CONTENTS

Using Statistical Analysis Technology to Improve Performance: A Case Study

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***Abstract*—With the popularity of baseball, numerous studies have been conducted to find methods to improve performance during a baseball match. However, it's still unclear that how the batter should hit a ball so that the batted ball speed is largest. In other words, where is the sweet spot that maximum energy is transferred to the ball when it's hit? In this paper, we take three factors into consideration to deter-mine position of sweet spot. We build three models to confirm corresponding factors: (1) relationship between batted ball speed and distance from hit point to pivot point when the pivot point is fixed, (2) loss of energy caused by vibration of bat, (3) loss of energy caused by rotation of bat. At last, by considering the above three models to get the final energy of ball. We find that the COP(Center of Percussion) point is just the sweet spot. At last, by statistical processing to results of baseball match in the last more than 30 years, we find that the aluminum bat shows a marked increase in hit-ball speeds. In addition to that, we also give reasons why Major League Baseball prohibits metal bats according to our model.**

***Index Terms*—Statistical Analysis, Improve Performance, Mathematical Modeling**

I. Introduction

A commonly accepted fact is that baseball became the one of most popular activity all over the world. The most important equipment of baseball is ball and bat. The balls in the games are same, then the Competition Results mainly depend on the bats which players use. The key factor to measure the bat performances is the batted ball speed. Then, how to make it? Here, a problem is inevitably involved in "the sweet spot of a baseball bat". But what and where is the "sweet spot" on a baseball bat? How to locate the sweet spot?

A lot of researches have been done to explain and find the sweet spot. One saying is that a sweet spot is a place, often numerical as opposed to physical, where a combination of factors suggests a particularly suitable solution. In the context of a bat or similar sporting instrument, sweet spot is often believed to be the same as the center of percussion [1].

Multimedia use can facilitate learning, in particular the acquisition of, and reasoning with, abstract concepts, via "scaffolding" [2]. This principle uses learning materials and strategies that accommodate to student's problem-solving skills and levels to encourage movement into an imminent zone of development [3].

Of course, some players believe that "corking" a bat enhances the "sweet spot" effect, is it right or wrong? What's more, does the material out of which the bat is constructed matter to the bat performance? In order to solve these problems, we divide our work into several steps. Our steps are as follows:

- Building model to confirm the relationship between batted ball speeds and distance from hit point to pivot point when the pivot is fixed.
- Building model to confirm loss of energy caused by vibration of bat in the process of impact between bat and ball, that is, the maximum energy should be transferred to the ball. Moreover, the batter should feel least sting during collision.
- Building model to determine loss of energy caused by rotation of bat in the process of collision between bat and ball.
- By a comprehensive analysis, get the preliminary conclusion of where should the sweet spot be.

II. Methodology

A. Assumptions

- Shape of bat is symmetrical, regular and the density of wood one is uniform;
- Work done by the batter to the normal bat and the corked one is uniform;
- With the corking problem, the node with the zero displacement which is gained in the vibration model and COP is the same on;
- Loss of energy caused by vibration and offset will be negligible when the hit point is the sweet point;

B. Location of Sweet Spot on a Baseball Bat

Trying to locate the exact sweet spot on a baseball bat is not as simple at ask as it might seem, because there are a multitude of factors having effect on selection of position of sweet spot on a baseball bat. What we take into consideration includes: (1) distance between hit point and pivot point.(2) bat's vibration caused by hitting a ball, (3) bat's rotation caused by hitting a ball.

1. Step One of Solution

As a sweet spot, there is no doubt that the batted-ball speed is relatively high, if not, no one in the normal state will choose it as an impact location. When an impact between bat and ball happens, no matter the bat is stationary or locomotors, there is no doubt that there will be a batted-ball speed, and the problem is that in which position that the batted-ball speed is the largest. Our task

is to find that position. For the bat, we only take torque into account when analyzing the motion of bat. In the transient moment (usually 1 ms) of impact between bat and ball, our model decomposes the motion of bat into translational part and rotational part about the pivot point which is shown in Figure 2.

When computing, we suppose the translational speed of bat is the pivot point is 0. As to the center of gravity is far from the knob end of bat and the mass of the knob end is lighter than the barrel end, so this suppose doesn't change the kinetic energy of bat dramatically.

2. Step Two of Solution

Whenever an object is struck, it vibrates in response. At one point, which is called "the node", the waves always cancel each other out, and the batter won't feel any stinging or shaking in his or her hands. Since little of the bat's energy is lost to vibration when this spot is hit, more can go to the ball. Our purpose in this model is to find the special node where the loss of energy is the least. Here we apply the experimental result of Daniel A. Russell.

The handle end of the bat is at the right, and the barrel end is at the left. The numbers on the axis represent inches (this data is for a 30 inch Little League wood baseball bat). The amplitude of the vibration is greatly exaggerated for clarity. When excited by an impact force, such as a baseball striking the bat, all of these modes, (as well as some additional higher frequency modes) are excited and the bat vibrates.

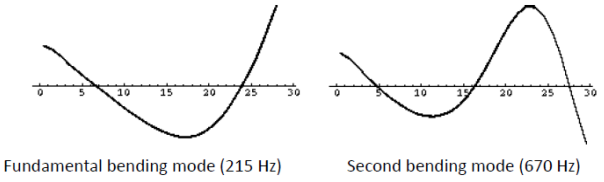

Figure 1. Mode shapes for 30-inch Little League wood bat

The fundamental bending mode has two nodes, or positions of zero displacement). One is about 6-1/2 inches from the barrel end close to the sweet spot of the bat. The other at about 24 inches from the barrel end (6 inches from the handle) at approximately the location of a right handed hitter's right hand.

The second bending mode has three nodes, about 4.5 inches from the barrel end, a second near the middle of the bat, and the third at about the location of a right-handed hitter's left hand.

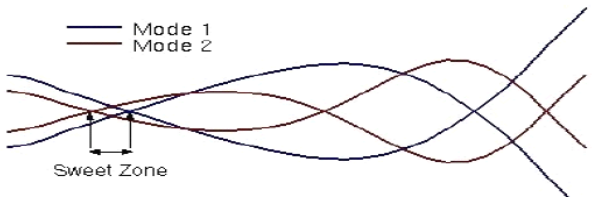

Figure 2. The sweet zone got from this model

An impact to the outside (towards the barrel end) or inside (towards the handle) of this zone will result in a much more significant vibration of the bat, often felt as a painful sting. And the ball will not travel as far because some of the energy is now being stored (or dissipated) in the bat's vibration.

3. Step Three of Solution

What makes the COP special is that an impact at the COP will result in zero net force at the pivot point. Impacts closer to the handle will result in a translational force at the pivot. Impacts closer to the barrel end will result attempt make the bat rotate about its center-of-mass, causing a force in the opposite direction at the pivot point. However, for impacts at the COP these two opposite forces are balanced, resulting in a zero enforce. The COP would seem to be a likely candidate for the sweet spot since an impact at that location would result in zero force at the batter's hands (the top hand is right about 6-inches from the knob). However, the COP is not a fixed point on the bat, but depends on the location of the pivot point. All current methods of testing baseball and softball bat performance use the 6-inch point as the pivot point, and thus as the reference for locating the COP.

4. The Normal Method

Here, we cite the model constructed by Daniel A. Russell [4]. As definition in textbooks, a solid object which oscillates about a fixed pivot point is called a physical pendulum. When displaced from its equilibrium position the force of gravity will attempt to return the object o its equilibrium position, while its inertia will cause it to overshoot. As a result of this interplay between restoring force and inertia the object twill swing back and forth, repeating its cyclic motion in a constant amount of time. This time, called the period, depends on the mass of the twill swing back and forth, repeating its cyclic motion in a constant amount of time. This time, called the period, depends on the mass of the object, the location 1 M of the center-of-mass relative to the pivot point d, the rotational inertia of the object about its pivot point I.

C. Calculation of Both Methods

This location L is known as the "center-of-oscillation", since it represents the length of an equivalent simple pendulum with the same total mass and that has the same period as the actually physical object. The exact location of this special point depends on the location of the pivot - a fact which will be very important to the application of this concept to a baseball bat, as we will see below. In our model, dm can be simplified as

$$dm=\begin{cases} p\pi r_1^2\,dx & 0<x<a \\ p\pi r_x^2\,dx & a\le x<b \\ p\pi r_2^2\,dx & b\le x\le c \end{cases} \tag{1}$$

D. Further Talk about This Model

As shown in our advanced method, we can get the conclusion that the composite force exerted to the pivot point can be expressed as

$$f_c = f(1-M_1\frac{\Delta r\bullet d}{I-M_1 d^2}) \tag{2}$$

We have to know acceptance range if we want to compute energy delivered to batter's hands. As the

acceptance range of the pivot point caused by vibration in batter's hands is relatively small, the loss of energy is

$$E = f_c l_1 = f(1 - \frac{M_1 \Delta r d}{I - M_1 d^2}) l_1 \quad (3)$$

III. Analysis of Different Materials

The above models we have built is based on the baseball bat made of wood, which has well solved the previous two problems. To the final issue, we have to take other material (usually aluminum) into account in order to verify our model and analyze the effect of different materials on the model. Given the amount of controversy over the metal versus wood bat issue, there have been surprisingly few scientific studies comparing the performance of wood and metal baseball bats. There is one paper from 1977, when aluminum bats were just beginning to assert their prominence, which concluded that the batted ball speed of an aluminum baseball bat was about 3.85 mph faster than a wood baseball bat [4]. A second phase of the study attempted to explain the increase in performance of the aluminum bat by comparing the size of the "sweet spot" for the two bats by locating the COP. The study found that the aluminum bat appeared to have a larger COP than the wood bat. In contrast to the 1977 study, a 1989 study concluded that metal bats did not outperform wood bats [5]. Then, now what confuses us is whether the material of bat is a matter.

We get statistics published by the NCAA for Division I college baseball starting from the year 1970 through this year. The raw data includes yearly results for batting averages, home runs per game, runs scored per game, strikeouts per 9 innings, pitcher earned-run-averages, stolen bases and fielding percentages [6]. Here we only concern batting averages, home runs per game.

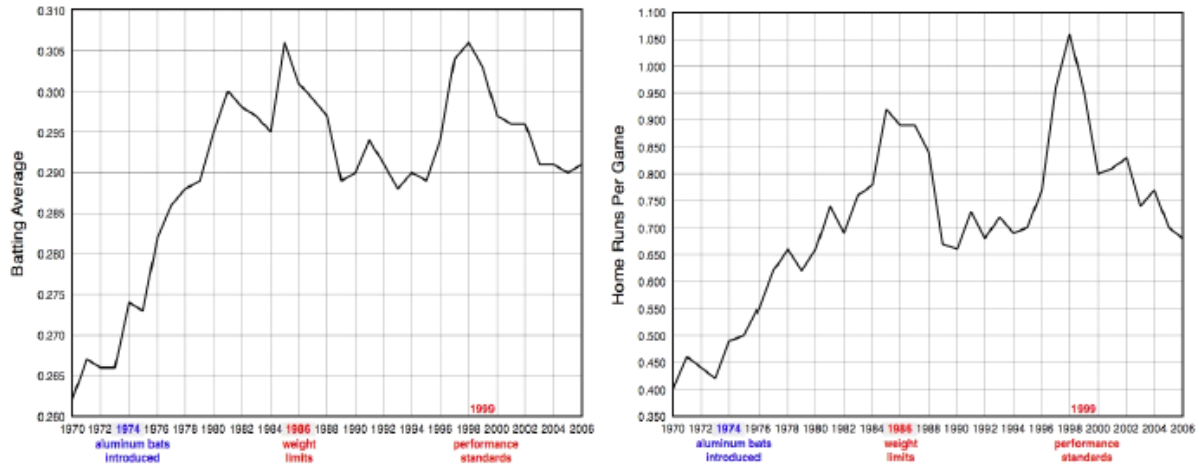

Figure 3. Batting average and Home Runs Per Game

The two plots at above which show the mean batting average and home runs per game for all NCAA Division I college baseball players as a function of year from 1970 through 2006. The two data have the same trends.Note that from 1970 through 1974 there appears to be an almost steady increase in both. After players using aluminum bats make solid contact with the ball more often than former players did with wood bats. During the same time period, batting averages were quickly increasing, so pitchers had increasing difficulty to strike batters out. One thing is true: Aluminum bats typically have lower moment of inertia than wood ones and therefore may be swung more quickly. As a result, the hit-ball will have higher speed and fly faster and further. From this we see aluminum bats outperform wood bats in games, in despite of performance standard to limit the performance of aluminum and composite bats.

IV. Conclusions and Further Explanations

Of course, only theoretical explanations are not completely convincing. But mass of data relevant to our calculation can be obtained through experiments. Owing to our limit conditions, we only quote some experimental results from other literatures to assist and analyze our derived theoretical Conclusions. For good measure, the hitting characteristics of a baseball bat are determined from its geometry and material. Once these are determined, other relevant properties such as mass, inertia and COP may be found. A comparison of the hit-ball speed versus impact location for the two bat types is presented in Figure 3. From this figure we can see, the aluminum bat shows a marked increase in hit-ball speeds, particularly for outside hits. Its sweet spot (the location of COP) also appears to be 25 mm (1 inch) closer to the barrel end of the bat than wood. That's to say, the value of COP is larger. Interestingly, the advantage of aluminum is not apparent for inside hits, and even appears lower than wood at an impact location of 500 mm (20 inch) from the knob.

This is likely due to the increased thickness to diameter ratio that occurs in aluminum as the barrel tapers into the handle. Low thickness to diameter ratios are generally thought to provide a "trampoline effect" in aluminum bats providing higher hit-ball speeds, which depends on the frequency of the hoop mode, the energy stored in the barrel deflection may be returned to the ball very efficiently, leading to a higher butterball speed than would be possible with a wood bat which has no hoop mode.

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Research on The capability Assessment of Information Industry Mobilization Based on Linguistic Variables

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***Abstract*—"Capability" is a new research frontier in the domain of information industry mobilization system, and the term is now a central concept in a variety of research contexts Based on the analysis of the evolution of capability concept and research content, this paper aims to find a generally applicable capability conceptual model and assessment methods of information industry mobilization system which are key factors to determine the development of capability science. In this paper ,capability index system in the information industry mobilization system is first constructed, on the basis of which the direct expert linguistic evaluation value is converted into interval number to establish the evaluation model based on gray correlation method and conclude the decision steps and finally a practical example is used to illustrate the validity of this method.**

***Index Terms*—information industry mobilization, capability assessment, linguistics variables, interval number**

I. Introduction

Information industry mobilization is an activity of department of information industry to support the war and the management of meeting the emergency by definite policy and administration designedly and systematically.

That Quantitative analysis and scientific evaluation of information industry mobilization ability can improve response capabilities to handle all kinds of unexpected events, the work efficiency and level for mobilization of the information industry and the national economy mobilization, and is conducive to the national security, promoting economic and social development.

Mobilization capacity is one of the important work in the field of national economy mobilization of current and future period . Information industry is a knowledge-intensive , technology-intensive and capital-intensive industries , involving industry correlation effect greatly. The development of this industry has a very strong social benefits , which can bring various related industry technology progress and promote national economic from resource consumption to quality efficiency, and thus help to improve the effectiveness and level of mobilization of the national economy as a whole.

At the same time, the development of information industry itself mainly by the information industry technological progress, enriched talents, perfect equipment and facilities, which can effectively improve the information war capability, and be good for national security. Information industry mobilization that will be the commanding heights of defense mobilization in the 21st century, has the characteristics of field permeability, knowledge and technology intensive, high efficiency. The disposal of all kinds of emergency will largely depend on the level of information industry development and mobilization ability.

Reasonable measure of the ability to the information industry mobilization, and Construction of evaluation system of scientific, strongly operational mobilization ability, which are conducive to a comprehensive grasp of the status quo of the development of information industry , the function of information industry mobilization and its economic externalities, making mobilization capacity building more targeted, effective , and thus contributing to promote the development of the information industry and the national economy to maintain a healthy proportion. Strengthening the mobilization capacity of the information industry to meet national emergencies of information technology can ensure steady economic development and national security.

In recent years, scholars carried out a lot of study on information mobilization, information industry mobilization, but more scattered, the lack of systematic, in-depth discussion. Chen Zhouqiu pointed out that as a new form of mobilization, in the knowledge economy and military boarded the stage of history, will inevitably show in front of people. Knowledge economy

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mobilization stressed from information, knowledge to the importance of high-tech, information industry mobilization is the important part of information industry [1].

Gu Jianyi[2], Zhou Tao [3], Mian Fucheng [4] and others have made the relevant definition for the content of information industry mobilization, which provides the theoretical basis for the study of information industry mobilization. In addition, Zhangxiao [5] proposed that strengthening the development of civil information resources can meet the needs of expanding civilian information resource mobilization potential, and enhance national information mobilization ability. Through the analysis of the information industry and information war, Gong Kai[6] put forward that the information industry must develop and grow, which is the only way to better protect the information war, be beneficial to the national security and conducive to national defense and military modernization, to achieve national rejuvenation.

In general, the national economic mobilization theory is still in its early stage of development. Information industry mobilization theory, as one of the national economic mobilization theory, is still in its infancy, mainly focusing on qualitative analysis and discussion. Therefore, Further mathematical analysis is of positive significance for construction work of information industry mobilization.

II. THE CAPABILITY ASSESSMENT INDEX SYSTEM OF INFORMATION INDUSTRY MOBILIZATION

According to the definition of information industry mobilization capability, we can divide it into hard and soft capacity in this paper. The specific analysis will be conducted on evaluation indexes for influencing factors in the system and build evaluation index system of information industry mobilization capability in the following. The capability evaluation index system is shown in TABLE Ⅰ.

TABLE I.
EMERGENCY LOGISTICS SYSTEM VULNERABILITY EVALUATION INDEX SYSTEM

First level indicator	**Second level indicator**
Hard capacity B1	The technical level of information industryC1
	The reserve of human resource information industry C2
	The regional distribution of information industryC3
	The information industrial scaleC4
Soft capacity B2	Mobilization command and control capabilities C5
	Decision-making abilityC6
	Planning abilityC7
	Monitoring and communication skillsC8

III. VULNERABILITY ASSESSMENT BASED ON LINGUISTIC VARIABLES

In this paper, because each indicator is unable to describe with the accurate, the data needed to normalize is only language variable which is a qualitative index.

A. Linguistic variable set

Qualitative attribute index value is generally expressed as fuzzy language , such as ". good " , " very good " , "absolute good " and so on . As it can not operate directly with quantitative indicators , standardized method for this attribute indicators generally use certain transformation rules ,namely fuzzy language - fuzzy digital conversion rules .

suppose linguistic value sets $S=(s_0,s_1,\cdots,s_{l-1})$ Should consist of an odd number of elements, namly l should be an odd. Generally take 3,5,7,9, etc. It is represented as : $S=(s_0,s_1,s_2)$ =(bad , medium , good); $S=(s_0,s_1,s_2,s_3,s_4)$ = (bad, less bad, medium, good, very good); $S=(s_0,s_1,s_2,s_3,s_4,s_5,s_6)$ =(very bad, bad, less bad, medium, less good, good, very good); $S=(s_0,s_1,s_2,s_3,s_4,s_5,s_6,s_7,s_8)$ = (super bad, very bad, bad, less bad, medium, less good, good, very good, super good).

B. conversion between linguistic variable and interval number

For the linguistic variable, we may transform the variables to interval number as fellow:

Suppose interval number is $s_i=[a_i,b_i]$, then:

$$\begin{cases} a_i = \dfrac{i}{l} & (0 \le i \le l-1) \\ b_i = \dfrac{i+1}{l} & (0 \le i \le l-1) \end{cases} \tag{1}$$

Based on the above formula, we can get the correspondence for linguistic variables and interval numbers (normalized),which is shown in TABLE Ⅱ.

TABLE II.
CONVERING 5 LINGUISTIC EVALUATION SETS TO IINTERVAL NUMBERS

Fuzzy linguistic level	Fuzzy linguistic express	normalized interval number
s_0	Very bad	(0,0.2)
s_1	bad	(0.2,0.4)
s_2	medium	(0.4,0.6)
s_3	good	(0.6,0.8)
s_4	Very good	(0.8,1)

A. assessment method

Grey relational analysis is an important part of grey system theory and an effective method of internal rules of data mining. The method of grey correlation analysis quantitatively compares and describes relative change with time in the process of development between the systems or the factors in a system , namely analysis of

the geometrical shapes for the time series curve, with the close degree of the size, direction and speed of their change to measure the size of their correlation. If the trend of change for two sequences is identical or similar and the higher degree of synchronous change, which can be thought of the connection degree is bigger; conversely, the correlation degree is smaller. The steps of multiple attribute decision making by gray correlation analysis are as follows:

Suppose weight is $W = (w_1, w_2, \cdots, w_n)$,normalized Decision Matrix is $\bar{R} = (r_{ij})_{m \times n}$.

1)construct weighted normalized matrix V:

$$V=(v_{ij})_{m\times n}=\begin{bmatrix} w_1r_{11} & w_2r_{12} & \cdots & w_nr_{1n} \\ w_1r_{21} & w_2r_{22} & \cdots & w_nr_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ w_1r_{m1} & w_2r_{m2} & \cdots & w_nr_{mn} \end{bmatrix} \quad (2)$$

Where $v_{ij}^L = w_j \times r_{ij}^L, v_{ij}^M = w_j \times r_{ij}^M$

2)determine the ideal and negative-ideal solution of interval numbers:

$$\begin{cases} V_j^+ = [\max_i(v_{ij}^L), \max_i(v_{ij}^M)] \\ V_j^- = [\min_i(v_{ij}^L), \min_i(v_{ij}^M)] \end{cases} . \quad (3)$$

3)calculate the Gray Correlation Coefficient of the i-th alternative with the ideal solution for the index jth：

$$r_{ij}^+ = \frac{m + \rho M}{\Delta_{ij}^+ + \rho M} \ , \ \rho \in (0,1) \quad (4)$$

Where $\Delta_{ij}^+ = \left|V_j^+ - v_{ij}\right|$, $m = \underbrace{\min}_{i}\underbrace{\min}_{j}\Delta_{ij}^+$, $M = \underbrace{\max}_{i}\underbrace{\max}_{j}\Delta_{ij}^+$, ρ is resolution ratio,generally take 0.5.then,define the Gray Correlation Coefficient matrix of each alternative to the ideal solution:

$$R^+ = \begin{bmatrix} r_{11}^+ & r_{12}^+ & \cdots & r_{1n}^+ \\ r_{21}^+ & r_{22}^+ & \cdots & r_{2n}^+ \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1}^+ & r_{m2}^+ & \cdots & r_{mn}^+ \end{bmatrix} \quad (5)$$

calculate the grey relational grade of the ith alternative to ideal solution:

$$\xi_i^+ = \frac{1}{n}\sum_{j=1}^{n} r_{ij}^+, (i = 1,2,\cdots,m) \quad (6)$$

Similarly calculate the Gray Correlation Coefficient of the i-th alternative with the negative-ideal solution for the index jth.

$$r_{ij}^- = \frac{m+\rho M}{\Delta_{ij}^- + \rho M} \ , \ \rho \in (0,1) \quad (7)$$

Where $\Delta_{ij}^- = \left|V_j^- - v_{ij}\right|$, $m = \underbrace{\min}_{i}\underbrace{\min}_{j}\Delta_{ij}^-$, $M = \underbrace{\max}_{i}\underbrace{\max}_{j}\Delta_{ij}^-$, ρ is resolution ratio,generally take 0.5.then,define the Gray Correlation Coefficient matrix of each alternative to the negative-ideal solution:

$$R^- = \begin{bmatrix} r_{11}^- & r_{12}^- & \cdots & r_{1n}^- \\ r_{21}^- & r_{22}^- & \cdots & r_{2n}^- \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1}^- & r_{m2}^- & \cdots & r_{mn}^- \end{bmatrix} \quad (8)$$

calculate the grey relational grade of the ith alternative to negative-ideal solution:

$$\xi_i^- = \frac{1}{n}\sum_{j=1}^{n} r_{ij}^-, (i = 1,2,\cdots,m) \quad (9)$$

4)calculate the grey relative closeness of each alternative:

$$C_i = \frac{\xi_i^+}{\xi_i^+ + \xi_i^-}, (i = 1,2,\cdots,m) \quad (10)$$

5) rank the order of the solutions

Sorted based on the size of the grey relative closeness. Closeness degree is bigger, the solution is better; otherwise, the solution is bad.

IV. AN ILLUSTRATIVE EXAMPLE

Consider to evaluate the level of emergency logistics system vulnerability of the four enterprises(a_1, a_2, a_3, a_4), the evaluation index system uses the index system shown in TABLE Ⅰ. Linguistic evaluation set is $S = (s_0, s_1, s_2, s_3, s_4, s_5, s_6)$ .linguistic evaluation matrix is shown in TABLE Ⅲ. suppose weight is given, namely W=[0.164 0.099 0.171 0.087 0.150 0.098 0.115 0.116]

TABLE III.
LINGUISIC EVALUATION VALUE OF THE FOUR ENTERPRISES

	C1	C2	C3	C4	C5	C6	C7	C8
a1	S_3	S_0	S_1	S_4	S_3	S_2	S_4	S_2
a2	S_2	S_1	S_2	S_2	S_3	S_4	S_3	S_2
a3	S_3	S_1	S_2	S_2	S_0	S_2	S_4	S_1
a4	S_1	S_3	S_0	S_3	S_1	S_2	S_3	S_4

according to table Ⅲ get the Initial evaluation matrix $\tilde{R}$:

1) construct weighted normalized matrix V:

2)according to formula (3) calculate the ideal and negative-ideal solution V^+, V^- :

$$\bar{R}=\begin{bmatrix} (0.6,0.8) & (0.0,0.2) & (0.2,0.4) & (0.8,1.0) & (0.6,0.8) & (0.4,0.6) & (0.8,1.0) & (0.4,0.6) \\ (0.8,1.0) & (0.2,0.4) & (0.4,0.6) & (0.4,0.6) & (0.6,0.8) & (0.8,1.0) & (0.6,0.8) & (0.4,0.6) \\ (0.6,0.8) & (0.2,0.4) & (0.4,0.6) & (0.4,0.6) & (0.0,0.2) & (0.4,0.6) & (0.8,1.0) & (0.2,0.4) \\ (0.2,0.4) & (0.6,0.8) & (0.0,0.2) & (0.6,0.8) & (0.2,0.4) & (0.4,0.6) & (0.6,0.8) & (0.8,1.0) \end{bmatrix}$$

$$V=\begin{bmatrix}(0.273,0.267) & (0.000,0.111) & (0.200,0.222) & (0.364,\ 0.333) & (0.429,0.364) & (0.200,0.214) & (0.286,0.278) & (0\ .222,0.231)\\ (0.364,0.333) & (0.200,0.222) & (0.400,0.333) & (0.182,\ 0.200) & (0.429,0.364) & (0.400,0.357) & (0.214,0.222) & (0\ .222,0.231)\\ (0.273,0.267) & (0.200,0\ .222) & (0.400,0.333) & (0.182,0.200) & (0.000,0.091) & (0\ .200,0.214) & (0.286,0.278) & (0.111,0.154)\\ (0.091,0.133) & (0.600,0.444) & (0.000,0.111) & (0.273,\ 0.267) & (0.143,0.182) & (0.200,0.214) & (0.214,0.222) & (0\ .444,0.385)\end{bmatrix}$$

$$V^{+}=\begin{bmatrix}(0.364,0.333) & (0.600,0.444) & (0.400,0.333) & (0.364,0.333) & (0.429,0.364) & (0.400,0.357) & (0.286,0.278) & (0.444,0.385)\end{bmatrix}$$

$$V^{-}=\begin{bmatrix}(0.091,0.133) & (0.000,0.111) & (0.000,0.111) & (0.182,0.200) & (0.000,0.091) & (0.200,0.214) & (0.214,0.222) & (0.111,0.154)\end{bmatrix}$$

3) according to formula (5) calculate the Gray Correlation Coefficient matrix of each alternative to the ideal solution R^{+}:

$$R^{+}=\begin{bmatrix}0.742 & 0.330 & 0.586 & 0.998 & 0.998 & 0.569 & 0.999 & 0.545\\ 0.998 & 0.415 & 0.999 & 0.590 & 0.681 & 1.000 & 0.780 & 0.545\\ 0.742 & 0.415 & 0.999 & 0.590 & 0.389 & 0.569 & 0.998 & 0.442\\ 0.489 & 0.999 & 0.415 & 0.742 & 0.488 & 0.569 & 0.780 & 0.998\end{bmatrix}$$

4)according to formula (8) calculate the Gray Correlation Coefficient matrix of the each alternative to negative-ideal solution R^{-}:

$$R^{-}=\begin{bmatrix}0.589 & 1.000 & 0.586 & 0.590 & 0.389 & 0.999 & 0.781 & 0.706\\ 0.489 & 0.586 & 0.414 & 0.999 & 0.389 & 0.568 & 0.999 & 0.706\\ 0.589 & 0.586 & 0.414 & 0.999 & 1.000 & 0.999 & 0.781 & 0.999\\ 0.999 & 0.321 & 1.000 & 0.742 & 0.657 & 0.999 & 0.999 & 0.444\end{bmatrix}$$

5)According to formula (6)and (9),calculate separately the grey relational grade of ith alternative to ideal and negative-ideal solution ξ_i^{+}, ξ_i^{-}:

$$\xi_i^{+}=\begin{bmatrix}0.720 & 0.722 & 0.643 & 0.685\end{bmatrix}$$

$$\xi_i^{-}=\begin{bmatrix}0.705 & 0.555 & 0.780 & 0.770\end{bmatrix}$$

6)According to formula (10) calculate the grey relative closeness of each alternative to the ideal solution C:

$C=\begin{bmatrix}0.505 & 0.565 & 0.447 & 0.471\end{bmatrix}$, thus we know the order of the emergency logistics system vulnerability level in the four enterprises:

$a_2 \succ a_1 \succ a_4 \succ a_3$.

V. CONCLUSION

The capability assessment study has been widely applied in many research fields as a new paradigm, and achieved many useful results. Based on the analysis of the evolution of capability concept and research content, this paper makes a review of the theoretical model and assessment framework of capability research. In this paper, Taking the information industry mobilization system as the research object, capability and its evaluation method of information industry mobilization system is studied. The practical application proved the effectiveness of this method.

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The simulation research of the linear time-invariant system based on domain response

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***Abstract*—In this paper, the MATLAB simulation is employed for linear time-invariant system, which is meaningful to the control theory teaching process of it. Meanwhile, the augmented state model is established to solve the problem of integral component in computation, and the simulation of second-order system is made to show the optimum parameters.**

***Index Terms*—education method of control theory; Analytical Solution; augmented state model, optimum damping ratio; simulation of second-order system**

I. INTRODUCTION

Classical control theory and state space theory are two parts of control theory, and some education department take the two parts into one course named <Automatic Control Theory>, the others treat them as <Automatic Control Theory> and < Modern Control Theory> separately. Control theory is the methodology of automation systems. and research point is focused on system's performances under control process, which is one of the main courses in some major such as Information Technology Engineering ,Power electrical Engineering and Automation.

It is not difficult to calculate the characteristic root of high order systems nowadays, but many researchers treat the computation of high order algebraic equations as a challenge, because of the influence on the initial control theory from the classical mathematics [1]. And it takes the research point away that teachers calculates system responses by Laplace transformation in teaching process, for Laplace transformation's large amount of calculation. [2-4]

Recently, the students training of Automation major is challenged by the requirements from national transformational development and industrial upgrading. We pay more attention to linear time-invariant system and take MATLAB into the teaching process with proper domain simulation [5], which makes the teaching process more efficient and briefer.

II. THE METHOD OF ANALYTICAL SOLUTION

The linear time-invariant system's analytical solution is a kind of accurate mathematical expression, which could be calculated by MATLAB.

A. The Analytical Solution of Transfer Function

The transfer function of linear time-invariant system is always shown as formula(1)

$$G(s)=\frac{b_1 s^m+b_2 s^{m-1}+\ldots+b_m s+b_{m+1}}{s^n+a_1 s^{n-1}+\ldots+a_{n-1}s+a_n} \tag{1}$$

If the input signal is $U(s)$, the it is shown as formula(2)

$$Y(s)=G(s)U(s) \tag{2}$$

On the partial fraction expansion， formula(2) is shown as formula(3)

$$Y(s)=\left(\frac{c_j}{s-s_j}+\ldots\right)+\left[\left(\frac{c_{j+1}}{s-s_{j+1}}+\ldots+\frac{c_{j+k}}{\left(s-s_{j+k}\right)^k}\right)+\ldots\right] \tag{3}$$

s_j means j non-multiple roots, s_{j+1} is k multiple roots, formula(4) is got by Laplace transformation.

$$y(t)=\left(c_j e^{s_j t}+\ldots\right)+\left[\left(c_{j+1}+\ldots+\frac{c_{j+k}}{(k-1)!}t^{m-1}\right)e^{s_{j+1}t}+\ldots\right] \tag{4}$$

s_j 、 s_{j+1} 、 j 、 k can be calculated by residue() function in MATLAB, and these value can be used to calculate analytical solution by codes:

[r,p,K]= residue(num,den)

B. The Analytical Solution of State Model

The state model of linear time-invariant system is always shown as formula(5)

$$\begin{cases}\dot{x}=Ax+Bu\\ y=Cx+Du\end{cases} \tag{5}$$

If the input signal is $u(t)$, the it is shown as formula(6)

$$x(t)=e^{A(t-t_0)}x(t_0)+\int_{t_0}^{t}e^{A(t-\tau)}Bu(\tau)d\tau \tag{6}$$

In formula(6), integral components is difficult to calculate, so we define additional value in formula(7),

$$\begin{aligned}x_{n+1}&=e^{f_1 t}\cos(f_4 t)\\ x_{n+2}&=e^{f_1 t}\sin(f_4 t)\end{aligned} \tag{7}$$

On general condition , the input signal is supposed to be formula(8)

$$u(t)=u_1(t)+u_2(t)=\sum_{i=0}^{r}c_i t^i+e^{f_1 t}\left[f_2\cos(f_4 t)+f_3\sin(f_4 t)\right] \quad (8)$$

And the augmented state model is established as formula(9)

$$\tilde{A}=\begin{pmatrix} A & f_2B & f_3B & B & 0 \\ 0 & f_1 & -f_4 & & 0 \\ & f_4 & f_1 & & \\ 0 & & 0 & 0 & 1 \\ & & & 0 & 0 \end{pmatrix},\tilde{x}(t)=\begin{pmatrix} x(t) \\ x_{n+1}(t) \\ x_{n+2}(t) \\ x_{n+3}(t) \\ x_{n+r+3}(t) \end{pmatrix},\tilde{x}(t)=\begin{pmatrix} x(0) \\ 1 \\ 0 \\ c_0 \\ c_r r! \end{pmatrix} \quad (9)$$

Then the state analytical solution of state model is formula(10)

$$\tilde{x}(t)=e^{\tilde{A}t}\tilde{x}(0) \quad (10)$$

The output analytical solution of state model is formula(11)

$$\tilde{y}(t)=\tilde{C}e^{\tilde{A}t}\tilde{x}(0)+\tilde{D}u(t) \quad (11)$$

III. Simulation of Typical Systems

A. Step Response of Systems

The typical step response is shown in figure 1, and the main performances index of control theory are:

(1) Steady value $y(\infty)$

$$y(\infty)=\lim_{s\to 0} s\bullet G(s)\frac{1}{s} \quad (12)$$

(2) Overshoot σ

$$\sigma=\frac{y_{\max}-y(\infty)}{y(\infty)}\times 100\% \quad (13)$$

(3) Settling time t_s

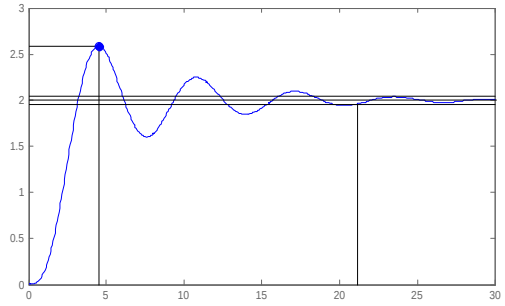

Figure 1. Step Response Performance of Systems

B. Simulations of Typical Second Order Systems

The second order systems is typical linear time-invariant system, and the structure is shown figure 2

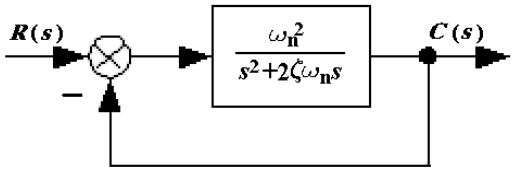

Figure 2. Typical Second Order Systems

The transfer function of figure2 is formula(14), and ζ is system damping ratio, ω_n is system undamping oscillation frequency.

$$G(s)=\frac{\omega_n^{\,2}}{s^2+2\zeta\omega_n s+\omega_n^{\,2}} \quad (14)$$

According to linear system analytical solution theory, the step response $y(t)$ is formula(15)

$$y(t)=1+\frac{\omega_n}{2\sqrt{1-\zeta^2}}\left(\frac{e^{\left(-\zeta\omega_n+\sqrt{1-\zeta^2}\omega_n\right)t}}{-\zeta\omega_n+\sqrt{1-\zeta^2}\omega_n}-\frac{e^{\left(-\zeta\omega_n-\sqrt{1-\zeta^2}\omega_n\right)t}}{-\zeta\omega_n-\sqrt{1-\zeta^2}\omega_n}\right) \quad (15)$$

(1) If $\zeta=0$, the response is formula non-damping response in formula(16) and the response curve is a sustained oscillation

$$y(t)=1-\cos(\omega_n t) \quad (16)$$

(2) If $0<\zeta<1$, the system response is underdamping response in formula(17), and the response curve is damped oscillation

$$y(t)=1-\frac{e^{-\zeta\omega_n t}\sin\left(\omega_n\sqrt{1-\zeta^2}\,t-\tan^{-1}\dfrac{\sqrt{1-\zeta^2}}{-\zeta}\right)}{\sqrt{1-\zeta^2}} \quad (17)$$

(3) If $\zeta=1$,the system response is critical damping response in formula(18), and the response curve is no oscillation

$$y(t)=1-\left(1+\omega_n t\right)e^{\omega_n t} \quad (18)$$

(4) If $\zeta>1$, the response is overdamping response in formula(19), and the response curve is no oscillation

$$y(t)=1+\frac{\omega_n}{2\sqrt{1-\zeta^2}}\left(\frac{e^{\left(-\zeta-\sqrt{\zeta^2-1}\right)t}}{-\zeta-\sqrt{\zeta^2-1}}-\frac{e^{\left(-\zeta+\sqrt{\zeta^2-1}\right)t}}{-\zeta+\sqrt{\zeta^2-1}}\right) \quad (19)$$

All the response curves are illustrated in figure3.

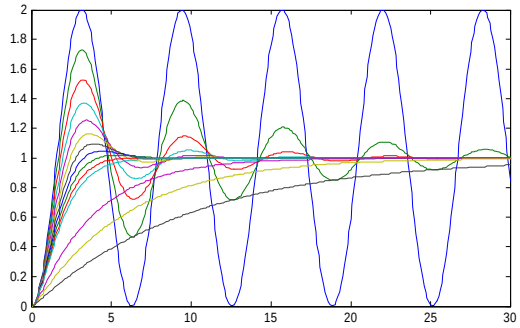

Figure 3. Second Order System Response Curves on Different Damping Ratio

From the curves, it is obvious that the too big ζ leads to long settling time and too small ζ causes serious system oscillation. In consideration of the two situation above, it Is better to make $\zeta=0.707$.

IV. Conlusion

We employ MATLAB in the process of control theory teaching, abandoning the idea of avoiding calculating characteristic roots, and MATLAB shows the curves of control system, which makes the teaching process efficient. All the research is based on second order system simulation, solving the problem of state model and getting optimum parameters of typical control systems.

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Study on Dynamic Properties and Micro-structure of Hardfill Materials

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***Abstract*—Hardfill is a roller compacted cement sand and gravel material which similar to the lean RCC (Roller Compacted Concrete). In recent years, hardfill materials has application in mass structure specifically in hydraulic structures, becase of its advantages such as low cost and environmentally friendly. In order to study dynamic properties of hardfill during earthquake, cyclic loading tests have been carried out. According to the results of tests, the elasticity of stress-strain relationship was confirmed by cyclic loading tests under conditions that the maximum compressive stress didn't exceed the linear range of hardfill. And than, the elasto-plasticity is observed when cyclic loads exceeds the linear range of Hardfill. Moreover, the reactive products for each specimen were examined, and it was observed that some typical needle structured ettringite was generated due to the blending of cement, the micro-structures of hardfill were studied by means of SEM and EDS.**

***Index Terms*—structure material, hardfill, dynamic properties, SEM, micro-structure**

I. Introduction

With increasing research on the development and usage of economically and environment friendly materials, many studies on new type structure material. Hardfill, a new type of structure material, which can be considered as a less strict sense lean RCC (Roller Compacted Concrete), is a roller compacted cement sand and gravel material. [1] The hardfill material was first proposed in 1992, which is called CSG (cemented sand and gravel) in Japan.[2-4] It has several advantages, including low cost, simple and quick construction and environmentally friendly. In recent years, hardfill materials has application in mass structure such as airfield runway, ports, docks, roadbed engineering of speedway, and more specifically in hydraulic structures.[5-6] China is known as a prominent earthquake country in the world. Therefore, important civil engineering structures must have sufficient aseismic performance against severe earthquakes. Especially, because the hydraulic structure is very important structure, it must be designed to ensure the safety against seismic loads.

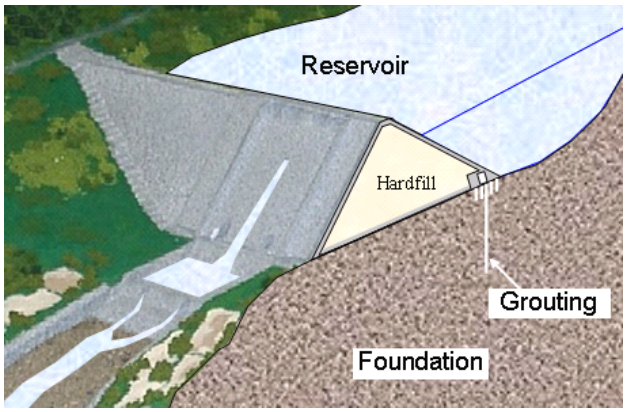
In this paper, introduction of a hardfill structure, result of stress analyses and dynamic properties of hardfill confirmed by cyclic loading tests are described. From the test results, it is confirmed that a stress-strain curve clearly showed non-linearity compared with concrete. The elasticity of stress-strain relationship was confirmed by cyclic loading tests under conditions that the maximum compressive stress did not exceed the linear range of hardfill. The purpose of this study is to examine the dynamic properties of hardfill and provide data that may be useful for evaluating the earthquake- resistance capability of hardfill structure.

II. About the Hardfill

In the face of urgent demands for lower cost and the protection natural environment, future hydraulic structures must be constructed at lower cost and environmentally friendly than in the past. Hardfill is a material prepared by adding cement and water to raw material such as riverbed gravel or excavation rock that can be easily obtained near dam sites, and mixing it by simple devices. Because a quarry, aggregate plants and turbid water treatment facility can be diminished largely by using hardfill, lower cost of dam construction works, protection and conservation of the environment can be achieved.

Mechanical properties of hardfill are effected by the grain size distribution curve of unit cement content, raw material, unit water content and so on. Basic properties of hardfill, such as modulus of elasticity, compressive strength, tensile strength, stress-strain curve and so on, are obtained by laboratory tests. As the shape of stress-strain curve is non-linear, it is considered that hardfill is an elasto-plasticity material.

As shown in Figure 1, a typical hardfill dam is a new type of dam, which uses a new type of material called "Hardfill". The dam has the advantages of both CFRD (Concrete Face Rockfill Dam) and RCCD (Roller Compacted Concrete Dam), and many other advantages of its own, such as greater safety, shorter construction period, lower construction costs and better performance on environmental protection.



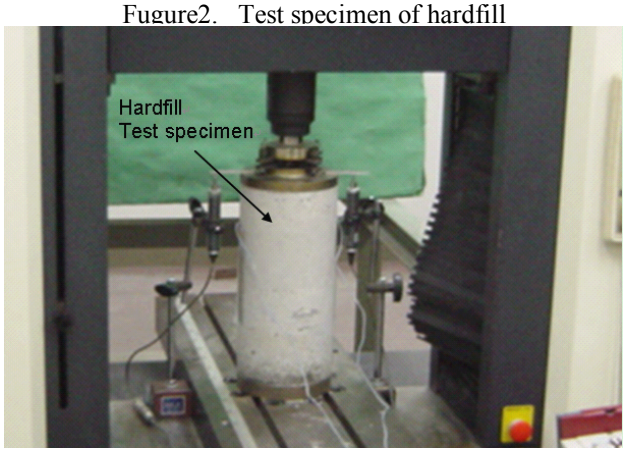
Fugure1. Sketch of a hardfill dam

III. Dynamic Test of Hardfill

A. Test conditions

In order to investigate dynamic properties of hardfill under earthquake conditions, cyclic loading tests of hardfill were carrying out by the uniaxial compression test in a laboratory. [7] Figure 2 shows the uniaxial compression instrument used for tests. The sizes of hardfill test specimen were 300mm in height and 150mm in diameter (shown in Figure 3). Hardfill test specimen was made by mixing the raw material with cement (80kg/m^3) and water (105-135kg/m^3), and compacted by hand vibrator.

Fugure2. Test specimen of hardfill



Fugure3. Uniaxial compression test of hardfill

Table 1 summarizes the test cases of cyclic loading tests.

TABLE I
Test Cases

Case	Estimated compressive strength of hardfill		Pattern of cyclic loading
	Peak Strength s σ_p (MPa)	Linear limit Strength σ_L (MPa)	
1	7.5	4.9	Peak load: 0.50s $_L$ Number of cycles: 5
2	7.5	4.9	Peak load: 0.75s $_L$ Number of cycles: 5
3	11.8	8.0	Peak load: 0.66s $_L$ Number of cycles: 20
4	10.2	6.1	Peak load: 0.45s $_L$, 0.85s $_L$, 1.25s $_L$, 1.50s $_L$ Number of cycles: 1 in each maximum load
5	7.3	4.3	Peak load: 0.50s $_L$, 1.15s $_L$, 1.35s $_L$ Number of cycles: 3 in each maximum load
6	7.9	4.8	Peak load: 1.15s $_L$ Number of cycles: 50

B. Results of cyclic loading tests

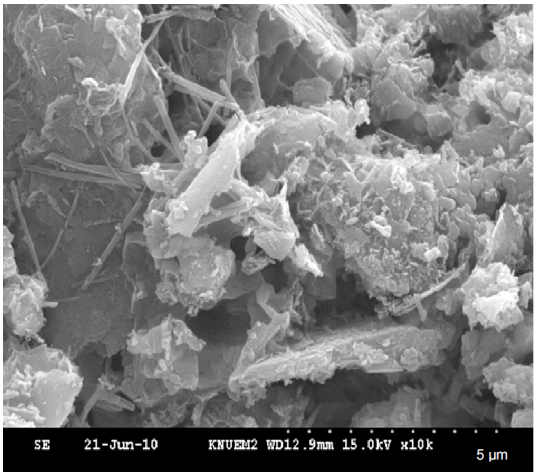
From the results of cyclic loading tests, the linearity of stress-strain relationship was observed when the maximum compressive load did not exceed the linear limit strength (σ_L). The linearity of stress-strain relationship was also confirmed by the result of case 3, even if the number of loading cycles increased. In case 4, peak loads were increased by cycles and exceeded the linear limit strength (σ_L). From the result of this case, it is observed that the elasto-plasticity was clearly appeared in the stress-strain curve and the residual strain increases cumulatively when a cyclic load exceeded the linear range of hardfill.

IV. Micro-structure of Hardfill

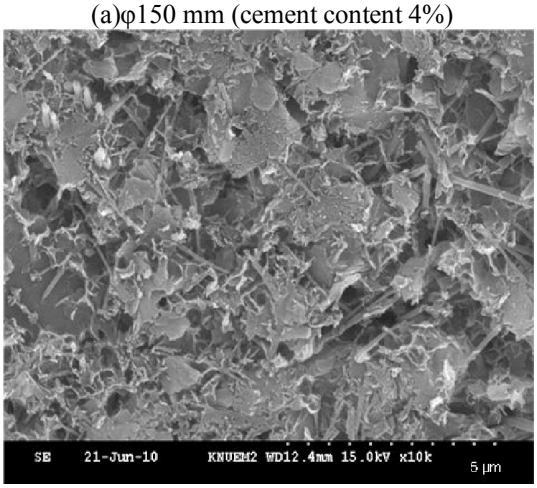
In this study, an SEM (Scanning electron microscopy [8]) was used to examine type and distribution of production due to hydration on the surface of a specimen. In addition, its constituents were analyzed by energy dispersive spectroscopy. EDS (Energy dispersive spectroscopy [8]) is an analytical technique used for the elemental analysis or chemical characterization of a sample. Figure 4 shows the micro- structure of specimens. As shown in the figure, some productions due to the hydration of cement mixed in the hardfill are observed. SEM results showed that the greater the volume of cement, the greater the generation of needle-shaped ettringite.

As mentioned earlier, the hydration production is proportional to the volume of cement, which means it could be one of the parameters affecting the compressive strength of the material. In addition, more needle-shaped ettringite was observed in the larger specimens, leading to a more comprehensive study of the relationship between hydration and specimen size. Figure 5 represents the results of EDS on the specimens of φ150 mm (cement

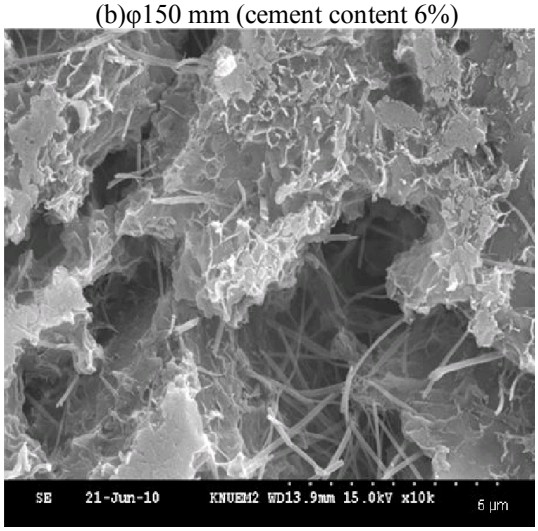
10%). As shown in the figure, the major constituents of the first two specimens were O and Si. Meanwhile, the specimen (φ150 mm) had O and Ca as the primary constituents. In addition, Si, C and S were found in the third specimen. In particular, sulfur was assumed to be ettringite. A small amount of aluminum (Al) was also detected.



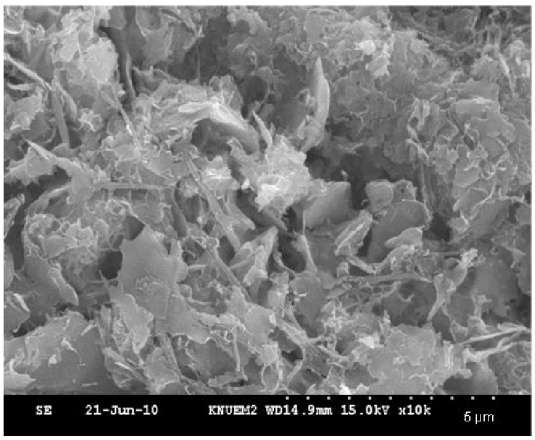
(a)φ150 mm (cement content 4%)



(b)φ150 mm (cement content 6%)

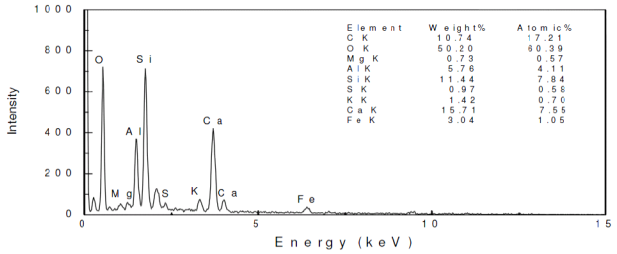


(c)φ150 mm (cement content 8%)



(d) φ150 mm (cement content 10%)

Fugure4. Micro-structure of hardfill materials (×10000)



Fugure5. EDS spectra of the hardfill materials (φ 150 mm, cement content 10%)

V. CONCLUSIONS

In this paper, the characteristics of the dynamic material properties of hardfill that were clarified by laboratory tests were described, and the micro-structures of hardfill were studied by means of SEM and EDS. The results of analyses and material tests are summarized in the following.

1) Compared with a conventional concrete dam, stress generated in a dam body of a trapezoid- shaped hardfill dam is small. In addition, the maximum stress is decrease in proportion as increment of the upstream and downstream slope gradient.

2) Dynamic properties of hardfill were confirmed by cyclic loading tests. The linearity of stress-strain curve was confirmed when the maximum compressive load did not exceed the linear limit strength of hardfill. In addition, it was also confirmed that the elasto-plasticity was clearly appeared when a cyclic load exceeded the liner limit strength of hardfill.

3) SEM results showed that the greater the volume of cement, the greater the generation of needle-shaped ettringite.

In a basic design of hardfill dam, the strength and the modulus of elasticity in linear range should be used as material properties of hardfill. Therefore, even if the large load that exceed the linear limit strength acted on a dam body in case of an unexpected serious earthquake etc., brittle failure would be hard to occur in the hardfill dam because hardfill has a wide range of plasticity. It means that the hardfill dam has a enough safety margin against severe earthquakes.

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An algebraic Method to Compute Generators of Finite Reflection Groups in 3-D Euclidean space

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***Abstract*—the generators of reflection groups in 3-D Euclidean space were obtained by observing geometrical models. However, this method is difficult to ascertain the generators of regular polytopes in higher dimension space for there are no visible models. Given an abstract presentation of a regular polyhedral group, this paper proposes a pure algebraic method to determine its generators. The method can be similarly extended to deal with the regular polytopes in arbitrary dimension space.**

***Index Terms*—regular polyhedra, generator, finite reflection group, spherical geometry.**

I. Introduction

Groups generated by reflections deserve special consideration for two reasons: there is a general theory covering them all, and they contain the remaining point groups as subgroups [1-4]. Finite reflection groups of Euclidean space are special Coxeter groups, namely, symmetry groups of regular polyhedra in R^3, or regular polytopes in $R^n, n \geq 4$ [5-8]. These groups have wide applications in a diverse range of fields, including physics, chemistry, discrete geometry, topology, etc [9, 10].

Generators are very important to groups because they describe the essential feature of groups. For convenience, we denote the n-dimension Euclidean space as R^n, and finite reflection in R^n as G^n. Generators of G^3 are derived by a deep recognition of regular polyhedra, especially for the symmetry group of regular dodecahedron or icosahedron. However, for the abstract regular polytopes in $R^n, n \geq 4$, there are no visible models in real world to refer. The motivation of this paper aims at providing a pure algebraic algorithm to determine the generators of G^3, which can be similarly extended to $G^n, n \geq 4$.

Given an abstract presentation of G^3, in Section 2, we discuss the geometrical meanings behind the presentation. The algebraic method to compute the generators of G^3 will be detailed described in Section 3.

II. Geometrical meanings behind the algebraic presentaion in 3-D Euclidean space

Definition 1. A *symmetry* of an object is a congruent or an isometric transformation (a common explanation of symmetry is that the object is invariant under this transformation). The *symmetry group* of an object consists of all symmetries of that object.

Definition 2. The *reflection group* is a discrete symmetry group which is generated by a set of reflections of the Euclidean space.

Definition 3.The elements $g_1, g_2, ..., g_n$ of a group G are called a set of *generators* if every element of G is expressible as a finite product of their powers (including negative powers).

A convex polyhedron is said to be regular if its faces are regular and equal, and its vertices are all surrounded alike. For convenience, we introduce Schläfli symbols. The Schläfli symbols *{p}* and *{p,q}* represent, respectively, a regular p-sided polygon and a regular polyhedron with each of its faces of type {p} and each vertex surrounded by q {p}s. There are three finite reflection groups in R^3, which closely relate to five famous regular polyhedra (namely, the so-called Platonic solids). A simple method to find possible {p,q}s can be described as follows [2, 7].

Suppose p and q are two integers. A solid angle at a vertex of {p,q} has q equal angles of $\frac{p-2}{p}\pi$ and the sum of angles is less than 2π, therefore, p and q must satisfy

$$q(\frac{p-2}{p}\pi) < 2\pi \text{ or } \frac{1}{p}+\frac{1}{q}<\frac{1}{2}. \quad (1)$$

The five integer solutions of inequality (1) are well-known Platonic solids: regular tetrahedron {3,3}, regular octahedron {3,4}, cube {4,3}, regular icosahedron {3,5} and regular dodecahedron {5,3}.

We adopt the notation */p,q/* of [2] to denote the group associated with {p,q}. By [2], symmetry group [p,q] is finite and is generated by three proper reflections through the center of {p,q}. Let $\alpha_{[p,q]}, \beta_{[p,q]}$ and $\gamma_{[p,q]}$

$$\alpha_{[p,q]}^2 = \beta_{[p,q]}^2 = \gamma_{[p,q]}^2 = (\alpha_{[p,q]}\beta_{[p,q]})^p = (\beta_{[p,q]}\gamma_{[p,q]})^q = (\gamma_{[p,q]}\alpha_{[p,q]})^2 = e. \quad (2)$$

is an abstract representation of [p,q], where e is the

identity of [p,q]. In this paper we use (2) to check that whether three matrixes are a set of generators of [p,q].

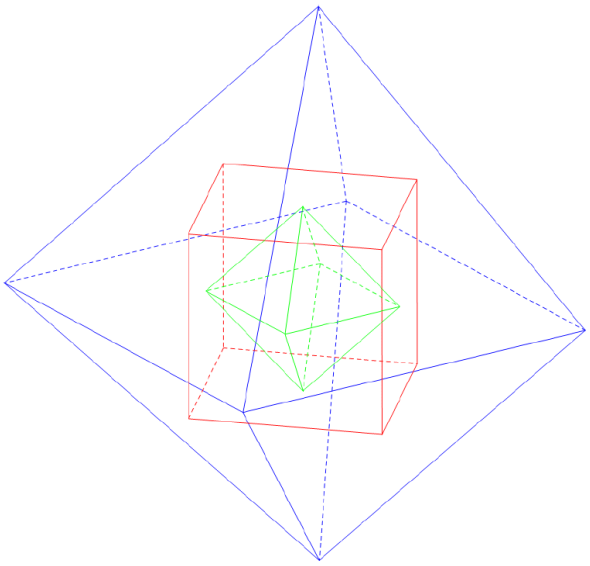

Figure 1. The dual relationship between regular polyhedra {p,q} and {q,p} for the case p=3 and q=4.

A significant fact is that: a {p,q} inscribed in {q,p} arises if we connect adjacent {p}s' centers of {p,q}; Or correspondingly, connecting adjacent {q}s' centers of {q,p} will give birth to a {p,q} inscribed in {q,p}. In this sense, we say that {p,q} and {q,p} are dual. The dual relationship between {3,4} and {4,3} is illustrated in Fig 1, showing that a red {4,3} is inscribed in a bigger blue {3,4}, and in turn, a smaller green {3,4} is inscribed in the same {4,3} perfectly. In group's words, duality means [p,q] and [q,p] are essentially isomorphic, which can be intuitively comprehended as follows. If the midpoints of adjacent faces of a {p,q} are joined by line segments. Then the resulting line segments are the edges of an inscribed {q,p}. Consequently, any solid transformation of R^3 that leaves a {p,q} invariant also leaves the inscribed {q,p} invariant, and vice versa.

Let $S^2 = \{(x, y, z) \in R^3 \mid x^2 + y^2 + z^2 = 1\}$ and {p,q} be a regular polyhedron inscribed in S^2. Then {p,q} has a symmetry about the plane determined by three points, namely, the center of {p,q}, any vertex and the midpoint of the vertex's opposite edge. This fact is explained by an example illustrated in Fig 2. We call a plane like $\sum$ of Fig 2 reflecting plane of {p,q}. Any reflecting planes of {p,q} will intersect S^2 and form a corresponding great circle on S^2. These great circles together decompose S^2 into a finite number of congruent spherical triangles, and the resulting triangles finally form a perfect spherical tessellation {p,q} on S^2. Fig 3 displays a spherical tessellation with [3,4] symmetry, obtained by shading the alternate spherical triangles.

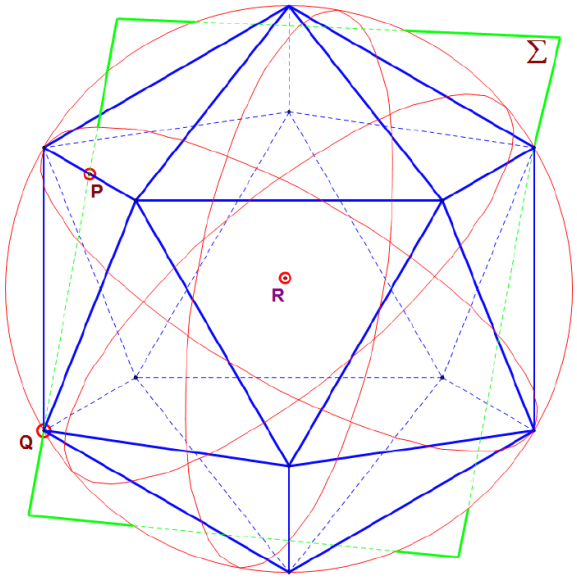

Figure 2. A {3,5} has the symmetry about a plane which is determined by the center, any vertex and the midpoint of this vertex's opposite edge, such as the marked plane $\sum$ determined by R,Q and P.

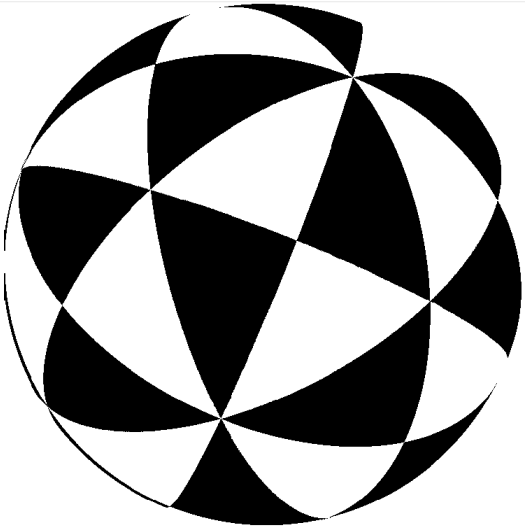

Figure 3. A spherical {3,4} tessellation obtained by shading the alternate spherical triangles.

In spherical geometry, a spherical angle between two spherical arcs (or geodesics) is defined as the dihedral angle of the planes determined by the great circles containing the arcs. Given normal vectors (k_1, k_2, k_3) and (l_1, l_2, l_3), the dihedral angle θ between planes $xk_1 + yk_2 + zk_3 = 0$ and $xl_1 + yl_2 + zl_3 = 0$ is

$$\theta = \frac{\sum_{i=1}^{3} k_i l_i}{\sqrt{\sum_{i=1}^{3} k_i^2}\sqrt{\sum_{i=1}^{3} l_i^2}} \tag{3}$$

The product of two reflections of [p,q] is a rotation through twice their dihedral angle [11], whose center is the origin and the reflecting plane perpendicular to the reflecting planes. By the geometrical meaning of (2), the

paired reflections $\alpha_{[p,q]}$ and $\beta_{[p,q]}$, $\beta_{[p,q]}$ and $\gamma_{[p,q]}$, $\gamma_{[p,q]}$ and $\alpha_{[p,q]}$, respectively, yield angles of π/p, π/q and $\pi/2$, which are angles of a spherical triangle of spherical tessellation {p,q}. The area of the triangle is measured by its angular excess $(\frac{\pi}{p}+\frac{\pi}{q}-\frac{\pi}{2})$. Repeating reflections along sides of triangles produce all elements of [p,q], and at the same time, yield a spherical tessellation {p,q} on S^2. This implies that every spherical triangle is a fundamental region with respect to [p,q]. The order of [p,q] is the number of such triangles that cover S^2 (of area 4π). Consequently, the number of triangles of tessellation {p,q} covering S^2 is

$$\frac{4\pi}{(\pi/p+\pi/q-\pi/2)}=\frac{8pq}{4-(p-2)(q-2)}.$$

III. ALGEBRAIC METHOD TO DETERMINE THE GENERATORS OF [P,Q]

Suppose k is a reflection in R^3 about a plane through origin with normal vector (n_1,n_2,n_3), then k can be represented as

$$k=I_3-2\begin{pmatrix}m_1\\m_2\\m_3\end{pmatrix}(m_1,m_2,m_3), \tag{4}$$

where I_3 is a 3×3 identity matrix and $(m_1,m_2,m_3)=\dfrac{(n_1,n_2,n_3)}{\sqrt{\sum_{i=1}^{3}n_i^2}}$ [8].

By discussing geometrical meanings behind formula (2), we now propose a strategy to compute the generators of [p,q] as follows.

Firstly, suppose Π_1 and Π_3 with normal vectors (k_1,k_2,k_3) and (l_1,l_2,l_3) are, respectively, the reflecting planes with respect to generators $\alpha_{[p,q]}$ and $\gamma_{[p,q]}$. By (2), $(\gamma_{[p,q]}\alpha_{[p,q]})^2=e$ implies that a spherical triangle with respect to [p,q] has a right angle. Thus we select mutually orthogonal planes Π_1 and Π_3 so that the associated generators $\alpha_{[p,q]}$ and $\gamma_{[p,q]}$ possess as simple as possible expressions. Secondly, since any nonzero multiple of a normal vector is still a normal vector of a plane. Without losing generality, assume $\beta_{[p,q]}$ is the third generator of [p,q] and the corresponding reflecting plane Π_2 has normal vector (n_1,n_2,n_3) with $n_1=1$, or $n_2=1$, or $n_3=1$. By (3), there is a solution (n_1,n_2,n_3) satisfying equations

$$\begin{aligned}\cos\frac{\pi}{p}&=a\cos\frac{\sum_{i=1}^{3}k_in_i}{\sqrt{\sum_{i=1}^{3}k_i^2}\sqrt{\sum_{i=1}^{3}n_i^2}},\\ \cos\frac{\pi}{q}&=a\cos\frac{\sum_{i=1}^{3}l_in_i}{\sqrt{\sum_{i=1}^{3}l_i^2}\sqrt{\sum_{i=1}^{3}n_i^2}}.\end{aligned} \tag{5}$$

Finally, by (4), use (n_1,n_2,n_3) to determine the third generators $\beta_{[p,q]}$ of [p,q].

Subsequently, we use this strategy to determine the generators of [3,3], [3,4] and [3,5].

■ Case [3,3]

We choose mutually orthogonal planes $\Pi_1: x+y=0$ and $\Pi_3: x-y=0$, with the corresponding generators being

$$\alpha_{[3,3]}=\begin{pmatrix}0&-1&0\\-1&0&0\\0&0&1\end{pmatrix},\gamma_{[3,3]}=\begin{pmatrix}0&1&0\\1&0&0\\0&0&1\end{pmatrix}.$$

Substitute $(k_1,k_2,k_3)=(1,1,0)$ and $(l_1,l_2,l_3)=(1,-1,0)$ into (5), we get a solution $(n_1,n_2,n_3)=(0,1,-1)$, whose associated reflecting plane is $\Pi_2: y-z=0$. By (4), we obtain the third generator

$$\beta_{[3,3]}=\begin{pmatrix}1&0&0\\0&0&1\\0&1&0\end{pmatrix}.$$

■ Case [3,4]

We select mutually orthogonal planes $\Pi_1: x-z=0$ and $\Pi_3: y=0$. Accordingly, the associated generators are

$$\alpha_{[3,4]}=\begin{pmatrix}0&0&1\\0&1&0\\1&0&0\end{pmatrix},\gamma_{[3,4]}=\begin{pmatrix}1&0&0\\0&-1&0\\0&0&1\end{pmatrix}.$$

Analogous to the process of case [3,3], we get the third reflecting plane $\Pi_2: x-y=0$ and the corresponding generator

$$\beta_{[3,4]}=\begin{pmatrix}0&1&0\\1&0&0\\0&0&1\end{pmatrix}.$$

■ Case [3,5]

Group [3,5] contains a very complicated generator for symmetries of {3,5} are much rich and complicated. Though direct determination of its generators is possible, it needs a profound insight on the symmetries of regular polyhedron {3,5}. According above method, it is quite easy to establish its generators. In this case, we choose mutually orthogonal planes $\Pi_1 : y = 0$ and $\Pi_3 : x = 0$. Then the associated generators are $\alpha_{[3,5]} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \gamma_{[3,5]} = \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$. With a tedious but not difficult computation we can find a solution $(n_1, n_2, n_3) = (-\zeta, 1, -1/\zeta)$, and the corresponding plane $\Pi_2 : \zeta x - y + z/\zeta = 0$. By (4), we obtain the third generator $\beta_{[3,5]} = \begin{pmatrix} 1/\zeta & \zeta & -1 \\ \zeta & 1 & 1/\zeta \\ -1 & 1/\zeta & \zeta \end{pmatrix}$, where $\zeta = \frac{1+\sqrt{5}}{2}$ is the golden ratio.

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Developing Color Calibration Device based on Fuzzy Delphi and DEMATEL-ANP

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***Abstract*—The medical display monitors (MDMs) are commonly used in medical service centers, and the industry has been growing rapidly in the past decades. The technical specifications of MDMs are very stringent due to the requirements of high quality medical judgment and functions, as well as growing market competition. The technological requirements of MDMS are higher than those of display monitors used for general purposes, but their gross profit margins are larger as well. There are many multiple criteria decision making (MCDM) problems in manufacturing industry. The purpose of this research is to build a hybrid MCDM model that is useful in developing new color calibration device for the MDM industry. The proposed MCDM model uses the fuzzy Delphi method to filter performance criteria, and then applies the analytic network process (ANP) to prioritize three alternatives of new product development. In this study, DEMATEL is used to build a relations-structure for ANP criteria. The paper also presents a case study on model implementation in a LCD high-tech company. The results indicate that the proposed model is efficient and effective in making decision for the case problem.**

***Index Terms*—fuzzy Delphi, color calibration device, ANP, DEMATEL**

I. Introduction

A survey done by Product Development and Management Association (PDMA) reveals that more than 50% of the sales in successful companies were coming from new products and that the percentage was even over 60% in the most successful overall company [1]. As a result, the advanced-technology product development and introduction process need to be improved to enhance a company's competitive advantage. However, successful execution of new product development must be implemented in most stages of product lifecycle management including market requirement, product concept, detailed design, process plan, production, etc. [2].

There are many multiple criteria decision making (MCDM) problems in manufacturing industry. Different from single criterion decision making problems, in multiple criteria problems, a decision maker (DM) has to choose the most appropriate alternative that satisfies the evaluation criteria among a set of candidate solutions [3]. For the situation where the evaluation criteria are in conflict with each other, how to make a scientific decision becomes a difficult problem [4]. MCDM is one of appropriate approaches in dealing with the new product development selection problem. The MCDM approach enables experts and decision makers to simultaneously consider the relevant factors or criteria, and then integrate their opinions in building an MCDM model. Subsequently, the model is applied to weight the alternatives and select the best.

In general, decision-making is the study of identifying and choosing alternatives based on the values and preferences of the decision-maker. Among various MDCM methods, analytic hierarchy process (AHP) [5] is a common and practical method, which makes use of relative assessment and prioritization of alternatives. A simple AHP model consists of a goal, criteria and alternatives. The hierarchical structure of AHP shows the relationships among the three levels from top to bottom. The modeling process consists of three phases: decomposition, comparative judgment, and synthesizing [6]. In practice, the evaluation index on performance systems frequently has a hierarchical structure; for example, reference [7] applies AHP to evaluate the performance of IDSS. The Analytic Network Process (ANP), introduced in [8], is a generalization of AHP. Whereas AHP represents a framework with a uni-directional hierarchical relationship, ANP allows for more complex interrelationships among decision levels and attributes [2]. The ANP feedback approach provides a flexible means in modeling MCDM problems, where the relationships between criteria are not easily represented with higher or lower level, dominating or being dominated, direct or indirect influence [9]. For instance, the ANP not only allows to assess the impacts of the criteria on the alternatives as in AHP, but also the impacts of the alternatives on the criteria. Saaty [8] proposed "supermatrix" technique, which uses Markov chain convergence theory to synthesize ratio scale.

There are many studies in literature using ANP to solve decision making problems. In two separate studies, [10, 11] used ANP to prioritize interdependent information system projects. The studies [12-14] also employed ANP to solve R&D project selection problems. Ref. [15] also used ANP to evaluate the homestay industry in north Taiwan. Recently, hybrid MCDM models are frequently used to solve complex decision problems. Ref. [16] studied the outsourcing provider selection problem, and developed a hybrid MCDM model that combines DEMATEL, ANP, and VIKOR to prioritize the alternatives. In their model, the DEMATEL

builds a relations-structure among criteria, the ANP determines the relative weights of criteria with dependence and feedback, and the VIKOR ranks the alternatives. Ref. [17] applied the same hybrid model to solve the investment decision problem in Iranian stock exchange. Ref. [18] developed a model based on AHP and Delphi methods for evaluating the performance of marine industries from the perspective of eco-economics. Ref. [19] presented a model hybridizing ANP and DEMATEL for the selection of independent media agencies, where DEMATEL performs a role similar to TOPSIS in [20, 21].

The purpose of this paper is to present a solution model for the decision problem on developing new color calibration device, allowing the consideration of interactions among decision levels and criteria. The device is used in medical display monitors. The fuzzy Delphi method is utilized to filter the elements of "criteria", whereas DEMATEL is used to build a relations-structure among elements of the model. The fuzzy Delphi method was first introduced by Ishikawa et al. [22].

The paper is structured as follows: Section 2 describes the process for establishing the hybrid MCDM model; Section 3 presents the numerical results of a case study utilizing this model; Section 4 concludes the paper.

II. Proposed Model

This paper presents a model adapted for developing color calibration device in the LCD high-tech industry. The overall process of the proposed approach is shown in Figure 1. A company in the industry was chosen and acts as the case study to validate the model. To build the model, ten experts and decision-makers were invited to participate in the activity. All are members of high management, including Departments of R&D, Marketing, Production, Information Technology, and Product Planning. Subsequently, a four-level hierarchical model with inner- and outer-dependence is proposed. We shall refer to the top element as the goal, the clusters at the second level as "perspectives", the clusters at the third level as "criteria", and the elements at the lowest level as "alternatives".

The evaluation process consists of the following steps:

Step 1: Form an expert/decision-maker group for this problem.

Step 2: Establish a preliminary evaluation framework via literature review and discussion with the group.

Step 3: Apply fuzzy Delphi method to filter the elements in the framework, including the perspectives and their respective criteria.

Step 4: Employ DEMATEL to identify the relationships between elements in the framework, and finalize the ANP.

Step 5: Use DEMATEL method to calculate the strength of influence between criteria, and the introduction of mixed weights [23].

Step 6: Perform ANP calculations to evaluate and rank the alternatives.

A. Fuzzy Delphi Method

The max-min Delphi method [22] is used to screen and establish the criteria.

The preliminary decision framework considers three perspectives and fifteen criteria. After applying the max-min Delphi, nine criteria are considered for the studied problem.

The resulting decision framework contains the following:

Level 1: Goal (G) – determine the device to be developed

Level 2: Perspectives (P) – Technical Capability (P_1), Marketing Environment (P_2), Organizational Management (P_3)

Level 3: Criteria for each perspective

P_1 : Technical Capability

C_{11} – Technology patent;

C_{12} –Customization capacity

C_{13} –R&D capability

P_2 : Marketing Environment

C_{21} – Product profitability

C_{22} – Competitiveness

C_{23} –Brand image

P_3: Organizational management

C_{31} – Relations & corporate support

C_{32} –Integration ability

C_{33} – Marketing capability

Level 4: Three alternatives

A_1: Front sensor – size: 18 x 10 mm; weight: 30g; imbedded USB; automatic control; technical difficulty: high; current market share: 30%; precision: ± 15%; applicable MDM: 19-27 inch; investment: USD100000; estimated selling price: USD1000; warranty: 3 years.

A_2: Color sensor – size: 68 x 41 mm; weight: 140g; external USB; manual control; technical difficulty: medium; current market share: 60%; precision: ±5%; applicable MDM: 19-60 inch; investment: USD60000; estimated selling price: USD300; warranty: 1 year.

A_3: Swing sensor – size: 117 x 29 x 96 mm; weight: 160g; external USB; automatic control; technical difficulty: very high; current market share: 10%; precision: ± 10%; applicable MDM: 19-27 inch; estimated selling price: USD1200; warranty: 2 years.

B. Decision Making Trial and Evaluation Laboratory (DEMATEL)

DEMATEL is a comprehensive method for designing and analyzing structural models of causal relationships between complex factors [24]. The method is capable of integrating experts' opinions to clarify the connections and causal relationships among criteria, and represents their inter- and inner-dependencies through a network structure. This scientific research method could improve understanding of the problem's specific features and the identification of relationships between factors, and produces workable solutions [25]. The observed method is based on graph theory, allowing visual planning and problem solving so that the relevant factors can be divided into causal group and consequential group for a better understanding of mutual relations [26]. For the

procedure to calculate the level of interdependence among the factors with DEMATEL method, please refer to [27]

C. Integrating DEMATEL and ANP with composite importance (DEMATEL-ANP)

DEMATEL method can cope well with the causal relationship among the elements, but unable to assess the weights of criteria which are at the same or different levels. Reference [23] uses composite importance to solve this weight-assignment problem while incorporating DEMATEL with ANP for building a MCDM model. The formula for calculating the composite importance z is given in (1), where I is an identity matrix, F is the full influence matrix generated in DEMATEL, and w is the limiting weights of criteria obtained by ANP.

$$z = (I + F) \cdot w \quad (1)$$

The following example illustrates the calculation of z for a case of 3 criteria. Suppose that w^T = (0.333, 0.333, 0.333) and F is calculated as shown below.

$$F = \begin{bmatrix} 0.117 & 0.195 & 0.671 \\ 0.555 & 0.107 & 0.866 \\ 0.051 & 0.027 & 0.040 \end{bmatrix}$$

By applying formula (1), we obtain z^T=(0.660, 0.842, 0.372). Note that the sum of the elements in z^T is not necessarily one.

D. Analytic Network Process (ANP)

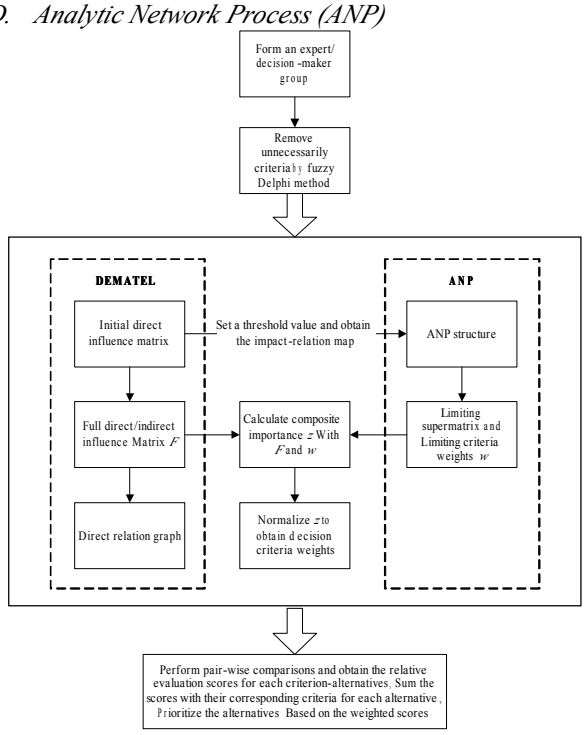


Figure 1. Overall process of proposed approach.

From subsections *A* and *B*, an ANP model can be established for the studied problem. The left side of Figure 2 displays the ANP in graphical form, and the right side of Figure 2 presents the corresponding unweighted supermatrix. Figure 3 shows the detailed network structure of the ANP. Matrix W_{21} is 3 x 1, which indicates the relative weights (importance) of the three perspectives with respect to the Goal. Matrix W_{22} is 3 x 3, which shows the influential strength among the three perspectives. Matrix W_{32} is 11 x 3, which specifies the relative importance of the criteria with respect to their individual perspectives. Matrix W_{33} is 11 x 11, which signifies the dependencies for criteria within the same cluster and between two distinct clusters. Matrix W_{43} is 3 x 11, which shows the relative weights of the three alternatives for each criterion. I is a 3 x 3 identity matrix, which implies that the three alternatives are independent.

III. Numerical Results

Table 3 illustrates the calculated results for W_{21}. The other matrices can be similarly obtained. First, arithmetic mean is used to integrate the pairwise comparisons of group members. For example, a_{12} = 0.327 in W_{21} is the mean of the values in the same position given by the group members. Afterwards, the geometric mean method is used to calculate the relative weights: 0.541 = $(1 \cdot 0.327 \cdot 0.485)^{1/3}$, 1.493 = $(3.061 \cdot 1 \cdot 1.087)^{1/3}$, and 1.238 = $(2.062 \cdot 0.92 \cdot 1)^{1/3}$. The weight of P_1 in W_{21} is 0.541/(0.541+1.493+1.238) = 0.165. By similar calculations, we obtain that the weights of P_2 and P_3 are respectively 0.456 and 0.378. Further calculations indicate that CR = 0.009, which confirms the consistency of the group's evaluations.

ANP uses limiting or convergent weights to rank the perspectives, criteria, and alternatives. To calculate the limiting supermatrix, we apply the Markov chain theory [6]. A Markov chain requires the sum of each column to be 1. Thus, the supermatrix M_S in Figure 2 needs to be normalized for the column sum requirement. A weighted supermatrix M_w can be obtained by dividing any column in P and C by 2, as shown in Fig 4. The details of the weighted supermatrix M_w is provided in Table 4.

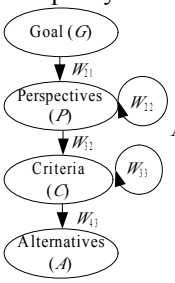
The limiting weight vectors of the respective three perspectives, eleven criteria, and three alternatives can be obtained by a series of matrix computations on the three matrices in Figure 4 until they converge.

For perspectives: Compute $(M_{w1}{}^T)^n$ for large n, where T represents matrix transpose. As a result, the limiting weight vector (P_1, P_2, P_3) = (0.544, 0.134, 0.322). Technical capacity ranks first, Product profitability second, Organizational management third.

For criteria (DEMATEL-ANP): Computed by the ANP $(M_{w2}{}^T)^n$ for large n; (C_{11}, C_{12}, C_{13}, C_{21}, C_{22}, C_{23}, C_{31}, C_{32}, C_{33}) = (0.137, 0.128, 0.120, 0.093, 0.109, 0.102, 0.123, 0.095, 0.093). Equation (1) calculated DEMATEL-ANP mixing weights; (C_{11}, C_{12}, C_{13}, C_{21}, C_{22}, C_{23}, C_{31}, C_{32}, C_{33}) = (0.269, 0.158, 0.336, 0.255, 0.157, 0.251, 0.192, 0.255, 0.233). ANP order to comply with a weight of 1, the normalized weights DEMATEL-ANP: (C_{11}, C_{12}, C_{13}, C_{21}, C_{22}, C_{23}, C_{31}, C_{32}, C_{33}) = (0.128, 0.075, 0.159, 0.121, 0.075, 0.119, 0.091, 0.121, 0.111).-

For alternatives: Weights obtained by the DEMATEL-ANP obtain the best solution. (A_1, A_2, A_3) = (0.412, 0.338, 0.250). Product A_1 has the advantage of compactness and long warranty. All other features are between A_2 and A_3. The group concludes that the case company should develop

product A_1, due to its ease of mobility and long availability. Product A_1 will best fit the company's R&D capacity and market profitability.



$$M_S = \begin{array}{c} \\ G \\ P \\ C \\ A \end{array} \begin{array}{c} \begin{array}{cccc} G & P & C & A \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ W_{21} & W_{22} & 0 & 0 \\ 0 & W_{32} & W_{33} & 0 \\ 0 & 0 & W_{43} & I \end{bmatrix} \end{array}$$

Figure 2. Graphical form and supermatrix of ANP

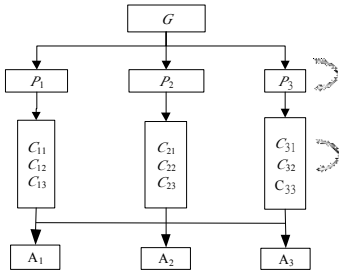


Figure 3. ANP decision framework

$$M_1 = \begin{bmatrix} 0 & 0 \\ W_{21} & W_{22} \end{bmatrix} \qquad M_{w2} = \begin{bmatrix} 0 & 0 & 0 \\ W_{21} & W_{22}/2 & 0 \\ 0 & W_{32}/2 & W_{33} \end{bmatrix}$$

$$M_w = \begin{array}{c} \\ G \\ P \\ C \\ A \end{array} \begin{array}{c} \begin{array}{cccc} G & P & C & A \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 \\ W_{21} & W_{22}/2 & 0 & 0 \\ 0 & W_{32}/2 & W_{33}/2 & 0 \\ 0 & 0 & W_{34}/2 & I \end{bmatrix} \end{array}$$

Figure 4. Weighted matrices

TABLE I.
PAIRWISE COMPARISONS AND WEIGHT MATRIX W21

	P_1	P_2	P_3	GM	W_{21}
P_1	1.000	0.327	0.485	0.541	0.165
P_2	3.061	1.000	1.087	1.493	0.456
P_3	2.062	0.920	1.000	1.238	0.378

λ_{max}: 3.011 ; CI: 0.005 ; RI: 0.58 ; CR: 0.009

TABLE II.
Weighted supermatrix Mw

	G	P_1	P_2	P_3	C_{11}	C_{12}	C_{13}	C_{21}
G	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P_1	0.083	0.194	0.357	0.370	0.000	0.000	0.000	0.000
P_2	0.228	0.080	0.052	0.051	0.000	0.000	0.000	0.000
P_3	0.189	0.226	0.091	0.080	0.000	0.000	0.000	0.000
C_{11}	0.000	0.093	0.000	0.000	0.040	0.047	0.098	0.087
C_{12}	0.000	0.223	0.000	0.000	0.056	0.127	0.054	0.019
C_{13}	0.000	0.184	0.000	0.000	0.096	0.107	0.012	0.048
C_{21}	0.000	0.000	0.117	0.000	0.041	0.083	0.026	0.024
C_{22}	0.000	0.000	0.193	0.000	0.069	0.027	0.016	0.131
C_{23}	0.000	0.000	0.190	0.000	0.016	0.016	0.130	0.039
C_{31}	0.000	0.000	0.000	0.173	0.137	0.018	0.022	0.122
C_{32}	0.000	0.000	0.000	0.246	0.035	0.011	0.103	0.015
C_{33}	0.000	0.000	0.000	0.081	0.011	0.064	0.038	0.013
A_1	0.000	0.000	0.000	0.000	0.083	0.340	0.138	0.374
A_2	0.000	0.000	0.000	0.000	0.180	0.060	0.276	0.042
A_3	0.000	0.000	0.000	0.000	0.237	0.100	0.085	0.084

	C_{22}	C_{23}	C_{31}	C_{32}	C_{33}	A_1	A_2	A_3
G	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P_1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P_3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_{11}	0.054	0.069	0.105	0.047	0.073	0.000	0.000	0.000
C_{12}	0.099	0.045	0.108	0.017	0.018	0.000	0.000	0.000
C_{13}	0.013	0.099	0.014	0.020	0.131	0.000	0.000	0.000
C_{21}	0.022	0.014	0.055	0.125	0.027	0.000	0.000	0.000
C_{22}	0.093	0.028	0.031	0.100	0.012	0.000	0.000	0.000
C_{23}	0.118	0.021	0.019	0.090	0.016	0.000	0.000	0.000
C_{31}	0.029	0.013	0.125	0.028	0.043	0.000	0.000	0.000
C_{32}	0.059	0.084	0.033	0.011	0.081	0.000	0.000	0.000
C_{33}	0.012	0.128	0.011	0.062	0.099	0.000	0.000	0.000
A_1	0.185	0.402	0.083	0.074	0.185	1.000	0.000	0.000
A_2	0.237	0.043	0.237	0.208	0.248	0.000	1.000	0.000
A_3	0.078	0.055	0.181	0.219	0.067	0.000	0.000	1.000

IV. CONCLUSIONS

This paper presents a hybrid MCDM model for selecting the best alternative in developing new color calibration device for medically used LCD. This model integrates several effective decision making methods, and assesses alternatives based on the following three phases: (1) apply fuzzy Delphi method to identify the relevant factors for the studied problem; (2) employ a DEMATEL relation analysis method to recognize the interdependency among perspectives, as well as criteria, and thus build the ANP model and generate composite importance for each criterion; (3) evaluate three alternatives and select the best one based on the ANP results, which are derived from the opinions of the high level management group in the case company. We are confident that the model can also be applied to various examples and deliver similar conclusions. This model is innovative, as it utilizes fuzzy Delphi method, and integrates DEMATEL and ANP with different concept. Combining these two methods allows decision-makers to capture key factors and identify interrelationships.

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Hub Location Problem in Emergency Material Reserve System Based on Rail-road Intermodal Transportation

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***Abstract*—Through observations from the construction of Chinese national emergency material reserve system, we introduce the rail-road intermodal hub location problem. We provide a mathematical model for finding the optimal hub locations and assignment of hub(s) for each origin–destination pair to minimize the total transportation time in the whole network. Then, a procedure for solving this model is proposed. By using a numerical example, we discuss the impact of the average speed of freight trains and the transshipment time at hubs on the performance of hub-and-spoke network. The results show that the average speed of freight trains has positive effects on the efficiency of the network, whereas the transshipment time has negative effects. Finally, we set future research directions on the intermodal hub-and-spoke network associated with emergency logistics.**

***Index Terms*—hub location problem, emergency logistics, multimodal transportation, hub-and-spoke network**

I. Introduction

Our research is motivated by the practices of the construction of Chinese national emergency material reserve system. In order to achieve quick response to the urgent need of emergency materials in affected areas right after disasters, China began to build a national emergency material reserve system in 1998. Until now, there have been 18 central-level warehouses in the whole country, and each province has established a provincial-level warehouse, as well as 92 percent of cities and 60 percent of towns own town-level warehouses. In the next ten years, China plans to build more emergency material warehouses with different levels to form a perfect-served emergency material reserve system. Meanwhile, great progress is being made in Chinese railway. Today, the length of rail lines in China has reached 98,000 kilometers by the end of 2012, ranked second in the world. China also has the world's longest high speed railway. Since 1997, train speed in China has been raised significantly six times. The top speed of freight trains has increased from 120 km per hour to 200 km per hour, and passenger trains can reach maximum speed of 350 km per hour on some sections of the high speed rail lines. Therefore, a lot of Chinese experts on the emergency management suggest that the government should take advantage of the development of rail transportation and based on multimodal transportation build a highly efficient emergency material reserve system.

In China, once a natural or man-made disaster occurs, the local town-level and provincial-level warehouses would transport the emergency materials to the affected areas as quickly as possible. If the amount of the materials required exceeds the available stock in the local town-level and provincial-level warehouses, the nearest central-level warehouses would be involved in supplying the materials to the local lower-level warehouses. The other central-level warehouses would gather the materials, receive the donations and transfer them to the disaster-affected area if needed. To a certain extent, Chinese emergency material reserve system works like a hub-and-spoke network since a certain portion of materials flowing among provincial-level warehouses and town-level warehouses is transferred via the central-level warehouses which can be regarded as hubs. The only difficulty for associating the hub-and-spoke network with emergency logistics is that in a hub-and-spoke network the transportation between any two nodes is performed only via hubs, whereas in emergency logistics system the flows of materials among the warehouses sometimes must be directly sent if there exists the time limit. However, in the context of rail-road intermodal transportation, if the emergency materials between any pairs of hubs are transported by rail rather than by road, the delay caused by the detours via hubs can be eliminated due to the fact that the average speed of freight trains is generally higher than that of trucks. As a result, we recommend that China introduce a rail-road intermodal hub-and-spoke network to form the backbone of the emergency material reserve system.

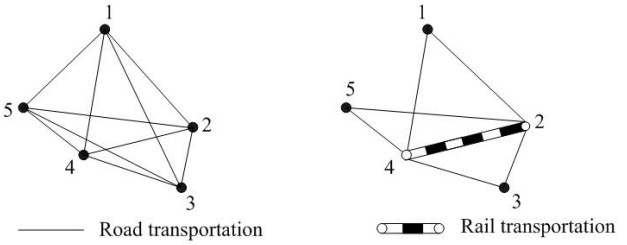
Hub-and-spoke network is widely used in many transportation networks where hubs usually act as sorting, transshipment, and consolidation terminals. Instead of sending flows directly between all origin–destination pairs of nodes, hub facilities consolidate flows in order to take advantage of the economies of scale. Hub Location

Problem (HLP) is an important issue arising in the design of hub-and-spoke network [1]. Much research has focused on presenting discrete hub median and related models to better capture behavior observed in practice. However, to our knowledge there is very limited research that studies intermodal (or multimodal) hub-and-spoke network associated with time limits. Ref. [2] reviewed all variants of HLP and discussed the mathematical models, solution methods, main specifications, and applications of HLPs. They found that a new subject in the hub location area was the multimodal HLPs. Ref. [3] considered transportation costs and travel times in a multimodal HLP, whereas it did not take time limits into consideration. Ref. [4] provided time definite models for multiple allocation p-hub median problems and hub arc location problems. However, it did not consider multimodal transportation. Ref. [5] presented a queuing model and a hub location-allocation model to investigate the effect of limited hub resources on the design of intermodal logistics networks. Ref. [6] determined the locations of rail–road transfer terminals using a single allocation p-hub median model. Ref. [7] extended the p-hub median model to include different modes of transportation, modal connectivity costs, and service time requirements. Ref. [8] used incapacitated hub location model with the inclusion of a service time constraint to solve for the location of hubs within a rail–road intermodal network. Ref. [9] proposed a mathematical formulation to design an intermodal hub network for multi-type container transportation. The above five papers did not take the time limit into consideration, whereas in our research time is the object that need to be optimized.

The rest of this paper is organized as follows. In Section II we describe the sequence of the operation of the emergency material reserve system based on rail-road intermodal hub-and-spoke network and then build a mathematical model for finding the optimal hub locations, assignment of hub(s) for each origin–destination pair to minimize the total transportation time in the whole network. Section III proposes an algorithm to find the optimal solutions of the model. The results of a numerical example are presented in Sections IV. Section V discusses the impact of the average speed of freight trains and the transshipment time at hubs on the performance of the hub-and-spoke network and provides some managerial insights. Finally, Section VI presents summary comments and discusses promising areas for future research.

II. Model Formulation

We consider an emergency material reserve system consisting of several nodes. In most cases, each origin-destination pair of nodes can be connected directly, which is so-called *direct connect network* (see Figure 1a). In the context of hub-and-spoke network, each origin–destination flow of emergency material must be routed via the hubs. The shipments among hubs are sent by rail, whereas those between non-hub nodes and hubs are sent by road. As a result, the flow of emergency material between the origin and the destination involves three legs of travel. The first leg is the pickup from the origin nonhub node and travel to the origin hub. The second leg is the inter-hub travel between the origin and destination hubs. The third leg is the drop off from destination hub to the destination nonhub node. In the case of a single hub shipment, the journey consists of only two legs: travel from the origin nonhub node to the hub and the drop off from the hub to the destination nonhub node. The hubs act as rail–road transfer terminals where the freight can be transshipped from freight trains to trucks, or vice versa (see Figure 1b). The main problem in this network is to decide on the location of the hubs, the allocation of the non-hub nodes to these hubs. We aim to design a rail-road intermodal hub-and-spoke network so that the demand for emergency materials in each origin–destination pair can be met in the shortest time [10][11]. The objective is to minimize the total transportation time which include road transportation time, rail transportation time and transshipment time between trains and trucks.



(a) Direct connect network (b) Intermodal hub-and-spoke network

Figure 1. Direct connect network and rail-road intermodal hub-and-spoke network.

A. Notations

Consider a complete graph $G(V, A)$ with node set $V = \{1,2,\ldots,N\}$ where nodes correspond to origins and destinations (i.e., provincial-level and town-level warehouses) and potential hub locations (i.e., central-level warehouse). The notations we used are as follows.

A: set of all arcs;

N: the number of nodes;

p: the number of hubs;

i: index for origin nodes ($i = 1, \cdots, N$);

j: index for destination nodes ($j = 1, \cdots, N$);

k, m: index for potential hub locations;

t_{gij}: road transportation time between nodes i and j;

t_{rij}: rail transportation time between nodes i and j. If i is equal to j, it represents the time for transshipping a unit of flow between trains and trucks;

h_{ij}: the amount of flows between nodes i and j;

J: set of origin-destination pairs of nodes, $J = \{(i, j) | h_{ij} > 0, i, j \in V\}$;

X_{ij}^{km}: fraction of flows from origin i to destination j via hubs k and m on path $i - k - m - j$;

Y_k, Y_m: the binary variable. Y_k (or Y_m) is equal to 1 if node k (or m) is chosen to be a hub, and zero otherwise;

T_{ij}^{km}: the transportation time of a unit of flow from origin i to destination j via hubs k and m on path $i-k-m-j$. Note that T_{ij}^{km} is composed of four parts: the road transportation time from origin i to the origin hub k, the road transportation time to destination j from the destination hub m, the rail transportation time from origin hub k to destination hub m, the transshipment times between trains and trucks at the hubs k and m. For this case,

$$T_{ij}^{km}=\begin{cases} t_{gik}+t_{rkk}+t_{rkm}+t_{rmm}+t_{gmj}, & i\neq j \\ 0, & i=j \end{cases} \quad (1)$$

B. Assumptions

The assumptions of our model are as follows:

(1) The transportation between any two nodes in the network is performed only via hubs.

(2) The rail transportation time among hubs is less than the road transport time among them.

(3) All the emergency materials are transported in batches. The network has enough arcs with sufficient capacity to enable all the flows generated at the origin nodes to reach all the destination nodes regardless of the quantity in the batch.

(4) Since the demands for emergency materials flowing through the network are generated depending on whether disasters occur, there is no periodicity in our problem. We only take one period into account.

C. Mathematical Model

In our model, the decision involves choosing X_{ij}^{km}, Y_k and Y_m to minimize the total transportation time. The mathematical formulation for this HLP is as follows:

$$\min\ z=\sum_i\sum_j\sum_k\sum_m h_{ij}X_{ij}^{km}T_{ij}^{km} \quad (2)$$

subject to

$$\sum_k\sum_m X_{ij}^{km}=1,\quad \forall(i,j)\in J \quad (3)$$

$$0\le X_{ij}^{km}\le Y_k,\quad \forall i,j,k,m \quad (4)$$

$$0\le X_{ij}^{km}\le Y_m,\quad \forall i,j,k,m \quad (5)$$

$$\sum_k Y_k=p \quad (6)$$

$$Y_k=0,1 \quad (7)$$

In the above formulation, z is the total transportation time. Constraint (3) ensures that each origin–destination flow is sent via some hub pair (possibly a single hub as in X_{ij}^{kk}). Constraints (4) and (5) ensure that nonhub nodes can only be allocated to the hubs which work as rail-road transfer terminals. Constraint (6) requires exactly p hubs are selected. Constraint (7) restricts the variables appropriately.

III. Solution Procedure for the Model

HLP is NP-hard. Although an enumeration-based approach has proven effective for the smaller HLP, it will be less attractive as problem size grows since the number of hub arc combinations increases faster than linearly. Here we propose a heuristic algorithm based on tabu search to solve this problem. The elements of tabu search include *initial solution*, *neighborhood structure*, *tabu lists,* and so on. Remember that V represents the set of all nodes. Let T be the set of hubs, $V-T$ be the set of nonhub nodes, $N(T)$ be the set of neighboring solutions for T. For simplicity, we adopt a 'single location exchange' rule to generate a neighborhood solution, denoted by T^i, for a given T, that is, replacing exactly one hub in T with one nonhub node in $V-T$. During the process of 'single location exchange', the node leaving T is denoted by V^i and the node leaving $V-T$ and entering T is denoted by W^i. Obviously, under this rule, there are $p(n-p)$ possible neighboring solutions for a given T, that is, $N(T)=\{T^i, i=1,2,\ldots,p(n-p)\}$. The node leaving T and generating a new T^i at the current iteration is recorded in the tabu list, named as *tabu status*. In order to forbid the reversal of this replacement unless the move leads to a solution better than the best found so far (that is the so-called aspiration criterion), the tabu status at the current iteration can not be selected to enter T again in a number (tabu list size) of future iterations. For instance, setting $tabu\_tag(i)=t$ means that node i acts as a tabu status and can not be an element of T in the next t iterations. The value of the objective function is expressed in terms of just the current T as

$$Z(T)=\sum_i\sum_j h_{ij}\min_{k,m\in T}\left(T_{ij}^{km}\right) \quad (8)$$

In order to improve the efficiency of tabu search, we would obtain the initial solution where the search starts by employing a local search method. The solution procedure can be summarized as follows.

Step 1. Choose arbitrarily p nodes as an initial solution T. Designate this initial solution as the optimal solution, that is, set $T^0=T$.

Step 2. Generate $N(T)$ for current T and calculate $Z(T^i)$ via (8) for all $T^i\in N(T)$. Find the smallest one and let T^* denote corresponding T^i.

Step 3. If $Z(T^*)<Z(T^0)$, set $T^0=T^*$, $T=T^*$, and then go to Step 2. Otherwise, go to Step 4 with the initial solution T.

Step 4. Initialize the tabu lists and the number of iterations, that is, set a value for the maximal number of

iterations denoted by max_itm and set $t=0$, $tabu\_tag(i)=0$ for all $i \in V$. Update the current optimal solution T^0 and set $T^0 = T$.

Step 5. Generate $N(T)$ for current T. Calculate $Z(T^i)$ via (8) for all $T^i \in N(T)$.

Step 6. Choose index l such that $Z(T^l) = \min_{i=1,2,\ldots,p(n-p)} Z(T^i)$. If $tabu\_tag(W^l)=0$ or $Z(T^l) < Z(T^0)$ (the aspiration criterion), then set $T = T^l$, record V^l in the tabu list (i.e., set $tabu\_tag(V^l)$ be equal to a uniform random number over the interval $\left[\sqrt{n},\ 2\sqrt{n}\right]$), and go to Step 7. Otherwise, delete T^l from $N(T)$ (that is, set $N(T) = N(T) - T^l$), and go to Step 6.

Step 7. Set $t = t+1$. If $Z(T) < Z(T^0)$, then update the current optimal solution (that is, set $T^0 = T$).

Step 8. If $t < max\_itm$, then update the tabu list, that is, set $tabu\_tag(i) = tabu\_tag(i) - 1$ for all i such that $tabu\_tag(i) > 0$, and go to Step 5. Otherwise, the best solution is T^0.

IV. NUMERICAL EXAMPLES

In this section we consider an emergency material reserve system based on rail-road intermodal hub-and-spoke network that consists of 5 cities (that is, $n=5$). Each city represents a node or a potential hub in the network. We assume that every city owns a railway station where a central-level warehouse (i.e., a hub) can locate. The rail and road distances between every pair of cities are shown in Table I and Table II, respectively. The flows of emergency materials in and out of these cities are shown in Table III. We set $p=2$.

TABLE I.
RAIL DISTANCE BETWEEN PAIRS OF CITIES IN KILOMETERS

		Destination j				
		1	2	3	4	5
Origin j	1	0	966	1202	1137	1560
	2	966	0	1230	837	1199
	3	1202	1230	0	391	358
	4	1137	837	391	0	418
	5	1560	1199	358	418	0

TABLE II.
ROAD DISTANCE BETWEEN PAIRS OF CITIES IN KILOMETERS

		Destination j				
Origin j		1	2	3	4	5
	1	0	1033	893	1152	1285
	2	1033	0	919	837	1223
	3	893	919	0	432	392
	4	1152	837	432	0	405
	5	1285	1223	392	405	0

TABLE III.
ORIGIN-DESTINATION FLOW BETWEEN PAIRS OF CITIES h_{ij} IN BATCHES

	Destination j					
Origin j		1	2	3	4	5
	1	60	80	80	250	120
	2	70	90	70	120	20
	3	20	70	70	243	45
	4	80	50	50	190	90
	5	80	60	60	180	20

According to assumption (2), we set the average speed of freight trains v_r to be 120 km/h and that of trucks v_g to be 80 km/h. Dividing the rail and road distances between the pairs of nodes by the average speed of freight trains and trucks, respectively, we can obtain rail and road transportation time between nodes i and j shown in Table IV and Table V. For simplicity, we set the transshipment time at all the hubs to be the same, that is, $t_{rii} = 0.05$ hours (see Table IV).

TABLE IV.
RAIL TRANSPORTATION TIME BETWEEN PAIRS OF CITIES t_{rij} IN HOURS

	Destination j					
Origin j		1	2	3	4	5
	1	0.05	8.1	10	9.5	13
	2	8.1	0.05	10.3	7	10
	3	10	10.3	0.05	3.3	3
	4	9.5	7.0	3.3	0.05	3.5
	5	13	10	3	3.5	0.05

TABLE V.
ROAD DISTANCE BETWEEN PAIRS OF CITIES t_{gij} IN HOURS

	Destination j					
Origin j		1	2	3	4	5
	1	0	12.9	11.2	14.4	16.1
	2	12.9	0	11.5	10.5	15.3
	3	11.2	11.5	0	5.4	4.9
	4	14.4	10.5	5.4	0	5.1
	5	16.1	15.3	4.9	5.1	0

We set $max\_itm = 50$ and program the algorithm described in Section III with MATLAB 7.1. The results show that nodes 1 and 4 are designated as hubs. The route that starting from origin i to destination j via two hubs are given below in Table VI. Here the symbol | indicates the pair of hubs. For instance, according to Table VI, the

flow from origin 1 to destination 5 is on path 1-1-4-5. The corresponding optimal total transportation time in this hub-and-spoke network z^* is 18625.6 hours.

TABLE VI.
THE ROUTE FOR ORIGIN-DESTINATION FLOWS

		Destination j				
		1	2	3	4	5
Origin j	1	-	1|1	1|1	1|4	1|4
	2	1|1	-	4|4	4|4	4|4
	3	1|1	4|4	-	4|4	4|4
	4	4|1	4|4	4|4	-	4|4
	5	4|1	4|4	4|4	4|4	-

By multiplying each of the individual terms in Table III by the corresponding term in Table V, and then summing up these individual products, we also calculate the total transportation time in the situation where the flows of emergency materials are sent directly through the arcs linking origin–destination nodes, denoted by z^d, as follows.

$$z^d = \sum_i \sum_j t_{gij} h_{ij} = 19091.1 \tag{9}$$

The results above show that compared to direct connect network, the hub-and-spoke network can save 465.5 hours.

V. THE IMPACT OF THE AVERAGE SPEED OF FREIGHT TRAINS AND THE TRANSSHIPMENT TIME AT HUBS ON THE PERFORMANCE OF HUB-AND-SPOKE NETWORK

Intuitively, the average speed of freight trains may have an effect on the performance of hub-and-spoke network, so does the transshipment time at hubs. Let $\Delta z = z^d - z^*$ be the reduction in the total transportation time in the context of a rail-road intermodal hub-and-spoke network compared to that in the direct connect network. Keeping the other parameters unchanged, for different values of v_r and t_{rii}, we calculate the corresponding Δz, respectively. Figure 2 and Figure 3 display Δz with different value of v_r and t_{rii}, respectively.

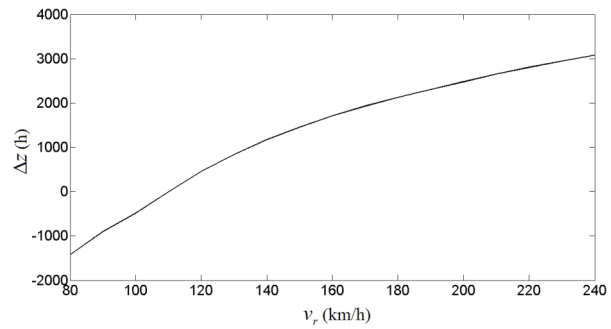


Figure 2. The influence of the average speed of freight trains.

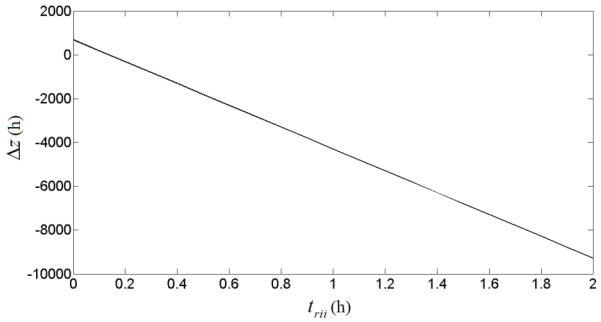


Figure 3. The influence of transshipment time at hubs.

From Figure 2, it can be seen that, as the average speed of freight trains is increased, the reduction in the total transportation time would increase, which means that the average speed of freight trains has positive effects on the performance of hub-and-spoke network. Nowadays, with the development of engine technologies and rail engineering, more and more countries have adopted high-speed rail system, which would dramatically improve the efficiency of the whole emergency material reserve system.

From Figure 3, it can be seen that as the value of the transshipment time at hubs is increased, the reduction in the total transportation time would decrease, and even become a negative value. This result shows that the transshipment time has negative effects on the performance of hub-and-spoke network. Therefore, in order to improve the efficiency of hub-and-spoke network, it is necessary to adopt some effective approaches to reduce to transshipment time, such as using large size containers, more efficient handling systems and equipments.

VI. CONCLUSION

In this paper we introduce a rail-road intermodal hub location problem to the emergency material reserve system. We provide a mathematical model for minimizing the total transportation time in the whole network. We then propose a heuristic algorithm based on tabu search for finding the optimal hub locations. Additionally, we also investigate the impact of the average speed of freight trains and the transshipment time at hubs on the performance of hub-and-spoke network. The results of a numerical example show that as the average speed of freight trains is increased, the reduction in the total transportation time would increase, whereas as the value of the transshipment time at hubs is increased, the reduction in the total transportation time would decrease. In other words, the average speed of freight trains has positive effects on the performance of hub-and-spoke network, whereas the transshipment time at hubs has negative effects.

There are several possibilities for furthering our research on this topic area. First, one could research the situation where the hub facility has limited capacity as well as the number of trucks or freight trains employed in the hub-and-spoke network is definite. Naturally, the problem will be harder to solve to optimality with the addition of these capacity restrictions. Second, one could

consider the cost in the whole network. In this paper we only take the transportation time into account. However the cost is still an important criterion for evaluating the performance of the reserve system. Thus, there will be a need to develop a multi-objective programming model for solving this problem. A third extension would be to include demand uncertainty, which means that the demands for emergency materials from origin node to destination node are stochastic. An efficient solution algorithms or heuristics need to be developed for dealing with such a problem.

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A Method of Three Dimensional Surface Reconstruction of Medical Images

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***Abstract*—Isosurface rendering algorithm is an important method for surface reconstruction of medical images. However, it requires the users to define threshold with the help of experience. In this paper, OTSU algorithm is employed to automatically obtain the gray threshold of different kinds of tissues in 3-D volumetric data, which is subsequently used to calculate the gray mean of each kind of tissue, and finally this gray mean is considered as the threshold of isosurface. The method is practically applied in VTK environment, and the result shows that it can reflect the characteristics of the gray distribution of different kinds of tissues, so the reconstructed surface is much smoother and contains more information.**

***Index Terms*—3-D surface reconstruction, isosurface, OTSU, VTK**

I. Introduction

With the development of medical imaging technologies, such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound Development (US) and so on, medical image 3-D reconstruction technology plays an increasingly important role in modern clinical medicine. 3-D surface reconstruction [1] refers to reconstruction of the 3-D shape of organs or tissues from the 2-D tomographic image sequences obtained from CT, MR and other medical equipments, which reveals the 3-D structure and shape of organs or tissues. It is beneficial to medical diagnosis, treatment and operation plan.

At present, there are two major categories [2] of the 3-D reconstruction methods of medical image: the surface rendering and the volume rendering. As the volume rendering algorithm has to deal with large amounts of volumetric data, it is unable to meet the needs of interoperability in practical application, even with the help of high-performance computers. However, the surface rendering algorithm neglects the internal information of the object, so that it can adopt relatively mature graphics algorithms to display. It reduces the calculating complex, so it can achieve the interactive display through rendering with high-performance computers.

In this paper, 3-D volumetric data are at first reconstructed from tomographic image sequences and afterwards they are pretreated. And then the gray thresholds of various types of tissues are calculated from the volumetric data by the OTSU [3] algorithm, which is used to classify the volumetric data. Then gray means of various types of tissues are calculated and treated as the thresholds of isosurfaces. Compared with the threshold defined by experience, the isosurface gained by this method pay more attention to gray distribution features of different volumetric data and the differences among various imaging equipments. So that, the reconstructed images possess more information and smoother surface, which is testified in this paper.

II. Process of 3-D surface reconstruction

The process [4,5] of 3-D surface reconstruction is displayed in figure 1. 3-D volumetric data are at first reconstructed from tomographic image sequences, and then they are pretreated, for example, through the way of gray interpolation. After that, the thresholds of isosurfaces are defined according to certain rules and a serial of surfaces are extracted from the volumetric data based on the thresholds. By fitting polygonal approximation, images are finally rendered and displayed via graphics algorithms.

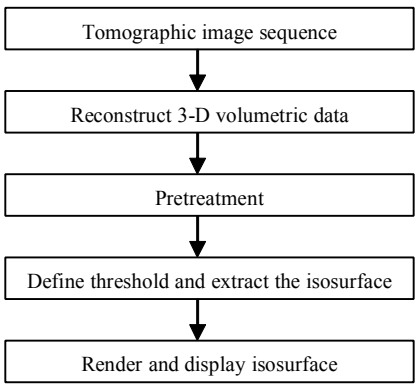

Figure 1. Process of 3-D surface reconstruction

A. Reconstruction of 3-D volumetric data

The 3-D volumetric data are sampled form the space of the tomographic image sequences [6], which is represented in figure 2. It is an array of sampling points of $X_{dim} \times Y_{dim} \times Z_{dim}$, among which X_{dim} and Y_{dim} respectively stand for width and height of images on X axis and Y axis, while Z_{dim} stands for the number of slices of image sequences on Z axis. The voxel is the basic unit forming 3-D volumetric data, and it is constituted by eight neighboring sampling points. Its spatial resolution is $D_x \times D_y \times D_z$, among which D_x and D_y represent pixel pitch of tomographic image on X axis and Y axis respectively, while D_z represents the distance between two sampling

points from neighboring slices on Z axis. The value of any point in voxel can be obtained through calculating interpolation of the gray value of sampling points.

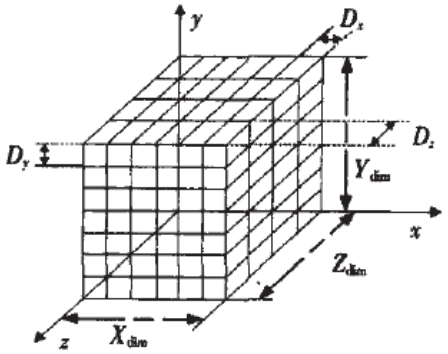

Figure 2. structure of 3-D volumetric data

B. Pretreatment

Due to the functional limitation of the devices, the resolution of the tomographic image sequences obtained from CT and MR is different from each other in 3-D space. Generally speaking, the interlaminar resolution is much smaller than inner layer resolution. If the distance between layers is relatively high, isosurface rendering directly from volumetric data will make the surface of the reconstructed image rough, which will weaken the effectiveness of 3-D surface reconstruction. Therefore, if interlaminar resolution is quite different from inner layer resolution, necessary pretreatment will be carried out. In the paper, gray interpolation is adopted to generate new tomographic image for the purpose of heightening the effectiveness.

Tri-linear Interpolation, with simple calculation and good effect, is a frequently used method of spatial interpolation. In this way, gray value of the interpolation points is gained through calculating the gray weighted means of the sampling points, and the weighted means are changed by way of adjusting the relative distance between interpolation points and sampling points. If the voxel space resolution is large, tri-linear interpolation will be used to achieve interpolation of volumetric data so as to raising the effect of image rendering.

C. Threshold Setting

If we regard the volumetric data as a collection of spatial sampling points, with the value of non-sampling points being determined by interpolation of its adjacent sampling point value, the set of points with the same value in this spatial region will define one or more surfaces, which is called isosurface. Because biological organs and tissues have their own physical properties, isosurface defined by appropriate value can represent the surface of certain organs and tissues.

The isosurface rendering algorithm needs a threshold, which is the gray value of the desirable tissues. The thresholds of isosurfaces are usually defined by the gray value of different tissues. For example, the gray value of the bone is about 1150, and that of the skin is around 500. However, this method does not take the gray distributional feature of volumetric data into consideration, and gray distribution of the image sequence of the identical tissue generated by different image equipments is not absolutely same. In this paper, we apply the OTSU algorithm. Various thresholds are gained adaptively according to categories of volumetric data, and based on those thresholds, volumetric data are classified into several categories. And then the gray means are calculated from each category, which are set as the thresholds when the isosurfaces are extracted. These thresholds are more adaptive to different data set than the thresholds given by experience.

The OTSU algorithm is also named as method of maximum classes square error, and it is a method of selecting threshold with the help of one dimensional histogram of the image and it is an automatic, nonparametric and unsupervised algorithm. It seeks the optimal threshold by way of searching the gray range of the image to make the classes variance maxium.

Assuming that the gray range of 3-D volumetric data belongs to 1~L, there are M-1 thresholds: $t_1,t_2,\ldots,t_{m-1}$, which divide the gray range into M classes: $C_1,C_2,\ldots,C_M$.

$$C_1 \leftarrow [1..t_1], C_2 \leftarrow [t_1+1..t_2], \ldots C_i \leftarrow [t_{i-1}+1..t_i], \ldots, C_M \leftarrow [t_{M-1}..L]$$

The optimal threshold $\{t_1^*, t_2^*, \ldots, t_{M-1}^*\}$ makes the classes variance σ_B^2 maxium.

where

$$\{t_1^*, t_2^*, \ldots, t_{M-1}^*\} = \arg Max\{\sigma_B^2(t_1, t_2, \cdots, t_{M-1})\}, 1 \le t_1 < \cdots < t_{M-1} < L$$

$$\sigma_B^2 = \sum_{K=1}^{M} \omega_K (\mu_K - \mu_T)^2, \omega_K = \sum_{i \in C_K} P_i,$$

$$\mu_K = \frac{\sum_{i \in C_K} iP_i}{\omega_K}, \mu_T = \sum_{K=1}^{M} \mu_K \omega_K, Pi = \frac{f_i}{N}$$

Where ω_K is the percentage of the number of sampling points in the class C_K in the total number of sampling points; μ_K is the gray mean of the class C_K; μ_T is the gray mean of the volumetric data; f_i is the number of sampling points of gray level i; P_i is the percentage of the sampling points of gray level i in the total number of sampling points; N is the total number of sampling points of the volumetric data. When the class $C_K (1 \le K \le M)$ is rendered, the threshold of isosurface is defined as μ_K. According to the OTSU algorithm, the classes variance σ_B^2 is maxium.

The pixel of the medical images is usually represented by 12 bits or 16 bits, and its gray level is from 0 to 4095 or from 0 to 65535. If the thresholds are obtained through the OTSU algorithm directly based on the volumetric data, the computation cost will be high when M is bigger. Consequently, Brink fast algorithm [7] is adopted. Image threshold vector is firstly estimated, and then the optimal threshold is searched in this range. This method can take less time than the OSTU algorithm used directly.

D. Rendering display

Visualization Toolkit (VTK) is a free software package with open source, and it is widely applied in the fields of computer graphics, image processing, and visualization. It supports a serial of visual algorithms

and many advanced modeling techniques, and now lots of algorithms have been integrated into VTK.

Marching Cubes algorithm is the classical algorithm of isosurface rendering. We use the class libraries provided by VTK to establish the pipeline model of 3-D surface reconstruction displayed in figure 3. Then we use the isosurface rendering algorithm to achieve surface reconstruction of 3-D image, which is displayed in figure 4.

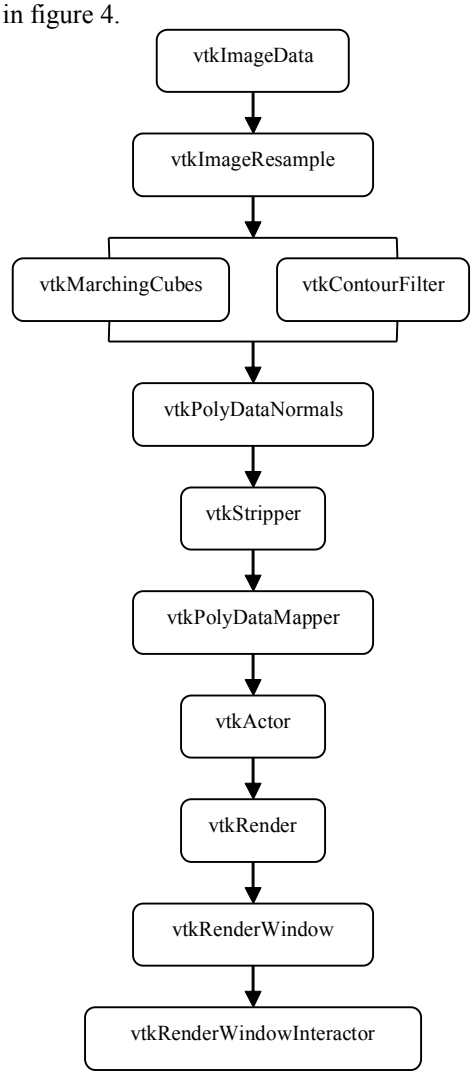

Figure 3. pipeline model of 3-D surface reconstruction

III. Results and discussions

Based on the process of the surface reconstruction introduced in the second section, we make experiments with VTK class libraries on VC.net. Parameters involved in the experiments are displayed in table 1, where ${}^{i}X$ is the gray mean of class i and *Two thresholds are used to divide image into three parts: background, skin and bone. Figure 4 shows 3-D reconstruction effects of different thresholds, where (a) and (b) are the reconstruction results before the processing of interpolation with the isosurface thresholds of 500 and 1150; (c) and (d) are that with the isosurface thresholds of 564 and 1215; (e) and (f) are the reconstruction results after the processing of interpolation with the isosurface thresholds of 779 and 1264, and each image are given the plan view and the top view. (Experimental data are tomographic image sequences of human heads and they come from http: //www.vtk.org/get- software.php)

TABLE I.
Parameters and thresholds

	Before interpolation	After interpolation
Dimensionality	64*64*93	202*202*139
voxel resolution	3.2*3.2*1.5	1.0*1.0*1.0
Number of sampling point	380928	1694925
The total number of voxels	365148	1651952
Gray range	0~3926	0~3667
*Two thresholds	295 [1]84	301 [1]87
	[-2]564	[-2]779
	861 [3]1215	1016 [3]1264

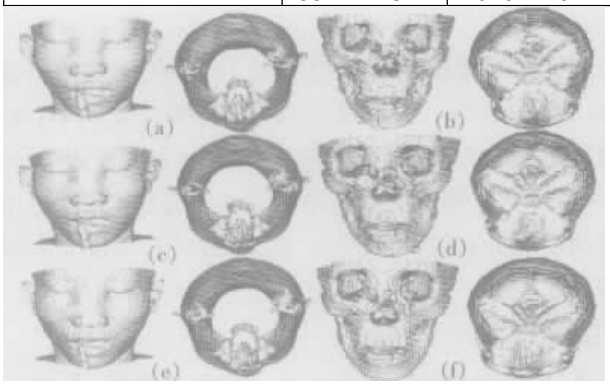

Figure 4. 3-D reconstruction effects of different thresholds

Through the experiments, we draw the following conclusions.

First, by comparing the reconstruction effects of the threshold defined by experience with those obtained through the method mentioned in this paper, and comparing between figure 4(a) and figure 4(c), and figure 4(b) and figure 4(d), we can see that the latter are clearer and contain richer information. As is displayed in figure 4 (d), the information of the nasal bone is much richer.

Second, interpolation operation has an effect on the surface smooth and quantity of information of the reconstructed images. By comparing figure 4(a) with (e), and figure 4(b) and (f), we can see that the images processed by interpolation are smoother and the information is much richer. However, the step-like structure in the image is more obvious due to the inherent defects of the gray interpolation. Even so, the reconstruction effects of the volumetric data processed by interpolation, to a certain extent, can satisfy the needs.

Third, this method is applied to render the tissues and organs with distinctive surface features, while it is not so effective in rendering the delicate tissues such as the soft-tissues, vessels, and bronchus without distinctive shape features and those with changeable brightness. Therefore, we need to further research the rendering algorithm in order to enhance the effect of medical image 3-D

reconstruction, and make 3-D medical images contribute more in clinical medicine.

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Evaluation and Analysis of Operational Efficiency in Zhejiang Eco-tourism Based on DEA Method

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***Abstract*—Taking 11 cities in Zhejiang Province as the research target, the operational efficiency is evaluated by the method of DEA, with all the data taken from The Report on Eco-tourism Development in Zhejiang province in The Year of 2011. It's found that its general efficiency and scale efficiency are relatively high, with the phenomena of excessive investment and deficient output existing in several cities, the eco-tourism efficiency is not located evenly. The departments and enterprises concerned can make proper adjustments of the investment of eco-tourism resources and utilization efficiency according to these features and regular rules.**

***Index Terms*—DEA method; eco-tourism; efficiency; evaluation of efficiency**

I. Introduction

According to a recent survey, Zhejiang has hosted 8,659, 000 visitors from abroad in 2012, 11.9% more than that in 2011, with the exchange revenue of 5,150 million $, increased by 13.4%. According to a sample research, it has 390 million of visitors from China , increased by 14.1% , while the income from eco-tourism reached 447,580 million RMB, increased by 18.2 %. The total income from eco-tourism is 480,120 million RMB, increased by 17.7%. All the travel agencies in Zhejiang Province have 1,606,000 visitors to foreign countries and areas , increased by 26.7%.

Zhejiang plays an important role both in the whole economy and in the eco-tourism industry, with every economic quota ahead of other province. From the perspective of building sustainable and harmonious society to evaluate the regional economy, the utilization and allocation of the investment must be taken into consideration while considering the benefits, that is , the efficiency must be taken into account. Therefore , this research is carried out in the ways of both input and output, gives a general appraisal to the eco-tourism efficiency in 11 cities in Zhejiang province, and divides its eco-tourism development pattern to give some inspirations and advices to help the concerned department and enterprises make decisions.

II. Research plan

A. The method choosing

DEA(Data Envelopment Analysis)， is one evaluation method of one parameter based on relative efficiency. The CCR model of DEA is taken to judge the scale income from DMU in this research.[3] A/m)." Figure labels should be legible, about 10-point type.

1.DEA Model

C^2R in DEA is applied in this paper to resolve the problem, and the model is as follows:

$$\min\ \theta-\varepsilon\left(\sum_{r=1}^{t}s_r^{+}+\sum_{i=1}^{m}s_i^{-}\right),$$

$$\sum_{j=1}^{n}\lambda_j y_{rj}-s_r^{-}-\theta x_{ij_0}=0,$$

$$\sum_{j=1}^{n}\lambda_j y_{rj}-s_r^{+}=y_{rj_0},$$

$$\lambda_j\geq 0, j=1,2,\ldots,n,$$

$$s_i^{-}\geq 0, s_r^{+}\geq 0.$$

n is called DMU, and the assessment system which consists of m*input and t*output, which means resources to be consumed and efficiency. xij is the i th input by the jth DMU, yrj is the r th output by jth DMU, vi is the assessment of the i th input(or called counterpoise), u is the assessment of the r th output, s_r^{+} and s_i^{-} are slack variables, and εis a non-Archimedean infinitesimal, and E= 10- 6 when calculated. λj, s_i^{-}, s_r^{+},θ are the parameter to be assessed.

2.The definition of the DEA model

1)Geneally speaking, whenθ*= 1and $s_i^{-}*=s_i^{+}*=0$, DMU DEA is valid, its return to scale in efficient frontier remains constant, and DMU , scale and technical efficiency. 2)Whenθ* < 1 or $s_i^{-}*\neq 0$, $s_i^{+}*\neq 0$, DMU DEA is technical or scale inefficient. If S + r = S - i = 0, it is technically efficient.If

$k = 1/\theta * \sum_{j=1}^{n} \lambda_j^*$,Supposing that K = 1, DMU is technically efficient. When K < 1,returns to scale decreases, otherwise it increases.3)If DMU is invalid, those units where is not work can be improved through the projection on the relatively effective plane .Efforts can be made to diminish the input under the precondition of not diminishing output(x0≥0)or to increase output if the input is not added to.. (y0≥0): $\begin{cases} x_0 = (1-\theta^*)x_0 + s^{*-} \geq 0 \\ y_0 = s^{*+} \geq 0 \end{cases}$

4)Consider the dynamic evaluation of DEA:Supposing i > 0,Ifθ0 (t - i) <θ0 (t).then the system is on the trajectory of sustainable development and the input-output & benefit will increase with the passage of time. Ifθ0 (t - i) =θ0,then the trajectory of system development is more attenuated than that of sustainable development.Ifθ0 (t - i) >θ0 (t) ,,then the trajectory of system development is more attenuated than that of sustainable development. In actual application, the amount of input and output has certain dimensions.Facts prove that the index of optimal efficiency of decision-making units is irrelevant to dimensions of the amounts of input and output.The chosen DMU should possess the follwing features:the sameness of objectives, conditions as well as inputs and outp.uts.It is worth noting that the best index of input should not be small,but that of output should be as large as possible .The number of the DMU output should be twice as much as (r + m),and correlation test should be made to prevent the excessive correlation.

3.Yung-ho Chiu&Ming-Feng Wu adopt the context-dependent DEA model to analyze the operating efficiency of 49 international eco-tourism hotels (ITHs) in Taiwan from 2004 through 2006. in Performance Evaluation of International Eco-tourism Hotels in Taiwan - Application of Context-dependent DEA ； A. George Assaf Alexander Josiassen Identifying and Ranking the Determinants of Eco-tourism Performance: A Global Investigation ， After a prolonged period of growth, driven, in part, by an increasing number of affluent consumers, the international eco-tourism industry is now suffering the effects of a weaker world economy. Bench marking the Asia Pacific eco-tourism industry: A Bayesian combination of DEA and stochastic frontier .This study measures and compares the efficiency of leading tour operator and hotel companies across several Asia Pacific countries.

B. The prudent choice of index to target selection

To give a full expression and analysis to the eco-tourism efficiency in Zhejiang Province, this research is targeted at 11cities in Zhejiang Province, each city is a DMU, and the input indexes are mainly chosen from the top 3 relevant indexes, that is : the respective amount of travel agency x1, star-rated restaurant x2 and scenic spot x3. In the meanwhile, the output indexes are based on the total travel income y1/one hundred million RMB , the amount of received guests y2/ten thousand . In addition, the method of DEA requires that the amount of DMU is above 2(input index +output index). In this research, DMU is 11. the input index is 3, and the output index is 2, which all meet the requirement. The firsthand data is listed in the Table 1.

TABLE I.
TABLE TYPE STYLES

City	Amount of travel agency X1	Amount of star-rated restaurant X2	Amount of scenic spot X3	total travel income Y1	The amount of received guests Y2
Hangzhou	563	230	37	1191.0	7487.27
Ningbo	265	190	36	751.3	5288.22
Wenzhou	195	100	28	391.83	4170.09
Jiaxing	108	57	21	354.22	3607.74
Huzhou	82	45	15	263.15	3559.36
Shaoxing	118	93	24	413.90	4187.96
Jinhua	138	79	19	344.3	3604
Quzhou	76	38	12	121	2092
Zhoushan	118	58	21	235.48	2460.53
Taizhou	136	54	24	329.25	3977.70
Lishui	61	46	9	155.91	2753.85

III .THE RESEARCH RESULT

C^2R model is based on DEA method by means of EMS software, and takes the overall efficiency (O.E) and scale efficiency (S.E) into calculation , which will determine the returns to scale level they are at.

According to table 2, 5 cities in 11 are effective DEA (H*=1 and s+=s-=0), and they are Hangzhou , Ningbo, Jiaxing , Huzhou and Shaoxing respectively, therefore, Wenzhou, Jinhua and Zhoushan are in the same group, which are 0 city high in both tourism gains and efficiency. In the meanwhile , Quzhou, Lishui and Taizhou are relatively on a small scale of tourism gains, however, they are also in the effective state , consequently, they are in the same group as underdeveloped cities of low gains and efficiency.

According to an effective analysis on returns to scale by means of EMS, the tourism elements in 4 cities are in the best scale period and can maximize their incomes. Quzhou, Lishui and Taizhou can not maximize their incomes from tourism elements. 4 cities are in a redundant state of resources and elements input which are indigestible for themselves.

TABLE II.
TABLE TYPE STYLES

city	Input redundancy			Output insufficieny s+		Returns to scale (k)	Efficiency value(θ)
	X1	X2	X3	Y1	Y2		
Hangzhou	0	0	0	0	0	1	1
Ningbo	0	0	0	0	0	1.376	0.688
Wenzhou	1	-1	0	0	0	1	1
Jiaxing	0	0	0	0	0	1	1
Huzhou	-1	-1	0	0	0	1	1
Shaoxing	0	0	0	0	0	1	1
Jinhua	0	0	0	0	0	1	1
Quzhou	-1	-1	0	0	0	1	0.876
Zhoushan	0	0	0	0	0	1	1

Taizhou	0	-1	0	0	0	1	0.925
Lishui	-1	-1	0	0	0	1	0.751

Ⅳ.USING THE TEMPLATE

A. Conclusion

The following conclusion comes from the relevant results from the analysis on the DMU chosen in Zhejiang province:

1.The general efficiency is high and most of the tourism resources are made use of.

2.The high efficiency mainly finds expression in such cities with good tourism resources as Hangzhou, Ningbo, Jiaxing, Huzhou and Shaoxing, which indicates the imbalance in the tourism development.

3.When the value of the returns to scale is above 1, that is , K>1, which shows the returns to scale is on the decrease, that is to say, on the basis of combined input, the increasing input will lead to low tourism output/scale 0.

4.When the value of the returns to scale in Huzhou, Quzhou and Lishui is below 1, that is , K<1, which shows the returns to scale is on the increase, that is to say, on the basis of combined input, the increasing input will lead to the tourism output/scale 0. The above-mentioned local governments' little enthusiasm in tourism development and little input lead to the improper scale of local tourism development.

5.When the value of the returns to scale equals 1, that is , K=1, which shows the returns to scale remains the same, that is to say, on the basis of combined input, the increasing input will lead to the increasing proportion in tourism output etc..

B. Analysis on influencing factors

1.economy level:Economy is the key factor in influencing tourism efficiency, and the local residents' disposable income has direct impact on their travelling frequency, and what's more, the economy level influences the scale and class of the local tourism infrastructure construction. In 2011, the tourism economy goes smoothly, the resident's travelling awareness , the travelling needs and consumption are increasing, and the general trend is appearing in a public, rational and pluralistic way. In the meanwhile , the tourism investment scale and tourism businesses' achievement increase a lot and the leading role of tourism industry in social economy becomes more clear.

2.geographical advantage: geographical advantage is the objective factor influencing the tourism efficiency, and for the most part, it determines the business absorption ability to resources, technology and information. Zhejiang lies in Yangtze delta area with good location and plentiful tourism resources. The good location and policy environment draw a lot of high-calibred elites.

3.Market:First,the effective market competition has noted linear positive influence on efficiency. Second, the tourism industrialization will influence and improve tourism efficiency. Zhejiang is one of the most competitive and industrialized areas. According to its recent statistics, in 2011, it has 1,860 travel agencies, 991 star-rated restaurants and 306 A-class scenic spots, and its tourism businesses far outnumber the other areas in the country. There are 550 tourism projects are under construction and 3.8 billion RMB has been invested in 2011. The numerous tourism businesses not only intensify the competition but also propel the tourism industrialization, both of which can improve the tourism efficiency.

The high-degree market industrialization brings about large-scale business. From the perspective of the scale, the large-scale business can internalize the cost of external dealings, in the meantime , its proficiencies is higher and the resources allocation is more reasonable. Consequently, the proper increase in returns to scale with relatively high efficiency is realizable

C. Advice and suggestion

"Quicken the development of modern tourism" is the general guideline that Zhejiang should stick to in the following days. Based on the above analysis, the following suggestions will be listed with a view to stepping up the tourism development to make the best proportion for input and output.

1.The potentials should be developed and the industrial cultivation and optimization should be deepened.

Its plentiful tourism resources, obvious geographical and economical advantage, and the relatively developed service industry lay a good foundation of basic condition and environment advantage for deeply developing tourism industry. The city clusters must develop in a coordinated and complementary way so that they can realize positive interaction. More emphasis should be laid on the guidance of needs and exploration of potential market. The pluralistic investment should be enhanced properly to consummate the products and input-output structure.

2.The tourism resources use plan should be carried out to the letter to deepen industry convergence and to guide rational investment.

The efficient use of capital and resources is preconditioned by the making of tourism project plan. The speculative and irrational investment and the information asymmetry lead to the inefficient meeting between tourism resources and investment. Consequently, the tourism governors and managers should do their good jobs in proper plan and correct guidance , which makes the tourism investment the important part of tourism construction.

3.Keep a close eye on the development factors of tourism market, and guide the tourism market development in an orderly way.

The marketing strategies should be explored and formulated differently and emphatically for the differences between home market and inbound market. In 2011, the home tourist market takes up more than 90% in Zhejiang province, therefore the strategy should be targeted at home market mainly with the inbound tourist market as an accessory to make the tourism market develop in an orderly way.

4.Transform the tourism development pattern, and improve the quality and efficiency of its development.

The exploration and use of tourism resources should be intensified , and the added value of products should be improved. The value of tourism products should be added by information, technology and culture to deepen the breadth and width of the "wisdom tourism" to explore fully the cultural connotations in products.

V .EPILOGUE AND FUTURE

The correctness of DEA depends mainly on the rational choice of indexes, however, the highly comprehensiveness and relevance of tourism industry and the ambiguity in border recognition of tourism industry from the academic circle make the rationality of the chosen indexes and the correctitude of the statistics remain to be discussed further.

The regional differences and spatial layout can be compared horizontally, in the meanwhile , its evolution law and transformation path can also be studied vertically, and the factors resulting in the regional difference and periodical evolution can be discussed and analyzed deeply. Take the time series as DMU, and make an appraisal of every city in Zhejiang . undoubtedly, other typical and comparable cities outside Zhejiang province can also be chosen. The tourism efficiency of every city will be classified to make a comparison and conclusion with a view to drawing more universal and practical rules and conclusions.

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Ahp in The College Financial Performance Evaluation Index Weight Determination of The Application

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***Abstract*—To effectively evaluate college financial performance , according to the Analytic Hierarchy Process (AHP) of the basic principles in establishing the foundation of university financial performance evaluation system based on the use of AHP for financial performance evaluation system to determine the right college weight empirical analysis . The results show that the construction of the index weight to reflect the real situation , can provide the basis for scientific evaluation.**

***Index Terms*—AHP,University,Financial Performance, Evaluation index,Weight**

I. Introduction

Scale expansion and management colleges jump in place so that our universities and other reasons some problems in financial management , caused widespread concern in the community . Therefore, we need the financial status of universities adequate understanding of the operation of the financial results of the evaluation to find out its inadequacies and correct , so that funds are fully utilized, this is the main purpose of university financial performance evaluation . But the focus is to establish a scientific and reasonable evaluation to determine the weight of each index , the only way to better play the role of evaluation system. [1] For this , the thesis AHP from financial efficiency , financial benefits , financial effect on the financial performance of the three dimensions of evaluation to determine the right college weight were studied .

II. Principles and Algorithm of AHP

A. Principles of AHP

The Analytic Hierarchy Process (AHP) was proposed by T.L.Satty, a famous American operational research expert, in the early 1970s. Weber, et al. proposed to use AHP for evaluation and selection of suppliers. [2]

AHP algorithm is a decision-making analysis method combining qualitative and quantitative. It is a process that models and quantifies decision makers' thinking process for a complex system. With this method, decision makers will decompose complex problems into several hierarchies and factors and obtain the weights of different schemes through simple comparisons and computations of factors, providing basis for selection of the optimal scheme.

The basic principle of AHP is to evaluate schemes based on the goal with a hierarchical structure, sub-goals (criterion), constraints, department, etc., determine judgment matrix through pairwise comparison and finally obtain the weights (priority) of schemes with the component of feature vector corresponding to the maximum feature vector of judgment matrix as the corresponding coefficient.

B. Steps of AHP Algorithm

1 Clarifying problems, i.e. clarifying the scope of problems, factors included, relationship between various factors, etc., for the purpose of grasping sufficient information as soon as possible.

2 Establishing a hierarchical structure. In this step, it is required to divide the factors included into groups, take each group as a hierarchy and arrange the groups in the form of highest hierarchy (goal hierarchy), several intermediate hierarchies (criteria hierarchy) and the lowest hierarchy (scheme hierarchy). If an element is connected with all the elements of the next hierarchy, there is a complete hierarchical relationship between this element and the next hierarchy; if an element is only connected with some elements of the next hierarchy, there is no complete hierarchical relationship between this element and the next hierarchy. Sub-hierarchy can be established between hierarchies and is subordinate to an element in the main hierarchy. Its elements are connected with the elements of the next hierarchy but will not form an independent hierarchy.

3 Building judgment matrix. This step is a critical step of AHP. Judgment matrix is specific to an element of the previous hierarchy and to assess the situation of relative importance of various relevant elements in this hierarchy. Assuming there are n indexes, $\{A_1, A_2, \cdots, A_n\}$, a_{ij} is the importance judgment value of A_i against A_j. a_{ij} generally takes 5 scales, i.e. 1, 3, 5, 7 and 9, of which 1 indicates that A_i and A_j are equally important; 3 indicates that A_i is a little more important than A_j; 5 indicates that A_i is much more important than A_j; 7 indicates that A_i is more important than A_j; and 9 indicates that A_i is extremely more important than A_j. 2,

4, 6 and 8 are the mid values of adjacent judgments. When 5 degrees are insufficient, these values can be used. [3]

Judgment matrix A is expressed in matrix form as follows:

$$A=\begin{pmatrix} \frac{w_1}{w_1} & \cdots & \frac{w_1}{w_n} \\ \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \cdots & \frac{w_n}{w_n} \end{pmatrix} \quad (1)$$

Obviously, any judgment matrix should satisfy the following formula:

$$a_{ij}=\begin{cases} 1 & i=j \\ \frac{1}{a_{ij}} & i\neq j \end{cases}(i,j=1,2,\cdots,n) \quad (2)$$

Therefore, in building judgment matrix, it is only required to write the upper triangular (or lower triangular) portion.

4 Single hierarchical sorting. Single hierarchical sorting is intended for determining the importance sequence of elements connected with this hierarchy for an element in the previous hierarchy. It is the basis for the importance sorting for all elements in this hierarchy against the previous hierarchy.

If the weight vector W = $\left[w_1, w_2, \cdots, w_n\right]^T$, then:

$$AW=\lambda W \quad (3)$$

λ is the maximum positive characteristic value of A and W is the feature vector of A corresponding to λ. The relative weights of this group of indexes can be obtained through converting single hierarchical arrangement into obtaining the maximum characteristic value of judgment matrix λmax and the feature vector corresponding to it.

In order to test the consistency of judgment matrix, it is necessary to calculate its consistency index:

$$CI=\frac{\lambda_{max}-n}{n-1} \quad (4)$$

When CI = O, the judgment matrix has complete consistency; conversely, the larger CI is, the poorer the consistency of judgment matrix will be.

In order to test whether the judgment matrix has satisfactory consistency, it is required to compare CI with the average random consistency index RI (as shown in Table Ⅰ). Generally, first or second order judgment matrixes always have full consistency. For judgment matrixes above second order, the proportion of its consistency index CI to the average random consistency index RI of the same order is known as the proportion of random consistency of judgment matrix and denoted by CR. In general, when

$$CR=\frac{CI}{RI}<0.10 \quad (5)$$

We consider that the judgment matrix has satisfactory consistency; otherwise, when CR ≥0.10, it is required to adjust the judgment matrix till it is satisfactory. [4]

TABLE I.
AVERAGE RANDOM CONSISTENCY INDEX RI

Order number	1	2	3	4	5	6	7
RI	0	0	0.58	0.90	1.12	1.24	1.32
8	9	10	11	12	13	14	15
1.41	1.45	1.49	1.52	1.54	1.56	1.58	1.59

5 Total hierarchical sorting. The importance weights of all elements against the previous hierarchy can be calculated with all the results of single hierarchical sorting in the same hierarchy. This is known as total hierarchical sorting, which requires sorting in hierarchies from top to bottom. For the highest hierarchy, its single hierarchical sorting is its total hierarchical sorting.

If the total hierarchical sorting has completed for all the elements of the previous hierarchy $A_1, A_2, \cdots, Am$, the obtained weights are a_1, a_2.... respectively. The single hierarchical sorting of $B_1, B_2, \cdots, B_n$ in this hierarchy corresponding to a_m and a_j is $\left[b_1^j, b_2^j, \cdots, b_n^j\right]^T$. Here, when B_i is not connected with A_j, b_i^j =0. Then, the obtained total hierarchical sorting: [5]

6 Consistency check. To evaluate the consistency of the calculation results of total hierarchical sorting, it is similar to single hierarchical sorting that consistency check is required.

$$CI=\sum_{j=1}^{m} a_j CI_j \quad (6)$$

$$RI=\sum_{j=1}^{m} a_j RI_j \quad (7)$$

$$CR=\frac{CI}{RI} \quad (8)$$

CI is the consistency index of total hierarchical sorting. CI_j is the consistency index of judgment matrix in hierarchy B corresponding to a_j; RI is the random consistency index of total hierarchical sorting and RI_j is the random consistency index of judgment matrix in hierarchy B corresponding to a_j; CR is the proportion of random consistency of total hierarchical sorting. Similarly, when CR <0.10, the calculation results of total hierarchical sorting are considered to be satisfactory consistency; otherwise, it is required to adjust the judgment matrixes of this hierarchy, thus making total hierarchical sorting have a satisfactory consistency .

III. Application of AHP in the Weight Determination for Evaluation Index of University Financial performance

A. Building evaluation index system of university financial performance

Building an index system consistent with the situation of university financial performance is the basis and critical for building the evaluation model of university financial performance. [5] From the characteristics of university financial performance, To be scientific, objective, effective evaluation of scientific financial performance in universities, we must construct a comprehensive scientific, practical evaluation index system of university scientific financial performance is strong, and the key point of constructing the system is to determine the weight of each index.The thesis uses relevant existing study results of evaluation of university financial performance for reference and selects 10 indexes with common characteristics from 3 aspects, i.e. the financial efficiency , financial benefits , financial results to build an evaluation index system of university financial performance, as shown in Table Ⅱ. [6]

TABLE II.
Evaluation Indexes of University Financial Performance

Intended Goal	Sub-goal	Sub-goal weight	Evaluation Index	Index Weights
Financial Performance Evaluation	Financial efficiency	0.1042	The efficient use of human resources	0.4290
			The fund use efficiency	0.4290
			Asset use efficiency	0.1420
	Financial benefits	0.6372	The effectiveness of teaching	0.1042
			Industrial efficiency	0.6372
			Foreign Service Benefit	0.2583
	Financial results	0.2583	Personnel training capacity	0.4723
			Scientific research and capacity	0.2854
			Ability to serve the community	0.0727
			Ability to obtain funding	0.1697

B. AHP is first applied for the design of index weight

Firstly, investigation is conducted on 25 experts. Finally, mode is taken from investigation results to obtain the judgment matrix for the indexes of all hierarchies of financial performance evaluation. index system. After that, the feature vector method is used to solve judgment matrix and for relevant calculations. The obtained results are as follows.

Firstly, Level 1 judgment matrix (relative to the intended goal, comparison of relative importance between criteria).

TABLE III.
Level 1 Judgment Matrix

	A	B	C	W
A	1	1/5	1/3	0.1042
B	5	1	3	0.6372
C	3	1/3	1	0.2583
λmax =3.0385, C. I.=0. 1193, C. R.=0. 0332<0 1				

Secondly, Level 2 matrix (relative to 3 level 2 indexes, i.e. the financial efficiency , financial benefits , financial results, comparison of relative importance between schemes). [7]

TABLE IV.
Level 2 Judgment Matrix A

	A1	A2	A3	W
A1	1	1	3	0.429
A2	1	1	3	0.429
A3	1/3	1/3	1	0.142
λmax =3, C. I.=0, C. R.=0<0. 1				

TABLE V.
Level 2 Judgment Matrix B

	B1	B2	B3	W
B1	1	1/5	1/3	0.1042
B2	5	1	3	0.6372
B3	3	1/3	1	0.2583
λmax =3.0385, C.I.=0. 1193, C. R.=0. 0332<0. 1				

TABLE VI.
Level 2 Judgment Matrix C

	C1	C2	C3	C4	W
C1	1	2	5	3	0.4723
C2	1/2	1	4	2	0.2854
C3	1/5	1/4	1	1/3	0.0727
C4	1/3	1/2	3	1	0.1697
λmax =4.04746, C. I.=0. 01582, C. R.=0.0176<0. 1					

Finally, establishment of evaluation index system of university research project ,as shown in Table Ⅱ.

Ⅳ. Conclusion

College financial situation has its own characteristics , is affected by many factors , financial performance evaluation using the analytic hierarchy process rights of university science conducted to determine the weight , can be based on the financial situation of universities

weights determined by the specific indicators analysis and objectively reflect the financial position of universities, effectively determine the main factors affecting the financial position of the university to identify deficiencies existing in the management based on the results , so managers can take appropriate measures to avoid one-sidedness caused by subjective making mistakes , help define the direction of future development universities, to develop a long-term development plans.

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Research and Implementation of the Video I-frame Compression Algorithm Based on Mathematical Morphology

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***Abstract*—DCT commonly used algorithms in video compression exist the square effect and " mosquito's noise flies ", especially under the low speed. Neither take up the narrow bandwidth in the satisfied video transmission nor transmit the high request in qualities. And mathematics morphology can remedy the deficiency in narrow bandwidth. To the P-frame, this thesis adopt a kind of new-type algorithm of motion compensation based on the transform of the mathematical morphology. Through compound morphological transform, the structure elements carry out open and close operation with irregular minuteness blocks to filter them, then, motion estimating and coding with size and sport vector of them，adopting SAD to find out matching blocks. In this way, we can achieve the purpose of frame prediction. Through computer emulation, the algorithm achieve fine compensation comparatively and improving the compression rate. Under the same compression rate, it can improve video quantity, to make up for the shortcomings of DCT algorithm in the image transmission, improve transmission effect and reduced operation complexity. The algorithm has certain practicability in video coding or encoding for internet.**

***Index Terms*—video compression, mathematical morphology, motion estimation, compound morphological transform.**

I. INTRODUCTION

Data compression is expressed in the smallest digital (bits) signals emitted from source, reduce must be assigned to a designated collections of information or data collection, the value of signal space. In what way, what kind of signal space compression, according to the needs and technical conditions to decide. In the bandwidth restricted narrow-band transmission, bandwidth utilization ratio is more important. Advanced digital modulation technique can higher digital flow within the same bandwidth transmission. Fax, real-time video demand higher transmission speed, etc. In recent years, digital system has become a big trend, desperately want to decrease the data storage space. The actual application, within the scope permitted distortion are often the combination of a variety of signal space compression.

In video sequence, the existing space time redundancy and redundancy, namely frame image redundancy and redundancy between the frame and the frame. At present some video compression standards such as h. 261 and MPEG - 1/2, adopts the two-dimensional block DCT transform and motion compensation block matching algorithm, effectively eliminate the redundancy of the image sequence in space and time, but what the p-frame prediction coding, motion compensation technique tend to have search the contradiction between computational cost and accuracy, limit the certain application of high-speed transmission occasions; And the adoption of block DCT transform and motion compensation block matching, make this kind of method to restore the image block effect.

To solve above problems, in between the frames in video coding morphological transform based on mathematical morphology is introduced. To encode sequence images between frames in image processing, through morphological transform in macro block can be irregular small filter out with different motion vector, and then the nature of the application framework for coding, in order to achieve more sophisticated compensation, in order to achieve the purpose of improving the efficiency of compression.

II. THE VIDEO I-FRAME COMPRESSION ALGORITHM BASED ON MATHEMATICAL MORPHOLOGY

Video image compression is divided into two parts of the I-frame coding and P-frame coding. I-frame coding used 8 bits surface model, a level 256 gray scale image is decomposed into binary image of the same size 8 bit plane, the original gray image into the highest bit plane coding, separately for each bit plane again according to the figures from high to low decompose step by step, identify the corresponding conditions, through the condition morphological transform, morphological skeleton algorithm for gray image coding.

Video coding p-frame coding mode is to use the past I frame or to predict the P frame, namely to predict frames, at the same time the P frame can be used to predict the next P frame, by predicting P frame as a reference to predict the next P frame, makes coding error diffusion, so every certain frames will insert an I frame, frame compression is helpful to reduce the p-frame coding error.

Frame image coding mode, through effective remove the spatial redundancy implementation frame compression. Here in this paper, the frame on the basis of the mathematical morphology gray scale image compression coding method.

A. the encoding mothed for bit - plane binary image

There is 8 bit, 256 gray scale image of the gray image, as made up of eight binary image of the same size, corresponding to the value of the binary image gray scale images when using a binary representation on the bit value. The binary image is called bit plane (bit - plane) . Each bit surface morphological transform coding block diagram as shown in figure 1:

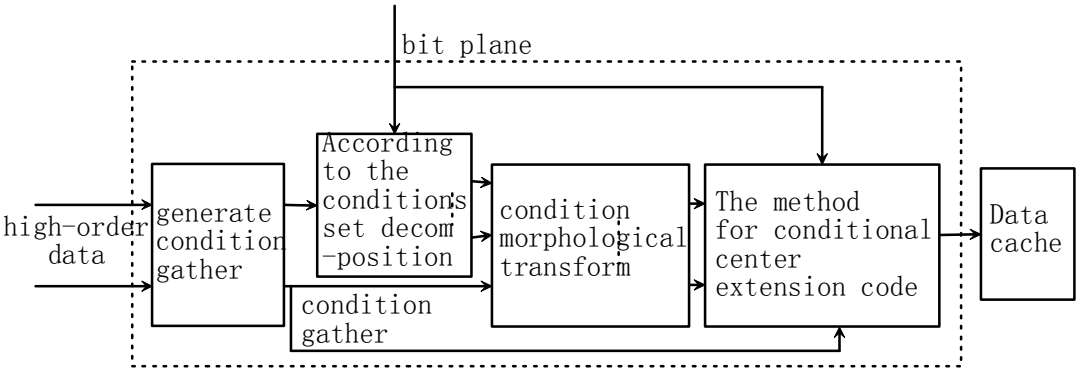


Figure 1. Encoding Block Diagram of Bit - Plane Condition Morphological Transform

Each layer on the surface of the bit specific coding algorithm is described as follows:

(1)Hypothesis binary image is X，condition set is R.

(2)if the number of point in X is greater than half of the number of condition set in R，thus $X \leftarrow X^c \bigcap R$.

(3)Calculation conditions skeleton is S_{Rn}， Ultimate corrosion conditions is U_{Rn}， $0 \le n \le N$， encode to $\tilde{U}_{Rn}$.

(4) $n \leftarrow N-1$， $Y_N \leftarrow 0$.

(5) $Z \leftarrow Y_{n+1}$， $\dot{Z} \leftarrow Y_{n+1}$.

(6) $p \leftarrow Z$ significance under the condition of external boundary point, if all external boundary point have been processed, go to step 9.

(7)if $n > 0$， Should be to test whether p may belong to S_{Rn}， by the corresponding Z instead of testing Y_{n+1}, if P impossibly belong to S_{Rn}， just go to step 6.

(8)If p is a skeleton point, encoded as 1, otherwise encoded as 0.

(9)If encoded as 1, $\dot{Z} \leftarrow (\dot{Z} \bigcup \{\dot{p}\})$, otherwise go to step 6.

(10)Scan recursive transfer p point. The unpredictable point whether according to the condition of skeleton point corresponding code is 1 and 0, using another probability model different from 8, If the code point q is condition skeleton point, $\dot{Z} \leftarrow (\dot{Z} \bigcup \{q\})$, if all the connection points are scanned, turn to step 6.

(11)If n=0, end of the encoding.

12) $n \leftarrow (n-1)$， $Y_{n+1} \leftarrow \dot{Z} \oplus_R B$， just go to step 4.

B. The coding method for bit plane composed of gray image

Shown in figure 2， it is block diagramfor gray image coding method composed of bit plane.

Coding algorithm is as follows： (The original gray image G to a certain size)

(1)First ,the gray image G decomposes into top of bit plane G_p ($p=1$), and assign it to binary image X.

(2)X should be carried out in accordance with the bit plane coding, conditions set is the entire image space.

(3)According to the step by step from the top to the lower order to decompose the G_p ($p=2,...,8$) of layer p of the gray image G.

(4)By senior encoded bits G_q ($q=1,...,p-1$) and G_p to determine X_r and R_r($r=0,1,...,2^{p-1}$)corresponding to the conditions set, X_r and R_r are determined by the following methods：

①All the determine value of former $p-1$ layer is r (binary for $G_1(i,j), G_2(i,j),..., G_{p-1}(i,j)$), the points (i,j) equal to r will been included condition set R_r.

②All the point (i,j) belong to R_r， the p-layer bit plane value (0 or 1)of R_r to X_r.

(5)It encode for all the X_r and conditions set R_r, $r = 0,1,...,2^{p-1}$.

(6)Until the end of encoding for all the bit-plane.

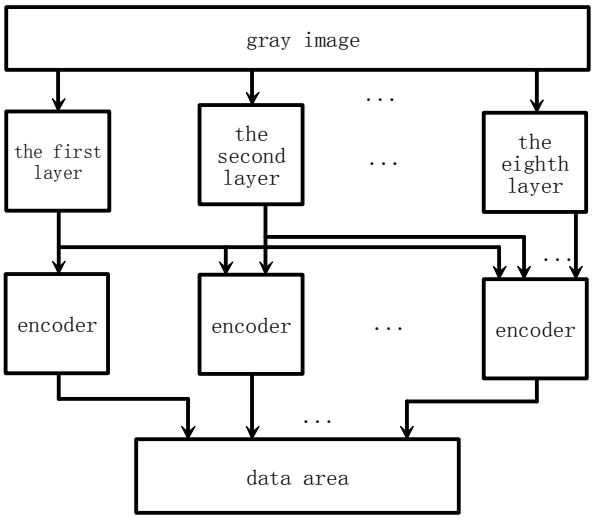


Figure 2. The Block Diagram of Condition Morphological Transform Encode For Gray Image

III. SOFTWARE IMPLEMENTATION AND SIMULATION RESULTS

A. Software implementation process

(1)Video image capture and storage

Get video image from CCD camera source data; Video input file can be Y: Cb: Cr for 4:1:1 yuv video files, can also be a continuous BMP file format of the single frame image sequence; Will be collected in the video image sequence on temporary into memory or cache, can also be collected images sequence data stored in the hard disk, easy to read when compression processing.

(2)Video image compression encoding

I read from the memory or hard disk image data frames and P frame coding, mainly on the I frame coding by software vc + + 6.0 programming to achieve compression.

(3)Video images decoding and displaying

Decoding program mainly is divided into three parts:

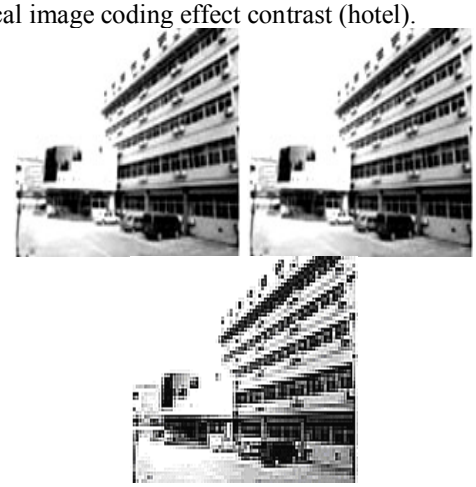
① read the compressed code stream

② the decompression for video image data

③ the decoded images in real time

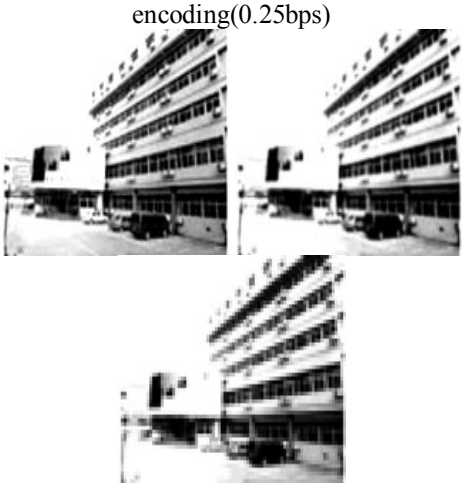
B. The contrast for simulation results

As shown in table 3.1, morphological coding compression effect and the condition of h. 263 standard and data compression, table 3.2 for morphological parameters under different transmission rate and compression ratio. As shown in figure 3 and figure 4, under different transmission rate for simulation, the physical image coding effect contrast (hotel).



(a)tested image (b)morphological encoding (c)h.263

Figure 3. the effect of I-frame image encoding(0.25bps)



(a)tested image (b)morphological encoding (c)h.263

Figure 4. The Effect of I-Frame Image Encoding (0.0625bps)

TABLE I.

MORPHOLOGICAL ENCODING COMPARE WITH H.263

bps		PSNR(hotel)	
0.0625	256：1	25.81	25.38
0.125	64：1	31.08	30.23
0.25	32：1	34.11	33.17
0.50	16：1	37.19	36.28
0.75	11：1	38.99	37.98
1.00	8：1	40.39	39.56

From table 3.1 can follow for scene images under the same transmission rate and the compression ratio, signal to noise ratio is superior to the corresponding h. 263 coding image, this is because the scene image skeleton is simple, in the frame coding, skeleton point is easy to determine, small error.

Experiments show that frame coding algorithm has a good effect. For the smooth area and therefore tend to obtain the good compression ratio and signal to noise ratio; And the texture is rich image, improved the effect is not very obvious. Visible, to frame more image coding algorithm is more suitable for smooth area.

IV. CONCLUSION

In order to give full play to the performance of mathematical morphology, and improve the coding efficiency, improve the quality of images based on human vision, adopt the bit plane layered coding method, when dealing with low bit plane, as the deal with the existing high bit face data bits of the comprehensive information available, each high bit will face the same points as a set of conditions, when to deal with the corresponding low bit plane, in the range of conditions set for the corresponding processing. The method according to the inspection frame coding, can significantly improve the compression ratio, and improve the subjective image quality.

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Improving Fault Localization Accuracy by Using PAM Clustering Algorithm

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***Abstract*—Spectrum-based method is one of the most important automated fault localization methods in the Software debugging techniques. Since most of the existing spectrum-based fault localization methods against some others in different test case set, therefore, the comparison of presenting methods is not comprehensive. This paper implemented the existing classic methods to evaluate the spectrum-based fault localization methods in the same test case suite. Furthermore, a new spectrum-based fault localization method, which utilize PAM algorithm, is proposed to gain a suspicious ranking of program statements and capture the statement with accepted high suspiciousness, so as to improve the accuracy of fault-localization. The experimental results show that our method can locate faults effectively with good performance.**

***Index Terms*—fault localization, Spectrum-based coverage, clustering, program debugging**

I. Introduction

Software debugging has become a challenging task since the size and complexity of software have increased enormously. Therefore, automated debugging has become popular due to its capability to reduce cost and increase the efficiency of debugging. In general, automated fault localization method first identify the suspicious program units that may contain bugs, and then examine these units to decide whether it contains bugs actually. Suspicious program units are ranked according to its probability of containing bugs to help locating bugs.

One of the most popular methods for fault localization is the Spectrum-based Fault Localization (SFL). The program spectrum which gained from dynamic execution information of program with associated test cases is utilized on the Spectrum-based methods. The execution information of pass or failure(Spectra), which record the statement execution information by the executing each test case, can be used to distinguish suspicious program statements.

At present, many formulas of SFL have already been proposed [1] [2] [3] [4]. SFL methods absorb a lot of attention since it is simple, feasible and efficient, however there are still some problems with these methods. This paper addresses the accuracy issue to improve the performance of Spectrum-based Fault Localization method.

II. Problem and Solution

Most of the proposed methods against the some other methods, whereas the comparison of presented methods is not comprehensive due to the different test case set is utilized. In addition, to the best of our knowledge, there is no single evaluation formula which is best in all situations. Therefore, this paper implemented the some existing methods to evaluate the effectiveness in the same test case set. Furthermore, A new clustering-based fault localization method, which utilize PAM algorithm, is proposed via calculating and clustering the suspicious value set of existing spectrum-based methods, hence the advantages of traditional fault localization methods can be utilized to capture the statement with accepted high suspiciousness, and a new suspicious ranking of statements can be obtained to improve the effectiveness of fault-localization. In addition, we presented the detailed experimental study to evaluate the efficiency of the proposed method. For the sake of clarity, we first give our spectrum-based fault-localization framework.

A. Framework of Our Method

Firstly, we implement existing 28 spectrum-based fault localization methods in Java by Eclipse. The aim is to achieve a comprehensive comparison of these methods in the same test case suite. In addition, another purpose is to gather the suspicious data set of these methods. Afterwards, the result data by implementing spectrum-based fault localization methods are utilized for clustering. Finally, a new suspicious ranking of program statements is generated. The spectrum-based fault-localization framework can be split into the following steps:

(1) Program spectrum information gathering. The statement coverage information and its execution result associated with certain test case set will be gathered.

(2) Calculate the suspicious value. For a program statement, the suspicious value, which denoted as $\{me1,me2,\ldots,me28\}$, is calculated by means of purpose fault localization method, respectively. The method and its corresponding suspicious value are saved in a CSV file.

(3) Cluster the result data. Our method takes the statement as node and the suspicious value of each method as property in order to achieve clustering operation. Then, the number of each cluster is calculated,

and the cluster with a maximum node is considered as main cluster.

(4) Seek out the central node of main cluster, then the distance value from other nodes to central node is calculated. The nodes are ranked by means of the distance value as new suspicious ranking..

B. Coverage Information Gathering

Coverage information reflects the a certain facet of a program execution. More specifically, coverage information shows whether a program unit is executed during an execution with a certain test case. In our study, statement coverage information is utilized since it is simple to calculate, and most important of all, the benefit of statement coverage is its ability to be used for statement-level fault localization. In addition, the corresponding execution result is also collected. Finally, a coverage information matrix is generated by mean of the gathered information. The matrix is listed as Table I.

TABLE I.
COVERAGE INFORMATION MATRIX

Statement&Test case	T_1	T_2	T_3	T_4	T_5	a_{ef}	a_{ep}	a_{nf}	a_{np}
$Statement_1$	1	0	1	1	1	1	3	1	0
$Statement_2$	1	1	0	1	0	1	2	0	2
$Statement_3$	0	1	0	1	1	1	1	2	1
……	…	…	…	…	…	—	—	—	—
TestResult	1	1	0	0	0	—	—	—	—

C. Coverage Information Gathering

Spectrum-based fault localization methods generally calculate the suspicious value by using collected information, such as a_{ef} , a_{ep}, a_{nf} and a_{np}. Researchers have been proposed many formulas for calculating the suspicious value, and program units are ranked by the value to predict the probability of containing fault. Some evaluation formulas we used in our study are listed in Table II, but for reasons of space we did not list the detail of all formulas. To the best of our knowledge, there is no single evaluation formula which is best in all situations. Some evaluation formulas have been shown optimal with respect to a simple performance measure for simple programs. Some are close to optimal out-perform other formulas using more reasonable performance measures.

D. Suspicious Value Clustering Algorithm

SFL methods aim to evaluate the fault risk of each program unit by using various statistical formulas. However, the emphasis of these formulas is not identical, therefore, the same program unit owns different suspicious value and ranking by using different evaluate formulas. These differences can be utilized to obtain new suspicious ranking of the program unit to improve the effectiveness of fault-localization. Therefore, we introduce the clustering algorithm to obtain new suspicious ranking by clustering the suspicious value of t statement which calculated by different evaluation formula. In our study, Partitioning Around Medoids (PAM) algorithm clustering algorithm is adopted. PAM is the most common algorithm of *k*-medoid clustering. This algorithm is more robust to noise and outliers than *k*-means by means of minimizing a sum of pairwise dissimilarities instead of a sum of squared Euclidean distances. The pseudo-code of the PAM algorithm is listed in Figure1.

Input: the number of clusters, k; the data set, n;
Output: k cluster set;

Step1. Initialize: randomly select k of the n data points as the medoids

Step2. Associate each data point to the closest medoid.

Step3. For each distance m

For each non-distance data point o

Swap m and o and compute the total cost of the configuration

Step4. Select the configuration with the lowest cost.

Step5.repeat step2 to Step4 until there is no change in the medoid.

Figure 1. Pseudo-code of PAM algorithm.

III. EXPERIMENTAL STUDY

In order to evaluate some existing spectrum-based methods in the same test case set, and determine whether fault localization from a program can benefit from our proposed clustering-based technique, we present a detailed experimental study. The experiment is designed to answer the effectiveness of existing fault-localization methods in the same program associated with test case set and the effectiveness of the our proposed method compared with some existing automatic fault-localization methods.

We first implement the existing 28 spectrum-based fault localization methods, then these methods are conducted on our Java plug-in sub-project, which is developed for implementing the spectrum-based fault localization methods. The project contains 35 classes and 1800 code lines. We collect the statement execution information associated with a test case set. The information then are saved in a database. In order to facilitate the experiment, we inject 9 faults into the Java project. The injected faults can be classified 7 types, some types are injected 2 faults. The testing code contains 49 test classes and 49 test cases. After execution, 32 test cases passed and 17 test cases failed. In addition, no error occurred. In addition, we deal with some particular cases to avoid meaningless, e.g., Overlap method needs a_{ef}, a_{nf} and a_{ep} not equal to 0, otherwise, the evaluation formula is meaningless. Due to the comparison of these methods in our experiment is performed in a same test case set, hence some assumptions of test case can be ignored.

For facilitating the comparison, if some evaluation formula, such as "Ample", "AnderbergMethod", "Dice", etc., of which denominator equal to 0, then the evaluation value is assigned to 9.99(all evaluation value less than 9.99 when the denominator of evaluation formula not equals to 0). Utilized when the formula of "Goodman", "Fleiss", "GeometicMean", "ArithmeticMean", "Cohen" and "Scott", if the denominator of evaluation formula is 0 and numerator greater than or equal 0, then the evaluation value is assigned to 9.99; if the denominator of evaluation formula is 0 and numerator smaller than 0, then the evaluation value is assigned to -9.99 (all evaluation value

between 9.99 and -9.99). Similarly, the evaluation value of "Hamann" is assigned between 99.99 and -99.99. Table II shows the ranking of 9 faults in each method, where s_1 *to* s_9 represent the 9 faults, respectively; "\" represents the statement that cannot be evaluated by corresponding method; NA represents the number of nodes that cannot be evaluated. For example, (Ample, s_1)=17 means the statement with fault 1 is ranked 17th by Ample method. (Amberg, NA)=522 represents that there are 522 statements of the program cannot be evaluated by Amberg method (division by zero or other exception). (Overlat, s_2)="\" represents a statement with fault s_2 cannot be evaluated by Overlat method. The last row is the result of our clustering method.

TABLE II.
COMPARISON RESULTS OF VARIOUS METHODS

Method /Statement	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	NA
Ample	17	47	49	50	5	7	12	1	2	—
Amberg	16	21	23	24	5	7	12	1	2	522
Arithmetic	16	21	23	24	5	7	12	1	2	—
Cohen	16	21	23	24	5	7	12	1	2	—
Dice	16	21	23	24	5	7	12	1	2	—
Euclid	16	19	21	22	5	7	12	1	2	—
Fleiss	16	21	23	24	5	7	12	1	2	—
Geometic	21	15	17	18	5	7	12	1	2	522
Goodman	16	21	23	24	5	7	12	1	2	—
Hamann	16	19	21	22	5	7	12	1	2	—
HammingEt	16	19	21	22	5	7	12	1	2	—
Harmonic	16	23	17	18	5	7	12	1	2	—
Jaccard	22	21	23	24	5	7	12	1	2	—
Kulczynski	14	15	17	18	5	7	12	1	2	522
M2	16	21	23	24	5	7	12	1	2	—
Ochiai	16	21	23	24	5	7	12	1	2	522
Ochiai2	16	21	23	24	5	7	12	1	2	522
Overlap	2	—	—	—	—	—	—	—	—	536
RogTanimo	16	19	21	22	5	7	12	1	2	—
Rogot	21	15	17	18	5	7	12	1	2	522
RussellRao	6	23	25	28	9	11	18	1	2	—
Scott	16	21	23	24	5	7	12	1	2	—
SDice	6	25	27	28	11	13	18	1	2	—
SimMatchin	16	19	21	22	5	7	12	1	2	—
Sokal	16	19	21	22	5	7	12	1	2	—
Tarantula	21	3	9	12	5	10	17	1	2	522
Wong	16	19	21	22	5	7	12	1	2	—
Zoltar	21	25	17	18	5	7	12	1	2	594
Clustering	6	19	17	22	5	7	12	1	2	—

As shown in Table II, our clustering-based method generally has good performance, and it can locate faults effectively. In addition, clustering-based method can ignore some properties and unstable factors in the traditional fault localization methods.

The advantages of traditional fault localization methods can be utilized by the clustering-based method, e.g., some methods exist the situations of division by zero in our experiment, however, our clustering-based method is unaffected, and obtain the satisfactory result. We also can see that if a statement has high suspicious value in most of methods, then it also has high suspicious value in our clustering-based method. That is to say, clustering method can capture the statement with accepted high suspiciousness. Furthermore, if a certain method is superior in a certain statement, although our clustering method cannot assign the highest suspicious value to the statement, it still can increase the suspiciousness greatly. In other words, clustering method can take the advantage of individual method.

IV. RELATED WORK

Early spectrum-based methods[5][6] only utilize failed information for locating faults. Based on these methods, the new studies obtain the better results by means of using both the successful and failed test cases. Renieris et al.[7] proposed a spectrum-based method named nearest neighbor. The method contrasted a failed test with another successful test which is most similar to the failed one by using "distance" to generate suspicious report. CBI method [8] gather information on predicates and ranks predicates using a metric. Similarly, Liu et al.[9] proposed SOBER method to rank suspicious predicates by comparison the predicates in terms of both passed and failed test cases. Wong et al.[10] proposed a method based on the crosstab analysis to compute the suspiciousness of each executable statement in terms of its likelihood of containing program bugs. Zhang et al. [11] proposed the concept of critical predicates and located faults by means of slicing techniques. Hao et al.[12] proposed a framework which combined the benefits of automated approaches and manual debugging. The approach first recommends checking points based on statements' suspicions continuously, then a robust approach based on this framework was proposed to handle the cases where developers make mistakes during the fault localization process. In addition, Tucek et al.[13] proposed Triage framework, which combined replay technique and difference of multiple program information, such as branch, variable, path and core dump etc., to locate faults. Xie et al. [14] introduced a new concept of slices-metamorphic slice (mslice), and mslice associated with metamorphic test result was utilized to locate faults. In addition, this method attempt to extend SFL to application domains without test oracles.

V. CONCLUSIONS AND FUTURE WORK

Many formulas of SFL have been proposed to locate the fault in the program, however, there are still some problems in these methods. Most of the proposed methods against the some other methods, but the comparison is not comprehensive due to the different test case set is utilized. In addition, there is no single method is best for all situations. Therefore, this paper implemented some classic spectrum-based fault localization methods in order to evaluate the its effectiveness in the same test case set. Furthermore, a new clustering-based method is proposed to improve the accuracy of fault-localization by taking advantages of traditional fault localization methods. This method can ignore some properties and unstable factors in the traditional fault localization methods and capture the statement with accepted high suspiciousness. The

experimental results show that this method can locate faults effectively and has good performance.

In future study, we intend to apply our method to more realistic applications to obtain further insights so as to make further improvements of efficiency.

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Security risk analysis and security design for Wireless LAN

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***Abstract*—Due to the design defects of IEEE802.11 standard, making the wireless local area network (WLAN) security problem is particularly prominent. First, this paper summarizes the attacks based on WEP wireless local area network (LAN), Analysis of the security flaws of WEP based on wireless LAN. Then it discusses the security problems in wireless LAN based on WPA mechanism. On this basis, respectively, for individuals and businesses, presents an effective wireless LAN security solution. A large number of facts have proven that ensure the network security is urgently needed, this study has some reference value for the wireless LAN security deployments.**

***Index Terms*—WEP, WAP, Risk Analysis, Safety and security**

I. Introduction

Because of the great advantages of wireless LAN reflected in many fields, so the study of wireless LAN technology has become the research focus of scholars. With the rapid development of WLAN, its security problems have become increasingly prominent [1]. Fragile 802.11 security mechanism and the attack on WLAN become simple and frequent. Threats can be divided into internal and external aspects. External threats means an attacker using a commercially available hardware and software or those public tools to illegal access wireless network, internal attackers are some legitimate users access to which contrary to authorization, internal attackers have wired and wireless networks for legitimate software and hardware and certificates. People carried out extensive research on security in WLAN, and achieved certain results [2-6], and proposed some solutions [7]. But existing research focuses on the theory, lack of operability. Based on the analysis on the wireless LAN security, this paper propose a complete wireless LAN security solution, in order to deploy a wireless LAN security to provide a reference.

II. Wireless LAN Security Analysis

Wireless LAN has flexible networking, access is simple and applicable to a wide range of features, But because of its path based on wireless transmission, so the openness characteristic mode of transmission to the wireless LAN security design and implementation is a big problem. The current mainstream wireless LAN standard is IEEE802.11, but its design flaws, lack of key management, there are many security vulnerabilities. After the IEEE organization for standardization released the 802.11 standard, also has realized the defects of its inherent safety, and put forward the encryption protocol of WEP(Wired Equivalent Privacy, WEP)to realize the protection of encryption and integrity of the data. Through this agreement to ensure data confidentiality, integrity, and provides access control for wireless LAN. But subsequent studies have shown that, WEP protocol also has fatal weakness. In order to solve the serious defects of 802.11 security mechanism, The IEEE802.11 working group has proposed a new security system, and developed a new safety standard IEEE802.11i, Its for WEP confidential mechanism various defects of the improvements in many aspects. WPA(Wi-Fi Protected Access, WPA) achieved most of the IEEE 802.11i standard, is a transition program for replacing WEP before 802.11i complete. But WPA also exist some security problems.

A. Analysis of Security Flaws Based on WEP wireless LAN

1) WEP security overview

WEP was adopted in September 1999 as part of the IEEE 802.11 standard, using RC4 (Rivest Cipher) stream encryption technology to achieve confidentiality. It is a wireless transmission between two devices in a way to encrypt data to prevent unauthorized users from eavesdropping or invasive wireless network. The goal of WEP is to realize the access control and information encryption. In terms of access control, preventing the correct WEP key user access to the network. In terms of information encryption, allowing only the user has the correct WEP key to decrypt the protected data stream.

IEEE 802.11 standard provides two WEP encryption scheme for wireless LAN. The first scheme provides four default keys for all the terminals sharing—Including all the access point and the client adapter within a subsystem when the users get the default key, can communicate with all users safely within subsystem, but there is widespread default key assignment would endanger security. The second scheme is to establish a link with other user key table at each customer adapter, this scheme is more secure than the first scheme, but with the increase in

number of terminals to each terminal distribution key difficult.

2) Method of attack against WEP mechanism

The attack method of WEP mechanism can be divided into two categories, one is independent of RC4 attack, the other is related to RC4 attack. Associated with RC4 attack is mainly aimed at WEP environment or class of RC4 WEP environment. The target of the attack is to obtain the key, not just for the pseudo random sequence. The main attack way including PTW [3] \ FMS attack [4], KoreK attack [5] and Klein first round attack [6].

Has nothing to do with the RC4 attack has the following four categories: (1) Packet injection attacks. The attacker to capture WEP network packets, and replay after a period of time, to realize injection attacks.(2)Authentication attack. An attacker would have to capture the mobile station (STA) and control the access point(AP) between the authentication data exchange package, construct new legal certification. (3)Chopchop attack. The attack using WEP weakness in the process of to check with CRC - 32.(4)Piecewise attack. The attacker was encrypted with m long pseudo random sequence, the segmentation of the data can send a length of 16(M-4) data load, and then obtain the long 16m-60m encryption using pseudo random sequence. Since IEEE802.11 allows up to 2304 Byte load, most applications are limited to a load of 1500 Byte. Attacker sends 34 fragment, can get 1504 Byte long encrypted with a pseudo random sequence. Because the AP will replace the IV value, segmented attack, so the attacker can establish a IV dictionary, pseudo random sequence corresponding to different IV.

3) Analysis of the defects of Wireless LAN based on WEP mechanism

False access point: IEEE802.11b shared key authentication table using one-way authentication, rather than mutual authentication. Access point need to authenticate the user, but the user cannot identify the access point. If a fake access point is placed within the wireless LAN, it can hijack legitimate user's client adapter or a denial of service attack.

Security issue of Hardware device lost: Statically assigned WEP key is usually stored in the card's non-volatile memory, so when the card is lost or stolen, the user can take advantage of this illegal unauthorized access to the network card.

The security defects of access control mechanism: Closed network access control mechanism: Management information includes the network name or SSID, and the message is the access point and the user broadcast in the network, does not have any obstacles.

Ethernet MAC address access control list: The MAC address is easy for an attacker to sniff. If activated the WEP, MAC address must also be exposed. And most of the wireless network card can use software to change the MAC address.

B. Analysis of wireless LAN Security Defects Based on WPA mechanism

1) WPA Introduction

WPA is a system to protect the wireless computer network security, `it is the first generation of systems researchers wired Equivalent Privacy found several serious weaknesses arising. WPA implements most of the IEEE 802.11i standard, prior to the complete replacement of WEP 802.11i transition program. WPA uses a method based on dynamic key generation and multi-level key management mechanism, It's convenient for the management and maintenance of WLAN. WPA consists of three parts of authentication, encryption and data integrity check.

Authentication: WPA requires the user to provide some form of evidence to prove that it is the legitimate user, can have on some cyber source access rights, and this is mandatory.

Encryption: WPA uses TKIP (Temporal Key Integrity Protocol) as the encryption introduces a new mechanism. It uses a key framework and management methods, dynamically generated by the authentication server, distribute keys to replace a single static key, the key is the header length from 24 to 128 and other methods to enhance security.

Message integrity check: In addition to keep 802.11 CRC check, WPA for each data packet added a 8 bytes message integrity check value, in order to prevent the attacker interception, tampering and resend data packet.

4) The security problems of WPA

Although the WPA is inherited the drawback of the basic principle of WEP and solved the WEP a reinforcement technique. Before the 802.11i officially launched, WPA is one of the safety standards of wi-fi enterprise alliance. Because the WPA is still a relatively weak RC4 encryption algorithm, so hackers only need to listen to enough packets, with powerful devices, even in TKIP under the protection of the network equally likely to crack. Therefore, WPA wireless LAN security can only be counted as a passer field. The WPA worked out based on mature version WPA2, although it cannot say a passer, but its security strength is also still being questioned.

III. WIRELESS LAN SECURITY SOLUTIONS

A. Personal WLAN security solutions

1) Physical layer security protection

Physical protection: Develop a comprehensive security policy and firm manner to ensure that the wireless AP and wireless network card's security. Because almost all of the wireless devices with reset button to reset the function of AP, makes a stolen AP can easily be reused by other people . Therefore, the AP can be placed in a position not easy contact, you can also lock the device and the bracket directly. In addition, the use of a built-in wireless network card desktop computers should also avoid wireless card is lost or the whole computers be stolen.

Isolation of AP: By reducing the AP transmission power, change the low gain wireless way can be AP signal coverage to the office area, can be completely isolated all the wireless client device, so can only access AP connection of the fixed network. For the special

department, the wireless signal working range can be strictly limited.

5) Technology layers safety protection

Using SSH replaces Telnet: Because the Telnet protocol is not encrypted, so from the safety point of view, Telnet should be banned.

Upgrading hardware devices: As a wireless security managers should often browse wireless equipment manufacturers website, view the latest vulnerability and related patch announcement, and in a timely manner for the safety of the equipment installation manufacturers released update or upgrade programs.

6) Management safety measures

Banning broadcasts SSID: The default setting of the SSID parameter in the equipment is AP broadcast, If prohibit the broadcast, generally roaming users who can't find the SSID is unable to connect to a wireless network.

MAC address filtering: MAC filtering can reduce the threat of a large number of attacks, for large-scale wireless networks is very viable option.

Replace WEP with WPA: 802.11 TKIP encryption technology was first used by WPA, the technology can greatly solve the problems existing in 802.11 using the original WEP security.

B. Enterprise WLAN security policy

Use WPA2: WPA2 and WPA backward compatible, and at the same time support AES encryption, better able to solve the problem of wireless network security. If the device supports, as an enterprise environment, should be set encryption to connected WPA2-PSK.

Using 802.1x system: 802.11x introduces extensible authentication protocol (EAP). As the extensible authentication protocol, EAP can be used MD5, a one-time password, smart card, public key certification mechanism, which provide a higher level of security. It is defined by the ppp protocol. In terms of user authentication, 802.11 x client authentication request can also be through external RADIUS server for authentication.

Using VPN: VPN can be used to ensure the confidentiality, integrity and authentication in the data communication network. IPSec can also be used to ensure the safety of WLAN, and the safety is far greater than the traditional PPTP VPN.

IV. CONCLUSION

This paper analyzes the security problems in WLAN, respectively, proposed the wireless LAN security solutions for individuals and enterprises, which provides reference for the safe deployment of WLAN. WLAN is currently in a boom period, and the security problem of the WLAN is one of the focus of particular concern for the industry. To ensure WLAN security, it is necessary from encryption and key management technology two aspects to provide protection. Using encryption technology can ensure the confidentiality of WLAN transmission of information, and can realize the wireless network access control. Although china's WLAN standards and enforcement caused a great impact, it shows that the national information security strategy has taken a solid step. Security risks that exist in the IEEE 802.11i and solutions will be our next research emphasis.

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Application of RBF in the informatization level evaluation in University Library

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***Abstract*—With the rapid development of China's informationization construction, University Library as the main provider for the information, the information construction is also more and more attention. However, evaluation of the level of University Library in the information science, must find a scientific and practical evaluation method. The application of RBF neural network model to try to evaluate the informationization level of university library, and achieved good results, to find a feasible way for the scientific evaluation of university library information level.**

***Index Terms*—RBF, University Library, The level of information**

I. Introduction

Today's society is the information society, information society and its importance has been recognized by the society, the development of information resources, accelerate the information transmission, the effective measures to meet the new technology revolution. China Academic Library as a storage repository of human knowledge, in a global information tide impetus, has become one of the main information mechanism of modern society. The university library information has become the main part of social informatization. Standardization of University Library in the information is an important problem, whether the specification is the key factor that restricts the normal development of information. On the informationization level evaluation should be based on certain criteria, need to develop a set of evaluation standard system of informatization development, the university library has the direction, goals, gradually standardized, so as to provide better services for the majority of teachers and students.

RBF neural network is one of the frontier research direction of rapid development of current information in the international field, has the widespread application prospect. Because the utility in the treatment of complicated decision problem and effectiveness of, very quickly in the world attention, its application has been throughout the economic planning and management, energy policy and allocation, military command, personnel, medical, environment etc.. In this paper, through the analysis of the information level of university library evaluation index, RBF method used in comprehensive evaluation of college library information management level, so that overall evaluation of informatization level of University library.

II. Construction of evaluation index system of Academic Library Informationization Level

The key to evaluate the informationization level is consistent with the actual situation of the construction of the evaluation index system. In the reality of China's colleges and universities, and based on the relevant research results for reference, this article from the information infrastructure, information resources development and utilization, the application of information technology, the informatization talented person, education policy, the 6 selected 29 common characteristics indicators to build the university library informatization evaluation index system, as shown in table 1.

TABLE I.
Average Random Consistency Index RI

Category	Variable Name	Indicator Name	Indicator Property
Information infrastructure	V_1	Library computer network density	Forward indicator
	V_2	Library telecom network density	Forward indicator
	V_3	Readers number of units per computer	Forward indicator
	V_4	Librarians per capita number of computer units	Forward indicator
	V_5	The number of readers per capita Electronic Reading Room	Forward indicator
Information resource utilization	V_6	Readers per capita funding for information technology inputs	Forward indicator

	V_7	Readers electronic publications per capita ownership	Forward indicator
	V_8	The number of copies per capita subscription newspaper readers	Forward indicator
	V_9	Readers journal subscriptions per capita number	Forward indicator
	V_{10}	Readers per capita subscription book number	Forward indicator
	V_{11}	The number of readers per paper books to borrow	Forward indicator
	V_{12}	The number of readers per capita borrow paper journals	Forward indicator
The use of information technology	V_{13}	Collections Digitization rate	Forward indicator
	V_{14}	A new set of document cataloging rate	Forward indicator
	V_{15}	Online reference service rate	Forward indicator
	V_{16}	Interlibrary loan rates online literature	Forward indicator
	V_{17}	Paper documents online procurement rate	Forward indicator
Information personnel	V_{18}	The proportion of managers in IT staff	Forward indicator
	V_{19}	The proportion of professional information technology staff	Forward indicator
	V_{20}	Master of information technology librarian proportion	Forward indicator
	V_{21}	Library and Information Science graduate librarians proportion	Forward indicator
	V_{22}	Library Information Organization	Forward indicator
Information policy	V_{23}	Library information policy, planning, standards, etc.	Appropriate indicator
	V_{24}	Library information regulations	Appropriate indicator
	V_{25}	Safety management	Appropriate indicator
Education	V_{26}	Number of readers per capita and technological achievements	Forward indicator
	V_{27}	Readers number of patents per capita	Forward indicator
	V_{28}	Employment Rate	Forward indicator
	V_{29}	The proportion of senior faculty	Forward indicator

Based on the 3 level standard were determined, namely preliminary, intermediate, advanced. According to national relevant specification or statistical data, combined with the actual situation of the University Library China, classification criteria are listed in table 2.

TABLE II.
EVALUATION INDEXES OF UNIVERSITY FINANCIAL PERFORMANCE

Index	Class		
	High	Medium	Low
Information infrastructure	3	2	1
Information resource utilization	5	3	1
The use of information technology	3	2	1
Information personnel	4	3	2
Information policy	5	3	1
Education	3	2	1

III. EVALUATION OF THE INFORMATIZATION LEVEL OF UNIVERSITY LIBRARY BASED ON RBF NEURAL NETWORK

Radial Basis Function (RBF) Neural Network was proposed by J.Moody and C.Darken in the late 1980s. It is a three-layer feed-forward network with a single hidden layer. Since it simulates the neural network structure of local adjustment and overlapping receiving fields (or Receptive Field), RBF network is a local approximation network, which can approximate any continuous function at arbitrary precision and is particularly suitable for solving classification problems. Compared with other networks, it has the following advantages: I. it has the characteristic of unique best approximation and has no local minimization problem; II. RBF neural network has a strong input and output mapping function, and theoretically proves that RBF network is the optimal network that can complete mapping function among forward networks; III. Network connection weights and output are in linear relationship;

IV. Good classification ability; V. Fast rate of convergence in the learning process. Therefore, the study selects RBF neural network as the modeling method.

A. Structure of RBF fuzzy neural network

As shown in Figure 1, the structure of RBF network is similar to that of multilayer forward network and it is a three-layer forward network. The first layer is the input layer composed of nodes of signal source; the second layer is the hidden layer, in which the number of hidden units is determined based on the needs of the problem described and the transformation function of hidden units is RBF. It is a nonlinear function with radial symmetry of symcenter and attenuation; the third layer is an output layer. It responds to the effects of input mode. Since the mapping of input to output is nonlinear, and the mapping of hidden layer space to output space is linear, the learning speed is greatly accelerated and local minimization problems are avoided.

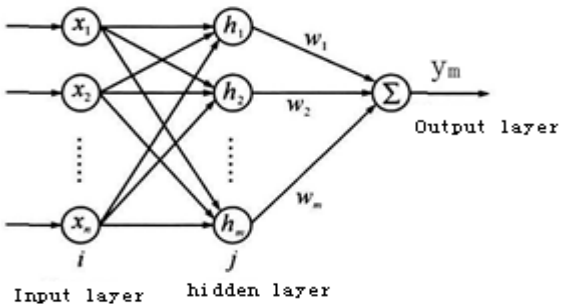

Figure 1. Structure of RBF Neural Network

In RBF network structure, set X as the input vector of network, then:

$X=[x_1,x_2,....x_n]^T$

Set the radial base vector of RBF network as H, then:

$H=[h_1,h_2,\cdots h_j..h_m]^T$

Wherein, hj is the Gauss function:

$$h_j=\exp(-\frac{\|X-C_j\|^2}{2b_j^2}),j=1,2....m$$

The vector of the center of the j-th node in network is as follows:

$$C_j=[c_{1j},c_{2j},...,c_{ij},...,c_{nj}]^T$$

Wherein, i=1,2,…n; j=1,2,…m

Set the base width vector of network as as follows:

$$B=[b_1,b_2,...,b_m]^T$$

bj is the base width parameter of node and is a number greater than zero.

The weight vector of network is as follows:

$$W=[w_1,w_2,...,w_m]$$

The network output at time k is as follows:

$$y_m(k)=wh=w_1h_1+w_2h_2+...+w_mh_m$$

Set the ideal output as y (k), and the performance index function is as follows:

$$E(k)=\frac{1}{2}(y(k)-y_m(k))^2$$

B. Learning algorithm of RBF neural network

The learning algorithm of RBF neural network requires solving 3 parameters: center of base function, hidden layer to output layer weights and node base width parameter. Based on different methods of selection of RBF center, there are a variety of learning methods of RBF neural network, e.g. gradient descent method, randomly selected center method, self-organized area selection center method, supervised area selection center method, orthogonal least square method, etc. The iterative algorithm based on gradient descent method, output weight, node center and node base width parameter is as follows:

$$w_j(k)=w_j(k-1)+\eta(y(k)-y_m(k))h_j+\alpha(w_j(k-1)-w_j(k-2))$$

$$\Delta b_j=(y(k)-y_m(k))w_jh_j\frac{\|X-C_j\|^2}{b_j^3}$$

$$b_j(k)=b_j(k-1)+\eta\Delta b_j+\alpha(b_j(k-1)-b_j(k-2))$$

$$\Delta c_{ji}=(y(k)-y_m(k))w_j\frac{x_j-c_{ji}}{b_j^2}$$

$$c_{ij}(k)=c_{ij}(k-1)+\eta\Delta c_{ij}+\alpha(c_{ij}(k-1)-c_{ij}(k-2))$$

C. An empirical study

This paper collected data of universities directly under the provincial library as the original data in Table 1, the informatization level evaluation index system of University Library as the research object, a total of 29 sets of data. In 29 the relative index selection, there are 26 positive indexes, 3 moderate index. We first on the appropriate index according to the interval corresponding reasonable positive treatment;

Finally, in order to avoid the dimension effect, the data was normalized, normalized function formula is as follows:

$$Yi=\frac{Xi-\min(Xi)}{\max(Xi)-\min(Xi)},\ i=1,2,\ldots,n$$

In simulation, we put the vector consisting of evaluation object is the informationization level of each evaluation index as the network input of the model, the evaluation results that the informatization level as the output, so as to realize the pattern recognition function. In the network training, the evaluation standards were classified as input training samples, the corresponding level as the output samples. In this paper the calculation by MATLAB software implementation of the RBF model, the result is 2.0752, refer to table 2 grade standard, between the school library informationization level between the intermediate and senior level, evaluation and the school library is basically the same, indicating that the evaluation result of the model is satisfactory.

Ⅳ. Conclusion

The RBF network has a unique optimal approximation properties, and no local minimum problem, is a good evaluation method. To evaluate the informationization level of university library by using RBF neural network,

this method as the technical theory, applied research and theoretical discussion, in practice need to be further improved. Implementation of the evaluation function of neural network, can make full use of past experience, so that the evaluation system with learning ability. At the same time, the weight of each evaluation index is composed of a network through automatic learning, it avoids the subjectivity of artificial weight in traditional assessment methods, make up the traditional methods, the informatization level evaluation is more objective and accurate. To provide scientific basis for formulating relevant policies for information development in University Libraries in china.

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An intelligent multi-channel switching power supply

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***Abstract*—This paper introduces a smart turn on and off with a multi-channel DC-frequency switching power supply. To meet the practical application with electrical isolation for multi-channel switching power supply needs. Using high-frequency switching power supply technology, homemade with electrical isolation of high-frequency transformer, the use of intelligent microprocessor control means designed and implemented to meet the controllable frequency switching inverter circuit. This paper details the design method from the power supply system of the economy, practicality, miniaturization, high-frequency and other aspects. Practical application test results met all performance requirements, performance and stability.**

***Index Terms*—DC-frequency switching power supply, electrical isolation, high-frequency transformer**

I. Introduction

With chip technology and the rapid development of electronic technology applications, high-frequency and soft switching technology of high-frequency switching power supply technology research [1]-[3] and development can be achieved, so that the power converter better performance, lighter weight, smaller size. Thus, in electricity, electronics, telecommunications, and many other circuit applications miniaturization, intellectualization, high-frequency, high-performance, high reliability and high efficiency DC power systems have a very important application prospect. In practical applications of the electronic circuit, switching power supplies are designed for different applications, and mode of performance requirements and different. This article applies to series battery voltage measurement system architecture and design parameters, from the design feasibility, reliability, economy and practicality considerations, the design of a suitable for this system uses intelligent multi-channel switching power supply [4]-[5].

II. Power supply design requirements

The author developed the intelligent multi-channel switching power supply, applied voltage to frequency converter type battery voltage inspection system, which count on the power supply design to make the following technical requirements.

(1) On the battery pack in series with each battery voltage is measured using a single block battery floating measurements. Working conditions for each positive and negative poles of the battery voltage drop can be done real time monitoring. This requires the power supply system to provide multiple, independent power supply to the measuring circuit of each battery use.

(2) Work in series with the battery voltage measurement system is characterized by multiple batteries while monitoring system, requires measurement circuits simultaneously, so that the auxiliary DC power source for providing greater energy requirements. Taking into account the measurement to improve the life of the whole system, the measuring system allows the case, taking into account the data collection time measurement circuit can be in power-on state, does not collect the measurement circuit is powered down, the power supply design may be considered a controllable open, cut-off function, namely soft-switch technology, MCU provides control signals used here.

(3)To ensure that the battery voltage measurement accuracy inspection system, inspection system of battery voltage requires signal acquisition circuit and signal processing circuit to take effective electrical isolation. Considering the uniformity of machine power, intelligent multi-channel switching power supply auxiliary power supply and the signal processing circuit using the same power supply, the signal acquisition circuit and a signal processing circuit to isolate the problem by the power inverter circuit of the transformer to achieve electrical isolation.

III. Intelligent multi-channel switching power supply schematic structure

Power structure is shown in Figure 1.

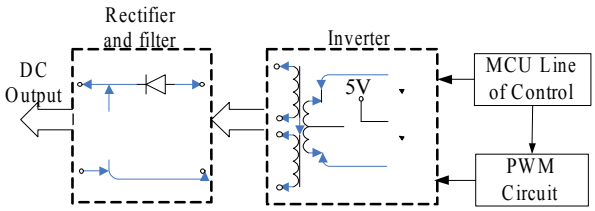

Figure 1. Block diagram of switching power supply

(1) single-chip control lines: the use of digital signal generation switching control start and stop the inverter circuit to control the power supply, namely the power on and off.

(2) PWM circuits: generating switch control circuit, while generating variable duty cycle square wave signal to control the inverter switching elements, changing the frequency or pulse width of the signal, to output stability, on the other hand, the control the occurrence of the signal or control signal to control the inverter operation.

(3) Inverter: the secondary current into high frequency alternating current, the core of the inverter switching power supply portion, PWM signal frequency higher (where the design of 36kHz), the size of the transformer used, the weight ratio of the output power is smaller.

(4) Output rectifier and filter: the load required to provide stable and reliable DC power supply. Here no regulator design, mainly due to acquisition circuit chip power supply voltage required for a certain range of I degree, therefore, this design not only meet the needs of the design, but also reduce the cost and simplify the circuit. If you need a stable voltage output, can be added to the regulator circuit.

(5) Auxiliary power: AC output power designed to provide a source of energy, this design using DC 5V

IV. Hardware Design

Switching power supply with small size, high efficiency series of advantages, in all kinds of electronic products have been widely used. However, due to the switching power supply control circuit is more complex, the output ripple voltage is higher, so the switching power supply applications are subject to certain restrictions. The key to the electronic device is compact and lightweight power supply of the small, so to minimize the losses in the power supply circuit. Switching power supply switching regulator operating in the state, there must be switching loss, and loss with the size of the switching frequency increases. Furthermore, the transformer of switching power supply, reactors and other magnetic components and capacitive component of the loss, but also with the frequency increases.

Current switching power supply circuit structure has a variety of commonly used type of circuit is nothing less than a PWM converters, isolated converters, quasi-resonant converter and other major type, so the designer to be based on the characteristics of a variety of ways effectively combined to produce a high quality to meet the needs of the switching power supply.

A. MCU

The selection consideration chip battery voltage detection apparatus, which is the higher demand for electricity circuit, the switching power supply control only to provide a level signal, for any one type of chip can meet this requirement. Control by software programming.

B. PWM circuit

As can be seen from Figure 2, this circuit uses the 555 timer adjustable duty cycle consisting multivibrator implemented generates high frequency square wave signal, the application of this method to generate a driving signal has the following advantages.

(1) Constituted by 555 timer adjustable duty cycle multivibrator circuit mature is easy to implement. Reasonable set of parameters to obtain the desired frequency square wave signal.

(2) 555 circuit output drive capacity, can drive multiple.

(3) The use of single signal (KEY) by digital logic means, a fourth pin 555 through the control output 555 of the third pin, to achieve controllable drive circuit, so that the overall control of the power supply can be realized

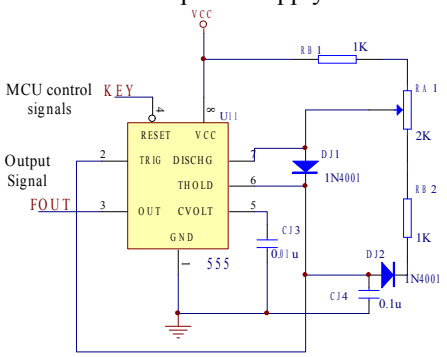

Figure 2. PWM circuit

C. Inverter circuit

Switching power supply circuit of the main components of the power of choice and protection is very important. At present, high-frequency switching power supply the most widely used power semiconductor devices have two types, one is a bipolar power transistor, and the other is the power metal oxide field effect transistor.

The choice of bipolar transistors and MOSFET is mainly used by the designer to select the power circuit structure (selection methods described are no longer state), should also be considered in the selection of which is the use of bipolar transistors and MOSFET tube disadvantages. Switching power supply system miniaturization is a key for the design of power circuit, therefore, studies using higher frequency power transformer is to reduce the power system size, increase power output than the key factors.

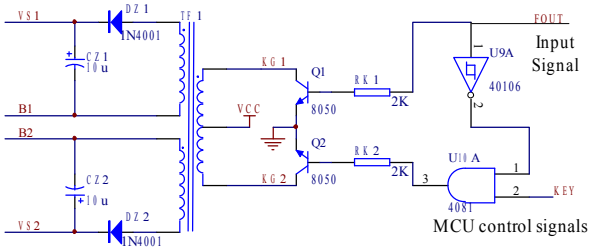

Figure 3 The circuit of inverter and the rectifier

Shown in Figure 3, the design of the rectifier circuit of the inverter, two voltage outputs used here is a reason that the use of 50% duty cycle rectangular wave (square wave) as a control switch input signal, the positive and negative half-cycle signal, respectively, the control transistor Q1 and Q2 is turned on, the two power supplies in the positive and negative half cycle to work separately, thus ensuring that the control signal within one cycle of the output of the power supply has an effect.

(1)High-frequency switching power supply transformer is an important factor in the design. Performance of the transformer can directly reflect the power over the miniaturization and reliability.

TABLE I.
INDICATORS HOMEMADE TRANSFORMER

Parameter	Index
Operating Frequency	36kHz ± 1%
Converter input voltage	DC5V
voltage	DC(10V ± 20%)
Converter output current	0.01A ± 50%
Rectifier circuit form	Half-wave rectifier
Duty	1%～90%
Output efficiency	≥80%
Pressure	DC500V
Temperature	＋50℃
Working conditions	－25℃～＋50℃

(2) Transformer core selection and determine the operating point.

According to the literature output power and core size relationships, the switching power supply optional select high saturation magnetic flux density Bs, good temperature stability, low cost, convenient Nanocrystalline alloy processing, is conducive to the realization of the transformer technical indicators.

The choice of magnetic core operating point is often from the material of core, transformer working condition, operating frequency, output power and insulation and other factors to consider. Nanocrystalline alloy has approximately 1.2T saturation magnetic flux density Bs, in bipolar switching power supply transformer design, the maximum operating core magnetic flux density Bm is generally preferable to 0.6 ~ 0.7T, specially treated core, Bm can be achieved 0.9T. In this design, the operating frequency, insulation, the use of environmental reasons, the maximum operating magnetic flux density Bm set at 0.6T, while the core structure is scheduled to not cut rectangular core. The core of this structure, compared with the annular core having a coil wound convenient distribution parameters of small, high utilization of core window, good heat dissipation, system insulation reliable but electromagnetic compatibility is poor.

(3) The main parameters of the calculation transformer.

The main parameters of the calculation includes the transformer output power, computing power, design output capacity, calculate the coil, the wire diameter, the thickness of the winding, transformer temperature rise calculation, these calculations are no longer dwell.

D. Rectifier and filter

As the battery voltage detection apparatus of this power requirements, the ripple voltage strict, as long as the changes can not be lower than the normal power supply, and therefore should be able to meet the design requirements of the rectifier filter, without regulation, this design is simple and easy to achieve, while still meeting design requirements.

V. CONCLUSION

Final This power obtained in the actual operation of the system the following conclusions.

(1)Designed to provide power output than large ones (designed for 8-way), but the circuit is simple and effective applications to meet the design requirements, thereby greatly reducing costs.

(2)Although the power output of more than large ones, but the control and drive circuit drives the results are stable, uniform distribution can be pulse width adjustable electrical power per channel, providing a stable supply voltage.

(3)Power applications, you can turn on and off through the MCU control, intelligent control at the same time, from the energy point of view but also greatly improved efficiency.

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