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If

by Rudyard Kipling

If you can keep your head when all about you
Are losing theirs and blaming it on you;
If you can trust yourself when all men doubt you,
But make allowance for their doubting too;
If you can wait and not be tired by waiting,
Or, being lied about, don't deal in lies,
Or being hated don't give way to hating,
And yet don't look too good, nor talk too wise;

If you can dream and not make dreams your master;
If you can think and not make thoughts your aim,
If you can meet with Triumph and Disaster
And treat those two impostors just the same;
If you can bear to hear the truth you've spoken
Twisted by knaves to make a trap for fools,
Or watch the things you gave your life to, broken,
And stoop and build'em up with worn-out tools;

If you can make one heap of all your winnings
And risk it on one turn of pitch-and-toss,
And lose, and start again at your beginnings,
And never breathe a word about your loss;
If you can force your heart and nerve and sinew
To serve your turn long after they are gone,
And so hold on when there is nothing in you
Except the Will which says to them: "Hold on!"

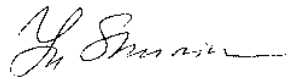
If you can talk with crowds and keep your virtue,
Or walk with Kings---nor lose the common touch,
If neither foes nor loving friends can hurt you,
If all men count with you, but none too much;
If you can fill the unforgiving minute
With sixty seconds' worth of distance run,
Yours is the Earth and everything that's in it,
And - which is more - you'll be a Man, my son!

****

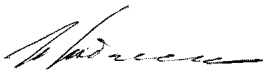
Rudyard Kipling (1865–1936) ♣

This 17th volume no. 3 presents actual papers on two main topics of Journal specialization, namely, Operation Research and Decision Making Models, Mathematical and Computer Modelling, Innovative Education Models. Contributors of this issue represent scientific institutions of China and Israel. Our journal policy is directed on the researches of fundamental and applied sciences, which are the basement of a full-scale modelling in practice. This edition is the continuation of our publishing activities. We hope our journal will be interesting for research community, and we are open for collaboration both in research and publishing. We hope that Journal's contributors will consider the collaboration with the Editorial Board as useful and constructive.

EDITORS



Yu.N. Shunin



I.V. Kabashkin

♣ **Rudyard Kipling** (1865–1936) – an English poet, short-story writer, and novelist chiefly remembered for his celebration of British imperialism, tales and poems of British soldiers in India, and his tales for children. Kipling received the 1907 Nobel Prize for Literature. He was born in Bombay, in the Bombay Presidency of British India, and was taken by his family to England when he was five years old. Kipling is best known for his works of fiction, including The Jungle Book (a collection of stories which includes "Rikki-Tikki-Tavi"), Just So Stories (1902) (1894), Kim (1901) (a tale of adventure), many short stories, including "The Man Who Would Be King" (1888); and his poems, including Mandalay (1890), Gunga Din (1890), The White Man's Burden (1899) and If – (1910). He is regarded as a major "innovator in the art of the short story"; his children's books are enduring classics of children's literature; and his best works are said to exhibit "a versatile and luminous narrative gift".

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CHANGE OF ECOLOGICAL ENVIRONMENT IN SHENFU MINING AREA OF CHINA BASED ON GIS AND RS

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The ecological environment in Shenfu mining area of China is fragile. Coal mining has impacted great influence on the ecological environment of mining area. To analyze the damage condition of ecological system and rapidly recover the damaged ecosystem plays an important role in regional sustainable development. Based on the remote sensing data of year 1989, 2002 and 2006, the index of NDVI, vegetation coverage, desertification and land use in the studied area were studied and analyzed. The research results showed that: The vegetation coverage was becoming better on the whole; however, in the mining area of large coal mines, the degree of vegetation coverage was still very low; the potential desertification area increased gradually, from 81661.02hm^2 to 149200.74hm^2; the severe desertification area reduced gradually. The research results provided a base for mine land reclamation and ecological restoration, which can play a positive role in promoting the construction of ecological environment in western area of China.

Keywords: Shenfu mining area; RS; GIS; ecological environment

1. Introduction

Shenfu mining area is rich in coal resources, and is one of the most important energy and chemical base in china. Since the nineteen nineties, the rapid construction in mining area provided an important contribution to the development of country and the local economy. But, the mine area locates in the transitional region of Loess Plateau in northern of Shaanxi and the Maowusu Desert, and is one of the most serious soil erosion areas in the Yellow River basin; the ecological environment of mining area is extremely fragile. In recent years, with the continuous exploitation of coal resources, environment problems such as geological disasters, environmental pollution, and so on, began to appear in Shenfu mining area, which resulted in deterioration of ecological environment, bring great difficulties to the normal production and the life of local people, pose a serious threat to the people's life and property security, therefore, how to realize the sustainable development while mining is a research topic of practical significance [1].

2. The Research Content and Basic Data

The study area located in arid and semi-arid area, and the ecological environment is fragile. Long time coal mining has caused serious damage to the land and ecological environment. According to the research data collected, the ecological environment change in the mining area was analyzed using RS and GIS, the main contents of the research area included vegetation coverage change, land use change and desertification. The main basis data included:

(1) TM (ETM) remote sensing data in September 11, 1989; August 6, 2002; September 10, 2006.
(2) Digital elevation model of the study area with 30 meters resolution.

3. Dynamic Monitoring for Vegetation Coverage Degree

Green vegetation is the key factor of ecological environment, and its changes directly or indirectly affect the changes of other environmental factors. The process of mine construction gave great damage to the vegetation. The factor of vegetation coverage was studied to monitor the vegetation damage [1, 2].

Vegetation information on remote sensing images can be calculated through changes of leaf and canopy spectral characteristics of green vegetation. For the extraction of vegetation information, the image can be enhanced through ratio method and the sub-cap transformation method, and then NDVI of the vegetation coverage can be calculated. According to the value of the vegetation coverage, the result can be divided into high vegetation coverage area, middle vegetation coverage area, low vegetation area,

and sparse vegetation area. If vegetation type was single and coverage was low, it will aggravate the soil erosion degree, and the ecological environment was more easily damaged. This study uses pixel-two-divide-model method to calculate vegetation coverage; the remote sensing data source was the TM series [1, 2].

According to classification standard for land desertification, referred some literature in vegetation coverage grade standards, combined with the characteristics of the study area of vegetation, the vegetation coverage in the study area were divided into four grades. Grade I: the degree of vegetation coverage was less than 40%, belonged to low coverage of vegetation, equivalent to desert grassland, sand, water, surface etc; Grade II: the degree of vegetation coverage of was 40% ~70%, belonged to middle vegetation coverage , equivalent to the medium yields of grassland, shrub land. Grade III: the degree of vegetation coverage was more than 70%, belonged to high vegetation coverage, equivalent to dense shrub forest, dense woodland, farmland and other excellent arable land. Statistics of vegetation coverage of different vegetation stage was listed in the Table 1.

Table 1. Vegetation coverage statistics of different period

year	coverage (%)	0-40	40-70	70-100	total
1989	Area (hm^2)	5862.25	963594.51	40360.70	1009817.47
	Proportion (%)	0.58	95.42	4.00	100.00
2002	Area (hm^2)	4202.18	908043.03	97572.26	1009817.47
	Proportion (%)	0.42	89.92	9.66	100.00
2006	Area (hm^2)	7168.96	869591.79	133056.72	1009817.47
	Proportion (%)	0.71	86.11	13.18	100.00

Based on monitoring result of vegetation coverage of Shenfu mining area between year 1989 and 2006, statistical results of vegetation coverage degree showed that: in the past 20 years, the vegetation coverage less than 40% decreased firstly and then increased; vegetation coverage between 40% and 70% showed a gradual decline trend. Vegetation coverage more than 70% increased.

The average vegetation coverage can be calculated according to vegetation coverage of each year with the method of weighted renormalization, the formula was as follows

$$P_{veg} = \frac{\sum_i * y_i}{\left(\sum y_i\right)} \tag{1}$$

where:

P_{veg} – the average vegetation coverage (%);

i – Intermediate values of coverage, the formula of i were 0.2, 0.5, and 0.8;

y_i – the area corresponds to coverage (hm^2).

Table 2. The average vegetation coverage of Each year (unit: %)

year	1989	2002	2006
average vegetation coverage (%)	51.02	52.77	53.74

The information referred form Table 2 showed that: average vegetation coverage in Shenfu mining area was mainly between 40% and 70%; the average vegetation coverage increased during twenty years; the overall vegetation area coverage was improved, which may be associated with the local policy of "returning farmland to forest". However, it also was found that, in the mining area of large coal mines and western water, the vegetation of coverage is still very low, mostly less than 20%. This showed that the vegetation restoration in coal mining area and water source development was insufficient, also showed that the destruction rate of vegetation caused by coal mining was far greater than the vegetation restoration process. Therefore, these two zones should be the focus for regional ecological repair in Shenfu mining area.

4. The Desertification Monitoring Theory Foundation and Technique Route Based on RS

In order to extract the information desertification evolution, three stage of TM remote sensing image (1989, 2002 and 2006) were treated through radiation correction, geometric correction, image registration and scope of cutting. The desertification index was calculated using the proposed crust index (Crust Index, CI) by Karnieli. The formula was as follows [3]:

$$CI = 1 - \frac{red - blue}{red + blue} \tag{2}$$

Among them:

CI – the crust index;
red – red band of remote image;
blue – band blue of remote image.

In the software of ENVI, using the band calculation method, the desertification index distribution was extracted. According to the exponential distribution, the desertification degree was divided into four types, namely: the severe desertification, moderate desertification, light desertification and potential desertification area. The statistical information of different periods was listed in the Table 3.The research results showed that potential desertification area increased gradually in Shenfu mining area, from 81661.02hm^2 to 149200.74hm^2. The severe area reduced gradually. This also showed that the investment of government in ecological treatment had achieved certain success from another point of view.

Table 3. The statistical information of desertification degree of different periods

Degree / year		1	2	3	4
		severe	**moderate**	**light**	**potential**
1989	Area(hm^2)	156160.02	364517.25	407479.18	81661.02
	Proportion(%)	15.46	36.10	40.35	8.09
2002	Area(hm^2)	193617.58	362926.54	352031.26	101242.09
	Proportion(%)	19.17	35.94	34.86	10.03
2006	Area(hm^2)	104961.52	388431.36	367223.85	149200.74
	Proportion(%)	10.39	38.47	36.37	14.78
1989-2002	Area(hm^2)	37457.56	-1590.71	-55447.92	19581.07
	Proportion(%)	23.99	-0.44	-13.61	23.98
2002-2006	Area(hm^2)	-88656.06	25504.82	15192.59	47958.65
	Proportion(%)	-45.79	7.03	4.32	47.37
1989-2006	Area(hm^2)	-51198.50	23914.11	-40255.33	67539.72
	Proportion(%)	-32.79	6.56	-9.88	82.71

5. Land Use Monitoring

Mining area as a special geographical area, mining leaded to large area of surface subsidence and coal waste occupation, which resulted in destruction of arable land and land use change. TM remote sensing image was used to obtain land use types and variation using the ENVI remote sensing image processing software with the methods of supervised classification [4-6].

5.1. Analysis of land use band characteristics of remote sensing

The spectral characteristics of different land use types are the basis of interpretation of remote sensing image. Automatic classification of TM can be done through comprehensive understanding of bands [7–9].

According to the different land use types and the features in the TM images of the study area, the land use was divided into of six types, i.e. water, arable land, grassland, villages and towns, sandy land and bare land. Five samples of each type of spectral measurement value (DN) of different bands were selected to rendering the spectral characteristic curve. The following conclusions can be obtained:

(1) For all types of land use, the change trends of the TM1, TM2 and TM3 were approximately same; three spectral values were strong correlation, not easily to the extraction and separation of thematic information of land use.

(2) In bands of TM3 and TM4, change trend of different types had different spectral values. The cultivated land and grassland spectral values in the TM3 was very low, but increased significantly in the TM4; water and sand in TM3 were higher than TM4. So it can use the TM3 andTM4 spectral values of the difference or ratio to extract land cover type information.

(3) Spectral value of sandy land and bare land in TM5 was higher. Other type of land cover spectral value was low.

5.2. The characteristics index of different land use type

Based on above analysis of spectrum character curve, the characteristics index of different land use type was calculated to enlarge the difference between different land types to prominent features of remote sensing information and facility automatic extraction and recognition during classification.

(1) Normalized difference index (NDVI). NDVI can be calculated with infrared and near infrared band of TM image. NDVI = (TM4 spectral value – TM3 spectrum values) / (TM4 spectral value + TM3 spectral values), the NDVI change of different land types were illustrated in Figure 1.

NDVI of arable land was more than 0.4, NDVI of grassland was 0.15 ~ 0.25, NDVI of bare soil was 0.1 ~ 0.15, NDVI of sand was near to 0, NDVI value of towns and water was negative. Therefore, various types of land use can be separate using NDVI value.

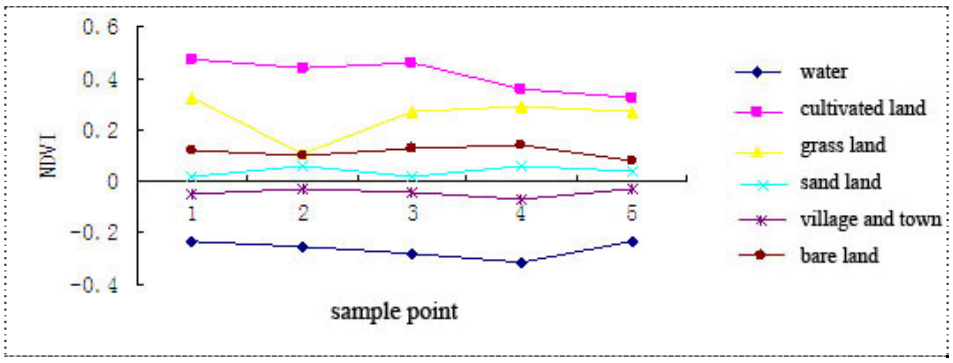

Figure 1. NDVI value of different land use type

(2) The value of slope. The ground slope represents tilt degree on the surface in quantity, which can be derived from the DEM through a certain transformation. According to DEM data in mine area, the slope of the ground was generated on Figure 2. Slope of different land use types was analyzed through selecting the sample. It showed that bare land and grassland slope values were above 5 degrees, the other kind of land was below 5 degrees.

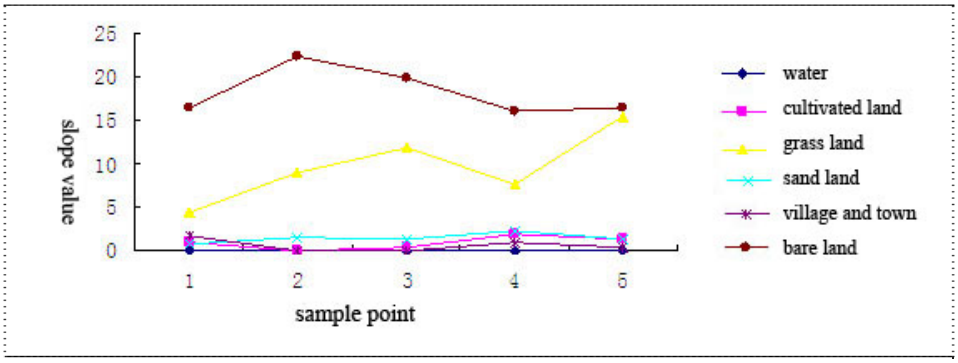

Figure 2. Slope value of different land use type

5.3. Land use classification

Land use in the study area of year 2006 was extracted with method of artificial neural network. The result is shown in Table 4.

Table 4. Land use structure in year 2006

Land use	Area(hm^2)	Proportion(%)
Water	11751.66	1.16
Cultivated land	12111.84	1.20
Sand land	37782.81	3.74
Villages and owns	11158.74	1.11
Bare land	603760.77	59.79
Grass land	333251.65	33.00
Total	1009817.47	100

6. Conclusions

Based on the remote sensing data of year 1989, 2002 and 2006 and the DEM data, NDVI, vegetation coverage, the extent of desertification and land use data in the studied area were analyzed. The research results showed that:

1) The overall vegetation coverage was becoming better, however, in the mining area of large coal mines and western area, the degree of vegetation coverage was still very low;
2) The potential desertification area increased gradually, from 81661.02hm^2 to 149200.74hm^2, the severe desertification area reduced gradually;
3) Land use types and change were obtained with the methods of supervised classification.
4) The spectral characteristics of different land use types were studied to comprehensive understand of the classification.
5) The characteristics index of different land use type was calculated to enlarge the difference between different land types to facility automatic extraction and recognition of land information.

The research results can play a positive role for promoting the construction of ecological environment in western area.

Acknowledgements

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RESEARCHES ON THE CONSTRUCTION OF INFORMATION TECHNOLOGICAL MULTI-DIMENSIONAL INTERACTION-BASED IDEOLOGICAL AND POLITICAL TEACHING MODE IN HIGHER EDUCATION INSTITUTIONS

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With the enhanced reformation promoted by The CPC Central Committee Propaganda Department and the Ministry of Education on the ideological and political education in higher education institutions, a number of higher education institutions in our country are making deep self-reflections on their modes of ideological and political education. This text makes deep analysis on the concept and characteristics of the multi-dimensional interactional teaching modes for the information technology in higher education institutions in the first place, obtaining better understandings for the multi-dimensional interactive teaching mode of information technology. In the meantime, it carries out researches on the current situation of the ideological and political teaching in the higher education institutions with the standard of "teaching contents, teaching modes, teaching environment and the overall satisfaction degree for teaching" and concludes that the ideological and political education in the higher education institutions requires further researches. Besides, with the class construction for the multi-dimensional interaction in the higher education institutions and with the deep data analysis on the students' course experience with the CEQ Questionnaire from the implementation results of the multi-dimensional interaction of information technology, it would play positive functions for the diversified teaching mode of the ideological and political teaching in higher education institutions.

Keywords: information technology, multi-dimensional interaction, ideological and political education of higher education institutions, teaching mode

1. Introduction

The multi-dimensional interaction is widely defined as "the multi-channeled and multi-layered teaching interaction process, which covers 3 forms of the interactions between teacher and students, between students and students and between human and machine" [1]. With the precondition of constructivism learning theories and the basic modes in modern teaching, the multi-dimensional interactive teaching mode allows the students to utilize the multi-dimensional interactive modes on the class and to perform the multi-sensory participating learning [2, 3], with which the students can experience with hands, to think with heads, to express with mouth and make innovation with head, therefore their autonomous researching potentials can be activated and the autonomy, multi-dimensionality and effectiveness in the multi-dimensional teaching mode for the information technology will be highlighted.

2. Analysis on the Information Technological Multi-dimensional Interaction

2.1. The Concept of Information Technological Multi-Dimensional Interaction

The information technological multi-dimensional interaction is defined as "to widely apply the computer technology and internet technology to the daily teaching practice, to make the collaboration categorization in the units of groups and to establish an open, interactive and researching teaching environment with the coordination and interaction with the dynamic factors in the teaching process, with which to improve the class efficiency effectively and take the team grade as the evaluation standard for teaching, therefore obtaining the interactive teaching goal of learning together".

2.2. The Characteristics of Information Technological Multi-Dimensional Interaction

Subjectivity. As the information technological multi-dimensional interactive teaching mode is established on the whole-brain learning and constructivism teaching mode, the application of the information technological multi-dimensional interaction to classes will greatly improve the autonomy of the students. As the students are the major elements for the class, the application of the information technological multi-dimensional interactional teaching mode would allow the students to emerge the diversified senses into the learning environment, letting them accessible to the overall feeling from the "auditory, visual, sensational and touching" senses. By paying attentions on the students' acquisition and application skills for knowledge, it obtains the objective as "to determine the things taught according to the things to learn" while getting free from the traditional spoon-fed teaching mode where the teachers took the major roles in the classes.

Multi-dimensionality. The "multi-dimensionality" in the information technological multi-dimensional interactive teaching mode is well demonstrated in the class teaching. The idea of the information technological interactive teaching has broken the traditional channel for information transmission and the single mode for the teacher-student interaction, instead, is establishing a new form of dimensional information transmission and teacher-student interaction from multiple perspectives. In the information technological multi-dimensional teaching, the 3 forms of teacher-students interactions as between the students, between the teachers and the students and between the human and machine, as well as the multi-sensory information perception have become the significant demonstrations for the multi-dimensionality of the multi-dimensional interactive teaching (Fig. 1).

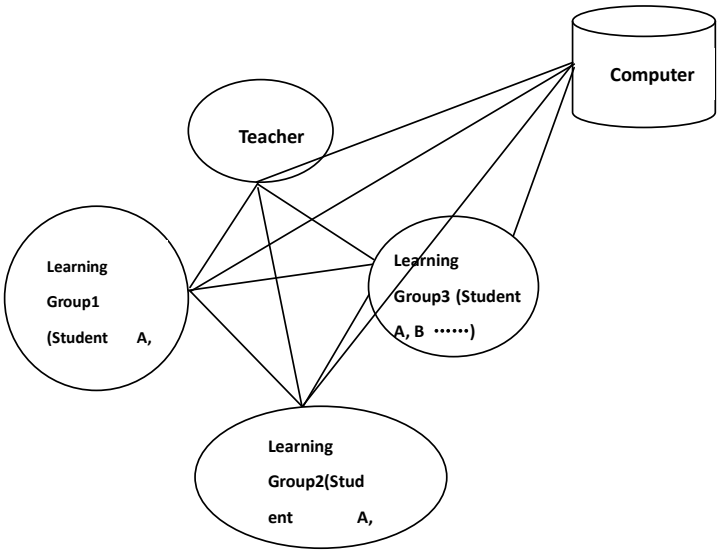

Figure 1. The Multi-dimensional Interactive Relations of Information Technology

Effectiveness. The multi-dimensional interaction of information technology would guarantee the effectiveness of the information communication. When the students raise questions for the ideological and political knowledge, the teachers can work out the synchronous learning program with the interactive electronic version, conversational system and relay session system, therefore guaranteeing the smoothness and time validity of information. In the meantime, the asynchronous information interaction means as BBS and E-mails can also be employed. Compared with the traditional teaching mode, the multi-dimensional interaction mode maintains a more effective information communication effect. Secondly, the means of information technology would not only save teachers' time for homework correction, but would also make timely feedback for the teaching information, showing not only the correct direction of the ideology and politics and the focus on the learning process and methods, but also the generation of ideological and political contents, allowing the students' autonomous and collaborated establishment for their outlook on the world, the life and the values in the self-reflection and experience, in which way the three-dimensional teaching objectives can be effectively obtained.

3. Analysis on the Ideological and Political Teaching Status in Higher Education Institutions

For the evaluation and analysis over the ideological and political teaching status in higher education institutions, the Questionnaire researching method is employed. The research mainly covers the question as the higher education institutions' satisfaction level over their ideological and political teaching conditions, including the "teaching contents, teaching modes, the teaching environment and the overall satisfaction for the teaching". The research takes place from X,Xth to X, Xth, 2012 and covers a participants of 200.

3.1. The Ideological and Political Classes in Highereducation Institutions is Taught with Old-Fashioned Contents, with the Time Validity and Innovation Being Lacked

The research finds out that 61% students of the higher education institutions believe the ideological and political contents they are learning call for a reformation, as the traditional ideological and political education in higher education institutions pays attention to the theoretical courses, which have bored them and in which the time validity and innovation are lacked. A number of teachers from these institutions have

paid too much attention on the accomplishment of the teaching objective and detach the theories from the reality; therefore, the students of the higher education institutions would feel bored with the ideological and political classes and feel unacceptable for the corresponding knowledge.

3.2. The Single Mode of Ideological and Political Teaching in Higher Education Schools

The traditional ideological and political teaching mode takes the single mode of theoretical feeding and the mechanical repeated training. The research finds 65% students unsatisfactory with the current teaching mode of ideological and political teaching in higher education institutions, only 13% students satisfactory with it and the 22% left find it just so-so and stand in the impartial position. As shown in the research, a majority of students are satisfactory with the teaching mode in the ideological and political classes. As a result, the single-teaching mode should be improved and more diversified teaching mode should be integrated to it, breaking the traditional "teachers' dictatorship" and "spoon-fed" teaching mode in the higher education institutions and paying more attentions on the students' capacities for autonomous researching (Fig. 2).

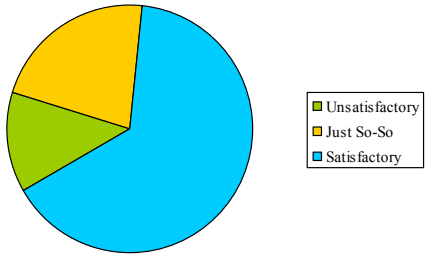

Figure 2. The Satisfaction Status for the Teaching Modes

3.3. The Teaching Environment for the Ideological and Political Classes in Higher Education Institutions

The continuously-changing social ideological form is creating a more complicated teaching environment for the ideological and political education in the higher education institutions. The college students in current days are being exposed in the influences of the "subcultures" and "money worship values". 42% of the students maintain a high level of satisfaction for the physical construction of the teaching environment. In the meantime, a majority of them believe in the insufficient ideological and political educational development. Harmony dominates the spiritual environment, while the autonomy and system for the ideological and political education is lacked.

3.4. A Majority of Students Maintain a High Level of Satisfaction over the Ideological and Political Education in Higher Education Institutions

The research for the students' general satisfaction level over the ideological and political education in higher education schools finds 54% students with comparatively sound satisfaction over the current education status, 32% with a general satisfaction and only 13% with a low level of satisfaction over it. The dissatisfaction for the 13% students is majorly concentrated on the single mode of ideological and political education in higher education institutions. Therefore, the top priority to improve the education quality for the ideological and political classes is the implementation of diversified teaching modes.

4. The Construction of Information Technological Multi-dimensional Interaction-based Ideological and Political Classes in Higher Education Institutions

The construction of the information technological multi-dimensional interaction-based ideological and political classes can be categorized into 3 links as the interaction introduction, the interactive teaching mode construction and the extension of interactive teaching. As the major chain for the construction of the multi-dimensional interactive ideological and political classes, the major interactive forms of the interactive teaching modes include 4 aspects of interactions as between the teacher and the students, between the students, between human and machine, as well as between knowledge (Fig. 3).

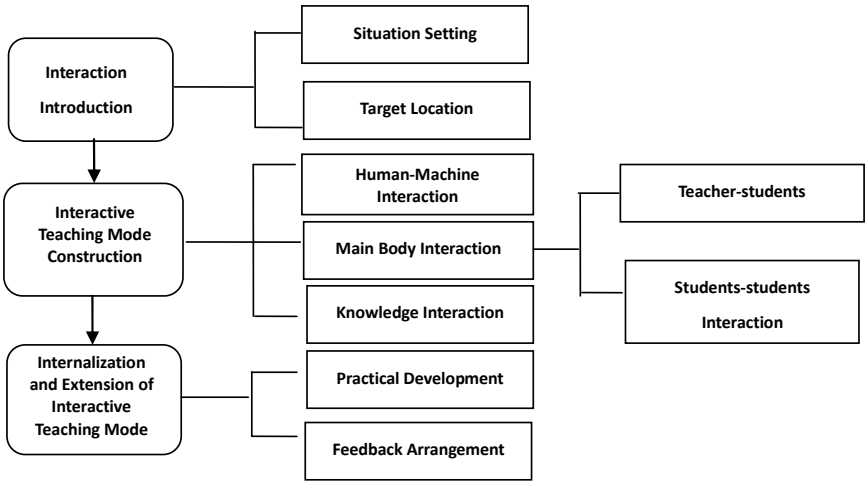

Figure 3. The Construction of Information Technological Multi-dimensional Interaction-based Ideological and Political Classes in Higher Education Institutions

4.1. Human-Machine Interaction

Human-machine interaction refers to the interactive process between the students and the environment of media information resources. The human-machine interaction is an innovated form of information technological multi-dimensional interaction by taking advantages of the computer information technology in the human-machine interactive process for the specific items as the courseware making, information communication, information inquiry and internet operation, etc. By making the courseware of the ideological and political courses or constructing the internet resources database, the teachers can implement the ideological and political teaching with computers, which helps to enhance the situational stimulus for the students and increase their interests in knowledge. For the students, with the computer information technology, they are allowed to carry out the information inquiry, data reading and downloading, webpage browsing or perform the teachers-students interaction with the network communication tools as BBS and E-mail, with which their autonomous researching capacities can be enhanced.

4.2. Students-Students Interaction

The students-students interaction refers to the interactive process between students, which takes the major form of the interaction and communication between a number of students. It is a way for the students to express their own ideas, opinions and solutions in the discussion and a process for them to locate the problems and solve them autonomously. They are allowed to employ the interactive electronic version, the conversational system and the relay session system for the synchronous communicative learning program, therefore the information smoothness and time validity can be guaranteed. In the meantime, the asynchronous information communication can be realized with the means as BBS and E-mails. Compared with the traditional teaching mode, the information technological multi-dimensional interactive mode maintains a more effective information communication effect. In the meantime, it would improve the students' efficiency in ideological and political courses. The students-students interaction creates a more harmonious learning atmosphere and a more open academic communication for the students, getting them accessible to the knowledge that can't be obtained on class in the communication, improving their capacities for independent researching and mutual learning, leading them to establish the correct outlooks on the world, on life and values.

4.3. Teacher-Students Interaction

The teacher-students interaction is one form of the main body interactions. It takes two major forms: the interactions between teacher and the single students, and the interaction between the teacher and a group of students. The interaction between teacher and the single student, which belongs to the category of remedial teaching, occurs when the single student raise questions to the teacher when confronted with

difficult issues. The teacher-students interaction contains not only the "face-to-face" interactive answering, but also the interactive answering mode with the communicative tools as E-mail and BBS, etc. The interaction between teacher and a group of students, which belongs to the teaching mode, happens in the teaching process. The teacher can ask questions to his students through this platform. With the information exchange between the teacher and the students, the students' knowledge-grasping capacities can be enhanced. The application of this interaction in the teaching process would activate the students' positivity for autonomous learning. The students, who were once received the spoon-fed education, would positively take part in the ideological and political norms, therefore internalizing the thoughts and obtaining sound effects for teaching. As the organizer, assistant and instructor for the teaching activity, the teacher takes the dominant position in the teaching process. This calls their attentions on the teaching design and teaching mode, creating a sound knowledge-acquiring environment for the students, taking positive instructions on the teaching thought and disciplines, keeping tracks of the dynamic ideological status of their students and implementing targeted teaching practice.

4.4. Knowledge Interaction

Knowledge is always intercommunicative and there is no such knowledge that can exist independently. Even for the ideological and political course, which composes an independent system itself, it also has a multiple disciplines covered. As a result, attentions should be paid on the knowledge intercommunication in the ideological and political education, realizing the sound interaction between the knowledge of the diversified disciplines and composing a more perfect knowledge network for the students. The process of knowledge acquisition is a collision process between the new and old knowledge, in which the learners are making continuous searching for the linking point between the knowledge learnt to obtain the knowledge linkage. The knowledge intercommunication would enhance the knowledge-grasping level and learning efficiency for the students.

5. Analysis on the Implementation Effects for Information Technological Multi-dimensional Interaction

5.1. Researching Method

100 students are withdrawn from the higher education institutions for the students' satisfaction level over the ideological and political courses with the Course Experience Questionnaire. The test aims to perform analysis on the implementation effects for the information technological multi-dimensional interaction with the comparison between the evaluation opinions on the ideological and political education before and after the implementation of the information technological multi-dimensional interaction.

5.2. Researching Tool

The Course Experience Questionnaire (CEQ) is a widely-applied questionnaire evaluated, examined and implemented by the Higher Education of Australia. With the three key indexes as good teaching, generic skills and overall satisfaction item, this is a systematic questionnaire for the standardized assessment of teaching. Being widely applied in Australia and with a comparatively mature development, its data maintains certain reference value. Based on the key indexes, this assessment has taken the additional testing ones as "learning positivity", "on-class learning efficiency", "cognition conversion rate" and "knowledge-application skills" based on the specific characteristics of ideological and political courses.

5.3. Data-Processing Tool

This text has employed SPSS10.0 Software for data processing and the comprehensive evaluation, and has employed the Difference Comparison Analysis and Relevance Analysis methods for data analysis.

5.4. Assessment Contents

To make comparisons for the class evaluation before and after the implementation of the information technological multi-dimensional interactive teaching, refer to Table 1.

Table 1. The difference comparisons between the class evaluation before and after the implementation of multi-dimensional interactive teaching (m ± sd)

	Before	After
Good Teaching	2.437±0.300	2.763±0.320
Generic Skills	2.494±0.353	2.832±0.410
Learning Positivity	2.307±0.399	2.934±0.315
On-class Learning Efficiency	2.238±0.309	2.654±0.358
Cognition Conversion Rate	2.423±0.332	2.524±0.398
Knowledge Application Skills	2.456±0.310	2.689±0.330
Overall Satisfaction Item	2.364±0.323	2.756±0.238

As shown in the data research and analysis, the average value of the Questionnaire Scale is laid between 2.374 ~ 2.837. The Scale Table tells that the ideological and political classes gain a higher grade after the implementation of the information technological multi-dimensional interaction in the education process, in contrast to the low grade before. This shows a significant difference before and after the implementation of the information technological multi-dimensional interaction, especially in the items of "good teaching", "on-class learning efficiency" and "learning positivity", which calls for further analysis.

6. Discussion

The major elements for the "good teaching" include the "the subject and object in the teaching activity, the teaching contents and the teaching carrier" [4–6]. With the practical on-class application of the information technological multi-dimensional interaction, the time validity for the ideological and political knowledge taught will be improved and the knowledge taught will be endowed with the sense of time and the things taught will be enriched, as shown on Figure 4. The students are allowed to obtain the latest and the most inclusive course materials, therefore the teaching quality can be effectively improved.

Further, it has realized the diversification of the teaching carrier and the visualized teaching mode. The traditional teaching took the single mode of language transmission as the carrier, therefore the multi-sensory learning experience couldn't be obtained [7, 8]. While for the information technology, it is one form of the cognitive tools, which refers to the tool that can assist people to accomplish the cognitive tasks, to enhance their capacities to think about and solve problems and acquire the cognitive abilities. With the wide application of the information technology, the information technology has become one of the significant tools to improve the students' cognitive capacities. The on-class application of the informational technological multi-dimensional interaction could realize the visualized teaching and improve the learning efficiency of the students. The visualized teaching was firstly generated in the middle part of the last century, when the US educationist Dell proposed the concept of "visualized teaching method" and illustrated the basic concept of "visualized teaching" in its work "Visualized Teaching Method" as the process of the externalized expression for the mental image in the visual form [9, 10]. Then, later in 1987, US National Natural and Scientific Funds defines "visualize" as the process to convert the data to the figures or pictures with the computer graphics and the computer processing technology and perform the interactive processing [11]. Therefore, the information technological multi-dimensional interaction would push the "knowledge visualization" for development, realizing the effective learning in each steps of learning, improving the students' understanding output for knowledge and the affirmative degree for teaching, therefore improving their experience for teaching [12].

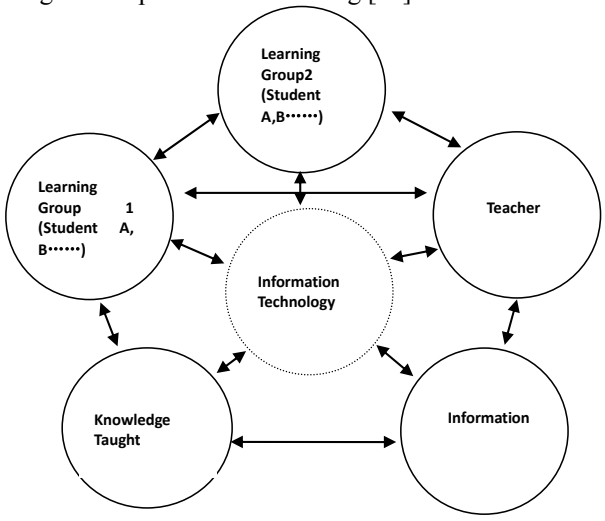

Figure 4. The Teaching System that Centered with Information Technology

On the learning efficiency. The improvement of the class efficiency would allow students to obtain the knowledge conversion within the shortest time, to obtain the understandable input and output of knowledge, allowing the students to grasp and learn how to apply the knowledge in the shortest time. The key factor in the improvement of the class efficiency lays in the improvement in the teaching concepts, teaching means and teaching thoughts. The effective ideological and political teaching in traditional sense focused majorly on the theoretical input, which really made the teaching process boring and,consequently, lowered the learning efficiency. With the information technological multi-dimensional teaching mode, however, students are allowed to practice with hands, to think and innovate with heads, to mark books with memory, which would realize the multi-sensory participation and obtain the whole-mind learning. The whole-mind learning theory holds that "as the life system for the human, the brain is a dynamic integration covering the body, mentality and brain". Therefore, our cognition for knowledge is not limited to the mental activity, but also the physiological functional parameter and only with the linkage between the physiology and psychology will we be equipped with the learning abilities for sure. The multi-dimensional interaction would effectively improve the sensory experience and emotional experience for the students in higher education institutions, getting them the enhanced learning capacities and accessible to the fun of knowledge learning. With this, the "immediate memory" in the cognitive process of the students, after the repeated stimulation, would be converted into the "long-term memory". By getting rid of single mode of language teaching in the traditional sense, it would further enhance the class efficiency [13, 14].

Furthermore, the Constructivism Teaching Theory by Ausubel holds that "Where there is the combination of the new and old knowledge into the established cognitive structure, which is when the new and old knowledge is correlated to each other, there, will be the meaningful learning". The current ideological and political teaching is still dominated by the receptive knowledge learning and the mechanical repeated training, which has resulted in the low knowledge-conversion rate of the students. In the multi-dimensional interactive teaching mode, the dominant position is held in the hands of learners', therefore their autonomous knowledge construction would be realized in the teaching situation and the learning efficiency will be enhanced, too [15].

7. Conclusions

This text first of all takes a deep analysis on the concept and characteristic of the information technological multi-dimensional interaction in the higher education institutions, then, it makes deeper understanding for its teaching modes. In the meantime, it carried out an analysis on the ideological and political teaching status in higher education institutions and performs researches on it with the indexes as "teaching contents, teaching mode, teaching environment and the overall satisfaction item". With the researches, it discovers that the teaching mode for the ideological and political classes of the higher education institutions call for a further development. Moreover, with the class construction for the information technological multi-dimensional interaction and the deep assessment over its implementation effects, it would pose positive effects on the diversified development for the teaching mode of the ideological and political classes in higher education institutions.

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APPLICATION RESEARCH OF MULTI-AGENT MODELING AND SIMULATION METHOD IN STAFF MORALE ASSESSMENT

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In the fierce market competition, the staff morale plays an important role in strengthening the core competitiveness of enterprises, a rapid, scientific and reasonable assessment on staff morale of enterprises is required, so as to provide scientific basis for agglomerating and enhancing staff morale. The enterprise staff morale index system has been established by taking the complex adaptive system's theory as the guidance and with reference to relevant research results, and it has been quantized; the morale unit model has been established by the multi-agent simulation method, thus establish the workshop first level morale simulation model system. Based on the modelling simulation of multi-agent staff morale assessment, a wholly new channel for the staff morale simulation assessment has been explored, met the requirements of combining the quantitative part with the quantification during the actual operation, and the assessment has such advantages as being easy for modelling, integration and expansion, etc.

Keywords: morale assessment, simulation model, multi-agent

1. Introduction

The morale plays a significant role to an organization; high morale is a mark representing the healthy mechanism of an enterprise and an important index for an enterprise to keep a long-term core competition. However, it is a difficult problem all the time that how to assess the staff morale of an enterprise scientifically and reasonably, so as to provide a scientific basis for developing the strategic decisions of managerial personnel. Previously, the assessment of staff morale mainly relies on the experience and feeling, thus the results always have a great difference with the actual conditions. Therefore, this paper takes complex adaptive system as the basic point of the staff morale assessment system's theory, adopts the modelling and simulation method based on multi-agent, and establishes the first level workshop morale simulation system initially, through expansion, it may conducts dynamic simulation assessment on the morale of other levels in an enterprises. Making use of such feature that this system may overcome the randomness during previous assessments, conduct quantitative assessment on an enterprise's morale in real time, grasp the moral status accurately, and clarify which factors are relating to the morale on earth and how these factors to impact and act on each other, how to conduct quantitative dynamic prediction on the development trend of an enterprise's morale, so as to provide the scientific basis for an enterprise to make decisions and win in the competition.

2. Morale, Dimensions and Quantification

2.1. Morale

The morale is used in the war field initially, and at present, the academic field has multiple interpretations for the morale. Siegel [1] considers that the morale refers to the team spirit, viz. that the members make every effort to achieve the target of the team; Yan [2], a scholar from Taiwan, considers that the morale is a potential spiritual strength based on the team relationship; Britt [3]et al consider that the morale is the reflection of motivation and energy instead of a kind of emotion or feeling; Hong [4] considers that the morale is, during the interaction between a person and his/her organization, the members identify their organization and show their cooperation attitude of working hard for their common goal. Li [5] considers that the morale is a kind of spiritual strength, a status meeting the demands or trending to the demands, an organization's sense of identity and a team's sense of competence. To sum up, the academic field usually considers that the morale refers to that under the guidance of the organization's vision and strategic target, the whole team's attitudes such as initiative, confidence, persistence, braveness, and tenaciousness, etc. formed by the interaction between the individuals and their organization.

2.2. Morale Dimensions

The "morale" is a relatively vague concept; therefore, it is difficult to define the morale dimensions. Lots of scholars at home and abroad have conducted a deep study on the morale dimension.

Johnsrud [6] et al have established the moral model at such three dimension levels as Institutional Regard, Mutual Loyalty and Quality of Work through study on ten universities and more than 1200 tested subjects. When Qin [7] et al study the staff morale level of state-owned enterprises, they investigated the morale dimensions from leadership behaviour, management approach, work content, working conditions, working atmosphere, psychological stress and company's performance. Hong [4] mainly combines the opinions of domestic and foreign scholars to study the morale dimensions from such three dimensions as organizational identification, work devotion, and team spirit. The studies of domestic and foreign scholars on morale dimensions haven't formed the opinion acceptable generally. However, most of scholars have defined the morale dimensions including the organizational commitment, working and living quality, and organization cohesion force, etc. The organizational commitment refers to a common sense emotion of the members of the organization for the objectives and culture of the organization, it is a kind of psychological phenomenon that the members feel proud of being a member of their own organization, and transfer the objectives and activities of their organization as their own awareness. Miller [8] et al, consider that the organizational commitment includes: organization belonging, organization loyalty, and common characteristics of an organization. The degree of working and living quality decides the degree of meeting from the low level physiological need to the high level senior need, while such degree is an important connation of the morale, it may include the material aspect and spiritual aspect. Sun [9] et al considers that the organization cohesion force refers to the motivation strength that a member would like to work at the organization through the interactions and reliance on the organization. Siebold [10] classifies the cohesion force into horizontal cohesion force, vertical cohesion force and the whole cohesion force, and designs the scale to conduct relevant measurement. The horizontal cohesion force mainly refers to the intimate relationship and team cooperation between the staffs; the vertical cohesion force includes: leader's care and abilities; the whole cohesion force includes: the pride and value sharing, and realization of demands and objectives. When Bartone [11] et al measured the team cohesion force of students of a Norwegian Navy Academy, mainly conducted the measurement through three aspects, and the scale has great influence and been applied extensively.

To summarize the studies of the said scholars on the morale dimensions, the following Chinese staff morale assessment dimensions have been established, see Table 1 as follows:

Table 1. Staff morale dimensions table of Chinese enterprises

Dimension No.	I-level Dimension	II-level Dimension
1	Ideological and political consciousness	The determination of carrying out the orders and resolutions, implementation of the party's policies and schemes; the attitude of participating in various anti-disaster activities and rescue activities, donation of money and materials, the attitude of anti-crime act and participation in labours
2	Professional quality and recognition of leadership ability	Examination results on various levels business attended and compliance; recognition of the decision-making power and executive force of the leader
3	recognition of the enterprise mission and vision	Reasonably handling the relationship between the self-development and the enterprise development, having a correct understanding for why to work, whom to work for, and how to work well
4	Awareness of the quality degree of equipment's and proficiency in using the equipment's	Understanding of the equipment's performance, the performance of the same kinds of foreign equipment's and comparison; proficiency in the using of equipment's, examination results on equipment's using, etc.
5	Relationship between superior and subordinate and among colleagues	Whether the relationship between superior and subordinate is harmonious, thus they can have an efficient communication; whether there is such phenomenon as grudge and in harmony among the colleagues, the condition of solidarity and friendship and mutual help
6	Economic standing and social standing of the staff	The level of remunerations in the whole society and the deposit condition, quantity of the staffs purchased houses and cars; the respect and trust degree of the society on the staff; the employment and marriage condition
7	Physical quality and psychological quality of the staff	The health and physical health of the staff; whether having a psychological disease, the opportunity of accepting the psychological education and practices and the ability of adaptation to the environment
8	Assessment on self-value realization degree and recognition degree to honours of the staff	Whether the staff has realized his life goal in this enterprise, comparing with the other people at the same aging period, whether the staff has a satisfaction feeling; the reward numbers, whether the staff feels pride that he is a member of the enterprise, the admiration degree to others' honours
9	Impact of the enterprise's environment on the staff and the force of the competitors	Whether the staff have deep awareness of the difficulty and challenges of the working environment in the enterprise; whether having a comprehensive understanding of the competitors
10	The satisfaction degree of the staff on the enterprise's spiritual life and material and cultural life	Cultural activities, sports activities of the staff, whether there are various knowledge sessions, humanistic knowledge contest; life supporting facilities; the nutrition, working and rest condition of the staff

2.3. Quantification of the Morale Dimensions

The quantification of the morale dimensions is the premise of the moral assessment. Here, it puts forward the method of taking initial value from two-dimensional square lattice and the method of taking value through moving from the neighbouring square lattice during the calculation (see Figure 1).

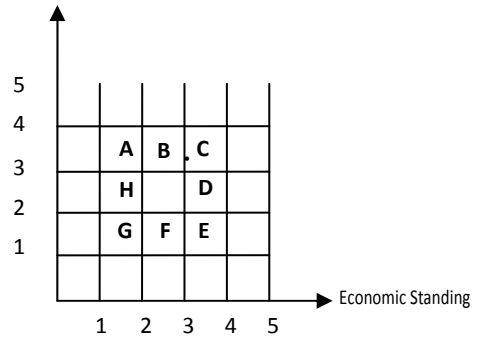

Figure 1. Method of taking value from the morale elements square lattice

The purpose of taking the initial value is to give a value during the initialization process of a computer. The method is to take the maximum value from the horizontal ordinates adding vertical coordinates of four corners of any one square in the two-dimensional square lattice. Taking the economic and social standings of the staff as an example, the horizontal axis represents the economic standing felt by a person, including five shares, if a person feels very satisfied to the economic standing, the maximum value is 5, and if a person feels very dissatisfied to the economic standing, the value may be 0. The vertical axis represents the social standing, including also 5 shares, and the maximum value is 5. They constitute a two-dimensional figure including $5 \times 5 = 25$ squares. In this figure, the square in black colour represents a certain time, the position of the economic and social standing of a person, the square has four coordinate points, and the dimensional value equals the sum of its horizontal ordinate adding vertical ordinate and when the result is the maximum value (i.e., the coordinate values at the black points at the top right corner of the square). In this figure, the dimensional value of the economic and social standing is $3 + 3 = 6$. The morale index may be considered as the results of the nonlinear interaction of the said factors and the self-adaptation under the stimulation of the environmental factors. Here, it gives the reference standard for the morale index: lower than 60 scores shall represents low emotion, 61–80 scores shall represent general, and 81–100 scores shall represent high emotion. The professional research institutions in USA, UK, Israel, etc. and Taiwan have conducted studies for the morale assessment and developed some scales. However, different countries have different results; the findings may only be taken as reference. At present, there are tens thousands of staffs in a large-sized enterprise in China, when assessing the morale, each person has to accept the investigation and measurement, it is not practicable and possible. In accordance with the statistics principle and rules, we can select certain representative individuals from different regions, different types of enterprises and different posts to conduct simulation, and thus get the morale index of the enterprises.

3. Morale Assessment Simulation and Theory Basis

3.1. Morale Assessment Simulation

"Morale Assessment Simulation" refers to a process of conducting the comprehensive analysis on the morale system, establishing an assessment simulation model of the morale system based on the determined goals, adopting the simulation technologies and methods, giving the random initial value and computation method to the morale dimensions, and obtaining the morale assessment results through

operating on the computer and analysing the results, which is also a process of "system → model → operation → results → analysis". In order to get the morale assessment results, during the process of establishing the simulation model, it is necessary to simplify the morale object body adopting the simulation modelling method and describe the morale dimensions and main characteristics using the appropriate presentation forms or rules, thus get the morale assessment simulation model and grasp the main features of the prototype system of the morale through studying the morale assessment simulation model.

3.2. Theoretical Basis of the Morale Assessment Simulation

Human is the carrier of the morale, human makes the morale complicated and mysterious. Adaptability of human is the strongest among all the objects, the morale system of human is a typical Complex Adaptive System (CAS). The morale system presents the obvious features which are the same with the Complex Adaptive System: the morale system is a structure with different levels composed of the highly intelligence and nonlinear interaction unit – human; there are materials, energies and information exchanges along the boundary of the morale system; the morale of enterprises is not the sample adding of several morale units, instead, it is a macro-feature of a system presented in a whole caused by interaction between multiple micro-level morale units – morale.

4. Morale Assessment Simulation Modelling Based on Multi-Agent

4.1. Multi-Agent

Multi-Agent is a frontier approach that the artificial intelligence and simulation studies use the most in recent years. Zhang [12], Yi [13]et al consider that the human society is a complex system composed of a large number of individuals, when establishing model for each individual in the computer, such model is called Agent, and these Agents follow certain rules and interactions, one Agent represents one person, multi-agent represents more than one people. Multi-Agent is a modelling approach used for making decisions for complicated social behaviours of humans (interaction between individuals) and for individuals to make decisions for the external environmental stimulations, the focus is the inter-behaviour and interaction between the Agents and between the Agent and the environment in the system. While the emergence of the morale complex system as a whole is a presentation of interaction between the Agents and between the Agent and the environment of the staff morale individual as a member of the system.

4.2. The Morale Unit Model Based on Multi-Agent

The morale unit refers to the basic action unit in the morale system, each unit is an independent information processing system, the information shall come from the information of the environmental module sensed by the sensor and the information from the database and algorithms library, after making decisions through the decision-making module, the execution module will drive the morale presentation module, so as to present the morale data. The modelling structure of the morale unit is to adopt the model of Deliberative Model + Response Model, see Figure 2. There are four big modules: 1) perceptive module; 2) communication/integration module; 3) decision-making module; 4) execution module. The content within the dashed line presents the modelling structure of the morale unit. Of which, as for the environment module: responsible for the collection and delivery of morale stimulation information by the external environment of the system; as for the perceptive module: responsible for the interaction information between the perceptive module, environment module and other action modules; as for the communication module: sending the perceptive information and system's information to the decision-making module through formatting; as for the decision-making module: under the support of database and algorithms library, upon conducting the intelligence processing for various information, sending them to the execution module for execution; as for the execution module: drive the environment module in accordance with the requirements, produce effects on the environment, thus change the environment;

as for the morale presentation module: present the execution results-morale through the presentation module. “The morale database” has collected different types of morale features data which can give to different morale units; “the algorithms library” has stored the interaction rules such as cluster rules, effect rules, stimulation response rules, etc. and the algorithms of such rules.

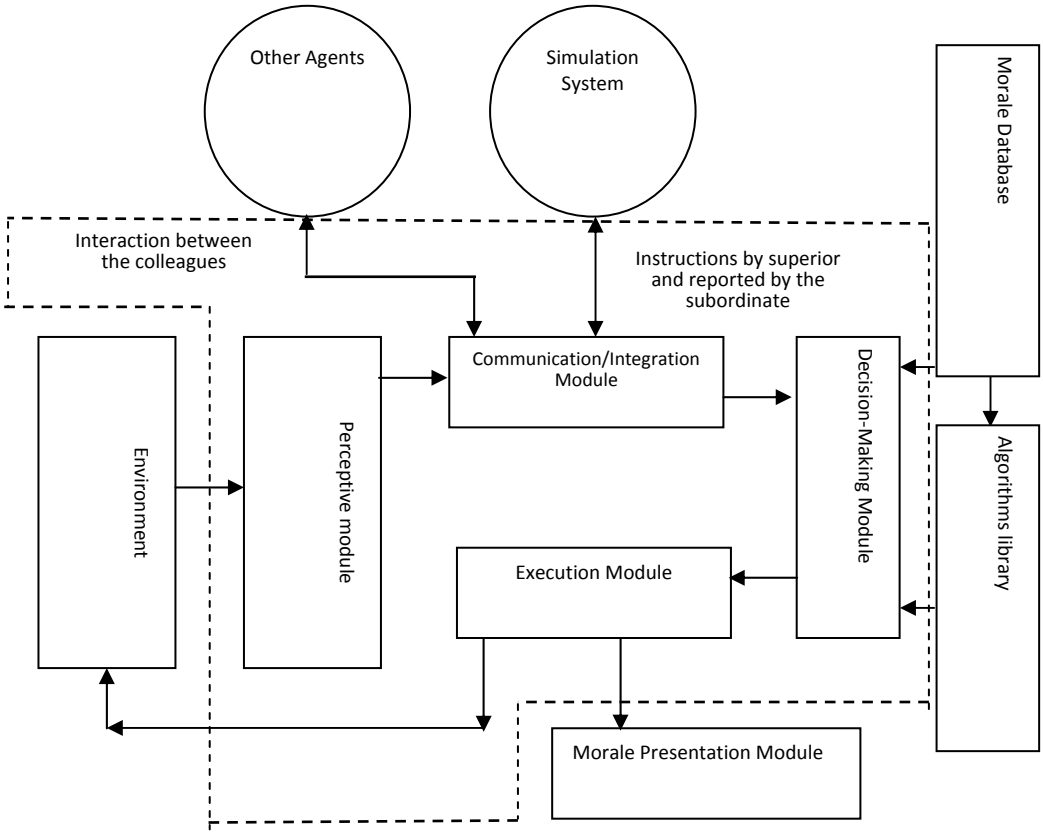

Figure 2. Structure of the moral unit

The abstraction of morale unit based on Multi-Agent: morale is a complex adaptive system, there are lots of factors influencing the morale, and such factors are nonlinear, hierarchical and self-adaptive. Therefore, we must start the study from the basic morale unit at the bottom; this unit refers to members in a team. Give the initial values of ten dimensions of morale to certain “person” (give different values to different persons random in accordance with relevant rules), so as to make his morale present such features, take the “person” through such abstraction processing as the basic unit of the morale simulation, thus obtain the morale unit based on Multi-Agent.

Structure of the Workshop Morale Assessment Simulation System based on Multi-Agent: in order to simplify study and expand to higher levels, here, we try to take the morale of one workshop (the workshop refers to the basic operating unit of a manufacturing enterprise and a logic starting point of studying the staff morale assessment simulation) as the study object, adopt the method based on Multi-Agent to establish the structure of the morale assessment simulation system.

Assume that there is one workshop Agent, which include two team Agents: “Team 1 Agent” and “Team 2 Agent”; each team has three morale units agents (the modelling approach based on Multi-Agent, it is easy for adding the morale unit Agent, here, in order to be convenient for description and computation, it is assumed that each workshop has two teams Agents, each team has three agents as representatives). The workshop morale simulation system has six morale units Agents in total, their feature is random, i.e., “SQ1Agent”, “SQ2 Agent”, “SQ3 Agent” and “SQ4Agent”, “SQ5Agent”, “SQ6Agent”. For the structure of the workshop morale simulation system, see Figure 3.

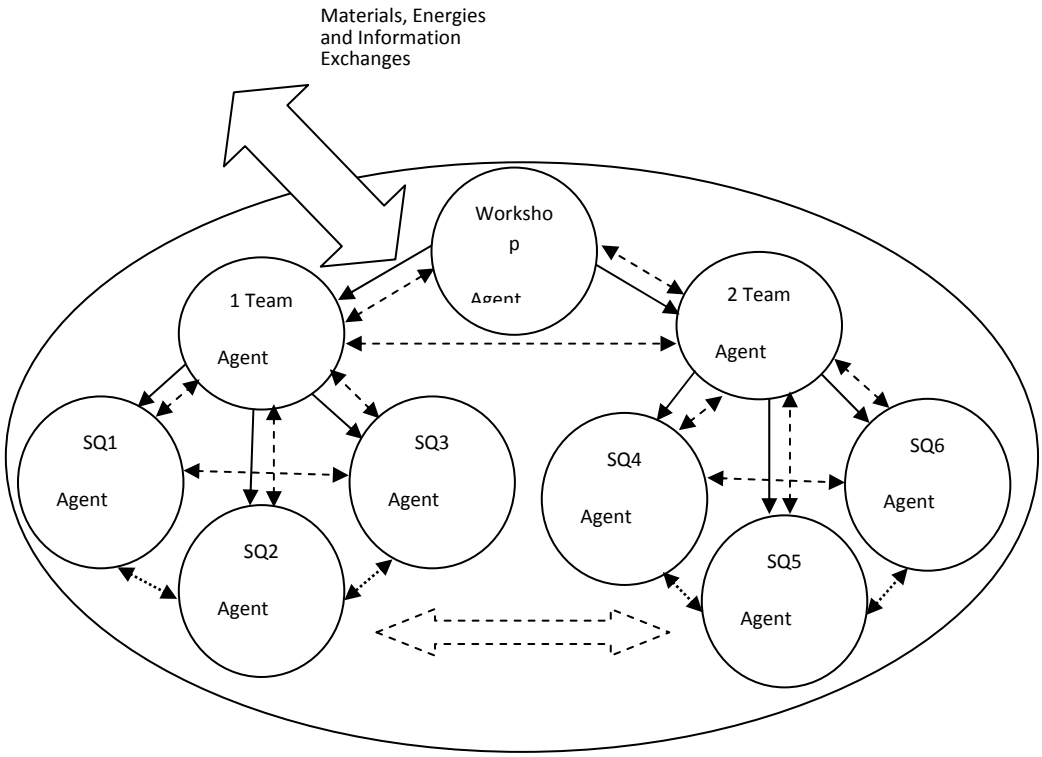

Figure 3. Structure of workshop morale assessment simulation system

Each perfect circle "○" represents an abstract functional unit of the morale, and it assembles all the morale properties of a person, the single sided solid line arrowhead represents the control relationship of the superior to the subordinate, the double sided dashed line arrowhead represents the information exchange and mutual influence among the Agents, the double sided hollow solid line arrowhead represents that there is exchanges of materials, information and energies along the boundary between the system and the external environment, the double sided hollow dashed line arrowhead represents the interactive influence between individuals of different teams. There are three levels from bottom to top, and such three levels respectively represent the morale individual, team and workshop. To be simplified, each team has three representatives, for example, Team 1 has four parts: "SQ1Agent" represents the group with higher morale, "SQ2Agent" represents the group with medium morale, and "SQ3Agent" represents the group with general morale, "Team 1 Agent". "Team 1 Agent" represents the agent of the leader of Team 1 and that it has the commanding, controlling and influence powers to the subordinate, it is aggregations which may represents the subordinate and show the whole ability properties and relations between the properties to the outside parties. Team 2 also has four parts: "SQ4Agent" represents the group with higher morale, "SQ5Agent" represents the group with medium morale, and "SQ6Agent" represents the group with general morale. "Team 2 Agent". "Team 2 Agent" represents the agent of the leader of Team 2 and that it has the commanding, controlling and influence powers to the subordinate, it is aggregations which may represents the subordinate and show the whole ability properties and relations between the properties to the outside parties. "Workshop Agent" represents the agent of the leader of the workshop and that it has the commanding, controlling and influence powers to the subordinate (teams), it is aggregations which may represents the subordinate and show the whole ability properties of the workshop and relations between the properties to the outside parties. The interaction of the Workshop Agent on the subordinate individual Agent is realized through the Team Agent. Combine the multiple morale functional units together in accordance with the enterprise's formation, then aggregate based on the commanding, commanded relationship and the relationship between the same levels among them, so as to form a tree shape net structure. The biggest oval frame on the external part represents the boundary of the morale system and the external environment to be studied, and the internal part of the oval frame is the scope of activity for the morale units. There are exchanges of materials, information and energies along the boundary. The external stimulation will break the original balance of the morale system, and

the interaction between the morale Agent in the system and the external stimulation and the interaction between the morale Agents will show the nonlinear, self-adaptive and "emergence" features of the complex adaptive system, the system will transfer from a balance status to another balance status, until reach a new balance, that is to say, the morale system will change and form a new workshop morale Agent, which is the workshop simulation morale index that we need.

5. Conclusions

The morale has the dynamic and changing nature, it is a complicated system, most of studies on morale are conducted through questionnaire, in order to improve the scientific nature of the morale studies, this paper has put forward the basic concept for the morale assessment simulation modelling and established the major index system influencing the enterprise's morale and conducted quantitative exploration on the dimensions, established the workshop morale assessment simulation model. Under the theoretical guidance of the complex adaptive system, simulation of morale assessment adopting the modelling simulation approach based on Multi-Agent is a feasible method, the establishment of Multi-Agent morale assessment simulation system may not only help the rapid scientific assessment on the enterprise's morale, but also have the important identification and guiding value for the study subject of combining qualitative nature with quantitative nature involved in other fields during the enterprise employee management.

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OPTIMAL BUDGET REASSIGNMENT PROBLEM AMONG SEVERAL PROJECTS WITH DIFFERENT PRIORITIES

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The problem of optimal planning for a design office comprising PERT-COST network projects with different priorities is solved. At the upper level – the design office level – the problem centres on reassigning the total budget in order to optimize the combination of projects' reliabilities and priority values. At the second level – the project level – the problem's solution boils down to optimal budget reassignment among the project's activities subject to the least permissible project's reliability value. The solution is obtained by a combination of heuristic and Monte-Carlo methods.

Keywords: budget reassignment, project's reliability, PERT-COST project, global search method, Monte-Carlo method, project's design office.

1. Introduction

This paper is actually a continuation of paper [6] where the problem centres on determining the minimal budget value assigned to a PERT-COST project as well as local budget values assigned to the project's activities. In the paper under consideration a hierarchical optimal planning model comprising two levels, is outlined. Only planning techniques are considered. Unlike papers [2–5], we will implement at each hierarchical level, Monte-Carlo methods.

2. Notation

Let us introduce the following terms:

C - total design office budget (pregiven);
$G_k(N, A)$ - the k -th stochastic network project (graph) of PERT-COST type, $k = 1,2,...,n$;
n - the number of projects;
D_k - the due date of the k -th project (pregiven);
η_k - priority value of the k -th project (pregiven); note that if $G_{k_1}(N, A)$ is of higher importance than $G_{k_2}(N, A)$, relation $\eta_{k_1} > \eta_{k_2}$ holds;
C_k - budget assigned to project $G_k(N, A)$ (to be optimized);
p_k^* - the minimal acceptable project's $G_k(N, A)$ reliability (pregiven);
T_k - random duration of project $G_k(N, A)$;
$(i, j)_k$ - activity entering $G_k(N, A)$;
$c(i, j)_k$ - budget assigned to $(i, j)_k$ (to be determined and optimized);
$t(i, j)_k$ - random duration of $(i, j)_k$;
$c_{\min}(i, j)_k$ - the minimal possible budget to operate activity $(i, j)_k$ (pregiven);
$c_{\max}(i, j)_k$ - the maximal possible budget to operate activity $(i, j)_k$ (pregiven);
$R_k(C_k)$ - the maximal reliability value $\Pr\{T_k < T_k | C_k\}$ on the basis of assigned budget C_k;
$\vec{X}$ - search point vector;
δC_k - search step value for the local budget C_k;
δc_d - search step value for the d -th coordinate, $d = 1,2,..., M_k$;

M_k - the dimension of the Euclidean search space (number of activities $(i,j)_k$);

Δ - the pregiven minimal accuracy of the local search process;

γ - a random M_k-dimensional value uniformly distributed on a unity simplex;

$p\{t(i,j)_k, c(i,j)$ - thep.d.f. of $t(i,j)_k$ on condition that budget $c(i,j)_k$ is assigned to $(i,j)_k$. Note that $R\{C_k\} = \max\limits_{\{c(i,j)_k\}} \Pr\left\{ T_k \le T_k \middle| C_k, \sum\limits_{\{(i,j)_k\}} c(i,j)_k = C_k \right\}$ subject to

$$\sum_{\{(i,j)_k\}} c(i,j)_k = C_k \,, c_{\min}(i,j)_k \le c(i,j)_k \le c_{\max}(i,j)_k, \qquad (i,j)_k \subset G_k(N,A),$$

holds;

Y_1 - the pregiven number of consecutive unsuccessful random steps undertaken from a routine initial search point;

Y_2 - the pregiven number of simulating initial search points.

Note, in conclusion, that similar to [5–6], for each activity $(i,j)_k$ budget $c(i,j)_k$ assigned to that activity enters parametrically in the corresponding p.d.f. $p\{t(i,j)_k, c(i,j)_k\}$.

3. The General Problem

The problem centres on determining:

- budget values C_k^*, $k = 1,2,...,n$, assigned to all projects $G_k(N,A)$,
- local budget values $c^*(i,j)_k$ assigned to activities $(i,j)_k \subset G_k(N,A)$,

– in order to maximize objective

$$W = \max \sum_{k=1}^{n} R_k\left(C_k^*\right) \cdot \eta_k \tag{1}$$

subject to

$$\sum_{k=1}^{n} C_k^* = C \,, \tag{2}$$

$$R_k\left(C_k^*\right) \ge p_k^* \,, \tag{3}$$

$$c_{\min}(i,j)_k \le c^*(i,j)_k \le c_{\max}(i,j)_k \,. \tag{4}$$

Problem (1–4) is a sophisticated and complicated problem which can be solved by a combination of heuristic and simulative methods.

4. Auxiliary Problem I

In [6] an auxiliary Problem I is formulated.

Given $G_k(N,A)$, D_k, $(i,j)_k \subset G_k(N,A)$, $c_{\min}(i,j)_k$, $c_{\max}(i,j)_k$, $p\{t(i,j)_k, c(i,j)_k\}$ and C_k, determine local budget values $c^*(i,j)_k$ assigned to all activities $(i,j)_k \subset G_k(N,A)$, in order to maximize the project's reliability, i.e., determine

$$R(C_k) = \max_{c(i,j)_k} \Pr\left\{ T_k \le D_k \middle| C_k, \sum_{\{(i,j)_k\}} c(i,j)_k = C_k \right\} \tag{5}$$

subject to (2, 4).

Two different algorithms of solving Problem I can be used, namely:

- the algorithm based on heuristic procedures;
- the Monte-Carlo algorithm.

In order to simplify the algorithms and taking into account that both algorithms refer to single projects, we will omit further on index *k*.

5. Heuristic algorithm (Algorithm I)

The steps of the well-known classical heuristic algorithm [2–4] are as follows:

Step 1. By any means reassign C among all activities (i, j) entering $G(N, A)$ subject to (2, 4). Note that C exceeds $\sum_{\{(i,j)\}} c_{\min}(i, j)$, otherwise project's reliability R equals zero. Thus, it is always possible to undertake a feasible, non-optimal distribution. In case $C \geq \sum_{\{(i,j)\}} c_{\max}(i, j)$ values $c^{opt}(i, j) = c_{\max}(i, j)$.

Step 2. Implement $c(i, j)$ obtained at Step 1 into the given p.d.f. $p\{t(i, j), c(i, j)\}$ for all activities $(i, j) \subset G(N, A)$.

Step 3. Simulate values $t(i, j)$ with p.d.f. obtained at Step 2, $(i, j) \subset G(N, A)$.

Step 4. Calculate the critical path length of the project $L_{cr}(G, \{t(i, j)\})$.

Step 5. Determine all activities $(i, j) \subset G(N, A)$, which belong to the critical path.

Step 6. Repeat Steps 2–5 N times in order to obtain a representative statistics.

Step 7. Calculate ratio $N'/N = R^{(q)}$, where N' is the number of simulated values $L_{cr}(G(N, A), \{t(i, j)\})$ which do not exceed the due date D, and q is the number of the current iteration.

Step 8. Compare two adjacent ratios $R^{(q)}$ and $R^{(q-1)}$. If both relations

$$R^{(q)} > R^{(q-1)}, \tag{6}$$

$$\frac{R^{(q)} - R^{(q-1)}}{R^{(q-1)}} \geq \Delta \tag{7}$$

hold (value Δ is externally given), apply the next step. If relation (6) does not hold, go to Step 14, with values $c(i, j)$ obtained at the $(q-1)$-th iteration. If relation (6) holds but (7) do not hold, proceed to Step 14 with $c(i, j)$ obtained at the q -th iteration.

Step 9. Calculate frequency $\bar{p}(i, j)$ of each activity (i, j) to be on the critical path (using Step5 for N simulations).

Step 10. Reschedule all the activities in a descending order of values

$$\nu(i, j) = \bar{p}(i, j) \cdot \mu(i, j, c(i, j)), \tag{8}$$

where μ is the average value for the p.d.f. $p\{t(i, j), c(i, j)\}$.

For activities with $\bar{p}(i, j) = 0$ reschedule those activities in descending order of their average values $\mu(i, j, c(i, j))$.

Step 11. Determine activity (i_ξ, j_ξ) *with the highest priority* for which relation

$$Z_1 = c_{\max}(i_\xi, j_\xi) - c(i_\xi, j_\xi) > 0 \tag{9}$$

holds. Activity (i_ξ, j_ξ) is placed at the beginning of the sequence and refers usually to critical activities.

Step 12. Determine activity (i_η, j_η) *with the lowest priority* for which relation

$$Z_2 = c(i_\eta, j_\eta) - c_{\min}(i_\eta, j_\eta) > 0 \tag{10}$$

holds. Activity (i_η, j_η) is placed at the end of the sequence and is usually a non-critical activity, which practically has no influence on the project's reliability.

Step 13. Reassign cost value $Z = \min(Z_1, Z_2)$ from activity (i_η, j_η) to activity (i_ξ, j_ξ). Return to Step2.

Step 14. The algorithm terminates. Values $c(i, j)$ obtained after decision-making at Step 7 determine the maximal project's reliability $R(C)$.

Extensive experimentation shows [2–4, 7] that the outlined above Algorithm I is less efficient than the Monte-Carlo algorithm, especially in cases of relatively small amounts of projects entering the design office. Therefore for both hierarchical levels – the project and the company level – we will use the Monte-Carlo approach.

6. Monte-Carlo algorithm (Algorithm II)

The algorithm's novel step-wise structure is as follows:

Step 1. Generate by means of Monte-Carlo method [1] M independent random varieties with p.d.f. $p(x)=e^{-x}$; let them be $\alpha_1,\alpha_2,...,\alpha_M$. Here M is the number of activities (i,j) entering project $G(N,A)$.

Step 2. Calculate random varieties $\beta_1,...,\beta_M$, where $\beta_d=\dfrac{\alpha_d}{\sum_{d=1}^{M}\alpha_d}$. It can be proven that vector $\vec{\beta}^*=(\beta_1,...,\beta_M)$ is distributed uniformly on simplex $\sum_{d=1}^{M}\beta_d=1$, $0<\beta_d<1$, $d=1,2,...,M$.

Step 3. Repeat Steps 1 $\rightarrow$ 2 to obtain another independent vector $\vec{\beta}^{**}$.

Step 4. Calculate vector $\vec{\gamma}=\vec{\beta}^{**}-\vec{\beta}^*$. The latter satisfies $\sum_{d=1}^{M}\gamma_d=0$, $-1<\gamma_d<1$, $d=1,2,...,M$.

Step 5. Enumerate all activities (i,j) entering the project $G(N,A)$, by different ordinal numbers from 1 to M. Denote the d-th activity by a_d, it's corresponding minimal and maximal local budgets by $c_{\min d}$ and $c_{\max d}$, and the budget to be assigned and determined in the course of solving the general problem – by c_d, $d=1,2,...,M$.

Step 6. Simulate by means of Monte-Carlo the initial search point $\vec{c}_d^{\,0}$

$$\vec{c}_d^{\,0}=\vec{c}_{\min d}+\vec{b}_d, \tag{11}$$

where

$$b_d=\left(c_{\max d}-c_{\min d}\right)\beta_d^*\cdot\Theta, \tag{12}$$

$$\Theta=\frac{C-\sum_{d=1}^{M}c_{\min d}}{\sum_{d=1}^{M}\left[\left(c_{\max d}-c_{\min d}\right)\beta_d^*\right]}. \tag{13}$$

Step 7. In case when for some activities a_d $c_d^0>c_{\max d}$, set $c_d^0=c_{\max d}$.

Step 8. Similarly to Step 10 of Algorithm I, reschedule all activities in the descending order of their contribution to the project's reliability.

Step 9. Calculate $C'=\sum_{d=1}^{M}c_d^0$. If $C'>C$, calculate the difference $C'-C$ and diminish the budget of non-critical activities in order to equalize the summarized decrease to that difference. The process of diminishing the budget starts from below, i.e., from the least important activities.

In case $C'<C$ the calculated difference $C-C'$ has to be spent on increasing the budget of critical activities, starting from above according to the previously rescheduled activity sequence.

Denote by c_d^0 the finally obtained budget levels, $d=1,2,...,M$.

Step 10. Solve the classical simulation problem to simulate reliability value $R(C) = \Pr\{T_{cr} < D/C, c(i,j), c_{\min}(i,j), c_{\max}(i,j)\}$. The problem can be solved by determining p.d.f. $p\{t(i,j), c^0(i,j) \leftrightarrow c_d^0\}$ for all activities entering the project and later on, by simulating values $t(i,j)$, $(i,j) \subset G(N,A)$. Afterwards, by repeating Step 10 numerous times (similar to Steps 2–7 of Algorithm I), reliability value $R(C)$ is determined. Call it henceforth value R^0, i.e., the initial search point's reliability.

Step 11. Undertake a local search from the initial point

$$\vec{X}^{(0)} + \Delta\vec{X} \Rightarrow \vec{X}^{(1)}, \tag{14}$$

where ΔX is the random search increment.

Here $\vec{X}^{(0)} = \vec{c}^{\,0}$ and $\Delta\vec{X} = \vec{\gamma} \cdot \delta c_d$, where δc_d is the d-th coordinate's search step and $\vec{\gamma}_d$ has been obtained at Step 4.

Step 12. In the course of carrying out the local random search, we will use the optimum trial random search algorithm [1]. Step 12 centres on considering a sequence of Q independent M-dimensional increments $\Delta\vec{X}_q$, $q = 1,2,...,Q$, with q vectors $\vec{\gamma}_q = (\gamma_{q1}, \gamma_{q2}, ..., \gamma_{qM})$ satisfying $\sum_{d=1}^{M} \gamma_{qd} = 0$. After implementing each q-th increment a correction of coordinate values is undertaken as follows: if $c_d^{(1)} > c_{\max d}$ set $c_d^{(1)} = c_{\max d}$ and in case $c_d^{(1)} < c_{\min d}$ set $c_d^{(1)} = c_{\min d}$.

Later on an additional correction for each q-th increment $\Delta\vec{X}_q$ has to be undertaken similar to that described at Step 9.

Step 13. At each search point $\vec{X}_q^{(1)}$, $q = 1,2,...,Q$, Step 10 is applied to calculate the project's reliability $R(\vec{X}_q^{(1)})$. Take the search point with the *maximal* value $R(\vec{X}_\xi^{(1)})$, $1 \le \xi \le Q$. If $R(\vec{X}_\xi^{(1)})$ exceeds $R(\vec{X}^0)$, point $\vec{X}_\xi^{(1)}$ is chosen as the new initial search point, i.e., $\vec{X}_\xi^{(1)} \Rightarrow \vec{X}^{(0)}$. Go to the next step.

If $R(\vec{X}_\xi^{(1)})$ does not exceed $R(\vec{X}^0)$ the search terminates at point $\vec{X}^0$.

Note that in the course of undertaking a local random search vector $\vec{\gamma}$ is always renewed by operating Steps 1–4.

Step 14. Check relation

$$\frac{R(\vec{X}_\xi^{(1)}) - R(\vec{X}^{(0)})}{R(\vec{X}^{(0)})} \ge \Delta. \tag{15}$$

If (15) holds, return to Step 11. Otherwise apply the next step.

Step 15. Store the results of the local search process [vector $\vec{c}_d$, $R(\vec{X}^{(1)})$] in a special array.

Step 16. Counter f of the number of simulating initial points $\vec{X}^0$ works, $f := f + 1$.

Step 17. If $f \le Y$, return to Step 1. Otherwise apply the next step.

Step 18. Take the *maximal* project's reliability of the Y initial search points stored in a special array (see Step 15). The corresponding reliability $R(C)$ together with the optimal vector $\vec{c}_d$, is the solution of Problem I.

7. Auxiliary Problem II

The problem is as follows:

For a single PERT-COST project $G(N,A)$ with given values $c_{\min}(i,j)$, $c_{\max}(i,j)$, $(i,j) \subset G(N,A)$ and p^*, determine the *minimal* budget C assigned to that project, together with values $c(i,j)$, which enables

$$R(C) \geq p^*. \tag{16}$$

Thus, the problem's formalization is as follows:

$$\min C \tag{17}$$

subject to

$$R(C) = \Pr\{T < D/C\} \geq p^* \tag{18}$$

and (2, 4).

The enlarged step-wise algorithm to solve Problem II is as follows:

Step 1. Set $C = \sum_{\{(i,j)\}} c_{\min}(i,j)$.

Step 2. Set counter $h := 1$.

Step 3. Calculate $C := C + h \cdot \delta C$.

Step 4. Solve auxiliary Problem I to obtain $R(C)$.

Step 5. Compare $R(C_G)$ and p^*. If $R(C_G) \geq p^*$ holds, proceed to Step 7. Otherwise apply the next step.

Step 6. Counter h works, $h := h + 1$. Return to Step 3.

Step 7. The algorithm terminates with the minimal budget value obtained at Step 3 and values $c(i,j)$ determined by solving auxiliary Problem I at Step 4.

Note that value C obtained at Step 1 enables solving Problem B at Step 4. However, the corresponding initial reliability value $R(C)$ will be extremely small.

8. The General Problem (GP)

The general idea of solving GP (1–4) is based on implementing the Monte-Carlo method and is very similar to the algorithm outlined in Section 6. The enlarged algorithm's step-wise structure is as follows:

Step 0. Given (see Notation):

- total budget value C;
- local projects $G_k(N, A)$, $k = 1,2,...,n$;
- priority values η_k, $k = 1,2,...,n$;
- due date values D_k, $k = 1,2,...,n$;
- values $c_{\min}(i,j)_k$ and $c_{\max}(i,j)_k$, $k = 1,2,...,n$, $(i,j)_k \subset G_k(N,A)$;
- minimal projects' reliability values p_k^*.

Step 1. Solve separately for each project $G_k(N, A)$ auxiliary Problem II. Determine the minimal budget values by C_k', $k = 1,2,...,n$. Thus,

$$C_k' = \min(C_k) \tag{19}$$

subject to

$$R(C_k) \geq p_k^*. \tag{20}$$

Step 2. Check inequality

$$C \geq \sum_{k=1}^{n} C_k' \ . \tag{21}$$

If the inequality does not hold, the general problem has no solution. Otherwise calculate

$$\Delta C = C - \sum_{k=1}^{n} C_k' \ .$$

Step 3. Similarly to Steps $1 \to 2$ of Algorithm II for solving auxiliary Problem I, generate n random values $\beta_1^*, \beta_2^*, ..., \beta_n^*$ with vector $\vec{\beta}^*$ being distributed uniformly on simplex $\sum_{k=1}^{n} \beta_k^* = 1$.

Simulate the initial search point $\vec{X}^{(0)}$

Step 4.

$$\vec{X}^{(0)} \equiv \vec{C}_k^{(0)} = \vec{C}_k' + \Delta C \cdot \vec{\beta}_k . \tag{22}$$

Step 5. Calculate objective W for the initial search point

$$W^{(0)} = \sum_{k=1}^{n} R_k\left(C_k^{(0)}\right) \cdot \eta_k , \tag{23}$$

where $R_k\left(C_k^{(0)}\right)$ is calculated by means of solving auxiliary Problem I (either by using Section 5 or Section 6).

Step 6. Similarly to Steps 3 and 4 of Monte-Carlo Algorithm II (see Section 6), calculate vector

$$\vec{\gamma} = \vec{\beta}^{**} - \vec{\beta}^{*} , \tag{24}$$

which satisfies

$$\sum_{k=1}^{n} \gamma_k = 0 , -1 < \gamma_k < 1 , \quad k = 1,2,...,n . \tag{25}$$

Step 7. Undertake a routine search step in an n -dimensional space $\vec{X}^{(0)} \Rightarrow \vec{X}^{(1)}$, where $\vec{X}^{(1)}$ is determined by

$$\vec{X}^{(1)} = \vec{X}^{(0)} + \Delta C \cdot \vec{\gamma} . \tag{26}$$

Step 8. If in the course of any search step coordinate k , $k = 1,2,...,n$, satisfies , the search step is regarded non-feasible, and we apply Step 11. Otherwise proceed to the next step.

Step 9. Calculate objective $W^{(1)}$ (see Step 5) for the search point $\vec{X}^{(1)}$ in order to compare values $W^{(0)}$ and $W^{(1)}$.

Step 10. If $W^{(1)} > W^{(0)}$, search point $\vec{X}^{(1)}$ is set as the initial one, $\vec{W}^{(1)} \equiv \vec{W}^{(0)}$; clear counter f and return to Step 6. Otherwise apply the next step.

Step 11. Counter f_1 of the number of consecutive unsuccessful search steps taken from search point $\vec{X}^{(0)}$ works, $f_1 = f_1 + 1$.

Step 12. If $f_1 \le Y_1$, return to Step 6 to simulate the next routine search step to be made from point $\vec{X}^{(0)}$. Otherwise, apply the next step.

Step 13. Counter f_2 of the number of simulated initial search points works, $f_2 = f_2 + 1$.

Step 14. If $f_2 \le Y_2$, return to Step 3. Otherwise, proceed to the next step.

Step 15. Choose the maximal value of objective W from Y_2 initial search points stored in a special array; consider the chosen value to be the optimal value $W^{(opt)}$.

Step 16. For all values $C_k^{(opt)}$ entering objective $W^{(opt)}$ remember all values $c(i,j)_k$ which have been previously determined at Step 5.

Optimal values $c^{(opt)}(i,j)_k$, which together with values C_k have to be stored in a special array, form the general problem's solution.

9. Conclusions

The following conclusions can be drawn from the study:

1. The paper presents a hierarchical budget reassignment model in the form of unification of several single-level models.
2. Single-level models can be optimized by means of Monte-Carlo methods as well as sophisticated heuristic techniques.
3. When the number of projects entering the design office is relatively small we suggest using the Monte-Carlo approach.

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REGION BASED MULTI-SPECTRAL SALIENCY DETECTION

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Visual saliency detection is useful for applications like image segmentation, image retrieval et al. According to the thought that the near-infrared image can provide complementary information to the corresponding visible image, a new region based multi-spectral saliency detection method is proposed. The source images are decomposed into homogeneous regions by superpixel algorithm in 6-dimentional vector space which is composed of the LAB colour values of the visible image, the grey value of the near-infrared image and the two-dimensional pixel coordinate. Then the final saliency map is obtained by measuring the region's contrast which is computed by using multi-spectral colour information and spatial distance. The publicly RGB-NIR dataset is adopted for experiment evaluation; Compared with five other state-of-the-art methods, the proposed method produces superior performance. Experimental results show that the proposed method is effective.

Keywords: saliency detection, multi-spectral, superpixel, region contrast

1. Introduction

The visual attention mechanism in humans can rapidly focus on the context relevant stimuli while suppressing the unimportant ones. The mechanism has been studied in computer vision for a long time; Visual saliency detection [1, 2] is useful for applications like image retrieval, image compression and object segmentation et al, by assuming there are one or several salient objects in the image.

Most of the existing saliency detection methods can be categorized as top-down computational model and bottom-up computational model. Generally the top-down model is in conjunction with task-driven or visual search, and the bottom-up model is stimulus-driven. Many researches [3, 4, 5, 6, 7] have focused on the bottom-up model by computing the feature contrast including colour variation of individual pixels, edge and gradient, texture, histogram, spatial frequency, or combinations thereof. Goferman et al. [3] propose the context-aware saliency method, which detects the important parts of the scene rather than the traditional salient object, however, the method uses multi-scale computation and it tends to acquire a high salience value on the edge, not highlight the entire salient region. Li et al. [4] combine the global information form frequency domain analysis and local information from spatial domain analysis to generate the saliency map. Cheng et al. [5] employ the colour histogram feature in Lab colour space to calculate the image contrast but it is difficult to handle cluttered and textured background. Achanta et al. [6] determine the saliency by using the maximum symmetric surrounds and Vikram et al. [7] compute the saliency map by random regions. The above three methods [5, 6, 7] do not downscale the input image to low resolution and generate full resolution saliency map, however, they calculate the saliency value of each pixel independently like many other methods, so the correlation between pixels is not considered properly. Cheng et al. [5] propose another contrast analysis method, region contrast, by combine region segmentation and histogram representation. It can generate spatially coherent saliency map at the cost of the reduced calculation performance. The above methods can show significant performance on the specific testing dataset, Borji et al. [1] review a large body of recent start-of-the-art visual attention models and provide a critical comparison of their capabilities and shortcomings.

Despite so many methods have been proposed and contributed to the specific task, the start-of-the-art performance is not satisfying. The same object should have an identical saliency value in an ideal case; however most of the existing methods ignore the spatial correlation between pixels. Also, almost methods are studied based on the visible image. Due to the differences in the characteristics of image sensor, the infrared image can provide differentially information which is complementary to the visible image [8, 9].

Motivated by this, our focus in this paper is proposing a new region based multi-spectral saliency method based on a pair of visible and infrared images. Our main contribution is that the source images are decomposed into homogeneous regions by superpixel algorithm in 6-dimentional vector space; we modify the SLIC (simple linear iterative clustering) superpixel algorithm [10] to execute the superpixel

segmentation in the 6-dimentional vector space which is constituted by the Lab colour component in visible image, the grey component in infrared image and the position of the pixel in image coordinates; and then the saliency map can be computed by the region's contrast, which is more emphasis on the object rather than single pixel. The proposed method is tested on the public benchmark [9] and it can obtain superior performance than the other comparable state-of-the-art methods.

2. Proposed Method

The framework of the proposed method is illustrated in Figure 1.

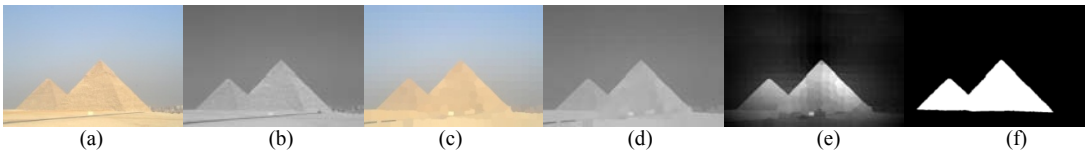


Figure 1. The framework of the proposed method
(a) and (b) are the visible source image and the corresponding near-infrared image;
(c) and (d) are the homogeneous regions using the superpixel segmentation method;
(e) is the saliency map by the proposed method and (f) is the ground truth

2.1. Color Space Illustration

Almost all saliency methods utilize a colour space to descript the visible image; some have used RGB while others have used the Lab. The Lab space is preferred to RGB space because the L component matches human perception of lightness, while the a component and b component approximate the human chromatic opponent system. We also adopt the Lab colour space to represent the visible image.

Near-infrared image is introduced into the saliency. It can be taken to interpret the different characteristics of the scene because its wavelength is discriminative to the visible wavelength. So the grey value of the near-infrared image represented by variable g is used as a complementary component to the Lab component of the visible image.

The visible image and the corresponding near-infrared image have the same resolution. We consider the resolution is $r \times c$, where r and c are the number of rows and columns respectively, thus the L, a, b, g components have the same resolution $r \times c$.

2.2. Generating Homogeneous Regions

We aim to decompose the input image into a series of perceptually homogeneous regions by clustering pixels with similar properties. Superpixel algorithm is able to group pixels into perceptually meaningful atomic regions. The SLIC algorithm [10] is faster, more memory efficient than the comparable superpixel methods and exhibits start-of-the-art boundary adherence. In this paper, the input images include a visible image which is a colour image and a near-infrared image which is a grey image. We extend the original SLIC algorithm to the $[Labgxy]$ 6-dimentional space, where $[Labg]$ is defined in the 2.1 section, $[xy]$ is the pixel position.

Assuming K is the desired number of superpixel, N is the pixel number of the input number. We initialize the cluster centres $C_k = [l_k, a_k, b_k, g_k, x_k, y_k]^T$ with $k = [1, K]$ at regular grid interval S. The grid interval S is set to $S = \sqrt{N/K}$ for approximately equally sized superpixels. To avoid initializing the cluster centre on the edge or a noisy pixel, the centres are moved to seed locations corresponding to the lowest gradient position in a 3×3 neighbourhood.

After initialization, each pixel i is associated with the nearest cluster centre according to the distance measure. Assuming the pixels that have similar properties lie in a region $2S \times 2S$ around the superpixel centre, the search is done in the $2S \times 2S$ region on the xy plane. The distance measure D is defined as follows:

$$d_{labg} = \sqrt{(l_k - l_i)^2 + (a_k - a_i)^2 + (b_k - b_i)^2 + (g_k - g_i)^2}, \quad (1)$$

$$d_{xy} = \sqrt{\left(x_k - x_i\right)^2 + \left(y_k - y_i\right)^2}, \tag{2}$$

$$D = \sqrt{{d_{labg}}^2 + \left(\frac{m}{S}\right)^2 {d_{xy}}^2}, \tag{3}$$

where D represents the distance between a pixel i with the cluster centre C_k. d_{labg} represents the colour distance and d_{xy} represents the spatial distance. The variable m is used to weigh the relative importance between colour similarity and spatial proximity. The greater the value of m, the more spatial proximity is emphasized and the more compact the region. The range of m is [1, 40] and m is set to 10 for all experiments.

Next, after each pixel has been associated to the nearest cluster centre, the new cluster centre is computed by the mean $\left[l, a, b, g, x, y\right]^T$ vector of all the pixels belonging to the cluster region. And the residual error E measured by L_2 norm is computed between the new centre and the previous centre.

We iteratively repeat the process of associating each pixel with the cluster centre and recomputing the new cluster centre until the residual error converges. We set the number of iterations is 10 which is appropriate for most images.

After the clustering step, a post-processing step is adopted by relabeling disjoint region with the labels of the largest neighbouring cluster using a connected components algorithm as depicted in [10]. We illustrate the effect of generating homogeneous regions in Figure 2.

(a) (b) (c) (d) (e) (f)

Figure 2. (a) and (b) are the visible image and the nir image
(c) and (d) are the images segmented using SLIC method;
(e) and (f) are the images segmented using the proposed method

2.3. Measuring Region Based Saliency

In this work, we define the saliency measure on the region level and then combine the saliency value with centre prior to get a pixel-accurate saliency map. Human are prone to pay more attention to meaningful regions instead of single pixels and they often concentrate the objects of interest near the centre of the image. So the saliency method based on region and centre prior is consistent with the characteristics of the human vision and it is robust to image noises.

When the labelling of the homogeneous regions is obtained, for each region, we calculate its saliency by measuring its colour contrast and spatial distance to other regions. The spatial weighting term is incorporated to emphasize the contrast of the region and its closer surrounding regions, the father regions in image plane are less considered.

The saliency of a region is defined as follows:

$$S\left(r_k\right) = \sum_{i \neq k} w\left(r_i, r_k\right) d_c\left(r_i, r_k\right), \tag{4}$$

$$d_c\left(r_i, r_k\right) = \max\left(\left|l_i - l_k\right|, \left|a_i - a_k\right|, \left|b_i - b_k\right|, \left|g_i - g_k\right|\right), \tag{5}$$

$$w\left(r_i, r_k\right) = e^{-\frac{d_s\left(r_i, r_k\right)}{\sigma^2}}, \tag{6}$$

where $S\left(r_k\right)$ is the saliency value of the region r_k. $d_c\left(r_i, r_k\right)$ represents the colour contrast which is calculated by the formula (5). We believe that there exists an optimal colour component representation

which would benefit measuring the difference of the two regions. We normalize the l,a,b,g components to [0, 1] and compute mean colour vector $[l,a,b,g]^T$ is computed for each region, then select the most discriminate colour component by formula (5). $w(r_i,r_k)$ represents the spatial weighting term, which is calculated by the spatial distance in the xy plane. $d_s(r_i,r_k)$ represents the spatial distance between the region centre position vector $[x,y]^T$ of the region r_i and r_k, which is calculated by the formula (2). And $d_s(r_i,r_k)$ is normalized to [0, 1]. σ^2 is used to control the strength of spatial weighting. The greater the value of σ^2, the more the effect of the farther regions is emphasized. σ^2 is set to 0.4 for all experiments.

We measure $S(r_k)$ for each region, when $S(r_k)$ is obtained, the value is assigned to each pixel of the region r_k and a pixel-accurate saliency map $S(r)$ is obtained.

As a consequence we further incorporate a centre prior to estimate our final saliency map. A two dimensional anisotropic Gaussian functions is employed to describe the centre prior knowledge which is defined as follows.

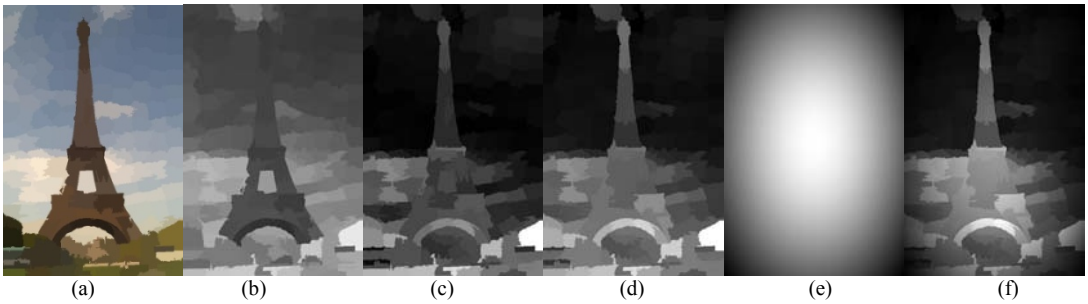
$$S_G = \exp\left\{-\left[\frac{(x_c - x_0)^2}{2\sigma_x^2} + \frac{(y_c - y_0)^2}{2\sigma_y^2}\right]\right\}, \tag{7}$$

where (x_c, y_c) is the centre of the image, (x_0, y_0) is the pixel coordinate in image plane, σ_x and σ_y are variants along the two directions respectively, and σ_x is set to $0.5W$ and σ_y is set to $0.5H$ where W and H are the width and height of the image respectively.

Therefore, the final saliency map can be obtained as

$$S = S_G S(r). \tag{8}$$

We compare the performance with and without the spatial weighting term and the centre prior as illustrated in Figure 3.



(a) (b) (c) (d) (e) (f)

Figure 3. (a) and (b) are the homogeneous regions representation in Figure 2;
(c) and (d) are without and with the spatial weighting term separately; (e) is the centre prior; (f) is the final saliency map

3. Experiments

To validate the proposed method in the salient region detection task, we select the publicly RGB-NIR dataset provided by Brown et al [9]. We choose 18 pairs of images from the dataset. Each pair contains a visible image in RGB format and a near-infrared image in grey format. And we manually label the ground truth image.

We compare the proposed region based multi-spectral saliency method (RMSS) with five start-of-the-art methods which are simply depicted in the section 2. Hereby they are respectively referred to as CA (Gorferman et al [3]), FS (Li et al [4]), RC (Cheng et al [5]), MSSS (Achanta et al [6]), RCSS (Vikram et al [7]). These methods are implemented with the author's original codes and our method is implemented in Matlab.

3.1. Visual Comparison of Saliency Maps

We select five typical images to illustrate the visual effects. Figure 4 shows the visual comparison of saliency maps of the various methods. It can be observed in Figure 4 that the performance of each method is different. CA method highlights the edges of the salient region. FS method can detect the salient region effectively, but it cannot uniformly highlight the total salient region. MSSS method is less effective than the others. RC method, RCSS method and the proposed RMSS method can highlight the whole salient region. Almost all of the effects are poorer than the others images due to the cluttered background as displayed in the column 5.

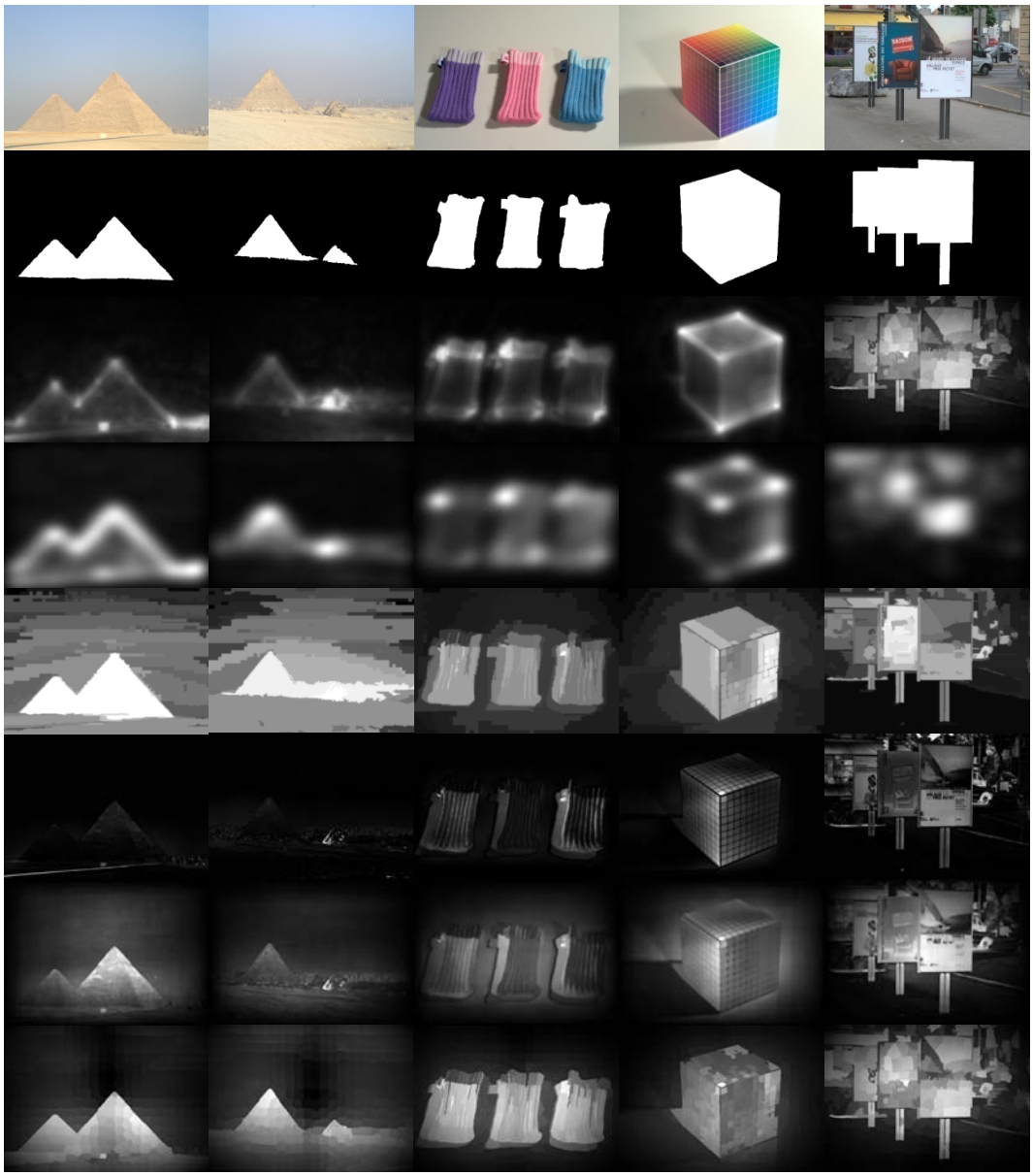


Figure 4. Visual comparison of saliency maps for state-of-the-art methods. Row 1: the original visible image; row 2: the ground truth; row 3–8 : results on CA, FS, RC, MSSS, RCSS and RMSS

3.2. Quantitative Evaluation

To quantitative comparison, we further adopt the metrics of the recall, precision, F-measure performance evaluation, and the experiment results are depicted in Figure 5.

The performance evaluation [11] of P (Precision), R (Recall), F (F-measure) are computed as in formula (9) – formula (11).

$$P = \sum(B \times A) / \sum(B), \tag{9}$$

$$R = \sum(B \times A) / \sum(A), \tag{10}$$

$$F = \left(1 + \beta^2\right) * P * R / \left(\beta^2 * P + R\right), \tag{11}$$

where B represents the segment result of the saliency map by threshold, A is the ground truth by manually annotation, β^2 is set to 0.3 which indicates the F-measure value has more emphasis on accuracy.

We perform two different experiments. In both cases we generate a binary saliency map based on some saliency threshold. In the first experiment we compare binary masks for every threshold in the range [0, 255]. The step of the threshold is set to 10. The resulting Precision-Recall curves in Figure 5 show that our algorithm (RMSS) consistently produces results closer to ground truth at every threshold and for any given recall rate. In the second experiment we use the adaptive threshold which is computed as formula (11). The results are observed in Figure 5. The larger the P value and F value, the better the effect of the method.

$$T = \frac{2}{W * H} \sum_{x=0}^{W-1} \sum_{y=0}^{H-1} S(x, y), \tag{12}$$

where W and H are the width and the height of the saliency map S.

From the quantitative evaluation in Figure 5, we can see that the RMSS method can obtain better results than the other comparable start-of-the-art methods.

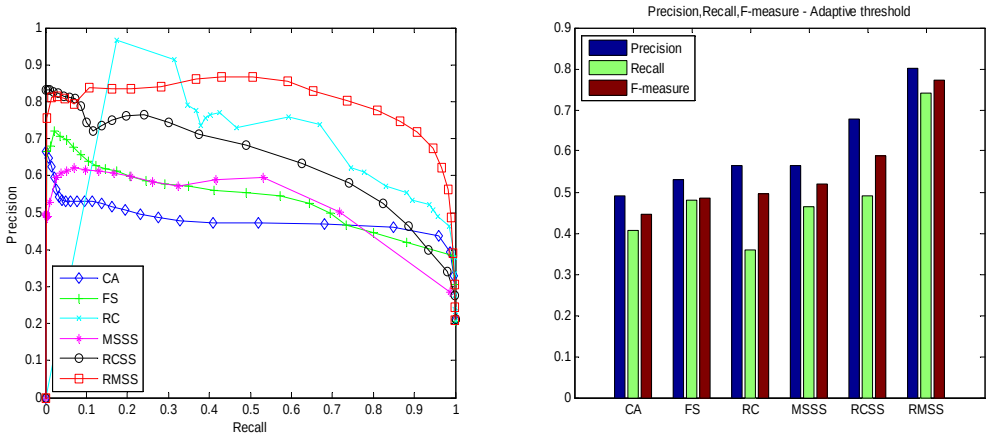
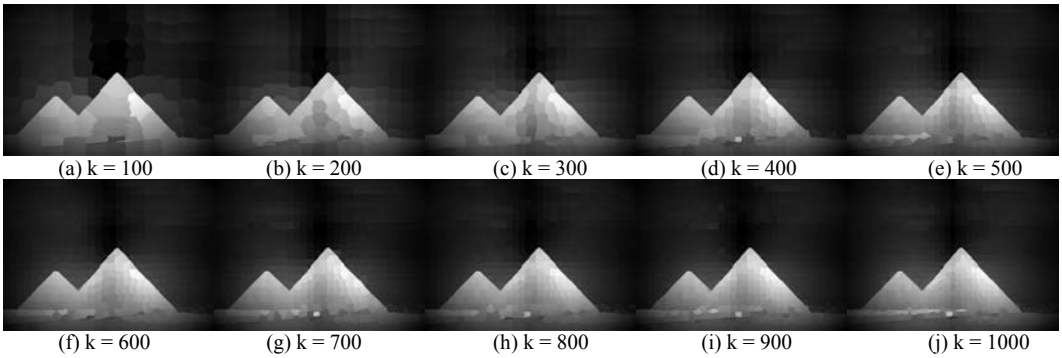


Figure 5: Left: Precision-Recall curves, Right: Precision, Recall, F-measure – adaptive threshold

3.3. Discussion

The parameter K is the only parameter of the proposed method. So we adapt one typical image to illustrate the effect of the number of superpixels. Figure 6 shows the visual effect which is computed by different K from 100 to 1000. And Figure 7 shows the precision, recall, and F-measure values which is computed by adaptive threshold.



(a) k = 100 (b) k = 200 (c) k = 300 (d) k = 400 (e) k = 500

(f) k = 600 (g) k = 700 (h) k = 800 (i) k = 900 (j) k = 1000

Figure 6. Visual comparison of saliency maps for the different number of superpixels

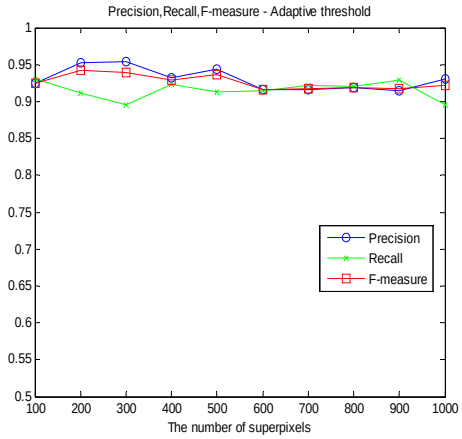


Figure 7. The Precision, Recall, F-measure curves for the different number of superpixels

From Figure 6 and Figure 7, we can see that the proposed method performs robustly over a wide range of the number of the super-pixels. We evaluate the runtime of the proposed method by computing the average processing time with reference to CA method, FS method and the matlab version of the RC method. The CA method is time-consuming due to the multi-scale computation. Our running time is similar to RC method because both of them adapt the image clustering processing.

As depicted in the column 5 of the Figure 4, our method also cannot obtain satisfied saliency maps because the difference between the object and the cluttered background is small. The concept of the generic object [12] may be able to solve this problem, so in the future we plan to consider the generic object detection strategy to improve the effect.

4. Conclusions

We present a new region based multi-spectral saliency detection method. The algorithm incorporates the near-infrared and the visible information into the procedure of saliency detection. The superpixel segmentation algorithm is employed to generate the homogeneous regions, and the saliency map is measured by calculating the region's contrast. We then compare the proposed algorithm with other five state-of-the-art methods and experimental results demonstrate that our algorithm performs better. Its shortcomings is that the performance get worse in the images which have the cluttered background, so in the future we plan to consider the generic object concept which can be combined with the saliency detection method to improve the saliency detection effect.

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TRAINING RADIAL BASIS FUNCTION NETWORK USING THE HONEY BEE MATING OPTIMIZATION

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The radial basis function (RBF) network is a popular type of neural network that is very useful for pattern classification. Several algorithms proposed for training the RBF network. This paper introduces a training algorithm of radial basis function (RBF) neural networks for classification based on the honeybee mating optimization (HBMO) algorithm. The training performance of the HBMO algorithm compared with the gradient descent (GD) algorithm, particle swarm optimization (PSO) algorithm and genetic algorithm (GA). In experiments, the well-known classification problems from the UCI repository are designed. Experimental results show that the usage of the HBMO algorithm is better than other methods.

Keywords: Radial basis function network, Honeybee mating optimization, Gradient descent algorithm, Particle swarm optimization, Genetic algorithm

1. Introduction

The radial basis function network is a type of neural network that uses a radial basis function as its activation function [1]. Because of the better approximation capabilities, simpler network structure and faster learning speed, the RBF networks attracted considerable attention and widely used in many science and engineering field [2–5]. In the RBF network, the number of neurons in the hidden layer always affects the network complexity and the generalizing capabilities of the network. If the number of neurons of the hidden layer is insufficient, the learning of RBF network fails to correct convergence, however, the neuron number is too high, the resulting over-learning situation may occur. In addition, the position of centre of the each neuron of hidden layer and the spread parameter of its activation function also affect the network performance considerably. The determination of three parameters that are the number of neuron, the centre position of each neuron and its spread parameter of activation function in the hidden layer is very important. Various algorithms proposed for training RBF network. The gradient descent (GD) [14] algorithm is the most popular method for training the RBF network. A derivative based optimization algorithm is used to search for the local minimum of a function. The algorithm takes steps proportional to negative of the gradient of function at the current situation. Several global optimization methods proposed to evolve the RBF network such as the genetic algorithm [6], the particle swarm optimization [7], the artificial immune system [8] and artificial bee colony algorithm [9]. The genetic algorithm inspired by the evolutionary biology is a popular method for finding approximate solutions to optimization and search problems. Three genetic operations that are selection, crossover and mutation, of the main aspects of GA evolve the optimal solution form an initial population. Ebecken [6] used the real-code genetic algorithm to decide the centres of hidden neurons, spread and bias parameters by minimizing the mean square error of the desired outputs and actual outputs. The particle swarm optimization is an evolutionary computation technique, first introduced by Eberhart and Kennedy [12], inspired by the social behaviour of bird flocks or fish schools. The computation of the PSO algorithm is dependent on the particle's local best solution (up to the point of evaluation) and the swarm's global best solution. Every particle has a fitness value, which evaluated by the fitness function for optimization, and a velocity, which directs the trajectory of the particle. Feng [7] designed the parameters of centres, the spread of each radial basis function and the connection weights as the particle, and then applied the PSO algorithm to search for the optimal solution for constructing the RBF network for classification.

An alternative, the honeybee mating optimization (HBMO), is a heuristic algorithm proposed by Abbasss [10]. The HBMO algorithm is inspired the mating behaviour of the honeybees that applied to searching for the optimal solution in many application domains. In this paper, the training of the RBF network with HBMO algorithm is proposed and the performance of the HBMO algorithm compared with the GD, GA and PSO on classification problems from the UCI repository.

2. Radial Basis Function Networks

A radial basis function (RBF) network considered a special three-layered network. The input nodes pass the input values to the internal nodes that construct the hidden layer. Each unit of hidden layer implements an activation function called radial basis function. The nonlinear responses of hidden nodes weighted in order to calculate the final outputs of network in the output layer. The input layer of this network has *m* units for *m* dimensional input vectors. The input units fully connected to *I* hidden layer units, which in turn fully connected to the *J* output layer units, where *J* is the number of output layer. Each neuron of the hidden layer has a parameter mean vector called centre. Figure 1 shows the detailed structure of an RBF network. Each input data *x* with *m* dimension, $\mathrm{x}=(x_1, x_2, ..., x_m)$, are located in the input layer, which broadcast to hidden layer. The hidden layer has *I* neurons and each neuron compute the distance between the centres and the inputs. Each activation function of the neuron in hidden layer is chosen to be Gaussians and is characterized by their mean vectors c_i and its spread parameter α_i (i = 1, 2,…,I). That is, the activation function $\phi(x)$ of the i^{th} hidden unit for an input vector **x** given by:

$$\phi_i(x) = \exp[-\alpha_i \cdot \|\mathrm{x} - c_i\|^2] . \tag{1}$$

The ϕ_i affects the smoothness of the mapping. Therefore, the output value – o_j, of the *j*-th neuron of output layer, is given in (2).

$$o_j = \sum_{i=1}^{I} w_{ij}\phi_i(x) + \beta_j . \tag{2}$$

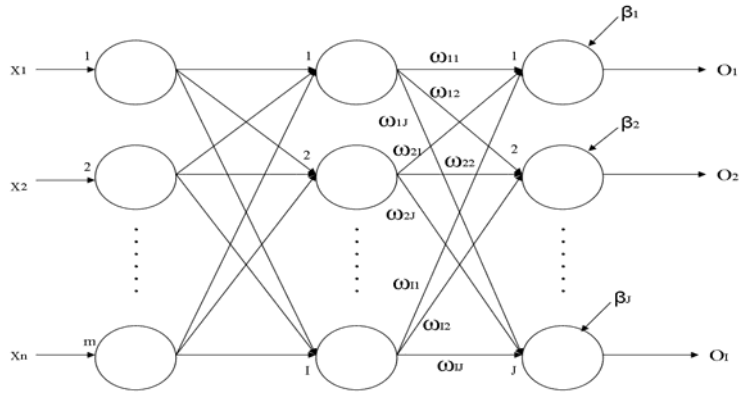

Figure. 1. The structure of radial basis function network

The β_j is the bias parameter which are added with each output is determined in the RBF network training procedure. The weights, w_{ij} (*i=1,2,…,I, j=1,2,…,J*), is the output of hidden layer that transmitted to the output layer. Furthermore, the actual output of input vector x is assigned by $o(x) = (o_1, o_2, ..., o_J)$. The designed procedure of the RBF network need to determine in advanced the number of neurons of the hidden layers; however, it is an important factor to affect the performance of classifications. In practice, the training procedure of RBF is to find the adequate parameters w_{ij}, α_i, β_i and c_i such that the error metrics such as the mean square error (MSE) is minimum.

$$\mathrm{MSE}(\mathrm{w}, \alpha, \beta, \mathrm{c}) = \frac{1}{N}\sum_{j=1}^{N}(d(x_j) - o(x_j))^2 , \tag{3}$$

where $d(x_j)$ and $o(x_j)$ are the desired output vector and their corresponding actual output vector of training sample x_j in the RBF neural network. The *N* is the number of the training samples.

3. Training of RBF Network Using the HBMO Algorithm

In the marriage process, the queen(s) mate during their mating flights far from the nest. A mating flight starts with a dance performed by the queen who then starts a mating flight during which the drones follow the queen and mate with her in the air. In each mating, sperm reaches the spermatheca and

accumulates them. A honeybee colony typically consists of a single egg-laying long-lived queen, anywhere from zero to several thousand drones and usually 10,000–60,000 workers Abbasss [10]. Queens are specialized in egg laying. A colony may contain one queen or more during its life cycle, which named monogynoes and/or polygynous colonies, respectively. A queen bee may live up to 5 or 6 years, whereas worker bee and drones never live more than 6 months. After the mating process, the drones die. The drones are the fathers of colony. They are haploid and act as amplify their mother's genomes without altering their genetic composition to form the genetic pool of the colony. Each time a queen lays fertilized eggs, she randomly retrieves a mixture of the sperm accumulated in the spermatheca to fertilize the egg. In practices, the mating flight may considered as a set of transitions in a state-space where the queen moves between the different states in some speed and mates with the drone encountered at each state probability. Furthermore, the queen initializes with some energy content during the flight mating and returns to her nest when the energy is within some threshold from zero to full spermatheca.

In order to develop the algorithm, the capability of workers restrained in brood care and thus each worker might be regard as a heuristic that acts to improve and/or take care of a set of broods. An annealing function is used to describe the probability of a drone (D) that successfully mates with the queen (Q) shown in Eq. (4).

$$P(Q,D) = \exp[-\Delta(f)/S(t)], \tag{4}$$

where $\Delta(f)$ is the absolute difference of the fitness of D and the fitness of Q, and the $S(t)$ is the speed of queen at time *t*. The fitness of the resulting chromosomes of drone, queen or brood, is determined by evaluating the value of the objective function. After each transition of mating, the queen's speed and energy are decayed according to the following equation:

$$S(t+1) = \alpha \times S(t). \tag{5}$$

The α is the decreasing factor ($\alpha \in [0,1]$). Workers utilize some heuristic mechanisms such as crossover or mutation to improve the brood's genotype. The popular five construction stages of the HBMO algorithm proposed by Fathian [11], which are also used to develop the algorithm of HBMO-based training algorithm for RBF network method as follows:

The individuals of the drones and broods include the parameters of weights (*w*), spread parameters (α), centre vector (**c**) and the bias parameters (β). The mean vector c_i of the i^{th} neuron of hidden layers defined as the $c_i = (c_{i1}, c_{i2}, ..., c_{im})$, therefore, the chromosome parametric vector t_i of each of drones, queen and broods with $I \times J + I + mI + J$ parameters expressed as:

$$t_i = (w_{11}^i, w_{12}^i, ..., w_{IJ}^i, \alpha_1^i, \alpha_2^i, ..., \alpha_I^i, \mathrm{c}_{11}^{\mathrm{i}}, \mathrm{c}_{12}^{\mathrm{i}}, ..., \mathrm{c}_{1\mathrm{m}}^{\mathrm{i}}, ..., c_{I1}^i, \mathrm{c}_{I2}^{\mathrm{i}}, ..., \mathrm{c}_{\mathrm{Im}}^{\mathrm{i}}, \beta_1^i, \beta_2^i, ..., \beta_J^i).$$

In fact, any chromosome parametric vector can represent a specific RBF network for classification. In our proposed HBMO-based training algorithm, we try to obtain the optimum chromosome parametric vectors t_i of specific trained RBF network, which can maximize the fitness function defined in the Eq. (6).

$$f(t_i) = \frac{1}{1+MSE} = \frac{1}{1+\frac{1}{N}\sum_{j=1}^{N}(d(x_j)-o(x_j))^2}, \tag{6}$$

where $d(x_j)$ and $o(x_j)$ are the desired output training samples and their corresponding actual output of RBF network designed by parametric vector t_i. The developed approach called the HBMO-based training algorithm for RBF network associated with the Fathian's five stages model proposed in this section. The details of the proposed algorithm described as follows:

Step 1. Generation of a set of initial solution

Randomly generate *n* drones with chromosome length $I \times J + I + mI + J$, denoted by the matrix D_{nc}.

$$D = [t_1, t_2, ..., t_n], \tag{7}$$

where the values of weights (*w*) and centres (*c*) assigned between -1 and 1, and the values of the spread and bias parameters α and β range from 0 to 1.

Step 2. Selection of queen

After generation of a set of initial solutions mentioned in the previous stage, we rank the initial solutions according to their fitness and select the best as the queen. The queen, *Q*, described as shown as the Eq. (8).

$$(w_{11}^{best},...,w_{IJ}^{best},\alpha_1^{best},....,\alpha_I^{best},c_{11}^{best},...,c_{1m}^{best},c_{21}^{best},...,c_{2m}^{best},...,c_{I1}^{best},...,c_{I1m}^{best},\beta_1^{best},,....,\beta_J^{best}). \quad (8)$$

Step 3. Flight mating

In this stage, the simulated annealing method used to select the best drone set during the flight mating of queen Q. The best drone D_k with the largest annealing function of $\Pr ob(Q, D)$ among the drone set D first selected as the object of mating for the queen Q. After the flight mating, the queen's speed and energy will decayed by Eq. (5). The flight mating is continues until the number of sperms in the queen's spermatheca is more than the threshold n_{sperm}. The n_{sperm} is a predefined parameter that is less than the number of the drones. The selected set of sperms, *Sperm*, described by Eq. (9).

$$Sperm = [Sp_1, Sp_2,...., Sp_{n_{sperm}}], \quad (9)$$

where $Sp_i = (w_{11}^{sp_i},...,w_{IJ}^{sp_i},\alpha_1^{sp_i},....,\alpha_I^{sp_i},c_{11}^{sp_i},c_{12}^{sp_i},...,c_{1m}^{sp_i},...,c_{I1}^{sp_i},c_{12}^{sp_i},...,c_{1m}^{sp_i},\beta_1^{sp_i},....,\beta_J^{sp_i})$ is the *i*th sperm in the queen's spermatheca.

Step 4. Breeding process

In this stage, a population of broods generated based on flight mating between the queen and the drones stored in the queen's spermatheca. In breeding process, the t[th] individual of the queen's spermatheca selected to breed if its corresponding random number R_j is less than a user-defined breeding ratio P_c. The breeding process transfers the genes of drones and the queen to the j^{th} individual based on the Eq. (10).

$$Brood_j = Q \pm \beta \times (Sp_j - Q). \quad (10)$$

The parameter β randomly generated in the interval [0, 1] during each breeding process. After the breeding procedures with respect to all sperms, the set of brood defined as *Brood* that expressed as below.

$$Brood = (Brood_1, Brood_2,...., Brood_n), \text{ where } n \text{ is the number of broods.} \quad (11)$$

$$\begin{aligned} Brood_i &= (Brood_i^1, Brood_i^2,....., Brood_i^{I\times J+I+mI+J}) \\ &= (w_{11}^{b_i},,...,w_{IJ}^{b_i},\alpha_1^{b_i},....,\alpha_I^{b_i},c_{11}^{b_i},c_{12}^{b_i},...,c_{1m}^{b_i},...,c_{I1}^{b_i},c_{12}^{b_i},...,c_{1m}^{b_i},\beta_1^{b_i},\beta_2^{b_i},....,\beta_J^{b_i}). \end{aligned} \quad (12)$$

Step 5. Brood mutation with the royal jelly by works

The population of broods improved by applying the mutation operators as follows:

Step 1. For all broods, the random number R_i of i^{th} brood generated.

Step 2. If the R_i is less than the predefined mutation ratio P_m, the i^{th} brood needs mutation. In the process of mutation, we first randomly select an integer value, *k*, ranged form *1* to $I \times J + I + mI + J$ and then the k^{th} element of chromosome parameter vector $Brood_i$ must be mutation according to the Eq. (13).

$$\begin{aligned} &Brood_i^k = Brood_i^k \pm (\delta + \varepsilon) \times Brood_i^k \\ &\delta \in [0,1],\ 0 < \varepsilon < 1. \end{aligned} \quad (13)$$

Step 3. The best brood, $brood_{best}$ with maximum fitness value selected as the candidate queen.

Step 4. If the fitness of $brood_{best}$ is superior to the queen, we replace queen by $brood_{best}$.

Step 6. Check the termination criterion

If the termination criterion is satisfied then finish the algorithm, else discard the all previous trial solutions (brood set). Then go to stage 3 until the assigned iteration completed.

4. Experimental results and discussion

The platform used to develop the four training algorithm included the gradient descent (GD), genetic algorithm (GA), particle swarm optimization (PSO) and the honey bee mating optimization (HBMO) is a PC with following features: Intel Pentium IV 3.0 GHZ CPU, 512 MB RAM, a Windows XP operating system and the Visual C++ 6.0 development environment. In experiments, the parameters of HBMO algorithms given at Table 1, respectively. The learning parameter of GD assigned to be $\eta = 0.01$ and the control parameters of GC and PSO used in experiments given at Table 2 and 3. In order to obtain the classification results with no partiality, the following data set used: Iris, Wine, Glass, Heart SPECT and Breast cancer (WBDC) listed in Table 4, taken from the UCI machine repository [13].

Table 1. The used parameters of HBMO algorithm

Parameter	Explanation	Value
	Number of queens	5
Iter	Number of iterations	200
M	Number of drones	100
A	Speed reduction schema	0.98
n_{sperm}	Capacity of spermatheca	50
S(0)	Speed of queen at first of flight	[0.5 · 1]
P_c	The breeding ratio	0.8
P_m	Mutation ratio	0.01
ε	Mutation variation	0.5

Table 2. The used parameters of GA algorithm

Control parameter	Value
Number of generation	200
Selection method	roulette
Mutation type	uniform
Mutation rate	0.05
Crossover type	Single point
Crossover rate	0.85

Table 3. The used parameters of PSO algorithm

Parameter	Explanation	Value
S	Number of particles	100
v	Velocities randomly	[-1.0 · 1.0]
Iter	Number of iterations	200
C1	Cognitive coefficient	2.1
C2	Cognitive coefficient	2.0

Table 4. Machine Learning datasets in this study

Dataset	Number of Class	Number of attributes	Number of patterns
Iris	3	4	150
Wine	3	13	178
Breast (WDBC)	2	30	569

In order to avoid the feature values in greater numeric ranges from dominating those in smaller numeric range, the scaling of feature is used, that is the range of each feature value can be linearly scaled to range [-1, 1]. Furthermore, the 4-fold method employed in experiments, thus, the dataset split into 4 parts, with each part of the data sharing the same proportion of each class of data. Three data parts applied in the training process, while the remaining one used in the testing process. The program ran 4 times to enable each slice of data to take a turn as the testing data. The rate of correct classification of this experiment computed by summing the individual accuracy rate for each run of testing, and then dividing the total by 4.

One of the most important issues of designing the RBF network is the number of neurons in the hidden layer. Thus, we implement the RBF network, which has 1 neuron to 8 neurons for comparison, and each dataset is running 10 times based on 4-flod cross-validation. The percentage of correct classification (PCC) defined as the Eq. (14) of the designed RBF network by different algorithms listed in Tables 3–5.

$$PCC = \frac{\text{correct classification samples}}{\text{total samples}} \times 100 . \quad (14)$$

The experimental results reveal that GD is the worst because the gradient descent algorithm is a traditional derivative method, which has some drawbacks such as trapping at local minima. As you can see form the Tables 5–7, as the number of neurons increases, the PCC of the deigned BNF networks using the GA, PSO and HBMO does not accordingly increase. The classification rate of the other three algorithms is not seriously sensitive to the number of hidden layer. In other words, the usage of bio-inspired algorithms is more robust than traditional GD algorithms. We also find that the methods of PSO and HBMO algorithms are better than the GA algorithm. This result may reveal that the GA algorithm needs more iterations and more number of initials (genes) to converge. As to the PSO and HBMO algorithms, their classification results is not significantly different, however, the smaller standard deviation of PCC of the usage of the HBMO reveals that the HBMO algorithm is more robust. In general, the average PCC results of Tables 5–7 show that the usage of the HBMO algorithm is better than PSO algorithm.

Table 5. Statistical average PCC results of Iris dataset. (Mean (Standard deviation))

	The number of neuron of hidden layer							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
GD	61.33(4.02)	75.33(6.09)	81.33(5.89)	84.67(4.98)	88.00(5.12)	89.33(4.34)	90.00(4.21)	89.33(3.13)
GA	57.33(9.23)	84.66(6.78)	89.33(6.88)	90.00(5.42)	90.67(4.65)	92.00(4.52)	94.00(3.45)	91.67(2.87)
PSO	77.33(5.34)	86.67(4.23)	92.00(4.01)	92.67(3.32)	94.00(2.89)	94.67(2.34)	94.00(2.55)	93.33(1.78)
HBMO	76.67(3.38)	88.00(2.13)	92.00(2.23)	94.00(2.98)	93.33(1.45)	94.67(1.23)	94.67(1.43)	94.00(1.02)

Table 6. Statistical average PCC results of Wine dataset. (Mean, Standard deviation)

	The number of neuron of hidden layer							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
GD	55.06(8.32)	70.79(6.53)	74.16(5.43)	76.97(6.32)	79.21(4.32)	84.83(3.89)	85.96(3.91)	88.76(3.23)
GA	58.43(8.93)	77.53(5.23)	78.65(3.42)	89.89(3.56)	90.45(2.21)	91.57(2.34)	94.38(1.98)	92.70(1.64)
PSO	75.84(5.76)	86.52(4.32)	91.57(3.29)	92.13(2.89)	93.82(2.45)	94.38(2.43)	92.70(1.98)	94.35(2.31)
HBMO	77.53(5.87)	88.76(3.21)	91.01(2.87)	92.70(2.67)	92.70(2.23)	93.82(2.45)	94.94(1.86)	96.07(1.22)

Table 7. Statistical PCC results of Breast (WDBC) dataset. (Mean, Standard deviation)

	The number of neuron of hidden layer							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
GD	63.44(9.92)	75.92(8.45)	80.49(6.78)	85.59(5.62)	87.52(5.67)	90.33(6.17)	91.04(4.78)	91.21(3.56)
GA	73.46(6.71)	79.44(6.87)	85.59(5.97)	93.50(4.21)	94.20(4.54)	93.85(3.91)	93.50(3.21)	94.20(3.67)
PSO	82.95(6.87)	88.05(5.34)	91.39(4.98)	94.38(3.76)	95.08(4.19)	96.49(3.27)	97.19(2.98)	97.36(2.65)
HBMO	84.01(5.42)	89.98(4.78)	93.32(4.98)	95.08(3.23)	96.13(3.43)	96.49(2.87)	96.84(2.57)	97.72(1.87)

5. Conclusion

In this study, the Honey Bee Mating Optimization (HBMO) used to construct the radial basis function network for classification. The well-known classification problems obtained from UCI repository used for comparing with other training algorithm such as GD, PSO and genetic algorithm. This proposed algorithm involves searching for the optimal values of parameters such as weights, centres, spread and bias parameters. Experimental results demonstrate that the classification performance of proposed algorithm is better than another.

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RANGE-DOPPLER DISTRIBUTED TARGET DETECTION BASED ON ADAPTIVE WAVEFORM DESIGN

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To resolve the problems of complicated clutter, fast-varying scenes and low signal-clutter-ratio (SCR) in application of distributed target detection on sea for space-based radar (SBR), a target detection approach based on clutter statistics update, adaptive waveform design (AWD) and advanced principal component analysis (PCA) is proposed in this paper. In this detection approach, a distributed target modelled as some scatters with Gaussian reflectivity on the range-Doppler space, and complicated sea clutter modelled as compound Gaussian process. The simulation results show that, considering the configuration of SBR and the condition of complicated clutter, 9dB reduced for SCR which reliable detection requires by this target detection approach. Therefore, the work in this paper can markedly improve radar detection performance for weak targets.

Keywords: space-based radar; distributed target; adaptive waveform design; principal component analysis; multiple particle filter; generalized likelihood ratio test

1. Introduction

Space-based radar (SBR) has many unique advantages for wide-area surveillance and theatre defence compared with airborne early warning (AEW) radar [1, 2, 3]. People paid more attention to this kind of SBR recently. Because it is well known, that there is the long operation range and the large beam footprint for SBR, the signal-clutter-ratio (SCR) is low when SBR monitors and tracks weak targets on sea. As the development of waveform-agility techniques, it has been possible to design radar waveforms on track in real time. Some research has borne out that the technique of adaptive waveform design (AWD) can give a new chance to the improvement of radar target detection [4, 5].

We propose a target detection approach based on clutter statistics update, AWD and advanced principal component analysis (PCA) in this paper to resolve the problems of complicated clutter, fast-varying scenes and low SCR in the application of target detection on sea for SBR. From the current open reports, this work is the first attempt to integrate the AWD technique into the Distributed target detection of SBR. Sea clutter described by the compound Gaussian (CG) model, and ships are modelled as distributed targets on the range-Doppler space. The procedure of this approach shown in Figure 1 and 2. Every dwell duration of the radar divided into several sub-dwells. The regular linear frequency modulated (LFM) pulses are transmitted at Sub-dwell 1, and its echo is used to pre-detection and estimations of clutter covariance matrices. The amount of the following sub-dwells needed equals to that of targets to test further. The covariance estimations updated at every following sub-dwell by multiple particle filtering (MPF) to cope with the fast-varying clutter scenes of SBR [6, 7]. Furthermore, the waveform of every following sub-dwell designed adaptively according to mean-square optimization technique. Finally, PCA and generalized likelihood ratio test (GLRT) used for mitigation of coloured interference and property of constant false alarm ratio (CFAR) respectively [8, 9]. The simulations show that the detection performance can be improved markedly by this work.

The process on every sub-dwell of the algorithm discussed above, except for Sub-dwell 1, corresponds to one of some distributed targets, so it is an algorithm, which works separately. On the other, all the targets to test further after Sub-dwell 1 can be dealt with together at Sub-dwell 2 while its waveform designed. Their detection results can get be obtained at the end of Sub-dwell 2 and no more sub-dwell is needed. The version of processing together adapts to wide-area surveillance while the version of processing separately adapts to tracking task. The detection for one single target at Sub-dwell 2 will be studied in this paper, as this case is the basis of the two versions.

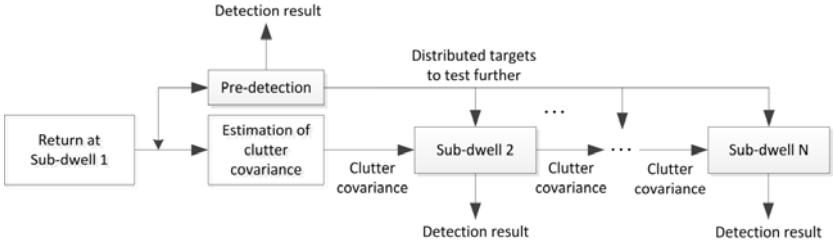

Figure 1. Overall, block diagram of algorithm based on AWD

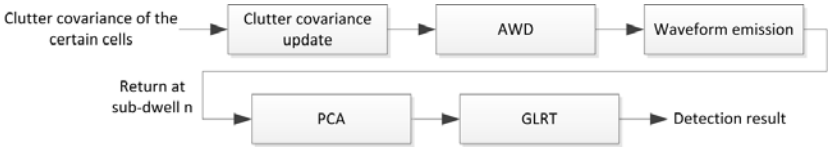

Figure 2. Detailed flow at Sub-dwell n ($n \geq 2$)

2. Description of Radar Scene

If the size of a target is much larger than the wavelength of transmitting radar signal, the backscattering field of this target can be regarded as the sum of some different scatters' contribution according to geometrical diffraction theory. When the range and Doppler resolution of radar is high enough, ships may be regard as extended targets.

The compound Gaussian model for sea clutter has been tested both theoretically and empirically. The CG model has two key parameters: the scale parameter and the shape parameter. The former influences the mean of the CG distribution, and the latter represents the model's similarity with Gaussian distribution. The value range of the shape parameter for sea clutter is 0.2-2 usually.

Define the transmitting signal matrix for Sub-dwell n as an $M_n \times N_v$ matrix P_n, where $N_v = N_s + M_n - 1$, N_s is the sampling length of the pulse, and M_n is the amount of the cells in valid gate of every sub-dwell [5]. It is assumed here that the pulses at all the sub-dwells have the same bandwidth and sampling length.

We denote the backscattering situation of the sea in the view field of the radar as the backscattering reflectivity matrix B_n, process B_n across every row (slow time) by discrete Fourier transform (DFT) and obtain the scattering matrix A_n. The relationship of A_n and B_n is shown as (1):

$$A_n = B_n D, \tag{1}$$

where D is the so-called DFT matrix. A_n is the range-Doppler expression of the matrix B_n. The length of B_n is $N_v \times K$, where K is the amount of the pulses transmitted coherently at every sub-dwell.
The observation matrix Y_n is expressed as (2):

$$Y_n = P_n B_n + V_n, \tag{2}$$

where Y_n is an $M_n \times K$ matrix and V_n is the noise matrix at Sub-dwell n.

Some scatters will move out of the valid gate, and some others will move into it because the scatters on the ground travel relative to the SBR platform. We introduce an evolution matrix F to represent the movement of the scatters, and the evolution of the vectorised scattering matrix is given as

$$a_n = F a_{n-1} + w_n, \tag{3}$$

where the vector a_n is obtained by vectorising the scattering matrix A_n and w_n is the zero mean Gaussian noise vector. The vectorised operation is represented as $a_n = vec(A_n)$ [4]. F is a $KN_v \times KN_v$ block-diagonal matrix.

According to equation (1) and equation (2), the vectorised observation is written as equation (4):

$$y_n = (D^{-H} \otimes P_n) a_n + v_n = \widetilde{P}_n a_n + v_n, \tag{4}$$

where $y_n = vec(Y_n), \widetilde{P}_n = D \otimes P$, and the superscript expresses Hermitian operation. a_n in (3) and (4) is unknown.

3. Update of Sea Clutter Statistic

The clutter covariance matrices of the cells to test further are estimated at Sub-dwell 1. It is the key point to update these matrices at the following sub-dwells according to the movement of radar platform. According to (3) and (4), we derive the dynamic and observation models as (5):

$$\begin{cases} r_{Cov\_a_n} = (F \otimes F) r_{Cov\_a_{n-1}} + r_{Cov\_w_n} \\ r_{Cov\_y_n} = (\widetilde{P}_n \otimes \widetilde{P}_n) r_{Cov\_a_n} + r_{Cov\_v_n} \end{cases}, \tag{5}$$

where $r_{Cov\_a_n} = vec(R_{Cov\_a_n})$, $r_{Cov\_y_n} = vec(R_{Cov\_y_n})$, $r_{Cov\_v_n} = vec(R_{Cov\_v_n})$ and $r_{Cov\_w_n} = vec(R_{Cov\_w_n})$. $R_{Cov\_a_n}$, $R_{Cov\_y_n}$, $R_{Cov\_v_n}$ and $R_{Cov\_w_n}$ are the covariance matrices of a_n, y_n, v_n and w_n, respectively. The length of $r_{Cov\_a_n}$ is $(KN_v)^2$. Its dimensionality will be very large even if a small amount of pulses considered. Such a high dimensionality makes particle filter (PF) or Kalman filter unavailable even if the transform is linear. Based on the block-diagonal structure of $F \otimes F$, the vector a_n is divided into K independent sub-vectors whose dimensionalities are KN_v^2. K PFs are working simultaneously, and a_n is composed eventually. The detailed update method of every PF's weights can be found in [6] and [7].

4. Waveform Design

Firstly, we consider the simpler case that the target lies in one cell. After Sub-dwell 1, assume that we have determined to access this cell, i.e. the test cell, at Sub-dwell 2. All the cells contribute the clutter energy to the return of the test cell after match filtering. We design the waveform $s_2(t)$ for Sub-dwell 2, whose autocorrelation function (ACF) is close to zero at the cells having high clutter energy, to minimize their clutter energy contamination to the test cell.

Let $s_2(t)$ be unimodular phase-modulated (PM) waveform. Its phase function is expanded by an orthogonal set of basis functions with the coefficient vector $\lambda = \left[\lambda_1, \lambda_2, ...\lambda_{N_S}\right]^T$. We shall obtain the certain coefficient vector to minimize (6):

$$J(\lambda) = \int_Z \left| z_{s_2}(\tau, \varpi) \right|^2 d\tau, \tag{6}$$

where $z_{s_2}(\tau, \varpi)$ is ACF of $s_2(t)$ and Z is the lags set corresponding to the cells, which have large texture values.

We compute the gradient and Hessian of $J(\lambda)$ using the squared magnitude of $z_{s_2}(\tau, \varpi)$. Next, we minimize equation (6) by the Newton-Raphson method, and the corresponding solution of λ is obtained. This is so-called mean-square optimization, and the more details can be seen in [4] and its references.

If a target distributes in J test cells $(J > 1)$, the lag of every cell having large texture component is different with regard to the different test cell. Let Z_j be the set of the lags corresponding to the cells, which have large texture values with regard to the test cell $j (j = 1,2,..., J)$, and $Z = Z_1 \cup Z_2 \cup ... \cup Z_J$ in (6).

We have discussed the procedure of waveform design at Sub-dwell 2, and the procedure at the following sub-dwells is the same.

5. Generalized Likelihood Ratio Test

At the end of Sub-dwell n ($n \geq 2$), we detect whether there is a target in the certain cells or not. Especially, we make a pre-detection at Sub-dwell 1 to determine the cells to test further. For the Gaussian scatterer model of a distributed target, the log-likelihood-ratio of the detector can be written as (7) [9]:

$$\ln\Theta(\tilde{\mathbf{r}}_j) = -KJ\ln K - \sum_{j=1}^{J}\ln\left(\left(K-K_j^{'}\right)\frac{\tilde{\mathbf{r}}_j^{\mathrm{H}}\tilde{\mathbf{Q}}_j\tilde{\mathbf{r}}_j}{\tilde{\mathbf{r}}_j^{\mathrm{H}}\tilde{\mathbf{Q}}_j^{\perp}\tilde{\mathbf{r}}_j} - \left(K_j^{'}-1\right)\right) + K\sum_{j=1}^{J}\ln\left(1+\frac{\tilde{\mathbf{r}}_j^{\mathrm{H}}\tilde{\mathbf{Q}}_j\tilde{\mathbf{r}}_j}{\tilde{\mathbf{r}}_j^{\mathrm{H}}\tilde{\mathbf{Q}}_j^{\perp}\tilde{\mathbf{r}}_j}\right), \tag{7}$$

where $K_j^{'}$, $\mathbf{r}_j$ and $\mathbf{Q}_j$ is the signal subspace's size, the echo signal and the orthogonal projector onto the signal subspace for the test cell j, respectively. $\tilde{\mathbf{r}}$ and $\tilde{\mathbf{Q}}_j$ are obtained by whitening $\mathbf{r}_j$ and $\mathbf{Q}_j$. $\tilde{\mathbf{Q}}_j^{\perp} = \mathbf{I} - \tilde{\mathbf{Q}}_j$, which is the orthogonal projector onto the clutter subspace. Note that the signal and clutter subspaces are independent of waveform agility [5]. The detection threshold of this GLRT is difficult to derive in a closed form, so we resort to the Monte-Carlo method to compute it.

This detector is applied to the returns of all the sub-dwells. Two thresholds $\mathrm{Th1}$ and $\mathrm{Th2}$ are set according to two different combinations of the false alarm probabilities and the detection probabilities respectively, namely $P_{fa} = 10^{-6} / P_d = 0.9$ (the reliable detection) and $P_{fa} = 10^{-4} / P_d = 0.5$ (the critical detection) where P_d is the detection probability and P_{fa} is the false alarm probability. At Sub-dwell 1, we will consider that one target exists in some certain cells if their test statistics are beyond $\mathrm{Th1}$, and the cells, whose test statistics lie between $\mathrm{Th1}$ and $\mathrm{Th2}$, will be considered to test further. At the following sub-dwells, $\mathrm{Th1}$ is used to check if there is a target or not in the test cells.

6. Simulation results

In [8], we gave one simple example firstly to illustrate the validity of AWD based on the mean square optimization shown in Section 4. Although the target studied in that paper was not range-distributed, it could be seen that the ACF amplitudes of the designed waveform on the lags that had large texture were small indeed. This example is not shown here for lack of space.

Subsequently, we simulate the clutter of SBR by the way discussed in [1] and analyse the performance of the detection approach. The details of the SBR candidate can be found in [2, 3]. There were 32 pulses processed coherently in these references while the amount of pulses in one sub-dwell, namely the amount of the pulses processed coherently, is set to 16 here. What's more, one single weak target modelled as some Gaussian scatterers lies in four cells. Therefore, one dwell duration is composed by two sub-dwells. The scatterers with unitary amplitude are located at different normalized Doppler frequencies that are represented in Table 1. Assumed that the shape parameter of the CG clutter is 0.4, the receiver operating curves (ROC) of four different detection approaches for the reliable detection are shown in Figure 3, which are

Case 1: The ROC obtained by the approach discussed in this paper is shown as the solid line;

Case 2: The ROC obtained by the approach discussed in this paper, without clutter covariance matrix updating at Sub-dwell 2 discussed in Section 3, is shown as the dotted line;

Case 3: The ROC obtained by the approach discussed in this paper, without AWD at Sub-dwell 2 discussed in Section 4, is shown as dashed line;

Case 4: The ROC obtained by processing 32 regular LMF pulses coherently, namely not dividing the dwell duration, but detecting as discussed in Section 5 is shown as the dot-dashed line.

Table 1. Doppler frequencies of scatterers

Cell Number	Frequencies
1	{0.1}
2	{0.1, 0.2, 0.3}
3	{0.1,0.2}
4	{0.1,0.2}

In Figure 3, compared with the approach that 16 regular LFM pulses are processed coherently (Case 3), the SCR for the reliable detection can decrease approximately 9dB by the complete approach discussed in this paper (Case 1). Compared with the approach that 32 pulses are processed coherently (Case 4), the SCR for the reliable detection can decrease approximately 6dB by the complete approach discussed in this paper (Case 1). Compared with the approach without clutter covariance matrix update (Case 2), the SCR for the reliable detection can decrease about 3 dB by the complete approach discussed in this paper (Case 1).

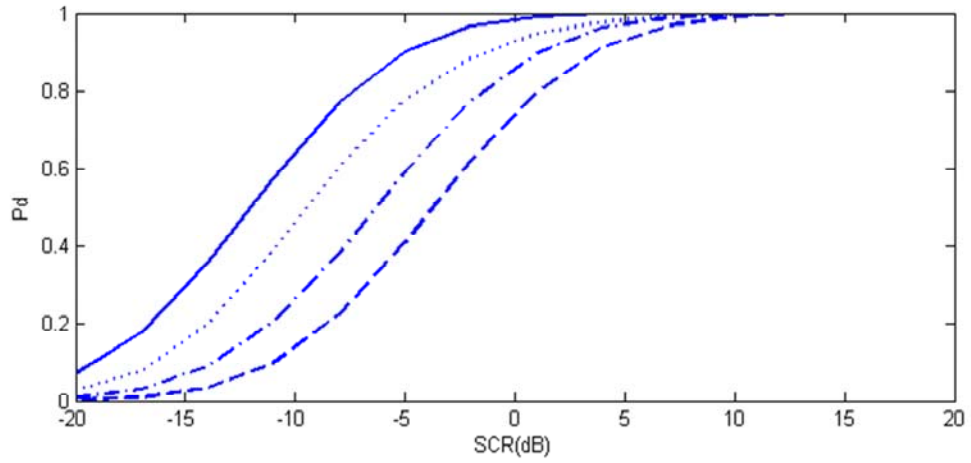

Figure 3. Detection performance comparison of four different detection approaches

In addition, based on the SBR configuration of the above simulation, we verify the performance of this detection approach further by changing the shape parameter of the CG sea clutter and the account of pulses in every sub-dwell. From the simulations, it can be seen that the performance of this detection approach is better when the sea clutter is more spiked or the account of the coherent pulses increases. The signal subspaces are assumed to be known apriori in the preceding simulations. Therefore, we design the simulation to evaluate the influence of two signal subspace estimation methods, namely root-MUSIC and ESPRIT, to the performance of the detection algorithm. It can be seen that the estimation deviation of both methods degrades the algorithm performance but that root-MUSIC works better. The results of these simulations are not given here for space limitation, too.

7. Conclusions

A novel algorithm based on adaptive waveform design for detecting distributed targets on sea is proposed for SBR in this paper, by which targets can be detected effectively on condition of heavy complicated fast-varying clutter. We carry out several simulation experiments, and their results show that the SCR for the reliable detection can improve about 9dB by the detection approach on condition of the spiked sea clutter and the SBR configuration, and that the dynamic update of clutter covariance matrices can offer SCR improvement of 2–3 dB. The work in this paper can improve the radar detection performance for weak targets markedly.

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MULTI-AGENT SYSTEM-BASED EMERGENCY CONTROL SCHEME FOR POWER SYSTEM

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In this paper, a novel coordinate scheme of emergency control is proposed, which is based on technology of Multi-agent. In order to identify the minimum control area, an algorithm based on the principle of Run the Horse Stable Place is put forward. During the process of minimum control area identification, power system's diagram and undirected graph are the only two aspects to consider. When a fault or sudden dramatic load change occurs, Lord Agent in the control area and agent in the action area consist of the MAS (Multi-agent System) to deal with the emergency fault. The proposed method is applied to the WSCC4-machine system, and the test result shows that using MAS an effective control result can be obtained.

Keywords: emergency control scheme, MAS, coordination, agent

1. Introduction

When power system failure occurs, how to make research on safety operation of power system restoration has been hot issue. If there is lack of communication and coordination in the control period, the negative impact could spread to the all power systems. Emergency control is a crucial step in protecting power systems from severe disturbances [1]. Therefore, developing fast and effective emergency control strategy is one of the key to improve power quality and system ability to resist disturbance [2]–[3].

During the past years, various emergency control strategies have been proposed. In [4], a feasibly and effective on-line emergency control strategy is proposed based on PMU data and forecasted trajectory. In [5]–[6], centralized methods and layered distributed methods were proposed to improve the emergency control strategy. As for centralized methods, it is very difficult to achieve stability control measures in a short time for the large number of area, equipment and parameters involved in generating strategy. There are some problems unsolved for emergency control strategy. For example, how to identify system control area and how to solve the inconsistency among equipment movement when stability control devices requires cooperation. Therefore, each subsystem action should be guided by the rules of proper coordination scheme.

The technology of Multi-agent is one of the most popular solutions to coordination control. In artificial intelligence, agent-based technology has been hailed as a promising paradigm for conceptualizing, designing, and implementing software systems [7]. Recently, MAS have been widely applied to the design and optimization of power control system for it can deal with complex situation that no single agent could ever do. In [8], the author proposed the framework of Multi-agent system in post-emergency voltage stability control. Besides, many research efforts have applied the Multi-agent system technique to power system restoration, voltage and reactive power optimization, protection [9]–[11], etc. Since the Multi-agent system technologies have great potential for solving challenging problems, this work explores its utilization for emergency control in power system.

Distributed coordination ability of agent is the basis of Multi-agent system. Organization structure and control method for multi-agent system has a significant impact on system performance. In order to organize groups made up of multiple-agent and achieve the coordination of multi-agent cooperation, on have important theoretical and practical significance, it is necessary to partition the important regional emergency control [12]. This paper presents a new method of control region partition. Under the circumstances of power system being partition into several control areas, MAS made of agent of each control area and agent host on the equipment can effectively solve the above problems to ensure the stable operation of power system.

The organisation of the rest of this paper is as follows. In Section 2, the algorithm of power system emergency control region identification based on Graph theory is present. In Section 3, a method of coordination for the emergency control is discussed, and the excogitation coordinative control strategy is given. Simulation results are provided in Section 4. Finally, in Section 5, conclusion of the simulation is stated.

2. Algorithm for Emergency Control Region Identification

The algorithm of power system emergency control region identification is a distributed interaction rule among agents. It is based on the basis of principle of "Run the Horse Stable Place". Graph theory is the foundation of the algorithm. It is integrated with artificial search technique [13]. For convenience, some conceptual frameworks are briefly introduced as follows.

In order to determine the minimum control area of power system, its diagram and undirected graph are the only two aspects to consider. Self-loops and parallel edges should not be contained so they must be deleted before searching for the minimum control area. Generators or loads of the network are vertices of Power system diagram while the power lines between them are edges of the diagram. Graph G is a triad [14]. It was written for

$$G = \langle V(G), E(G), \varphi(G) \rangle, \tag{1}$$

where:

$V(G)$: set of nodes

$$V(G) = \{v_1, v_2, ..., v_n\} \tag{2}$$

$E(G)$: set of edges

$$E(G) = \{e_1, e_2, ..., e_m\},\ e_i = \{v_i, v_j\}, \text{ or } < v_i, v_j >, \text{ if } e_i = \{v_i, v_j\} \tag{3}$$

v_i is the end vertices and v_j is the undirected edge; and if $e_i = \{v_i, v_j\}$, v_i is the origin and v_j is the directed edge.

$\varphi(G)$: incidence function

$$\varphi(G) = E \to V \times V \tag{4}$$

Adjacency matrix is adopted for the diagram of power system with the purpose of convenient for computer processing [15]. $G = \langle V, E \rangle$ is the diagram of power system, where $V = \{v_1, v_2, ..., v_n\}$ and $E = \{e_1, e_2, ..., e_m\}$. Matrix $A = a_{ij}$ is the Adjacency matrix of graph G, where a_{ij} signifies whether there are edge between node v_i and v_j.

- $a_{ij} = 1$, there is power line between node v_i and v_j.
- $a_{ij} = -1$, there are no power line between node v_i and v_j but they connect to the same bus through the power line.
- $a_{ij} = 0$, v_i and v_j is the same one or inaccessible.

The algorithm is present mathematically as follows. Assume that the graph G have n vertices with the set of vertices named as V. If v_i is a subset of V, where $V = \{v_1, v_2, ..., v_n\}$, $1 \le i_1, i_2, ..., i_m \le n$, and there is a close chain $l_r : v_{i_1} \to v_{i_2} \to ... \to v_{i_m} \to v_{i_l}$ in the subset. Form point of adjacency matrix, the close chain l_r makes up set $M = \{1, -1, -1, ..., 1\}$. It has the following properties:

- If the number of elements of set M is k, $1 < k < n-1$.
- All elements of set M are nonzero.
- Not all the elements of set M is -1.

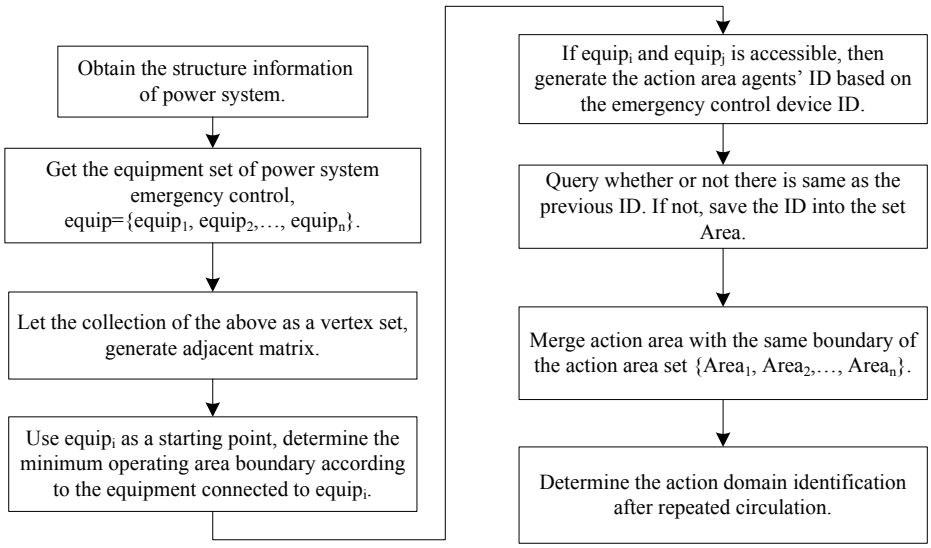


Figure 1. Flow-chart of algorithm

The purpose of the algorithm is to find out all the subset attributable to graph G's vertex set. Thus, the multi-node complicated graphics can be effectively divided into a number of minimum operating areas. The steps of algorithm for region identification are asFigure.1.

3. Coordination of the Emergency Control in Power System Network

Emergency Control for power system of intelligent agent in collaboration can be simplified as collaboration between the two sets of intelligent agent. That is the collaboration of collections between leading intelligent agent and non-leading intelligent agent. Collaboration is to share the task. Through the implementation of all the subtask of the entire mission, the mutual cooperation can realize [16]. Under the guidance of the target, the collaborative control system will finish the mission. The treatment goal of intelligent agent is part of the solution to the entire mission.

3.1. The Procedure of Collaborative Agent Network's Identification and Dealing with Failure

Systems' stability restore is a major objective when a fault or sudden dramatic load change appear. Once the emergency control procedure is performed, the target will be broken down. Some executable links associated with each other based certain constrains can be obtained which can be further decomposed as sub-goal. The elements of non-leading intelligent agent perform the executable links. The procedure of collaborative agent network's identification and dealing with failure is present as follows.

1) Detector agent detected fails within the observation area. It send p-judge agent failure detection time t_s when activating the isolator to cut off faults.

2) To generate the C-Judge Agent, P-Judge Agent seek critical clearing time $t_{\lim}$ conforming to the fault message from the database storage of clearing time. Then t_s and $t_{\lim}$ will be stored in the C-Judge Agent.

3) Lord Agent gets the fault message from the Isolator Agent and search for the appropriate emergency control policy in the database. When Isolator Agent indicates that the CB Trip Agent action, lord agent will control the target decomposition.

4) The trip time combined into a set $\left\{t_e^1, t_e^2, ..., t_e^n\right\}$ of circuit breaker reported by CB Trip Agent will be collected by Tripping Data Collector. Then the Tripping Data Collector selects the maximum (t_e) of the set of elements and submits to the C-Judge Agent.

$$t_e = \max\left\{t_e^1, t_e^2, ..., t_e^n\right\} \tag{5}$$

5) If $|t_e - t_s| > t_{\lim}$, according to the mathematical description of power system transient stability, C-Judge Agent makes judgments about whether power system transient stability was destroyed and reports the emergency faults information Lord Agent host to regional sub-station.

6) Lord Agent and others form the collaboration network. Then they complete the target together. The collaborative network S of imminent failures in the handling can use the following element expression description.

3.2. The Decomposition and Allocation of Emergency Control Task

This is the important elements of collaborative network in power system. The leading intelligent agent is responsible for the decomposition. Task allocation is essentially a leading intelligent agent to bear the child of the target partner of choice. An approach about combination of the contract net and collaborative planning is used in this paper.

Assuming the Power System is split into n controlled area and each area is equipped with only one Lord Agent. When a failure occur in the Control Area A, and the fault clearing time is greater than the critical clearing time, and then power system transient stability was destroyed. Then of this area is the leading agent and it is in a position of manager of the emergency control tasks. According to the stability control strategy of Action Data Base the $LordAgent(\alpha)$ exercise control over the equipment set $equip = \{equip_1, equip_2, ..., equip_n\}$. Then the emergency control target G will generate. With the following principle, the Lord Agent put G broken into automatic control scheme and external control scheme.

1) Automatic control scheme: Equipment subset

$$equip = \{equip_{i_1}, equip_{i_2}, ..., equip_{i_l}\} \quad (1 \le i_l \le n, 1 \le j \le l) \tag{6}$$

It is within the implementation capacity of leading $LordAgent(\alpha)$, and $equip_1$ produces the Automatic control scheme G1.

2) External control scheme:

$$\overline{equip} = equip - equip_{l_1} = equip_{l_2} \cup equip_{l_3} \cup ... \cup equip_{l_m} \tag{7}$$

They are within the implementation capacity of non-leading $LordAgent(\alpha_{l_2}), LordAgent(\alpha_{l_3}), ..., LordAgent(\alpha_{l_m})$, and they produce the External control scheme $G_2, G_3, ..., G_m$ respectively. Therefore, accomplish the control target G will be broken down into n sub-goals only with collaboration.

There are a lot of control strategy stored in the Action Database of Lord Agent provided a broad and rich source of information for its cooperative partnership. When a fault turns up, Lord Agent of each control area fits in a large virtual collaboration team to maintain stable operation of power system. Therefore, our leading Lord Agent selects a candidate partner from the external control scheme, requiring them to collaborate and consult. If others whom have not been invited to collaborative browsing information find the collaborative projects, they can send a request to the leading Lord Agent. Then the Lord Agent will determine the task for sub-goal through competition. In addition, the method of task allocation show as follows.

1) Leading Lord Agent searches for the stability control strategy in the database after receiving the information about removal of the fault line and action of the breaker and gets emergency control task broken down into a series of problems.

2) When failed removal time exceeds the critical value, power system transient stability destroy, leading Lord Agent is responsible for these sub-targets bidding matters after known this information is responsible. It sends cooperation invitation to candidate cooperation Lord Agent.

3) If a Lord Agent of candidate cooperation is preparing for biding, it puts forward solution for its sub-goal based on its own resources and submits the solution to the leading Lord Agent for evaluation.

4) Leading Lord Agent negotiates with candidate cooperation ones and studies out collaboration contract after approval its solution.

5) Candidate cooperation Lord Agent confirms the contract and sends confirmation letter to the leading one. Then it becomes formal member of the emergency control task collaboration team.

6) Formal members are responsible for the achieving of sub-goal fully. It must report the implementation information after done.

The flowchart of stability control measures implementation is shown as Figure 2.

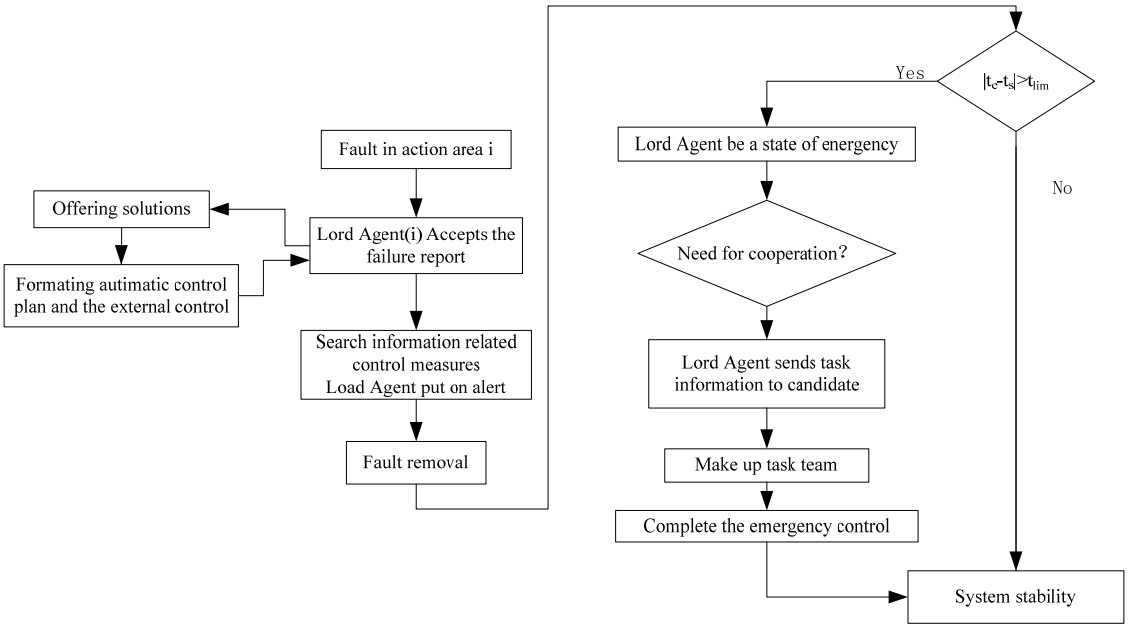


Figure 2. Flow diagram of stability control measures implementation

4. Simulation Scenarios

This section discusses the validation of algorithm and coordination method mentioned above in WSCC 4-machine system. Where G is a generator, T is the transformer, B is the bus, L is the line and R is the circuit breaker. Generator tripping and load shedding is the emergency control measures to ensure the stable operation of power system in this paper. The Lord Agent direct corrective actions of Agent hosted on equipment occurring based on its own control aim.

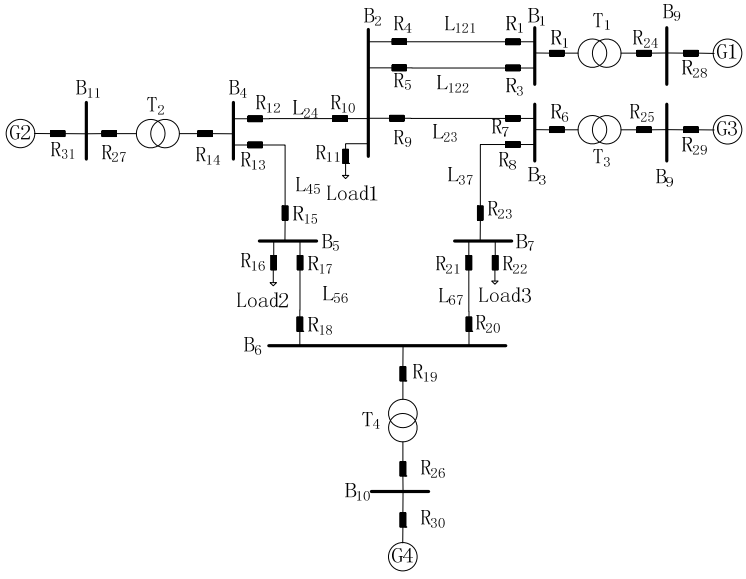
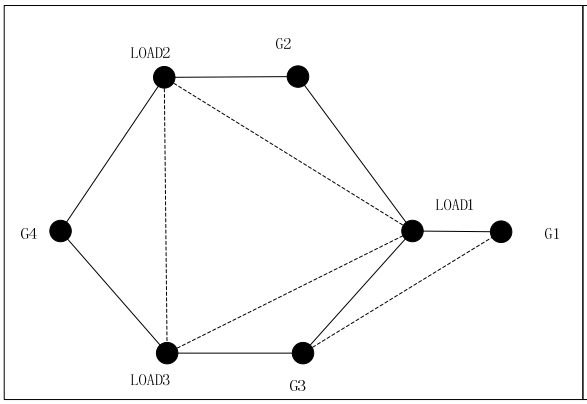


Figure 3. WSCC 4-machine system

Algorithm of power system emergency control region identification is conducted on the diagram of power network. In order to facilitate the identification of the algorithm, WSCC 4-machine system should be simplified as Figure 4. Moreover, the number of vertices of the Diagram is n = 7, so its adjacency matrix is symmetric sparse matrix A.



$$A=\begin{pmatrix} 0 & 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & -1 & -1 \\ 0 & 1 & 0 & 1 & -1 & 0 & -1 \\ 0 & 0 & 1 & 1 & -1 & -1 & 0 \end{pmatrix}$$

Figure 4. Diagramof WSCC 4-machine system

Algorithm is implemented in Microsoft Visual Studio. When input the adjacency matrix A, the result print out is shown in Table 1.

Table 1. Results action area after using the algorithm

Control area	Host	Equipment for emergency control	Operational equipment
1	B3	Load1,Load3, G1,G3	B2, L23, B3, L37, B7, B8, T1, B1, L121,L122, B9, T3
2	B4	Load1,Load2,G2	B2, L24, B4, L45 ,B5,B11,T2
3	B6	Load2,Load3,G4	B5, L56, B6, L67, B7. B10, T4

It can be seen from the table that WSCC 4-machine system was divided into three control area. For example, the host of Lord Agent is located in bus B3 in control area 1. Load1 and Load3 are the boundary point respectively. G1 and G2 are used to enforce the emergency control measures.

If a fault occurs at control area 1, the set of corresponding control target is $G_a\{Load_1, Load_3, G_1, G_3\}$. Lord Agent 861908013CC0 put G broken into automatic control scheme and external control scheme for the time being as shown in Table 2.

Table 2. Automatic Control Scheme & External Control Scheme

Leading Lord Agent ID	Scheme	Equipment agent	Active power demand	Reactive power demand
841908013CC0	Automatic Control Scheme	G2	-1.2600	0
		Load1	-1.8000	-0.5400
	External Control Scheme	G1	-0.1349	0
		Load3	-0.8805	-0.1957
		Load3	-0.8805	-0.1957

Therefore, Lord Agent 861908013CC0 put G broken into 3 sub-goal: $G_a = \{G_1, Load_1\}$, $G_b = \{G_1, Load_3\}$, $G_c = \{G_1, Load_3\}$. The emergency control tasks collaboration team was also defined. The result of the cooperation is shown in Table 3.

Table 3. Result of the cooperation team

	Lord Agent ID	Equipment Agent	Active power demand	Reactive power demand
Leading Lord Agent	861902013CC0	G2	-1.2600	0
		Load1	-1.8000	-0.5400
Non-Leading Agent	841908013CC0	G1	-0.1349	0
		Load3	-0.8805	-0.1957

The implement time of control strategy is Td = 9.27 ms. All the Non-leading Lord Agent has the ability of completing sub-goal. Network transmission time of Leading Lord Agent 861908013CC0 and Non-leading Lord Agent 841908013CC0 are 1.5 ms and 1.6 ms, respectively. From Table 3, team members are based on distribution to control the sub-goal operation well.

5. Conclusions

Generally speaking, there are only 50 ms used to perform the control strategy. The control scheme proposed in this paper use the collaborative planning method to guide the emergency control of power system. Through the actual example, simulation has verified the effectiveness of the decomposition of control goal and the allocation and implementation process of emergency control task under the guidance of collaborative planning. The results show that the time of control strategy implementation is far less than 50 ms. It conforms to the rapidity of the power system emergency control. The emergency control scheme can shorten the time of implementation and distribution of emergency control strategies.

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A COLOR FRACTAL-BASED MORPHING ALGORITHM

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In this paper, based on the idea of fractal key frame algorithm and by giving the colour correspondence principle of contractive mapping, the interpolation algorithm is conducted between the initial object and target object. Then the process of in-between colour fractal images is obtained. Applying the fractal to colour morphing animation, a colour fractal-based morphing algorithm is provided. The experimental simulation shows that for the animation generated by using this algorithm, the transition between frames is natural and smooth, the images are also smooth, colour matching is accurate and the effect is lifelike and controllable.

Keywords: *fractal, key frame, animation*

1. Introduction

The key frame technology is an important technology of animation generation, as well as the most basic and most widely used method in computer animation. Much animation software, such as Softimage, Wavefront, TDI, 3DS, etc., also provide this basic setting method. In the traditional animation production, designers usually first draw some key images, called as key frames, to show the movements or shape changes of animation at various time points, so that an effect of a variation or movement can be produced. As the transition image between two adjacent key frames, the in-between frame (or interpolation frame) is produced mainly in three main ways: by key frame method, algorithm and based on physical animation. Now the main research object of key frame animation technology is the Euclidean geometric objects. The key frame interpolation problem can be seen as a parameter interpolation problem. In order to find a good solution to time control problem in the interpolation process, Steketee et al. [1] proposed that the motion parameters can be controlled by bi-interpolation method. Kort [2] proposed a layer-based key frame algorithm and assumed that the order of layers is variable. The algorithm developed an interactive approach. Based on quaternion and V spline curve, Gregory proposed a new method for smoothly interpolating orientation matrix [3]. The expansion parameter and variable node space of the new method has been proved to be very effective in the design and control of key frame animation. By constructing a new set of bases, Kim proposed a general method that changes space curve to unit quaternion space curve [4]. Barr et al. proposed a method that conducts smooth interpolation to the orientation of landscape with angular velocity constraints by using quaternion. Their method allows users to restrain the angular velocity at trajectory endpoints. In order to solve the defect caused by using Euler angles, Shoemake is the first person who introduced the quaternion into animation and put forward that the Bezier spline in unit quaternion space can be interpolated to the quaternion. Kochanek et al. put forward a type of cubic interpolation spline, which is suitable for key frame system. Liu Ligang et al. proposed an intrinsic solution algorithm based on the space triangular grid shape blending of intrinsic variable interpolation [5].

In the traditional Euclidean geometry space, it cannot be achieved to describe any one of the fractal geometries, such as a fractal tree, a flower petal, complex mountains and clouds, etc. by using mathematical language. Therefore, it is impossible to handle all the fractal geometric objects that can be seen everywhere in nature by using traditional key frame algorithm, while the fractal geometry is fully competent. Therefore, the key frame algorithm should not only study the Euclidean geometries, but also involve fractal geometry.

With the help of literature [6], the fractal-based key frame animation idea should be studied and applied to morphing animation. In this paper, the contractive mapping correspondence principle between two morphing objects, the correspondence principle of probability and the correspondence principle of colours are proposed. Finally, based on these three principles, a morphing algorithm based on colour fractal putted forward and the effectiveness of algorithm is verified through simulation experiment. This algorithm can improve production efficiency and the quality of in-between frame, meanwhile; reduce the cost of animation production, having great practical value.

2. Problem description

This paper proposes a morphing algorithm based on colour fractal that overcomes the difficulty to describe fractal geometric objects, which is irresoluble for traditional Euclidean geometry, having its own unique advantages. The algorithm provides a good solution to contractive mapping correspondence principle between the initial key frame and final key frame and the correspondence principle of probability respectively. The main features of the proposed algorithm are that it can handle fractal objects, which are difficult for traditional key frame algorithm to deal with. In practical applications, the algorithm can not only improve production efficiency and the quality of the in-between frame, but also effectively reduce the cost of animation production.

In the animation production, some methods are often adopted to continuously change the initial object to target object visually, the process of which is called as metamorphosis. Currently, the main work of researchers is to make the morphing process transition as naturally and smoothly as possible. There can be endless situations in the morphing progress from the initial object to the target object. In addition, in order to obtain a satisfactory morphing, there are three conditions to be met:

1) The intermediate state transformation from the initial object to the target object should maintain monotonic and smooth as possible.
2) The boundary surface of intermediate state should be ensured to be smooth.
3) The common features shared by the initial object and the target object in the morphing process should be retained as possible.

Through mathematical methods, the nature of morphing algorithm can be abstractly described as follows: With setting an initial object as H_b (starting time $t = 0$) and the morphed target object as H_b (end time $t = 1$), the morphing process is, in fact, the process that produces a set including all the in-between frames from H_b to H_e, that is: $\{H_b = H_0, H_1, ..., H_{n-1}, H_n = H_e\}$.

The images generated by fractal method have much more details, which can provide stronger sense of reality. Through iterated function system, for producing computer images successfully the fractal method used. Its main idea is: The whole and the part of geometric object have a self-similar structure in the sense of affine transformation. Therefore, based on certain rules, a simple point or a geometric drawing can be iteratively repeated to generate a complex image. In this method, the initial set has no effect on the obtained final target set, which, in fact, is only related to the iteration rule, namely, depends on a set of coefficients obtained by affine transformation.

As for fractal geometries, the colour morphing animation needs to solve three problems:

1) The problem about the correspondence principle of contractive mapping, namely: What principle should be used to make one contractive mapping of the initial object able to correspond to one contractive mapping of the target object?
2) The problem about the correspondence principle of probability, namely: What principle should be used to realize a one-to-one correspondence in the utilization probability of one contractive mapping of the initial and the target objects.
3) The problem about the correspondence principle of colour, namely: What principle should be used to realize a one-to-one correspondence in the used colour of one contractive mapping of the initial and the target objects.

For these three questions of fractal geometry, this paper presents a better solution and, at the same time, verifies the effectiveness of the solution by experiment. The experimental results show that: Each intermediate frame in the animation, generated by applying this algorithm, is still a fractal image. Moreover, the overall transition is smooth and natural and the images are smooth as well.

3. Colour fractal-based morphing algorithm description

The theory of IFS with parameters and algorithm principle are the key part for understanding the algorithm. Therefore, before describing the specific algorithm, these contents should be described first.

3.1. Ifs with Parameters

The IFS with parameters is the theoretical basis of the colour fractal-based animation proposed in this paper. A fractal set can be generated by using the iterated function system, where, however, exist only stationary objects, which can be transferred into animation by using the iterated function system with parameters. The "with parameters" means adding a parameter p to the mapping relations, indicated by $W(p,\bullet)$.

Theorem1: Suppose the affine transformation $W: R^2 \to R^2$ is in the form of $W(x) = Ax + t$ if and only if the spectral radius of matrix A is $\rho(A) < 1$, the transformation W is contractive.

Theorem2: Suppose (X, d) is the metric space, $\{X; (W_0), W_1, W_2, ..., W_N\}$ an IFS (with coherence) and compression factor $s = \max\{s_n : n = 0,1,...,N\}$, if every W_n depends continuously on the parameter $p \in P, P$ is the metric space, then the attractor $A(p) \in \Phi(X)$ depends continuously on $p \in P$, according to the Hausdorrf metrics $h(d)$.

Theorem1 shows that the attractor can be continuously controlled by adjusting some parameters in the transformation.

3.2. Algorithm Principle

The principle of algorithm in this paper is mainly related to the following theorems [6], whose detailed proof could refer to the corresponding literature.

Theorem3: Suppose $\{X; \omega_i, i = 1,2,...,n\}$ is a hyperbolic iterated function system, its attractor is A. If $\omega_k = \omega_l . \omega_m$. $(k, l, m \in \{1,2,...,n\})$, then the attractor of this hyperbolic iterated function system is still A.

The Theorem3 is mainly used to adjust the total quantity of contractive mapping in the contractive mapping set.

Theorem4: Suppose the corresponding affine transformation matrixes of contractive mapping sets $W_i, i = 1,2,...,m$ and $\psi_i, j = 1,2,...,n$ are A and B respectively, then the new matrix $M = (1 - f(t)) \times A + f(t) \times B$ formed by both of them is still a puncturing matrix, wherein $f(t) \in [0,1]$, $t \in [0,1]$.

The Theorem4 guarantees that every intermediate frame obtained is a fractal image.

3.3. The Interpolation Function of the Intermediate Frame

The selection of interpolation function f(t) determines the quality of the generated intermediate frame, and it is also an important function to generate intermediate frame [6]. Therefore, one of the key factors of generating high-quality animations is to select a good interpolation function. In applications, the interpolation function f(t) is taken to form the intermediate frame function $H(t)=(1- f(t))*H_b+ f(t)*H_e= H_b+ (H_e-H_b)* f(t)$, wherein $0 \le t \le 1$. And f(t) has the following properties: $f(0)=0$, $f(1)=1$, $0 \le f(t) \le 1$, $0 \le t \le 1$.

In the interpolation function f(t), t is the tempo factor which can control interpolation generating intermediate frames, and the number of frames of the intermediate frames can be changed through the change of step length of *t*. Interpolation function f(t) determines the degree of shape change of intermediate frames, and the application of different f(t) will get different deformation effects. Interpolation function f(t) determines the degree of shape change of intermediate frames, and the application of different f(t) will not only have different deformation effects, but also affect the degree of similarity and changing speed of the intermediate frames from H_b to H_e.

3.4. The Interpolation Function of the Intermediate Frame

Suppose the probability formula of the contractive mapping of the given intermediate frames is $P_k = p_k(1 - f(t)) + q_k f(t), k = 1,2,...,m$, where f(t) is interpolation function, p^k is the contractive mapping usage probability of each initial object, q^k is the contractive mapping usage probability of each target object and $\sum_{k=1}^{m} p_k = 1, \sum_{k=1}^{m} q_k = 1$. Prove $\sum_{k=1}^{m} P_k = 1$.

Prove:

Step 1.

If t=0 or t=1, f(t)=0 or f(t)=1, then $\sum_{k=1}^{m} P_k = \sum_{k=1}^{m} p_k = 1$ or $\sum_{k=1}^{m} P_k = \sum_{k=1}^{m} q_k = 1$. Equation is clearly tenable.

Step 2.

If $t \in (0,1)$, $\sum_{k=1}^{m} p_k = \sum_{k=1}^{m} p_k(1 - f(t)) + q_k f(t) = (1 - f(t)) \sum_{k=1}^{m} p_k + f(t) \sum_{k=1}^{m} q_k$. From the known condition $\sum_{k=1}^{m} p_k = 1$ and $\sum_{k=1}^{m} q_k = 1$, hence $\sum_{k=1}^{m} p_k = (1 - f(t)) + f(t) = 1$.

This completes the proof.

3.5. Selection Principle of the Correspondence Principles in Algorithm

There are three main correspondence principles involved in this algorithm:

First: the correspondence principle of the contractive mapping between the initial object and the target object.

Second: the correspondence principle of the probability of contractive mapping.

Third: the correspondence principle of colour of contractive mapping.

In the iterated function system, affine transformation utilization probability is used to adjust the density of points. Simulation results show that the uniform distribution of points on the intermediate frames depends on correspondence principle. The principle of correspondence principle mentioned in the algorithm is that: if the probability of the applied affine transformation of the initial object or the target object is too small (or too large), then during the interpolation process it has to be remain small (or large), so that each branch of the intermediate frame will have the uniform generation speed.

If the quantity of contractive mapping of the initial object and the target object is not equal, then Theorem3 will be used to increase the number of mapping and the colour used by mapping until they reach the same number. Then, the changed probability in initial object or target object will undergo a re-normalization process. Next, the subscripts of all the contractive mappings of the initial object and the target object will be renumbered and rearranged ascending, according to their utilization probability (the probability here is arranged descending), to ensure that the utilization probability of contractive mapping with the smallest subscript is the highest in each contractive mapping set. Then, according to the subscripts of contractive mappings, each contractive mapping in the initial object and the target object is one-to-one corresponded respectively.

4. Specific Steps of the Algorithm

Based on the above discussion, the morphing algorithm based on colour fractal that is proposed in this article is described as follows:

With any given two fractal geometry objects, assuming that the contraction affine transformation of the initial object H_b and the target object H_e are: W_i and ψ_j; the colours used for each affine transformation are: B_i and E_j; the probability of each affine transformation are: p_i and q_j, wherein $i = 1,2,...,m(m \geq 2)$, $j = 1,2,...,n(n \geq 2)$. In this algorithm, colour is expressed by RGB system, namely: $B_i \equiv \left[\overline{r_i}, \overline{g_i}, \overline{b_i}\right]$, $E_j \equiv \left[\overline{r_j}, \overline{g_j}, \overline{b_j}\right]$, and the range of values of $\overline{r_i}, \overline{g_i}, \overline{b_i}$ and $\overline{r_j}, \overline{g_j}, \overline{b_j}$ is [0,255].

Assume that a group of H_b contraction mapping is: $W_i\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \overline{a_i} & \overline{b_i} \\ \overline{c_i} & \overline{d_i} \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \overline{e_i} \\ \overline{f_i} \end{bmatrix}, i = 1,2,...,m$,

and a group of H_e contraction mapping is $\Psi_j\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a_j & b_j \\ c_j & d_j \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \overline{e_j} \\ \overline{f_j} \end{bmatrix}, i = 1,2,...,n$, the colour fractal-based morphing algorithm is the process of getting middle colour fractal chart $M=(1-f(t))H_b+ f(t)H_e$ by the interpolation algorithm between H_b and H_e, wherein, f (t) is the interpolation function. Below are the specific steps of the algorithm:

Step 1. If m = n, namely there is one-to-one correspondence between the contraction mapping between H_b and H_e, then perform Step5;

Step 2. If m≠n, assuming m<n, from the theorem 4–3 in this chapter, we can select ω_i which is corresponding to the maximum probability value p_i in H_b. Make $\omega_{m+1} = \omega_i \times \omega_i$, $p_{m+1} = p_i \times p_i$, $B_{m+1} = \lambda * B_i$, and add it to the contraction mapping of H_b. as a new contraction mapping, then $\{\omega_i, p_i, i = 1,2,...,m+1\}$, in which λ is the colour scale factor and $\lambda \in (0,1)$.

Step 3. m = m +1, turn to Step2;

Step 4. Normalization arithmetic should be performed for the H_b probabilities, then $\sum_{i=1}^{n} p_i = 1$.

Step 5. Re-sequence all contractive mappings subscripts of H_b and H_e in ascending order based on the order of the probability used by contraction mapping (sort the probabilities in descending order), and assume that the new contraction mapping of H_b and H_e respectively are: W_k and $\psi_k, k = 1,2,..., \max(m,n)$.

Step 6. For the required intermediate frame number N and interpolation function f(t), if the interpolation algorithm M=(1- f(t)) H_b+ f(t)H_e is performed between H_b and H_e with any given starting point, then the contraction mapping of M will be:

Step 7. $$\eta_k \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \bar{a}_k(1-f(t)) + a_k f(t) & \bar{b}_k(1-f(t)) + b_k f(t) \\ \bar{c}_k(1-f(t)) + c_k f(t) & \bar{d}_k(1-f(t)) + d_k f(t) \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \bar{e}_k(1-f(t)) + e_k f(t) \\ \bar{f}_k(1-f(t)) + f_k f(t) \end{bmatrix},$$

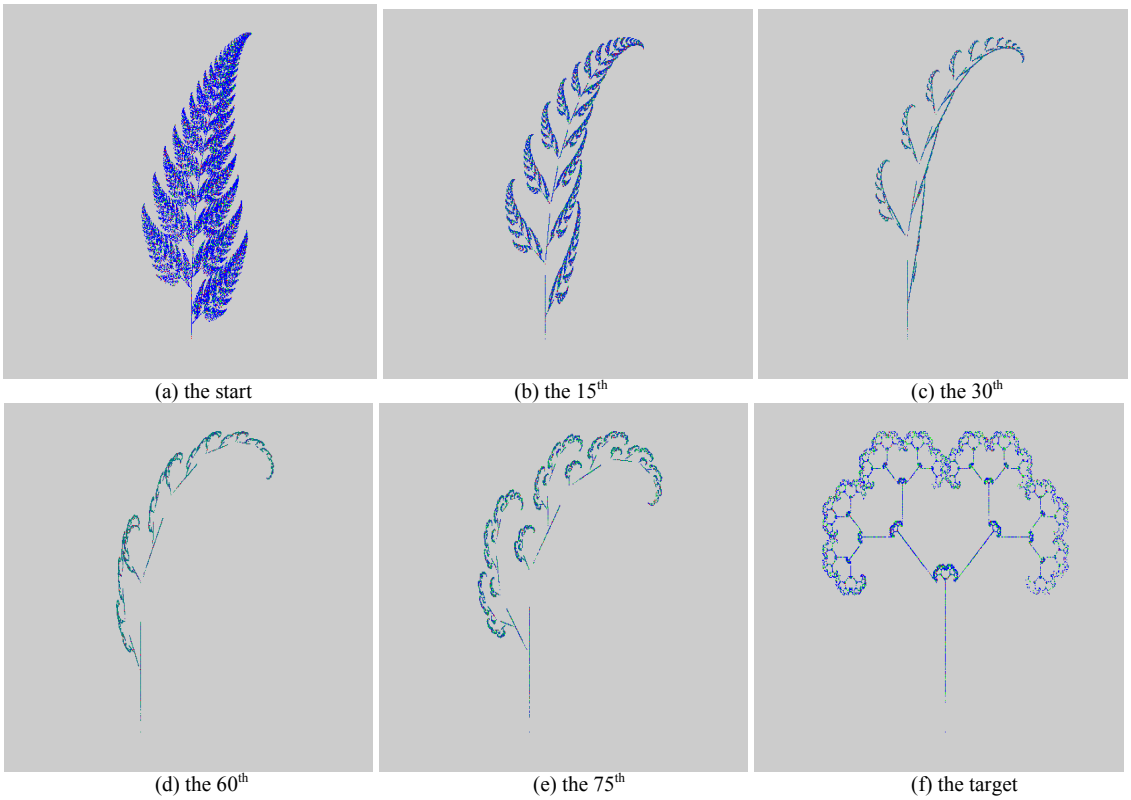
$k = 1,2,..., \max(m,n)$; at the same time, the probability and the colour applied by one group of contraction mappings of M can be calculated as: $P_k = p_k(1-f(t)) + q_k f(t)$, $M_k = (1-f(t)) * B_k + f(t) * E_k$.

Step 8. When i=1,2,3,…, N-1, intermediate frame M=(1- f(t))H_b+ f(t)H_e will be generated by iterative function system, in which t=i/N.

5. Experimental Results and Analysis

The machine configurations in this experiment are: OS is Windows XP; CPU is P4 3.0G; RAM is 4G; experiment environment is Matlab7.0. Figure 1 shows a specific example of this algorithm, in which Fig 1 (a) is the selected initial object in the algorithm, namely a colour Barnsley fern; Figure 1 (f) is the selected target objects in the algorithm, namely, a colour fractal tree. By programming in Matlab7.0, the algorithm of automatically inserting 100 intermediate frames between Figure 1(a) and Figure 1(f) has been realized, and four intermediate frames have been selected from the results.

The speed of generating intermediate frames by the algorithm mentioned in this article is quite fast, which can reach more than 40 frames per second in experiment. The generated morphing animation is smooth and lifelike, which is quite satisfactory.



(a) the start (b) the 15th (c) the 30th

(d) the 60th (e) the 75th (f) the target

Figure 1. The interpolation process of the intermediate frame

6. Conclusion

The research of this chapter is based on the thought of fractal key frames algorithm, and puts forward a morphing algorithm that is based on colour fractal by applying it to the colour gradient animation. In the meantime, it also presents a better solution to these three problems, namely, the problems of contractive mapping correspondence principle, probability correspondence principle and colour correspondence principle between initial object and the target object. Simulation results show that: animations generated by this algorithm have a smooth transition and frames with accurate colour matching. They are also stable and easy to control. Therefore, the algorithm can improve the production efficiency and the quality of the intermediate frame effectively, and it can reduce the cost of animation production. Therefore, it has a high application value.

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A MONTE-CARLO SIMULATION INVESTIGATING THE VALIDITY AND RELIABILITY OF TWO-STAGE CLUSTER SAMPLING SURVEY WITH SENSITIVE TOPICS

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A two-stage cluster sampling was designed to select males who have sex with males (MSM) in Beijing. Quantitative additive randomized response technique (RRT) model was presented to asking questions on sensitive topics in population survey. Monte Carlo simulations were used to evaluate validity and reliability in two-stage cluster sampling survey with sensitive topics. The one sample *Z*-test was performed to compare every simulated sample mean to simulated population mean. No significant differences exited between most every simulated samples and the simulated population. Survey methods and statistical formulae applied to large-scale complex sampling survey on sensitive topics and showed strong validity and reliability.

Keywords: RRT; sensitive topics; Monte Carlo simulation; validity; reliability

1. Introduction

Sampling survey is usually referred to as one of the most basic methods of scientific research in numerous fields, including demography, sociology, medicine and health [1]. Almost inevitably, sampling survey related to sensitive subjects is encountered. Sensitive issues often carry three different implications. The first meaning is that the questions themselves are considered as intrusive. The second meaning is that the questions elicit answers that are socially undesirable or unacceptable. The last meaning involves threat of disclosure [2]. Broadly speaking, it is difficult to collect valid and reliable information in the area of sensitive topics, such as homosexuality, prostitution, HIV-positive and drug abuse. Direct enquiring often leads to refusals or untruthful replies so that respondents would rather provide socially desirable or undesirable responses than accurate ones [3]. Non-response and reporting error are potential important threat to the accuracy estimates from sample surveys.

One of alternative data collection techniques that can be used to measure sensitive questions validly is the RRT that has been developed to deal with both quantitative and categorical responses and has been designed to mitigate social desirability bias (SDB), assure confidentiality, improve respondent cooperation and procure reliable data [4].

Warner originally introduced the RRT in 1965 [5]. The Warner's design is applied to the respondents who are given two logically opposite questions including sensitive one and non-sensitive one. A first alternative to Warner's method is known as Simmons' model or unrelated question model [6]. In this method, the respondents are provided with the opportunity of replying to one of two questions that include sensitive one and innocuous or unrelated one. Further modifications and extensions of the RRT involve quantitative measures and polychotomous measures, such as additive model, multiplicative model and RRT tree model, which could reduce response or non-response bias and improve upon the accuracy levels of the estimators [7].

Our primary focuses in this work are not only on statistical methods for two-stage cluster sampling survey in dealing with quantitative sensitive topics, but also on Monte Carlo simulations to examine the validity and reliability of survey methods and statistical formulae.

2. The Concept of Two-Stage Cluster Sampling and Additive RRT Model

2.1. The Concept of Two-Stage Cluster Sampling

Suppose the population is composed of N_1 primary units, and the i^{th} primary unit contains N_{i2} second-stage units (i = 1, 2, 3,..., N_1). On average, each primary unit contains $\overline{N}_2$ second-stage units. The j^{th} second-stage unit of the ith primary unit contains N_{ij3} third-stage units (i = 1, 2, 3,..., N_1 , j = 1, 2, 3,..., N_{i2}). On average, each second-stage unit contains $\overline{N}_3$ third-stage units. The population totally includes N third-stage units.

At the first stage of sampling, n_1 primary units were randomly drawn from the population. At the second stage of sampling, n_{i2} second-stage units were randomly chosen from the i^{th} chosen primary unit (i = 1, 2, 3,..., n_{i2}). On average, $\overline{n}_2$ second-stage units were randomly drawn from per chosen primary unit. All the third-stage units from the chosen second-stage units were investigated.

2.2. Quantitative Additive RRT Model

The quantitative additive RRT model is designed to create uncertainty about the validity of the respondent's answer and, thereby, provide the respondent with some degree of confidentiality in answering sensitive questions that require a numerical response [8]. The respondents would be asked to scramble his responses utilizing a pre-set randomization device. We had chosen our randomization device to be a deck of ten cards identical in all respects, labelled by the integers from 0 to 9.

Each respondent sampled (all the third-stage units from the chosen second-stage units) was asked to pick one card without letting the interviewer see that card. Then the respondent simply reported the sum of the "true response" and the "number listed on the card" back to the interviewer [9].

2.3. The Statistic of Two-Stage Cluster Sampling

2.3.1. The calculation of μ_{ij}

Note that μ_{ij} represents the mean of the true study variety value obtained for the jth second-stage unit randomly drawn from the ith primary unit, μ_{ijZ} stands for the mean of all the reported values obtained for the jth second-stage unit randomly drawn from the ith primary unit, μ_Y denotes the mean of random variable generated by our randomized device. The unbiased estimator for is given by

$$\mu_{ij} = \mu_{ijZ} - \mu_Y \tag{1}$$

where $i = 1, 2, \cdots, n_1$, and $j = 1, 2, \cdots, n_{i2}$.

2.3.2. The estimator and the variance of the population mean

Define y_{ijk} the value obtained for the k^{th} third-stage unit in the jth second-stage unit drawn from the ith primary unit, $\hat{\mu}_i$ the estimator of the mean of the ith primary unit, $\hat{\mu}$ the estimator of the population mean μ, $V(\hat{\mu})$ the variance of $\hat{\mu}$, $v(\hat{\mu})$ the estimator of $V(\hat{\mu})$.

Sample sizes were required to meet precision level in a complex survey design [10]. Then by Cochran [11], we could approximately get the estimators of the population mean and the mean of the ith primary unit are

$$\hat{\mu} = \frac{N_1}{Nn_1}\sum_{i=1}^{n_1}\frac{N_{i2}}{n_{i2}}\sum_{j=1}^{n_{i2}}\sum_{k=1}^{N_{ij3}} y_{ijk} = \frac{N_1}{Nn_1}\sum_{i=1}^{n_1}\frac{N_{i2}}{n_{i2}}\sum_{j=1}^{n_{i2}} N_{ij3}\mu_{ij}\,, \tag{2}$$

where $i = 1, 2, \cdots, n_1$, and $j = 1, 2, \cdots, n_{i2}$.

$$\hat{\mu}_i = \frac{\sum_{j=1}^{n_{i2}} N_{ij3}\mu_{ij}}{\sum_{j=1}^{n_{i2}} N_{ij3}}, \tag{3}$$

where $i = 1, 2, \cdots, n_1$.

Further approximate variance of $\hat{\mu}$ is given by

$$V(\hat{\mu}) = \frac{\sigma_1^2}{n_1}\left(1 - \frac{n_1}{N_1}\right) + \frac{\sigma_2^2}{n_1\overline{n}_2}\left(1 - \frac{\overline{n}_2}{\overline{N}_2}\right), \tag{4}$$

where

$$\sigma_1^2 = \frac{1}{N_1 - 1}\sum_{i=1}^{N_1}(\mu_i - \mu)^2 , \tag{5}$$

$$\sigma_2^2 = \frac{1}{N_1}\sum_{i=1}^{N_1}\frac{1}{N_{i2} - 1}\sum_{j=1}^{N_{i2}}(\mu_{ij} - \mu_i)^2 . \tag{6}$$

The sample estimators of σ_1^2 and σ_2^2 are:

$$S_1^2 = \frac{1}{n_1 - 1}\sum_{i=1}^{n_1}(\hat{\mu}_i - \hat{\mu})^2 , \tag{7}$$

$$S_2^2 = \frac{1}{n_1}\sum_{i=1}^{n_1}\frac{1}{n_{i2} - 1}\sum_{j=1}^{n_{i2}}(\mu_{ij} - \hat{\mu}_i)^2 . \tag{8}$$

3. Monte-Carlo Simulation

3.1. Simulated Population

3.1.1. Field survey

Two-stage cluster sampling was employed to investigate behavioural features of MSM in Beijing, China, between August and December 2010. Define districts/counties as the primary units, the potential gay-identified venues (e.g., bathhouses/saunas, cinemas, bars, nightclubs, or parks where men belonging to different economic and social classes meet) as the second-stage units, i.e. clusters, and the MSM as third-stage units. To ensure similar size for all the second-stage units, all the clusters were reconstructed. Either smaller clusters were properly merged or larger clusters were appropriately split.

Beijing currently comprised 16 administrative county-level subdivisions, of which 14 were districts and 2 were counties (N_1 = 16). At the first stage of selection, 6 administrative county-level subdivisions were randomly drawn (n_1 = 6). At the second stage of selection, 5 reconstructed clusters were, on average, selected from each chosen administrative county-level subdivision ($\overline{n}_2$ = 5). A total of 1523 MSM were recruited to participate in this study from all the chosen reconstructed clusters. The overall response rate was 100% for MSM. The quantitative additive RRT model was used to estimate the mean value of same-sex sexual behaviour and associated characteristics. For each respondent, survey questions included: A. When did you have the first sexual encounter with a male partner? B. How many masculine sexual partners did you have last month? C. How often did you have sex with homo partners last month?

All study interviewers completed a training program for this survey. At the training sessions, investigators were given detailed instructions concerning the administration of the RRT questionnaire.

From formulae (1) to (8), we could get answers to these three questions. Answer to Question A: The MSM who reported first sex with a male partner had a mean age of 20.24 years ($\hat{\mu}$ = 20.24), and the estimator for $V(\hat{\mu})$ was 0.31 ($v(\hat{\mu})$ = 0.31). Answer to Question B: The MSM had an average of 2.09 masculine sexual partners last month ($\hat{\mu}$ = 2.09), and the estimator for $V(\hat{\mu})$ was 0.05 ($v(\hat{\mu})$ = 0.05). Answer to Question C: MSM had homosexual acts an average of 4.72 times last month ($\hat{\mu}$ = 4.72), and the estimator for $V(\hat{\mu})$ was 0.08 ($v(\hat{\mu})$ = 0.08).

3.1.2. Construct a simulated population

A simulated population was defined as a finite population which comprising the 1523 virtual MSM who were recruited in the field survey. The simulated population consisted of 6 primary units (N_1 = 6). Primary units contained 7, 5, 4, 5, 6 and 3 reconstructed clusters respectively. On average, each primary unit contained 5 reconstructed clusters ($\overline{N}_2$ = 5) and 51 third-stage units ($\overline{N}_3$ = 51) existed within each reconstructed cluster. This finite population entirely contained 1523 third-stage units (N = 1523).

For the 1523 MSM, answer to sensitive question was obtained from real survey and was accepted true value. Therefore, suppose that the simulated population mean of Question A was 20.24 (μ_A = 20.24). The simulated population mean of Question B was 2.09 (μ_B = 2.09). The simulated population mean of Question C was 4.72 (μ_C = 4.72).

3.2. Sample Size Determination for Performance under Simulated Sampling

To have both acceptable viability and reliability in parameter estimates, we could get sample size of simulated sampling from Wang et al. [10]. At the first stage of sampling, 4 primary units were randomly drawn from the simulated population (n_1 = 4). At the second stage of sampling, 60% reconstructed second-stage units were randomly drawn from all the chosen primary units. The virtual MSM respondents from all the chosen second-stage units, which approximately accounted for 40% of the entire third-stage units, were investigated in this computational simulation.

3.3. Monte-Carlo Simulation

Figure 1 gave the procedures, which were allowed us to implement Monte-Carlo simulation. Firstly, 1523 virtual MSM were created in the simulation environment. Secondly, the virtual MSM respondents were randomly drawn by two-stage cluster sampling design. Next, additive RRT model was used to estimate homosexual characteristics of simulated population from formulae (1)–(8). This process was seen as the equivalent to playing simulation sampling out one time.

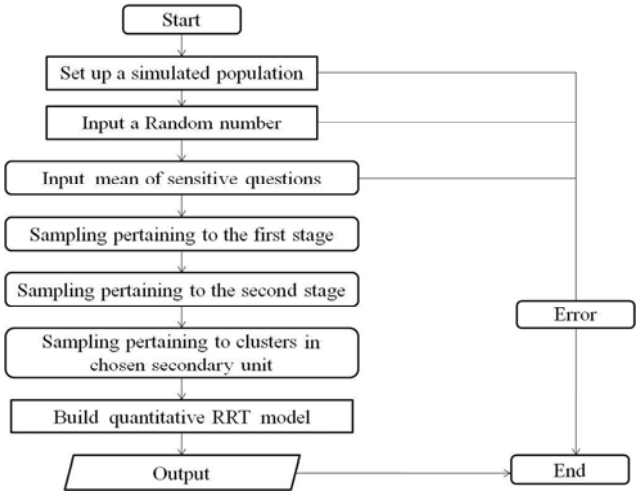

Figure 1. Monte Carlo simulation procedures

In Monte-Carlo simulation, let $\hat{\mu}$ denote the estimator of the simulated population mean, and let $v(\hat{\mu})$ be the estimator of the variance of $\hat{\mu}$. Sampling survey in simulation population was performed fifty times. All the results of simulated sampling were presented in Table 1.

3.4. Validity and Reliability in Performance Assessment

The principles of validity and reliability are fundamental cornerstones of the scientific method. Validity generally refers to the degree to which a test measures what it purports to measure. Reliability usually indicates the extent to which a measurement is repeated under identical conditions. A good way to assess surveys is in terms of their validity and reliability. Both high validity and reliability is arguably the most important criteria for good quality of survey.

The hypothesis test was laid out in this study for evaluation of validity and reliability. For each sensitive question (Question A, Question B or Question C), we could get 50 simulated samples after playing simulation sampling out fifty times. Each $\hat{\mu}$ could be considered as a simulated sample mean.

The one sample *Z*-test was used to compare every simulated sample mean to simulated population mean. If no statistically significant differences between simulated sample and simulated population were observed, all the results from Monte Carlo experiments got close to the simulated population mean. In that way, the difference between simulated samples was very small or did not exist. Thus, survey methods and formulae were repeatable and reliable. What is more, the simulated populations mean, researchers when carrying out real survey acquired this accepted value. Therefore, survey methods and formulae proved to be accurate and valid.

For Question A, the one-sample *Z*-test was used to compare every $\hat{\mu}$ to simulated population mean (μ_A = 20.24). Table 1 gave a summary of statistical analyses on data from simulation survey. The *p*-value statistic for a two-tailed test ranged from 0.016 to 0.837. It was exact that 90% of all the observed p-values were greater than 0.05. There were no statistically significant differences between every sample out of these 45 simulated samples and the simulated population.

The one-sample *Z*-test was used to compare the mean of every simulated investigation about Question B with the simulated population mean (μ_B = 2.09). Table 1 showed a summary of statistical analyses for simulation output data. 96% of all the *p*-values were greater than 0.05, with a value ranging from 0.001 to 0.993. No significant differences between every one of 48 simulated samples and the simulated population were observed.

The one-sample *Z*-test was performed for the comparison of the mean of every simulated investigation for Question C to the simulated population mean (μ_C = 4.72). Table 1 summarized statistical analysis on the output data produced from the simulation. The *p*-values that were more than 0.05 accounted for 94% of all the *p*-values. It was indicated that no significant differences existed between every one of 47 simulated samples and the simulated population

The one-sample *Z*-test about Question A was

$$Z_A = \frac{\hat{\mu} - \mu_A}{\sqrt{v(\hat{\mu})}}. \tag{9}$$

The one-sample *Z*-test about Question B was

$$Z_B = \frac{\hat{\mu} - \mu_B}{\sqrt{v(\hat{\mu})}}. \tag{10}$$

The one-sample *Z*-test about Question C was

$$Z_C = \frac{\hat{\mu} - \mu_C}{\sqrt{v(\hat{\mu})}}. \tag{11}$$

Table 1. Monte Carlo experimental results and assessment of validity and reliability

Question A				Question B				Question C			
$\hat{\mu}$	$v(\hat{\mu})$	Z_A	*p* value	$\hat{\mu}$	$v(\hat{\mu})$	Z_B	*p* value	$\hat{\mu}$	$v(\hat{\mu})$	Z_C	*p* value
17.93	1.57	-1.84	0.066	1.96	0.49	-0.19	0.853	4.60	0.15	-0.30	0.762
21.91	2.50	1.06	0.291	1.13	0.37	-1.58	0.115	4.47	0.08	-0.85	0.393
21.83	1.55	1.28	0.202	1.98	0.55	-0.15	0.882	4.62	0.08	-0.34	0.736
22.67	1.80	1.81	0.070	2.38	0.53	0.40	0.690	4.54	0.13	-0.50	0.619
17.92	2.83	-1.38	0.168	2.88	0.54	1.08	0.282	4.76	0.12	0.12	0.902
18.22	2.03	-1.42	0.156	1.34	0.54	-1.02	0.307	4.14	0.10	-1.84	0.065
21.63	1.84	1.03	0.305	1.27	0.42	-1.27	0.206	4.27	0.17	-1.11	0.268
17.65	2.61	-1.60	0.109	1.32	0.45	-1.15	0.251	4.63	0.25	-0.18	0.855
21.57	2.08	0.92	0.357	1.82	0.57	-0.36	0.721	4.08	0.05	-2.95	0.003*
19.31	1.86	-0.68	0.495	1.54	0.48	-0.79	0.427	3.75	0.06	-4.00	0.000*
17.53	2.61	-1.68	0.093	3.10	0.46	1.49	0.136	4.76	0.31	0.06	0.949
18.48	2.70	-1.07	0.284	1.95	0.64	-0.18	0.861	4.40	0.10	-1.00	0.320
18.76	2.26	-0.98	0.325	2.33	0.64	0.30	0.764	4.06	0.11	-1.95	0.052
18.26	1.99	-1.40	0.161	2.63	0.80	0.60	0.546	4.26	0.12	-1.33	0.184
18.85	2.05	-0.97	0.332	1.01	0.56	-1.44	0.149	4.96	0.41	0.37	0.709
22.01	1.80	1.32	0.188	2.43	0.82	0.38	0.707	4.53	0.28	-0.36	0.718
18.39	1.94	-1.33	0.185	1.68	0.77	-0.47	0.640	4.42	0.11	-0.90	0.371
19.21	1.94	-0.74	0.459	1.45	0.49	-0.91	0.361	4.09	0.21	-1.39	0.163

The continuation of Table 1

Question A				Question B				Question C			
$\hat{\mu}$	$v(\hat{\mu})$	Z_A	p value	$\hat{\mu}$	$v(\hat{\mu})$	Z_B	p value	$\hat{\mu}$	$v(\hat{\mu})$	Z_C	p value
17.36	2.46	-1.84	0.066	1.64	0.56	-0.60	0.548	4.43	0.15	-0.73	0.466
22.62	2.60	1.48	0.140	2.06	0.49	-0.04	0.966	4.17	0.33	-0.96	0.336
21.63	1.92	1.00	0.316	2.45	1.24	0.32	0.748	3.98	0.23	-1.54	0.125
22.14	1.42	1.59	0.111	1.78	0.01	-3.40	0.001*	4.32	0.13	-1.13	0.259
22.81	2.27	1.71	0.088	1.99	2.36	-0.06	0.950	4.10	0.10	-1.94	0.052
22.15	1.66	1.48	0.138	2.75	0.73	0.77	0.442	4.46	0.41	-0.40	0.689
22.71	1.98	1.76	0.079	1.40	0.26	-1.34	0.181	3.69	0.95	-1.05	0.293
19.90	1.20	-0.31	0.756	2.93	2.42	0.54	0.589	4.26	0.44	-0.69	0.491
22.94	1.49	2.21	0.027*	0.86	1.02	-1.22	0.223	4.73	0.38	0.01	0.989
21.52	2.21	0.86	0.389	1.87	0.03	-1.37	0.170	5.86	0.70	1.37	0.172
22.39	1.29	1.90	0.058	2.79	2.22	0.47	0.641	4.42	0.30	-0.54	0.588
22.09	1.28	1.64	0.102	1.99	0.02	-0.67	0.506	3.93	0.12	-2.25	0.024*
21.46	1.44	1.02	0.309	1.57	0.34	-0.89	0.373	4.90	1.16	0.16	0.870
22.82	1.77	1.94	0.053	1.25	0.21	-1.81	0.070	5.24	0.80	0.58	0.559
23.72	2.09	2.41	0.016*	1.57	0.12	-1.51	0.130	4.26	0.51	-0.64	0.522
21.97	1.40	1.46	0.143	1.93	0.60	-0.21	0.832	5.86	0.51	1.60	0.110
22.96	2.26	1.81	0.070	2.73	0.30	1.18	0.239	4.09	1.35	-0.54	0.588
22.02	2.96	1.04	0.301	2.03	0.50	-0.08	0.935	3.84	1.33	-0.76	0.445
22.93	1.65	2.09	0.036*	1.93	0.30	-0.29	0.768	5.52	0.59	1.04	0.298
22.56	1.77	1.74	0.081	3.14	0.62	1.34	0.181	3.81	1.41	-0.77	0.443
22.36	2.15	1.45	0.148	1.76	0.27	-0.63	0.531	3.74	1.41	-0.83	0.409
22.79	2.14	1.74	0.081	1.79	0.22	-0.64	0.525	5.24	0.75	0.60	0.548
23.27	2.71	1.84	0.066	2.10	0.73	0.01	0.993	6.33	1.52	1.31	0.192
22.10	2.44	1.19	0.234	1.93	0.92	-0.16	0.870	4.96	1.92	0.17	0.862
22.90	2.62	1.64	0.100	1.33	0.32	-1.36	0.175	5.12	1.30	0.35	0.726
21.86	2.95	0.94	0.345	1.98	0.89	-0.12	0.904	3.94	1.21	-0.71	0.478
20.48	1.37	0.21	0.837	1.79	0.55	-0.41	0.685	6.43	0.87	1.83	0.067
22.90	1.38	2.26	0.024*	2.39	0.89	0.32	0.750	5.43	1.20	0.65	0.517
23.08	1.71	2.17	0.030*	1.26	0.15	-2.14	0.032*	5.78	0.54	1.44	0.149
23.30	3.01	1.76	0.078	2.76	0.63	0.84	0.401	3.97	0.78	-0.85	0.396
22.88	1.84	1.95	0.051	2.17	0.74	0.09	0.928	4.21	1.93	-0.37	0.714
23.46	2.87	1.90	0.057	2.69	0.76	0.68	0.494	5.02	1.82	0.22	0.824

Note: asterisk indicated $p < 0.05$

4. Discussion

Monte Carlo methods can be divided into two categories: sampling methods and the optimization methods [12]. Many useful applications are available for physics, biology, pharmacy, and general statistics [13–15]. The purpose of Monte Carlo simulations in this research was to imitate the operation of practical survey. It seemed difficult for interviewer to repeatedly conduct sampling survey among MSM. The procedures of simulation involved constructing a stochastic model for repeated random sampling in which the estimators of simulated survey parameter were provided. Thus Monte Carlo scheme showed certain innovation in evaluating validity and reliability under complex survey design for sensitive topics.

RRT have been used successfully in studies of sensitive topics [16–19]. The merit of the RRT is providing more valid and reliable population estimates for embarrassing questions compared with conventional data collection designs such as face-to-face interviewing, telephone interview, computer-assisted interviews and self-administered questionnaires (SAQ) [20].

Survey respondents, invited to participate in research on sensitive topics, are always confined to small area and are usually drawn by simple sample survey methodology. In addition, only simple random sampling might be taken into account in the analysis of data from complex sampling survey. What's more, accessing validity and reliability of sensitive questions in survey research implemented using RRT have been seldom reported. However, these weaknesses had been successfully overcome in our present work.

The survey methods and statistical formulae in this paper indicated strong validity and reliability. Thus, additive RRT model in the context of large-scale complex survey could be identified as an effective technique for obtaining more accurate population estimates for sensitive quantitative characteristics. This would be expected to provide scientific evidence for effectiveness of policy-making on behalf of HIV/AIDS prevent and control among high risk group.

Conclusion

Survey methods and formulae on sensitive topics demonstrated in this study were strongly valid and reliable. Monte Carlo method showed certain innovation in evaluating validity and reliability under complex survey design for sensitive topics. Future research to deduce new RRT models combined with

complex survey sampling design has to be undertaken not only in MSM population, but also in female sex worker in China as well.

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DESIGN OF WEB 2.0-BASED DOCTOR-PATIENT INTERACTION SERVICE SYSTEM

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With the continuous emergence of contradictions, most of which are made by less communication between doctors and patients, it becomes increasingly necessary and possible to construct and implement the doctor-patient interaction service system for the rapid development of hospital informatisation. In this paper, we will presents a web 2.0 based doctor and patient interaction service system, which is platform, system and application-independent, flexible and open to each doctor and patient. By making use of Web 2.0, XML and Atlas technology, the system provides the doctors and patients a rapid, accuracy and versatile interaction platform. The paper first illustrates the makeup and functions of the whole system, and then brings up the design and process of four functional modules: The web interface module, user data to XML module, database module as well as the system security management module. At last, the paper figures out the importance of such interaction system for enlarging the hospital information service range and increasing the medical service quality and the efficiency.

Keywords: Doctor-patient interaction service system, Web 2.0, XML, Atlas technology, system security management

1. Introduction

Medical service has the characters of high professional technology and high skill demand. One of the main disputes between doctors and patients is made because of poor communication between them; medical information technology system can increase the communication between doctors and patients and optimize the treat processes to reduce the incidence of patients disputes. In the course of medical treatment of patients, there exists information asymmetry between doctors and patients, which physicians and hospital are in a strong position, while the patients are in a weak position [1]. 80% of the Medical malpractices during the clinic are caused by the insufficient communication between the doctors and patients [2]. It is necessary and urgent to find some kind of doctor-patient interaction services to solve this problem. Moreover, the development of computer technology has provided the user a convenient way to share their information through the internet. In 1990s, lots of hospital information systems (HIS) based on the internet have been built [3], which provide the hospital introduction, email service, treatment guidelines and so on. However, most of the HIS is based on Web 1.0, which provides single direction information issue, which is not sufficient to satisfy the demand of the patients and doctors.

From the prospective of patients, in the "patient centred" age, the patients and their relations have the right to know the detail about his medical information [4]. What's more, the information share should not be limited just between the medical institutions, but also between the patients. From the hospitals' standpoint, they have the needs that science and research communication and cooperation. So new, both doctor and patient covered platform that is platform, system and application independent, should be constructed to satisfy the demands. The new solution should make sure that everyone on the interaction platform could easily get all needed information that is in his purview.

To solve this problem, we designed a web 2.0 [5] based doctors and patients interaction service system, which makes use of the Web 2.0, XML[6], and Atlas technology [7]. Except the traditional functions, the patient can easily get his information in the medical record sub-system, contract with the doctors, report his symptoms to the doctors and get some consults from the doctors in the online doctor consult sub system, communicate with other patients who have the same illness in the patient sub-system, and lastly scores for the doctors in the scoring sub-system. The rest of the paper is organized as follows: in section 2, we will introduce the related technologies which are used to build the system in the system as well as the reasons to use them; in section 3, the frame of the system will be illustrated; and section 4 will talk about the database management, and in section 5, the design of the system will be explained.

Moreover, the last part will make a conclusion about this paper and figures out the importance of such interaction system for enlarging the hospital information service range and increasing the medical service quality and the efficiency.

2. The Introduction of Relation Technologies

2.1. The Use of Xml in The Doctor-Patient Interaction Service System

Extensible Mark-up Language (XML) is a mark-up language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the XML 1.0 Specification produced by the W3C, and several other related specifications, all free open standards. The design goals of XML emphasize simplicity, generality, and usability over the Internet [8].

As a simple data storage language, XML describes the data by using tags. It is easy to transport XML on the internet for its features, and as a uniform international standard, it is free to everyone. The special structure and tags make it easy to judge the network boundary, which also makes it portable between different platforms. XML overcomes the difficulties that caused by different development platform, different communication protocol. Supporting by XML technology, the data of different protocol can be uniformed. For example, transport personal information, which includes his name, gender, and age between two different systems by using XML, the meaning of different fields, can be easily to figure out for the tag of the field. The existence of the tag also indicates the boundaries of the data. Of course, the added tags make the transmission data on the internet lagers. In short, XML provides a simple, effective, meaningful and flexible standard format for the web-based applications

There are many Structured Reporting (SR) in medical services, which provide an effective mechanism to generate, distribute and management. The semantics descriptions about image and wave contents are perfectly supported in the SR, which make it easy to share the image and related patient information between the doctors and patients. According to the structural features as well as the advantages of XML, many researchers proposed the solutions that transform the SR into XML files. For example, the DICOM work group 10 that it is an effective and simple way to recode the SR by using XML [9] has proved it. In 2009, K. P. Lee make the point that it is the trend that store and exchange the medical information by using XML, and they construct their own SR-to-XML translate system [10].

2.2. WEB 2.0

Web 2.0 describes web sites that use technology beyond the static pages of earlier web sites. A Web 2.0 site may allow users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community, in contrast to websites where people are limited to the passive viewing of content. Examples of Web 2.0 include social networking sites, blogs, wikis, folksonomies, video sharing sites, hosted services, web applications, and mash-ups. The fashion SNS websites, such as the Facebook, Twitter, are based on the Web 2.0. These sites may have an "architecture of participation" that encourages users to share their personal information on the website [11]. Some scholars have put forth cloud computing as an example of Web 2.0 because cloud computing is simply an implication of computing on the Internet.

3. The Frame of the System

There are five subsystems in the doctor-patient interaction service system, and the hospital information subsystem, which is used to provide the base information of the hospital, just as the functions provided by web 1.0 system, Medical report query subsystem, which is used to query the personal medical report on the hospital databases for the patients, doctor scoring subsystem, which is used to score the doctors' service during the medical period, patient communication subsystem, which provides the patients a platform to communicate about their ideas, and the doctor consult system, which provides the patient a convenient channel to find the guideline of the medical, and find some suggestions from the doctors, which is helpful for the illness. The detail structure of the system is described in Figure 1.

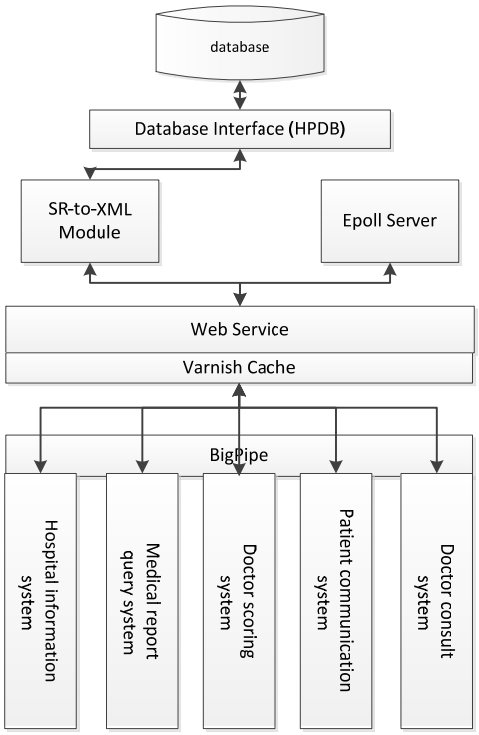

Figure 1. The frame of the interaction service system

Let us explain the detail function of each module in the system.

BigPipe [12] is a fundamental redesign of the dynamic web page serving system. The general idea is to decompose web pages into small chunks called pagelets, and pipeline them through several execution stages inside web servers and browsers. This is similar to the pipelining performed by most modern microprocessors: multiple instructions are pipelined through different execution units of the processor to achieve the best performance.

Varnish [13] is a web application accelerator. Install the accelerator in front of web application and it will speed it up significantly. All of the subsystem need web page to show the content of the web service. This accelerator can make the user have a better user experience.

Web Service module provides the users the basic service from the web server, and the quality of the services depend on the performance of this level.

Epoll Server [14] is a chat server, which provides services for patients' communication subsystem and doctor consult subsystem. Moreover, the server is written by Erlang [15], which is a multi-purpose programming language used primarily for developing concurrent and distributed systems. However, the data of the server is not store in the database, so the messages between the doctor and the users cannot be viewed for a second time, because that the user are free to log on the system with no register, and store such messages are meaningless.

SR-to-XML module is one of the biggest features in the system; it makes the SR sharing and communication possible and easier. It turns the medical image into XML, and then transmitted on the internet. From one aspect, the doctors can share the images, and the patient can also download and upload his own SR from and to the hospital website. The detail of the part will be discussed in section 5.

High Performance Database (HPDB) is a middleware, which is used to construct a high performance and high available MySQL middleware. Because there are many users, including doctors, students and the patients, using the database, so it is necessary to construct a high reliable database system to support the total system. Ant this part will be discussed in section 4.

4. Structure of Database in the System

Database of the system is very essential for that it store the one of the most important part – SR, which can be both from the patient uploading and from the hospital providing. As the centre of the whole system, the performance of the database directly determines the quality of the service of the system.

To provide a high stable and high concurrency database, we adopt the HPDB in our system. The structure of the HPDB is shown in Figure 2.

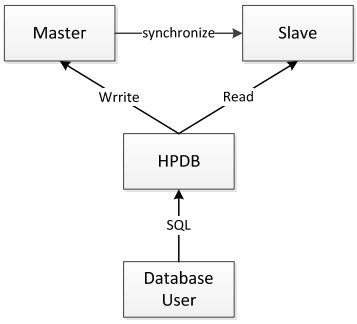

Figure 2. Structure of the HPDB

The idea of the database is made from the Google File System [16], which emphasizes on the cloud storage on the internet. There are multiple servers in the system; one of them is taken as the master node, which does not store the real data but accepts the write data from the but it will not do the write operation, when the data is enough, it will call for the slave nodes in the system and synchronize the data into the slaves nodes. The other servers in the system are taken as the slave nodes, which accept the user read operation.

HPDB module is a request dispatcher, it accept all the database read and write request from the client applications, and then decide what kind of the operation, and then resend the request to related servers. To accelerate the handle procedure, the server, which runs the HPDB module, keeps an index about the tables on the slave nodes. The handle procedure is described in Figure 3.

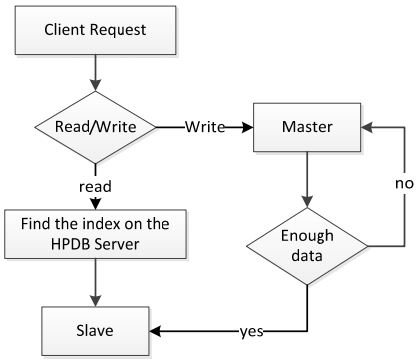

Figure 3. Procedure of the HPDB

The HPDB middleware has four advantages toward the traditional DB system: 1) the database and the applications are separated to some extent; 2) the application programmer can focus on the business logic without caring about the structure of the database; 3) lower the work burden of database administrator; 4) reduce the influence making by the change of the database.

5. Design of the Doctor-patient Interaction Service System

This section will introduce the components and the function design, and then illustrate the four functional modules from the technical point of view: 1) Web interface module; 2) SR to XML translate module; 3) database module; 4) ASP.NET 2.0 based security management module.

5.1. Components of the System and Their Design

As described in figure 1, there are five basic functional modules in the system. In addition, there are three groups of user to use the system: 1) patient users; 2) doctor users; 3) Administrator users.

Patient users: patients can log on the website to get his personal information about his treatment, upload his case history to the doctor, and update his personal information and his feedback to the treatment. Another important function is communicating with the doctors and the other patients.

Doctor users: doctor can log on the website to communicate with his patients, check the patient's feedback about his treatment. The doctor can also find the patient's complaint about his service, and find the defects and shortcomings.

Administrator users: Administrator the right to manage both the doctor users and patient users, make the access strategy that keeps the website from being attacked. One of the most important part is the

database, which carries all the data of the system, for example, the patients SR record and the doctors treatment records.

5.2. Design of the WEB Interface

The purpose of the system is to provide the patients and the doctors a platform to communicate and to provide the patients an easy way to access his personal treatment records. Moreover, most of the functions such as database query are implemented on the server, which most of them use the dynamic interaction between the server and the client. Therefore, a powerful technology – ASP.NET 2.0 [17] to realize the dynamic web interfaces.

During the dynamic interaction between the client and server, a lot of synchronizing request/response models is used, for example, the query, update interactions. There usually exists a fresh phase in the classic web applications: the request will send to the server, and waiting for the server's response for a second time. The main defect of the structure is that this operation wastes a lot of precious user time and the bandwidth of the server, the situation will even worse if the fresh operation happened frequently. In addition, the Ajax has solved the problem perfectly.

Ajax asynchronous technology. Ajax (Asynchronous JavaScript and XML) [18] is a group of interrelated web development techniques used on the client-side to create asynchronous web applications. With Ajax, web applications can send data to, and retrieve data from, a server asynchronously (in the background) without interfering with the display and behaviour of the existing page. As we all known, the main technology in client development is JavaScript in web applications. In addition, ASP.NET is the main technology in server development in web applications. Most of the time, the two have no relationship. Ajax is a new model to merge them together. The client application that connects to the server applications can be very powerful. The web browser has no relationship with the web server, for the Web has no state, except the request and response operations.

The most advantages of Ajax are: 1) better interactivity. This is pretty much the most striking benefit behind why several developers and webmasters are switching to AJAX for their websites. AJAX allows easier and quicker interaction between user and website as pages are not reloaded for content to be displayed; 2) easier navigation. AJAX applications on websites can be built to allow easier navigation to users in comparison to using the traditional back and forward button on a browser; 3) compact. With AJAX, several multipurpose applications and features can be handled using a single web page, avoiding the need for clutter with several web pages; 4) backed by reputed brands. Another assuring reason to use AJAX on your websites is the fact that several complex web applications are handled using AJAX, Google Maps [19] is the most impressive and obvious example, other powerful, popular scripts such as the vBulletin forum software has also incorporated AJAX into their latest version.

Atlas framework. The ATLAS Framework is a front-end development framework includes all 3 layers of front-end: presentation, behaviour, and data. The Ajax strategy, which faced to web application development, constructed by Atlas, can call the web applications on the web server from the client script. The part of the page that has been changed will be reloaded from the web server instead of the whole page.

Atlas is composed by client script library and the Atlas component on the server. The structure of Atlas described in the following Figure4 and Figure 5.

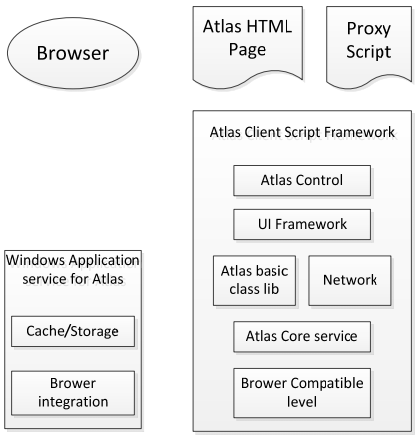

Figure 4. The structure of Atlas client

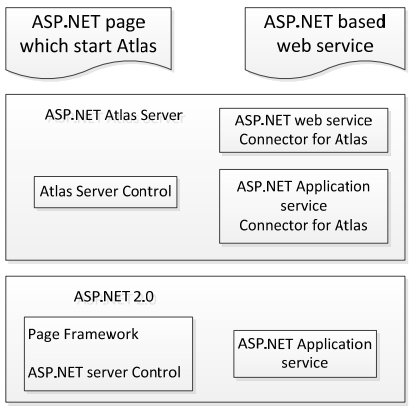

Figure 5. The structure of Atlas server

Example of web retrieval interface. To describe how Atlas works, we will present an example of the patient query about his SR.

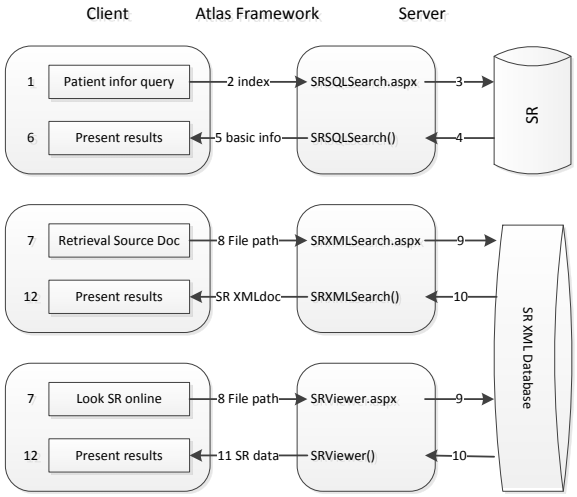

Figure 6. Example of SR Retrieval

The flow of interface implementation is as follows.

1) A button control on client that calls for the ASP.NET service is clicked, the text that input in the Textbox control will send to the ASP.NET service as the parameters. Because of the asynchronous mode employed by the Atlas framework, the information sent to the server is not the whole page but the query information;

2) The ASP.NET application on the server queries the SR database by using ADP.NET for the detail information of the patient, and sends it back to the client;

3) Check the detail information about the patient in the return Atlas data grid.

Image file online translate and web interface. This interface is to realize the image online translate by using web service. The flow of the interface is as follows: 1) select the image files that to be translated on the page by employing the FileUpload control; 2) click the button control which calls for the ASP.NET service that upload the image file; the click message can control the operations of all kind after the file is uploaded; 3) the image file will be translated into XML file by the Web Services. If translate successfully, store the XML file into the database and some other operations. Then return a value to the client to tell the client the translate result. Else, return the false value to the client.

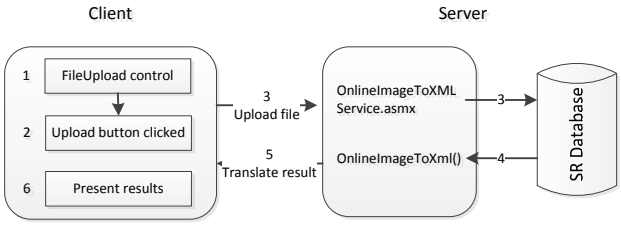

Figure 7. Image file online translate and present

5.3. Implementation Of SR To XML Module

The rules of SR to XML file. The purpose of XML based SR files is to show the related medical data, and to transmit on the internet. Therefore, the SR file should include the patient personal information, treatment information, medical images, physiological parameters and other related information. Consider the same structure between the SR files, the maximization of the related SR file should be presented in the XML file. According to the rules above, the rule of the XML file is described as the following figure.

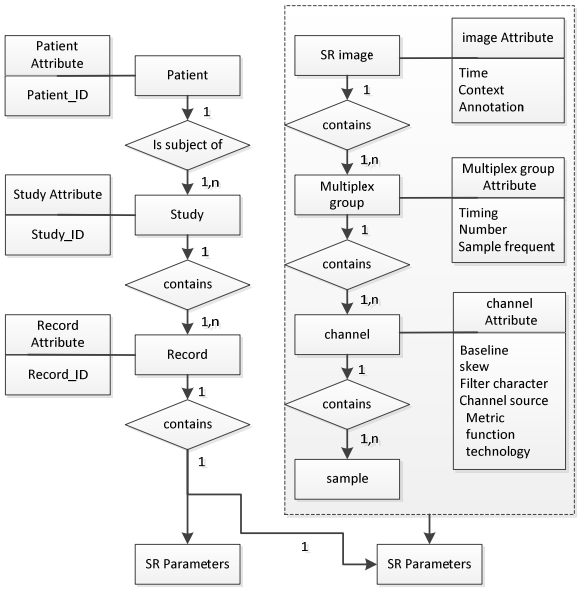

Figure 8. The rules of SR to XML file

Every XML based SR file takes patient as a node, who is identified by the attribute Patient_ID, which includes some sub attributes, such as the personal information and related medical information. A patient may have more than one medical experience for his needs, so there are may be more than on SR record in his SR file, for short, his study sub attribute, to keep track about his illness. The whole module is described in Table 1.

Table 1. Patient module

Title	Attribute
Name	Type=string, minOccur=1, maxOccur=1
Birth_date	Type=data, minOccur=1, maxOccur=1
Sex	Type=Male/Female, minOccur=1, maxOccur=1
Address	Type=string, minOccur=0, maxOccur=1
Phone_num	Type=string, minOccur=0, maxOccur=1
Occupation	Type=string, minOccur=0, maxOccur=1
Size	Type=string, minOccur=0, maxOccur=1, cm
Weight	Type=string, minOccur=0, maxOccur=1, kg
Comments	Type=string, minOccur=0, maxOccur=1
History	Type=string, minOccur=0, maxOccur=1
Study	minOccur=0, maxOccur=unbounded

This module provides the information of the patient's treatment, the unique identify is Study_Instance_UID, including the treatment date and time, treatment agency, and so on. The detail is described in Table 2.

Table 2. Treatment module

Title	Attribute
Study_Date	Type=date, minOccur=1, maxOccur=1
Study_Time	Type=time, minOccur=1, maxOccur=1
Inistitution_name	Type=string, minOccur=1, maxOccur=1
Inistitution_address	Type=string, minOccur=0, maxOccur=1
Station_name	Type=string, minOccur=1, maxOccur=1
Performing_physician_name	Type=string, minOccur=1, maxOccur=1
Referring_physician_name	Type=string, minOccur=1, maxOccur=1
Study_description	Type=string, minOccur=0, maxOccur=1
Record	minOccur=1, maxOccur= unbounded
Results	minOccur=0, maxOccur=unbounded

The treatment records, which record the data during the treatment, are the core module of the SR file, the unique identify is SOP_Instance_UID. The detail is described in Table 3.

Table 3. Treatment record module

Title	Attribute
Acquisition_datetime	Type=datetime, minOccur=1, maxOccur=1
Equipment	minOccur=0, maxOccur=1
PhysiologicalParameters	minOccur=1, maxOccur=1
SR image	minOccur=1, maxOccur=unbounded

The other modules will not list in the paper.

Translate flow. To translate the SR file into XML file, we must first extract the image file, and translate the image into XML according the XML schema, and then write the image file into the XML file. The total flow is described in Figure 9.

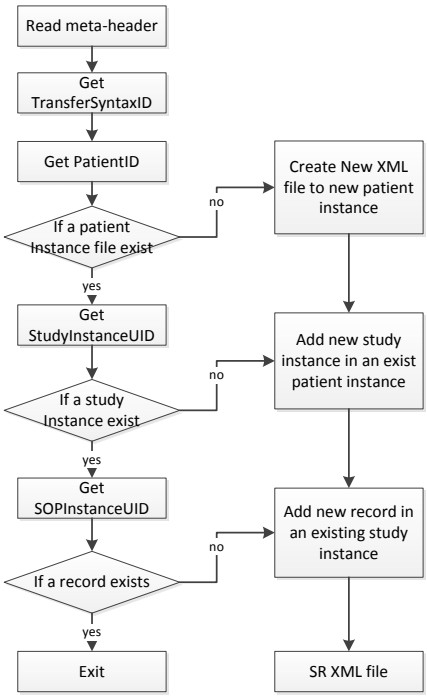

Figure 9. SR to XML translate flow

According to the object oriented programming concepts in C#, we create all the classes, attributes and functions. The following part of the section is an example of a class.

Data element class: data element is the basic operation of the SR file. According to the constitution of the data element, the only operation to the data elements, which include Tag, Data type and Data length, is read and writes.

5.4. Design of the Database

The information in the doctor-patient interaction service system includes the basic information of the patient, patient's treatment records, doctor information, hospital information and so on, the translated XML included as well. In this system, we use SQL Server 2008 to store all the information. As we described in section 4, the structure is to reduce the pressure of the database.

There are 4 types to store the XML files: plat file database, relational database, object database and native XML database [20].

In this system, according to the characters of the data, we adopt object database to store basic patient information, and native XML database to store the XML files. As to the basic patient information, we implement the ADO.NET to realize web interface access to the relational database. The characters of the translated XML file have the hierarchy of the patient-study-record organization. Native XML database can keep this hierarchy character, so the XML file will store in the native XML database.

The query of the database is described in figure 10. According to client's request, the system will decide which database to access, if the relational database is needed, then by using ADO.NET to get the data. If the SR file is needed, then we can first get the path of the SR XML file, and then access the native XML database according to the XML file path.

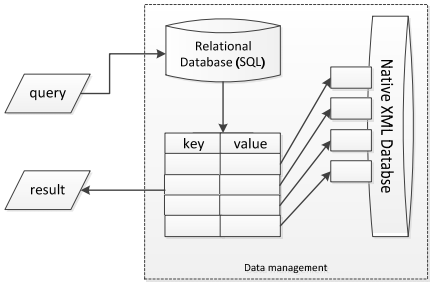

Figure 10. Database query

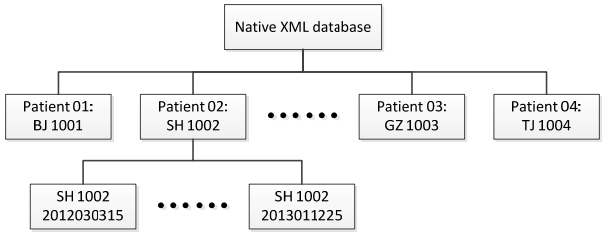

Figure 11. Structure of XML database

Native XML database design: XML database has the same structure to the folders. In addition, the name of the folder is the patient's ID. Every XML document includes the treatment record and his other record. The design of the XML is described in figure 11.

5.5. ASP.NET 2.0 Based Security Management

As an ASP.NET based system, the security of the website is very important.

There are two mechanisms for the security management in the web resource access, one is authentication, and the other is authorization. Authentication is responsible for verifying the user's user name and password. However, not all the users who login in the system have the same privilege to access the data. Then we need authorization, which is a more sophisticated management mechanism to restrict the user's access to the data.

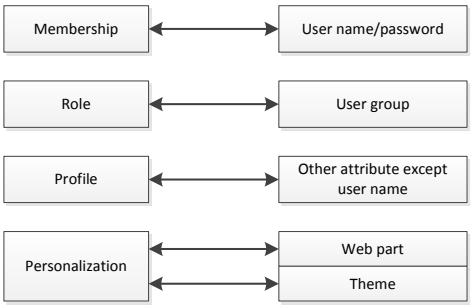

Figure 12. ASP.NET 2.0 function corresponding

Membership is used to create and manage user account. However, membership does the work with some other classes; the main classes used in the system are membership and membershipuser.

Role Management is to create and manage user's roles; this function also needs other classes to cooperation. Before we user the ASP.NET role management, it should be started in the web.config.

There are four authentication modes in ASP.NET: Windows; forms; passport; none. In the system, we select forms. It gives the user more freedom to define his username and password. If the user is authenticated, next page access operation can be processed, if the request is denied, browser will be directed to the default page to force the user to login.

The system employs the URL Authorization mode, the authorization is performed by the UrlAuthorizationModule, it will correspond the users with its roles on ASP. NET application's URL. This module can be used to selectively allow or deny specific users (or roles) to access any part of the application, so it has greater flexibility. User will get different permissions according to his role. Moreover, the website will get different information and run a different operating.

6. Conclusions and Future Research

This paper designed a web 2.0 based doctors and patient interaction service system, which is platform, system and application-independent, flexible and open to each doctor and patient. By making use of Web 2.0, XML and Atlas technology, the system provides the doctors and patients a rapid, accuracy and versatile interaction platform. First, we introduce the technologies in our system, which include XML, Atlas and Web 2.0. Secondly, the framework of the system is introduced. The system includes 5 functional modules, hospital information subsystem, medical report query subsystem, doctor scoring subsystem, patient communication subsystem, and the doctor consult system. Then in part 4, Structure of database in the system is illustrated. Next section is the design of the doctor-patient interaction service System, and at last, we make a conclusion about the whole paper.

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GRADING OF BEEF MARBLING BASED ON IMAGE PROCESSING AND SUPPORT VECTOR MACHINE

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Beef marbling is the most important indicator of beef quality grading via measuring the abundance of intramuscular fat (IMF) in rib-eye muscle. A beef marbling grading method was developed herein based on image processing and support vector machine (SVM). 123 images of beef rib eye steak were acquired for manual evaluation and image processing. After the marbling, scores were labelled to each image by 5 expert graders; several steps of image processing algorithm were used to extract marbling features, boundary tracking operation for background removal, Otsu's thresholding for fat segmentation, morphological operation and logical operation. Seven features computed from the processed images were used as the input for SVM classifier. The optimum SVM classifier was chosen according to the maximum accuracy of K-fold cross validation based on the data of training set, and then was validated by an independent test set. The accurate rate of the proposed method at 86.0465% shows that the image processing technology combined with SVM algorithm can effectively predict beef marbling scores.

Keywords: beef, marbling, image processing, support vector machine

1. Introduction

Beef colour, marbling and surface texture are key factors used by trained expert graders to classify beef quality [1]. Of all factors, the beef marbling score is regarded as the most important indicator [2]. The Ministry of Agriculture of the People's Republic of China has defined four grades of beef marbling and correspondingly published standard marbling score photographs. Referring to the standard photographs, graders determined the abundance of intramuscular fat in rib-eye muscle and then labelled the marbling score [3]. Since the classification of beef marbling score largely depends on the subjective visual sensory of graders, the estimations on the same beef region may differ. Therefore, developing an objective system of beef marbling grading independent on subjective estimation is imperative in beef industry.

Image analysis technology has been considered as objective and consistent in the estimation of beef quality. Many related studies using image analysis technique for marbling measurements [3–7], beef colour judgments [8–9] and quality grading [10–14] have been reported. However, beef marbling classification by computer vision or image analysis has seldom been studied. As machine vision technology aims to objectively assess marbling, a machine vision system will first collect the entire rib-eye muscle image of a beef sample. Then the sample image can be segmented into exclusively marbling region and rib-eye region images with the image processing algorithm. As a result, marbling features can be computed according to the processed images, which are more prone to objectively and consistently determining beef marbling grading compared with visual sensory.

Support vector machine proposed by Cortes and Vapnik [15] is a new learning machine to solve classification problems. Support vector machine (SVM) can solve the problem of small sample size better to obtain the global optimal solution in finite samples, and can also map practical problems to a high-dimensional feature space to solve the nonlinear inseparable problem by establishing a linear classification equation. Therefore, machine vision combined with the SVM method was proposed in this study to estimate beef marbling scores, aiming to:

1) Segment marbling from beef rib-eye muscle by using image processing algorithm;
2) Extract marbling features from processed images;
3) Develop an optimal SVM classifier to grade marbling scores via the proposed marbling features.

2. Materials and Methods

2.1. Sample Preparation

Experimental samples were prepared as described by Chen et al. [8]. One hundred and twenty-three wholesale beef rib eye steak were purchased from a local supplier. After being aged for 72 h at 4°C, individual longissimus dorsis (l.d.) muscle was sliced into 2.5 cm thick samples for image acquisition. Images were acquired on a dark green lint background. Chen et al. [8] described the computer vision system utilizing a colour digital camera and a dedicated lighting chamber. Images were recorded in 24-bit colour and the resolution was 1600 by 1200 pixels in RGB format. Then marbling scores were labelled to each image by 5 expert graders.

2.2. Image Processing

An image was randomly selected from the original image samples of the rib-eye section of beef carcass (Fig. 1a). Image background segmentation was performed by boundary tracing to acquire the rib-eye muscle image of beef carcass (Fig. 1b) and the image of beef target area (Fig. 1c). Otsu's method was used to binarise the grey image in Fig. 1b to obtain the marbling region image (Fig. 1d). Image logic "exclusive or" operation was conducted for the target area (Fig. 1c) and the marbling area (Fig. 1d). After omni-directionally corroding the calculation results, a small-area removal was performed once again. Then the image was expanded to all directions, yielding the beef muscle region (Fig. 1e). As l.d. was the largest muscle connected area in the rib-eye image of beef carcass, cavity filling was conducted for Fig. 1e (Fig. 1f). The rib-eye area mask was then obtained by reserving the largest connected area in Fig. 1f (Fig. 1g). Fig. 1c and 1g were subjected to logic "and" operations to obtain the beef marbling region, as shown in Fig. 1h.

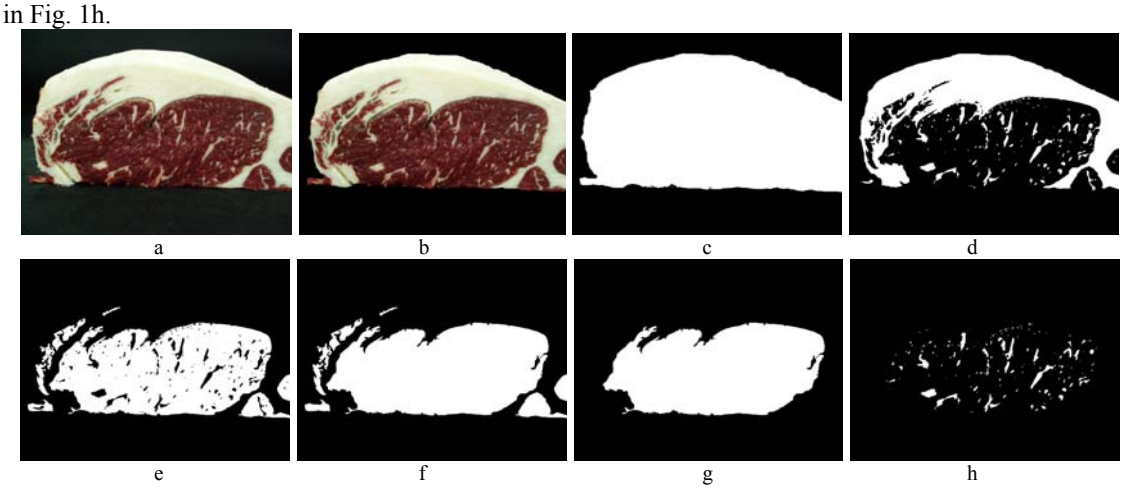

Figure 1. Segmentation of marbling region from a representative beef steak image

2.3. Feature Extraction

Referring to a previous study [5], the area of marbling (AM), area of rib eye (AR), number of marbling particles (NM), average area of marbling particles (AAM), area of large marbling particles (ALM), number of large marbling particles (NLM), area of small marbling particles (ASM) and number of small marbling particles (NSM) were first extracted from the processed image in this study. Then all features of beef marbling were calculated based on these parameters.

AM was expressed as the sum of all white pixels in the marbling image, AR was expressed as the sum of all white pixels in the rib-eye area image, NM was expressed as the sum of all disconnected independent regions in the marbling image, and AAM was expressed as the ratio of AM to AR. ALM was expressed as the number of pixels after independent regions where the number of pixels was lower than AAM were removed from the marbling image, NLM was expressed as the number of all disconnected independent regions in the image in this case, ASM was expressed as the difference between AM and ALM, and NSM was expressed as the difference between NM and NLM.

The 7 feature values were thereafter calculated according to the above parameters. Features 1–7 are the ratios of AR/AM, NLM/NM, ALM/AM, ALM/AR, NSM/NM, ASM/AM and ASM/AR, respectively.

2.4. SVM Classifier

2.4.1. SVM

The basic theory of SVM was put forward based on classification problems. The linearly separable training sample set is $T=\{(x_1,y_1),\cdots,(x_m,y_m)\}$, where $x_i\in R^n$ and $y_i\in\{1,-1\}$ are the class labels. In other words, we intend to find ω and b to realize the structural risk minimization of function $f(x)=\langle\omega\bullet x\rangle+b$, so as to maximize the classification margin $\text{Margin}(H_1,H_2)=\frac{2}{\|\omega\|}$. The problem of pending optimization can be expressed as:

$$\begin{cases}\min\frac{1}{2}\|\omega\|^2\\ y_i\left(\langle x_i\bullet\omega\rangle+b\right)\geq 1.\end{cases}\tag{1}$$

Lagrange multiplier method was used to solve this constraint optimal problem, and to establish the corresponding Lagrange function:

$$L(\omega,b,a)=\frac{1}{2}\|\omega\|^2-\sum_{i=1}^{l}a_i\left[y_i\left(\langle x_i,\omega\rangle+b\right)-1\right].\tag{2}$$

where $a_i\geq 0$ and $a=(a_1,a_2,\cdots,a_m)$ are the Lagrange multipliers. According to the Wolfe dual definition, the minimal values of ω and b of the Lagrange function were evaluated first. The dual problem of quadratic programming was obtained from extremum conditions as:

$$\begin{aligned}&W(a)=\sum_{i=1}^{l}a_i-\frac{1}{2}\sum_{i=1}^{l}\sum_{j=1}^{l}y_iy_ja_ia_jx_i^Tx_j\\ &a_i\geq 0,\sum_{i=1}^{l}a_iy_i=0\end{aligned}.\tag{3}$$

According to the relationship between the solutions of primal and dual problems, if a^* is the optimal solution to the dual problem:

$$\begin{aligned}&\omega^*=\sum_{i=1}^{l}a_i^*y_ix_i\\ &b^*=\frac{1}{2}\left[\langle x_i(+1),\omega^*\rangle+\langle x_i(-1),\omega^*\rangle\right].\end{aligned}\tag{4}$$

Therefore, the optimal separating hyper plane is:

$$\langle x,\omega^*\rangle+b^*=0.\tag{5}$$

The non-negative slack variable ξ and error penalty factor C were introduced in case of acceptable noise, and the problem of pending optimization can be expressed as:

$$\begin{cases}\min\frac{1}{2}\|\omega\|^2+C\sum_{i=1}^{l}\xi_i\\ y_i\left(\langle x_i,\omega\rangle+b\right)\geq 1-\xi_i,\xi_i\geq 0\end{cases}\tag{6}$$

ω and b can be obtained in accordance with the specific solution of quadratic programming problems. Linearly inseparable problems of classification can be handled by inputting samples into the space and transforming them into a linear problem of a certain high-dimensional space to solve the linear optimal

separating hyper plane therein. SVM ingeniously transforms this problem into a characteristic space for calculation by defining a kernel function. If the kernel function $K(x,y)=\Phi(x_i)\bullet\Phi(x_j)$ was used, the original optimal problem of nonlinear SVM can be transformed into:

$$\begin{cases}\min\dfrac{1}{2}\|\omega\|^2+C\sum\limits_{i=1}^{l}\xi_i \\ y_i\left(\left\langle\Phi(x_i),\omega\right\rangle+b\right)+\xi_i\geq 1,\xi_i\geq 0\,.\end{cases} \tag{7}$$

2.4.2. Construction of SVM classifier

Before building a suitable SVM classifier, we need to carefully select an appropriate kernel function. Linear, polynomial, sigmoid and radial basis function (RBF) kernel functions are most frequently accessed, of which RBF kernel function has been widely applied in SVM with good performance. Thus, RBF kernel function was used in this study to build SVM classifier, which can be expressed as:

$$K(x_i,x_j)=\exp\left(-r\left|x_i-x_j\right|^2\right). \tag{8}$$

When the class number is higher than 2, it is necessary to build a multiclass SVM. Particularly, a 4-output SVM classifier was needed to identify beef at four marbling levels in this study. Besides, several two-class SVM classifiers were connected to development a multiclass SVM classifier.

In terms of optimally selecting SVM parameters r and C, they (r and C) are commonly evaluated in a certain range using the grid search method. When r and C g are set, the K-fold Cross Validation (K-CV) method is used to obtain the classification accuracy of validation of the training set for c and g in this group with the training set as the original set of data. r and C were then selected repeatedly, and eventually the group of r and C with the highest accuracy of classification are rendered as the optimal parameters. In this study, a training set with 80 sample data was equally divided into 4 subsets. Each subset was once used as the validation set and the remaining three were used as the training set, which thus yielded 4 models. The average classification accuracy of the final validation set of the four models was utilized as the performance index of the 4-CV classifier, and the optimal combination of r and C was determined by the average accuracy maximum.

2.4.3. Algorithm implementation

The above algorithm was implemented with Matlab under Windows XP SP3 on an Intel(R) Dual-Core CPU E5300 processor, 2.60GHz machine.

3. Results and Discussion

3.1. Marbling Extraction

As described in Section 2.3, 7 features that characterized beef marbling were extracted from the processed image. The minimum, maximum, average, and standard deviation of marbling characteristics are listed in Table 1. The substantial changes of the features indicate the beef samples are representative. After being assessed by expert graders, the 123 beef samples were marked with levels 1, 2, 3 or 4. The standard deviation of the marbling features fluctuated less significantly than the average, suggesting that the standard deviation is not a critical index. Additionally, 12 marbling feature values with 95% confidence interval were plotted against marbling scores respectively (Fig. 2). Fig. 2 shows that marbling scores and the features are complicatedly correlated. It is difficult to build a simple model, such as a linear model based on these marbling features, to predict the marbling level.

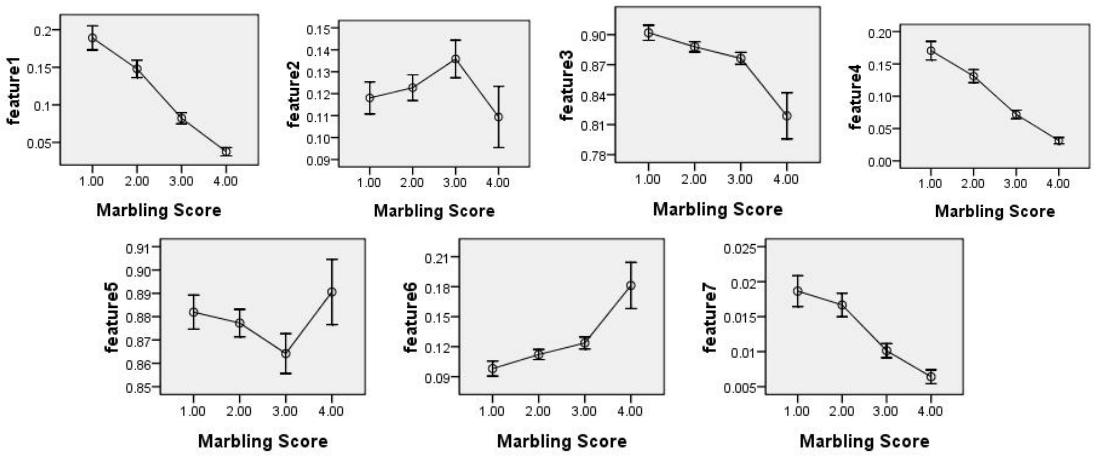

Figure 2. Relationship between beef marbling features and scores

Table 1. Descriptive statistics of beef marbling features

Marbling feature	N	Minimum	Maximum	Average	Standard Deviation
Feature 1	123	0.0130	0.2719	0.1148	0.0648
Feature 2	123	0.0590	0.1827	0.1219	0.0265
Feature 3	123	0.6970	0.9261	0.8720	0.0450
Feature 4	123	0.0091	0.2450	0.1018	0.0590
Feature 5	123	0.8173	0.9410	0.8781	0.0265
Feature 6	123	0.0739	0.3030	0.1280	0.0450
Feature 7	123	0.0031	0.0275	0.0130	0.0064

3.2. Prediction of Marbling Scores by SVM Classifier

According to the description in Section 2.4, the training set containing 80 sample data was used to train the SVM classifier to find out the optimal combination of r and C. Fig. 3 presents the results of SVM selection. The combination of $r = 90.5097$ and $C = 0.35355$ resulted in the highest cross validation accuracy ($CV_{Accuracy}$) of 83.7209%. Thus, we selected $r = 90.5097$ and $C = 0.35355$ to build the optimum SVM classifier to predict beef marbling scores.

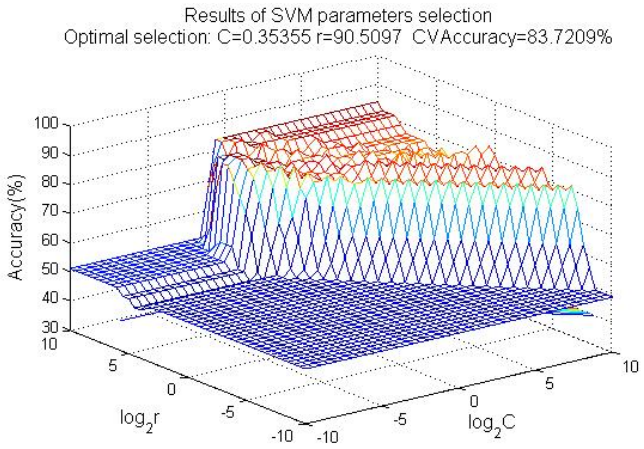

Figure 3. Results of SVM parameters selection

The optimal SVM classifier was validated using the test set containing the residual samples to evaluate its performance. Out of the 43 samples, the proposed classifier correctively classified 37 samples. The performance percentage of the optimal SVM classifier was 86.0465%. The results reveal that the marbling features extracted from the processed beef images contained useful information to distinguish beef marbling scores.

4. Conclusion

In this paper, the automatic grading of beef marbling was studied by combining image processing with SVM. Beef marbling was segmented by image processing such as boundary tracking, Otsu's thresholding and morphological operations. Then SVM algorithm was used to predict beef marbling scores and an optimal SVM classifier was constructed. Applying the proposed method in estimating the marbling scores led to an accurate rate of 86.0465%.

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RESEARCH ON THE APPLICATION OF WORKFLOW MANAGEMENT SYSTEM IN COLLABORATIVE PLATFORM FOR ENGLISH TEACHING

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With the varied tools and technologies of the workflow and Business Process Management System adopted, this paper is aimed to put forward a method to improve the collaborative English teaching platform. In the collaborative system and based on those varied processes, a simple process flow has been defined. Then, a participated entity, namely the Business Process Management System is designed in this paper.

Keywords: workflow, collaborative English teaching platform, Education, management system

1. Introduction

Collaborative teaching platform provides clients with full theories and practical systems by enterprise projects, which is standard and practical. In addition, its feature can imitate the open process of enterprise so that teachers can put books into the system out of limit of time and space. Besides, teachers can assign homework or task, make and publish the network courses conveniently. Most importantly, the learner can be free to choose what they want to study. Moreover, it includes many exercises that can be tested by computers. Teachers can publish plans and tasks that have the deadline to hand in freely according to it. They can correct homework when they receive them. The system will figure up the number of learners who did not hand in homework automatically. Besides, teachers can make use of the technology of workflow to answer questions online or remind learners when they are off-time and make the collaborative teaching come true [1].

Aim of study redesign teaching and co-operative platform using the principle of workflow. Therefore, it could make the Management System change into the mode for business process-oriented from the mode for the function, which makes it have the function of business process management.

2. Introduction of Workflow Technology

2.1. Concept of Workflow

Nowadays, the workflow technology is becoming more and more perfect, which is applied to many fields. Nevertheless, it does not have common and clear. WFMC is defined as the whole or part of process of business to be automatic. During the process of achieving some business goals, ruler to make workmates work together better will deliver the files, messages and tasks. That is, workflow is a series of interrelated, automated or semi-automated business activities and processes of implementation [2–3].

2.2. Structure of Workflow

As we know, it needs the right software system to support in order to realize the management of workflow. Therefore, Workflow Management System is to support the definition of workflow, and its principle is as follows: Firstly, according to workflow process model that is predestined, application environment is transformed into workflow instance. Secondly, we should keep the definition of the whole or part of process active [4].Finally, we can achieve our goals by instance of the interface and processing the external resources required to interact.

The workflow system is made of workflow model, workflow engine and interface of client-side. The workflow model is the foundation of designing the whole workflow engine, which is the summarization and abstract of the process of business [5].

The workflow engine is responsible for the implementation of business processes. It is also responsible for monitoring, the external application call, task distribution, task status control, data transfer, event triggers and notification reminders. The workflow engine explains the implementation process instance. It is mainly java process that is executed in the background.

The workflow engine must provide client-side with package routing algorithms. Moreover, the engine routing mechanism plays a key role in whether the process execute efficiently. Moreover, it can call automatically application types such as java and Web Service.

3. Workflow is introduced into Collaborative Teaching

Collaborative teaching is the teaching model based on the face-to-face teaching style, the Individual teaching style and collaborative learning, aimed to improve learners' ability of cognizance and healthy feelings. In addition, its theme is about learning, so learners can form the good habit of studying by competing, discussing and interacting. In addition, the model of collaborative teaching has four styles, which are competition, cooperation, partnership and role-playing.

For example, learners will act as the analyst, auditor and Regulators and so on during the software training, which can develop learners' ability of software development [6].

Collaborative teaching provides a development platform that includes some learners. In addition, learners can join in the actual project groups to experience roles of different jobs and study the process of software development in enterprise so that they can adapt to it after graduated.

3.1. Process of Teaching and Learning Should Have "Flow" Features

During the common teaching, most of work is solved by some regular process. Such as planning lab classes, giving a mark and presenting learners' grade [7]. These fixed or similar business processes in a formal way of the computer can handle that, this formal representation called the process model or workflow process definition model.

The description of the workflow is follows in Figure 1.

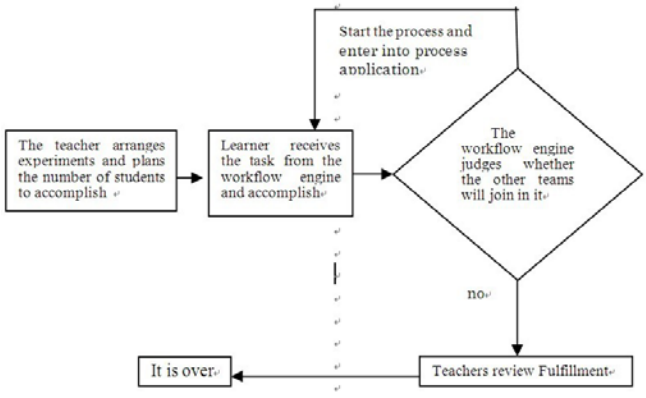

Figure 1. Program flow analysis

3.2. Technology of Workflow is Applied to the Teaching Management Efficient

Nowadays, instructional theory thinks that it can improve the efficiency of learning if learner can study together better. Besides, it has many advantages, for instance, it can improve learners' communication skills and teamwork spirit, and the workflow technology can improve the teaching management system greatly.

It can make the right plans by studying tasks, support the idea that learners can study at their own pace, support the information management and knowledge sharing, encourage learners and teachers to work together and provide the function of monitoring person and teams. And traditional teaching management system usually gives learners courses and exercises when it begins, while the teaching management system based on workflow technology can decide to transfer further learning data by the completion of the learning tasks.

According to the rules of teaching activities, we use the workflow to define the process. All the process will be sent to workflow engine after being dealt with. Moreover, workflow engine will decide what to do next by the business process in advance. And all the tasks will be submitted to performer's desktop timely and exactly.

3.3. Workflow Running Model

It makes the definition of workflow simple and clear because it provides imaging tools and workflow frame construction without business. A workflow-running model is shown in Figure 2.

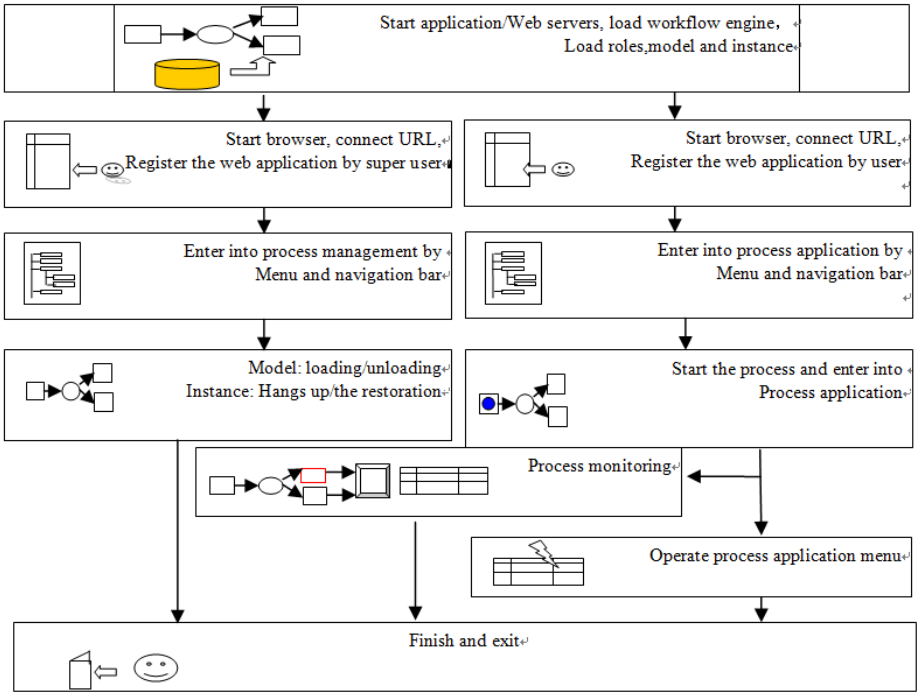

Figure 2. Workflow running model

Workflow management system runs by business process rules, at the same time, it has the ability of controlling process. All the tasks are sent to everyone's desktop by workflow engines that follow the time limit of dealing with the tasks. Then faculties and learners deal with their own business according to the menu of tasks in desktop. In addition, faculties can choose preferentially the task that is near the deadline by the menu, aimed to void some tasks to be delayed.

Workflow management system will record the processing procedure, which lays the foundation for inquiring, examining and evaluating. For example, each course will be divided into some chapters and learners will finish each chapter [8]. Learners can choose the way of studying by the basic process or by themselves and can achieve help from teachers, classmates and systems by the records of each chapter.

In the teaching platform design, we create one point of the process of knowledge nodes, by order, parallel, branch, loop connecting the different processes into a process.

It can define, built and execute the process of teaching business, and can realize the functions of managing and monitoring them by applying workflow technology to the system of teaching platform. Moreover, it could make the MIS change into the mode for business process-oriented from the mode for the function, which makes it have the function of business process management.

4. Instance, which Workflow is applied to Collaborative Teaching Platform

Now, we may have a look at the design of workflow in collaborative teaching platform. Process is dealt with and designed logically are shown in Figure 3. Firstly, teachers can set a group. In addition, learners can submit a paper to others in the group and others will correct the paper and add some knowledge, then he or she can submit it to the next, finally, this paper will be sent to the teacher. Of course, learners will also finish their work by themselves in no order. Describe of logic diagram are depicted in Figure 4. Therefore, it can improve and communication for learners on the remote network [9].

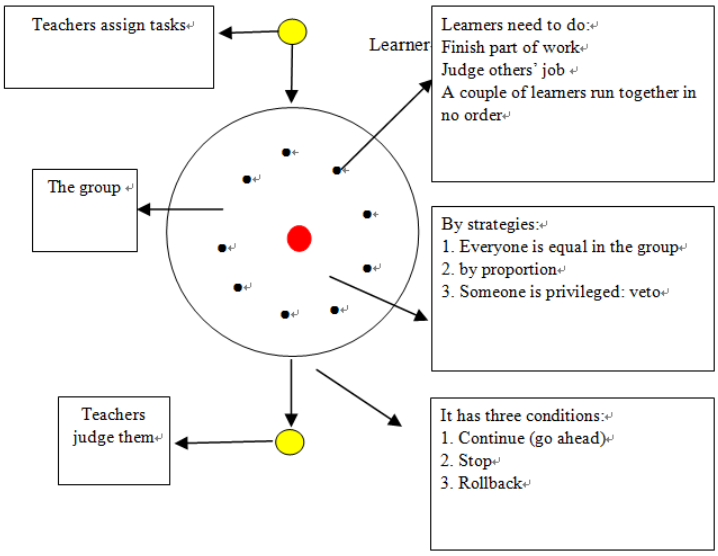

Figure 3. The logic design of workflow teaching platform

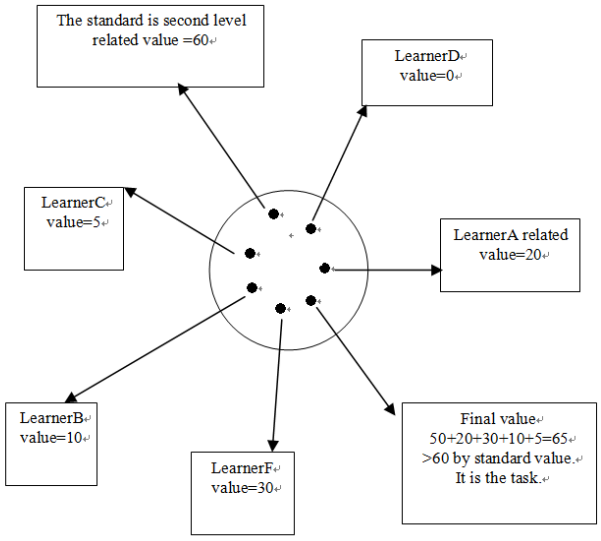

Figure 4. A logic diagram of collaboration between learners in workflow teaching platform

4.1. Design of Logic Element

Stage 1: The logic element which stands for business: Form Task, Tool Task, Sub flow Task.

The logic element which stands for workflow Start Node, Activity, Synchronizer, End Node, Transition, Loop.

Stage 2: Data object of the process: Data Field.

Synchronizer node stands for the counting of workflow engine, for example, workflow needs to deal with some logical problems and these problems are sequential, branching, converged and cyclical.

Tasks are logic of subsystem of collaborative teaching, while Activity, Synchronizer, Start Node, End Node, Transition, Loop are logic of subsystem of workflow, meanwhile, Transition, Loop are applied to transfer the right of controlling between subsystem of collaborative teaching and subsystem of workflow [10].

4.2. Instance of Running

Definitions of roles are given as tabulated in Table 1. The first operation is using by the workflow teaching platform in the background.

Table 1. Definition of roles

Simulation model variable	Meaning
Role User(Find Bug)	User Tom
Role Developer (Fix Bug)	User Jack Jee
Role Tester (Test Fix)	User George

Status bit of workflow system running are given as tabulated in Table 2. This marked the status of the workflow system process.

Table 2. Code of status

Code of status	Name of status bit	Description of status bit
00	Begin	When recording the new data, It will save the default state, if the state
01	Be submitted	Only the initial state(00) and the returned state(97) can only be submitted for review, and after the official launch of the workflow, it can be considered to trial
97	Rollback	Only the person who create the returned documents can logically deleted and re-trial
98	Delete logically	When the documents are returned, if the documents were invalid in this document complete, executable tombstone, which is a process status bit is set to bit 98, in principle, should be controlled to return after the tombstone, the other state should not execute tombstone.
99	Approval	Final approval by the documents, making the end of the process, approval workflow engine is no longer monitored by the documents

Figure 5 illustrates login the system using the user named tom (role Find Bug). Submit it to fix bug or rollback to previously role is shown in Figure 6.

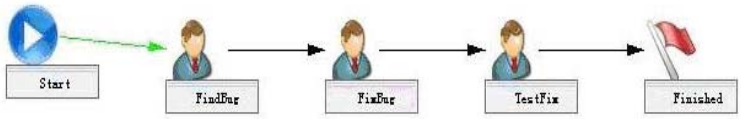

Figure 5. Login the system using the user named tom

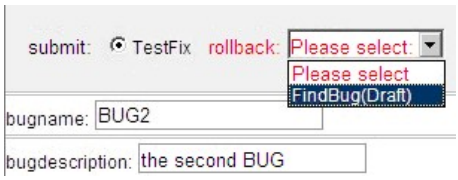

Figure 6. Submit to fix bug or rollback to previously role

The system of teaching platform that is finished supports collaborative learning and creates the functional model of business system, such as personnel management, process controlling, reporting forms, managing the rights and communication .And it can produce the functional models quickly by setting some parameters, so void to develop it again because the system is different [11–12].

5. Conclusions and Future Work

Managers only need to use the mouse to choose or fill in data by using the visual tools. At the same time, managers can use the typical process or part of configuration that is user-defined to some typical teaching processes, which is simple, quickly and meeting the demand of different teaching processes [13].

The model of collaborative learning shows individual learning based on workflow technology, which is open, sharing and interactive. Moreover, it can improve the ability of communication between learners or between learners and teachers by combining electronic messages, which can contribute to collaborative learning and resource sharing.

From now on, we will improve our system from the following points: We will make the workflow model which is faced to business perfect, and make it deal with complicated problems simply and make it more flexible, which can adapt to the stronger business process.

Acknowledgment

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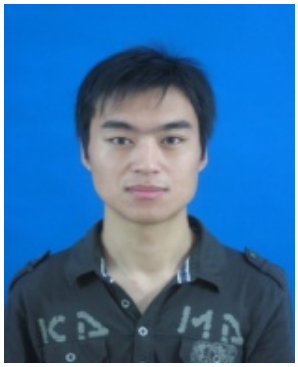

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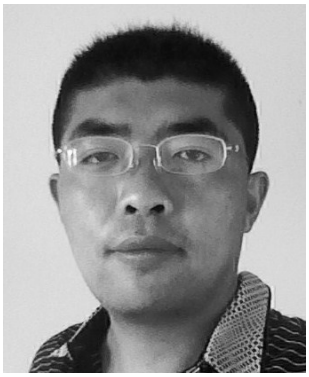

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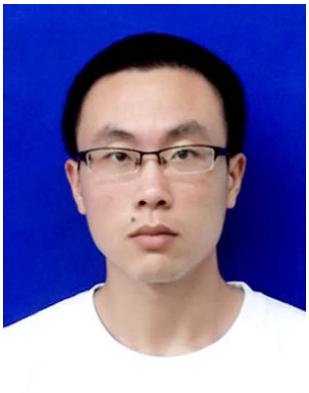

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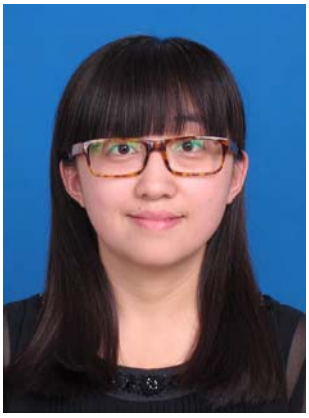

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CUMULATIVE INDEX

COMPUTER MODELLING and NEW TECHNOLOGIES, volume 17, no. 3, 2013 (Abstracts)

Q. Chen. Change of Ecological Environment in Shenfu Mining Area of China Based on GIS and RS, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 7–11.

The ecological environment in Shenfu mining area of China is fragile. Coal mining has impacted great influence on the ecological environment of mining area. To analyze the damage condition of ecological system and rapidly recover the damaged ecosystem plays an important role in regional sustainable development. Based on the remote sensing data of year 1989, 2002 and 2006, the index of NDVI, vegetation coverage, desertification and land use in the studied area were studied and analyzed. The research results showed that: The vegetation coverage was becoming better on the whole; however, in the mining area of large coal mines, the degree of vegetation coverage was still very low; the potential desertification area increased gradually, from 81661.02hm^2 to 149200.74hm^2; the severe desertification area reduced gradually. The research results provided a base for mine land reclamation and ecological restoration, which can play a positive role in promoting the construction of ecological environment in western area of China.

Keywords: Shenfu mining area; RS; GIS; ecological environment

J. Gao, W. Zhang. Researches on the Construction of Information Technological Multi-Dimensional Interaction-Based Ideological and Political Teaching Mode in Higher Education Institutions, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 12–19.

With the enhanced reformation promoted by The CPC Central Committee Propaganda Department and the Ministry of Education on the ideological and political education in higher education institutions, a number of higher education institutions in our country are making deep self-reflections over their modes of ideological and political education. This text makes deep analysis over the concept and characteristics of the multi-dimensional interactional teaching modes for the information technology in higher education institutions in the first place, obtaining better understandings for the multi-dimensional interactive teaching mode of information technology.

In the meantime, it carries out researches on the current situation of the ideological and political teaching in the higher education institutions with the standard of "teaching contents, teaching modes, teaching environment and the overall satisfaction degree for teaching" and concludes that the ideological and political education in the higher education institutions requires further researches. Besides, with the class construction for the multi-dimensional interaction in the higher education institutions and with the deep data analysis on the students' course experience with the CEQ Questionnaire from the implementation results of the multi-dimensional interaction of information technology, it would play positive functions for the diversified teaching mode of the ideological and political teaching in higher education institutions.

Keywords: Information Technology, Multi-dimensional Interaction, Ideological and Political Education of Higher Education Institutions, Teaching Mode

L. Kang, G. Qian. Application Research of Multi-Agent Modeling and Simulation Method in Staff Morale Assessment, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 20–26.

In the fierce market competition, the staff morale plays an important role in strengthening the core competitiveness of enterprises, a rapid, scientific and reasonable assessment on staff morale of enterprises is required, so as to provide scientific basis for agglomerating and enhancing staff morale. The enterprise staff morale index system has been established by taking the complex adaptive system's theory as the guidance and with reference to relevant research results, and it has been quantized; the morale unit model has been established by the multi-agent simulation method, thus establish the workshop first level morale simulation model system. Based on the modeling simulation of multi-agent staff morale assessment, a wholly new channel for the staff morale simulation assessment has been explored, met the requirements of combining the quantitative part with the quantification during the actual operation, and the assessment has such advantages as being easy for modeling, integration and expansion, etc.

Keywords: morale assessment, simulation model, multi-agent

D. Greenberg. Optimal Budget Reassignment Problem Among Several Projects with Different Priorities, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 27–34.

The problem of optimal planning for a design office comprising PERT-COST network projects with different priorities is solved. At the upper level - the design office level - the problem centers on reassigning the total budget in order to optimize the combination of projects' reliabilities and priority values. At the second level - the project level - the problem's solution boils down to optimal budget reassignment among the project's activities subject to the least permissible project's reliability value. The solution is obtained by a combination of heuristic and Monte-Carlo methods.

Keywords: budget reassignment, project's reliability, PERT-COST project, global search method, Monte-Carlo method, project's design office.

G. P. Zhao, Y. M. Bo, M. F. Yin. Region Based Multi-Spectral Saliency Detection, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 35–42.

Visual saliency detection is useful for applications like image segmentation, image retrieval et al. According to the thought that the near-infrared image can provide complementary information to the corresponding visible image, a new region based multi-spectral saliency detection method is proposed. The source images are decomposed into homogeneous regions by superpixel algorithm in 6-dimentional vector space, which is, composed of the LAB color values of the visible image, the gray value of the near-infrared image and the two-dimensional pixel coordinate. Then the final saliency map is obtained by measuring the region's contrast, which is computed by using multi-spectral color information and spatial distance. The publicly RGB-NIR dataset is adopted for experiment evaluation; Compared with five other state-of-the-art methods, the proposed method produces superior performance. Experimental results show that the proposed method is effective.

Keywords: saliency detection, multi-spectral, superpixel, region contrast

M.-H. Horng. Training Radial Basis Function Network Using the Honey Bee Mating Optimization, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 43–49.

The radial basis function (RBF) network is a popular type of neural network that is very useful for pattern classification. Several algorithms have been proposed for training the RBF network. This paper introduces a training algorithm of radial basis function (RBF) neural networks for classification based on the honey bee mating optimization (HBMO) algorithm. The training performance of the HBMO algorithm is compared with the gradient descent (GD) algorithm, particle swarm optimization (PSO) algorithm and genetic algorithm (GA). In experiments, the well-known classification problems from the UCI repository are designed. Experimental results show that the usage of the HBMO algorithm is better than those of other methods.

Keywords: Radial basis function network, Honey bee mating optimization, Gradient descent algorithm, Particle swarm optimization, Genetic algorithm.

H. T. Wang, G. Xu, X. Ch. Hu, D. Ben. Range-Doppler Distributed Target Detection Based on Adaptive Waveform Design, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 50–55.

To resolve the problems of complicated clutter, fast-varying scenes and low signal-clutter-ratio (SCR) in application of distributed target detection on sea for space-based radar (SBR), a target detection approach based on clutter statistics update, adaptive waveform design (AWD) and advanced principal component analysis (PCA) is proposed in this paper. In this detection approach, a distributed target is modeled as some scatterers with Gaussian reflectivity on the range-Doppler space, and complicated sea clutter is modeled as compound Gaussian process. The simulation results show that, considering the configuration of SBR and the condition of complicated clutter, 9dB is reduced for SCR which reliable detection requires by this target detection approach. Therefore, the work in this paper can markedly improve radar detection performance for weak targets.

Keywords: space-based radar; distributed target; adaptive waveform design; principal component analysis; multiple particle filter; generalized likelihood ratio test

G. Wu, B. Wu, L. Qin, X. Chen, F. Qian, Y. Fan. Multi-Agent System-Based Emergency Control Scheme for Power System, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 56–62.

In this paper, a novel coordinate scheme of emergency control is proposed, which is based on technology of Multi-agent. In order to identify the minimum control area, an algorithm based on the principle of Run the Horse Stable Place is put forward. During the process of minimum control area

identification, power system's diagram and undirected graph are the only two aspects to consider. When a fault or sudden dramatic load change occurs, Lord Agent in the control area and agent in the action area consist of the MAS (Multi-agent System) to deal with the emergency fault. The proposed method is applied to the WSCC4-machine system, and the test result shows that using MAS an effective control result can be obtained.

Keywords: Emergency control scheme, MAS, Coordination, Agent

H. Guo, J. He. A Color Fractal-Based Morphing Algorithm, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 63–68.

In this paper, based on the idea of fractal keyframe algorithm and by giving the colour correspondence principle of contractive mapping, the interpolation algorithm is conducted between the initial object and target object. Then the process of in-between colour fractal images is obtained. Applying the fractal to colour morphing animation, a colour fractal-based morphing algorithm is provided. The experimental simulation shows that for the animation generated by using this algorithm, the transition between frames is natural and smooth, the images are also smooth, colour matching is accurate and the effect is lifelike and controllable.

Keywords: Fractal, Keyframe, Animation

Z. Jin, H. Zhu, B. Yu, Ge Gao. A Monte-Carlo Simulation Investigating the Validity and Reliability of Two-Stage Cluster Sampling Survey with Sensitive Topics, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 69–75.

A two-stage cluster sampling was designed to select males who have sex with males (MSM) in Beijing. Quantitative additive randomized response technique (RRT) model was presented to asking questions on sensitive topics in population survey. Monte-Carlo simulations were used to evaluate validity and reliability in two-stage cluster sampling survey with sensitive topics. The one sample *Z*-test was performed to compare every simulated sample mean to simulated population mean. No significant differences exited between most every simulated samples and the simulated population. Survey methods and statistical formula applied to large-scale complex sampling survey on sensitive topics and showed strong validity and reliability.

Keywords: RRT; sensitive topics; Monte-Carlo simulation; validity; reliability

X. Wei, D. Yunlong, L. Yang. Design of Web 2.0-Based Doctor-Patient Interaction Service System, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 76–86.

With the continuous emergence of contradictions, most of which are made by less communication between doctors and patients, it becomes increasingly necessary and possible to construct and implement the doctor-patient interaction service system for the rapid development of hospital informatisation. In this paper, we will presents a web 2.0 based doctor and patient interaction service system, which is platform, system and application-independent, flexible and open to each doctor and patient. By making use of Web 2.0, XML and Atlas technology, the system provides the doctors and patients a rapid, accuracy and versatile interaction platform. The paper first illustrates the makeup and functions of the whole system, and then brings up the design and process of four functional modules: The web interface module, user data to XML module, database module as well as the system security management module. At last, the paper figures out the importance of such interaction system for enlarging the hospital information service range and increasing the medical service quality and the efficiency.

Keywords: Doctor-patient interaction service system, Web 2.0, XML, Atlas technology, system security management

B. Pang, X. Sun, Ch.-W. Ye, K.-J. Chen. Grading of Beef Marbling Based on Image Processing and Support Vector Machine, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 87–92.

Beef marbling is the most important indicator of beef quality grading via measuring the abundance of intramuscular fat (IMF) in rib-eye muscle. A beef marbling grading method was developed herein based on image processing and support vector machine (SVM). 123 images of beef rib eye steak were acquired for manual evaluation and image processing. After the marbling scores were labeled to each image by 5 expert graders, several steps of image processing algorithm

were used to extract marbling features, boundary tracking operation for background removal, Otsu's thresholding for fat segmentation, morphological operation and logical operation. Seven features computed from the processed images were used as the input for SVM classifier. The optimum SVM classifier was chosen according to the maximum accuracy of K-fold cross validation based on the data of training set, and then was validated by an independent test set. The accurate rate of the proposed method at 86.0465% shows that the image processing technology combined with SVM algorithm can effectively predict beef marbling scores.

Keywords: beef, marbling, image processing, support vector machine

J. Zhu, Y. Deng. Research on the Application of Workflow Management System in Collaborative Platform for English Teaching, *Computer Modelling and New Technologies*, vol. 17, no. 3, 2013, pp. 93–98.

With the varied tools and technologies of the workflow and Business Process Management System adopted, this paper is aimed to put forward a method to improve the collaborative English teaching platform. In the collaborative system and based on those varied processes, a simple process flow has been defined. Then, a participated entity, namely the Business Process Management System is designed in this paper.

Keywords: Workflow, Collaborative English Teaching Platform, Education, Management System

COMPUTER MODELLING and NEW TECHNOLOGIES, 17. sējums, Nr. 3, 2013 (Anotācijas)

Q. Chen. Ķīnas Shenfu raktuves ekoloģiskās vides izmaiņās uz GIS un RS datu pamatā, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 7.–11. lpp.

Ķīnas Shenfu raktuves ekoloģiskā vide ir trausla. Uz ekoloģisko vidi ļoti ietekmēja ogļu ieguve. Reģiona ilgtspējīga attīstībai ir liela nozīme bojātās ekoloģiskās sistēmas analizēšanai un atgūšanai. Indekss NDVI, veģetācijas segums, pārtuksnešošanās un zemes izmantošana pētītajā apgabalā tika izpētīti un analizēti pamatojoties uz 1989., 2002. un 2006. gadu RS datiem. Pētījuma rezultāti paradīja, ka: veģetācijas segums kopumā kļuva labāks, taču potenciālā pārtuksnešošanās pakāpeniski palielinājās no 81661.02hm^2 līdz 149200.74hm^2.

Atslēgvārdi: Shenfu raktuves, RS, GIS, ekoloģiskā vide

J. Gao, W. Zhang. Pētījumi par daudzdimensiju informācijas tehnoloģiju veidošanu pamatojoties uz ideoloģijas un politiskās mācībām augstskolās, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 12.–19. lpp.

Līdz ar ideoloģiskās un politiskās izglītības reformu augstākās izglītības iestādēs, kuru veicina CPC Centrālā Propagandas komitejas departaments un Izglītības ministrija, daudzās augstākās izglītības iestādes pārskatīja ideoloģiskās un politiskās izglītības veidus. Šis teksts sniedz padziļinātu analīzi pār informācijas tehnoloģiju daudzdimensiju mācību veidu koncepciju un īpašībām augstākās izglītības iestādēs pirmajā vietā, iegūstot labāku izpratni par informācijas tehnoloģiju daudzdimensiju interaktīvo mācību veidu. Kā arī ir veikts pašreizējas situācijas ideoloģiskās un politiskās mācības augstākajās izglītības iestādēs pētījums ar standartu "mācību saturs, mācīšanas metodes, mācību vide un vispārēja apmierinātības mācīšanas pakāpe", kura rezultātā ir izdarīts secinājums, ka ideoloģiskā un politiskā izglītība augstskolās prasa papildu pētījumus.

Atslēgvārdi: informācijas tehnoloģijas, daudzdimensiju mijiedarbība, ideoloģiskā un politiskā izglītība augstākās izglītības iestādēs, mācīšanas veids

L. Kang, G. Qian. Multi-aģenta pielietošanas pētījums darbinieku morāles vērtēšanai, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 20.–26. lpp.

Spēcīgās tirgus konkurences apstākļos, darbinieku morālei ir liela nozīme uzņēmumu konkurētspējas paaugstināšanai. Uzņēmuma personāla morāles indeksu sistēma ir izveidota, izmantojot adaptīvas sistēmas teoriju, kā vadlīnijas, un, atsaucoties uz pētījumu rezultātiem, morāles vienības modelis ir izveidots ar multi-aģentu simulācijas metodi, tādējādi izveidojot pirmā līmeņa morāles simulācijas modeļu sistēmu darbnīcas.

Atslēgvārdi: morāles vērtējums, simulācijas modelis, multi-aģents

D. Greenberg. Optimālā budžeta pārdales problēma starp vairākiem projektiem ar dažādām prioritātēm, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 27.–34. lpp.

Tiek risināta projektēšanas biroja optimālas budžeta plānošanas problēma. Augšējā līmenī – projektēšanas biroja līmenī – problēma koncentrējas uz kopēja budžeta pārdali, projektu drošuma un prioritāro vērtību kombinācijas optimizēšanai. Otrajā līmenī – projektu līmenī – problēmu risinājums aprobežojas ar optimālu budžeta pārdali starp projekta pasākumiem. Risinājums tika sasniegts, apvienojot heiristisko un Monte-Carlo metodes.

Atslēgvārdi: budžeta pārdale, projekta drošums, PERT-COST projekts, globālās meklēšanas metode, Monte-Carlo metode, projekta dizaina birojs

G. P. Zhao, Y. M. Bo, M. F. Yin. Zonu nozīmīguma noteikšana uz multispektrālās metodes pamata, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 35.–42. lpp.

Vizuālā nozīmīguma noteikšana ir noderīga tādam aplikācijām, ka attēlu segmentācija, attēlu izgūšana utt. Tiek piedāvāta jauna zonu nozīmīguma noteikšana uz multispektrālās metodes pamata, sakarā ar to, ka attēla infrasarkanas zonas tuvumā var dabūt papildu informāciju par attēlu. Avota attēlus jāsadala uz homogēnām zonām, izmantojot 6-dimensiju telpu, kas sastāv no dota attēla LAB krasu vērtībām, attēla pelēkās vērtības un 2-dimensiju pikseļa koordinātes. Tad galīgā nozīmīguma karti iegūst mērot zonas kontrastu, kas ir aprēķināts, izmantojot multispektrālo krāsu informāciju un telpisko attālumu. Eksperimenta rezultāti parāda, ka piedāvātā metode ir efektīva.

Atslēgvārdi: nozīmīguma noteikšana, multispektrāls, superpikselis, zonas kontrasts

M.-H. Horng. Radiālo bāzes funkciju tīkla apmācība, izmantojot bišu sapārošanas optimizācijas metodi, *Computer Modelling and New Technologies,* 17. sēj., Nr. 3, 2013, 43.–49. lpp.

Radiālā bāzes funkcijas (RBF) tīkls ir populārs neironu tīkla veids, kas ir ļoti noderīgs tipu klasifikācijai. Vairāki algoritmi tiek piedāvāti RBF tīkla apmācībai. Šis raksts piedāvā RBF neironu tīkla apmācības algoritmu klasifikācijai uz bišu sapārošanas optimizācijas algoritma (BSOA) pamata.

Atslēgvārdi: Radiālā bāzes funkcija, bišu sapārošanas optimizācijas metode, gradienta nolaišanas algoritms, daļiņu spieta optimizācija, ģenētiskais algoritms

H. T. Wang, G. Xu, X. Ch. Hu, D. Ben. Sadales Doplera diapazons mērķu noteikšanai uz adaptīvā viļņveida dizaina pamata, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 50.–55. lpp.

Šajā rakstā tiek piedāvāta traucējumu sarežģīto problēmu, ātri mainīgo ainu kā arī zema signāla un trokšņa attiecības (STA) risināšanai mērķa noteikšanas sadales jūrā uz kosmosa radara pamata pielietojumā, mērķa noteikšanas metode, kas balstīta uz traucējumu statistikas, adaptīvas viļņveida dizaina (AVD) un attīstītās galveno komponentu analīzes (GKA) izmaiņām. Šajā noteikšanas metodē, sadalīšanas mērķis ir modelēts kā daži izkliedētāji ar Gausa atstarošanos Doplera dizpazona telpā un sarežģītie jūras traucējumi ir modelēti kā Gausa procesa salikums.

Atslēgvārdi: kosmosa balstīts radars, sadales mērķis, adaptīvs viļņveida dizains, galveno komponentu analīze

G. Wu, B. Wu, L. Qin, X. Chen, F. Qian, Y. Fan. Multi aģenta sistēma, balstīta uz enerģijas ārkārtas kontroles shēmas, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 56.–62. lpp.

Šajā rakstā tiek piedāvāta jauna ārkārtas kontroles koordinēšanas shēma, kura ir balstīta uz multi aģenta tehnoloģijas. Tiek virzīts algoritms, balstīts uz Run the Horse Stable Place principa minimālas kontroles zonas noteikšanai. Minimālās kontroles zonas noteikšanas procesā, enerģijas sistēmas diagramma un nevirzītais grafs ir vienīgie divi aspekti, kurus jāņem vērā. Vainas vai nozīmīgas slodzes risināšanai, galvenais aģents kontroles zonā un aģents darbības zonā sastāv no MAS (multi aģenta sistēma). Piedāvātā metode tiek piemērota WSCC4 mašīnas sistēmai un testa rezultāti parāda, ka izmantojot MAS efektīvo kontroli var iegūt rezultātu.

Atslēgvārdi: ārkārtas kontroles shēma, MAS, koordinēšana, aģents

H. Guo, J. He. Krasa uz fraktālā Morfinga algoritma pamata, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 63.–68. lpp.

Šajā darbā interpolācijas algoritms tiek īstenots starp sākotnējo objektu un mērķa objektu. Tad tiek sasniegts starp krāsu fraktālo attēlu process. Piemērojot fraktālu morfinga animācijas izkrāsošanai, tiek paredzēts krāsu fraktāla Morfinga algoritms. Eksperimentālās simulācijas liecina, ka radītās, izmantojot šo algoritmu, animācijās, pāreja starp rāmjiem ir dabiska un gluda, attēli arī ir gludi, krāsu saskaņošana ir precīza, un ir reālisma efekts un tas ir kontrolējams.

Atslēgvārdi: fraktāls, sākotnējais objekts, animācija

Z. Jin, H. Zhu, B. Yu, Ge Gao. Monte-Carlo simulācijas pētījums divpakāpju klastera izlases derīguma un drošuma izpēte ar jutīgām tēmām, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 69.–75. lpp.

Divpakāpju klastera izlase tika izstrādāta vīriešu, kuri nodarbojas ar seksu ar vīriešiem (MSM) Pekinā, atlasei. Kvantitatīva nejaušības atbildes tehnikas (RRT) modelis tika piedāvāts uzdodot jautājumus par jutīgām tēmām iedzīvotāju aptaujā. Monte-Carlo simulācijas, tika izmantotas, divpakāpju klasteru izlases derīguma un uzticamības ar jutīgiem jautājumiem izpētes novērtēšanai.

Atslēgvārdi: RRT, jutīgās tēmas, Monte-Carlo simulācija, derīgums, drošums

X. Wei, D. Yunlong, L. Yang. Ārsta-pacienta mijiedarbības apkalpošanas sistēmas izstrāde uz Web 2.0 pamata, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 76.–86. lpp.

Ar nepārtraukto pretrunu rašanos, no kurām lielākā daļa rādās ar mazāku komunikāciju starp ārstiem un pacientiem, kļūst arvien nepieciešamāk un iespējamāk izveidot un īstenot ārsta-pacienta

mijiedarbības apkalpošanas sistēmu strauji attīstošās slimnīcas informatizācijai. Šajā darbā tiek piedāvāta doktora un pacienta mijiedarbības apkalpošanas sistēma uz Web 2.0 pamata, kas ir platforma, sistēmu un lietojumprogrammu neatkarīga, elastīga un atvērta katram doktoram un pacientam. Rakstā ir aprakstīti dizaina un procesa četras funkcijas: Web-interfeisa modulis, lietotāja datu XML modulis, datu bāzes modulis kā arī sistēmas drošības vadības modulis.

Atslēgvārdi: doktora-pacienta mijiedarbības apkalpošanas sistēma, Web 2.0, XML, sistēmas drošības vadība

B. Pang, X. Sun, Ch.-W. Ye, K.-J. Chen. Liellopu galas lāsumu klasifikācija uz attēlu apstrādes un atbalsta vektoru mašīnas, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 87.–92. lpp.

Liellopu lāsumi ir svarīgākais rādītājs gaļas kvalitātes klasifikācijā, izmantojot mērīšanas pārpalikuma intramuskulāro tauku (IMT). Liellopu lāsumu klasifikācijas metode tika izstrādāta, balstoties uz attēlu apstrādes un atbalsta vektoru mašīnas (AVM). Pēc lāsumiem rādītāji tika marķēti katram attēlam ar 5 ekspertu klasifikatoriem, vairāki attēla apstrādes algoritma soļi tika izmantoti, lai iegūtu lāsumu funkcijas, robeža sekošanas darbības fona noņemšanai, Otsu robežvērtību tauku segmentācijai, morfoloģiskām un loģiskām darbībām. Piedāvātās metodes precīzs līmenis liecina, ka attēlu apstrādes tehnoloģija apvienojumā ar AVM algoritmu var efektīvi prognozēt liellopu lāsumu rādītājus.

Atslēgvārdi: liellopa, lāsumi, attēlu apstrāde, atbalsta vektoru mašīna

J. Zhu, Y. Deng. Darba procesa vadības sistēmas pielietojuma pētījums kopīgajā platforma angļu valodas apguvei, *Computer Modelling and New Technologies*, 17. sēj., Nr. 3, 2013, 93.–98. lpp.

Šajā rakstā ir piedāvāta kopīgas angļu valodas apguves platformas uzlabošanas metode ar dažādu darba procesa instrumentu un tehnoloģiju, kā arī biznesa vadības sistēmas izmantošanu. Šajā darbā ir izstrādāta biznesa procesu vadības sistēma.

Atslēgvārdi: darba process, kopīgā angļu valodas apguves platforma, izglītība, vadības sistēma

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