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Multi-objective Optimization of Group Decision-making Based on Matter-element Extension Set

L'OPTIMISATION MULTI-OBJECTIF DE PRISE DE DÉCISION EN GROUPE SUR LA BASE DE L'EXTENSION SET DE MATIÈRE-ÉLÉMENT

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Abstract: On account of the problem of group decision-making with matter-element extension set, this paper studies multi-objective conversion and standardization, the extension association under decision-making preferences and the extension decision-making space under no preference of the multi-dimensionality group decision-making by combining extension transformation with group decision optimization; as a result, comparison and selection of objects in changing environment can be made, and systematic decision-making problems of multi-objective conversion and multi-project optimization in multi-objective decision-making can be solved, thus improving the accuracy and the reliability of group decision-making.
Key words: group decision-making; matter-element; extension set; extension transformation; extension association

Résumé: En raison du problème de la prise de décisions en groupe avec l'extension set de matière-élément, le présent document examine la conversion et la standardisation multi-objectif, l'extension d'association en vertu des préférences de prise de décision et l'espace de l'extension de prise de décision sans préférence de la multi-dimensionnalité de prise de décision en groupe en combinant l'extension de transformation avec l'optimisation de la décision en groupe, de sorte que la comparaison et la sélection d'objets dans l'environnement en changement peut être

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effectuées, et des problèmes systématiques de prise de décision de conversion multi-objectif et d'optimisation multi-projet dans la prise de décision multi-objectif puissent être résolus, ce qui améliore la précision et la fiabilité de la prise de décisions en groupe.

Mots-Clés: prise de décision en groupe multi-objectif; matière-élément; extension set; extension de transformation; extension d'association

1. INTRODUCTION

Extension decision-making is a new subject which integrates scientific thinking, systems science and mathematics through the dependent function and the extension transformation to seek satisfaction in the decision-making space (CAI, 1999). Extension decision-making analyses the various sub-system compatibility with dependent function based on a mathematical tool of extension set, and through matter-element transformation to change contradictory issue into a compatibility issue in order to extend relevant decision-making strategy. It tends to formalize the scientific methods of thinking, which supplies experts in the fields of economic management, engineering, business intelligence, life science, social science, military theory, geological science, system science and information technology with a new tool or way of thinking to complete some creative work.

By using knowledge presentation and reasoning technique in extension theory (CAO & PENG, 2006) established intelligent decision support system based on extension expert system (ZHANG & WANG, 2000) develops fuzzy gray matter-element space and fuzzy extension economic space which is combined with newly emerging fields such as fuzzy sets and fuzzy systems, extension sets, gray system and set pair analysis, and then some fuzzy extension mathematical models are suggested; several sets of fuzzy decision support systems based on the extension theory are presented to apply to the large scale systems. Based on extension matter-element theory (SHENG & ZHAO, 2006) presents an automatic on-line measuring method of distributed production plan track using the multi-sensor and a new extension measurement method which can realize the right time to finish the production plan and to supply data guarantee for the production plan and control in core enterprise under supply chain. According to limitation of FGES-DSS (YANG & ZHANG, 2007) puts forward a new approach for decision-making that is called Set Pair Extension Space Decision Support System based on set pair analysis and extension theory, the model can characterize both the favoring evidence and the opposing evidence for every scheme. Based on extension theory and extension engineering methods (W.LIU,W.N.LIU, 2007) brings forward a new kind of machine-learning method that is called extension machine method which can pile up experience in the continually use, obtain the exact knowledge about decision, correct its parameter and ameliorate the arithmetic of itself, thus improving its capability of self-learning (WANG & Tseng, 2008). A novel classified method called Extension Genetic Algorithm (EGA) is presented The model ,which combines extension theory and genetic algorithm (GA), is extremely innovative, in order to eliminate try and error adjustment of modeling parameters and increase accuracy of the classification.

In addition, the extension method also applies to the land development and consolidation project evaluation and decision-making (ZHANG &WEI, 2007), ground-to-air missile composite group firing command decision making (ZHANG & CHENG, 2007), large power transformer condition evaluation (XIA & LI, 2008), intelligent traffic light control (Kuei-Hsiang Chao et al, 2008), decision support system for risk investment (BAI, 2008), the third party logistics comprehensive evaluation (ZHAO & ZHU, 2008), urban industrial water-saving evaluation（WANG & ZHENG, 2007）,data mining（CHEN, 2003）, multiple fault diagnosis (JIN & CHEN, 2006) ,etc.

Based on matter-element extension theory, this paper studies multi-objective conversion and standardization, the extension association under decision-making preferences and the extension decision-making space under no preference of the multi-dimensionality group decision-making, the goal of multi-objective extension identification, selection, update based on the group interaction and individual preferences assembly is achieved.

2. MULTI-OBJECTIVE OPTIMIZATION OF GROUP DECISION-MAKING BASED ON MATTER-ELEMENT EXTENSION SET

2.1 Extension set and dependent function

Matter-element extension set and dependent function are the cores of extension decision-making. Extension set theory is developed on the base of the classical set theory and fuzzy set theory. The classical set theory studies the definiteness of matter and the fuzzy set theory studies the fuzziness of matter while the extension set theory studies the transformability of matter.

The classical set describes possessing the same character or not with 0 and 1, while extension set expresses the degree of possessing a certain character with the real number within $-\infty$ and $+\infty$. The positive number expresses the degree of possessing the character, and the negative expresses the degree of not possessing the character, while 0 expresses possessing the character and not possessing the character. Dependent function's concept is set up in extensive set. by which we can quantitatively describe which field does an element belong to the positive field, the negative field or zero boundary, and we could distinguish the different level of the elements in the same field by the value of dependent function.

A matter-element is the basic element to describe matter or a thing. Supposed that thing N possesses the characteristic c_i and the feature value of the characteristic is v_i, the matter-element R_i of N is defined as (YANG et al, 2002)

$$R_i = (N, c_i, v_i) \tag{1}$$

Supposed that x is a point in the real field $X = (-\infty, +\infty)$ and $X_0 = [a, b]$ is a real interval in the real field X, then define the distance on real axis between point x and real interval X_0 as (2) and the position of point x with respect to the real interval X_0 and X as (3). Supposed interval X_0 and X have no superposition point, we define the dependent function as (4).

$$\rho(x, X_0) = \left| x - \frac{a+b}{2} \right| - \frac{b-a}{2} \tag{2}$$

$$D(x, X_0, X) = \begin{cases} \rho(x, X) - \rho(x, X_0) & x \notin X_0 \\ -1 & x \in X_0 \end{cases} \tag{3}$$

$$K(x) = \frac{\rho(x, X_0)}{D(x, X_0, X)} \tag{4}$$

The dependent function can express the dependent degree of point x with respect to the intervals X_0 and X. If $K(x) \geq 0$, it expresses the level that x belongs to interval X_0. If $K(x) \leq -1$, it means that x does not belong to interval X_0. If $-1 < K(x) \leq 0$, it means that x has the possibility of belonging to interval X_0 and the bigger $K(x)$ is, the more the possibility is. So the dependent function can be regarded as the tool to describe the qualitative change and quantitative change of things.

When the denominator in equation (4) is zero, the dependent function is defined as

$$K(x) = -\frac{\rho(x, X_0)}{b-a} \tag{5}$$

Usually, X_0 is called classical field, while X is called joint field.

2.2 Multi-objective conversion and standardization of matter-element group decision-making

Definition 1(CAI, 1999)：let matter-element $R_1 = (N_1, c_1, v_1)$ and $R_2 = (N_2, c_2, v_2)$."And" refers to both get R_1 and R_2, call $R = R_1 \wedge R_2$."Or" means taking either R_1 or R_2, call $R = R_1 \vee R_2$.All appearance:

$$R_1 \wedge R_2 = R_2 \wedge R_1 \tag{6}$$

$$R_1 \vee R_2 = R_2 \vee R_1 \tag{7}$$

Definition 2: let matter-element $R = (N, c, V_0)$. If $R_1 = (N, c, u)$, $u \notin V_0$, call R_1 is a non-matter-element of R, $\overline{R} = R_1$; if $V_0 = \{v_0\}$, that $\overline{R} = (N, c, u)$, $u \neq v_0$, $\neg R$ means "Not" operation which change matter-element R to $\overline{R}$.

Inference 1: the rules of logic operation under the matter-element with same matter:

$$R_1 \vee R_2 = (N, c, v_1) \vee (N, c, v_2) = (N, c, v_1 \vee v_2) \tag{8}$$

$$R_1 \wedge R_2 = (N, c, v_1) \wedge (N, c, v_2) = (N, c, v_1 \wedge v_2) \tag{9}$$

Inference 2: the rules of logic operation under the matter-element with same features:

$$R_1 \vee R_2 = (N_1, c, v_1) \vee (N_2, c, v_2) = (N_1 \vee N_2, c, v) \tag{10}$$

$$R_1 \wedge R_2 = (N_1, c, v_1) \wedge (N_2, c, v_2) = (N_1 \wedge N_2, c, v) \tag{11}$$

Matter-element combines the thing, its characteristics and feature values into one set. For a multiple dimension matter-element can describe multiple aspects of a thing, it is possible to build a modal which can describe systematic decision-making problems of multi-objective conversion and multi-index evaluation in group decision-making by matter-element.

Let $O = O_1 \times O_2 \times \cdots O_s$, $R_t \in O_t$, $(t = 1,2,\cdots s)$ and $R_i^t = (R_1, R_2, \cdots, R_n)$, $(i = 1,2,\cdots n)$, $c_j^t = (c_1, c_2, \cdots, c_m)$, $(j = 1,2,\cdots m)$ means m decision-makers of R_i^t, R_i^t of field t is $c_j^t(R_i^t) =$ $(c_1^t(R_i), c_2^t(R_i), \cdots, c_m^t(R_i))$ $= (v_{i1}^t, v_{i2}^t, \cdots v_{im}^t)$, then the composite matter-element of multi-objective and multi-dimensional group decision-making is

$$R_i = (O_t(N, c_j, v_{lj})) \tag{12}$$

Due to differences goals would affect the outcome of the decision-making, through the composite matter-element should to be standardization in order to meet the needs of data processing under the multi-objective matter-element with same matter or same features. According to definition 2, let multi-objective group decision-making matter-element $R = (O_t(N, c, V_0))$. The smaller the better for the composite matter-element $R_i = (O_1(N, c, u))$, $u \in V_0$, which can change to the bigger the better for the composite matter-element $\neg R_i =$ $(O_1(N, c, v_0 - u))$ $=$ $(O_1(N, c, u_0))$ under objective

$O_1, u_0 \notin u$, $u_0 \in V_0$. The same principle, as well as the object that is changed from the bigger the better to the smaller the better for the composite matter-element.

2.3 The extension association of matter-element group decision-making under decision-making preferences

According to definition 1 and inference 1, based on target conformity under decision-making preference α, a correlation matrix $k^{\alpha}(c_j^{\alpha}(R))$ of the target O_t is established with $c_j^{\alpha}(R_i) = u_{ij}$ $= (\alpha \times \bigvee_{i=1}^{n} c_j(R_i) + (1-\alpha) \times \bigwedge_{i=1}^{n} c_j(R_i))$ of R_i about c_j . If $\alpha = 0$, then $u_{ij} = \bigwedge_{i=1}^{n} c_j(R_i)$, which is pessimistic decision making method; if $\alpha = 1$, then $u_{ij} = \bigvee_{i=1}^{n} c_j(R_i)$, which is optimistic decision making method; if $\alpha = 0.5$, $u_{ij} = 0.5 \times (\bigvee_{i=1}^{n} c_j(R_i) + \bigwedge_{i=1}^{n} c_j(R_i))$, which is compromise decision making method. Then

$$k^{a}(c_j^{a}(R)) = (k_j^{\alpha}(u_{ij})) \tag{13}$$

The comprehensive association degree is :

$$K_i(R_i) = \frac{1}{\bigvee_{1\le j\le m} \left| k_j^{\alpha}(u_{ij}) \right|} \sum_{j=1}^{m} \beta_j k_j^{\alpha}(u_{ij}) \tag{14}$$

which of R_i about c_j, β_j is the weight factor of c_j.

If $\alpha = 1$, then the association degree under optimistic decision making method is:

$$K_i^{+}(R_i) = \frac{1}{\bigvee_{1\le j\le m} \left| k_j(\bigvee_{i=1}^{n} c_{ij}(R_i)) \right|} \sum_{j=1}^{m} \beta_j k_j(\bigvee_{i=1}^{n} c_{ij}(R_i)) \tag{15}$$

If $\alpha = 0$, then the association degree under pessimistic decision making method is:

$$K_i^{-}(R_i) = \frac{1}{\bigvee_{1\le j\le m} \left| k_j(\bigwedge_{i=1}^{n} c_{ij}(R_i)) \right|} \sum_{j=1}^{m} \beta_j k_j(\bigwedge_{i=1}^{n} c_{ij}(R_i)) \tag{16}$$

Let $K(R) = \sum_{i=1}^{n} \gamma_i K_i(R_i)$ is the comprehensive association degree of R about c_j, γ_i is the weight factor of R_i.

Then, the optimistic comprehensive association degree is:

$$K^{+}(R) = \sum_{i=1}^{n} \gamma_i K_i^{+}(R_i) \tag{17}$$

and the pessimistic comprehensive association degree is:

$$K^-(R)=\sum_{i=1}^{n}\gamma_i K_i^-(R_i). \tag{18}$$

To make matter-element extension set $\tilde{X}$ and to give transform $T_i=(T_{w_i},T_{K_i},T_{R_i})$ under field $V\ (c_{ij})$, call:

$$\tilde{A}(R_i)(T_i)=\{\ (R_i,Y_i,Y_i^{'})\big|R_i\in T_{w_i}W_{R_i},$$

$$Y_i=K(R)=\sum_{i=1}^{n}\gamma_i K_i(R_i)\in(-\infty,+\infty)$$

$$Y_i^{'}=T_K K(T_{R_i}R)=\sum_{i=1}^{n}\gamma_i T_{K_i}K_i(T_{R_i}R_i)\in(-\infty,+\infty)\ \} \tag{19}$$

is a matter-element extension set of multi-dimensionality group decision-making. Among them,

$$T=(T_W,T_K,T_R)=(T)_{n\times m},\ \ T_W=(T_W)_{n\times m},$$

$$T_K=(T_K)_{n\times m},\ \ T_R=(T_R)_{n\times m},\ T_W W=W_n(T_W)_{n\times m} \tag{20}$$

2.4 The matter-element extension set of group decision-making under decision-making preferences

Definition 3: let both $\tilde{A}$ and $\tilde{B}$ are the same attribute extension set in fields U and V , If for any $u\in U$, corresponding $v\in V$ to meet the need of $u\leftrightarrow v$ and $K\tilde{A}(u)\le K\tilde{B}(v)$, call $\tilde{A}$ contained in $\tilde{B}$ or $\tilde{B}$ contains $\tilde{A}$, $\tilde{A}\subseteq\tilde{B}$. If $K\tilde{A}(u)<K\tilde{B}(v)$, call $\tilde{A}$ true contained in $\tilde{B}$ or $\tilde{B}$ true contains $\tilde{A}$, $\tilde{A}\subset\tilde{B}$.

Inference3: if $\tilde{A}\subseteq\tilde{B}$, $\tilde{B}\subseteq\tilde{C}$, then $\tilde{A}\subseteq\tilde{C}$.

Inference4: if both $\tilde{A}$ and $\tilde{B}$ are the same attribute extension set in fields U and V , then the necessary and sufficient condition of $\tilde{A}\leftrightarrow\tilde{B}$ are $\tilde{A}\supseteq\tilde{B}$ and $\tilde{B}\supseteq\tilde{A}$.

Inference5: let U and V are fields to describe the same attributes, $U^{'}=U\cap V$, $V^{'}=U\cup V$, if $U^{'}\subseteq V^{'}$, then $K\tilde{A}(u^{'})\le K\tilde{B}(v^{'})$, call extension set $\tilde{A}$ contained in $\tilde{B}$ or $\tilde{B}$ contains $\tilde{A}$, $\tilde{A}\subseteq\tilde{B}$; if $U^{'}\subset V^{'}$, $K\tilde{A}(u^{'})<K\tilde{B}(v^{'})$, then $K\tilde{A}(u^{'})<K\tilde{B}(v^{'})$, call extension set $\tilde{A}$ true contained in $\tilde{B}$ or $\tilde{B}$ true contains $\tilde{A}$, $\tilde{A}\subset\tilde{B}$.

If $T=e$, $\tilde{A}(R_n)(T_{R_n})=\tilde{A}(R_n)$, then

$$A^{\max}(R_i)=\{\ R_i\big|R_i\in W_{R_i},Y_i=K^+(R)\ge 0\ \} \tag{21}$$

$$A^{\min}(R_i)=\{\ R_i\big|R_i\in W_{R_i},Y_i=K^-(R)\ge 0\ \} \tag{22}$$

are positive fields of W_{R_i} under optimistic and pessimistic conditions;

$$A^{\max}(R_i) = \{\ R_i | R_i \in W_{R_i}, Y_i = K^{+}(R) \geq 0\ \} \quad (23)$$

$$\overline{A}^{\min}(R_i) = \{\ R_i | R_i \in W_{R_i}, Y_i = K^{-}(R) \geq 0\ \} \quad (24)$$

are negative fields of W_{R_i} under optimistic and pessimistic conditions;

$$J^{\max} = \{\ R_i | R_i \in W_{R_i}, Y_i = K^{+}(R) = 0\ \} \quad (25)$$

$$J^{\min} = \{\ R_i | R_i \in W_{R_i}, Y_i = K^{-}(R) = 0\ \} \quad (26)$$

are zero sectors of W_{R_i} under optimistic and pessimistic conditions.

If $T \neq e$, $\tilde{A}(R_n)(T_{R_n}) \neq \tilde{A}(R_n)$,then

$$\hat{A}_{+}^{\max}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i = K^{+}(R) \leq 0, Y_i^{'} = T_{K_i} K_i^{+}(T_{R_i} R_i) \geq 0\ \} \quad (27)$$

$$\hat{A}_{+}^{\min}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i = K^{-}(R) \leq 0, Y_i^{'} = T_{K_i} K_i^{-}(T_{R_i} R_i) \geq 0\ \} \quad (28)$$

$$\hat{A}_{-}^{\max}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i = K^{+}(R) \geq 0, Y_i^{'} = T_{K_i} K_i^{+}(T_{R_i} R_i) \leq 0\ \} \quad (29)$$

$$\hat{A}_{-}^{\min}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i = K^{-}(R) \geq 0, Y_i^{'} = T_{K_i} K_i^{-}(T_{R_i} R_i) \leq 0\ \} \quad (30)$$

are positive extension fields and negative extension fields of matter-element for $\tilde{A}(R_n)(T_{R_n})$ under optimistic and pessimistic conditions.

$$A_{+}^{\max}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\quad Y_i = K^{+}(R) \geq 0, Y_i^{'} = T_{K_i} K_i^{+}(T_{R_i} R_i) \geq 0\ \} \quad (31)$$

$$A_{+}^{\min}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\quad Y_i = K^{-}(R) \geq 0, Y_i^{'} = T_{K_i} K_i^{-}(T_{R_i} R_i) \geq 0\ \} \quad (32)$$

$$A_{-}^{\max}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\quad Y_i = K^{+}(R) \leq 0, Y_i^{'} = T_{K_i} K_i^{+}(T_{R_i} R_i) \leq 0\ \} \quad (33)$$

$$A_{-}^{\min}(R_i)(T_i) = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i = K^{-}(R) \leq 0, Y_i^{'} = T_{K_i} K_i^{-}(T_{R_i} R_i) \leq 0\ \} \quad (34)$$

are positive steady fields and negative steady fields of matter-element for $\tilde{A}(R_n)(T_{R_n})$ under optimistic and pessimistic conditions.

$$J^{\max} = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i^{'} = T_{K_i} K_i^{+}(T_{R_i} R_i) = 0\ \} \quad (35)$$

$$J^{\min} = \{\ (R_i, Y_i, Y_i^{'}) | R_i \in T_{w_i} W_{R_i},\ Y_i^{'} = T_{K_i} K_i^{-}(T_{R_i} R_i) = 0\ \} \quad (36)$$

are extension sectors of $\tilde{A}(R_n)(T_{R_n})$ under optimistic and pessimistic conditions.

2.5 The matter-element extension space under no preference of group decision-making

Based on the division of extension set under preference, we can get:

$$\hat{B}_+ = \hat{A}_+^{\max}(R_i)(T_i) \cup \hat{A}_+^{\min}(R_i)(T_i) \quad (37)$$

$$\hat{B}_- = \hat{A}_-^{\max}(R_i)(T_i) \cup \hat{A}_-^{\min}(R_i)(T_i) \quad (38)$$

If $\hat{A}_+^{\max}(R_i)(T_i) \cap \hat{A}_+^{\min}(R_i)(T_i) \neq \varnothing$ and $\hat{A}_-^{\max}(R_i)(T_i) \cap \hat{A}_-^{\min}(R_i)(T_i) \neq \varnothing$, then

$$\hat{B}_+^* = \hat{A}_+^{\max}(R_i)(T_i) \cap \hat{A}_+^{\min}(R_i)(T_i) \quad (39)$$

$$\hat{B}_-^* = \hat{A}_-^{\max}(R_i)(T_i) \cap \hat{A}_-^{\min}(R_i)(T_i) \quad (40)$$

$\hat{B}_+$ is the largest positive extension fields under optimistic conditions and $\hat{B}_-$ is the largest negative extension fields under pessimistic conditions. They constitute the upper limit of positive extension fields and negative extension fields for $\tilde{A}(R_n)(T_{R_n})$. $\hat{B}_+^*$ and $\hat{B}_-^*$ are the extension of the core fields which are the foundation and basis of extension transformation under preference based on the steady extension fields in positive extension fields and negative extension fields.

$$B_+ = A_+^{\max}(R_i)(T_i) \cup A_+^{\min}(R_i)(T_i) \quad (41)$$

$$B_- = A_-^{\max}(R_i)(T_i) \cup A_-^{\min}(R_i)(T_i) \quad (42)$$

If $A_+^{\max}(R_i)(T_i) \cap A_+^{\min}(R_i)(T_i) \neq \varnothing$ and $A_-^{\max}(R_i)(T_i) \cap A_-^{\min}(R_i)(T_i) \neq \varnothing$, then

$$B_+^* = A_+^{\max}(R_i)(T_i) \cap A_+^{\min}(R_i)(T_i) \quad (43)$$

$$B_-^* = A_-^{\max}(R_i)(T_i) \cap A_-^{\min}(R_i)(T_i) \quad (44)$$

B_+ means the largest positive steady fields under optimistic conditions and B_- means the largest negative steady fields under pessimistic conditions. They constitute the upper limit of positive steady fields and negative steady fields for $\tilde{A}(R_n)(T_{R_n})$. B_+^* and B_-^* are the steady of the core fields which will not change with the decision-making preferences under no preference.

But, $\hat{B}_+^*, \hat{B}_-^*$ or B_+^*, B_-^* are empty set which means the expectations of optimism is far away from pessimism, through the extension transformation can not obtain core field of extension fields and steady fields. At this time the decision-making preferences can be adjusted to achieve the goal of extension changes.

According to researches and analyses of the extension set of the multi-dimensionality group decision-making under preferences, we can achieve a comprehensive multi-objective decision-making under no preference, i.e. we can get the decision-making space of multi-dimensional group decision-making based on extension set which is not influenced by preferences. It is very helpful to us to study the core and region of extension set to determine the variable scope of the projects and determine the foundation of decision conditions converting, in order to achieve the goal of extension identification, selection and update.

3. APPLICATION OF MULTI-OBJECTIVE EXTENSION GROUP DECISION-MAKING MODEL

According to study the extension association under decision-making preferences and the extension decision-making space under no preference of the multi-objective group decision-making, this paper establish a model which shows the unity of group interaction and individual preferences assembly in order to improve the accuracy and the reliability of decision-making.

3.1 The ideas and structure of model

The core of the model include the following: Firstly, to achieve multi-objective conversion and integration under the matter-element theory and extension methods; Secondly, to gain the optimal weight in decision-making based on combining objective weight with subjective judgments; Thirdly, through changes preferences in decision-making, to observe the optimal space of extension group decision-making in order to determine the best choice.

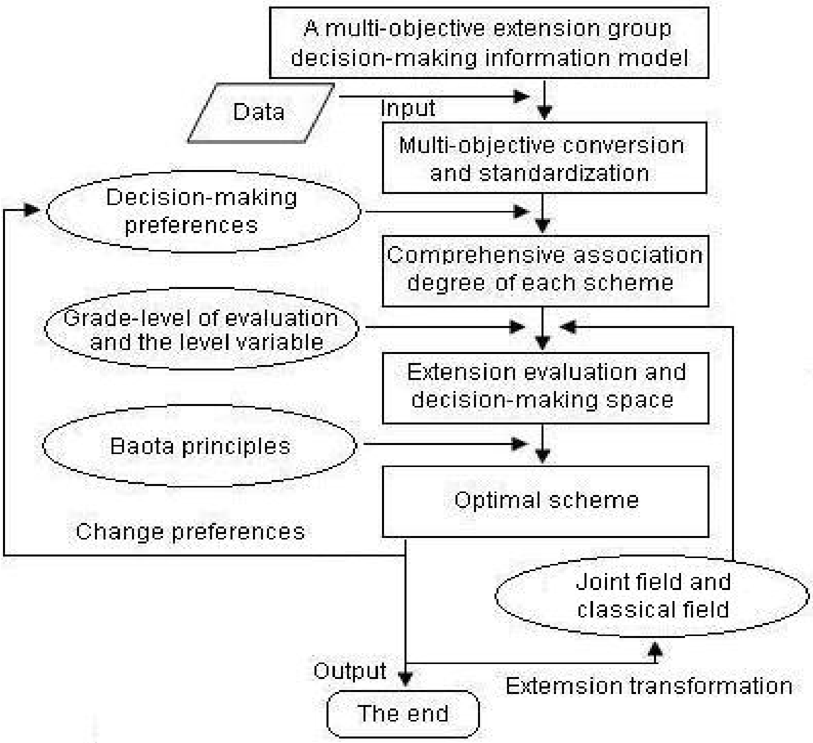

Figure 1. Operation process of the multi-objective extension group decision-making model

3.2 The steps and content of model

The main steps of model are as follows:

Step1: To establish a multi-objective extension group decision-making information model which includes expert set, scheme set and target set in order to obtain the composite matter-element $R_i = (O_t(N, c_j, v_{lj}))$ of extension evaluation and decision-making;

Step2: Let $\alpha = 0$, $\alpha = 0.5$ and $\alpha = 1$, to achieve the goal of multi-objective conversion and standardization in order to gain a comprehensive matrix of multi-objective extension decision-making;

Step3: To obtain correlation matrix $k^a(u_{ij})$ of different preferences α in group decision-making based on correlation formula;

Step4: To determine weight factor β_j of c_j , According to (15) and (16) we can obtain $K_i^+(R_i)$ and $K_i^-(R_i)$ in order to get the initial order for the schemes;

Step5: To determine joint field and classical field, and to let grade-level of extension evaluation and the level variable d $(d = 1,2,\cdots,g)$, we can get extension decision-making space E based on (45) and (46);

$$\overline{K}_d(R) = \frac{K_d(R) - \min K_d(R)}{\max K_d(R) - \min K_d(R)} \tag{45}$$

$$E = \sum_{d=1}^{g} d\overline{K}_d(R) / \sum_{d=1}^{g} \overline{K}_d(R) \tag{46}$$

Step6: According to the formula (27) to (36), we can observe the extension transformation of comprehensive association degree $K_d(R)$ under different preferences;

Step7: To get the best scheme through the Baota principles based on $K_d(R)$ in different preferences;

Step8: To change classical field and preferences of extension group decision-making, we are able to observe the changes of optimal scheme from the dynamic point of view in order to obtain a optimal scheme under no preference;

Step9: According to the formula (37) to (44), we can find the extension of the core fields under preference $\hat{B}_+^*$ and $\hat{B}_-^*$, and we can get the steady of the core fields under no preference B_+^* and B_-^* which can help us to make a rational choice based on comparing best scheme with optimal scheme.

4. A CASE STUDY

In order to catch hold of business opportunities of Beijing Olympic Games to expand market and increase sales, a larger toy manufacturing enterprise in Guangzhou which established a multi-objective extension group decision-making information model provides decision-making support to evaluate the new creative projects plans. Among them, experts set is $c = (c_1, c_2, c_3, c_4, c_5)$, schemes set is $R = \{R_1, R_2, R_3, R_4\}$, targets set is $O = \{O_1, O_2, O_3\}$, O_1 is the target which means income(positive index), O_2 is the target which means cost(negative index) and O_3 is the target which means production efficiency(positive index).

Table 1. Composite matter-element matrix of extension evaluation and decision-making

Scheme	$O_1(R)$					$O_2(R)$					$O_3(R)$				
	c_1	c_2	c_3	c_4	c_5	c_1	c_2	c_3	c_4	c_5	c_1	c_2	c_3	c_4	c_5
R_1	7.9	14.2	8.1	24	9.8	1.8	5.2	0.9	7	2.1	9.6	10.5	9.2	21	9.5
R_2	8.9	14.8	8	17	8.7	2.5	4.1	0.8	8	3.4	8.3	9.7	8.8	21	8.9
R_3	9.7	10.1	9.8	22	10.9	2.2	6.2	1.3	9	5.2	9.1	13.6	9.2	18	8.8
R_4	9.2	13	8.6	20.9	12.4	1.3	2.1	0.8	4.1	2.8	8.6	13.1	9.2	22.5	12.2

According to the requirements of assessment and decision-making for creative projects, we should determine the joint field and classical field of schemes based on extension group decision-making. Matrix of classical field is as follows Table 2:

Table 2. Matrix of classical field

Classical Field	c_1	c_2	c_3	c_4	c_5
Eligibility	6.5-7.5	8.5-9.8	7.5-8	15-17	8-10
Middling	7.5-8.5	9.8-12	8-9	17-20	10-12
Good	8.5-9.5	12-14	9-9.5	20-23	12-14
Excellent	9.5-10	14-15	9.5-10	23-25	14-15

According to joint field and classical field which the police-makes given, we can obtain comprehensive association degree under different preferences in order to determine the level of each scheme. We can receive the following Table 3:

Table 3. The dynamic order of schemes under preference

α	Index	Classical Field				Sequence
		Eligibility	Middling	Good	Excellent	
$\alpha = 1$	$K_d(R)$	-0.797	-0.575	0.125	-0.284	$(R_1 \approx R_3) > (R_2 \approx R_4)$
	Scheme			R_2, R_4	R_1, R_3	
$\alpha = 0.5$	$K_d(R)$	-0.745	0.076	0.047	-0.778	$R_4 > (R_1 \approx R_3) > R_2$
	Scheme		R_1, R_2, R_3	R_1, R_3, R_4		
$\alpha = 0$	$K_d(R)$	-0.036	-0.040	-0.491	-0.836	$R_4 > R_1 > (R_2 \approx R_3)$
	Scheme	R_2, R_3	R_1	R_4		

According to Table3, in the optimistic state, R_2 and R_4 belong to the good type, R_1 and R_3 belong to the excellent type. But, in the pessimistic state, R_2 and R_3 belong to the eligibility type, R_1 belongs to the middling type, R_4 belongs to the good type. And in the compromise state, R_1 and R_3 not only belong to middling type but also belong to good type. R_2 belongs to middling type and R_4 belongs to good type.

The method is compared with other common multi-objective methods, we can receive the following Table 4. We get the same decision-making result which optimal scheme under preference α is R_4 based on comparing of four methods to sort the results of the decision-making.

Table 4. Schemes' sequence of four decision-making methods under preference

α	Optimum Ordering	Osculating Value	TOPSIS	Extension Group decision-making
$\alpha = 1$	$R_1 > R_3 > R_4 > R_2$	$R_1 > R_4 > R_2 > R_3$	$R_1 > R_4 > R_2 > R_3$	$(R_1 \approx R_3) > (R_2 \approx R_4)$
$\alpha = 0.5$	$R_4 > R_1 > R_3 > R_2$	$R_4 > R_1 > R_2 > R_3$	$R_4 > R_1 > R_2 > R_3$	$R_4 > (R_1 \approx R_3) > R_2$
$\alpha = 0$	$(R_4 \approx R_1) > R_3 > R_2$	$R_4 > R_1 > R_2 > R_3$	$R_4 > R_1 > R_2 > R_3$	$R_4 > R_1 > (R_2 \approx R_3)$

Otherwise, according to step 5, if $\alpha = 1$, we can get $E^{\alpha=1}$ =3.18 which means the evaluation space of schemes is belong to good and excellent type, if $\alpha = 0$, we can get $E^{\alpha=0}$ =2.20 which means the evaluation space is belong to middling and good type. Based on step 9, we find good type is the only steady of the core fields under no preference, and R_4 is only scheme which is able to meet this requirement. Therefore, although the best scheme is R_1 based on Baota principles, but the optimal scheme is R_4 under extension transformation. It is proved that Matter-Element Extension Method for multi-objective conversion and multi-project optimization in group decision-making is feasible.

5. CONCLUSION

The present decision-making problems are often ones under uncertainty which is a dynamic, complex and correlated decision-making process. On account of the problem of group decision-making with matter-element extension set, this paper analyses the idea and the operating process of group decision-making model based on multi-objective extension optimization which combines dynamic analysis with extension transformation in order to obtain the matter-element extension space under no preference of the multi-dimensionality group decision-making. The model can improve the accuracy and the reliability of group decision-making by solving systematic decision-making problems of multi-objective assessment and multi-project optimization in multi-objective decision-making under uncertainty.

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REFERENCES

C.Y.YANG, Y.J.ZHANG, W.CAI. (2002). Study on Extension Set and Its Applications. *Mathematics in Practice and Theory*, 3, 301-308

H.J.CHEN. (October 2003). *The application in data mining by integrating matter-element with fuzzy theory*. 2003 IEEE international Coference on Systems, Man and Cybernetics, 3251-3256.

Kuei-Hsiang Chao,R.H.Lee,K.l.Yen. (July 2008). *An intelligent traffic light control method based on extension theory for crossroads*.7th International Conference on Machine Learning and Cybernetics,1882-1887.

L.CAO, W, PENG.(June 2006). *Extension Expert System and Its Application to IDSS*. 6th World Congress on Intelligent Control and Automation (WCICA 2006), 2566–2569.

M.H.WANG, Y.F.Tseng. (June 2008). *Extension genetic algorithm and its applications*. 3rd Internati onal Conference on Innovative Computing Information and Control(ICICIC 2008), 601-604.

Q.XIE,Y.Q.LI. (April 2008). *Large power transformer condition evaluation based on multilevel extension theory*. 3rd International Conference on Deregulation and Restructuring and Power Technologies(DRPT 2008), 933-936.

S.K.YANG,Y.ZHANG. (November 2007). *Intelligent Grey Extension decision support system based on set Pair Analysis*. IEEE International Conference on Grey Systems and Intelligent Services(GSIS 2007), 799-803.

S.ZHANG, Q.Y.CHENG. (November 2007). Study on strategies of uncertain problems in the ground-to-air missile composite group firing command decision making. *Systems Engineering and Electronics, vol. 29*, 1904-1907.

W.CAI. (1999). Extension management engineering and applications. *International Journal of Operations and Quantitative Management, 5(1)*, 59-72.

W.CAI. (1999). Extension theory and its application. *Chinese Science Bulletin, 17*, 1538-1548.

W.JIN, C.Z.CHEN. (August 2006).*Multiple fault diagnosis approach for rotary machines based on matter-element*. International Conference on Intelligent Computing(ICIC 2006), 643-648.

W.J. ZHANG, Z.Y.WANG. (June 2000). *On fuzzy extension decision system of the large scale system*. 3rd World Congress on Intelligent Control and Automation(WCICA 2000), 2302-2306.

W.LIU,W.N.LIU. (2007). *Research on extension's utilization in model's self-learning*. 2nd International Conference on Innovative Computing Information and Control(ICICIC 2007), 47-50.

Y. C.BAI. (June 2008). *Decision support system for risk investment based on SPA and extension*. 7th World Congress on Intelligent Control and Automation(WCICA 2008), 86-90.

Y.J.WANG, X.H.ZHENG. (August 2007). *Research on urban industrial water-saving evaluation based on extension matter element model*. 14th International Conference on Management Science and Engineering, 2271-2276.

Y.W.ZHAO, L.ZHU. (April 2008). *A comprehensive evaluation approach for key clients of the third party logistics based on the extension theory*. 12th International Conference on Computer Supported Cooperative Work in Design(CSCWD 2008), 312-316.

Z.L.SHENG,S.Z.ZHAO. (June 2006). *On-line measurement of production plan track based on extension matter-element theory*. 3rd International Symposium on Neural Networks, 906-913.

Z.ZHANG, C.F.WEI. (October 2007). Comparisons of land consolidation projects in the hilly and mountainous, southwestern China. *Transactions of the Chinese Society of Agricultural Engineering, vol. 23*, 98-105,.

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