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Introduction to soft-set theoretic solution of project selection problem

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Abstract

Purpose – The purpose of this paper is to introduce a model of decision-making problem in multi-criteria optimization domain for project selection. The model is built by combining the soft set theory and analytic hierarchical model under fuzziness. Soft set model gives us the opportunity to use parameterization properties. Here, the authors have proved that multiple alternatives can be reduced to make the selection process computationally efficient. Here, the authors illustrate the hybrid method by means of an application of the new mathematical model of soft set theory.

Design/methodology/approach – This paper is designed to excel a decision support system with multiple criteria analysis tool, analytic hierarchy process combined with soft set theory under fuzziness.

Findings – In this paper, the authors have taken four projects *P1, P2, P3* and *P4*. As per chosen parameters of softest theory the result of the illustrative example reveals that *P2* is the best project. The ranking the authors get is in the order of *P2, P3, P4* and *P1*. The algorithm leads the authors to maximize the proper choice in the environment of imprecise information. The main advantage of this method compare to others is that this hybrid method is very simple in terms of calculation and the computational complexity of the proposed algorithm is low.

Originality/value – This proposed decision support strategy for an intended project manager helped to take decision in the perspective environment.

Keywords Project management, Decision support systems, Analytical hierarchy process, Project selection, Multiple criteria analysis, Soft set theory

Paper type Research paper

1. Introduction

In the real world, we have to deal with many complex computational problems pertaining to the areas of engineering, medical sciences, environmental sciences, economics, social sciences, etc., which involve data that are not always crisp and precise. Therefore, most of our traditional models for formal reasoning and computing the crisp, deterministic and precise data fail. We cannot use the well-known classical methods because of various inherent uncertainties present in those problems. There are theories such as theory of probability, theory of fuzzy sets (Zadeh, 1965) and theory of intuitionist fuzzy sets (Atanassov, 1986, 1994), vague sets (Gau and Buehrer, 1993), rough sets (Pawlak, 1982) which can be taken into consideration for mathematical model formulation and for dealing with uncertainties. But all the above theories have their inherent difficulties, including lack of parameterization of tools due to which they are not capable of successfully solving such complicated problems. Reason for these

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difficulties, being the inadequacy of the parameterization tool of these theories (Molodtsov, 1999), introduced the concept of soft set theory as a mathematical tool for dealing with such uncertainties. We know that Pawlak (1994) first use the term "soft set" and also defined. But that was a different concept.

According to Hwang and Yoon (1995) multi-criteria decision making (MCDM) is applied preferably for decisions among available classified alternatives by multiple attributes. So MCDM is one of the most widely used decision methodology in project selection problems (Bakshi and Sarkar, 2011). The MCDM is a method that follows the analysis of several criteria, simultaneously. In this method economic, environmental, social and technological factors are considered for the selection of the project and for making the choice sustainable. Several framework have been proposed for solving MCDM problems, namely analytic hierarchy process (AHP) (Saaty, 1980), analytical network process (ANP) (Satty, 1996), which deals with decisions in absence of knowledge of the independence of higher level elements from lower level elements and about the independence of the elements within a level. Other framework available are data envelopment analysis, technique for order performance by similarity to ideal solution (Hwang and Yoon, 1981), VIKOR (Wang and Lee, 2009), COPRAS (Datta *et al.*, 2009), with gray number (Zavadskas *et al.*, 2008d, 2009b), simple additive weighting LINMAP (Srinivasan and Shocker, 1973), etc. With these techniques alternative ratings are measured, weight of the criteria is expressed in precised numbers. The projects' life cycle assessment is to be determined and the impact of all actors is to be measured. There are some mandatory axioms that the criteria describing feasible alternatives are dimensions of the projects. These dimensions are most important to determine the performance

There are several decision support system models available in the domain of multi-criteria optimization. These have been successfully used for making decision in multi-objective constraint satisfaction problem.

An application of AHP (Bayazit and Karpak, 2005) to the project selection problem is not now in the art. Satty's ANP (Sarkis and Talluri, 2002) is assumed to be suitable for project evaluation process. On the other hand, attempt to integrate the cardinal and ordinal preferences using ANP/AHP for project selection decisions failed to give stable models (Bayazit, 2006; Chan, 2003; Kahraman *et al.*, 2003).

Bakshi and Sanyal (2011) have successfully established fuzzy AHP-QFD model for software project selection. Fuzzy methods are applied to the multi-attributes decision model (Razmi *et al.*, 2009; Sreekumar, 2009), Sevkli *et al.* (2008) have proposed a method for project selection hybridized with fuzzy linear programming and AHP. The weights of the project selection criteria are measured using AHP model. Several types of integrated QFD techniques (Ju and Hwang, 2004) have been proposed for ranking candidate supplier.

The application of soft sets in decision-making problem with the help of rough sets was proposed by Pawlak (1982). Previously Lin (1998) and Yao (1998) have presented the rough set model for decision-making problem. Maji *et al.* (2003) has given a soft set theoretic model for decision-making problem and Som (2007) have given a fuzzy soft matrix model for decision-making method. However, it is noted that so far no researcher has developed soft set theoretic hybrid model combining AHP. So it can be assumed to be an introductory attempt of making soft set theory a tool for deriving a mathematical model for decision support system.

2. Theoretical preliminaries

In this section we present the concept of decision support system and decision-making problem briefly. Thereafter, we give a very brief introduction to MCDM problem. In the last phase we shall give the short introduction of fuzzy soft set and AHP model.

2.1 MCDM problem

Decision making is the core area of administrative activities. By decision making we mean a specific type of human activities aimed as choosing the best among available alternatives (Trukhayev, 1981). This definition includes three necessary objectives in decision-making process. The problem to be solved; a person or collective body which takes a decisions; several alternative among which a choice is to be made.

The decision-making procedure is essentially maintained by the contents, scale and time interval in which the problem is required to be solved. We can formulate a decision-making problem in a logical statement of the form (Kolbin, 2000-2001):

$$\text{“Given : } V; \text{required : } W; \text{”} \tag{1}$$

where V is the specified condition and W is the objective to be fulfilled. As a first approximation, the specified condition V includes $V^{\boldsymbol{s}}$ – the set of probable states of some objectives and $V^{\boldsymbol{p}}$ – set of operators transferring the object from one state to another. Obviously there can be a set of mappings of the subset $V^{\boldsymbol{s}}$ into $V^{\boldsymbol{p}}$. The objective W determines the state of objects.

Since the problem-solving procedure mainly depend on the statement and structure of the problem itself, we consider the general formal structure given in (Kolbin, 2000-2001):

$$\text{“Given : } Y, Z, D, S, U; \;\; \text{required : } W\text{”} \;\; (Y, Z, D, S, U_i), \tag{2}$$

where Y is the set of input factors which is control, Z is the set of unrestricted input factors, S is the set of outcomes or final results, D is the set of operators d from $Y \times Z$ on S, W is the objective of choosing subset S^* from S (where S^* can consist of a single element of criterion from U), U is the set of criteria for evaluation of elements of S and selection of S^*.

The real world decision problem necessitates the development of a model to construct the set of admissible alternatives, from a criteria space, ordered the alternatives by aspects and obtain the estimates under the chosen criteria. The methods for solving the estimation problems are based on the use of expert opinion.

The expert evaluation is applied with the idea of feedback systems when experts obtain the result of processing their estimate by a specific algorithm. A quantitative composition of expert team is important in expert evaluation.

2.2 Brief introduction toward multi-criterion problem of selection and optimization

In the problems of selecting the set $\prec$ is known and the principle of optimality is generally unknown. In the classical mathematical programming of optimization problem we consider a possibility to use the theory of choice and theory of optimization, where the set C is referred as the set of controls and the mapping ϕ: $C \rightarrow E_m$ are specified. The vector $\phi(c) \in E_m$ is interpreted as the outcome from C, where E_m is decision-making environment.

In general we formulate the multi-criteria problem as follows.

Find all or some $c^* \in C$ such that $\phi(c^*) \subseteq C_{\text{optimal}}(\phi)$, specific types of problems can be obtained by specifying the principle of optimality, the type of the set c and the mapping ϕ.

The MCDM problem can be represented as the triplet:

$$< C, \phi, R > \tag{3}$$

where C is the set of control variables, ϕ is the mapping from C in E_m, R is the binary relation on E_m by which the alternative outcomes are compared.

The method of comparison of alternative outcomes should be equipped with numerical evaluation of alternative utility and preference relations.

Here we summarize the main notion of utility theory as follows (Kolbin, 2000-2001; Kolbin and Suvorova, 2002).

The set of alternatives A together with the preference relation $\prec$ specified on it, is called the structure or the preference space. The utility function is called the real valued strictly isotones function on A; if there exists function c such that:

$$x \prec y \Rightarrow c(x) \prec c(y) \tag{4}$$

From (4) we can say that the relation $\prec$ is acyclic. This condition is normally supplemented with the constancy condition for function c on equivalence classes:

$$x \approx y \Rightarrow c(x) = c(y) \tag{5}$$

If the preference relation is not acyclic, it can no longer be represented in any sense by the ordinary utility function. Nevertheless any relation $\prec$ can be represented by some function c defined on $A \times A$ in the sense that:

$$x \succ y \Leftrightarrow u(x, y) > 0 \tag{6}$$

Where u is the comparative utility function.

2.3 Decision making under incomplete information

The quality of decision-making process depends directly on the extent to which all the control factors essential to making decisions and to decisions effects are allowed for. The decision authority often has to perform under uncertainties where it has a smaller amount of information than the requirement for reasonable actions during decision making. The uncertainty can be partially minimized by the information available to or additionally received by decision-making authority.

Uncertainty in decision making is characterized by insufficient reliability and the amount of information on the basis of which the decision-making authority chooses a decision. We summarize the various kind of uncertainty commonly occurring during decision-making process as follows:

(1) uncertainty in principle;

(2) uncertainty due to lack of information;

(3) uncertainty generated by decision authority;

(4) uncertainty involving constraint in decision-making process; and

(5) uncertainty caused by behavior of environment.

Another important class of uncertain situation is based on Zadeh's notion of fuzzy set. These tools are adequate to description of situations having a clear cut boundary.

2.4 Fuzzy decision-making environment

The uncertain information situation characterizes the case where the control authority (c) has a "fuzzy" knowledge of states of environment (E_m). We assume that the control authority C has an exact knowledge of the complete set Δ of probable state ∂_j of environment, the set ϕ has its decision ϕ_k and the value of evaluation functional:

$$F = \{f_{jk}\}_{j,k=1}^{n,m}$$

Based on concepts of theory of fuzzy sets we model the "behavior" of uncertainties and define the decision situations as triplet $\{\phi, R_\theta, F\}$ where R_θ are the fuzzy sets or fuzzy random event determined by membership function μ_R and the probability distribution p in the states of environment E_m (Kolbin, 2000-2001).

We list the main operations of fuzzy sets as follows:

(1) Equivalence $A \sim B \Leftrightarrow \mu_A(x) \equiv \mu_B(x)$.

(2) Inclusion $A \subset B \Leftrightarrow \mu_A(x) \leqslant \mu_B(x)$.

(3) Complement $\overline{A} \Leftrightarrow \mu_{\overline{A}}(x) = 1 - \mu_A(x)$.

(4) Union $A \cup B \Leftrightarrow \mu_{A \cup B}(x) = \max\{\mu_A(x), \mu_B(x)\}$.

(5) Intersection $A \cap B \Leftrightarrow \mu_{A \cap B}(x) = \min\{\mu_A(x), \mu_B(x)\}$.

(6) Product $A.B \Leftrightarrow \mu_{A.B}(x) = \mu_A(x).\mu_B(x)$.

(7) Sum $A+B \Leftrightarrow \mu_{A+B}(x) = \mu_A(x)+\mu_B(x)-\mu_A(x).\mu_B(x)$.

(8) Multiplication of A by $\alpha \in [0, 1]$: $\alpha \Leftrightarrow \mu_{\alpha A}(x) = \alpha\mu_A(x)$.

(9) Exponentiation of A to $\alpha > 0 : A^\alpha \Leftrightarrow \mu_{A^\alpha}(x) = (\mu_A(x))^\alpha$.

(10) Concentration $CON(A) = \mathrm{A}^{\mathbf{k}}$, $k \geqslant 2$.

(11) Dilation $DIL(A) = A^{0,5}$.

The notion of fuzzy sets and relations define the construction of various model for fuzzy specification of "behavior" of environment E_m as applied to formal scheme of definition of decision situations $\{\phi, \Delta, F\}$ which have been discussed above preciously.

2.5 Introduction to soft set theory

In this subsection we try to give a precised introduction of soft set theory and its competence in decision making.

Let U be the initial universal set and let Q be the set of parameters:

Definition 1. Maji *et al.* (2003). A pair (F, Q) is called a soft set over U if and only if F is a mapping of Q into the set of all subsets of the set U, that is F: $Q \rightarrow P(U)$, where $P(U)$ is the power set of U.

Soft set is a parameterized family of subsets of the set U. Every set $F(\varepsilon)$, *for* $\varepsilon \in Q$, from this family may be considered as the set of ε-elements of the soft set (F, Q) or as the set of ε-approximate elements of the soft set.

According to Zadeh, fuzzy sets can be considered as a special case of soft set. Let A be a fuzzy set of U with membership μ_A, that is μ_A is a mapping of U into [0, 1]. Let us consider the family of α-level sets for the function μ_A given by:

$$F(\alpha) = \{x \in U; \mu_A(x) \geqslant \alpha\}, \alpha \in [0, 1].$$

If we know the family F, we can find the functions $\mu_A(x)$ by means of the following formulae:

$$\mu_A(x) = \sup_{\alpha \in [0,1].x \in F(\alpha)} (\alpha)$$

Thus every fuzzy set A may be considered as the soft set $(F[0, 1])$.

3. Proposed methodology

In this paper, a hybrid model of decision-making problem has been proposed. The fuzzy soft set problem has been represented and converted into its equivalent binary form. Then the information is reduced into reduct soft set. The best alternative has been selected on the basis of the proposed algorithm. The detail steps are discussed below:

Step 1: formation of soft set:

- input: set of decision parameters and set of sub-optimal decision parameters/ choice parameters.

Step 2: formation of reduce soft set:

- input: soft set (F, E), set of choice parameters P of the soft set, which is subset of E.

Step 3: computation of all reduce soft set of (F, P).

Step 4: choose any one reduce soft set, say (F, Q) of (F, P).

Step 5: computation of weight value of soft set using fuzzy AHP method:

- Step 5.1: identify the alternatives.
- Step 5.2: determine the importance of alternatives as per expert opinion.
- Step 5.3: choose the criteria as per expert opinion.
- Step 5.4: determine the importance of criteria.
- Step 5.5: generate triangular fuzzy number (TFN) for alternatives and criteria.
- Step 5.6: defuzzify the fuzzy data.
- Step 5.7: calculate the eigenvalue and eigenvector.
- Step 5.8: test the consistency.
- Step 5.9: rank the alternatives.

Step 6: selection of optimal choice objects.

4. Proposed fuzzy soft AHP hybrid model of decision making

We construct a hybrid model of decision-making problem as follows.

First we represent the problem and convert it into equivalent binary tabular representation. Then reduce the table of binary information into reduced soft set.

In the next step we construct an algorithm to select the best project using choice criteria.

In the third step, we construct the weighted table of the proposed soft set problem. For finding the weight by fuzzy AHP method have been used. Finally, the best alternatives are chosen. The schematic diagram of fuzzy AHP method is described in Figure 1 and the proposed soft theoretic AHP model is described in Figure 2.

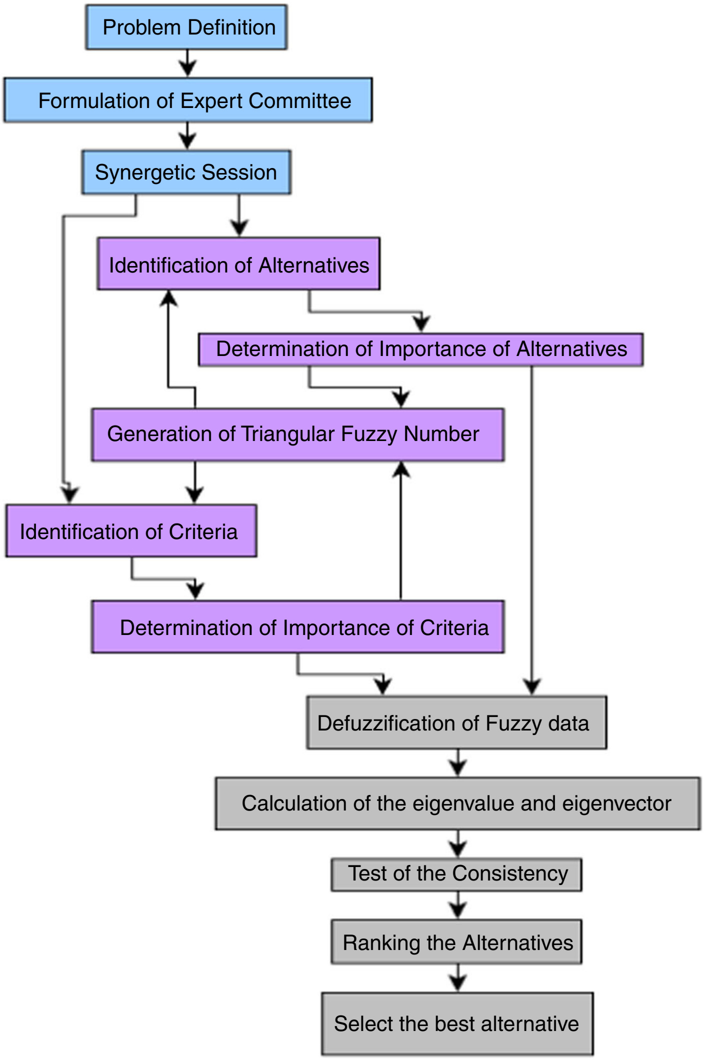

Figure 1. Schematic diagram of fuzzy AHP

5. Case study of proposed model

Let us consider four projects: P_1, P_2, P_3 and P_4.

Let E = {NPV; ROR; PB; PR; Highly Beneficial; Beneficial; Average; Poor} be a set of parameters.

Consider the soft set (F, E) which describes the "profit of the organization" given by:

$$(F,E) = \{\text{Max NPV}\{P_4,P_2\},\text{Max ROR}\{P_3,P_2\},\text{Max PB}\{P_1,P_2,P_3,P_4\},\text{Min PR}\{P_1,P_2\},$$

$$\text{Highly Beneficial}\{P_4,P_3,P_1,P_2\},\text{Beneficial}\{P_3,P_2\},\text{Average}\{P_4,P_1\},\text{Poor}\{P_3,P_1,P_2\}\}.$$

Suppose that an organization is interested to take the project on the basis of its choice of parameters: "maximum ROR," "maximum payback period," "beneficial" and

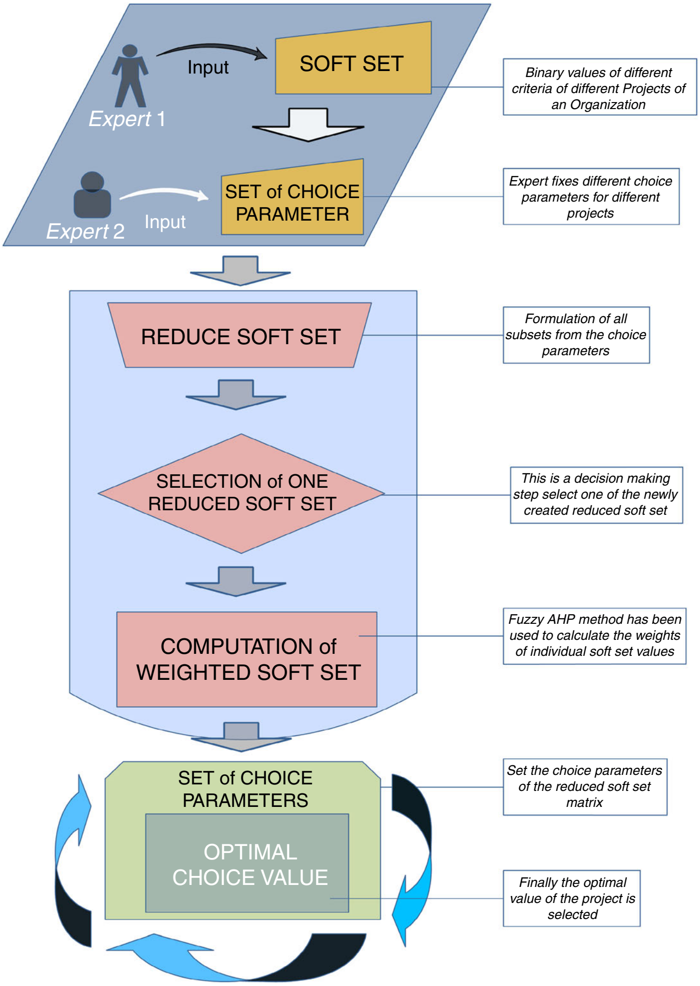

Figure 2.
Proposed soft theoretic AHP model

"minimum project risk," etc., which consider the subset:

$$P = \{\text{Max ROR; Max PB; Beneficial; Min Project Risk, Max NPV}\} \text{ of the set } E.$$

That means, out of available projects in U, organization would select that project which qualifies with all (or with max number of) parameters of the soft set P.

Tabular representation of a soft set (F, P) above on the basis of the set P of the choice parameters of the organization A. We can represent this soft set in a tabular form as shown below. This style of representation will be useful for storing a soft set in a computer memory. If $h_i \in F(\varepsilon)$ then $h_{ij} = 1$, otherwise $h_{ij} = 0$ where h_{ij} are the entries in Table I.

5.1 Reduce – table of a soft set

From the table we see that $\{e_1, e_2, e_4, e_5\}$, $\{e_2, e_3, e_4, e_5\}$ are the two reduces of $P = \{e_1, e_2, e_3, e_4, e_5\}$.

Choose any one say $Q = \{e_1, e_2, e_4, e_5\}$.
Incorporating the choice values the reduced soft set can be represented in Table II.
Now using reduced table using fuzzy AHP method.
Revised algorithm for selection of the best project using fuzzy AHP method:

(1) input the soft set (F, E);
(2) input the set P of choice parameters of the organization is a subset of E;
(3) compute all reduce soft sets of (F, P);
(4) choose one reduce soft set say (F, Q) of (F, P);
(5) compute weighted table of the soft set (F, Q) according to the weights computed by fuzzy AHP Method; and
(6) find k, for which $C_k = \max C_i$. Then h_k is the optimal choice object.

5.2 Algorithm of fuzzy AHP method

The fuzzy AHP technique can be viewed as an advanced analytical method developed from the traditional AHP. According to the method of Chang's (1996) extent analysis, each criterion is taken into account and extent analysis for each criterion, g_i's is performed on, respectively. Therefore, m extent analysis values for each criterion can be obtained by using following notation:

$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3, M_{g_i}^4, M_{g_i}^5, \ldots, M_{g_i}^m$, where g_i is the goal set ($i = 1, 2, 3, 4, \ldots, n$) and all $M_{g_i}^j$ ($j = 1, 2, 3, 4, \ldots, m$) are TFNs. The steps of the analysis can be given as follows.

Step 1. The fuzzy synthetic extent value (S_i) with respect to the ith criterion is defined as equation (1):

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left(1 \Bigg/ \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right] \right) \tag{7}$$

Operation $\otimes$ is defined as the one to one multiplication.

U	Maximum ROR e_1	Maximum PB e_2	Beneficial e_3	Minimum PR e_4	Maximum NPV e_5
P_1	0	1	0	1	0
P_2	1	1	1	1	1
P_3	1	1	1	0	0
P_4	0	1	0	0	1

Table I. Initial soft matrix

U	e_1	e_2	e_4	e_5	Choice value
P_1	0	1	1	0	$C_1 = 2$
P_2	1	1	1	1	$C_2 = 4$
P_3	1	1	0	0	$C_3 = 2$
P_4	0	1	0	1	$C_4 = 2$

Table II. Reduce soft matrix

To obtain (2) as:

$$\sum_{j=1}^{m} M_{g_i}^{j} \tag{8}$$

Perform the fuzzy addition operation of m extent analysis values for a particular matrix given in equation (9), at the end step of calculation, new (l, m and u) set is obtained and used for the next:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{9}$$

where l is the lower limit value, m is the most promising value and u is the upper limit value and to obtain the following equation:

$$\left(1 \Big/ \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right] \right) \tag{10}$$

Perform the fuzzy addition operation of $M_{g_i}^{j}$ $(j = 1, 2, 3, 4, \ldots, m)$ values given as follow:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{11}$$

And then compute the inverse of the vector in the equation (11) and equation (12) is then obtained as:

$$\left(1 \Big/ \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right] \right) = \left[\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right] \tag{12}$$

Step 2. The degree of possibility of $M_2 = (l_2, m_2, u_2) \geqslant M_1 = (l_1, m_1, u_1)$ is defined as follows:

$$\mathrm{V}(M_2 \geqslant M_1) = \sup\left[\min\left(\mu_{M1}(x), \mu_{M2}(y)\right)\right] \tag{13}$$

$$y \geqslant x$$

And x and y are the values on the axis of membership function of each criterion. This equation can be written as:

$$\begin{aligned} \mathrm{V}(M_2 \geqslant M_1) &= 1, \quad \text{if } m_2 \geqslant m_1 \\ &= 0, \quad \text{if } l_i \geqslant u_2 \\ &= \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, \quad \text{otherwise} \end{aligned} \tag{14}$$

Step 3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i=1, 2, 3, 4, 5, \ldots, k$) can be defined by:

$$V(M \geqslant M_1, M_2, M_3 \ldots, M_k) = \min \; V \; (M \geqslant M_i),$$

$i=1, 2, \ldots, k$. Assume that equation (15) is:

$$d^*(A_i) = \min \; V(S_i \geqslant S_k) \tag{15}$$

For $k=1, 2, 3, \ldots, n$; $k \neq i$. Then the weight vector is given by the following equation:

$$W^* = \left(d^*(A_1), d^*(A_2), \ldots\ldots\ldots\ldots d^*(A_n)\right)^T \tag{16}$$

where A_i ($i=1, 2, 3, \ldots, n$) are n elements.

Step 4. Via normalization, the normalized weight vectors are given in the following equation:

$$W = (d(A_1), \;\; d(A_2), \;\; d(A_3) \ldots d(A_n))^T \tag{17}$$

where W is non-fuzzy numbers.

5.3 Case study of fuzzy AHP method

According to expert's decision, the following matrix is formed and then by using TFN the fuzzy evaluation matrix is formed (Bakshi *et al.*, 2012) (Tables III and IV).

Now calculating all the values by applying Chang's (1996) theory the following results are obtained:

$$\begin{cases} S_{\mathrm{NPV}} = (3.50, 5.00, 6.50) \otimes (0.04, 0.057, 0.078) = (0.14, 0.28, 0.51) \\ S_{\mathrm{ROR}} = (4.13, 6.00, 9.33) \otimes (0.04, 0.057, 0.078) = (0.17, 0.34, 0.73) \\ S_{\mathrm{PB}} = (3.13, 3.83, 5.33) \otimes (0.04, 0.057, 0.078) = (0.13, 0.22, 0.42) \\ S_{\mathrm{PR}} = (2.08, 2.75, 3.75) \otimes (0.04, 0.057, 0.078) = (0.08, 0.16, 0.29) \end{cases}$$

Criteria	NPV	ROR	PB	PR
NPV	1	1	2	1
ROR	1	1	2	2
PB	0.5	1	1	1.33
PR	0.5	0.5	0.75	1

Table III. Evaluation matrix

Criteria	NPV	ROR	PB	PR
NPV	(1,1,1)	(0.75,1,1.25)	(1,2,3)	(0.75,1,1.25)
ROR	(0.8,1,1.33)	(1,1,1)	(1,2,3)	(1.33,2,4)
PB	(0.33,0.5,1)	(0.8,1,1.33)	(1,1,1)	(1,1.33,2)
PR	(0.25,0.5,0.75)	(0.33,0.5,1)	(0.5,0.75,1)	(1,1,1)

Table IV. Fuzzy evaluation matrix

And:

$$\begin{cases} V(S_{\text{NPV}} \geqslant S_{\text{ROR}}) = 0.85, V(S_{\text{NPV}} \geqslant S_{\text{PB}}) = 1, \\ V(S_{\text{NPV}} \geqslant S_{\text{PR}}) = 1, \\ V(S_{\text{ROR}} \geqslant S_{\text{NPV}}) = 1, V(S_{\text{ROR}} \geqslant S_{\text{PB}}) = 1, \\ V(S_{\text{ROR}} \geqslant S_{\text{PR}}) = 1, \\ V(S_{\text{PB}} \geqslant S_{\text{NPV}}) = 0.82 \quad V(S_{\text{PB}} \geqslant S_{\text{ROR}}) = 0.67, \\ V(S_{\text{PB}} \geqslant S_{\text{PR}}) = 1, \\ V(S_{\text{PR}} \geqslant S_{\text{NPV}}) = 0.55, V(S_{\text{PR}} \geqslant S_{\text{ROR}}) = 0.4, \\ V(S_{\text{PR}} \geqslant S_{\text{PB}}) = 0.73 \end{cases}$$

Minimum of all values (0.85, 1, 0.67 and 0.4).

The weight $W=(0.29, 0.34, 0.23, 0.14)$.

So in our case study, e_1 denotes the maximum ROR and its weight $w_1=0.34$; e_2 denotes the Max PB and its weight $w_2=0.23$; ; e_4 denotes the Min PR and its weight $w_4=0.14$; e_5 denotes the Max NPV and its weight $w_5=0.29$.

Using these weighted values Table V is constructed.

So $P_2 \rightarrow P_3 \rightarrow P_4 \rightarrow P_1$, that is P_2 is the best project.

6. Result analysis and discussion

First, in this algorithm we need not to consider the whole soft set directly in decision making but only deal with the related reduct soft sets. Finally, the best result of the decision support system has been decided by the choice value of the weighted factor which is measured by very simple method as proposed fuzzy AHP. This makes our algorithm simpler and easier for application in practical problems than (Maji *et al.*, 2003).

This algorithm can be modeled with various techniques to find out weighting values. We have considered fuzzy AHP method in this paper. Fuzzy AHP is the most popular and standard and well-accepted technique to find weight in case of imprecise information. Therefore, we can say it has minimized error in our hybrid algorithm.

Third, many decision-making problems are mainly humanistic and subjective in nature; hence there actually does not exist a unique or uniform criterion for decision making in an imprecise environment. This hybrid feature makes our algorithm not only efficient but more appropriate for many practical applications.

6.1 Computing time complexity of proposed algorithm

Suppose that in this decision-making system there are n alternatives, m attributes/parameters and l is the maximum distinct values (choice parameter) of each attribute.

Table V. Weighted soft matrix

Weight U	0.34 $e_1.w_1$	0.23 $e_2.w_2$	0.14 $e_4.w_4$	0.29 $e_5.w_5$	Choice value
P_1	0	1	1	0	$C_1=0.37$
P_2	1	1	1	1	$C_2=1$
P_3	1	1	0	0	$C_3=0.57$
P_4	0	1	0	1	$C_4=0.52$

Computational value to determining elementary set of all attributes is *nm*. So it takes *ml*(*ml*−1) times to determine the total support for each category. Thus the computational complexity for the proposed technique is of the polynomial:

$$O(ml(ml-1)+nm+1).$$

7. Conclusion

In the present paper, we modeled an application of fuzzy soft theory in decision support system. In this context, we have introduced the soft theoretic model of AHP to have better decision. This proposed decision support strategy for an intended project manager helped to take decision in the perspective environment. The data set used in this paper is collected from experts' opinion. The algorithm involved from the resultant soft set theoretic AHP, which lead us to maximize the proper choice in the environment of imprecise information. The main advantage of this method compare to others is that this hybrid method is very simple in terms of calculation and the computational complexity of the proposed algorithm is very low.

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