Design of Intelligent Wearable Device Based on Grey Relational Analysis Model

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***Abstract* — To improve the accuracy, rapidity, comfort and user friendliness of intelligent wearable device, this paper used the grey relational analysis model for the design process. The development status and key technologies of intelligent wearable device are analyzed in this paper, including sensor technology, display technology, chip technology, operating system, wireless communication technology, data processing technology and improve battery life extension technology. In accordance with the characteristics of intelligent wearable device, the grey relational analysis algorithm has been researched and combined with expert system. Thus the developing platform based on grey relational analysis can be used for intelligent wearable device is designed and implemented. The final test indicates that the grey relational analysis algorithm is simple in calculation and its result is accurate; the simulation result of expert system is consistent with the theoretical analysis result.**

Keywords - intelligent wearable device; grey relational analysis model; supply model; expert system

I. INTRODUCTION

In the 21st century, computer and communication technologies develop and spread rapidly. With the continuous development of smart devices and the increasingly important role in the direction of the mobile computing, a wide variety of applications have been applied well on smart devices. The design of a framework for intelligent equipment systems is important. The framework is divided into four levels: Sensor layer, gateway layer, management layer and application layer.

The intelligent wearable device is always discussed with embedded system. Embedded system is the hardware and software system, which has been embedded in the application of product and engineering, and is cored with MCU. The embedded system, which came from the combination of embedded system and Internet, has become a new technology with the development of computer and network. It builds up the ability of connecting Internet through the embedded system. It bring that embedded system, which is cored with low-cost MCU, directly connects Internet without PC.

With the development of the intelligent device such as PDA, Pocket PC, the mobile application market is getting more and larger in Chinese software field. Many domestic software companies are joining in the field of the enterprise mobile applications, even more in the recent days. The mobile application market, with a good view, drives the development of the mobile sync mid-ware applications. The current leading international enterprises, such as Sybase, Microsoft, Oracle, IBM and etc., all have its own sync mid-ware products, which have good functions and performances and also have continuous improving points. But some shortcomings of these products have been found in the implement process, such as Microsoft's product only supports its own database SQL server; Sybase's product is complex to develop the mobile applications; the core technology is not open and some problems is difficult to solve; they can't support the current existed business systems without special patches, all these defects and shortcomings need to be solved and improved. So Chen's [1] paper, based on these products and making some research on the international sync protocol and taking the good points from them, comes out some good solutions for these defects and shortcomings. Firstly, his paper analyzes the system requirements including the gateway engine, server, client and other requirements; Secondly, his paper makes the system design including system structure, sync engine, sync protocol, interaction and protocol binding. Zhang's [2] paper discussed the system implementation including the technology selection, sync process flow, client and server function development. His paper summarized the technology features which are core of the ebGate project and the paper. With the design and implementation of this project, it is proved that it is practicable to use XML format to enclose and operate data transferring commands and is much more reference for other likely kind of projects.

In the modern market, the virtual reality (Virtual Reality) technology has been integrated in some product areas, it has been more than just science fiction movie catches the eye effects, but gradually in our real life can be achieved, such as virtual products, virtual clothing, virtual city system, virtual homeland so on. With the development of the Internet, virtual reality technology through a more intuitive visual performance in all kinds of ways to experience the product, and given people a new life experience in the way. But as a new technology used in modern product design virtual reality technology meets ergonomic requirements, can really be accepted by the people with the use of, or the direction of a pending study. The topics to be wearable intelligent devices designed as a research starting point, import the virtual interactive experience design, by drawing physical product ergonomics research methods to study the virtual

reality technology in the new field of ergonomics and innovative.

II. The framework of grey relational analysis model

With the continuous development of science and technology, information has penetrated into every parts of human life, and become essential elements of modern society. In the era of life filled with information, people began to realize the importance of how to scientifically collect, screen, deal with information. Grey system theory is just one of the emerging disciplines used for information processing. Using mathematical methods, the theory put forward the theories and methods of how to process and analyze systems with incomplete information. Because it can describe the behaviors and development trends of things by extracting known information, grey system theory has a wide range of applications. Including agriculture, military, economic, ecological and other fields, the grey relational analysis is a factor analysis method based on grey system theory. This analysis method can determine the relational degree of the factors which influence the system by considering the similarities between them. By analyzing and comparing the relational degrees, we can determine the dominant factor which influences the system development so as to make a quantitative description of the system development trend. Compared to other methods of statistical analysis methods, grey relational analysis has the following obvious two advantages: (1) the small sample size; (2) the ability to study the dynamic process of the system and things. So far, the grey relational analysis has been adopted in various fields to forecasting and analyzing system. With the deepening and expansion of the application, a variety of new models and theories have been further excavation.

Based on the existing relational analysis algorithms, and to fit the practical applications, Zheng [3] improved part of the relational models and methods. The experiments show that our work got good results. He briefly summarized the sequence grey relational analysis methods and found that these methods existed rarely can carry on asynchronous comparison. So he put forward the sliding grey relational analysis. The method uses the concept of analogical reasoning for reference to carry on comparison in asynchronous sequence. Taking Jilin Province for example, we used sliding grey relational grade to study the development trend of Jilin Province's GDP. This can guide for better development of macro-control policies and provided new ideas for achieve economic transformation during the "12th Five-Year" period of Jilin province. In practice, things are always described in matrix form.

When using grey system to analyze and process such things, we usually convert the matrix into sequence and then compare. Such processes would introduce errors and miss many features of things. So we need to optimize the existing relational analysis methods. In this paper, we deeply analyze of the characteristics of grey relational analysis and matrix, put forward to a class of matrix grey relational analysis method. Zheng [4] successfully uses them to provide new technology in the two-dimensional signal processing. Such as noise monitoring point position optimization, speech recognition and image processing techniques. And he also proved the rationality of his methods. From distance "antisense" and grey correlation four axioms, he gave the derivation process of the three matrix grey relational degree he proposed (the absolute matrix grey relational degree, relative matrix grey relational degree and matrix grey type B absolute relational degree).

Due to time constraints, Wei's [5] paper only completed some preliminary research in the grey relational analysis theories and applications. He did not actually involve the field of matrix grey relational analysis. There are also many problems to be explored and dig. For example, he only defined sliding grey relational degree and three kinds of matrix grey relational degree. During these problems, matrix grey relational analysis use in noise fluctuations is still unconsidered; this will be the focus of the future work. In addition, there are still a lot of prosperities existed in these grey relational degrees, as well as the application value and character proof. Also how to choose the appropriate reference matrix is urgent need to address the problem in the car of Chinese speech signal recognition and face recognition.

Aiming to reduce sensitivity to parameter by using Gaussian function as the similarity measure in spectral clustering and to identify multidimensional clusters with reducing the outliers interference, a new approach is presented, in which grey relational analysis based on the balanced closeness degree is integrated with spectral clustering and an adaptive weighted similarity measure is used, and finally the improved FCM algorithm is used for clustering in Chen's paper [6]. The proposed algorithm is compared with the existing algorithms on the artificial and real-world datasets. The experimental results demonstrate that the proposed algorithm can avoid the effect of parameter and achieve higher clustering accuracy by using F measurement index.

Grey system theory is an effective approach for solving a kind of problems with poor information uncertainty. It has been widely applied in agriculture, industry, national defense, science and technology, education, economy, management and other fields. With the deepening research, this theory has been continuously improved, but it still has many unsolved theoretical problems. With regard to the theories and methods for grey uncertain systems modeling, Wei's [7] paper conducts a series of basic theory research, including constructing new buffer operator, proposing an novel grey forecasting model, studying the characteristic parameters of the novel grey forecasting model, optimizing the existing grey relational model, creating a novel grey relational analysis model, optimizing approach for solving the index weight, and presenting a novel grey decision-making model, etc. The paper established some novel buffer operators. According to the principle of new information, based on the existing researches on buffer operator, several novel weakening buffer operators and some novel strengthening buffer operators were built, and the compare novel buffer operators with the existing buffer operators in performance that buffer modeling data effect were carried out through a

numerical example. With regard to the preprocessing of original grey modeling data, the paper studied the parameters characteristics of the novel grey NGM (1, 1, k) model under multiple transform.

III. THE ALGORITHM

Based on gray correlation analysis, presents a new kind of TOPSIS. First take the gray correlation coefficient matrix between primitive data sample and ideal scheme as new decision-making matrix, and then use TOPSIS to evaluate and arrange all schemes. This method overcomes the traditional TOPSIS's shortcoming of excavating the inherent law of the data difficultly. An example shows its validity. Based on principal component analysis method (PCA) and gray correlation clustering analysis, presents an index integration method. In the process of analyzing and evaluating multiple index problems, first we analyze these indexes using grey correlation clustering analysis method, in order to classify them into several classes which can be defined. Then we analyze these classes based on PCA to get principal component set of every class. Finally we integrate all indexes based on the weight of every class. This method not only includes the information of all indexes, but allows for the relations among these index classes. An example shows this method is easy and national. Introducing the grey system theory, this paper presents a new grey correlation technique for order preference by similarity to ideal solution (GC-TOPSIS) to develop traditional TOPSIS.

The equation of basic function is as equation (1) as follows:

$$\partial_j(C_{ijkl}\partial_k u_l + e_{kij}\partial_k\varphi) - \rho\ddot{u}_i = 0 \tag{1}$$

Under the linear relationship, basic equation is shown in equation (2):

$$\partial_j(e_{ijkl}\partial_k u_l - \eta_{kij}\partial_k\varphi) = 0 \tag{2}$$

The linear differential equation can be expressed into the following simplified forms:

$$L(\nabla,\omega)f(x,\omega) = 0,$$
$$L(\nabla,\omega) = T(\nabla) + \omega^2\rho\mathsf{J} \tag{3}$$

In which,

$$T(\nabla) = \begin{Vmatrix} T_{ik}(\nabla) & t_i(\nabla) \\ t_k^T(\nabla) & -\tau(\nabla) \end{Vmatrix},\ \mathsf{J} = \begin{Vmatrix} \delta_{ik} & 0 \\ 0 & 0 \end{Vmatrix},$$
$$f(x,\omega) = \begin{Vmatrix} u_k(x,\omega) \\ \varphi(x,\omega) \end{Vmatrix} \tag{4}$$
$$T_{ik}(\nabla) = \partial_j C_{ijkl}\partial_l,$$
$$t_i(\nabla) = \partial_j e_{ijk}\partial_k,\ \ \tau(\nabla) = \partial_i\eta_{ik}\partial_k$$

Consider an infinite situation, we have the equation (5) in the following:

$$L^0 = \begin{Vmatrix} C^0_{ijkl} & e^0_{kij} \\ e^{0T}_{ikl} & -\eta^0_{ik} \end{Vmatrix} \tag{5}$$

Consider the propagation, instead the equation (3) with the following form:

$$C(\mathrm{x}) = C^0 + C^1(\mathrm{x}),\ \ e(\mathrm{x}) = e^0 + e^1(\mathrm{x}),$$
$$\eta(\mathrm{x}) = \eta^0 + \eta^1(\mathrm{x}),\ \ \rho(\mathrm{x}) = \rho_0 + \rho_1(\mathrm{x}) \tag{6}$$

Then we have equation (7) to (11):

$$C^1 = C - C^0,\ \ e^1 = e - e^0,$$
$$\eta^1 = \eta - \eta^0,\ \ \rho_1 = \rho - \rho_0 \tag{7}$$

The containing inclusions can be simplified into the following integral equation set:

$$f(x,\omega) = f^0(x,\omega) + \int_V \mathcal{S}(x-x')(\mathrm{L}^1F(\mathrm{y}') + \rho_1\omega^2\mathbf{g}(R)\mathrm{T}_1 f(\mathrm{y}')]S(\mathrm{y}')\mathrm{d}\mathrm{y}' \tag{8}$$

In view of the following relationship:

$$\frac{1}{2\pi}\int_{-\infty}^{\infty} e^{-ik_3x_3'}dx_3' = \delta(k_3) \tag{9}$$

Equation (8) can be converted into the following form:

$$f(y,\omega) = f^0(y,\omega) + \int_s S(y-y',\omega)\mathrm{L}^1F(\mathrm{y}',\omega)\mathrm{d}\mathrm{y}' + \rho_1\omega^2\int_s \mathbf{g}(y-y',\omega)\mathsf{J}f(\mathrm{y}',\omega)\mathrm{d}\mathrm{y}' \tag{10}$$

In which, S is cylinder cross section, $y = (x_1, x_2)$, and

$$\mathbf{g}(y-y',\omega) = \frac{1}{(2\pi)^2}\int_0^{\infty}\bar{k}d\bar{k} \qquad \bar{k} = (k_1,k_2) \tag{11}$$
$$\int_0^{2\pi}\mathbf{g}(\bar{k},\omega)\exp(-i\mathrm{k}\square(\mathrm{y}-\mathrm{y}'))d\phi$$

Suppose $k_3 = 0$, $\mathbf{g}(\bar{k},\omega)$ can be obtained from Equation (8).

For such kind of material, general form of equation (10) is expressed as following equation (12-14):

$$G_{ik}(\bar{k},\omega)=\frac{1}{\rho_0\omega^2}[\frac{\beta^2}{\bar{k}^2-\beta^2}\theta_{ik} +\bar{k}_i\bar{k}_k\left(\frac{1}{\bar{k}^2-\alpha^2}-\frac{1}{\bar{k}^2-\beta^2}\right)+m_i m_k\frac{\beta_\perp^2}{\bar{k}^2-\beta_\perp^2}] \quad (12)$$

$$\mathcal{g}_{ik}(\bar{k},\omega)=-\frac{1}{\eta_{11}^0}\frac{1}{\bar{k}^2}+\frac{1}{\rho_0\omega^2}\left(\frac{e_{15}^0}{\eta_{11}^0}\right)^2\frac{\beta_\perp^2}{\bar{k}^2-\beta_\perp^2} \quad (13)$$

$$\gamma_i(\bar{k}_i,\omega)=\frac{1}{\rho_0\omega^2}\left(\frac{e_{15}^0}{\eta_{11}^0}\right)^2\frac{\beta_\perp^2}{\bar{k}^2-\beta_\perp^2}m_i \quad (14)$$

Our scheme has two main advantages as compared to prior work: It is immediately suitable for the distribution of a large-sized file that consists of multiple generations. This method established a new kind of relative similarity degree by combining the Euclidean distance with grey correlation degree. The new similarity degree reflects the distance and the different shape between a selected scheme and the ideal solution and negative ideal solution. Its implication is very clearer.

IV. The Design Process of Intelligent Wearable Device Based on the Grey Relational Analysis Model

In recent years, the rapid rise of smart products, and developed a wide variety of abundance category. Differs from traditional products, intelligent products showed a functional complex and diverse, interactive strange combination of hardware and software products as well as physical attributes embodied in the course of multiple features. In terms of attributes, social attributes of smart products have a connection, active behavior attributes and multidimensional logic properties, which on the one hand to enhance the product caused the learning costs, but also contains a lower learning costs, improve the learning ability of great potential.

In this paper, we chose a smart bracelet called DS190 for the experiment. The structure of this bracelet is shown in the following figure 1. The circuit diagram of DS190 is shown in the figure 2.

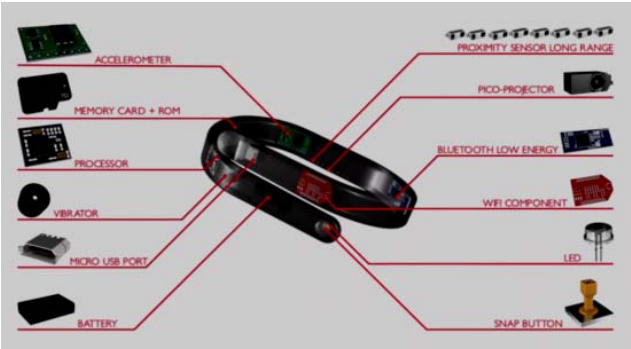


Figure 1. The structure of a smart bracelet called DS190.

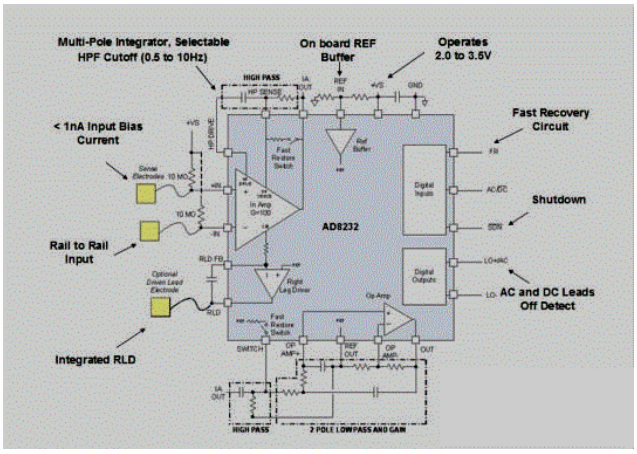


Figure 2. The circuit diagram of DS190.

As discussed in the first section, the intelligent wearable device is always discussed with embedded system. Embedded system is the hardware and software system, which has been embedded in the application of product and engineering, and is cored with MCU. The embedded system, which came from the combination of embedded system and Internet, has become a new technology with the development of computer and network. It builds up the ability of connecting Internet through the embedded system. It bring that embedded system, which is cored with low-cost MCU, directly connects Internet without PC.

The experiment is taken in the following 4 steps:

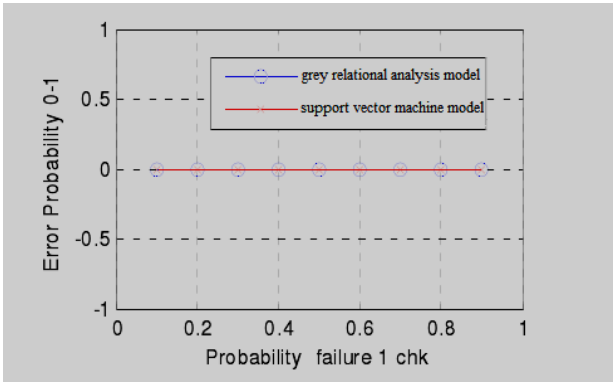
(1) In the first step, the interference intensity is the primary disturbance, and the time length is 1 units. Disturbance is exerted on the intelligent wearable device -- a smart bracelet called DS190 based on the grey relational analysis model and the intelligent wearable device based on the support vector machine model separately. We choose error probability to represent the accuracy. The output is detected by the signal fluctuation analyzer in the 1st chunk. The comparison of the result is shown in the figure 3a.

(2) In the second step, the interference intensity is the middle disturbance, and the time length is 1 units. Disturbance is exerted on the intelligent wearable device -- a smart bracelet called DS190 based on the grey relational analysis model and the intelligent wearable device based on the support vector machine model separately. We choose error probability to represent the accuracy. The output is detected by the signal fluctuation analyzer in the 2nd chunk. The comparison of the result is shown in the figure 3b.

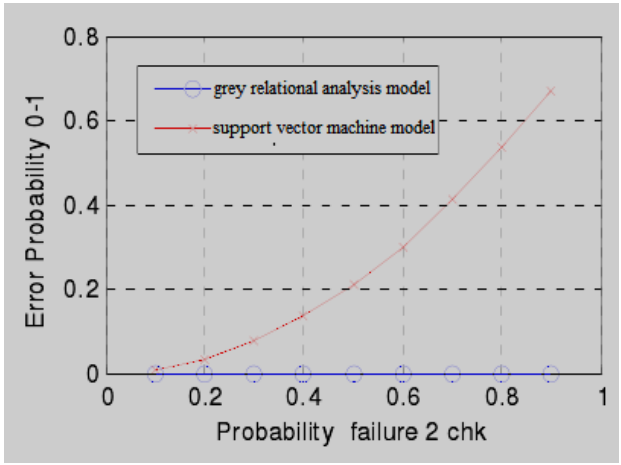
(3) In the third step, the interference intensity is the strong disturbance, and the time length is 1 units. Disturbance is exerted on the intelligent wearable device -- a smart bracelet called DS190 based on the grey relational analysis model and the intelligent wearable device based on the support vector machine model separately. We choose error probability to represent the accuracy. The output is detected by the signal fluctuation analyzer in the 3rd chunk. The comparison of the result is shown in the figure 3c.

(4) In the fourth step, the interference intensity is the strong disturbance, and the time length is 5 units.

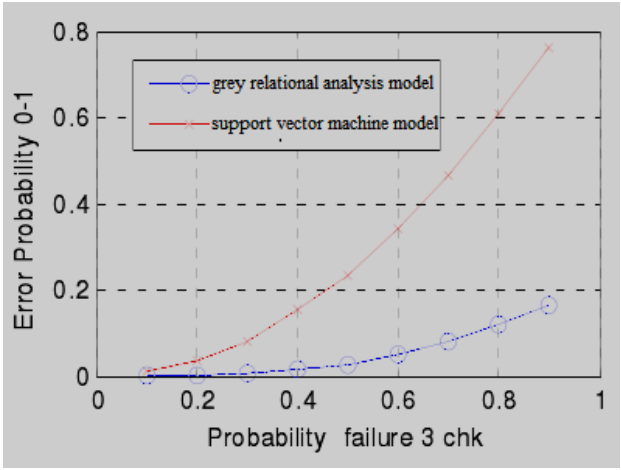
Disturbance is exerted on the intelligent wearable device -- a smart bracelet called DS190 based on the grey relational analysis model and the intelligent wearable device based on the support vector machine model separately. We choose error probability to represent the accuracy. The output is detected by the signal fluctuation analyzer in the 4th chunk. The comparison of the result is shown in the figure 3d.



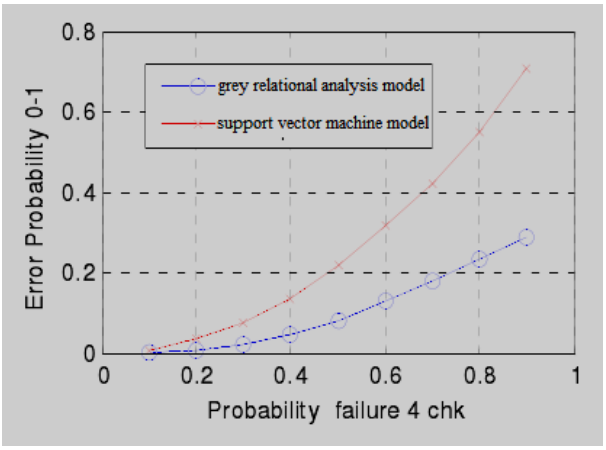
a)



b)



c)



d)

Figure 3. The error rate of the system as a function of the probability of failure of any chunks.

From the result, we can see with the increase of interference intensity, the error rate of the device based on the grey relational analysis model is lower than the intelligent wearable device based on the support vector machine model. But with the increase of interference time length, the error rate of the two models is increasing.

V. Conclusion

In this paper, the grey relational analysis model is used to improve the accuracy, rapidity, comfort and user friendliness of intelligent wearable device in the design process. Grey system theory is just one of the emerging disciplines used for information processing. Using mathematical methods, the theory put forward the theories and methods of how to process and analyze systems with incomplete information. It is immediately suitable for the distribution of a large-sized file that consists of multiple generations. This method established a new kind of relative similarity degree by combining the Euclidean distance with grey correlation degree. The development status and key technologies of intelligent wearable device are analyzed in this paper, including sensor technology, display technology, chip technology, operating system, wireless communication technology, data processing technology and improve battery life extension technology. In accordance with the characteristics of intelligent wearable device, the grey relational analysis algorithm has been researched and combined with expert system. Because it can describe the behaviors and development trends of things by extracting known information, grey system theory has a wide range of applications. Including agriculture, military, economic, ecological and other fields, the grey relational analysis is a factor analysis method based on grey system theory. Thus the developing platform based on grey relational analysis can be used for intelligent wearable device is designed and implemented. This analysis method can determine the relational degree of the factors which influence the system by considering the similarities between them. The final test indicates that the grey relational analysis algorithm is simple

in calculation and its result is accurate; the simulation result of expert system is consistent with the theoretical analysis result.

REFERENCES

[1] Chen Lirong, Yan Liming and Luo Lei, "An Isolation and Protection Mechanism of Automotive Electronic Embedded Operating System", Journal of University of Electronic Science and Technology of China, No. 3, pp. 154-155, 2014.

[2] Zhang Lvhong, "Design and Implementation of Smart OSEK OS4.0 Based on AUTOSAR", Hangzhou: Zhejiang University, pp. 188-189, 2010.

[3] Zheng Gang, Liu Qingchen, Deng Xu et. al., "Measurement and analysis of excavation under the influence of both the box lying subway operators". Rock and Soil Mechanics, vol. 4, pp. 1109-1116 + 1140, 2012.

[4] Zheng Pengyi, Deng Longzhao, "Application of deep cement mixing pile foundation reinforcement in revetment". Water Transport Engineering, vol. 5, pp. 134-138, 2012.

[5] Wei Kuang Lai, Yi-Uan Chen, Tin-Yu Wu, Mohammad S. Obaidat, "Towards a framework for large-scale multimedia data storage and processing on Hadoop platform". The Journal of Supercomputing, pp. 681-696, 2014.

[6] Zhijian Chen, Wenhai Luo, Dan Wu, Xiang Huang, Jian He, Yuanhuan Zheng, Di Wu, "Exploiting application-level similarity to improve SSD cache performance in Hadoop". The Journal of Supercomputing, pp. 703-715, 2014.

[7] Wei Qian, Xia Qingguo, "The research of associated engine technology based on security management center". Computer Engineering and Design, vol. 28, pp. 3085-3087, 2007.

[8] Chen Siluo, "The design and construction of distributed network security management platform". Beijing: Beijing University of Posts and Telecommunications,2008.