Large System Fuzzy Decision Study and its Intelligent Decision Support System

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Abstract: In this paper, we would use fuzzy maths's principle in large system decision theory and method, design corresponding, mutiuse and intelligent system IDSS.
Key words: Large system decision, Fuzzy information, Process, Artificial intelligence, Decision support system .

1.INTRODUCTION

In modern science and technology progressing constantly social economy developing rapidly, resource and ecological environment deteriorating day by day. Human beings are face the problem of major decision, more and more complex large system organization management, harmonization program, calculation and control et al. These problems show more and more complex in construction of layer, more and more wide in scope of space activity, more and more fast in time scale, more and more wide and deep in result and influence. Owing to complexity of large system, fuzziness of many factors and the property of limitation of theory of existent large system, many complicated problems would be in large system decision.

In the paper, by using theory with practice, we study to use the principle of fuzzy mathematics in the theory and method of large system decision, to design six types intelligent decision support system about large-scale decision activity. Dss, of " integrated evaluation of whole developing standard in city", "integrated evaluation of university benefit of running a school", "integrated evaluation of economic benefit in middle-and-small enterprise", "integrated benefit evaluation of longitudinal investment about funds of scientific research", "integrated utilized decision of water resource in HuaBei's region", "integrated benefit evaluation in AnYang, Puyang and Xinxiang et al.", agricultural science and technology.

2.THE PROBLEM OF FUZZY DECISION ABOUT LARGE SYSTEM

Large system denotes. 1) Between system itself and its around environment has material exchange, energy exchange and information, 2) System including young system are good much, 3) type of young system are good much, 4) fuzziness is in some middle layer and property of factor of system. The practice of decision prove if achieving scientific decision about large system, by making good use of theory of existent large system, must use human knowledge and experience that we could not call it "science". Especially absolutely distinct limit does not exist between some factors of system decision wants to have the aid of corresponding theory and method of fuzzy mathematics. The basic method of large system decision is: First, large system breaks down into a series of young system which are inter-independent and interconnected (These young systems are in gradations and stages); Second, by building relation between high and low layer and between first and back phase, Solving large system decision can be turn to a series of simple young system decision. Decision process can generally be divided four steps. Determine the objective ,Raise a program, Choose a decision program, Perform the program.

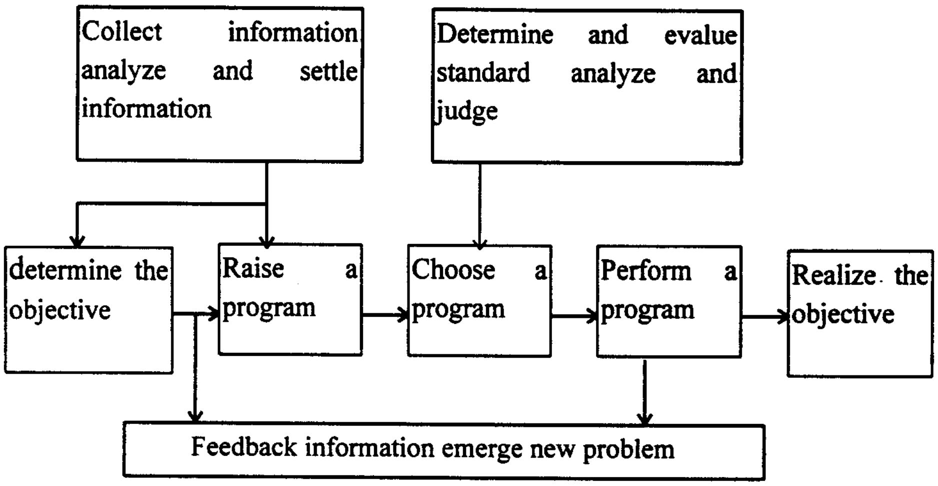


Fig.1

Their relation is showed in fig.1.

But fourth feature of large system makes that decomposable conditions of system are not content in general cases. How can this kind of problem come to idea decision ? By present people have realized it on the whole by using method of group decision. For many inter-restriction and interact etc. have fuzziness so that the related theory and the method of large system fuzzy decision must be made further study. In this paper, we would discuss following three questions, 1) Proving reliability of group decision in theory, 2) Making a study the theory and the method of composition of decision information. 3) Researching supporting system of intellectualization of that setting large-scale fuzzy (complicated) decision problem.

3.THE RELIABILITY PROBLEM OF GROUP DECISION

In this paper, we would raise some claims that group decision: Group has only common benefit and objective. There are not evident conflict of benefit, but understanding between individuals. Because identical between individuals and understanding standard with difference. The participant of this kind of decision must not be the whole individual and should be some more standard individuals---experts. In general, this kind of problems have objectively best or correct programs. If we disregard the understanding standard of individual and regard to sum up the idea of individual, we would guarantee selected programs against being best or correct. Present method of group evaluation has taken note of the difference of understanding standard of individual about the selection of the expert, but about analysis of expert's evaluated results, it generally is concentrated method of various individuals and do not investigate correct errors of various programs. For this reason, it is lack of deep demonstration of theory and belief . Here we would give an example of problem of expert's evaluated problem of collective of factors and discuss it from probability.

Suppose υ is a arbitrary known evaluated factor. δ is a corresponding evaluated value, and υ has objective value, $\delta \in R$, $I = \{1,2,3,\ldots,n\}$ is a expert's set, $X = \{x_1, x_2, \ldots, x_n\}$ is a evaluated vector, where x_i is a evaluated value of its expert of υ: The group evaluation problem of υ may write as:

$$F = (\delta, I, X) \qquad (1)$$

In general condition, factor υ is a soft index without clear extension, therefore expert's evaluation is not always correct. This is a random occurrence. Expert evaluating correct probability value depends on expert's ability to evaluation about some kind of problem may be thought relatively stable in some time. If existing a serious of same difficult evaluation problems in theory, this expert evaluating correct frequency should has limit stability, this limit is expert evaluation correct probability.

Definition: Suppose δ^* is objective value of δ, x_i is evaluation value of its expert, if $|x_i - \delta^*| \le \alpha$,then x_i is α accurate, we abbreviate it as α-quasi.

Suppose P_i is probability of that x_i is α-quasi. Make $P = (P_1, P_2, \dots, P_n)$, then group evaluation problem about υ may express as

$$\Theta = (\delta, I, Z, P, \alpha)$$

Where I, Z, δ is same with (1),α is precision.

Theorem 1: Suppose $\Theta = (\delta, I, Z, P, \alpha)$,arrange $x_1, x_2, \dots, x_n$ from large to small, suppose $x_1 \le x_2 \le \dots \le x_n$,their central-digit number is x_T

$$x_T = \begin{cases} x_{\frac{n+1}{2}} & \text{n is odd number} \\ x_{\frac{n}{2}} & \text{n is even number} \end{cases}$$

Suppose v_n is digit which is α-quasi in X, when $v_n > \frac{n}{2}, |x_T - \delta^*| \le \alpha$, where δ^* is objective value of δ.

Proof of this theorem is quite obvious and omitted.

Theorem 2: Suppose $\Theta = (\delta, I, Z, P, \alpha)$ v_n is frequency of x_i is α-quasi is independent evaluation of n times. A_k express that x_k is α-quasi in kth evaluation. If $A_1, A_2, \dots A_n$ is inter-independent. P_k express the probability of α-quasi in kth evaluation, and for each $K \in I = \{1,2,\dots,n\}, P_k \ge r > 1/2$, then $\ni N > 0$,when $n > N$,the central-digit number v_n of being α-quasi, the probability equals one namely, when $n > N$,

$$P\left\{ |x_T - \delta^*| \le \alpha \right\} = 1$$

Proof: by condition of theorem, according to Kirmegalof's theorem, we have

$$P\left\{ \frac{u_n}{n} \to \frac{1}{n} \sum_{k=1}^{n} P_k \right\} = 1$$

that is, for each $\varepsilon > 0$, there exist $N > 0$, when $n > N$

$$P\left\{ \left| \frac{u_n}{n} - \frac{1}{n} \sum_{k=1}^{n} P_k \right| \le \varepsilon \right\} = 1$$

since

$$P\left\{ u_n : \left| \frac{u_n}{n} - \frac{1}{n} \sum_{k=1}^{n} P_k \right| \le \varepsilon \right\} \subseteq \left\{ u_n : u_n \rangle \sum_{k=1}^{n} P_k - n\varepsilon \right\}$$

$$\subseteq \{ u_n : u_n \rangle n(\gamma - \varepsilon) \} \qquad (set \varepsilon_0 \langle \gamma - 1/2)$$

$$\subseteq \{ u_n : u_n \rangle n/2 \} = 1,$$

according to theorem 1, when $n > N$

$$P\left\{ |x_T - \delta^*| \le \alpha \right\} = 1$$

This theorem shows that if the probability of each expert's evaluation value being α-quasi is larger than 1/2 and evaluation value is inter-independent. When experts are quite enough, probability which central-digit number of evaluation vector is α-quasi equals one. This theorem has proved in theory that the result of group decision is reliable under given conditions.

4.FUZZY COMPOSITION (DECISION) OF MULTIPLE CRITERIA DECISION MESSAGE

For group decision in some layer and came stage, its composition of message may use method of fuzzy coordination to message . Have we would study that different group expert (group)gives problems of multiple criteria decision composition to same decision suppose $Y=\{y_1,y_2,\ldots,y_n\}$ is set of problem,
$G=\{g_1,g_2,\cdots,g_n\}$set of multiple criteria decision about problem . let $f_j(y_i)$ is evaluation of g_j for y_i, obtain original data table

	g_1	g_2	$\cdots$	g_m
y_1	$f_1(y_1)$	$f_2(y_1)$	$\cdots$	$f_m(y_1)$
y_2	$f_1(y_2)$	$f_2(y_2)$	$\cdots$	$f_m(y_2)$
$\vdots$	$\vdots$	$\vdots$		
y_n	$f_1(y_n)$	$f_2(y_n)$	$\cdots$	$f_m(y_n)$

For each g_j, establish fuzzy advantageous relations y_k, for y_i

$$u_j^{\bullet}(y_k,y_l)=\begin{cases} 1 & f_i(y_l)-f_i(y_k)\le 0 \\ 0 & f_j(y_l)-f_j(y_k)\ge s_j \\ \left[1-\dfrac{f_j(y_l)-f(y_k)}{s_j}\right]^{\lambda} & 0<f_j(y_l)-f_j(y_k)<s_j \end{cases} \qquad (2)$$

where λ>0, s_j>0 are unknown parameter, by (2) we can calculate matrix of fuzzy advantageous relation

$$N_j=\left(u_j^{\bullet}\right)_{\min}(j\le m)$$

For g_j, if $f_j(y_j)-f_j(y_k)\ge s_j$, then $u_j(y_k,y_l)$=0, that is, y_k is not more advantageous than y_l. But if three exits $g_i(i\ne j)$ and y_k is more advantageous than $f_j(y_k)$, even y_k is more advantageous because of other factors, it is possible to exclude y_k problem. Therefore it is necessary to introduce fuzzy inconsistent relation . For g_j, u_n consistent relation of y_k for y_l is

$$v_j(y_k,y_l)=\begin{cases} 1 & f_j(y_l)-f_j(y_k)\ge u_j \\ 0 & f_j(y_l)-f_j(y_k)\le s_j \\ \left[1-\dfrac{f_j(y_l)-f_j(y_k)}{s_j-u_j}\right]^{\lambda} & s_j\langle f_j(y_l)-f_j(y_k)<u_j \end{cases} \qquad (3)$$

Where λ>0, u_j>0, s_j>0 are unknown parameter. By (2), we can calculate matrix of fuzzy inconsistent relation

$$v_j=\left(v_j\right)_{n\times n},\quad j\le m$$

For proportional coefficient $w_j>0,\sum_{j=1}^{m}w_j=1$ established general fuzzy consistent relation

$$c_j(y_k,y_l)=\sum_{j=1}^{m} w_j * u_j(y_k,y_l) \qquad (4)$$

general fuzzy advantageous relation is

$$u(y_k,y_l)=\begin{cases} c_j(y_k,y_l) & c_j(y_k,y_l)\geq v_j(y_k,y_l) \\ \dfrac{c_j(y_k,y_l)}{1-c_j(y_k,y_l)}\prod_{j\in A}\left(1-v_j(y_k,y_l)\right) & c_j(y_k,y_l)\langle v_j(y_k,y_l) \end{cases} \qquad (5)$$

where $A=\{f:c(y_k,y_l)\langle v_j(y_{k,}y_l)\}$ By (5), we can calculate matrix of general fuzzy advantageous relation $R=(u)_{n\times n}$

by R we can calculate fuzzy advantageous relation:

$$d(y_k,y_l)=\begin{cases} u(y_k,y_l)-u(y_l,y_k) & u(y_k,y_l)\geq u(y_l,y_k) \\ 0 & u(y_k,y_l)\langle u(y_l,y_k) \end{cases} \qquad (6)$$

By (6) we can calculate matrix of fuzzy advantageous relation $D=(d)_{n\times n}$, again by

$$d`(y_k,y_l)=1-d(y_k,y_l) \qquad (7)$$

Obtain matrix of fuzzy judgment $D`=(d`)_{n\times n}$

Set $d`(y_k)=\min_{y_l\in Y} d'(y_l,y_k)$ (8)

If $d`(y_{k0})=\min_{y_l\in Y} d'(y_l,y_k)$, then y_{k0} is most satisfactory decision.

For example, suppose $\overline{Y}=\{y_1,y_2,y_3,y_4\}$, $G\{g_1,g_2,g_3,g_5\}$, original data of criterion evaluation is

	g_1	g_2	g_3
y_1	5.2	5.6	2.6
y_2	7.1	4.5	1.9
y_3	3.8	8.0	6.5
y_4	6.4	4.2	9.0

Let λ=1, $s_j=2, u_j=5$ $j=(1,2,3)$, $(w_1,w_2,w_3)=(0.25,0.4,0.35)$, By(2),(3),(5), obtain

$$R=\begin{bmatrix} 1 & 0.7 & 0.12 & 0 \\ 0.64 & 1 & 0.2 & 0 \\ 0.83 & 0.75 & 1 & 0.4 \\ 0.72 & 0.85 & 0.6 & 1 \end{bmatrix}$$

by(6), obtain

$$D=\begin{bmatrix} 0 & 0.12 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0.7 & 0.73 & 0 & 0 \\ 0.72 & 0.85 & 0.2 & 0 \end{bmatrix}$$

by(7), obtain

$$D` = \begin{bmatrix} 1 & 0.88 & 1` & 1 \\ 1 & 1 & 1 & 1 \\ 0.3 & 0.27 & 1 & 1 \\ 0.28 & 0.15 & 0.8 & 1 \end{bmatrix}$$

by(8), obtain $\{ d`(y_1) d`(y_2) d`(y_3) d`(y_4) \} = \{0.28, 0.15, 0.8, 1\}$

by(9), obtain that y_4 is most satisfactory decision.

5.DESIGN OF INTELLIGENT DECISION SUPPORT SYSTEM

IDSS(Intelligent Decision Support System), supported by the Association of Higher Education Management of China, based on original author's Relative Decision Software, was finished through more than 3 years. The system has been put in use at more than 30 units and departments, and results is good.

5.1 Basic Functions of IDSS

IDSS can realize the following three layer objects:

(1) Be a tool for decision management department to finish selecting and optimizing actual decision model; (2)Became a emulating experimental system for researchers to check new ideas and new algorithm;(3)Automatically realize information synthesis, coordinated decision, information output, et al. Functions. Particularly, the system supports the five following large decision activities:

1)Integrated Evaluation of Whole Developing Standard in City IDSS-1. The subsystem has 48 second-subsystem. Each subsystem has been designed 6 to 8 third-subsystem, respectively. Some third-subsystem has also 2 to 6 fourth-subsystem. Every last-subsystem consists of 8 to 36 checking norms, respectively. Relative qualitative evaluation factor has been designed 3 to 6 comment grade. The information processing model of literature [6] has applied in the subsystem partly.

2)Integrated Evaluation of University Benefit of Running a SchoolIDSS-2.The subsystem is designed according to the relative norms of evaluating university benefit of running in the world, the specific demand of Essentials of Education Developing in China and the situation of China up till now. It can select and transfer corresponding evaluation subsystem according to users' condition. By using IDSS-2, we can obtain (quantitative and qualitative)evaluation running a school of evaluated liberal arts or science department, respectively. Among which, liberal arts can be supported 28 department, institute, and center etc. lower level departments; science can be supported 56 departments, institute, center etc. lower level departments at the most; every lower level can support 19 next lower level department at the most. For every evaluated factor, qualitative comment has been designed 4 to 6 grades, respectively. Among which, information synthesis algorithm, design of evaluated factor and its corresponding distributive principle of ratio see literature.[9]

3)Integrated evaluation of economic benefit in large-and-middle enterprise IDSS-3. The subsystem is designed based on literature[6]. It consists of 8 lower level subsystem; every subsystem has its corresponding evaluation norm. The treatment of related information is same as literature.[7]

4)Integrated benefit evaluation of longitudinal investment about funds of scientific research IDSS-4. The subsystem has following secondary subsystem for Evaluation funds given by school, Committee of Education and Committee of Science, respectively. Every secondary subsystem has "Funds for Social Science", "Funds for natural science" two model.(Evaluated department can transfer corresponding model according to source of funds.) The model of "Funds for natural science" has 6 categories, totally 48 items evaluation norm for users to select, while the model of "Funds for social science" has 5 types, 58 items evaluation norm for users to select.

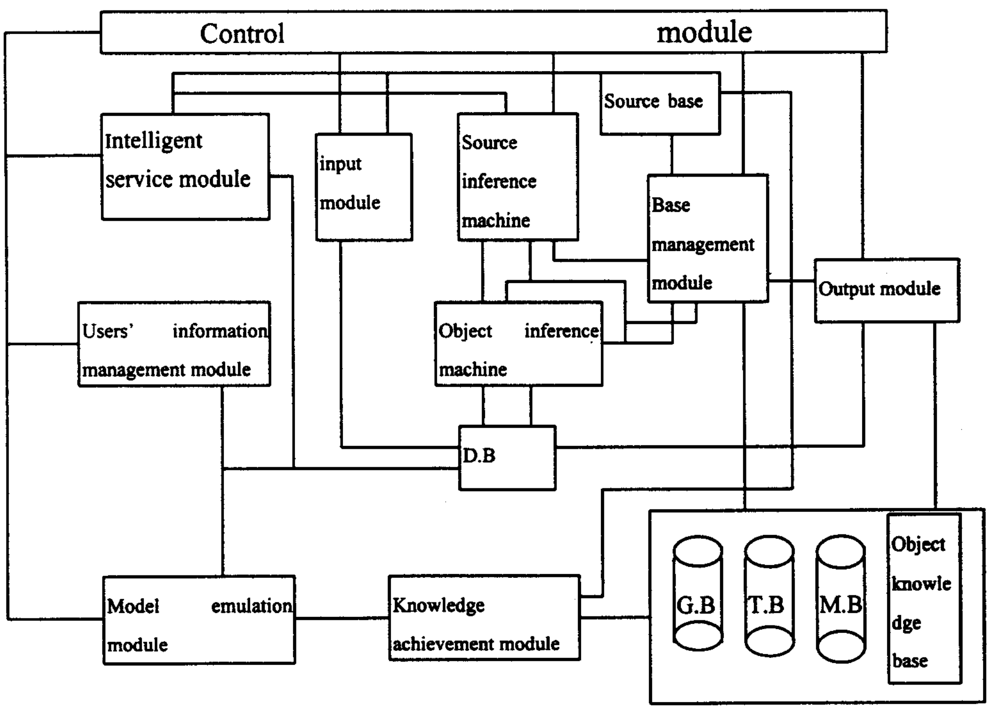
1)Integrated benefit evaluation in Anyang, Puyang, Xinxiang et al. Agriculture science and technology

IDSS-5. The subsystem has 8 secondary subsystems, totally 106 evaluated norms. The algorithm of nerve network in literature [6] applied in this subsystem.

In the light of operation method, establishment of decision model, checking norm and corresponding comment grade content, conversion formula of quantitative to value of the previous of five subsystem see also "IDSS operation instructions".

5.2 **The total structure of IDSS**

The system adopts module structure. It consists of control module, source base, object base, source inference machine, object inference machine, base management module, knowledge achievement module, input module, output module, intelligent service module, and model emulation module, et al.. As shown in fig.2.



D.B...Data Base
E. B...Model Base G.B...Graph Base
F.B...Select Text Knowledge Base

Fig.2

Control module generally controls system; reflects generality of control. It doesn't change according to library.

Source library is compose of source principle of features of depicted problem; it also reflects special knowledge experts owned---control knowledge. That is to say: for specific problem, the analysis method is different. Source inference machine determines tactics and direction solving the problem according to current problem and its characteristic by utilizing knowledge of source library.

Object inference machine is designed for solving problem. By adopting reasonable inference mechanism, the inference has much audio-visual; and can search whole possible problem simultaneously; and it can easily embed every indefinite inference so that it approaches thought method that human beings deal with diagnosis and inference.

Knowledge in object library is mainly on decision target. Among which, consists of Fuzzy opinion decision(qualitative), Fuzzy opinion decision(quantitative), Fuzzy opinion decision(qualitative and

quantitative), Fuzzy preferred-relation sorting(quantitative), Fuzzy classification decision(qualitative and quantitative) etc. model and corresponding information synthesis algorithm.
The intention of knowledge management library is to help organize knowledge corresponding to present during the process decision. The model also provides a tool for users to self-adaptation, extension and redefinition. For the sake of preventing the system from unexpected damage, this function of the model designs for specific users only.
Knowledge achievement module intends to aid users establishing library.
Input module adopts moving cursor to select information same as that results by diagnosis . It can also select using keyboard directly to put diagnosis data (decision) to system at batch.
Output module makes screen to several windows, during decision process it can display current structure frame of IDSS, related prompt information and decision results, and users can link printer to print related information at any moment.
Intelligent help module provides users how to use IDSS knowledge, specific knowledge in management decision, system function, operation rule, professional terminology, etc.. During the process of running every interactive stage of IDSS, users can ask for system help about contents on the present interface at any time; and intelligent help model will display related character directions at designed information service window. When users misoperate, the system will provide prompt initiative. The subsystem can also regard as teaching system for new users running single.
Users' information management module manages and decides every kind of information of system, such as source ratio vector of decision system, corresponding evaluation of every factor, identically information, precision α , coordinated term, bearing condition of all-around decision etc. The module is a user-oriented information query system.
Model emulation module. The basic function is to emulate according to provided model and environment. The module has two effect: 1) provide emulated running data of ideal system for analysis and research; 2) check rationality of selected actual model, forecast running condition that might happen during the process of decision.
IDSS has the following features:
A: Possess good human-machine interface. Adopt menu input by moving cursor and select keyboard input according to prompt, so that it makes operation very easily. By adopting carved screen, displays present decision process flowchart, decision selected space, prompt information etc. , improves transparency of decision.
B: Possess much strong graphics interpretation function, so that largely improves people's acceptance level for decision system in the heart.
C: By adopting varieties of methods of knowledge expression, varieties of information synthesis algorithm, expresses much appropriate every type knowledge that decision needs.
D: Library of system adopts "layer model", "separated pattern" structure, by decomposing according to structure and function of different decision model, so that it can be managed conveniently and improve decision efficiency.
E: System program adopts module design method; and it can be easily debugged and extended.
F: The system can be hold every non-precise inference model.
G: Inference process suits for directness of people.

5.3 **Design of the main function of the system**

5.3.1 In-line help

Since MUDSS is an intellectualized multi-technological system that involves many-sided knowledge, the function of the in-line help is very necessary to users. The in-line help function of the MUDSS runs through all of the process of the running system. The function is accomplished together with the status tracking apparatus records automatically the position of current interactive of the control path tree of the system. While system runs, it has two working statutes: one is execution status, another is help status. In execution status, every selective item in the interface has a corresponding program. In help status, the system will determine the current interfaces according to the records of status tracking apparatus, from dynamically an information index table corresponding the selective items in interface, and pick up related knowledge in-line dictionary from the knowledge base. The selected items will be taken as the key words to index in-line dictionary. When user needs help for some problem from current interactive interface of the system, what he only to do is to use mice to select the help function and to determine what item he wants to know. The help system will pick up related interpretation or suggestion automatically from the in-line dictionary and displays them in the information window setting by the system.

5.3.2 Selection of interface model

In order to make scientific decision task to select model and information correctly. To do this, the system has to depend on the professional knowledge and experience of the decision makers. A module that can supply a tool for optimizing model is designed. By using this tool, a user interaction method can be used to help users determine the decision model and the information composed algorithm.

The model which can be selected by MUDSS are: 1) model of Fuzzy decision of level 1,2 and 3. 2) Model of Fuzzy opinion decision. 3) Model of Fuzzy intention decision. 4) Model of Fuzzy priority relative arrangement decision. 5) Model of Fuzzy classifying decision.

In models given above, the information composed algorithm can be selected from one of the equations below according to the actual condition.

1) "$\wedge$","$\vee$": $a_i \vee b_j = \max(a_i, b_j), a_i \wedge b_j = \min(a_i, b_j)$

2) $M(\cdot,\vee): b_j = \bigvee_{k=1}^{n} (a_k \cdot r_{jk})$

3) "$\cdot$","$\hat{+}$": $a \cdot b = ab, a \hat{+} b = a + b - ab$

4) "$\otimes$","$\oplus$": $a \otimes b = \max(0, a + b - 1), a \oplus b = \min(1, a + b)$

5) "ε","$\overset{+}{\varepsilon}$": $a \varepsilon b = \dfrac{ab}{1 + (1-a)(1-b)}, a \overset{+}{\varepsilon} b = \dfrac{a+b}{1+ab}$

6) $M(\cdot,+)$

According to the practical system knowledge and experience mastered, users put forward a probing selection for the model and algorithm. The supporting subsystem makes a simulating decision to the model according to the samples that have similar decision problems, and displays the decision information on the contrasting analysis window for users to select. If users are not satisfied the results, he can do it again, until a better decision model and algorithm are selected. If necessary, users can also modify the model and algorithm in some way.

5.3.3 Knowledge based precision selection

In MUDSS, a knowledge based inference method is used. The precision α is determined according to the actual data of consistent degree matrix and classification of the harmonious decision. The harmonious process is accomplished by means of service menu that can guide user to do what he should to do .

6.CONCLUSION

In actual production and management, the theory and the method of the fuzzy decision provide an efficient tool for the scientificalness of making decision.

The main program of MUDSS is developed with Microsoft C++7.0 and should be used under the environment of Windows 3.1. The hardware of the system should be IBM 486 compatible computer. MUDSS can be used to support decision in a distributed environment that is made up of several computers. A terminal can be taken as the decision harmonies. Every decision maker accomplishes his decision on his terminal, and consults with the harmonies, until the consistent decision that meets the need of the precision is reached.

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