chaotic. Thus, it is quite hard for students to indentify valuable information. Teachers can filtrate and extract useful information via blog to their students and students can also transfer the information to other partners via blog. By browsing other people's blog journals, it becomes more efficient to acquire knowledge.

4. Information evaluation

Students can publish their understandings on the opinions from teachers or in the books through replying the posts, which requires the pertinence and independency of their ideas instead of unifying ideas. In addition, during the process of curriculum provision, it can set several more different topics for discussion and allow students to select their interested topics freely.

5. Multimedia teaching

The blog combines electricity, light, shape and sound together by applying various multimedia means, which is favorable for the learning situation and understanding on the teaching contents.

6. Students' participation and cooperation

The blog can greatly encourage students' enthusiasm of participation and cooperation. Students can read teachers' and other classmates' blog journals and make comments; besides, they can also set up their own blog and the problems for discussion and share their thought with others. While writing blog journals, users can use their mastered scattered knowledge, without the requirements for professional web page technique and FTP technology. They can complete setting their blog by just applying for an account.

7. Digital archives

Blog can be used as a digital archive and learning record for teachers' teaching. Through such kind of blog journal, teachers can achieve cooperation and communication. Many teachers share their teaching experiences with other teachers through blog.

8. Knowledge management system

Individual knowledge management is a continuous process and individuals have to do all aspects of work, including collecting, classifying, searching and re-gaining their own knowledge during daily activities, and also a process of obtaining new information, learning new knowledge, clearing up the existing documents, building personal knowledge base and actively sharing knowledge with other people so as to realize personal knowledge innovation.

4. English Teaching Mode of Colleges and Universities With Interactive Technology Under Computer Network Environment

The integration of computer network and foreign language teaching is quite different from computer-assisted instruction in essence: computer-assisted instruction focuses on assistant function, namely, assisting teachers to improve the teaching effect; while the integration of computer and teaching becomes an organic component of the whole teaching system. Thus, the integration of computer and teaching has changed the nature of teaching fundamentally. Computer-assisted instruction actually is based on classroom and textbooks, namely, textbooks are the only sources for knowledge. In the relationship among teachers, textbooks and students, the teachers take charge of the classroom and transfer knowledge to students through using, analyzing and explaining the textbooks; while textbooks are just a medium for the communication between teachers and students; and students can learn knowledge by teachers' analysis and explanation on the textbooks. The natural feature of this mode lies in that teachers dominate the teaching while students are in a passive position and become the object receiving the infused knowledge, although computers is employed by teacher as an auxiliary tool for teaching. Through the demonstration or explanation via computer to teach knowledge from textbooks to students, the computer just enhances the teaching effect and means; while the traditional teaching method of classroom + textbook as well as the situation where textbooks are the only sources for students to acquire knowledge are still not broken. However, the integration of computer and teaching can alter this situation, for the teaching frame has changed completely. See below fig. 2:

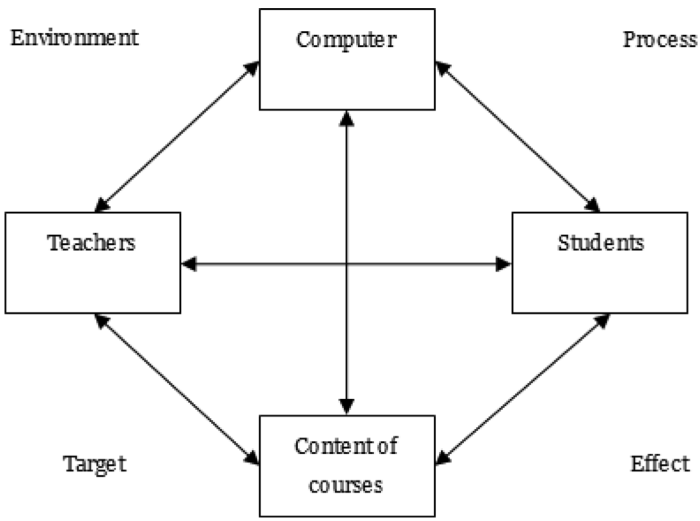

Figure 2 – Frame of the Integration of Computer and English Teaching

The frame of the subsystem contains an informationalized foreign language teaching environment. Here, the mentioned informationalized teaching environment not just refers to hardware system, but a comprehensive system integrating three key factors, including hardware, software and man-machine environment. In such system, teachers, students, teaching contents and teaching medium all play their role in their specific ecological niche; at the same time, they bring about certain teaching effects with mutual consistency and interaction. Through such integrated curriculum subsystem frame, it should observe the principles of teaching ecological environment (stabilization of teaching structure and compatibility of teaching key factors; restriction on teaching operation and promotion of individual development) and apply these principles flexibly and comprehensively during the actual operation. In the process of concrete teaching practice, the mode may change with varied forms along with changes of interaction between teachers and students as well as the increase and decrease of information contents. Each mode may take on different features along with the mode of action of information technology as well as the subject (center) effect of teachers and students; meanwhile, all key actors in the system may proactively interact, co-exist and inter-converse during the dynamic changes so as to become the best dynamic mode.

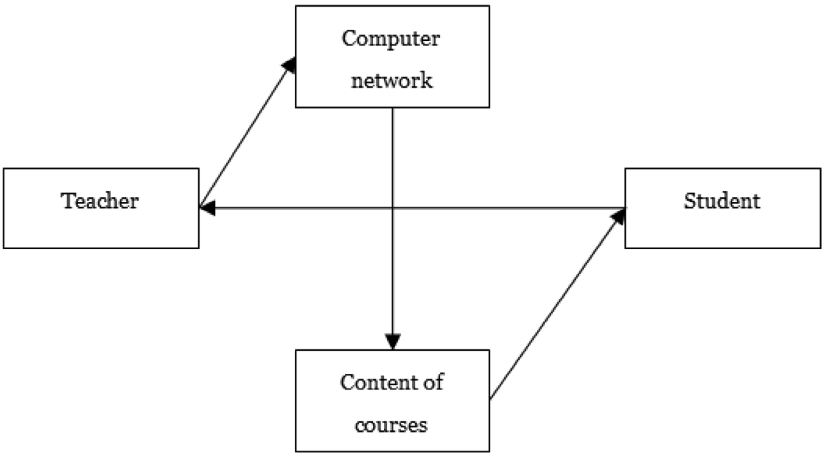

Figure 3 – Teacher-Centered Interactive Mode

This is a traditional computer-assisted teaching mode or teacher-centered mode, in which teachers and students achieve two-way communication. The teaching contents will be pre-stored into computer and teachers take on the teaching information by controlling the computer and obtain feedbacks from learners. The most typical teaching scene is that teachers use multimedia teaching system to assist classroom teaching; teachers apply CAI courseware to demonstrate the teaching contents, and students give feedbacks or conduct various language exercises according to contents; teachers control and supervise the whole teaching process.

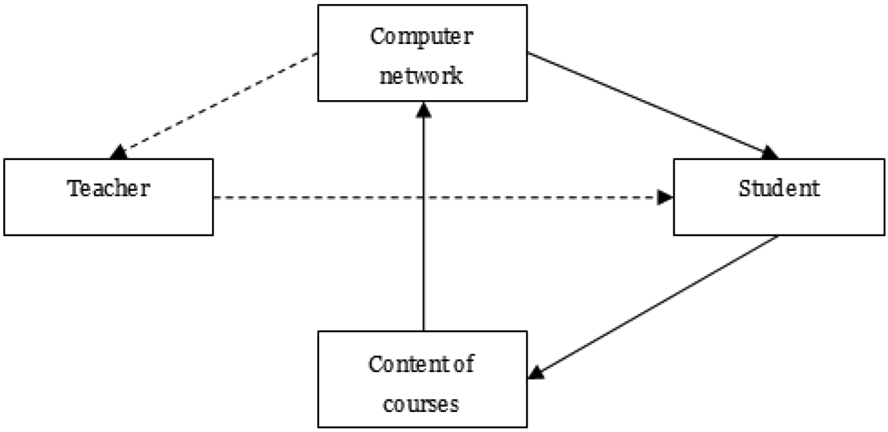

Figure 4 – Student-Centered Interactive Mode

This is a tool-type student-centered interactive mode with weaker self-feedback. Learners construct their own information works by applying computers as a means and obtain some feedback (weak feedback) from the self-evaluation on their own informationalized works, such as learners use such cognitive tools software as EXCEL and database to learn. Teachers can watch learners' learning process and works through operating medium and then give evaluative information as feedbacks.

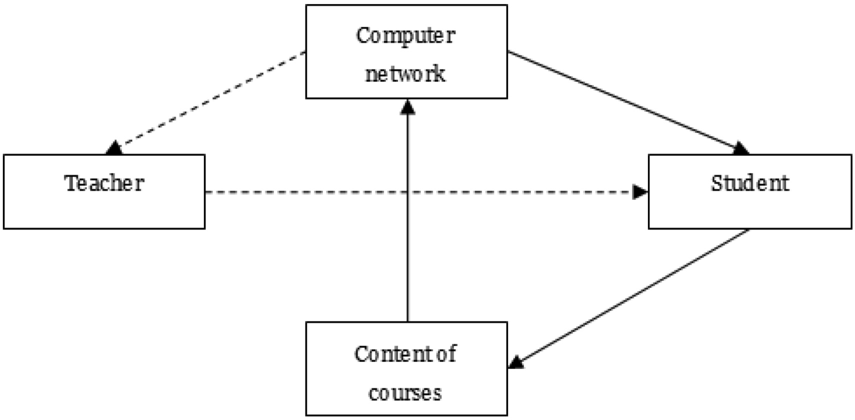

Figure 5 – Student-Centered and Teacher-Assisted Interactive Mode

Student-centered and teacher-assisted interactive mode refers to an exploratory teaching mode with strong self-feedback. Learners can obtain information by operating computers (also according to their own learning demand and interest) and conduct discovery learning through a series of learning activities, such as observing, supposing, trying, verifying and adjusting, etc. This kind of mode may also be along with man-machine communication process at the same time. Thus, learners can communicate with teachers via computer and ask for consultation or gain guidance.

5. Conclusion

The information era indicates different features compared with traditional teaching, which lies in: teachers turn from traditional knowledge docent and teaching authority into teaching researcher, pathfinder and assistant; while students are no longer passive knowledge receiver but become people who can study independently and pursue questions during the teaching process, and they become the subject of the teaching activities. The previous teaching activities are “textbook-centered”, “teacher-centered” and “classroom-centered”; now they turn into “teacher –centered with students as subjects”, as a result of which, a new teacher-student relationship equipped with mentioned teaching mode must be established under Web2.0 environment and the role relationship between teachers and students must be altered and re-shaped.

Computer-assisted instruction actually is based on classroom and textbooks, namely, textbooks are the only sources for knowledge. In the relationship among teachers, textbooks and students, the teachers take charge of the classroom and transfer knowledge to students through using, analyzing and explaining the textbooks; while textbooks are just a medium for the communication between teachers and students; and students can learn knowledge by teachers’ analysis and explanation on the textbooks.

The paper makes a conclusion based on features of traditional English teaching mode: (1) it greatly emphasizes the “interactivity and equality” of English teaching mode under Web 2.0 environment; the knowledge students have acquired is not just taught by teachers, and students can conduct knowledge construction on their own; individualized development is advocated. Then it discusses the English teaching mode of colleges and universities on interactive technology under computer network environment, and combines and integrates various effective interactive teaching modes based on man-machine computer network according to actual situations. After the integration of modern information technology based on computer network as its core and foreign language curriculum, the teaching key factors have changed and many traditional factors (such as textbooks, contents and methods, etc.) have been replaced by new ones (such as multimedia, network contents and technique methods, etc.).

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A University-Student Management Computer System Based on K-means Algorithm

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Abstract: The study of student activities in university campuses can enable the teachers to conduct individualized, classified student management in a more convenient, intelligent and accurate way, bring significant innovation to the student-management work in the university and enhance the efficiency of student management. In this paper, the computer system of university-student activity management is deeply studied using the optimized *K*-means algorithm. The optimal *K* value for clustering is calculated; six major features of campus behaviors—namely, intellectual performance, financial condition, amount of scholarship, moral achievement, sports achievement and competition performance—are used as the six dimensions of *K*-means clustering, and are coupled with the dimensional matrix coefficient to cluster the behavioral characteristics of the students; finally, the prominent behavioral characteristics of several categories of students are analyzed, so as to provide reliable data weight values to the computer system of university student management service.

Keywords: Student management, Data mining, *K*-means algorithm, cluster analysis.

1. Introduction

Enrollment expansion has resulted in the continuous increase of university students, and the large amount of student-information management work poses a large challenge to the counselors. On the other hand, the development of computer hardware and software as well as the advancement of computer technology allows the informatization and systematization of student management. Nowadays, almost every university has its own student-work management system, used for the comprehensive management of the study and life of students. The student work system in my work unit, for example, brings convenience to both the teachers and the students. A lot of important information about students is stored as data in the database of the widely applied student work system.

Based on the data mining technology, Zhou et al. analyzed consumer behaviors (Xia Qing., 2013); Ding predicted the employment of university graduates based on *K*-means algorithm and CBR method (The Automation Technology and Computer Technology. 2011); Muhammad et al. analyzed the behaviors of telecom customers based on data warehouse (Shi Yunping, Xin Daxin., 2006);Takashi et al. analyzed the behaviors of

YOUCITY users mainly by employing the method of model recognition: they used fixed models to analyze the users, and regarded the model that best suited certain users as the category of these users (Li Zhe, et al., 2014; Liu Yuhua. et al., 2015; Li Qiaojun. Yan Bing., 2015). Most of the student management systems currently applied in universities are incapable of analyzing the campus activities, and consequently there still lacks a mature solution in the analysis of campus activities. Due to the lack of a systematic design idea for student management, the analysis of the campus activities of students is very time-consuming process. In foreign countries, a lot of data are available for the analysis of campus activities. In general, all the information about a student is digitally managed there: information about a student's bank card, credit card, phone number, IC card for bus, security, insurance, subway card, etc. is integrated to establish a relatively sound digital scheme for user-behavior information management. In these countries, due to the abundance of available data, data mining is relatively easy, thus their systems are much more advanced than those in China. Considering that the student management patterns at home and abroad are different, however, foreign patterns cannot be directly applied in China.

The study of students' campus activities aims to enable the teachers to conduct individualized, classified student management in a more convenient, intelligent and accurate way, bring significant innovation to the student management work in the university and enhance the efficiency of student management. In order to analyze the campus activities of students (Cruz-Cunha, M. M., Simões, R., Varajão, J., & Miranda, I., 2014), the approach of data mining can be applied to conduct cluster analysis and further optimization analysis of the data in the student-work management system. And through the mining analysis of student activities, the K-means algorithm proposed herein allows the teachers to further analyze and classify the specific student information in the student work management system, so that classified student management by taking into account their characteristics can be conducted and accordingly the student management work can become easier (Guo Xiujuan, Zhan DongMei., 2009; Fu Zhennan., 2009). Thus student management can be strengthened, and even the level of higher education in China can be enhanced.

2. Preprocessing of Data Regarding Students' Campus Activities

In the existing student work systems, the daily student management will produce a large amount of data, and these data probably include various noises due to data format inconsistency and data missing, which are caused by the database design and affect the analysis(Tan Qing. 2009). Therefore data preprocessing is a very important step. The initial data can be converted and simplified by means of data cleaning, integration, specification, etc., so as to simplify the operations.

2.1. Storage of Student Information

The student-work management system mainly includes the following data tables:

X_student: The natural information about the students is mainly listed in this table;

X_studentdetail: Detailed student information is mainly listed in this table;

X_teacher: This table mainly includes information about the teachers, and is connected to the "x_org" table for management;

X_poor: Information about poor students in each term is listed in this table;

X_termscore: The students' scores for every subject in each term are listed in this table;

X_society: Information about the societies the students take part in is listed in this table;

X_creditcard: Information about the bank cards under the students' names is listed in this table; in the "x_score" table, the students' sports scores and moral performance scores are recorded, but information about intellectual performance and competition performance, which can be found in the "x_termscore" table, is not included in this table;

X_studentorg: The names of the organizations the students take part in are listed in this table;

X_scholarship: The names of the existing university-level scholarships and the amount of the money involved are listed in this table;

X_countryscholarship: The names of the existing country-level scholarships and the amount of the money involved are listed in this table;

X_societyscholarship: The names of the existing donated scholarships and the amount of the money involved are listed in this table;

X_honor: Information about the students' winning of the university-level scholarships;

X_countryhonor: Information about the students' winning of the country-level scholarships;

X_societyhonor: Information about the students' winning of the donated scholarships.

The student-related table items in the whole student-work management system are shown above. It can be seen that the design of the entire database is flawed, and may lead to data redundancy. For example, "x_scholarship", "x_countryscholarship" and "x_societyscholarship" can be integrated into one table, and the following tables of scholarships can also be integrated.

2.2. Specification of Data about Student Information

Data mining means extracting information from mass data. Despite the bulk of mass data, data mining can result in significantly decreased workload. Through specifying the data from the data source, the data quantity is made much smaller yet the result will not be changed (Ding Qing, et al., 2010; Zhang Xiaoyi, et al., 2010; Ge Jiting., 2014). The purpose of data specification is to cut down the duration of data analysis, thereby truly enhancing the efficiency.

In this paper, specification of the tables is conducted, including the table of intellectual performance, the table of student information, the table of poor-student information and the table of competition-award information. From the observation and analysis of the above information tables, it can be found that a lot of redundant data exist. For example, detailed information on students is listed in the table of student information, and the tables of scholarships also include class information and so on, part of which is useless in the whole campus-activity data analysis process(Chen Yijun, Yin Li., 2013). Therefore, by utilizing the data specification method, part of the attributes are selected and integrated, and the characteristic values are worked out. Through the analysis of the existing attributes, new attributes are acquired. Finally, the table items that are most conducive to data analysis are obtained herein, as shown in Table 1:

Serial number	**Field name**	**Type**	**Meaning**
1	ID	into	Index
2	SNO	archers(13)	Student number
3	Poorness	Decimal(18,3)	Poorness level
4	Honor	Decimal(18,3)	Scholarship level
5	Moral	Decimal(18,3)	Moral performance
6	Sports	Decimal(18,3)	Sports performance
7	Competition	Decimal (18,3)	Competition performance
8	Intelligence	Decimal (18,3)	Intellectual performance

Table 1 – The Integrated Data Table

For the poorness item, word information is converted into numeric information, with “2” representing extremely poor, “1” representing poor and “0” representing non-poor. Specifically, program is used to match and substitute the word information and then insert the numeric information into the integrated data table. As for honor, data conversion is also conducted here by substituting the word-described scholarship levels for the amount of scholarship money. With regard to the conversion of the intelligence item, the overall grade point for all the subjects is calculated from the formula below:

$$J = \frac{\sum_{1}^{i} \frac{S_i}{100} * X_i}{\sum_{1}^{i} X_i}$$

Therein, i represents the number of subjects, iS represents the score for the i-th subject (in a hundred-mark system), iX represents the credit for the i-th subject, and J represents the grade point. Here, the program calculates the grade point of each student according to the formula $J = \sum_{i}^{i} (S_i * X_i / 100) \Big/ \sum_{1}^{i} X_i$, and inserts it into the final integrated table. For the competition item, an award rule, which is shown in Table 1, is also adopted in this paper, and the word-described competition results are also converted into numerical ones; specifically, certain program is applied to match and substitute the words and insert the numbers into the integrated data table. The scores for moral performance and sports performance are not converted, and the full scores for them are 20 points and 5 points, respectively. Through the data preprocessing, the following results are obtained:

SNO	STUDENT_ ID	Intelligence	Moral	Sports	Competition	Poorness	Honor
0511101	14747	3.157	16.800	4.000	.500	.000	600.000
0511102	14758	3.066	15.300	4.000	.000	.000	.000
0511103	14759	2.381	15.400	4.000	.000	.000	.000
051105	14762	2.366	16.100	4.000	.000	.000	.000
051107	14763	3.004	12.200	4.000	.000	2.000	.000
051110	14766	2.485	15.400	4.000	.000	.000	.000
051111	14767	2.530	15.700	4.000	.000	1.000	.000
051113	14769	3.262	13.800	4.000	.000	.000	.000
051114	14770	1.749	15.300	4.000	.000	.000	.000
051115	14771	3.368	15.400	4.000	1.000	.000	300.000
051116	14772	3.017	15.800	4.000	.000	.000	900.000
051119	14775	2.885	15.400	4.000	.000	.000	.000
051121	14777	2.668	15.400	4.000	1.000	1.000	.000
051122	14778	2.589	15.400	4.000	.000	.000	.000
051123	14779	3.523	15.400	4.000	.000	.000	300.000
051124	14780	2.500	15.400	4.000	.000	.000	.000
051125	14781	2.379	15.400	4.000	.000	.000	.000
051126	14782	3.204	16.800	4.000	.000	.000	300.000

Table 2 – The Results of the Data Preprocessing

3. Optimization of K-means Algorithm

Clustering analysis is the major task in data mining. Clustering is a process of analyzing the target data objects and classifying them according to their similarity. The cluster analysis technology, which is a result of interdisciplinary development, involves such subjects as mathematics, statistics and computer science, and has been widely, successfully applied in many fields (Cheng Hua, et al., 2008; Zeng Xu Sima Yu., 2012). The main function of this technology is to analyze the similarities among mass data and then cluster data sources according to their similarity. In this paper, *K*-means algorithm in clustering analysis is optimized and subsequently used for the clustering of the data about students' campus activities.

A method for selecting the initial *K* value is proposed herein. Specifically speaking, the clustering scope is decided based on the actual situation; assuming that the scope of the cluster number *K* is (m, n), the traditional *K*-means algorithm will be run n-m times; then, an optimal cluster number will be selected based on the several clustering processes by using the following formula, and be regarded as the optimal cluster number. The calculation formula for *V* value is shown below:

$$V = \frac{d_{NJ}}{d_{WJ}}, \left(d_{NJ} = \sum_{i=1}^{K} \sum_{j=1}^{n_i} \left(x_{ij} - c_i \right)^2, d_{WJ} = \frac{1}{k(k-1)} \sum_{i=1}^{K} \sum_{j=1}^{K} \left(c_i - c_j \right)^2 \right)$$

Therein, *V* represents the Euclidean distance between each point and the center within the cluster, the external distance is 1/*k*(*k*-1) times the sum of Euclidean distances among various centers, and *k* represents the quantity of centers. According to this formula, the smallest ratio of internal distance to external distance would indicate high-level cohesion within each cluster and low-level coupling among clusters, suggesting that the cluster number is optimal.

With regard to the selection of the initial point, it is determined herein that the initial point should meet the following requirements:

The distances among the center points should be as large as possible.

The points surrounding the initial point should be densely distributed.

The distances among the center points can be calculated using the following formula:

$$d = \frac{1}{k(k-1)} \sum_{i=1}^{K} \sum_{j=1}^{K} \left(c_i - c_j \right)^2$$

The result is the average of the distances among all the center points, and can generally reflect the distances among the cluster centers. The density of points is calculated from the following formula:

$$p_i = z_i \Big/ \sum_{1}^{n} Z_k$$

This formula can reflect the density of points around the point *xi*. A greater value would indicate more surrounding points and a larger density, while a smaller value would indicate a smaller quantity of surrounding points and a smaller density.

In the above formula, z_i represents the distance between the sample points, and the denominator represents the sum of the distances among all the sample points. Therefore it can be easily understood that this p_i is a good reflection of the density of points surrounding the point *i*. z_i can be calculated from the formula below:

$$z_i = \sum_{j=1}^{n} \left(x_i - y_j \right)^2$$

Thus the main procedure of the textually optimized K-means algorithm is as follows:

Set the scope of *K* value change to achieve the optimal clustering effect of the dataset in the training sample space, and accordingly determine the *K* value and the initial clustering point. The specific steps are:

- To choose a high-quality dataset in the training sample space (the departments in the university are chosen here as the test data).

- To select K value = 1;
- To execute the traditional K-means algorithm model;
- To validate and calculate according to the model;

$$V = \frac{d_{NJ}}{d_{WJ}}, \left(d_{NJ} = \sum_{i=1}^{K} \sum_{j=1}^{n_i} \left(x_{ij} - c_i \right)^2, d_{WJ} = \frac{1}{k(k-1)} \sum_{i=1}^{K} \sum_{j=1}^{K} \left(c_i - c_j \right)^2 \right)$$

- To let $K = K+1$, and repeat Steps 3 and 4 until K value reaches $2K$ ($2K$ is the default, and the scope of K value change can be manually set);
- To regard the K value that the minimum V value corresponds to as the final K value.

The flow chart of this algorithm is as shown in Figure 1:

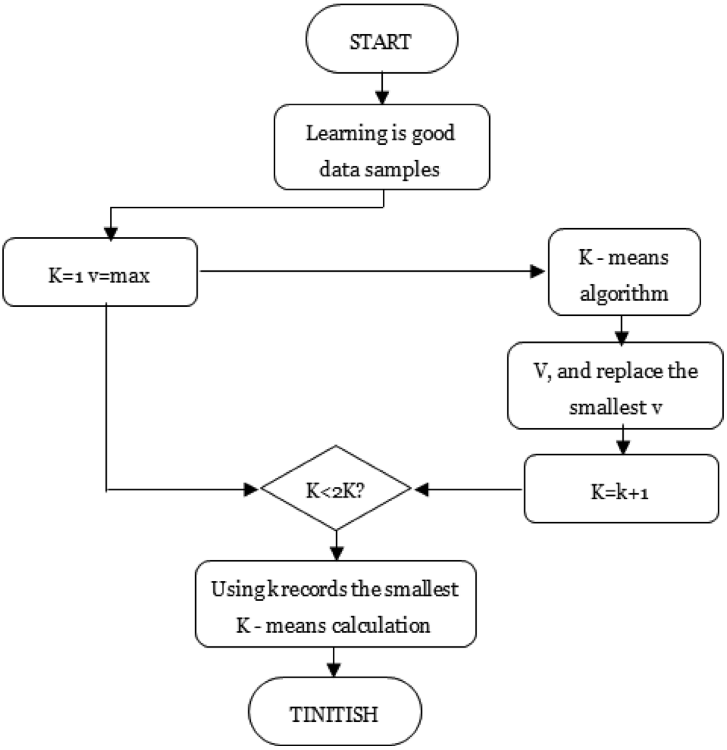
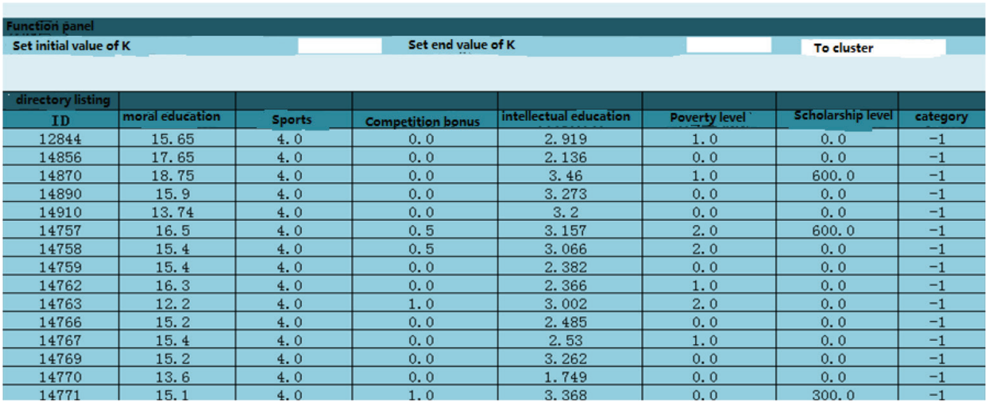


Figure 1 – The Procedure of the Improved K-means Algorithm Running on Computer

4. Experimental Analysis

Through experimenting with the data about students' campus activities, the traditional K-means algorithm is compared with the optimized K-means algorithm. The analysis of the students' campus activities is mainly intended for the cluster analysis of the campus-activity data. The students are divided into several categories, and the main characteristics of each category are pointed out.

Figure 2 below shows the data prior to the cluster analysis:



Function panel

Set initial value of K | Set end value of K | To cluster

directory listing

ID	moral education	Sports	Competition bonus	intellectual education	Poverty level	Scholarship level	category
12844	15.65	4.0	0.0	2.919	1.0	0.0	-1
14856	17.65	4.0	0.0	2.136	0.0	0.0	-1
14870	18.75	4.0	0.0	3.46	1.0	600.0	-1
14890	15.9	4.0	0.0	3.273	0.0	0.0	-1
14910	13.74	4.0	0.0	3.2	0.0	0.0	-1
14757	16.5	4.0	0.5	3.157	2.0	600.0	-1
14758	15.4	4.0	0.5	3.066	2.0	0.0	-1
14759	15.4	4.0	0.0	2.382	0.0	0.0	-1
14762	16.3	4.0	0.0	2.366	1.0	0.0	-1
14763	12.2	4.0	1.0	3.002	2.0	0.0	-1
14766	15.2	4.0	0.0	2.485	0.0	0.0	-1
14767	15.4	4.0	0.0	2.53	1.0	0.0	-1
14769	15.2	4.0	0.0	3.262	0.0	0.0	-1
14770	13.6	4.0	0.0	1.749	0.0	0.0	-1
14771	15.1	4.0	1.0	3.368	0.0	300.0	-1

Figure 2 – The Processing Page on Computer Before the Analysis

The computation with the traditional *K*-means algorithm will produce the student categorization information, the category information (no longer -1), the averages of values for various items, etc., most of which are shown in Tables 3 and 4:

ID	Moral	Sports	Competition	Intelligence	Poorness	Honor	Category
14840	13.65	3.0	0.0	2.927	1.0	0.0	1
14811	16.65	3.0	0.0	2.223	0.0	0.0	2
14970	16.75	3.0	1.0	3.448	1.0	600.0	4
14890	15.9	3.0	0.0	3.279	0.0	0.0	2
14915	15.75	3.0	0.5	3.2	2.0	0.0	1
14757	17.8	3.0	0.5	3.157	0.0	600.0	4
14768	15.3	3.0	0.0	3.066	0.0	0.0	2
14758	15.4	3.0	0.0	3.381	0.0	0.0	2
14762	15.8	3.0	0.0	2.560	0.0	0.0	2
14663	12.2	3.0	0.0	3.004	2.0	0.0	1
14756	16.1	3.0	1.0	2.885	0.0	0.0	2

Table 3 – Analysis of Detailed Student Information

Portal	Passport	Poem	Pin	Poor	Phonier	Category	Number
15.841212	4.000000	.000000	2.578110	1.455321	.000000	1	6
15.475651	4.000000	.000000	2.320051	.000000	.000000	2	15
15.535856	4.000000	.4.000000	3.531243	.000000	900.000000	3	2
16.854201	4.000000	.2354852	3.751045	.155567	355.578544	4	7

Table 4 – The Average Values for Each Category

According to the tables, the optimized *K*-means algorithm divides all the students into four categories, each with prominently unique characteristics. The first category features average intellectual performance, mostly poorness and the lack of scholarship and competition award. The second one features relatively low-level intellectual performance, good financial condition, and the lack of scholarship and competition award. The third one features excellent competition performance, a very large amount of scholarship money, good intellectual performance and good financial condition. And the fourth one features the best intellectual performance, a large amount of scholarship money, mostly poorness, and average competition performance. It can be seen that the optimized *K*-means algorithm leads to a better categorization of the students—the gaps among categories are larger, and each category is distinct, which facilitates student management.

5. Conclusion

Clustering analysis is the major task in data mining. Clustering is a process of analyzing the target data objects and classifying them according to their similarity. The cluster analysis technology, which is a result of interdisciplinary development, involves such subjects as mathematics, statistics and computer science, and has been widely, successfully applied in many fields. The main function of this technology is to analyze the similarities among mass data and then cluster data sources according to their similarity. In this paper, *K*-means algorithm in clustering analysis is optimized and subsequently used for the clustering of the data about students' campus activities.

Using the optimized *K*-means algorithm, all the students are divided into four categories, each with prominently unique characteristics. The first category features average intellectual performance, mostly poorness and the lack of scholarship and competition award. The second one features relatively low-level intellectual performance, good financial condition, and the lack of scholarship and competition award. The third one features excellent competition performance, a very large amount of scholarship money, good intellectual performance and good financial condition. And the fourth one features the best intellectual performance, a large amount of scholarship money, mostly poorness, and average competition performance.

Through the analysis of data about students' campus activities, an intelligent analysis module is added to the student-work management computer system. The purpose of this campus-activity analysis is to enable the teachers to conduct classified student management in a more comprehensive, intelligent and accurate way. The optimized version of the cluster analysis algorithm *K*-means is applied to the clustering in the campus-activity analysis. In this paper, *K*-means algorithm is optimized; the approach of setting a clustering scope is used for selecting the number of *K* clusters in *K*-means algorithm; and the optimal *K* value is chosen by calculating the ratio of internal distance to external distance. In terms of the selection of the initial center point, several points featuring large density and great between-cluster distances are chosen herein, so as to enhance the clustering accuracy. The comparison between the traditional *K*-means algorithm and the optimized *K*-means algorithm demonstrates that the optimized one leads to better clustering effects.

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Study on Tourism Development and Protection under Computer-Based Virtual Tourism

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Abstract: Computer virtual tourism system is a simple type of virtual tourism system using computer and other equipment to implement interaction with virtual tourist attractions. Such virtual tourism system can only provide visual and audio (even tactile) experience for virtual tourists, thus having inferior sense of indulgence. However, the cost of development is low, the required equipment is unsophisticated, easy to popularize and generalize. This paper applies the computer virtual model in regional tourism development and protection, and acquires an overall appraisal of touring experience in combination with multi-factor analysis. According to the value of appraisal, the hard-to-quantify procedures during the researching process are addressed, and a reasonable system for tourism development and protection is contrived. Plus, a systematic exposition and analysis is conducted into the characteristics and applications of virtual tourism and other virtual tourism related conditions. It is hoped that more scholars' attentions can be raised within the industry to promote the theoretical exploration on virtual tourism and improve the theoretic system of virtual tourism.

Keywords: Tourism protection, computer virtualization, supervisory institution

1. Introduction

In the booming tourism, virtual tourism is a comparatively new subject of research. Whether in terms of theoretical or practical research, it remains in a starting stage and lacks certain theoretical analysis and guidance, requiring continuous exploration in both theory and practice to enrich and perfect its theoretical system. The tourism industry is burgeoning rapidly over the recent years so that the tourism resources in all places have been exploited deeply (Bill Kerr. et al., 2001). However, the issue of public tourism resource protection in the exploitation still receives inadequate attentions, academic research is rarely concerned with tourism, and even the construction of governmental system of rules and regulations is a brand new domain (Kenji Yoshida., 2004). Tourism resources are so valuable that they can hardly recover once devastated. Such is the case not only for tangible tourism resources but for intangible tourism resources(Na Li. 2010). Overuse of tangible tourism resources beyond its load of tourism will result in irreversible destruction; while intangible tourism resources are hardly restored within a short time period once impaired.

The mechanism of tourism development and protection is aimed at protecting integrity and sustainability of tourism industry (Wei Wang., 2009). Process supervision and control is adopted for tourism development. Qualitative and quantitative evaluations are given to the conducts produced by different tour subjects under different stages so as to keep tourism resources from being destructively exploited and to give sustainable play to their maximum effectiveness.

For the development of tourism industry in China, the practice of tourism development and construction with definite tourism planning has had almost a history of approximately 2 decades (Reynares, E., Caliusco, M. L., & Galli, M. R., 2014). Over the recent few years particularly, the state has attached considerable importance to the development of virtual tourism by investing in vast quantities of material and manpower resources for infrastructure construction of virtual tourism programs, which also fully manifests the resolution of socialism to implement the sustainable development strategy of virtual tourism (Zhengyu Ouyang., 2012). Nevertheless, due to the variance in geographical location and discrepancy of tourism resources between places, the virtual tourism programs have developed unbalanced (Zhiqiang Hou., 2003). Depending on the selection of virtual tourism locations and the bearing capacity of social environment, its degree of development will also vary accordingly. Harmonious interaction between human and nature is an inexorable demand for comprehensive development.

Radically speaking, virtual tourism is a comprehensive and systematic particular way of consumption predominated by consumption service. Through tourists' personal experience, and as tourists consume in the experience, it fosters a corresponding industry chain (Zhou Guozhong., 2007). Compared with traditional industries, the inter-dependency and internal association of the internal systems of virtual tourism industry will become even closer, and exert even direct and significant influence on the result of operation of virtual tourism industry as well as on the industry's sustainable development (Yang Wenjuan. et.al., 2012). Therefore, the virtual tourism industry can be regarded as an organic virtual system of supply chain with similar laws to life movement.

Just because of these characteristics with virtual tourism, the construction and operation of virtual tourism by local government are typically interactive, which can be called as a little leak will sink a great ship (Chen Xiaoying., 2013). Careful consideration should be given to virtual tourism construction programs in some regions with natural tourism resources. Precise consideration should be given to the interactions between all processes in virtual tourism, which is also a correct viewpoint of the real system adopted for the risk analysis in this case of virtual tourism.

2. Model Building

The development of traditional tourism industry precedes virtual tourism. Moreover, traditional tourism industry lays the emphasis on bringing about economic benefits for the local area. Consequently, there is excessively commercialized development around the destination of tourism, thereby prone to causing deprivation of resource effectiveness in some tourism regions and deterioration of the local environment. The issue of sustainable development of tourism industry is also closely linked with the environment on which humankind relies for survival. In order to find more comfortable and healthy primitive virtual living environment, we need to make joint efforts. Therefore, virtual tourism has increasingly received people's attentions. As shown in Figure 1, domestic touring populations in China increased year by year during 1998 - 2007.

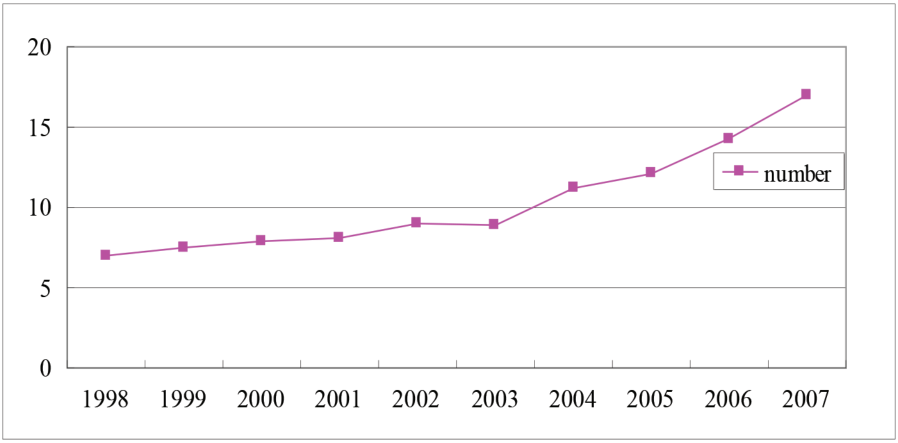

Figure 1 – Domestic Touring Population (in 10 Thousand) During 1998 - 2007

The ultimate objective of virtual tourism construction programs is to ensure healthy and sustainable development of the local resources and environment, which is inherently contradictory between increasing economic benefits and preventing the environment from being devastated(Bi Yanna. 2012). So whether the construction of virtual tourism programs and the risks produced in the operating process can be controlled effectively needs to be appraised effectively against whether the construction and operation of virtual tourism programs turn out successful. This issue has been discovered in many countries and regions which are also endeavoring to promote virtual tourism programs - which are on earth a kind of sustainable green tourism programs. From the perspective of sustainable development strategy, the development of virtual tourism programs is situated in a larger environment of system. For comprehensive exploitation of natural resources, virtual maintenance and economic sustainable development are achieved through environmental perception and educational approaches. The domestic revenues from tourism during 1998 - 2007 are shown in the following Figure 2.

2.1. Theory on Computer-Based Virtual Tourism Analysis and Evaluation

The comprehensive evaluation method in fuzzy mathematics converts qualitative evaluation into quantitative evaluation according to the theory of degree of membership in fuzzy mathematics, namely fuzzy mathematics is used to make an overall evaluation of things or objects which are restrained by multiple factors. With such characteristics as clear-cut result and strong systematicness, it can solve fuzzy and hard-to-quantify problems (Song Yongpeng., 2012; Zhou Yongzheng., 2010). The basic steps go as below:

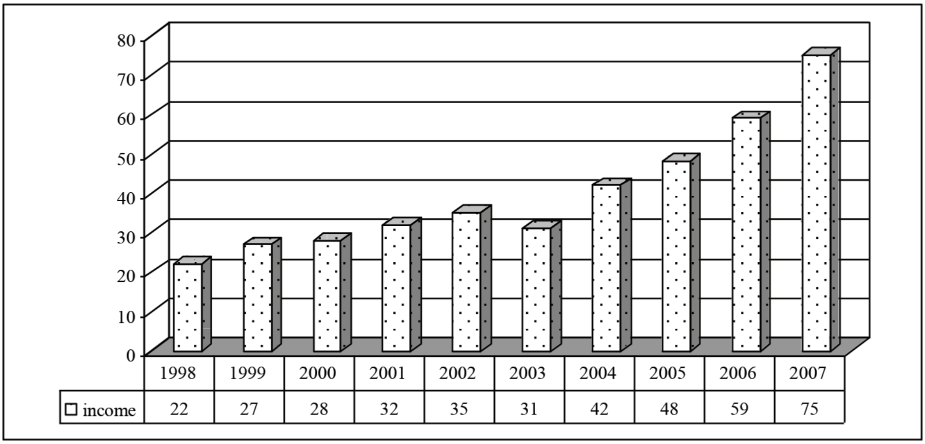

Figure 2 – Domestic Incomes (in 10 Thousand CNY) from Tourism During 1998 - 2007

1. Begin by determining a set of factors in the modeling process:

$$U = \{u_1, u_2, \cdots, u_n\}$$

2. Determine a set of judgment:

$$V = \{v_1, v_2, \cdots, v_m\};$$

3. Determine a fuzzy judgment matrix $R = (r_{ij})_{n \times m}$:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \quad (1)$$

First, make a judgment $f(u_i)(i = 1,2,\cdots,n)$ for each factor u_i to get a fuzzy mapping f from the set of factors U to the set of judgment V :

$$f : U \to F(U)$$
$$u_i \mapsto f(u_i) = (r_{i1}, r_{i2}, \cdots, r_{im}) \in F(V)$$

Next, find out a fuzzy relation $R_f \in F(U \times V)$ from f , namely:

$$R_f(u_i, v_j) = f(u_i)(v_j) = r_{ij}(i = 1,2,\cdots,n; j = 1,2,\cdots,m)$$

4. Weight setting, $A=(a_1,a_2,\cdots,a_n)\in F(U)$, and the condition of normalization is:

$$\sum_{i=1}^{n} a_i = 1 \quad a_i \ge 0$$

$$\begin{aligned} B &= A\cdot R \\ &= \left(a_1,a_2,a_3,\cdots,a_n\right)\cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \\ &= \left(b_1,b_2,b_3,\cdots,b_n\right) \end{aligned} \tag{2}$$

Comprehensive judgment: For weight $A=(a_1,a_2,\cdots,a_n)\in F(U)$, use model $M(\wedge,\vee)$ to take max-min synthetic operation to get a comprehensive judgment:

$$B = A\circ R \quad (\Leftrightarrow b_j = \bigvee_{i=1}^{n}(a_i \wedge r_{ij}),\, j=1,2,\cdots,m)$$

In the model building process, it is highly crucial to determine the set of judgment *V*. Starting from the realistic angle, this paper determines the fuzzy relation between regional tourism development and protection.

The fuzzy comprehensive judgment model selected in this paper during the model building process is (U, V, R). For the weight $A=(a_1,a_2,\cdots,a_n)\in F(U)$, the fuzzy judgment matrix is $R=(r_{ij})_{n\times m}$. By using the model $M(\wedge,\vee)$, the comprehensive judgment process is derived as $B=A\circ R=(b_1,b_2,\cdots,b_m)\in F(V)$, where $b_j=\bigvee_{i=1}^{n}(a_i\wedge r_{ij})\quad (j=1,2,\cdots,m)$.

The workflow of computer application of virtual tourism is shown as Figure 3.

2.2. Evaluation and Analysis of Computer-Based Virtual Tourism

Establish a set of factors U :

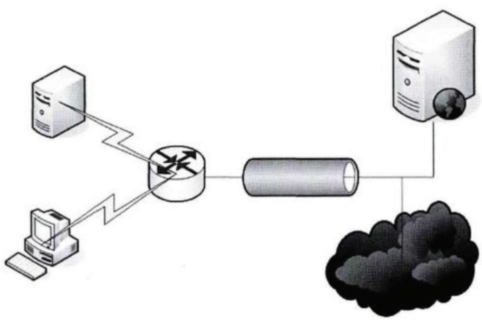

Figure 3 – Workflow of PC Transmission in Computer-Based Virtual Tourism

$$U = \begin{pmatrix} U_1 & U_2 & U_3 & U_4 \end{pmatrix}$$

Five key factors are tourism resource type U_1, government institution U_2, overview of tourism resources U_3, devastation and restoration of regional tourism U_4, and regional governance U_5, which create Table 2. This paper establishes tiny-factor sets among the sets of the five key factors.

Tourism resource type u_1	**Government institution u_2**	**Overview of tourism resource u_3**	**Devastation and restoration of regional tourism u_4**	**Regional governance u_5**
Virtual and Natural Tourism Resources u_{11}	Issue of Over-development u_{21}	Environmental Capacity u_{31}	Virtual Vulnerability u_{41}	Range and Mode of Development u_{51}
Non-material Heritage Tourism Resources u_{12}	Issue of Tourism Demarcation u_{22}	Environmental Sensitivity u_{32}	Post-Destruction Recoverability u_{42}	Intensity of Protection u_{52}
Modern Tourism Resources u_{12}	Supervisory Institution u_{23}	—	—	—
—	Issue of Property u_{24}	—	—	—

Table 1 – Evaluation Index System of Virtual Tourism Development and Protection

Sets of evaluation are obtained via the above factors.

$$U_1 = \{u_{11}, u_{12}, u_{13}\};$$

$$U_2 = \{u_{21}, u_{22}, u_{23}, u_{24}\};$$

$$U_3 = \{u_{31}, u_{32}\};$$

$$U_4 = \{u_{41}, u_{42}\};$$

$$U_5 = \{u_{51}, u_{52}\};$$

In the model building process, a ranking matrix is obtained in terms of tourism resource type U_1, government institution U_2, overview of tourism resources U_3, devastation and restoration of regional tourism U_4 and regional governance U_5.

A weighting vector is obtained in the ranking process:

$$\beta = \{\beta_1, \beta_2, \beta_3, \beta_4, \beta_5\} = \{0.3, 0.3, 0.2, 0.1, 0.1\}$$

$$U_i^* = U_i \cdot \beta^T$$

$$U_1^* = 10\, , U_2^* = 9.4\, , U_3^* = 5.6\, , U_4^* = 4\, , U_5^* = 4$$

Normalization is processed:

$$U_1^* = 0.303\, , U_2^* = 0.285\, , U_3^* = 0.170\, , U_4^* = 0.121\, , U_5^* = 121$$

To get,

$$\bar{A} = \begin{pmatrix} 0.303 & 0.285 & 0.170 & 0.121 & 0.121 \end{pmatrix} a$$

Construction of simple tourism scenery under a virtual computer is shown as Figure 4.

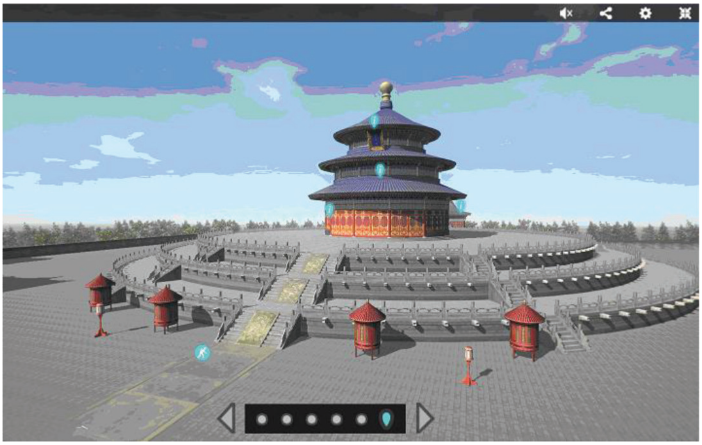

Figure 4 – Computer Virtualized Tourism Scenery

Through the evaluation of regional tourism development and protection in terms of tourism resource type U_1, government institution U_2, overview of tourism resources U_3, devastation and restoration of regional tourism U_4 and regional governance U_5, this paper derives Table 3.

This paper derives the fuzzy sets of weighting factors with single-layered indicators as:

$$U_1^* = \{U_{11}, U_{12}\} = \{0.5, 0.25, 0.25\}$$

$$U_2^* = \{U_{21}, U_{22}, U_{23}, U_{24}\} = \{0.54, 0.1, 0.24, 0.14\}$$

$$U_3^* = \{U_{31}, U_{32}\} = \{0.4, 0.6\}$$

Each indicator,	value	Each indicator	value
The ecological, natural tourism resources u_{11}	Very good	The capacity of the environment u_{31}	Good
The intangible cultural heritage tourism resources u_{12}	General	Environmental sensitivity u_{32}	Good
Modern tourism resources u_{13}	Very good	The ecological fragile degree u_{41}	Good
The excessive development u_{21}	Very good	Recovery after failure u_{42}	General
Tourism planning problem u_{22}	General	Development of the scope and method u_{51}	Good
The supervision system u_{23}	Very good	The degree of protection u_{52}	General
Property rights u_{24}	General		

Table 2 – Evaluation Value of Regional Tourism Development and Protection

$$U_4^* = \{U_{41}, U_{42}\} = \{0.55, 0.45\}$$

$$U_5^* = \{U_{51}, U_{52}\} = \{0.65, 0.35\}$$

Compute and get the sets of evaluation in terms of tourism resource type U_1, government institution U_2, overview of tourism resources U_3, devastation and restoration of regional tourism U_4 and regional governance U_5.

Influential power of tourism resource type:

$$U_1 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Influential power of government institution:

$$U_2 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Influential power of overview of tourism resources:

$$U_3 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

Influential power of devastation and restoration of regional tourism:

$$U_4 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \end{pmatrix}$$

Influential power of regional governance:

$$U_5 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$$

According to the formula:

$$B_i = A_i \cdot R_i$$

Apply normalization to the obtained B_i to get a fuzzy evaluation matrix:

$$\bar{B} = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{pmatrix} = \begin{pmatrix} 0.07 & 0.26 & 0.13 & 0.42 \\ 0 & 0.15 & 0.76 & 0.54 \\ 0.14 & 0.24 & 0.21 & 0.17 \\ 0.14 & 0.2 & 0.3 & 0.36 \end{pmatrix}$$

And the values of comprehensive evaluation:

$$Z = U^* \cdot B = \begin{pmatrix} 0.33 & 0.28 & 0.21 & 0.18 \end{pmatrix}$$

Judged from the values of fuzzy comprehensive evaluation, since $0.33 > 0.28 > 0.21 > 0.18$, the rank of the values of evaluation is higher. In computer-based virtual regional tourism development and protection, the five aspects - tourism resource type, government institution, overview of tourism resources, devastation and restoration of regional tourism, and regional governance - are a good layer of decision-making playing a dominant role in evaluating and designing releant matters regarding regional tourism development and protection(Wan Xinghuo., 2007; Li Sumin., 2008; Xue Lei., 2007; Jiang Huixian, Lin GuangFa., 2005). The human-computer interaction processes in virtual tourism process are shown in Figure 5:

3. Conclusion

Virtual tourism is a relatively new subject of research, remaining at the starting stage in both terms of theoretical and practical researches, lacking certain theoretical analysis and guidance, and requiring continuous exploration in both theory and practice to enrich and improve its theoretical system. Virtual tourism is a comprehensive and systematic form of tourism, and particular way of consumption predominated by consumption service. Through tourists' personal experience, and as tourists consume in the experience, it fosters a corresponding industry chain. Compared with traditional industries, the inter-dependency and internal association of the internal systems of

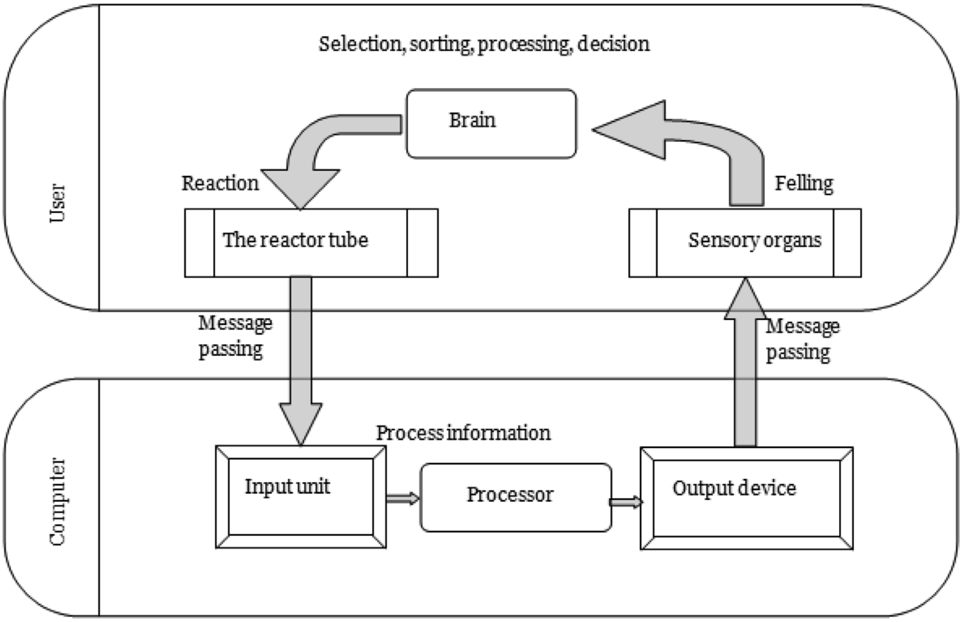

Figure 5 – Human-Computer Interaction Processes

virtual tourism industry will become even closer, and exert even direct and significant influence on the result of operation of virtual tourism industry as well as on the industry's sustainable development. Therefore, the virtual tourism industry can be regarded as an organic virtual system of supply chain with similar laws to life movement.

The ultimate objective of virtual tourism construction programs is to ensure healthy and sustainable development of the local resources and environment, which is inherently contradictory between increasing economic benefits and preventing the environment from being devastated. So whether the construction of virtual tourism programs and the risks produced in the operating process can be controlled effectively needs to be appraised effectively against whether the construction and operation of virtual tourism programs turn out successful. This issue has been discovered in many countries and regions which are also endeavoring to promote virtual tourism programs - which are on earth a kind of sustainable green tourism programs. From the perspective of sustainable development strategy, the development of virtual tourism programs is situated in a larger environment of system. For comprehensive exploitation of natural resources, ecological maintenance and economic sustainable development are achieved through environmental perception and educational approaches. On the base of predecessors' accomplishments of research, this paper defines the concept of virtual tourism and conducts systematic exposition and analysis into the characteristics and applications of virtual tourism and other virtual tourism related theories. It is hoped that more scholars' attentions can be raised within the industry to promote the theoretical exploration on virtual tourism and improve the theoretic system of virtual tourism.

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Evaluation Study on the Integrated Application of Computer Information Technology in the Development and Protection of Regional Tourism

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Abstract: There is a very wide application of computer information technology in The Development and Protection of Regional Tourism teaching and with the development of multimedia technology, the application has a breakthrough. In higher vocational The Development and Protection of Regional Tourism teaching, on the premise of paying attention to complete course design, teachers should also tap into the application of computer technology both in breadth and depth on a larger scale. This study combines corresponding multimedia technology with specific teaching design model and then with the aid of mathematical model for comprehensive evaluation of teaching effect to achieve better teaching results. An analysis on the key technologies of computer information technology is specially conducted and the model of The Development and Protection of Regional Tourism teaching based on computer information technology is designed. With the adoption of experiment teaching method and fuzzy comprehensive evaluation, the remarkable results of "cloud computing" as an auxiliary teaching technology, FLEX technology in construction of The Development and Protection of Regional Tourism listening test system, the construction of The Development and Protection of Regional Tourism autonomous teaching mode in computer network environment as well as the integration of computer multimedia teaching technology and other varieties of computer information technology into The Development and Protection of Regional Tourism teaching are verified in hope of increasingly spreading computer information technology in The Development and Protection of Regional Tourism teaching to realized efficient and vivid The Development and Protection of Regional Tourism lessons.

Keywords: Multimedia technology, Higher vocational The Development and Protection of Regional Tourism, Teaching design, Teaching experiment, Comprehensive evaluation.

1. Introduction

The Development and Protection of Regional Tourism teaching is a language teaching which involves training the five skills of listening, speaking, reading, writing and translating. It requires stimulating learners all around and leading learners into the language teaching environment. In traditional The Development and Protection of Regional Tourism listening teaching, recorder and other electronic equipment have been introduced and actually the prototype of multimedia teaching has appeared. However, with the rapid development of multimedia technology nowadays, The Development and Protection of Regional Tourism teaching has been made better. This study just focuses on the key technologies of multimedia technology in order to verify the positive effect of multimedia technology in higher vocational The Development and Protection of Regional Tourism teaching through designing teaching model and teaching experiment.

Many studies have been made on multimedia technology and its application in teaching. For example (He Gaoda. etc., 2007) made an analysis on the environment of multimedia assisted college The Development and Protection of Regional Tourism teaching and learning and discussed such questions as the adaptation strategy, resource development (Felizardo, V., Sousa, P., Oliveira, D., Alexandre, C., Garcia, N. C., & Garcia, N. M., 2014), teaching mode as well as management and evaluation in multimedia assisted college The Development and Protection of Regional Tourism teaching and learning environment. (Zhang Zhihua. etc., 2011) carried on an empirical analysis on college students' satisfaction with multimedia The Development and Protection of Regional Tourism teaching process adopting factor analysis in multivariate statistical analysis. (Jiang Baiqiang., 2013) pointed out that multimedia teaching with its unique function caters to the requirements of new curriculum reform and makes The Development and Protection of Regional Tourism classroom teaching revitalized. (Wang Yongguo. etc., 2014) proposed multimedia teaching network central controller system based on ARM11 processor system by making use of its upper computer software frame to control start-stop of the total power, computer and projector' s start-up and shut-down as well as the screen's rise and fall in multimedia classrooms controlled by wireless network. (Li Jiang. etc., 2015) studied the concrete application of four dimensional mapping from the three aspects of multimedia theoretic knowledge teaching, software tools teaching and creation of works, and summarized the application methods and skills in order to promote the reform of course teaching and improve teaching quality.

The above studies can be roughly divided into teaching evaluation, multimedia technology and teaching application, but the relationship with teaching experiment has not been established. If the corresponding multimedia technologies are combined with specific teaching design model, which is done in this study, and then make comprehensive evaluation for teaching effect with the help of mathematical model, better research results would be achieved and meanwhile the unique application of multimedia technology in higher vocational The Development and Protection of Regional Tourism teaching would also be revealed.

2. Multimedia the Development and Protection of Regional Tourism Teaching Projection Model

Multimedia technology (multi-media technology, MMT) refers to the technology of integrating image information into interactive interface by using computer technology (Zhang Chunlai., 2012). It has three basic characteristics (Hu Hang. 2000): multi-dimensionality, integration and interactivity. Just because of the above three characteristics of MMT, its application becomes increasingly extensive and its application in teaching is more outstanding. The purpose of this study is to design The Development and Protection of Regional Tourism teaching system through applying multimedia technology, expecting to realize efficient and vivid The Development and Protection of Regional Tourism teaching classrooms.

2.1. Multimedia Technology

The key technologies for MMT are mainly audio processing technology (Tian Ping, Tian Feng., 2015) (APT), video processing technology (VPT), image processing technology (Yi Zhun., 2014) (IPT) and cartoon processing technology (Zhang Zhun., 2013) (CPT) as well as Flash technology. The implementation of APT is realized by Cool Edit Pro Software, the implementation of VPT by Corel VideoStudio Software, the implementation of IPT by Photoshop Software and the implementation of CPT by Animator Pro Software.

The purpose of applying APT for audio processing lies in audio segmentation, noise reduction and sound beautification, etc., among which, noise reduction processing is the key application of Cool Edit Pro Software. The expression for the model of voice with noise can be written as shown in formula (1), in which $s(n)$ stands for pure voice, $d(n)$ stands for noise and $y(n)$ stands for voice with noise. The purpose of noise reduction is to filter out $d(n)$ by means of wave filtering or reduce $d(n)$ as much as possible.

$$y(n) = s(n) + d(n) \tag{1}$$

This study applies adaptive noise canceler and the filter to conduct noise reduction processing for voice with noise. The principle of this filter (Lun Shuxian. et al., 2003) is shown in figure 1:

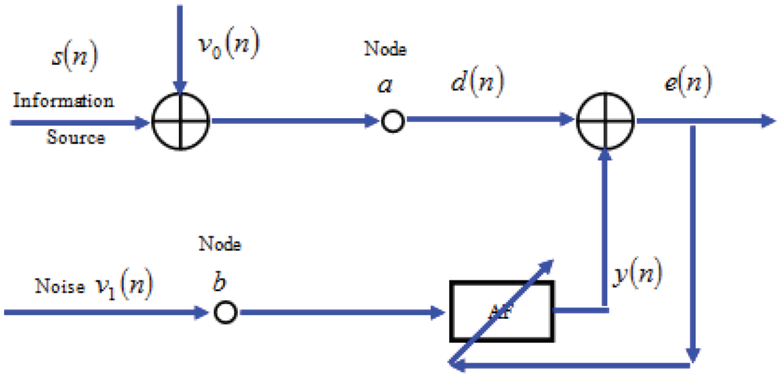

Figure 1 – Schematic diagram for audio noise filter

In Figure 1, the sensor receiving signal not only receives $s(n)$, but also receives a noise field. The original input is an interfered signal $d(n)$ that is the overlay of $s(n)$ with $v_0(n)$. Because the reference input $v_1(n)$ is relevant to $v_0(n)$, but irrelevant to $s(n)$, and the original input is added to end a of the adaptive filter, while the reference input is added to end b of the adaptive filter (AF) that allows the control of error $e(n)$ and thus makes output $y(n)$ approximate to $v_0(n)$ in a larger degree, the output results close to information source are realized and the purpose of noise reduction is achieved.

The purpose of applying VPT for processing video is to complete video footage clips and composition, subtitles adding, effect converting and other screen display effects. Due to the large storage space for video files, it is very necessary to adopt reasonable video compression technology. Video compression usually includes steps of sampling, pre-processing, interframe prediction, transformation, quantization, entropy coding and packaging, etc., as shown in Figure 2 Video compression encoding block diagram (Lv Ning, Liu Ying., 2015):

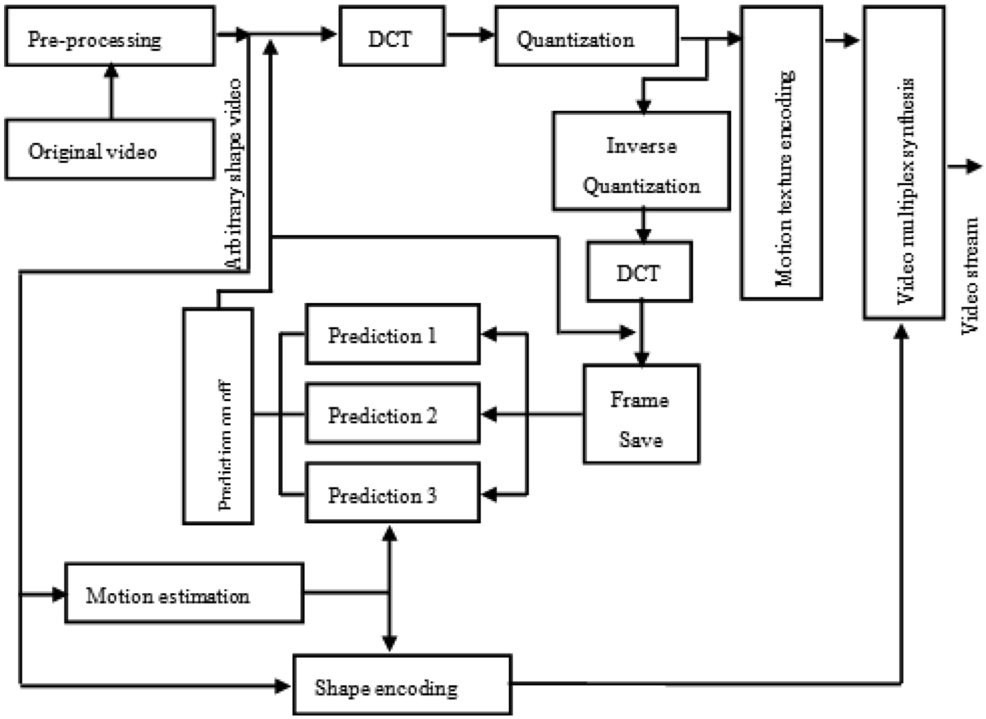

Figure 2 – Video Compression Encoding Block Diagram

IPT is applied to image cropping and an effect adding in multimedia, CPT is applied to making two-dimensional animation courseware, while the final presentation of applying teaching courseware is mainly by the means of Flash.

2.2. Construction of FLEX Application Model

The FLEX application program adopts a real-time model for compiling to ensure the continuity of users' experience. The program conducts compiling on the first call and then it is stored in the client cache for later call. When any relevant documents are updated, the FLEX application program will automatically recompile accordingly. Standard FLEX application program does not require service from the server and it can conduct compiling locally and directly deploy it on the server's page. Figure 3 shows the working principle of FLEX technology applied in The Development and Protection of Regional Tourism listening test system.

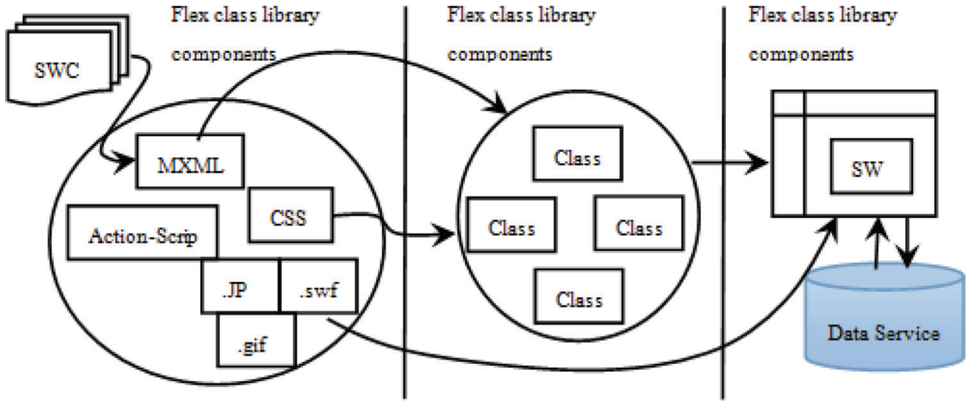

Figure 3 – Working Principle of FLEX Technology in the Development and Protection of Regional Tourism Listening Test System.

On the server's side, BlazeDS exists in JAVA application server in the way of Servlet and it provides 3 types of communication services, remote call-in, and message service and access agency. Meanwhile, the framework allows you to add custom service. The structure of the server is shown in Figure 4.

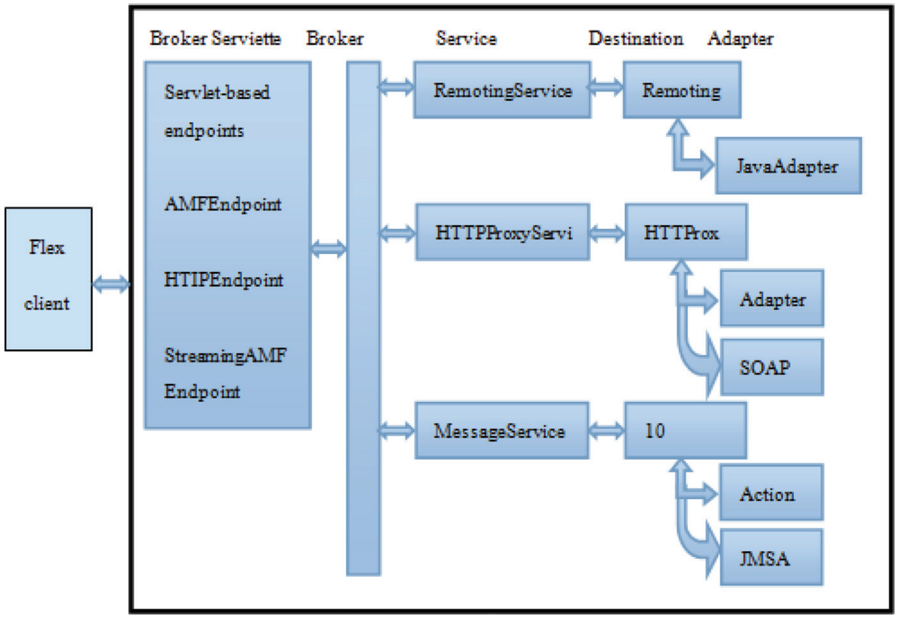

Figure 4 – BlazeDS Structure of the Server

2.3. Construction of Teaching Projection Model

Teaching projection (TP) is the necessary channel linking to practical teaching. The relationship between different elements in teaching system and the demand in different teaching processes can be clarified through TP(He Kekang. et al,2002) in order to guide practical teaching. TP model is a theoretic construction of ideal teaching activities, a simplification form for describing the structure of teaching and learning activities or the stable relationship between different elements in the process, and a theory form reflecting or reproducing real teaching activities. The constructed teaching projection model for higher vocational The Development and Protection of Regional Tourism teaching based on computer technology is shown in Figure 5.

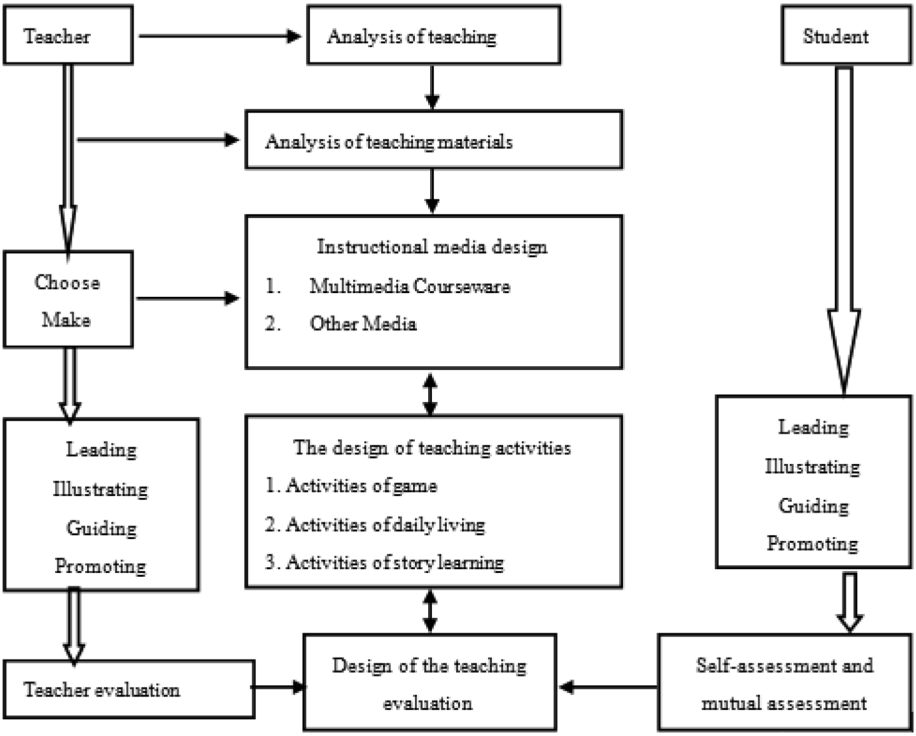

Figure 5 – Higher Vocational the Development and Protection of Regional Tourism Teaching Projection Model Based on Computer Technology

3. Model Construction for Teaching Experimental Design and Comprehensive Evaluation

3.1. Teaching Experimental Design

This study selected a class of Grade One in a higher vocational school for implementing experiment teaching activities and conducted a questionnaire survey among 412 students receiving computer assisted The Development and Protection of Regional Tourism teaching. In the survey, students are required to make curriculum evaluations according to actual situation. Totally 412 questionnaires were handed out and 400 effective questionnaires were collected. The semester began from September 8, 2014 and the experiment teaching material was selected from “Gump Forrest”. Through the contrast of effects in The Development and Protection of Regional Tourism listening and oral The Development and Protection of Regional Tourism teaching, this teaching experiment verified the effects of computer assisted higher vocational The Development and Protection of Regional Tourism teaching. The independent variable in the experimental course was computer assisted The Development and Protection of Regional Tourism teaching methods, while the target variables were instructionality, scientificity, technicality, artistry, learnability and organization of teaching activities. Teaching stages were divided into five stages as shown in Table 1:

In accordance with the basic experiment teaching schemes as shown in Table 1, the concrete implementation processes of this experimental lesson is as follows:

- play simple The Development and Protection of Regional Tourism dialogue without background sound. Play twice in succession and then students are asked to complete self evaluation and quiz.
- Play The Development and Protection of Regional Tourism dialogue with background sound. Play twice in succession and students are asked to complete self evaluation and quiz.
- Play The Development and Protection of Regional Tourism dialogue with background sound and provide scene prompt information synchronously with PPT. Play twice in succession and students are asked to complete self evaluation and quiz.
- Play The Development and Protection of Regional Tourism dialogue with background sound and synchronously play video clip. Play twice in succession and students are asked to complete self evaluation and quiz.
- First give scenario introduction by E-text, then play listening teaching materials which are The Development and Protection of Regional Tourism dialogues with background sound, and play video clip synchronously. Play twice in succession and students are asked to complete self evaluation and quiz.

Stage of teaching	**New multimedia elements**	**Form of multimedia art**	**Stage teaching output**
First stage	Dialogue voice	Video audio clips	Quiz scores and students' comments
Second stage	Background sound	Video audio clips	Quiz scores and students' comments
Third stage	Picture	PPT	Quiz scores and students' comments
Fourth stage	Video	Video clips	Quiz scores and students' comments
Fifth stage	Text	E-text	Quiz scores and students' comments

Table 1 – Teaching Projection Scheme

3.2. Construction of Evaluation Index System

The integration of computer technology into The Development and Protection of Regional Tourism teaching will exert positive influence on teaching effect, but it needs to construct the evaluation index system and evaluation model to measure the influence quantitatively.

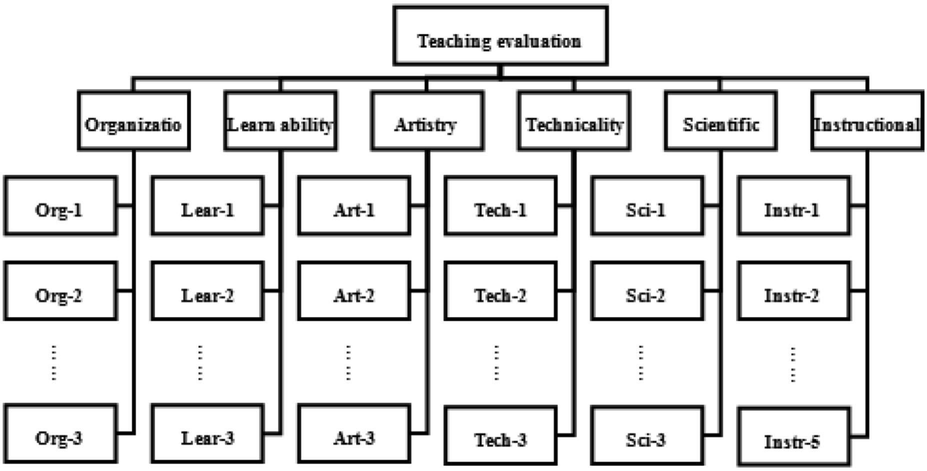

Figure 6 – Evaluation Index System for Computer the Development and Protection of Regional Tourism Teaching

This study designs an index system taking Instructional, Scientificity, Technicality, Artistry, Learnability and Organization of teaching activities as its evaluation criteria. The indexes for criterion Instructional are Instr-1-specific goals, Instr-2-richness of teaching mode, Instr-3-rationality and scientificity of selected materials, Instr-4-rationality of The Development and Protection of Regional Tourism teaching projection and Instr-5-appropriateness of selected topic; The indexes for criterion Scientificity are Sci-1-specification of pictures and texts, Sci-2-novelty of The Development and Protection of Regional Tourism teaching mode, Sci-3-standardization of The Development and Protection of Regional Tourism language environment, Sci-4-authenticity and realism of selected materials and Sci-5-logic; The indexes for criterion Technicality are Tech-1-stability of courseware operation, Tech-2-interactivity and navigation function, Tech-3-friendly interface and image clarity, Tech-4-ease of operation, control, installation and unloading, and Tech-5-storage security and compatibility of software running; The indexes for criterion Artistry are Art-1-graphic audio-visual elegancy and harmony, Art-2-intuitively and vividly present teaching content, Art-3-concise and beautiful layout, Art-4-audio clarity of background sound and music, and Art-5-novel technique of expression, vivid and interesting plot; The indexes for criterion Learnability are Lear-1-large amount of information and rich resources, Lear-2-cultivating and training students' such basic skills as listening, speaking, reading, writing and translating, Lear-3-with functions of evaluation and timely feedback of learning effects; Lear-4-rich and appropriate cultural input, and Lear-5-cultivating learners' autonomous learning and innovation ability; The indexes for criterion Organization are Org-1-focusing on key points, scattering difficult ones and explaining the profound in simple terms during teaching, Org-2-explaining, questioning and inspiring students from multiple perspectives to arouse students' enthusiasm, Org-3-giving play to teacher's guidance and strengthening the interactivity between teachers and students, Org-4-targeted teaching content and method and implementation of personalized teaching, and org-5-orderly classroom organization and management, proper allocation of teaching time and adjustment of classroom atmosphere. Through designing the above criteria and indexes, the evaluation index system can be obtained as shown in Figure 6.

3.3. Fuzzy Comprehensive Evaluation Model

The higher vocational The Development and Protection of Regional Tourism teaching evaluation system integrated with computer technology in this study is a secondary fuzzy multi-objective decision making system. Steps for the model construction and application are shown below (Hu Shuli., 1994):

STEP1. Get the factor set $U=\{x_1,x_2,\cdots,x_n\}$ divided into six sub factor sets according to the six criteria. $u_i=\{x_{i1},x_{i2},\cdots,x_{i5}\}$, and it meets $u_1\cup u_1\cup\cdots\cup u_s=U$ and $u_i\cap u_j=\varnothing,(i\neq j)$.

STEP2. Make primary fuzzy multi-objective decision for each sub factor set u_i, and set the evaluation set $V=\{y_1,y_2,\cdots,y_m\}$. The weight allocation of each factor in u_i for V is $A_i=\{a_{i1},a_{i2},\cdots,a_{im}\}$. Set R_i as single factor evaluation matrix, then the primary evaluation vector $B_i=A_i\circ R_i=(b_{i1},b_{i2},\cdots,b_{im}),(i=1,2,\cdots,s)$ can be obtained.

STEP3. Regard each u_i as a factor, set $K=\{u_1,u_2,\cdots,u_s\}$, then K constitutes another set of factors. The single factor evaluation matrix is composed of primary evaluation vector:

$$R=\begin{bmatrix}B_1\\B_2\\\vdots\\B_s\end{bmatrix}=\begin{bmatrix}b_{11}&b_{12}&\cdots&b_{1m}\\b_{21}&b_{22}&\cdots&b_{2m}\\\vdots&\vdots&&\vdots\\b_{s1}&b_{s2}&\cdots&b_{sm}\end{bmatrix}$$

In the above formula, as part of U, u_i reflects certain attribute of U and weight allocation $A=(a_1,a_2,\cdots,a_s)$ can be given according to their importance, then secondary fuzzy multi-objective decision making $B=A\circ R=(b_1,b_2,\cdots,b_m)$ can be obtained.

In order to determine the weight of each factor, this study adopts fuzzy analytic hierarchy process (FAHP) for determining weight. The factor set is still $U=\{x_1,x_2,\cdots,x_n\}$. Triangle fuzzy number is used to express comparisons between any two factors quantitatively, i.e. when factor x_i is obviously more important than factor x_j, it is expressed with the triangular fuzzy number $a_{ij}=(L,5,P)$, in which L,P represents the fuzzy degree of judgment. Greater $P-L$ shows higher fuzzy degree of judgment. When $P-L=0$, it is very fuzzy. When $\frac{n(n-1)}{2}$ fuzzy judgments are made, fuzzy judgment matrix $A=(a_{ij})_{m\times n}$ composed of triangular fuzzy number can be got. "Fuzzy judgment degree" of defining factor x_i to other factors is defined in function (2), the definition of all factors' "overall fuzzy judgment degree" is shown in function (3), the definition of "comprehensive fuzzy degree" of factor x_i to other factors is shown in function (4), and the "comprehensive importance" $d(x_i)$ of factor x_i compared with other factors is shown in function (5). After getting the weight vector of each factor as shown in function (6), make it normalized. In the above discussed functions (2)-(6), $\oplus$ stands for generalized addition and $\oplus$ stands for generalized multiplication.

$$m(x_i)=a_{i1}\oplus a_{i2}\oplus\cdots\oplus a_{in}=\sum_{j=1}^{n}\oplus a_{ij},(i=1,2,\cdots,n) \tag{2}$$

$$m(X)=m(x_1)\oplus m(x_2)\oplus\cdots\oplus m(x_n)=\sum_{i=1}^{n}\oplus m(x_i) \tag{3}$$

$$S_i = m(x_i)\otimes m(X)^{-1} \tag{4}$$

$$d(x_i)=K(S_i\geq S_1,S_2,\cdots,S_n)=\min_{k=1,2,\cdots,n,(k\neq i)} K(S_i\geq S_k) \tag{5}$$

$$W\left(d(x_1),d(x_1),\cdots,d(x_1)\right) \tag{6}$$

4. Empirical Evaluation

The weight of each index is determined with the FAHP method and the results are shown in Table 2:

Criteria		**Secondary indexes**		**Criteria**		**Secondary indexes**	
Name	**Weight**	**Name**	**Weight**	**Name**	**Weight**	**Name**	**Weight**
Instructional	0.20	Instr-1	0.20	Artistry	0.10	Art-1	0.20
		Instr-2	0.22			Art-2	0.24
		Instr-3	0.20			Art-3	0.22
		Instr-4	0.22			Art-4	0.16
		Instr-5	0.16			Art-5	0.18
Scientificity	0.15	Sci-1	0.18	Learnability	0.20	Lear-1	0.18
		Sci-2	0.24			Lear-2	0.24
		Sci-3	0.22			Lear-3	0.20
		Sci-4	0.20			Lear-4	0.16
		Sci-5	0.16			Lear-5	0.22
Technicality	0.15	Tech-1	0.25	Organization	0.20	Org-1	0.22
		Tech-2	0.22			Org-2	0.24
		Tech-3	0.22			Org-3	0.20
		Tech-4	0.17			Org-4	0.18
		Tech-5	0.14			Org-5	0.16

Table 2 – List of Results for Each Layer of Index Weight

It can be obtained from the statistical results of survey that the percentages for students' evaluation on computer teaching as excellent, good, qualified and unqualified are 30%, 35%, 26% and 9% respectively, so it can be expressed as shown in function (7):

$$T_1 = \{0.30, 0.35, 0.26, 0.09\} \tag{7}$$

In this way, the judgment results of the other four factors' fuzzy sets can be obtained. The fuzzy evaluation matrix V_1 for Instructional is shown in function (8):

$$V_1 = \begin{bmatrix} 0.30 & 0.35 & 0.26 & 0.09 \\ 0.16 & 0.40 & 0.36 & 0.08 \\ 0.41 & 0.38 & 0.14 & 0.07 \\ 0.18 & 0.33 & 0.41 & 0.08 \\ 0.20 & 0.35 & 0.28 & 0.17 \end{bmatrix} \tag{8}$$

Then use the Instr-1~Instr-5 weight coefficients as shown in Table 2 for weighted average and the primary evaluation scale for indexes of Instructional can be obtained as shown in function (9).

$$R_1 = \begin{bmatrix} 0.20 \\ 0.22 \\ 0.20 \\ 0.22 \\ 0.16 \end{bmatrix}^T \cdot \begin{bmatrix} 0.30 & 0.35 & 0.26 & 0.09 \\ 0.16 & 0.40 & 0.36 & 0.08 \\ 0.41 & 0.38 & 0.14 & 0.07 \\ 0.18 & 0.33 & 0.41 & 0.08 \\ 0.20 & 0.35 & 0.28 & 0.17 \end{bmatrix} = \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \end{bmatrix} \tag{9}$$

In accordance with the calculation method as shown in function (9), primary evaluation scale $R_2, R_3, \cdots, R_6$ for Scientificity, Technicality, Artistry, Learnability and Organization can be obtained successively and then get the evaluation matrix *S* as shown in function (10):

$$S = \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \\ 0.27 & 0.33 & 0.29 & 0.11 \\ 0.30 & 0.32 & 0.28 & 0.10 \\ 0.27 & 0.31 & 0.27 & 0.15 \\ 0.26 & 0.30 & 0.30 & 0.15 \\ 0.28 & 0.31 & 0.29 & 0.12 \end{bmatrix} \tag{10}$$

Then use the weight coefficients of Scientificity, Technicality, Artistry, Learnability and Organization as shown in Table 2 for weighted average and get the comprehensive evaluation results *F*:

$$F = \begin{bmatrix} 0.20 \\ 0.15 \\ 0.15 \\ 0.10 \\ 0.20 \\ 0.20 \end{bmatrix}^T \cdot \begin{bmatrix} 0.25 & 0.36 & 0.29 & 0.10 \\ 0.27 & 0.33 & 0.29 & 0.11 \\ 0.30 & 0.32 & 0.28 & 0.10 \\ 0.27 & 0.31 & 0.27 & 0.15 \\ 0.26 & 0.30 & 0.30 & 0.14 \\ 0.28 & 0.31 & 0.29 & 0.12 \end{bmatrix} = \begin{bmatrix} 0.27 & 0.32 & 0.29 & 0.12 \end{bmatrix} \tag{11}$$

It is made clear in function (11).

5. Conclusion

The Development and Protection of Regional Tourism teaching is a language teaching which involves training the five skills of listening, speaking, reading, writing and translating. It requires stimulating learners all around and leading learners into the language teaching environment. In traditional The Development and Protection of Regional Tourism listening teaching, recorder and other electronic equipment have been introduced and actually the prototype of multimedia teaching has appeared. However, with the rapid development of multimedia technology nowadays, The Development and Protection of Regional Tourism teaching has been made better.

For the comprehensive evaluation results of computer technology integrating into higher vocational The Development and Protection of Regional Tourism teaching, 27% are excellent, 32% are good, 29% are qualified and 12% are unqualified, so computer technology plays a certain positive role in higher vocational The Development and Protection of Regional Tourism teaching and it can effectively improve teaching quality.

The trend for computer technology development in future lies in its design supporting software algorithm and improvement in hardware performance. The application of computer information technology into The Development and Protection of Regional Tourism teaching not only relies on the degree of advanced technology, but also relies more on the rationality of curriculum design and the teacher's originality. This study makes a design for higher vocational The Development and Protection of Regional Tourism teaching based on survey. Through experiment design and results and with the application of fuzzy comprehensive evaluation model, the teaching effects are reviewed. The final evaluation results show that the cloud computing technology in assisting teaching, FLEX technology in constructing The Development and Protection of Regional Tourism listening test system, the construction of The Development and Protection of Regional Tourism autonomous teaching mode through the computer network environment as well as computer multimedia teaching technology and other varieties of computer information technology integrated into The Development and Protection of Regional Tourism teaching have very significant effects. Therefore, higher vocational The Development and Protection of Regional Tourism teaching projection based on computer technology has quite good practical effect and it can be promoted in a certain range. If applied to teaching of other subjects, it needs to be redesigned and adjusted.

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Research on the Inheritance and Extension of Ya Drum in Cixian County Based on Computer Prediction System

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Abstract: The Ya Drum in Cixian County has a long history and its inheritance and extension have attracted the attention of people. This study discusses the ARMA model, ARIMA model and CAR model and based on these three types of time series models, researches the prediction and forecasting system from the six aspects of method, category, classification, basic model, structure and data acquisition system of computer prediction and forecasting. Stationary time series based on computer prediction and non-stationary time series based on computer prediction are respectively discussed. Computer-based time series predictions are conducted focusing on the inheritance and extension of the Ya Drum in Cixian County. The inheritance and extension modes of the Ya Drum in Cixian County and the functional relationship between quantity and time as well are provided. Additionally, comparisons are made between the predicted values and actual values, proving the rationality of predicted results. The results show that in future development, the number of inheritance and extension modes of the Ya Drum in Cixian County will continue to grow, but the speed of growth will slow down. To improve this situation, reasonable suggestions are put forward.

Keywords: The Ya Drum in cixian county, time series model, computer prediction, inheritance and extension

1. Introduction

Prediction is inferring or estimation for the development direction and process as well as possible results of things. Scientific prediction is the premise of decision making and it provides reliable basis for plan making and choosing. The Ya Drum in Cixian County has a long history and the earliest document about it can be traced back to Song Dynasty (Zhang Haoling., 1988). The Ya Drum in Cixian County is one of the forms of art that laboring people are favorite with. With the inheritance and carrying-forward of traditional culture, the Ya Drum in Cixian County is also being inherited and extended in various types of modes (Li Runsheng., 2013; Liu Jiangyuan, Tian Qing., 2014; Liu Na. et al., 2011). The Ya Drum in Cixian County has its unique artistic form, so its inheritance and extension also have special rules and modes. In the current great boom of culture, the continuous development and extension of traditional Chinese art forms like the Ya Drum in Cixian County and the unceasing inheritance of Chinese culture can be only realized through inheriting cultural tradition and constantly protecting and developing traditional arts (Xiang Chang-sheng, Zhou Zi-ying., 2010; Guan Xiaoyan. et al., 2011). As time shifts, the Ya Drum in Cixian County, as a profound traditional art form existing from ancient times till now, has its own evolution rule and great opportunities to development as well (Liu Juan. et al.,2005). In the new century when the protection of national folk culture is attached great importance to, only through expanding and creating a contemporary mode of manifestation and advancing with time, can a new historical change of the Ya Drum in Cixian County be realized and then develops sustainably ever after.

2. The Extension Modes of the Ya Drum in Cixian County

2.1. Inheritance Mode Based on Folk Group

Faced with the current increasingly deteriorating cultural ecological environment, we should not only win support from functional government departments for the inheritance and protection of the Ya Drum in Cixian County, but also should actively explore new ways for the Ya Drum's inheritance and protection independently (Jun Chao., 2014). First of all, social forces should be encouraged to hold various activities associated with Ya Drum performance and so as to make people have more knowledge about the Ya Drum in Cixian County and arouse the public's recognition of the Ya Drum and their participation into Ya Drum performance, making the Ya Drum naturally inherited and protected among folk groups (Zhang Zhiyun., 2015). Second, with the help of non-governmental organizations, plans and preparation should be made to make Ya Drum performance become a special fitness activity in communities and culture squares, which is not only beneficial for the inheritance and protection of the Ya Drum, but also helpful for physical fitness. Moreover, it will enrich the cultural and recreational life of the public, express their emotion, cultivate their sentiment, strengthen the exchange of ideas among the public and promote to build a harmonious society positively.

2.2. Inheritance Mode Based on Cultural Tourism

Located on the riverside of the Fuyang River, the Xingren Street in Cixian County embraces a superior geographic environment and potential tourism resources. One of the eight famous scenes "Autumn Moon Above Fu Bridge" is in this place (Jia., 2012). Trying to combine the cultural resource of the Ya Drum with the local tourism resources will be a way of inheriting and protecting the Ya Drum and will bring certain economic benefits as well. Typical modes and cases like this such as "Impression · Sanjie Liu", "Song Dynasty Dongjing Dream", "Mount Tai Worship Ceremony" "Golden Dynasty Emperor Kangxi" and other large-scale live-action performances all provide us with successful models worth our appreciation and imitation.

2.3. Inheritance Mode Based on School Education

The art of the Ya Drum in Cixian County is a combination of aesthetics, humanity and education. School education is an effective way to inherit and protect it. First, include the art of Ya Drum in school-based curriculum and make students know about the development history of the Ya Drum and understand its cultural implication in order to get the sense of identity with and national pride about the Ya Drum and thus inspire their consciousness of protecting the Ya Drum(Qing Yu., 2010). Second, introduce the Ya Drum into music teaching to enrich the content of teaching, improve students' cognition of music and promote the basic formation of their music ability (Cruz-Cunha, M. M., Simões, R., Varajão, J., & Miranda, I., 2014). Third, regard Ya Drum performance as a specialized course of physical class teaching because the performance itself is a physical activity. Besides, the stress of body's coordination, strain capacity of the brain and tenacious perseverance, etc. in the process of performance all have more ideal teaching effects than all these in other sports(Chen Yingjin., 2012).

2.4. Inheritance Mode Based Research Association

Local government is the representative and executive of public power and it has the responsibility and obligation to protect and manage social public affairs(Li Mingqi., 2012). So there is no shirking the responsibility for inheriting and protecting the Ya Drum. Its primary task is to establish an association for Ya Drum performance and build an excellent team for researching the art of Ya Drum, creating a strong atmosphere for the inheritance and protection of the art of Ya Drum (Zhu Dandan., 2015). On the one hand, take the initiative to engage local Ya Drum actors into the association. Ask these actors to regularly organize training classes for all ages and select outstanding performers to participate in activities of folk art exchange and performances held in different places so as to promote the Ya Drum in Cixian County and expand its popularity. On the other hand, cordially invite relevant academic experts to participate in academic research in the association(Liu Yongquan, Zhang Guoyan., 2005; Lv Peichen., 2005; Lai Hongling., 2014). Research is inheritance. Extract rich ethnic culture essence through research to provide good nutrition for contemporary and future culture and art development. Make scientific analysis for the ecological status, protection ways and innovative development of the Ya Drum, and propose creative reform and development ideas to make the ancient art of Ya Drum keep up with the pace of time and become a unique folk art brand of Cixian County.

3. Time Series Models

Time-series models are models used to study predictions based on the matter of time and to reveal the internal relations of matters.

3.1. ARMA Model

When the time series $\{x_t\}$ based on computer prediction is a null means stationary series, the equation deriving from establishing a fitting difference for $\{x_t\}$ is as follows:

$$x_t - \phi_1 x_{t-1} - \phi_2 x_{t-2} - \cdots - \phi_n x_{t-n} = \varepsilon_t - \theta_1 \phi_{t-1} - \cdots \theta_m \varepsilon_{t-m} \tag{1}$$

Simplified as:

$$x_t - \sum_{i=1}^{n} \phi_i x_{t-i} = \varepsilon_t - \sum_{j-1}^{m} \theta_j \varepsilon_{t-j} \tag{2}$$

In the equation:

$\{\varepsilon_t\}$ —White noise series;

ϕ_i —Auto-regressive parameters;

θ_j —Moving average parameters;

$n,\ m$ —Order of corresponding parts;

The model is called AR Model; if the model's Order n=0, the model is called MA Model, expressed as (Liu Jiangyuan, Tian Qing., 2014):

$$\sum_{i=1}^{n}\phi_i x_{t-i} = \varepsilon_t \tag{3}$$

$$x_t = \sum_{j=1}^{m}\theta_j \varepsilon_{i-j} \tag{4}$$

Adding backward shift operator B to the above equation:

$$(1-\phi_1 B-\phi_2 B^2-\cdots\phi_n B^n)x_t = (1-\theta_1 B-\theta_2 B^2-\cdots\theta_n B^m)\varepsilon_t \tag{5}$$

$$\text{If } \phi(B) = (1-\sum_{i=1}^{n}\phi_i B^i), \theta(B) = (1-\sum_{j=i}^{m}\theta_j B^j) \tag{6}$$

Then:

$$x_t = \frac{\theta(B)}{\phi(B)}\varepsilon_t \tag{7}$$

In the equation:

ε_t —Input item;

x_t —Output item;

$\frac{\theta(B)}{\phi(B)}$ —Transfer function;

$\phi(B)$ —Inherent characteristics of system;

$\theta(B)$ —Relations of the system with the outside world.

3.2. *ARIMA* Model

For some matters where the time series $\{x_t\}$ under non-stationary computer prediction exists, usually the difference method can be used to get corresponding increment series:

$$\vee x_t = x_t - x_{t-1} (t = 2,3,\cdots,N) \tag{8}$$

Through difference, correlation between increment series reduces and the entire sequence gets stabilized. If the increment series $\{\vee x_t\}$ is a stationary one, then for

$\{\vee x_t\}$, the ARMA time-series model can be obtained; if the increment series $\{\vee x_t\}$ is a non-stationary one, then calculate the second-order increment series for $\{x_t\}$. Recycle it until the increment series $\{\vee^d x_t\}$ becomes a stationary one.

Through the interrelation between backward shift operator and difference operator, the following equation can be obtained:

$$\vee = 1 - B, \cdots, \vee^d = (1-B)^d \tag{9}$$

Then get the common form for $ARIMA$ Model:

$$\phi(B)(1-B)^d x_t = \theta(B)\varepsilon_t \tag{10}$$

In the equation:

n, m—Auto-regressive and moving average order;

d—Difference operation order.

If $(1-B)^d x_t$ in equation $(1-\phi_1 B - \phi_2 B^2 - \cdots \phi_n B^n)x_t = (1-\theta_1 B - \theta_2 B^2 - \cdots \theta_n B^m)\varepsilon_t$ is expressed as y_t, then get:

$$(1-\phi_1 B - \phi_2 B^2 - \cdots \phi_n B^n)x_t = (1-\theta_1 B - \theta_2 B^2 - \cdots \theta_n B^m)\varepsilon_t \tag{11}$$

Call it *ARIMA* Model (Qing Yu., 2010).

3.3. *CAR* Model

ARIMA Model is used to solve the problem of time series based on computer prediction when there is only one variable, but in real problem solving probably exists multiple time series based on computer prediction and multidimensional time series problems based on computer prediction. *CAR* Model can be used to solve this kind of multidimensional time series problems based computer prediction.

Usually the expressive method of the first-order of time series based on computer prediction is as follows:

$$\overline{X_t} = \theta_1 X_{t-i} + \cdots \theta_n X_{t-n} + \varepsilon_t \tag{12}$$

The auto-regressive *ARIMA* Model based on n is expressed as:

$$\overline{X_t} - \alpha_1 X_{i-1} - \cdots \alpha_n \overline{X_{i-n}} = \varepsilon_t - \beta_i \varepsilon_{t-1} - \cdots \beta_n \varepsilon_{t-n} \tag{13}$$

4. Time Series Analysis Based on Computer Prediction

4.1. Stationary Time Series Analysis Based on Computer Analysis

The matter of time series based on computer prediction usually consists of stationary time series and non-stationary time series. The general process of stationary time series analysis is mainly to generate data acquisition into time series based computer prediction according to time characteristics of the researched object. Getting related models for the matter of time series through setting up auto-regression analysis and moving average analysis for the data and auto-regressive moving analysis as well. The main analysis process is shown in Figure 1:

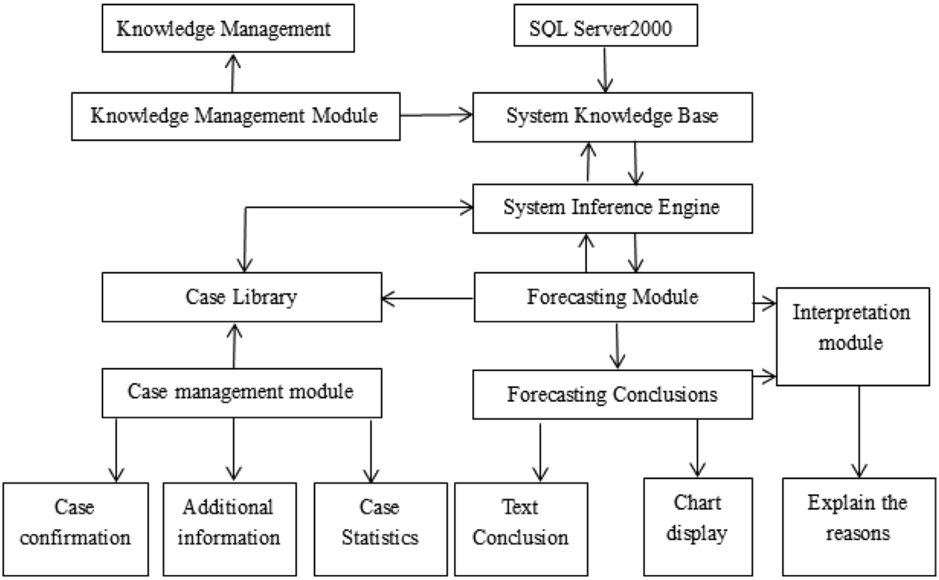

Figure 1 – Analysis Process Block Diagram

Mesh generation of time series based on Matlab.

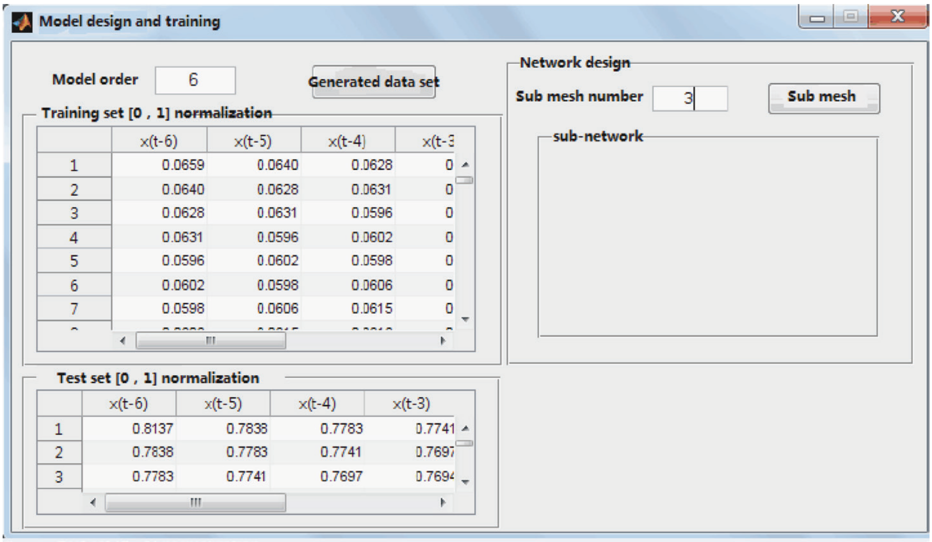

Figure 2 – Mesh Generation of Time Series

1. Auto-Regressive $AR(p)$

If time series $X_t(t=1,2,\cdots)$ based on relevant computer prediction is stationary series and there is corresponding relation between data at the same time, if there is relevance between X_t and $X_{t-1},X_{t-2},\cdots,X_{t-p}$, and there is no relation between X_t and white noise of time series model typed in an earlier time, if there is memory relations of Order P at this time, then the auto-regressive prediction model of Order P showing the interrelationship is as follows(Zhang Zhiyun., 2015):

$$X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \cdots + \phi_{\mathrm{p}} X_{\mathrm{t}-p} + a_t \tag{14}$$

In the equation:

a_t —White noise.

If add backward shift operator to $X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \cdots + \phi_{\mathrm{p}} X_{\mathrm{t}-p} + a_t$, then get:

$$(1 - B\phi_1 - B^2\phi_2 - \cdots - B^P \phi_P) X_t = a_t \tag{15}$$

2. Moving Average $MA(q)$

If time series $X_t(t=1,2,\cdots)$ based on relevant computer prediction is stationary series and there is corresponding relation between data at the same time, if there is relevance between X_t and $X_{t-1},X_{t-2},\cdots,X_{t-p}$, and there is relation between X_t and white noise of time series model typed in an earlier time, if there is memory relations of Order *P* at this time, then the moving average prediction model of Order *q* showing the interrelationship is as follows:

$$X_t = a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q} \tag{16}$$

Add backward shift operator *B*, then get:

$$X_t = (1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q) a_t \tag{17}$$

3. Auto-Regressive Moving Average $ARMA(p,q)$

If time series $X_t(t=1,2,\cdots)$ based on relevant computer prediction is stationary series and there is corresponding relation between data at the same time, if there is relevance between X_t and $X_{t-1},X_{t-2},\cdots,X_{t-p}$, and there is relation between X_t and white noise of time series model typed in an earlier time and also there is relation between. Then the system is referred to as auto-regressive moving average system and the prediction model is as follows:

$$X_t - \phi_1 X_{t-1} - \cdots - \phi_p X_{t-p} = a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q} \tag{18}$$

Namely:

$$(1 - B\phi_1 - \cdots - B^P \phi_P) X_t = (1 - B\theta_1 - \cdots - B^q \theta_q) a_t \tag{19}$$

4.2. Non-Stationary Time Series Based on Computer Prediction

In practical matter, there is law for time series, so when considering a problem, we cannot simply take it as a process of stationary time series. To solve such problems, there is a need to consider their development trend and to indicate the comprehensive effect. The model:

$$X_t = U_t + Y_t \tag{20}$$

In the equation:

U_t —Mean value of X_t about time change.

There are two calculation methods:

1. First, eliminate the law of data existing in X_t through relevant data processing, and then regard Y_t as a stationary process and study it with related treating method. Get the predicted results of X_t adopting the calculation method of inverse operation.
2. First get function U_t by fitting, then analyze it through the residual sequence $\{ X_t - \hat{U}_t \}$ of $\hat{U}_t$. Regard it as stationary in the analysis process and finally determine $\hat{Y}_t$. Correlation functional equation:

$$\hat{X}_t = \hat{U}_t + \hat{Y}_t \tag{21}$$

5. AIC Test for the Inheritance and Extension Modes of the Ya Drum in Cixian County

Get the specific order of time series model by *AIC* order determination code:

$$ACI(p,q) = \ln(\hat{\sigma}_a) + \frac{2(p+q)}{N} \tag{22}$$

Through inputting the statistic data of the number and time of inheritance and extension modes of the Ya Drum in Cixian County and its development status, prediction of the mode trend is available.

It is shown through auto-correlation and partial auto-correlation that auto-correlation presents sine waveform and certain tailing phenomenon exists. All other parts are within stochastic region after the partial auto-correlation function $K = 3$. Assume:

$$M = \left[\sqrt{N} \right] = 5,$$

$$\frac{2}{\sqrt{N}} = 0.3182$$

After step 3, all values deriving from M are within $(-0.3735, 0.3911)$. Thus get the residual sequence AR of time series model. Then calculate Y with the statistical software *Eviews* and get the model:

$$\hat{Y}_t = 1.8812Y_{t-1} - 1.0765Y_{t-2} \tag{23}$$

Therefore, the computer prediction process based on Matlab software is:

```
clc,clear
y=[];
yt=y'; n=length(yt);
alpha=[0.2 0.5 0.8];m=length(alpha);
yhat(1,1:m)=(yt(1)+yt(2))/2;
fori=2:n
yhat(i,:)=alpha*yt(i-1)+(1-alpha).*yhat(i-1,:);
end
yhat
err=sqrt(mean((repmat(yt,1,m)-yhat).^2))
xlswrite('lilv.xls',yhat)
yhat2014=alpha*yt(n)+(1-alpha).*yhat(n,:)
```

Research development prediction for the inheritance and extension modes of the Ya Drum in Cixian County based on time series model is available as follows:

$$X_t = 10.355 \times 1.256^t + 1.554Y_{t-1} - 1.205Y_{t-2} \tag{24}$$

Diagram showing contrast between computer-simulated time series prediction values and original ones is presented in Figure 3.

6. Conclusion

Forecasting decision system is a new field of the application of computer in management developed based on management information system. On this theoretical basis, this study builds relevant model and predicts the number of inheritance and extension modes for the Ya Drum in Cixian County. The model can effectively explain the development trend of the number of inheritance and extension modes for the Ya Drum in Cixian County. Besides, this model can also be used in prediction of the development modes for such traditional cultures as Quanzhou Nanyin and Chinese embroidery. The predicted results of the model are beneficial for the country to formulate corresponding policies for the development of traditional culture so as to make Chinese traditional culture develop better. As for the inheritance and development of the Ya Drum in Cixian County, first, the development law of the Ya Drum in Cixian County should be respected. Moderate development and innovation can be proceeded under the circumstance where the essential characteristics of the Ya Drum in Cixian County are not damaged, resulting in distortion and fission of the Ya Drum itself. In a word, the inheritance, protection and development of the Ya Drum in Cixian County should be common mission of the whole society. The country and government should first raise the inheritance and development

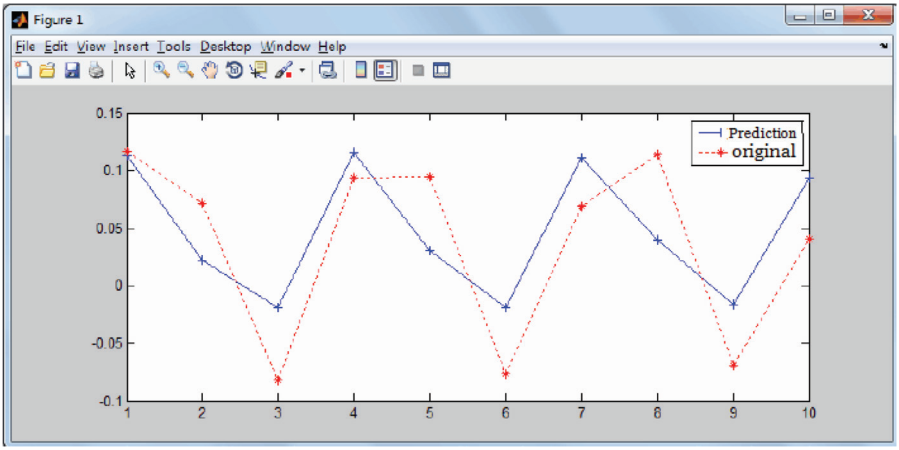

Figure 3 – Contrast Between Simulated Time Series Prediction Values and Original Ones

of the Ya Drum in Cixian County to the important position of social development by legal, administrative, economic and other various ways and means. As a member of the society, we should also form the self-awareness of inheriting and protecting the Ya Drum in Cixian County and make the splendid folk cultural art inherited permanently and utilized scientifically.

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Spatial Analysis Based Analysis on Landscape Pattern of Villages and Towns and Application of Simulation

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Abstract: Guided by theories of landscape ecology, this paper studies the changes in western ecological landscape pattern of Jilin and spatial optimization. With the change in land utilization as the entry point of the research, this paper analyzes the change in number of categories of land utilization and spatial transfer law using the model of change in land utilization; conducts quantitative analysis into the change in the landscape pattern of this area, and discloses the characteristics and process of the change in landscape pattern; conducts spatial auto-correlation analysis and spatial regression analysis into the ecological landscape pattern of this area and its influential factors with 500m-by-500m grids as the base and using spatial analytic method, sifts influential factors related to the spatial distribution of ecological landscape pattern, and performs simulation of all factors. The result suggests that the edge density of dry farmland, various grasslands, water domains, beach lands and wetlands is decreasing year by year; the degree of fragmentation of paddy fields, dry farmlands and saline-alkaline lands is dropping continuously, the area are enlarging gradually, distributed in tracts; the area of water domains, wetlands and grasslands decreases.

Keywords*:* Spatial analysis, grids, landscape pattern of villages and towns.

1. Introduction

China is being situated in a transitional period from an agricultural country to a new type of industrialized and urbanized country, when urbanization is fast developing. Studies show that China entered a mid-term accelerating stage after the level of urbanization reached 25% or so in the mid-1980s. For 8 consecutive years from 1996 to 2003, it even grew at a super speed of 1.43~1.44 points of percentage increase per year. As of the end of 2011, the national level of urbanization reached 51.27%. Both the large scale and fast tempo of China's urbanization are unprecedented in human history. Urbanization means both opportunities and challenges to China. On July 23, 1999, World Bank convened "Advanced Symposium on Urbanization Development" in Beijing. CJ.E.Stieglitz, senior vice banker and chief economist of World Bank and century's famous economist, associates China's urbanization and US's high-tech as two key factors impacting human's progress in the 21st Century.

In fact, the square-field system over the Xizhou Period in 1066 B.C marked the start of China's land governance inland. "Till over a square field of nine hundred mu, with the center granted for aristocracy and the rest eight hundred mu equally distributed to common families."(Mengzi). This form was the initial form of land governance which divided a large area of land into 9 segments with pathways and ditches as borders such that the area of each segment is one hundred mu. This was the land-sharing system for each family. Since foundation of the state, China has undertaken land governance in various forms, but it falls behind overseas both theoretically and technologically (Freixo, J., & Rocha, Á., 2014). Until the 1990s, the 41st article in *Land Administration Law*, "The state encourages land governance" gave a new stage to China's land governance activities, which was also the beginning of China's land governance activities in a real sense. In 2007, the seventy-fourth order of the president of the People's Republic of China promulgated the *Town and Country Planning Act*, which presented a requirement of being concentrated on urban-rural integration and establishing the concept of urban-rural integration against the previous planning construction that was tendentious to cities. The twenty-ninth article of the Act stipulates the principle and objective for construction and development of towns, countries and villages, respectively, highlighting town's driving role for service in nearby countrysides, the role of villagers' self-organization in construction of villages and hamlets, as well as the overall objective of "improving rural production and living condition" in construction of villages and hamlets. In October the same year, the seventeenth session of Third Session of Communist Party of China decided to ascend "advancing rural reform and development unswervingly" to the cognitive height of emancipating the minds, reform and open-up, scientific development, harmonious society, etc. A key point was focuses on exploring reforms in the areas of farmland protection, transfer of land use rights, rural homestead, and requisition system and rural collectively operated land for construction, etc. The objective is to establish an urban-rural uniform market of ingredients, institutionally secure reasonable transfer of elements of production and elements of market between urban and rural areas, and restrict the loss of the value of rural resource elements, so as to promote healthy development in rural areas. In 2010, the 1st document of CPC Central Committee associated the "Three Rural Issues" related urban-rural integration, improving rural livelihood, expanding rural demands, agricultural modernization, new country construction and advancing urbanization with a series of crucial issues for national development including comprehensively constructing a well-to-do society, adjusting the pattern of income distribution among nationals, driving domestic demands, transforming the mode of economic development and keeping steady and fast economic development, and attached high importance to them. In 2012, the Report of the Party's Eighteenth CPC National Congress noted "a priority among priorities for the entire Party's work is to address the issues of agriculture, rural areas and farmers... The effort shall be strengthened on integrating urban-rural development and the vigor shall be enhanced for rural development, so as to gradually minimize the urban-rural gap and promote urban-rural common prosperity." Aside from the policies issued by the government on land planning, relevant scholars have studied the ways of division and methods of planning.

In 2005, (Jiao Feng et al, 2005). employed GIS and statistical analysis and other methods to investigate into the spatial distribution of the landscapes in the area of loess hills, arriving at the conclusion that human activities have significant impacts on various types of landscapes. In 2011, (Xu Jiaxing. et al.,2011) employed GIS and approaches of landscape ecology to analyze the changes in landscape pattern of the Hongzehu Lake area over 18 years, finding the changes in utilization of various lands in this area. In 2013, (Ji Yazhe et al., 2013)employed a GIS and probabilistic matrix combined method to make an analysis into the landscape pattern of land utilization, arriving at the conclusion that advantageous landscape types are insensitive to spatial granularity.

Employing a method of spatial analysis, this paper adopts indices of landscape pattern to study the sample of the data of landscape pattern in western villages and towns of Jilin during 1990-2005, and simulates the changes in former residences of landscape in western villages and towns of Jilin during 2015-2030.

2. Analysis on Landscape Pattern of Land Utilization

Generally, a GIS spatial data model consists of three organically associated layers - conceptual data model, logical data model and physical data model. "Among them, the conceptual data model is a set of abstract concepts about entities and interrelations between the entities, the logical data model is used to express the data entities (or records) in the conceptual data model and their interrelations, while the physical data model describes the physical organization, storage path and database structure of data in computer." The interaction among the three is shown in Figure 1.

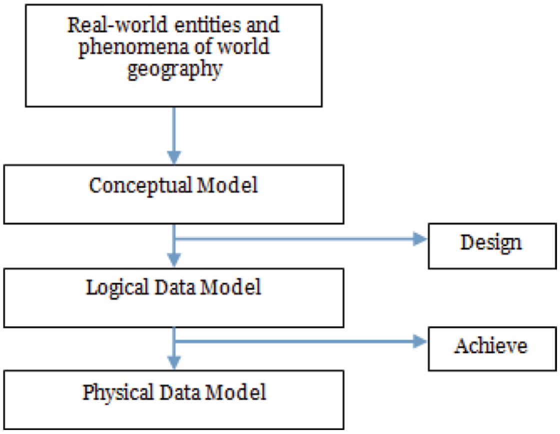

Figure 1 – Three Layers of Spatial Data Model

On the base of the illustration of land utilization, this paper establishes 12 types of landscape patches based on 500m-by-500m grids. The grid data model is a typical domain-based model. The grid data model is based on continuous pavements. It discretizes a continuous space, using 2D pavements or area pavements to cover the entire continuous space. The pavements can be regular or irregular(Tang Guoan, Song Jia., 2006; Yu Kongjian. et al., 2009). The latter can be treated as topological polygons such as socioeconomic subdivision and urban block; the characteristic parameters of pavements include size, shape, bearing and gap. There may be numerous pavements of different sizes and agglomeration properties for a same phenomenon. Grid data structure: A data structure that expresses the distribution of spatial ground objects or phenomena using regular array of pixels, in which each datum expresses the attributes and characteristics of the ground objects or phenomena(Yu Kongjian. et al., 2009; Jia., 2012). The grid data structure is an array of pixels in which the rank-column id of each pixel is used to determine the position while the value of each pixel is used to represent the type of entities. Grade and other attribute codes "adopt the indices of landscape pattern to analyze land changes".

2.1. Indices of Landscape Pattern

2.1.1. Density and Index of Its Gap

(1) Number of patches (Franklin J.F. Forman R.T.T. 1987).

$$NP = n \tag{1}$$

NP is the number of patches.

(2) Density of patches

$$PD = N_i / A(10000)(100)$$

$$PD = N / A(10000)(100) \tag{2}$$

Where, N_i is the number of patch i, N is the number of patches, A is the area.

(3) Mean size of areas of patches

The mean area of patches MPS is determined by the following formula:

$$MPS_i = \frac{1}{N_i}\sum_{j=1}^{N_i} A_{ij} \tag{3}$$

Where, MPS is the mean area of a certain patch; N_i is the total number of patches for landscape i; A_{ij} is the area of the j th patch for landscape i.

(4) Largest patch index (LPI)

$$LPI = \frac{\max\left(a_{ij}\right)}{A} \times 100 \tag{4}$$

LPI ($0 < LPI < 100$) is the percentage occupied by a certain landscape.

2.1.2. Edge Index

$$ED = \frac{\sum_{k=1}^{m} e_{ik}}{A_i}(10000), ED = \frac{E}{A}(10000) \tag{5}$$

e_{ik} is the circumference of the K th patch in patch i, A_i is the area of patch i.

2.1.3. Diversity Index

Shannon diversity index.

$$SHDI = -\sum_{i=1}^{m}\left(P_i \ln P_i\right) \tag{6}$$

$SHDI$ = 0, composed of a single patch; greater $SHDI$ coincides with more types of patches.

2.1.4. Agglomeration Index

(1) Contagion index

$$CONTAG = \left(1 + \frac{\sum_{i=1}^{m}\sum_{k=1}^{m}\left[\left(P_i \frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right)\ln\left(P_i \frac{g_{ik}}{\sum_{k=1}^{m} g_{ik}}\right)\right]}{2\ln m} \right) \times 100 \tag{7}$$

$CONTAG$ ($0 < CONTAG \leq 100$), g_{ik} is the sum of contiguous grids between types i and k; P_i is the percentage occupied by landscape type i; m is the total of landscape types.

(2) Index of dissemination and parallelism

$$IJI = -\sum_{k=1}^{m}\sum_{k=1}^{m}\left[\left(\frac{E_{ik}}{E}\right)\ln\left(\frac{E_{ik}}{E}\right)\right] \Big/ \left(\ln - m\left(m-1\right)\times 100\right) \tag{8}$$

IJI ($0 < IJI \leq 100$) is the situation of dissemination and parallelism between various types of patches(Lu Lin. et al. 2001).

2.2. Analysis of Landscape Pattern of Land Utilization

2.2.1. Analysis of Landscape-Horizon Landscape Indices

7 indicators (NP, PD, MPS, LPI, SHDI, ED and CONTAG) are selected to conduct an analysis into the situation of land utilization in western villages of Jilin. According to Formulas 1-8, indices of landscape-horizon landscape pattern in all periods are derived as shown in Table 1.

According to Table 1, there occurred dramatic changes with the landscape pattern of western villages in Jilin, as presented in the following details:

Year	NP	PD	LPI	ED	CONTAG	SHDI
1990	3642	0.0777	14.0776	6.3567	31.6480	1.9986
1995	3760	0.0748	15.6237	6.5037	32.3098	1.9026
2000	3315	0.0721	15.2332	5.9296	33.6416	1.8289
2005	3297	0.0704	17.8841	5.8567	44.7725	1.7133

Table 1 – Table of Landscape-Horizon Landscape Indices in Western Villages of Jilin

NP: The number of patches took on a tendency of increase during 1990-1995; the number of patches decreased gradually after 1995, suggesting the landscapes in western villages of Jilin tended to be overall integral.

PD: Decreasing gradually, suggesting the degree of fragmentation of landscapes in villages was declining.

LPI: Decreasing gradually, indicating advantageous landscape types of villages were gradually expanding.

ED: Dropping continuously, evincing the edge of landscape pattern of villages was approaching continuously towards the regular.

CONTAG: Ascending gradually, indicating excellent contiguity between landscapes of villages.

SHDI: Dropping gradually, indicating the degree of uneven distribution of landscapes was increasing.

2.2.2. Analysis of Type-Horizon Landscape Indices

Five indices (NP, MPS, LPI, ED and IJI) are selected to investigate the landscape pattern of villages (as shown in Figure 2) to derive the indices of landscape pattern in the four periods as shown in Tables 2-4 and Figures 3-7.

Figure 2 – Landscape Pattern of Villages

Type	NP				MPS			
	1990	1995	2000	2005	1990	1995	2000	2005
PF	81	77	70	64	1374.63	2163.42	2608.74	3491.23
DL	265	258	254	250	7625.88	7899.36	8223.17	8413.31
WO	304	327	393	468	486.69	546.22	587.43	538.73
TG	245	203	183	163	932.36	657.27	652.35	658.33
MG	561	628	472	413	562.30	413.38	425.76	498.38
LG	496	648	524	579	598.63	442.73	472.26	462.53
WA	438	393	278	221	605.37	606.25	698.11	688.27
BL	52	51	49	47	1623.00	1857.34	1567.24	1117.26
RC	209	228	258	292	671.23	719.37	771.98	827.45
SD	167	178	194	230	1613.21	1526.46	1389.37	1081.43
ST	578	596	505	478	991.44	1145.23	1598.64	1823.57
WE	248	162	127	89	910.75	996.24	1092.28	974.36

Table 2 – Type-Horizon Landscape Indices of Western Villages in Jilin – 1

Note: PF: Paddy field; DL : Dry land; WO: Woodland; TG: Tall grass; MG: Medium grass; LG: Low grass; WA: Waters; BL: Beach land; RC: Residence Community; SD: Sand; ST: Salt ; WE: Wetland

Type	LPI			
	1990	1995	2000	2005
PF	0.9455	1.0564	1.0934	1.3654
DL	14.0775	14.6227	15.2343	17.8798
WO	0.1467	0.2178	0.2204	0.2962
TG	0.4912	0.1623	0.1836	0.1601
MG	0.1705	0.2348	0.1039	0.0979
LG	0.0901	0.1125	0.2654	0.1987
WA	0.8768	0.7417	0.7208	0.7032
BL	0.6661	0.6905	0.4683	0.2761
RC	0.0768	0.0982	0.0986	0.1508
SD	2.3423	1.2333	0.9453	0.9513
ST	1.5329	4.9793	5.1917	8.5682
WE	0.9201	0.6584	0.4637	0.3935

Table 3 – Type-Horizon Landscape Indices of Western Villages in Jilin - 2

Type	ED				IJI			
	1990	1995	2000	2005	1990	1995	2000	2005
PF	0.276	0.461	0.552	0.435	67.055	67.574	67.867	68.225
DL	2.598	2.280	2.126	2.051	87.871	88.862	86.749	86.762
WO	0.450	0.691	0.798	0.890	63.146	66.572	66.671	70.311
TG	0.689	0.598	0.454	0.351	80.954	82.862	83.923	81.506
MG	1.181	1.062	0.935	0.801	80.342	85.479	83.121	76.155
LG	1.737	1.545	1.426	1.091	80.346	79.309	76.264	70.915
WA	0.842	0.671	0.586	0.392	85.853	84.891	83.712	82.757
BL	0.192	0.273	0.241	0.132	68.013	67.745	66.914	65.52
RC	0.234	0.263	0.291	0.337	54.949	54.687	54.372	53.443
SD	0.872	0.893	0.902	0.924	84.821	84.710	80.452	74.142
ST	2.034	2.143	2.031	2.463	77.421	78.331	80.312	83.871
WE	0.771	0.689	0.607	0.244	90.114	89.031	88.321	86.467

Table 4 – Type-Horizon Landscape Indices of Western Villages in Jilin - 3

2.3. Application of Simulation

A simulation is performed over the tendency of changes in edge density and agglomeration index of various types of landscapes. The landscape planning design is assisted with interdependence among GIS, ecological aided design technique and model building. Different computer aided design strategies are adopted in accord to the requirements of different design projects. For instance, the planning design of landscapes can input various data such as elevation, river, pathway, hamlet or city, even demographic and biological distribution, economic indicators and other statuses using GIS on the regional scale, and conduct comprehensive analysis so as to acquire fitness evaluation of biological habitats, landscape security pattern or aided site-selection, route-selection for pathway, etc.; in further dimensional planning design (e.g. village planning in a certain region), site selection can be aided by simultaneous dint of analyses of wind and water, and reasonable planning and arrangement are performed to create an apropos village environment; 3D speculative planning layout or architectural spatial sculpture can be constructed by virtue of model, along with computer aided ecological design to optimize the layout and spatial sculpture, thereby making effective use of computer to assist planning design of different dimensions and contents of design(Qing Yu., 2010; Chen Yingjin. 2012; Li Mingqi., 2012).

The author designs and implements a practically operating system using Visual C++ in combination with basic theories on GIS and by employing GIS spatial analysis algorithm. The system contains a spatial analysis module which consists of spatial query, spatial measurement, analysis of spatial relations, buffer analysis and spatial statistical classification analysis, etc. In the system, spatial query and analysis of spatial relations can be conducted between any two ground objects or basic graphical elements; buffer analysis and spatial statistical classification analysis can be conducted for any ground object and basic graphical element (Zhu Dandan., 2015; Liu Yongquan, Zhang Guoyan., 2005).

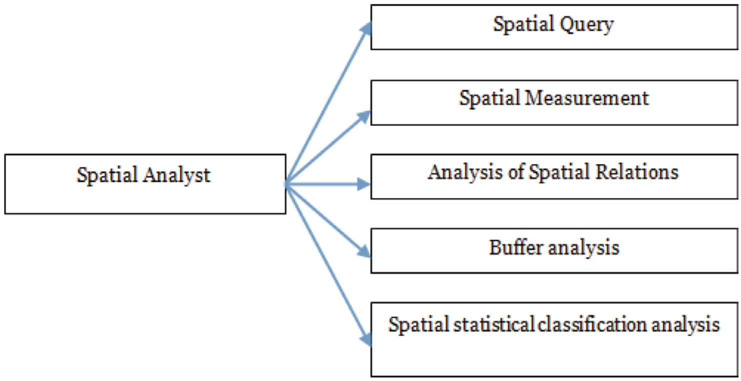

Figure 3 – System Function of Spatial Analysis

On the base of the above data, an analysis is conducted into the number of patches of all types of landscapes, mean area of patches of all types of landscapes(Lv Peichen., 2005), and index of largest patch of all types of landscapes in western villages of Jilin during 2015-2030, with the result shown as below:

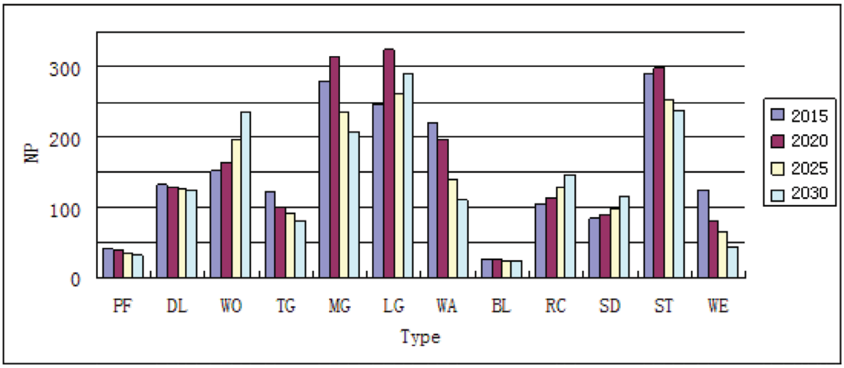

Figure 4 – Number of Patches of All Types of Landscapes in Western Villages of Jilin during 2015-2030

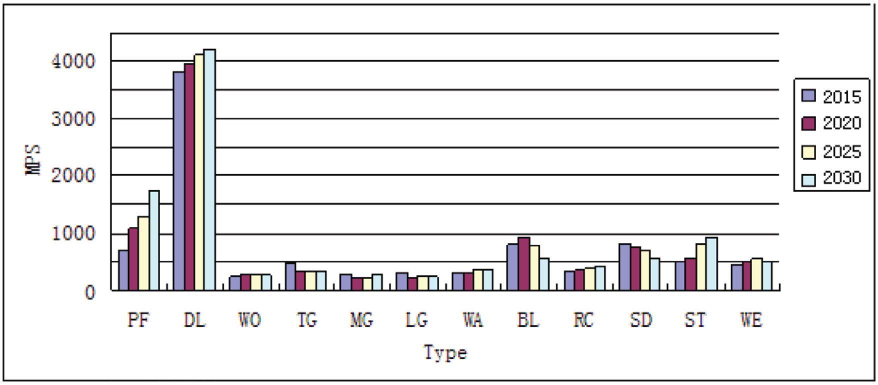

Figure 5 – Mean Average of Patches of All Types of Landscapes in Western Villages in Jilin during 2015-2030

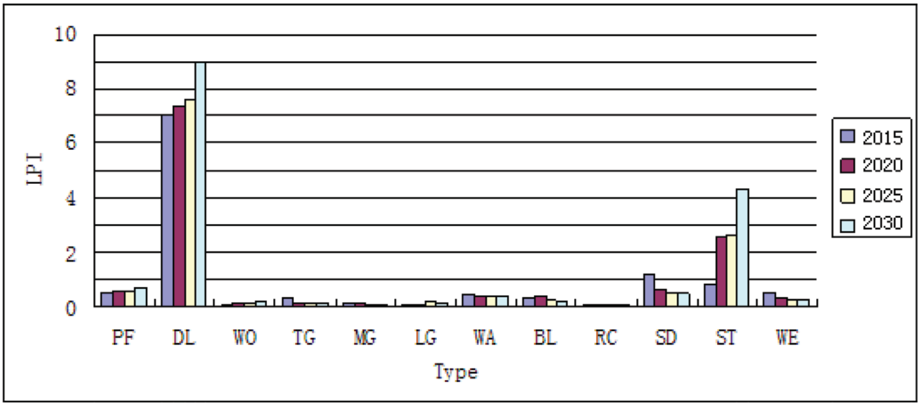

Figure 6 – Index of Largest Patch of All Types of Landscapes in Western Villages of Jilin during 2015-2030

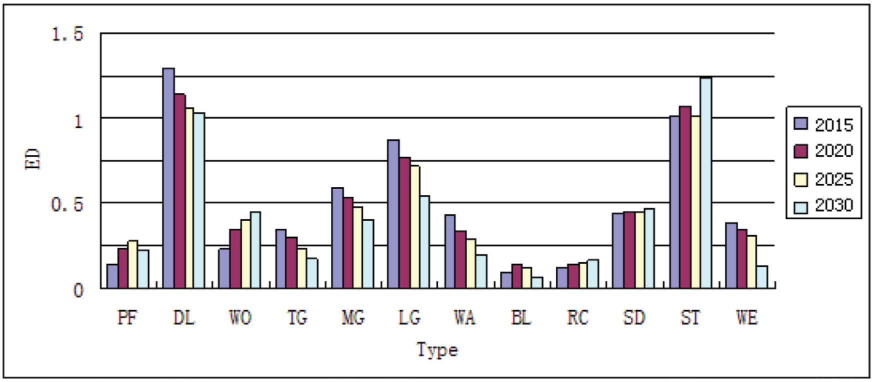

Figure 7 – Edge Density of All Types of Landscapes in Western Villages of Jilin during 2015-2030

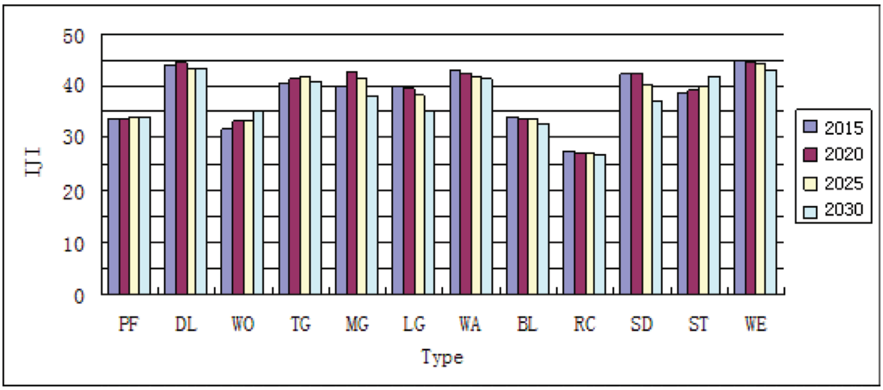

Figure 8 – Agglomeration Index of All Types of Landscapes in Western Villages of Jilin during 2015-2030

NP: According to Table 2 and Figure 4, the number of patches increases gradually in woodlands, low-lying grasslands, habitats, and sands, with the rest all decreasing continuously.

MPS: According to Figure 5 and Table 2, the mean area of paddy fields and dry farmlands increases gradually, whereas the number decreases gradually, which indicates the degree of fragmentation is dropping.

LPI: According to Table 3 and Figure 6, the LPI value of dry farmlands and saline-alkaline lands decreases gradually, which indicates the water domains and wetlands are shrinking year by year; the LPI value and area of high- and middle-lying grasslands decrease continuously, which indicates the high- and middle-covered grasslands are gradually differentiated.

ED: According to Table 4 and Figure 7, the indirect density values of dry farmlands and saline-alkaline lands are maximal, which indicates dry farmlands and saline-alkaline lands occupy a large proportion.

IJI: According to Table 4 and Figure 8, the IJI values of dry farmlands, high-covered grasslands, water domains and wetlands are all larger, which suggests the probabilities of bordering upon other categories of patches are relatively equal. The IJI values of paddy fields, woodlands and saline-alkaline lands increase continuously, whereas the IJI values of middle- and low-lying grasslands, water domains and wetlands decrease, which suggests this type of landscape rarely borders upon other landscapes.

3. Summary

With the data about landscape pattern in western villages of Jilin during 1990-2005 as sample, indices of landscape pattern are adopted for the investigation, and their development trend during 2015-2030 is predicted via a simulation. The result suggests: the degree of fragmentation of paddy fields, dry farmlands and saline-alkaline lands is dropping, while the areas are enlarging progressively, rendering a distribution in tracts; the areas of water domains, wetlands and grasslands are diminishing. Full use is made of GIS spatial analysis technique combined with illustrated modeling method to establish a practical spatial analysis model, which can well implement the basic functions of GIS spatial analysis, thereby enhancing the overall function of GIS.

4. Acknowledgments

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Classification of Distance-regular Graphs and Application of Ant Colony Algorithm in Three Regular Graph Coloring

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Abstract: In this paper, the ant colony algorithm is improved in terms of environment, foraging rule, moving rule, obstacle avoidance rule and pheromone rules. On this basis, the coloring of three regular graphs is studied; the optimized ant colony algorithm corresponding to the coloring and numbering problems is designed and solved; the improved algorithm is programmed using the software MATLAB, and accordingly the optimization solution of the three regular graph coloring is calculated. Through comparison, it is found that the coloring graph after the optimization has more colors and requires less operation time. Furthermore, by utilizing the nature of distance-regular graphs, crosstab, circle search techniques and the like, the regular graphs with k=10 and a1=1 are classified herein, and a number of classification results are presented. According to the results, the effect of three regular graph coloring by using the improved ant colony algorithm is better than the classic coloring effect.

Keywords: Distance-regular graphs, graph coloring, ant colony algorithm, three regular figure

1. Introduction

Put forward by the British mathematician N. L. Biggs in the 1970s, the concept of distance-regular graph is a mix derivative of distance-transitive graphs. (G. M. Adel'son-Vel'skii et al., 1969). Got the first example of distance intransitivity distance-regular graphs, and the distance-regular graph with the smallest distance intransitivity is Shrikhande Figure (S. S. Shrikhande., 1959).

The classification of distance-regular graphs is one of the core problems in the research of distance-regular graphs. (T.Ito, N.L.Biggs and A.G.Boshier., 1989) completed the classification of Dgree-3 distance-regular graphs in the 1980s; in 2000, (A.Hiraki, Suzuki et al., 2000) completed the classification of distance-regular graphs with and $a_1 = 1$, and failed to find a satisfactory solution to the classification of those with $k \geq 7$ and $a_1 > 1$; in 2002, (A. E. Brouwer and J.Koolen., 2002) improved the results obtained by (E. Bannai and T.Ito., 1989), and classified Degree-4 distance-regular graphs with the help of computer . In 2008, (Zhang Yuan., 2008) pointed out that when

$k=8$, and $c_{r+1}>1$, the distance-regular graphs with $d=r+1$ don't exist. In this paper, the distance-regular graphs with $k=10, a_1=1$ is studied and characterized, with the purpose of making some contribution to the improvement of the theory on distance-regular graphs.

Graph coloring is actually the process of classifying some objects according to certain rules, thus it is of large application significance in both theory and engineering practices. As an NPC problem, graph coloring doesn't involve exact algorithms of polynomial time (Lindo-Salado-Echeverría, C., Sanz-Angulo, P., De-Benito-Martín, J. J., & Galindo-Melero, J., 2015), and therefore the solving algorithm for it has become a hot research topic. Some achievements in graph coloring have currently been made at home and abroad by employing some intelligent algorithm models, such as taboo search, simulated annealing and genetic algorithm (Salari E, Eshghi., 2008; E. Bannai and T. Ito., 1987). The ant colony algorithm, which is a bionic algorithm, is applied herein to the study of the three regular graph coloring problem, in order to gain a more reasonable solution to the problems of coloring and number labeling.

2. Discussion about Existence of Distance-regular Graphs

2.1. Existence Theorem

Theorem 1: Supposed that Γ is a distance-regular graph with $k=10, a_1=1$, it is set that $c_{r+1}=4$, then: $a_{r+1}=4, d=r+s+1$ and $c_d=5$, thus in this case Γ is a 1-homogeneous graph; when $c_{r+1}=3$, Γ does not exist (Van Dam E R, Haemers W H., 2003).

Supposed that $\Gamma=(X,E)$ is a graph and $u\in\Gamma$, then:

$\Gamma_i(u)=\{v\in\Gamma \,|\, \partial_\Gamma(u,v)=i\}$ and $\Gamma(u)=\Gamma_1(u)$

Definition 1: It is supposed that $\Gamma=(X,E)$ is a connected graph, wherein X is a vertex set and E is a side set. Two random points u,v are extracted randomly and $\partial(u,v)=h$. If $|\Gamma_i(u)\cap\Gamma_j(v)|$ is only related to h,i,j and not related to the selection of u,v, then Γ is a distance-regular graph.

The basics of distance-regular graphs, including the number of crosses and cross table, are presented in Reference (Tommy R, Jensen, Bjarne Toft. 1994).

Proposition 2: Supposed that Γ is a distance-regular graph with a diameter of d, for each side w of Γ, $D_1^1(u,v)$ is the cluster, then Γ is a 1-homogeneous graph if and only if $a_i=a_1\cdot c_i$ (i = 0, 1,..., d).

2.2. Theorem Proving

It is supposed that Γ is a distance-regular graph with $k=10, a_1=1$ considering that the graph $C_{r+1}-$ is a residual cluster and $c_{r+1}=4$, thus $a_{r+1}=4$, 5 or 6.

$a_{r+1}\neq 5,6$ should be proved to obtain the theorem conclusion (A. E. Brouwer, J. Koolen., 1996; Cranston D W, Kim S J., 2008).

Firstly, $a_{r+1}\neq 6$ is proved. And the following lemma is accordingly put forward:

Lemma 1: Supposed that Γ is the distance-regular graph with $k=10, a =1$, if $c_{r+1}=4$, then for any $x \in D_{r+1}^{r+1}$, $e(x, D_r^r) \le 1$ stands. Particularly, when $a_{r+1}=4$, the equation stands, namely, $D_{r+1}^{r+1} \subset \Gamma_r(\gamma)$.

Lemma 2: Supposed that Γ is the distance-regular graph with $k=10, a_1=1$, if $c_{r+1}=4$, then $a_{r+1} \ne 6$.

Proving: (disproof) It is supposed that $a_{r+1}=6$, then $d=r+1$. Lemma 1 indicates that there is $x \in D_r^r$ which makes $e(x, D_r^r)=0$. Thus

$$\partial(x,\gamma)=d=r+1. \tag{1}$$

Given $c_{r+1}=4$, and supposed

$$\{\eta_1,\eta_2,\eta_3,\eta_4\}=\Gamma(x)\cap D_{r+1}^r \tag{2}$$

$$\{\eta_5,\eta_6,\eta_7,\eta_8\}=\Gamma(x)\cap D_r^{r+1} \tag{3}$$

$$\eta_1,\eta_2,\eta_3,\eta_4,\eta_5,\eta_6,\eta_7,\eta_8 \in A_{r+1}(\gamma,x) \tag{4}$$

Which contradicts with $a_{r+1}=6$.

Secondly, $a_{r+1} \ne 5$ is proved.

Supposed that Γ is the distance-regular graph with $k=10, a_1=1$, $c_{r+1}=4$ is set. Supposed that $a_{r+1}=5$, each graph C_{r+2} – would be the union of a number of k_2; and given that each C_{r+2} – graph contains a C_{r+1} – graph, then, c_{r+2} would be equal to 8 or 10. In order to prove that c_{r+2} cannot be 8 or 10, the following lemmas are put forward:

Lemma 3: Supposed that Γ is the distance-regular graph with $k=10, a_1=1$, if $b_{d-1}=1$ and $c_d=8$, then $k_d \equiv 0 (\bmod 3)$.

Lemma 4: Supposed that Γ is the distance-regular graph with $k=10, a_1=1$, if $a_{r+1}=5$ and $d=r+2$, then $c_{r+2} \ne 8$.

Proving: Supposed that $c_{r+2}=8$, because $d=r+2$ and $b_{r+1}=b_{d-1}=1$, Lemma 3 indicates $k_d \equiv 0 (\bmod 3)$, which obviously contradicts with $k_d=(10 \cdot 8^r \cdot 1)/(1^r \cdot 4 \cdot 8)$.

Lemma 5: Supposed that Γ is the distance-regular graph with $k=10, a_1=1$, if $c_{r+2}=8$, then D_{r+1}^{r+1} contains two and only two types of points, namely $(1,0,1)$ and $(1,2,1)$, each with one determined cluster model.

Proving: $a_{r+1}=5 \ne 0$, so $D_{r+1}^{r+1} \ne \Phi$. Because there is no $(1,1,1)$ point related to any side in Γ, there is no $(1,1,1)$ points in D_{r+1}^{r+1}.

$x \in D_r^r$ is taken randomly.

Because $b_r \ne 0$ and $e(D_r^r, D_{r+1}^r)=e(D_r^r, D_r^{r+1})=0$, there is $y \in D_{r+1}^{r+1}$ which makes $x \sim y$, and obviously $y=(1,0,1)$.

It is supposed that D_{r+1}^{r+1} does not contain $(1,2,1)$ point, then.

$$e(D_r^r, D_{r+1}^{r+1}) = b_r \cdot |D_r^r| = 8^r \tag{4}$$

which contradicts with $e(D_r^r, D_{r+1}^{r+1}) = 1 \cdot |D_{r+1}^{r+1}| = 5 * 8^r/4$. Therefore D_{r+1}^{r+1} does contain $(1,2,1)$ points.

$\vec{x} = (1,0,1)$ is taken, then $e(x, D_{r+2}^{r+2}) = 0$.

Because $b_{r+1} = 1$, $e(x, D_{r+2}^{r+1}) = e(x, D_{r+1}^{r+2}) = 1$ can be obtained. Supposed that

$$\{u_1\} = \Gamma(x) \cap D_{r+2}^{r+1} \tag{5}$$

$$\{v_1\} = \Gamma(x) \cap D_{r+1}^{r+2} \tag{6}$$

u_1 and v_1 are apparently non-adjacent.

Because $e(x, D_r^r) = 1$, $\{x'\} = \Gamma(x) \cap D_r^r$ is supposed. And because $c_{r+1} = 4$

$$\{\eta_1, \eta_2, \eta_3\} = \Gamma(x) \cap D_{r+1}^r \tag{7}$$

$$\{\omega_1, \omega_2, \omega_3\} = \Gamma(x) \cap D_r^{r+1} \tag{8}$$

are supposed. Because $a_{r+1} = 5$, $\{y\} = \Gamma(x) \cap D_{r+1}^{r+1}$ is supposed.

It is noticed that in $\Gamma(x) = \{x', y, \eta_1, \eta_2, \eta_3, \omega_1, \omega_2, \omega_3, u_1, v_1\}$.

There is no sides existing between $(1,0,1)$ points and $(1,2,1)$ points, thus $x' \sim y$. Because

$$\eta_1, \eta_2, \eta_3 \in C_{r+1}(\alpha, x) \tag{9}$$

η_1, η_2, η_3 are mutually non-adjacent.

$$\omega_1, \omega_2, \omega_3 \in C_{r+1}(\beta, x) \tag{10}$$

so $\omega_1, \omega_2, \omega_3$ are mutually non-adjacent, thus $u_1 \sim \eta_1$, $v_1 \sim \omega_1$, $\eta_2 \sim \omega_2$ and $\eta_3 \sim \omega_3$ are supposed, then the group model of $(1,0,1)$ points are unique.

$\vec{x} = (1,2,1)$ is taken, and because $c_{r+1} = 4$ and $e(x, D\ )\quad 0$, $\{\eta_1, \eta_2, \eta_3, \eta_4\} = \Gamma(x) \cap D_{r+1}^r$ and $\{\omega_1, \omega_2, \omega_3, \omega_4\} = \Gamma(x) \cap D_r^{r+1}$ are set. $b_{r+1} = 1$ and $c_{r+2} = 8$, so $e(x, D_{r+2}^{r+1}) = e(x, D_{r+1}^{r+2}) = 0$ and $e(x, D_{r+2}^{r+2}) = 1$, and $\{u\} = \Gamma(x) \cap D_{r+2}^{r+2}$ is set. Because $a_{r+1} = 5$, $\{v\} = \Gamma(x) \cap D_{r+1}^{r+1}$ is set and in

$$\Gamma(x) = \{\eta_1, \eta_2, \eta_3, \eta_4, \omega_1, \omega_2, \omega_3, \omega_4, u, v\} \quad u \sim v \tag{11}$$

It is noticed that $\{\eta_1,\eta_2,\eta_3,\eta_4\}=C_{r+1}(\alpha,x)$, so $\eta_1,\eta_2,\eta_3,\eta_4$ are mutually non-adjacent; $\{\omega_1,\omega_2,\omega_3,\omega_4\}=C_{r+1}(\beta,x)$, so $\omega_1,\omega_2,\omega_3,\omega_4$ are mutually non-adjacent. It is set that $\eta_1 \sim \omega_1$, $\eta_2 \sim \omega_2$, $\eta_3 \sim \omega_3$ and $\eta_4 \sim \omega_4$, thus the group model of $(1,2,1)$ points is unique.

Lemma 6: Supposed that Γ is a distance-regular graph with $k=10, a_1=1$, if $a_{r+1}=5$ and $d \geq r+3$, then $c_{r+2} \neq 8$.

Lemma 7: Supposed that Γ is a distance-regular graph with $k=10, a_1=1$, $c_{r+1}=4$ is set. If $a_{r+1}=5$, then $c_{r+2} \neq 10$.

Proving: According to the proving of Lemma 5, D_{r+1}^{r+1} contains $(1,0,1)$ points. Like the proving of $c_{r+2} \neq 8$, $c_{r+2}=10$ is supposed. A circle with a length of $2r+3$ can also be taken and the deduction leads to contradiction, thus $c_{r+2} \neq 10$.

Hence, $a_{r+1} \neq 5$ is proved.

Supposed that Γ is a distance-regular graph with $k=10, a_1=1$, if

$$(c_{r+1}, a_{r+1}, b_{r+1}) = (4,4,2)$$

it can be asserted that each $C_{r+2}-$graph is a redundant group. In fact, $y \in \Gamma(x) \cap \Gamma_{r+2}(x)$ is set, then apparently $x \in C_{r+2}(\alpha,y)$. Because $a_{r+1}=4$,

$$\{x_1,x_2,x_3,x_4\} = \Gamma(x) \cap \Gamma_{r+1}(\alpha) \tag{12}$$

can be set. For a random point z in $C_{r+2}(\alpha,y)$ that is different from x, apparently $z \neq x_1,x_2,x_3,x_4$ stands. Therefore x and z are not adjacent, indicating that $C_{r+2}-$ graph is redundant group.

$C_{r+2}-$ graph is redundant group, thus $c_{r+2}=4$ or 5.

If $c_{r+2}=5$, then $d=r+2$, which is the conclusion in this paper.

If $c_{r+2}=4$, it can be asserted that $b_{r+1}=b_{r+2}$. In fact, because $C_{r+2}-$graph is redundant group, for a random $y \in D_{r+1}^{r+1}$, $\partial(y,\gamma)=r+1$. And since $c_{r+1}=c_{r+2}=4$ and y is arbitrary, $e(D_{r+2}^{r+2}, D_{r+2}^{r+1}) = e(D_{r+2}^{r+2}, D_{r+2}^{r+1}) = 0$, thus $b_{r+1}=b_{r+2}$.

Like the proving and recursion above, $(c_{r+1},a_{r+1},b_{r+1})=(c_{r+2},a_{r+2},b_{r+2})=\cdots=(c_{d-1},a_{d-1},b_{d-1})=(4,4,2)$ can be obtained, and C_d-graph is a residual cluster. Furthermore, $c_d=4$ or 5 can be obtained.

$e(D_d^d, D_d^{d-1}) = e(D_d^d, D_{d-1}^d) > 0$, so $c_d \neq 4$ and $c_d=5$. At this time, Γ is a 1-homogeneous graph.

Supposed that Γ is a distance-regular graph with $k=10, a_1=1$, $c_{r+1} \neq 3$ can be obtained according to inter nature of $k_{r+1}=\dfrac{10 \cdot 8^r}{1 \cdot c_{r+1}}$. Hence, when $c_{r+1}=3$, Γ does not exist.

3. Research of Conditional Coloring Problem in Three Regular Graph based on Ant Colony Algorithm

3.1. Derivation of Problem

Is it set that $k>0, k\in Z$, one normal $k-$coloring of Graph $G=(V(G),E(G))$ is $c:V(G)\rightarrow\{1,2,\cdots,k\}$, which satisfies $c(u)\neq c(v)$. As for any $uv\in E(G)$, the minimum positive integer k which satisfies normal $k-$coloring is called as the color number of G and recorded as $\chi(G)$. The problem of graph coloring aims to obtain the color number of a graph. The model is described as follows (Liu Jiangyuan, Tian Qing., 2014; Liu Na. et al., 2011):

Target: minimum color types applied in coloring of the whole graph.

Constraint conditions: (1) each point is colored by only one color type; (2) previous colors are used preferentially; (3) different colors are used by two adjacent points; (4) colors with smaller numbers will be used more frequently.

Hence, the mathematical model of the graph coloring problem is as follows:

$$\begin{array}{llll} \min & z & =\sum_{h=1}^{n} y_h & \\ \text{s.t.} & \sum_{h=1}^{n} x_{ih} & =1, & i\in V(G) \\ & x_{ih}+x_{jh} & \leq y_h, & (i,j)\in E(G), h=1,2,\cdots,n \\ & y_h & \geq y_h+1 & h=1,2,\cdots,n \\ & \sum_{i\in V} x_{ih} & \geq \sum_{i\in V} x_{i,h+1} & h=1,2,\cdots,n-1 \\ & x_{ih}\in\{0,1\} & & i\in V, h=1,2,\cdots,n \\ & y_h\in\{0,1\} & & h=1,2,\cdots,n \end{array} \tag{13}$$

Where: h refers to a color number. x_{ih} shows whether the h-th color is colored by the i-th point. y_h shows whether the h-th color is used, wherein $n=|V(G)|$.

3.2. Design and Optimization of Ant Colony Algorithm for Graph Coloring

Ant colony optimization (ACO) is a probability-type algorithm used to find optimized routes in a graph. It was proposed by Marco Dorigo in his doctoral thesis during 1992, wherein its inspiration was derived from ants' route discovery during food search(Xiang Chang-sheng, Zhou Zi-ying. 2010). ACO is a simulated evolutionary algorithm. Preliminary researches show that the algorithm has many advantageous natures. ACO is an algorithm simulating random route search of ants(Xiang Chang-sheng, Zhou Zi-ying., 2010). An ant stays in a square grid. By setting ant parameters, speed and radius (assumed as 3), it can be observed that the ant can move in the square grid with scope of 3*3, wherein its moving or walking distance will not exceed the scope.

Environment

Environment refers to a virtual surrounding environment for moving of an ant. There are obstacles and other ants as well as pheromones left by the ant in its action environment. The pheromones are classified into two types: pheromones secreted for food search and pheromones secreted for search of ant nest. Pheromones of environmental factors around the ant disappear according at a certain rate.

Foraging Rules

The ant searches food within a near distance and can directly obtain the food after finding it. If the ant cannot find food within the sensing scope, it will conduct searching based on food pheromones. By comparing pheromone contents in different directions within the sensing scope, the ant can determine multiple directions of the pheromones and select them. The probability is small for an ant to make mistakes, so one direction determined by the ant may not be the location containing most pheromones.

Moving Rules

The ant begins moving in the direction with the most pheromones. However, when there is no pheromone around which can be taken as the judgment direction, the ant will carry out food search in the original moving direction. In addition, a small random disturbance will take place in the moving direction. The ant will remember the points passed by it. It will try to avoid the point as much as possible if it finds that the next point has been passed before.

Obstacle Avoidance Rules

In the face of obstacles encountered during moving, the ant will move according to pheromones under their guidance. Otherwise, it will select the direction randomly in order to bypass the obstacle. After that, the ant will change the next position under the pheromone guidance according to the foraging rules.

Pheromone Rules

The disseminated pheromones will gradually decrease along with the increase of ant moving distance. In addition, the ant will secrete the most pheromones when it finds food or nest. According to ant behaviors, there are no direct interactive relations among ants. Through interactions between pheromones and environment, all the ants are correlated in fact. When an ant finds food, it will release food pheromones to the surrounding environment rather than directly transmit the food position source to another ant. Other ants can determine direction and route for food search by judging pheromones around them in order to get the food position information indirectly from other ants.

Initial colored point and new colored points at each step are completely controlled by the transition probability randomly. There are 7 basic steps, as shown below:

STEP1: Parameters are initialized. (Parameters include total quantity of ants, circulation times, adjacent matrix of graph and pheromone matrix.).

STEP2: Usable color sets of all the points are set. The first node is taken as the initial colored point and colored by the first color. The usable color set for points adjacent to the first point is updated.

STEP3: Transition probability from a colored point to each uncolored point is calculated. Each probability is multiplied by a random number. The point corresponding to the maximum value is taken as the next colored point. Pheromones are also updated.

STEP4: The selected colored points are colored. Colors used in coloring can be selected from the usable color set. The usable color set of points adjacent to the colored point are updated.

STEP5: If any uncolored point still exists, the STEP3 will be restarted.

STEP6: The scheme applying the minimum color types in each round of iteration is selected. Corresponding results are stored, wherein $NC = NC + 1$.

STEP7: If $NC \leq NC\_\text{MAX}$, STEP2 will be restarted. Otherwise, the scheme with the minimum color number in each iteration is selected, and the algorithm is then ended.

Optimization of above algorithm is mainly realized at STEP2 and STEP3. At first, the first colored point selected at STEP2 is colored by the first color. Instead, the first point is selected randomly and colored by one color randomly. After that, the STEP3 is started. During pheromone updating, one maximum value is set initially. Updating of each step is controlled within a scope. Pheromones are updated only when the optimal solution is found in the current circulation. The updating formula is as follows:

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}^{\min}, \Delta\tau_{ij}^{\min} = \frac{Q}{\min(L_k)} \tag{14}$$

Where: $\min(L_k)$ refers to the current optimal solution of the iteration, namely the current minimum coloring number during the iteration. Q refers to a constant which represents the total quantity of information released during a circulation completed by the ant. τ_{ij} refers to the pheromone content from point i to point j. ρ refers to a pheromone volatilization factor. If $\tau_{ij} \geq \tau_{\max}$ stands, $\tau_{ij} = \tau_{\max}$ will be set. If $\tau_{ij} \leq \tau_{\max}$ stands, $\tau_{ij} = \tau_{\min}$ will be set. In the following formulas, P is a parameter constant and NC is the number of iterations.

$$\tau_{\max} = \left[(1-\rho)\min(L_k)\right]^{-1}$$

$$\tau_{\min} = \begin{cases} \tau_{\max}/20, NC \leq 2 \\ \dfrac{\tau_{\max}\left(1-\sqrt[NC]{P}\right)}{\dfrac{NC}{2}-1} \cdot \sqrt[NC]{P} \end{cases} \tag{15}$$

The above algorithm is tested. In MATLAB, the graph is converted into an adjacent matrix. After that, according to algorithm programming, the random graph and the standard calculation example are respectively tested. The maximum number of iterations is set to be 100. The ant colony number is set to be 30. The pheromone volatilization factor is set to be 0.1. Weight of pheromones is set to be 10. Testing results of the obtained random graph are shown in Table 1.

Point number	Maximum degree before improvement	Maximum degree after improvement	Color number before improvement		Color number after improvement		Calculation time before improvement (second)		Calculation time after improvement (second)	
			Ant colony	Maximum and minimum ant colonies	Ant colony	Maximum and minimum ant colonies	Ant colony	Maximum and minimum ant colonies	Ant colony	Maximum and minimum ant colonies
60	41	38	16	13	14	13	16.313	10.109	15.232	5.294
60	37	37	15	13	13	15	17.657	10.344	16.157	4.981
100	60	65	20	18	19	19	62.094	36.859	58.694	14.390
100	63	62	21	18	19	19	64.547	37.485	60.329	16.562
100	62	61	21	19	19	19	61.703	37.696	55.226	16.338

Table 1 – List of Testing Results of Random Graph

Minimization of the used colors means that each independent color set C_i shall contain as many points as possible. All the updated pheromones consider number of elements added into the color subset as a parameter. The updating formula is as follows:

$$\begin{gathered} \tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}^{\min} \\ \Delta\tau_{ij}^{\min} = \frac{1}{\min(L_k)} + \frac{\sum_i |C_i|^2}{n} \end{gathered} \tag{16}$$

3.3. Discussion of Conditional Coloring in Three Regular Graph based on Improved Ant Colony Algorithm

Conditional coloring of a three regular graph *G* can be converted into classical coloring of its square graph. According to results of Cranston and Kim[15], except for *G* which is a Petersen graph with $\chi_r(G) \le 8$, the three regular graphs are tested. The three regular graphs, namely all the graphs with vertex degree of 3, are generated randomly at first. The algorithm of three regular graphs is generated as follows:

STEP1: n unconnected points are generated. The first point is connected to other 3 random points.

STEP2: If degree of the i-th point exceeds 3, the STEP1 will be restarted. Otherwise, the i-th point will be connected to several points from i+1 to n. The degree of i is set to be 3.

STEP3: If i is not bigger than n, STEP2 will be restarted.

STEP4: Whether the matrix is a three regular graph is determined. If the result is YES, results will be output and the step is ended; otherwise, STEP1 will be restarted.

When the adjacent matrix is obtained, it can be tested by the above graph coloring processes. Testing results are shown in Table 2:

Point number	Maximum degree	Color number		Calculation time (second)	
		Classical coloring	Coloring under condition 3	Classical coloring	Coloring under condition 3
10	3	3	5	0.515	0.813
20	3	3	6	1.172	3.344
30	3	3	6	2.156	6.516

Table 2 – List of Testing Results of Three Regular Graph Coloring Processes

4. Conclusions

Existence theorem of a distance-regular graph with $k=10, a_1=1$ stands, which is proved in this paper from the theoretical level. The focused ant colony algorithm is a bionic algorithm. The algorithm is very applicable to overall optimal solution. It is highly applicable to graph conditional coloring problem after the improvement. The paper also applies MATLAB software to verify the testing programs. Results show that application effect of the improved ant colony algorithm in the three regular graph conditional coloring is better than classical coloring effect. In ant colony coloring algorithm, new colored points are selected randomly and dynamically in a reversed order according to coloring progress and degrees of points adjacent to uncolored points in order to equip the algorithm with strong ability to search overall optimal solutions. Solution quality of the ant colony coloring algorithm is improved. Its convergence rate is accelerated. Its excellent characteristics are also proved. Meanwhile, efficiency improvement of the algorithm also ensures that the algorithm can be applied to solution of large-scale coloring problems. In future researches, it is still necessary to research the methods for shortening operation time of ant colony algorithm.

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Research of Multidimensional Indexing in a Cloud Computing System

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Abstract: Cloud computing is a computing model for enabling the Internet to gain on-demand, easy access to a shared pool of resources (such as computing facilities, storage devices, applications, etc.) at anywhere and anytime. As more and more data and applications migrate from super-servers to public cloud or private cloud computing systems, how to effectively carry out data management in cloud computing systems has become a research work of great significance. For ubiquitous multi-dimensional data in the real world, this paper builds an index structure RT-CAN in a cloud computing system to improve query performance of the system. RT-CAN can position and query multidimensional data needed in large-scale cloud computing systems. These systems use hundreds of thousands of computers as a platform for data storage and computing, thereby providing ample computing and storage capacities for a large number of online users. RT-CAN indexing performance to support multi-dimensional queries is tested in a commercial cloud computing platform offered by Amazon, and the experimental results show that RT-CAN index structure has good scalability to effectively support multidimensional data management in cloud computing systems.

***Keywords**:* Cloud computing, spatial database, query processing, aggregate queries.

1. Introduction

Cloud computing is an emerging computing model. It hides computing resources and implementation details of computing; users need only to submit computation tasks or service requests through a browser or application interface, without having to consider how to build computing architecture. Computer resources as services are an important form of cloud computing. It shields users from such problems as data center management, large-scale data processing and application deployment. Through cloud computing, users can quickly apply for or release resources conforming to their business load, and pay for resources used on demand to improve the service quality while reducing operational costs.

Massive data management is the foundation and core technology of cloud computing, and it manages massive data produced by cloud users through building large-scale data centers and deploying distributed storage systems. With the advent of social networks, e-commerce and new generations of large-scale Internet applications, application data show such characteristics as large memory space and rapid growth. To ensure the I/O performance and scalability of the massive data management platform, major cloud service providers have proposed distributed storage systems based on a shared nothing architecture. In the shared nothing architecture, each node in the data center has independent local storage and data are distributed to store on each node, while at the same time computing tasks are first scheduled and executed in the data node, thereby reducing data transfer overhead in the task execution process (Martins, J., Gonçalves, R., Santos, V., Cota, M. P., Oliveira, T., & Branco, F., 2015). Currently distributed storage systems based on the shared-nothing architecture include Google File System (GFS) and its open-source implementation Hadoop Distributed File System (HDFS), Amazon Dynamo and Facebook's Cassandra.

In the shared nothing architecture, each node runs independently in the data center and inter-node status is transparent, so a distributed data storage system needs to maintain a global view about the data information. Current solutions are mainly to extract and record metadata through creating a data index, such as data storage location and creation time. Distributed storage systems employ data indexes for data organization and management, which provide data query capabilities for cloud users. With the introduction of data indexes, the data query process of distributed storage systems no longer needs to traverse all nodes, which has speeded up the query speed and improved storage system performance.

Currently data index schemes for distributed storage systems in a cloud computing environment are divided into two categories: centralized and distributed index schemes, in which distributed storage systems using centralized index include Google File System (GFS) and Hadoop Distributed File system (HDFS). In GFS, files are divides into a number of fixed-size chunks of 64B, and the data index is stored centrally in the management node memory to ensure the reading speed of metadata. GFS has good performance when storing GB and even TB files, but data index will consume large amounts of data management node memory when storing large amounts of small files (such as pictures that users upload in a social network). In the meantime, there is a single point of failure in a single management node, which is easy to become a system performance bottleneck.

In recent years, query processing and indexing techniques in cloud computing systems have aroused widespread concern in academic circles. The main research topics are to design high-efficient query algorithms and to use effective cloud computing index techniques to provide scalable query performance for applications in a cloud computing system. Literature (Saravanakumar C, Arun C., 2015) proposes an efficient method of batch insertions of data on a cloud storage system, and data in the system are horizontally divided by the key range and distributed across all storage nodes. Literature (Gopinath R, Geetha B G., 2015) considers a compromise between data migration costs and system throughput after insertion in the data insertion process and proves the problem belongs to the NP-hard problem. Literature(Ali A M, Ramakrishnan M., 2015) studies how to start an effective query in parallel ranges in the system. Considering the differences between customer application consumption data speed and query speed in the storage system, this paper increases or decreases the node number of queries in parallel processing ranges by dynamic adaptation, thus making the system obtain enough query results in parallel and send to the client application. Literature (Liu D, Yang G., 2015) builds a distributed data stream processing system in MapReduce. Literature (ARSLAN F., 2015) studies the mechanism of using indexes and views in large-scale distributed data management systems. This paper uses two views, namely remote and local view tables, and thus provide compromise processing between system throughput and view update speed. This paper presents the construction and maintenance of icons and the use of views to answer and gather queries, link queries and select queries. Literature (DONDURUCU Z B, ULUÇAY A P., 2015) designs Crescando, a scalable, distributed relational table implementation, to support a large number of queries and updates, and provide predictable operational delays. Crescando uses parallel collaborative scanning operations and "Query-Data" connection technology in data flow to ensure workload reaction times and result updates. Crescando cannot achieve optimal performance in dealing with a variety of workloads, but it has certain advantages when the workload is unknown and varied. Literature (Safiye G., 2015) designs a cloud computing data storage system Spinnaker, which can achieve a new compromise between data accessibility and consistency. Spinnaker has high accessibility and timeline consistency by using consistent backup agreements, and achieved the ACID in handling tuple-level transactions. Compared with Dynamo, Spinnaker has better data consistency and pays fewer performance costs. Literature (KABAL L., 2015) designs simulation software CloudSim for cloud computing platform testing to simplify the performance evaluation of applications developed by cloud computing.

Focusing on ubiquitous multidimensional data in the real world, this paper builds an index structure RT-CAN in a cloud computing system to improve query performance of the system. RT-CAN can position and query multidimensional data needed in large-scale cloud computing systems (SÖNMEZ A S, BİÇAKCI H, YILDIRIM C. 2015; ÇELİKKOL H, Fatma K., 2015). These systems use hundreds of thousands of computers as a platform for data storage and computing, thereby providing ample computing and storage capacities for a large number of online users. Index structure in cloud computing systems should have good scalability (QOSJA E, DRUGA E., 2015). When the node computing number increases, the system should provide better query throughput. Therefore, the traditional single-node routing query mode can no longer meet the demand. Under the traditional model, each computing node needs to send index of local data to the routing node, and all queries find computing nodes that contain the required data by the routing nodes. Single routing nodes are a bottleneck of system performance, and therefore increasing the system's computing nodes cannot improve query throughput.

2. RT-CAN Index

RT-CAN is built on the local R tree in the computing nodes and selects part of the R-tree nodes as a global index. Among them, a key question is how to map the R-tree nodes to the computing nodes in the system. This chapter describes the RT-CAN index structure in cloud computing systems and how to map R-tree nodes to cloud computing systems to compute nodes. Subsequently, it introduces the method to release the global index in an RT-CAN indexing system.

2.1. System Structure

RT-CAN index acts on shared-nothing distributed clusters, in which datasets are divided into data chunks and distributed in each computing node in the system(akbayir z, kuşay y., 2015). As shown in Figure 1, each computing node N_i in the system plays two roles, which are storage nodes N_{si} and index nodesN_{oi}. Wherein, N_{si} is added in a distributed storage system and responsible for storing a portion of data in the system. In order to accelerate local multidimensional query responses, N_{si} uses R-trees to index local data. By interacting with the index nodeN_{oi}, N_{si} publishes a global index. N_{oi} is a node of the structured peer network topology CAN that the system uses and maintains division of the entire multidimensional data space. According to the current workload mode, N_{si} adaptively selects some nodes from the local R-tree for global indexes, and is released into the system through peer network topology interface provided byN_{oi}. The global index format released into the system is (ip, port, addrmbr), where ip is the IP address of the index owner Ni; port is the network port used by Ni; addr is the storage address of each R-tree node corresponding to the global index in N_i external memory; mbr is the smallest multi-dimensional area corresponding to the R-tree node in the global index. When N_{oi} receives the global index distribution requests fromN_{si},N_{oi} maps the corresponding R-tree node to the CAN index node, and send global index release requests to the corresponding index node through the CAN routing protocol. N_{oi} is responsible for maintaining global index of the system; when it receives a global index release request from the system, N_{oi} first uses the RT-CAN mapping mechanism to check whether it is the recipient of the global index. If yes, the global index will be stored in N_{oi} memory to accelerate queries accordingly. In the RT-CAN index structure, the global index is composed of nodes selected from the local R-tree and distributed in the index node of the system.

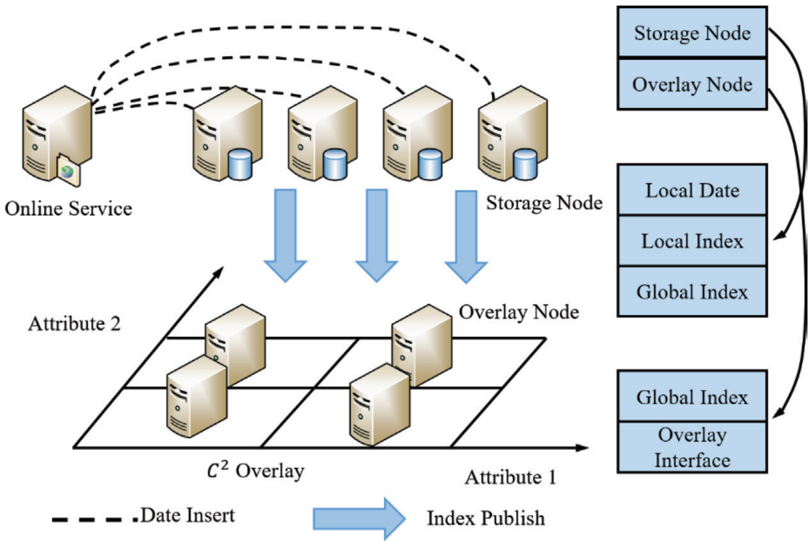

Figure 1 – RT-CAN System Architecture

2.2. Global Index Mapping Mechanism

RT-CAN uses C^2peer-to-peer network architecture for the global index of multidimensional data maintenance in the system. C^2 peer-to-peer network architecture has improved search performance on the basis of CAN and increased several logical connections pointing to neighbors in each dimension, and the routing message cost searched is limited to O (logN), where N is the number of system nodes. RT-CAN proposes a mapping mechanism that maps the R-tree nodes to a number of nodes in C^2 peer-to-peer network architecture and assigns these nodes as recipients of global index. For a given R-tree node n, RT-CAN first computes the center $c_n$of n and the radius r_n, and uses these values in the mapping process. If r_n is less than the pre-established thresholdr_{max}, then n is mapped to an index node. Otherwise, n will be mapped to multiple index nodes. The global index mapping method of RT-CAN is as follows. For a given R-tree node n, RT-CAN will map n to the index node N_c, where the division part of multidimensional data space thatN_c maintains contains the center c_n of R-tree node n. Then N_c compares the radius r_n of n and the pre-established threshold r_{max}. If r_n is no less than r_{max}, N_c will send n to the index nodes where the multi-dimensional space and n intersect. RT-CAN uses the center of n in the mapping process, because the R-tree nodes at a similar distance to the center are more likely to contain similar data, which are data to be visited by the same query(Elmas A. 2015; ÖNDER H B. 2015). RT-CAN mapping mechanism creates multiple global index backups for R-tree nodes with large radii in the system, signifying that R-tree nodes n of which r_n is no less than r_{max} are stored in a plurality of index nodes. Such a mapping method comprehensively considers the costs for updating global indexes and searching in the system. R-tree nodes of small radii are often from the bottom. Compared to the top R-tree nodes, bottom nodes will consume greater costs for updating global indexes in the system, so RT-CAN maps R-tree nodes of small radii to an index node(BAŞIBÜYÜK E. 2015). On the other hand, R-tree nodes of large radii may intersect with the space region of multiple index nodes, so there are multiple corresponding global indexes in the system. More queries intersect with such a global index node, so using the unique index node is bound to lead to global index access bottlenecks, thus reducing the query performance.

Parameter r_{max} has an important influence on the query search space in the system. Increasing r_{max} may make more queries need to access multiple index nodes in the system. Figure 2 shows an example of using different r_{max} to produce different query search spaces. In a two-dimensional C^2 peer-to-peer network, when r_{max} is set as R_1 and R_2, search spaces for point queries are the circular areas with radii of R_1 andR_2. If r_{max} is increased from R_1 to R_2, more index nodes should be accessed to gain all global indexes intersecting with the queries. r_{max} is an adjustable parameter in the system. A large r_{max} will reduce query performance because more index nodes will be accessed. On the other hand, a small r_{max} will cause greater global index maintenance costs, as more global indexes have multiple backups in the system. In the RT-CAN index used in this chapter, r_{max} is greater than the radius of most R-tree nodes in the system, and r_{max} can be determined based on the size of R-tree node samples in the system.

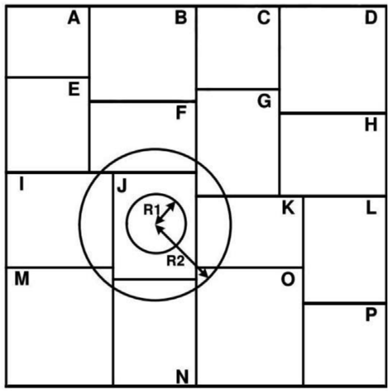

Figure 2 – Different Search Space of an Point Query with Different r_{max} Values

2.3. Global Index Selection

Global index selection algorithm must ensure the integrity and uniqueness of indexes. Figure 3 shows an example of dynamically selecting global indexes in an R-tree, in which the shadow-filled R-tree nodes are selected as global indexes. By using the current query and update modes, the global index selection algorithm selects a set of nodes from a local R-tree as global indexes, and this process meets the integrity and uniqueness of indexes at the cost of minimal indexing strategy (the sum of index maintenance costs and inquiry processing costs). The global index selection problem is defined as follows.

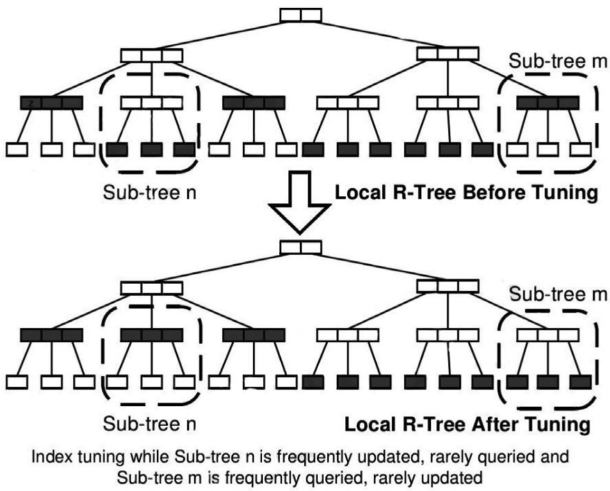

Figure 3 – Adaptive Global Index Selection

Definition: Give a local R-tree T_R and its node set V, where the cost of each R-tree node $n \in V$ is denoted as C(n), which is the index cost of n. As for the global index selection problem, the node set S is selected from T_R and satisfies the following conditions:

1. $S \subseteq V$;

2. $\forall n_i, n_j \in S, n_i$ is not the ancestor node of n_j, and vice versa;

3. For any leaf node n_i in T_R, $n_i \in S$ or there is an ancestor node n_j of n_i that satisfies $n_j \in S$;

4. Minimize Equations 1 and 2 and compute the index cost of S.

$$C(S) = \sum_{n \in S} C(n) = \sum_{n \in S} (C_{FP}(n,Q) + C_M(n,L)) \tag{1}$$

$$C(S) = \sum_{n \in S} \log \frac{N}{4} (|Q_{FP}(n)| + 3(p_{split}(n) + p_{merge}(n))) \tag{2}$$

In Equations 1 and 2, $\log \frac{N}{4}$ is a constant for a given peer-to-peer network size, and remove it in the cost model and the following cost model is obtained.

$$C(S) = \sum_{n \in S} (|Q_{FP}(n)| + 3(p_{split}(n) + p_{merge}(n))) \tag{3}$$

The index cost of global index n becomes,

$$C(n) = |Q_{FP}(n)| + 3(p_{split}(n) + p_{merge}(n)) \tag{4}$$

3. Performance Evaluation

This section uses the Java language to implement the RT-CAN indexing system, and employs the commercial cloud computing platform EC2 offered by Amazon to test RT-CAN index query performance and update performance. JDK Version used in this experiment is Java 1.6.0.13, and the computing node used in EC2 is small-unit computing element. For each computing node the configuration is Xeon CPU, with dominant frequency at 1.7GHz, 1.7GB memory and 160GB disk. Computing nodes are connected by 250Mbps LAN. The numbers of computing nodes used in the test are 32, 64, 96 and 128, and the experiment uses two datasets. In the homogeneous dataset, the experiment produces 500000N multidimensional data objects by artificial synthesis, where N is the number of computing nodes in the system. Each object has 2-5 numerical attributes as multidimensional coordinates, and the value of each attribute is an integer of $[0,10^9]$. The entire dataset is divided into N_g parts, where N_g is several times of N. Subsequently, the resulting data partitioning is randomly assigned to each computing node. In this way, each computing node maintains multiple data partitioning, and each computing node has roughly the same amount of data. In the traffic datasets, experiments using the data generator to produce 100,000N two-dimensional data objects, and this process uses a city map, where N is the number of computing nodes used in the experiment. Data objects in the traffic dataset have skewed distribution in the space, and a method similar to uniform datasets is used for dividing traffic datasets and assigning resultant data partitioning between computing nodes.

3.1. Range Query Performance

Multidimensional range query is one of the most common query types of Web2.0 applications. Multidimensional point query can be regarded as a special kind of multi-dimensional range query, of which the range length of each dimension is 0. kNN query processing in the system is also completed by a number of multidimensional range queries. The experiment testing RT-CAN handles multi-dimensional range query performance. Query selectivity here means the proportion of query ranges in the entire data space. For example, in a three-dimensional space, 0.05% of query selectivity indicates the query length ratio on each dimension is about 8%. Figure 4 and Figure 5 depict different numbers of computing nodes used to handle multi-dimensional range queries of different degrees of query selectivity in traffic datasets and uniform datasets. As can be seen from Figure 4 and Figure 5, after increasing the number of computing nodes in the system, RT-CAN query throughput will also increase linearly. This shows that RT-CAN has good scalability and is suitable for cloud computing system comprised of by a large number of computing nodes. As query selectivity increases, more global indexes should be acquired, while more local queries are executed in the storage node, so the query throughput of the system has declined. Wherein, the traffic dataset has greater query throughput than the uniform dataset, because the traffic dataset is composed by two-dimensional data whereas the uniform dataset is composed by three-dimensional data. Therefore, queries in uniform datasets need more routing messages, more global indexes and local disk search.

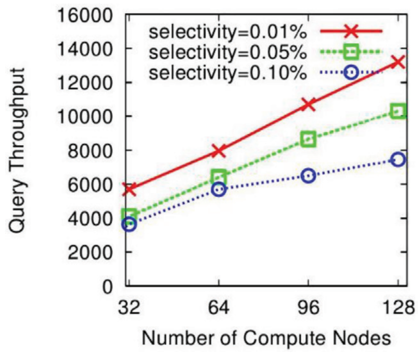

Figure 4 – Effect of Selectivity (Traffic Dataset)

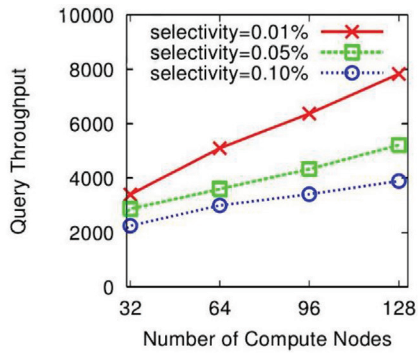

Figure 5 – Effect of Selectivity (Uniform Dataset)

In the real world, queries tend to have skewed distribution, meaning that users tend to focus on data in a space area. In Figure 6 and 7, this section tests the query throughput of skewed distribution, as well as the impact of varying degrees of skew on query performance. In the experiment, queries of data chunks follow zipfian distribution, and the skew factors are 0, 0.5 and 1, respectively. A skew factor of 0 means queries are evenly distributed; a skew factor of 1 means 80% of the queries will visit 20% of data, and query distribution is very skewed. The experimental results show that RT-CAN has the highest query throughput in uniformly distributed data, and query performance drops as query skew levels increase. Since the dynamically adjusted global index is used, RT-CAN can still provide good query throughput in the case of very skewed queried (a skew factor of 1).

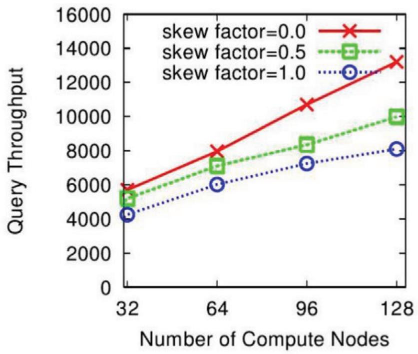

Figure 6 – Effect of Skewness (Traffic Dataset)

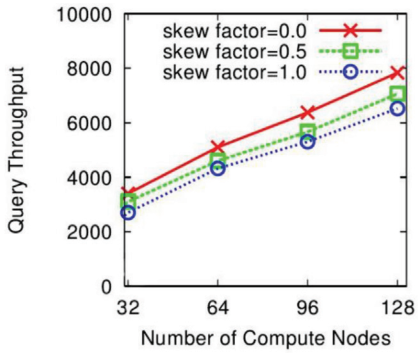

Figure 7 – Effect of Skewness (Uniform Dataset)

3.2. Dimension Effect

RT-CAN is the index structure built for multidimensional data in cloud computing systems. In this section, RT-CAN performance to handle range queries is explored under different dimensions. As traffic datasets are two-dimensional, this experiment solely uses uniform datasets of which data dimensions grow from 2 to 5. Figure 8 exhibits the range query throughput by RT-CAN for data of different dimensions. As per the experimental results, along with an increase in data dimensions, system query throughput slowly decreases. This is because adding data dimensions will cause queries to intersect with more global indexes, thus generating more storage node local R-tree search and increasing the processing cost of a single query. For instance, in a 5-dimensional uniform dataset, the range query Q searches 0.01% of the entire data space. In this case, the search length of Q in each dimension is 16% of the total length of that dimension, which will cause more global indexes to intersect with the search space.

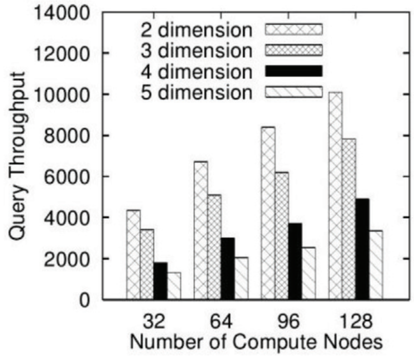

Figure 8 – Effect of Dimensionality

4. Conclusion

This paper designs the multidimensional index RT-CAN in cloud computing systems. RT-CAN is built on the local index R-tree and supports efficient multidimensional data acquisition in cloud computing systems constructed inside of large-scale shared-nothing clusters. RT-CAN dramatically selects part of nodes from the local R-tree as global indexes and releases them into the system instead of using the tuple-level indexing technology. Global indexes released into the system are scattered in memory of various computing nodes, which are organized into C2 peer-to-peer network architecture. This paper advocates using RT-CAN to handle a variety of multi-dimensional query algorithms, including multi-dimensional point queries, range queries and k-NN algorithm query. To reduce the query and index maintenance costs of RT-CAN indexing, this paper presents to dynamically select global index algorithms, and uses dynamic programming techniques for solving the optimal set of global indexes through the designed cost model. In the selection process of global indexes, index costs for various index strategies are estimated in accordance with the current query distribution pattern and update distribution pattern. By testing RT-CAN indexing performance in Amazon EC2, the experiment shows that RT-CAN index has good scalability and is capable of handling a variety of multi-dimensional queries effectively in large-scale cloud computing systems, and provides good system throughput for the mixed workloads of updating and queries, so RT-CAN is an effective multidimensional index structure in cloud computing systems.

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