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A project decision support system based on an elucidative fusion system

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Abstract -Within the framework of project design, many solutions and criteria to be satisfied are involved in the decision making processes. Knowledge about criteria satisfaction versus potential solutions are often coming from a large and dynamic group of people from different backgrounds. In this complex context, we propose to associate a Referential Knowledge Base with an Elucidative Fusion System in order to perform a decision support system. The contribution is on elucidation functionalities for fuzzy integral aggregation operators applied to the problem of movie award attribution.

Keywords: Decision-making support system, Multi-criteria fusion, Elucidative fusion system, Knowledge engineering, Fuzzy Integrals.

1 Introduction

Project management is now developed in many various application areas (aerospace, automotive, financial market analysis, ...). It is generally considered as a supervision activity involving the knowledge of a large and dynamic group of people from different backgrounds through their evaluations of adequate project tracking indicators. In fact, each competing technological solution (service or product) is evaluated by means of a set of criteria. The evaluation results from an interpretation of the knowledge expressed by people in terms of value judgments of the solutions according to specific criteria. Aggregating these partial appraisals provides a classification of all the solutions by preference order.

In order to manage all these pieces of information, they have to be structured. The concept of Referential Knowledge Base (RKB) is a solution to monitor the scientific output of projects [1]. It makes possible to simulate decision strategies and to automatically evaluate

candidate solutions thanks to the knowledge contained in the RKB.

But, the deployment of such automated fusion and decision systems is often hindered by the 'fear of unknown' on the part of the user communities and their ultimate human decision maker. So we are interested in a system that not only proposes a decision but also provides an explanation as to why a specific decision is made: one would like to have a system that can elucidate its decisions [2] and identify the decision drivers so that the user (decision maker) can develop trust in the performance of the system. This paper is a contribution to this issue in the case of fusion of criterion satisfactions by fuzzy operators belonging to the fuzzy integral family [3].

The paper is organized as follows. In section 2, the referential knowledge base is presented through its functionalities, particularly the evaluation mode of solutions through multiple criteria within a collective decisional framework. Section 3 is devoted to the multi-criteria decision making with an emphasis on the interest of using aggregation operators of the fuzzy integral family. Section 4 is dedicated to our specific approach of elucidation in the multi-criteria fusion framework by fuzzy integral operators. Two particular cases illustrate our theoretical results through an application devoted to the awards attribution to movies within the specific framework of "Avoriaz" fantastic movie festival.

2 The referential knowledge base

The function of a referential knowledge base (RKB) is to manage change in the body of knowledge connected with a project so as to facilitate executive reporting [1]. Technically, RKB is an intranet tool: a web server interfaced with a SQL data base and a SPIRIT document base.

2.1 Collective mode and space of evaluation

The RKB must include observers that allow it to be used for evaluation and dynamic project monitoring, for tracking the decisions and the related arguments that constitute project milestones.

A project measurement space, the evaluation grid (figure 1), is defined in order to progress from a simple qualitative image to a quantitative observer of the status of the project and the solutions it develops. The decision support functionality's are derived from a grid for rating the possible solutions (columns) based on specified criteria (in lines).

The individual ratings embodied in the KIs and integrated in the grid allow the differing intensities of voter preferences to be taken into account: each vote is an evaluation of a solution with respect to a criterion. It expresses the degree of satisfaction (compatibility) of a criterion with a solution assigned by the author of the KI (so that, KI represents a value judgement by its recorder). Because we felt a numerical notation system would be difficult to implement in evaluating a *solution i* according to a *criterion j*, we opted for a color palette rather than a purely quantitative notation : bright red indicates that *solution i* is incompatible with *criterion j* while dark green indicates a perfect match. The color palette of course depends on the granularity of the rating scale that it is desirable or possible to express. A symbolic/numeric interface provides from the transition from colors to numbers. Note that the number in a box in the collective evaluation grid (fig.1) corresponds to the mean of the several individual evaluations.

	s^1	s^2	s^3	s^4	s^5
c_1	0.7	0.75	0.65	0.9	0.1
c_2	0.95	0.7	0.9	0.8	0.7
c_3	0.65	0.9	0.6	0.5	0.3
c_4	0.8	0.8	0.5	0.1	0.4

Figure 1. Collective evaluation grid

Then, the overall rating of a solution is thus obtained by aggregating the collective partial degrees of satisfaction obtained for each criterion. Various mathematical operators can be used to model this aggregation procedure that must represent the behavior of the decision maker. This aspect will be further developed in section 3.

2.2 Application description

The preceding ideas are applied to a decision support system dedicated to the movies selection process in the "Avoriaz" festival, so that the movies are seen as the

solutions to be evaluated according to a given set of criteria.

For each specialized film festival, selection criteria are pre-established. That's the case for the Avoriaz film festival which is dedicated to fantastic, science fiction and horror films. At the Avoriaz festival, it is easy to understand that the main criteria that support the jury decisions are : the scenario (suspense...), the image quality and the special effects. Each member of the jury festival is supposed to follow a collective logic : in our modeling framework, it corresponds to the idea that each member of the jury acts upon a unique selection strategy identified to a common aggregation operator of the pre-established criteria. It is also obvious that the criteria in such an evaluation process are seldom independent : for example, it is difficult to objectively distinguished image quality and special effects.

When the prizes are awarded, the recurrent question in the general public is "How did the expert international committee draw these conclusions from the set of candidate films ?", "What are their grounds for awarding this film". Indeed the general public is always more or less doubting concerning the integrity and the objectivity of the awards. Concerning the first interrogation an elucidative fusion system defined as a system that has the ability to offer, in addition to the decisions it develops through multi-source information fusion, the reasons or drivers for such decisions, is thus really relevant in such a case. For the second question it must also be able to offer a measure of influence of the different information sources on the fused decision (in our case the criteria).

This information system, which would be comforting to the end-user, elucidates its decisions and identifies the decision drivers so that the user can develop "trust" in the performance of the system. It would be desirable for the user to, not only obtain the decisions from the fusion system, but also understand the rationale underlying the decisions derived from such automated multi-source information fusion systems. It can so be imagined to feed the RKB with the jury critics that are interpreted in terms of value judgements—a critic is seen as a partial score relatively to a given criterion—and classified in the evaluation grid of the RKB. Then, after the selection of the awarded films, it would be possible to provide the radio/television news or the specialist press with the most significant critics of the famous jury members that can support these decisions. This argumentation or elucidation mode would probably promote the reliability and the objectivity of the festival selection.

For example, in the evaluation grid (figure1), the movies to be evaluated are: sol1= "Star wars3", sol2="sixth sense", sol3="Friday 13", sol4= "Matrix", sol5=element five ", sol6="Men in black ". For each box (solution, criterion), a criticism is given by a jury member, these

criticisms constitute for our approach the KI's base, these KI's represents a value judgement (favorable or not and to which degree) of the solution via the specific criterion. The criteria taken into account are: Cr1="scenario", Cr2 = "special effects", Cr3 ="actors game" and Cr4 ="image quality".

In this kind of festival, there are several types of prices which are used to reward each film according only to one criterion: the best scenario, the best actor,... The evaluation grid allows easily to visualize the film which is more appreciated according to a given criterion and the justification of this choice is given since one capitalizes the whole of the criticisms of the jury members in the grid. We will interest particularly, at the jury special price which involves all the criteria to determine the "best" film.

3 Multi-criteria fusion and decision

In this section one specify the election process, in other words the way in which the KIs votes are made up and aggregated. The overall score of a candidate then requires the aggregation of all its partial evaluations according to each criterion.

3.1 Notations

In the remaining of the paper, we will work in a finite universe $C = \{c_1, c_2, \dots, c_n\}$ of n criteria, $P(C)$ is the power set of C , $x = \{x_1, x_2, \dots, x_n\}$ represents the numerical satisfaction values of the criteria, such that x_i is the satisfaction degree of criterion c_i . Let us still consider a set of solutions (candidates) $S = \{s^1, s^2, \dots, s^p\}$. Each solution $s^k \in S$ is associated with a profile $s^k = (x_1^k, x_2^k, \dots, x_n^k)$ where x_i^k represents the partial evaluation (score) of s^k related to the criterion c_i . For the sake of simplicity, it is assumed that we deal with scores on criteria, expressed on a $[0,1]$ scale, 1 corresponds to the complete satisfaction of a criterion, and 0 corresponds a no complete satisfaction of a criterion. The problem of aggregation is the construction of a function $C_\mu: [0,1]^n \rightarrow [0,1]$, so that, for each solution s^k : $C_\mu(s^k) = C_\mu(x_1^k, \dots, x_n^k)$, where $C_\mu(s^k)$ represents the overall evaluation of the solution s^k according to the all n criteria.

3.2 Aggregation operator requirements

Until recently, the most common tool which is used in multicriteria decision making is the weighted arithmetic mean. But, this aggregation function is too poor to model

the three main attitudes of decision maker : conjunction (t-norm, like the min), compromise (like the weighted mean) or disjunction (t-co-norm, like the max); all the intermediate attitudes can also be imagined [4].

Moreover, it is important that an aggregation operator can satisfy other behavioral properties: possibility of expressing weights of importance on criteria, and interactions among them. All operators are not able to model all this properties. However, this problem has been partially solved since the introduction of fuzzy integrals [5].

Indeed, aggregation operations based on the family of fuzzy integrals include many operators (weighted mean, min, max, median, ordered weighted average) and can thus express a variety of decision maker's behaviors (severity, compromise, tolerance) and various effects of importance and interaction among criteria [6-7]. In the next paragraph, we present briefly, the definition of Choquet fuzzy integral and its principal properties as operator of multi-criteria aggregation.

3.3 The Choquet fuzzy integral family

Definition 1. A (discrete) fuzzy measure on C is a monotonic set function $\mu: P(C) \rightarrow [0,1]$, satisfying $\mu(\emptyset) = 0, \mu(C) = 1$; monotonicity means that $A \subset B \subset C \Rightarrow \mu(A) \leq \mu(B) \leq \mu(C)$. Where $\mu(A)$ is seen as the weight of importance of the subset of criteria A .

Definition 2. Let μ be a fuzzy measure on C . the (discrete) Choquet integral of $x = \{x_1, x_2, \dots, x_n\}$ w.r.t μ is defined by [8]:

$$C_\mu(x_1, \dots, x_n) = \sum_{i=1}^n (x_{(i)} - x_{(i-1)}) \cdot \mu(A_{(i)}) \quad (1)$$

where $\cdot_{(i)}$ indicates a permutation such that: $x_{(0)} = 0, 0 \leq x_{(1)} \leq \dots \leq x_{(n)} \leq 1$, and $A_{(i)} = \{c_{(i)}, \dots, c_{(n)}\}$.

Let us use the notations : $\mu_i = \mu(\{c_i\})$ (resp. $\mu_{ij} = \mu(\{c_i, c_j\})$) represents the importance of criterion c_i (resp. (c_i, c_j)), ..., for example, in the application, the solution (movie) s^4 "Matrix" is evaluated according to tree criteria : the scenario (c_1), the special effects (c_2), and actors (c_3). Let us put $s^4 = (x_1, x_2, x_3) = (0.9, 0.8, 0.5)$; and let consider a given measures: $\mu_1 = \mu_2 = 0.4; \mu_3 = 0.3; \mu_{12} = 0.5 \mu_{123} = 1$. Then $(x_{(1)} = 0.5) \leq (x_{(2)} = 0.8) \leq (x_{(3)} = 0.9)$, this order implies that: $A_{(1)} = \{c_{(1)}, c_{(2)}, c_{(3)}\} = \{c_3, c_2, c_1\}$, $A_{(2)} = \{c_2, c_1\}$ and $A_{(3)} = \{c_1\}$. Then $\mu(A_{(1)}) = 1; \mu(A_{(2)}) = 0.5;$

$\mu(A_{(3)})=0.4$. Using (1), it can be deduced : $C_{\mu}(x_1, x_2, x_3)=0.69$. Note that the values of x_i and their order have an important influence on the $C_{\mu}(x)$ value.

Following this approach, a decisional problem involving n criteria requires 2^n coefficients in $[0,1]$ in order to define the fuzzy measure μ on every subset of $P(C)$. Of course a decision maker is not able to give such an amount of information. To overcome this problem, we will consider only a particular case of Choquet fuzzy integrals known as the 2-additive measure (interactions are considered only two by two) [8]. Indeed, only $n(n+1)/2$ coefficients are required to define the fuzzy measure; the Choquet integral can thus be expressed in the interpretable form as follows :

$$C_{\mu}(x)=\sum_{I_{ij}>0}(x_i \wedge x_j)I_{ij}+\sum_{I_{ij}<0}(x_i \vee x_j)|I_{ij}|+\sum_{i=1}^n x_i(v_i-\frac{1}{2}\sum_{j \neq i}|I_{ij}|) \quad (2)$$

where $v_i-\frac{1}{2}\sum_{j \neq i}|I_{ij}| \geq 0$ and where v_i are the Shapley

indices, representing the overall importance of each criterion relative to all the others, with the propriety

($\sum_{i=1}^n v_i=1$); I_{ij} represents the interactions between pairs of

the criteria (c_i, c_j) with values contained in the interval $[-1;1]$; a value 1 signifies a positive synergistic effect between the two objectives, a value of -1 is indicative of negative synergy, and a null value means the objectives are independent. We may thus decompose the Choquet integral into three parts: one conjunctive, another disjunctive and the third additive:

- a positive I_{ij} implies that the simultaneous satisfaction of criteria c_i and c_j will have a significant effect on the aggregated performance, and that satisfying only one criterion will have no effect;
- a negative I_{ij} implies that the satisfaction of c_i or c_j is sufficient to obtain a significant effect on the aggregated performance;
- a zero I_{ij} implies that there is no interaction between the two criteria considered: the v_i indices correspond to classic weighted means.

The coefficients of importance v_i and I_{ij} being more natural to decision maker, their determination by asking the decision maker is possible. Other methods based on the identification of these coefficients from experimental data exists but it is an other problematic (see [6]), that is not the object of this article.

4 Elucidation of the fused result

The need for elucidation aims to light the decision maker during phases of process decision. This elucidation is explained in the “how” (and the “why”) such a decision is taken. This understanding of the “why” (and how) of the decisions derived by the fusion system, can be expressed qualitatively or /and quantitatively at several levels. The why can be quantitatively expressed in terms of the relative influence or dominance of particular criterion satisfactions on the ultimate decision. Indeed, we are interesting in the partial contribution of a specific criterion for a considered fused result.

Let us consider that the solution that has been elected is s^k : it has been adopted following a strategy identified with the aggregation operator $C_{\mu}(s^k)$. Thus: $\forall l=1, \dots, p$;

(where p is the candidates-solutions number), $C_{\mu}(s^k) \geq$

$C_{\mu}(s^l)$. Our approach to determine the contribution of partial evaluations is to decomposed the fused value as a sum of terms where partial evaluations are involved. Three kinds of elucidation have been considered as developed in the following subsections.

4.1 Absolute elucidation

First, it may be pertinent to identify the elements related to the excellence of s^k : it is an absolute elucidation. It should then be possible to parameterize the level of detail required for the explanation. We might wish to include several levels of detail in the argumentation: a “one-word” justification, the essential reasons or the main reasons for this preference, detailed reasons, or an exhaustive—and even anecdotal—report. For this, by (1) we have :

$$C_{\mu}(s^k)=\sum_{i=1}^n (x_{(i)}^k - x_{(i-1)}^k) \cdot \mu(A_{(i)}^k), \quad \text{let us note :}$$

$$\mu_{(i)}^k = \mu(A_{(i)}^k), \quad \text{then :}$$

$$C_{\mu}(s^k)=(\mu_{(1)}^k - \mu_{(2)}^k)x_{(1)}^k + \dots + (\mu_{(i)}^k - \mu_{(i+1)}^k)x_{(i)}^k + \dots + \mu_{(n)}^k x_{(n)}^k$$

$$C_{\mu}(s^k)=\sum_{i=1}^n \Delta \mu_{(i)}^k \cdot x_{(i)}^k \quad (3)$$

where, $\mu_{(n+1)}^k=0$, and $\Delta \mu_{(i)}^k = \mu_{(i)}^k - \mu_{(i+1)}^k$.

We can initially simply re-rank the terms of the sum (3) so that $\forall j=1, \dots, n-1, \Delta \mu_{(j)}^k x_{(j)}^k \geq \Delta \mu_{(j+1)}^k x_{(j+1)}^k$.

We can then partition the absolute contributions of the scores related to the criterion $c_{(j)}$, $\Delta \mu_{(j)}^k x_{(j)}^k$ (this term is defined as the absolute potential of criterion $c_{(j)}$) into classes relative to the orders of magnitude of the

$\frac{\Delta\mu_{(j)}^k x_{(j)}^k}{\Delta\mu_{(1)}^k x_{(1)}^k}$ ratio. The closer this ratio to 1, the greater the contribution of the score w.r.t the criterion $c_{(j)}$, and the more $c_{(j)}$ represents an essential dimension in the decision (local interpretation of elucidation).

4.2 Relative elucidation

In the second step of elucidation, it is important to provide evidence concerning the dimensions according to which s^k was preferred over s^l , the axes along which s^k made the difference over s^l . We use the following analysis criterion:

$$\forall l, \Delta C_{\mu_R}(s^k, s^l) = C_{\mu}(s^k) - C_{\mu}(s^l) = \sum_{i=1}^n R_{(i)}^{k,l} \quad (4)$$

where, $R_{(i)}^{k,l} = \Delta\mu_{(i)}^k x_{(i)}^k - \Delta\mu_{(i)}^l x_{(i)}^l$.

This is a relative argument in which the quantities analyzed are the sums of the *individual relative potentials* $R_{(i)}^{k,l}$. We may adopt the same order-of-magnitude reasoning for $\Delta C_{\mu_R}(s^k, s^l)$ as for $C_{\mu}(s^k)$ as discussed in the preceding step 4.1, after permuting the subscripts of $\Delta C_{\mu_R}(s^k, s^l)$ for each candidate s^k to rank the individual relative potentials in decreasing order.

4.3 Average relative elucidation

At a more synthetic final level of elucidation, it may be advisable to situate the elected solution with respect to all the other solutions. This is again a relative argument, but in this case with respect to the entire group. In this case, we use the following analysis criterion:

$$\Delta C_{\mu_{\bar{R}}}(s^k, s^l) = \sum_{k \neq l} C_{\mu}(s^k) - C_{\mu}(s^l), \text{ then}$$

$$\Delta C_{\mu_{\bar{R}}} = \sum_{i=1}^n \left[(p-1) \Delta\mu_{(i)}^k x_{(i)}^k - \Delta\mu_{(i)}^l \sum_{k \neq l} x_{(i)}^l \right] = \sum_{i=1}^n \left[\bar{R}_{(i)}^k \right]$$

with $\bar{R}_{(i)}^k = (p-1) \Delta\mu_{(i)}^k x_{(i)}^k - \Delta\mu_{(i)}^l \sum_{k \neq l} x_{(i)}^l$ (5)

to obtain a problem similar to the preceding order-of-magnitude interpretation. This time the $\bar{R}_{(i)}^k$ terms are mean relative potentials, and the most important of them correspond to the criteria according to which candidate s^k differed significantly from the mean.

4.4 Illustration on two particular cases

As seen before, the proposed approach is applied to the application presented in section 2.3. The specific criteria taken into account are: the scenario (c_1), the special effects (c_2), and the actors (c_3). Let us consider, the three movies to be evaluated : “star wars 3” (s^1), “the sixth sense” (s^2), and “Friday 13” (s^3). After, the vote and evaluation modes, as explained in section 2, we obtain the collective partial evaluations summarized in the table 2.

	s^1	s^2	s^3
c_1	0.7	0.75	0.65
c_2	0.95	0.7	0.9
c_3	0.65	0.9	0.6

Table 2. Score table

4.4.1 The weighted mean

In this sub-section, we assume for a sake of simplicity that all criteria are independent (i.e. there is no interactions among them), as a consequence, the measure is supposed to be additive (i.e. $\mu(A \cup B) = \mu(A) + \mu(B)$, even if $A \cap B = \emptyset$; $A, B \subset C$). In this case, it is easy to prove that the expression of the Choquet integral (3) becomes:

$$C_{\mu}(x_1, \dots, x_n) = \sum_{i=1}^n w_i x_i \quad (6)$$

where the $w_i = \mu_i$ represents the weights of the criteria chosen a priori by the decision maker. It is easy to see that $\Delta\mu_{(i)}^k$ of (3) becomes: $\Delta\mu_{(i)}^k = \Delta\mu_{(i)} = w_{(i)}$, $\forall k = 1, \dots, p$.

In this case, the value of $\Delta\mu_{(i)}^k$, is independent on the order of the elements x_i^k . Now, let us apply the elucidation procedure, as suggested in the preceding subsections. In the application, the weights corresponding to each criterion c_1 (SC), c_2 (SE) and c_3 (AC) are respectively: $w_1 = 0.3$, $w_2 = 0.4$, $w_3 = 0.3$. Then the weighted mean operator (6) give the following results for the three solutions s^1 , s^2 , s^3 :

$$C_{\mu}(s^1) = 0.21 + 0.38 + 0.195 = 0.785; \quad C_{\mu}(s^2) = 0.775; \\ C_{\mu}(s^3) = 0.735; \text{ thus, } s^1 \text{ is the best solution chosen collectively.}$$

In terms of the first type of elucidation, we can see that the absolute potential related to the criterion of special effect (SE) c_2 ($\Delta\mu_2 \cdot x_2^1 = 0.38$), is the largest and leads more to this ultimate decision, after it came, the absolute potential ($\Delta\mu_1 \cdot x_1^1 = 0.21$) related to the criterion of scenario (SC) c_1 , and finally, that of actors (AC) c_3 ($\Delta\mu_3 \cdot x_3^1 = 0.195$).

Let us now consider the dimensions according to which s^1 was preferred over to s^2 and s^3 . The relative potential related to the criterion c_2 (SE) ($R_2^{1,2} = 0.38 - 0.28 = 0.1$) is the most significant in the preference of s^1 over s^2 . By carrying out the same reasoning with respect to preference of s^1 over s^3 , we find that the relative potential of c_2 (SE) ($R_2^{1,3} = 0.02$) is the most significant, and, one finds, that of c_1 and c_3 ($R_1^{1,3} = R_3^{1,3} = 0.015$) in the second rank. Finally, we interest to the dimensions according to which s^1 was preferred over the entire solutions. One finds that, the mean potential w.r.t. of c_2 ($\bar{R}_2^{-1} = 2 * 0.38 - (0.36 + 0.28)$) is the more significant in this preference ($\bar{R}_2^{-1} = 0.12$).

4.4.2 The Choquet integral 2-additive

In the case of 2-additive fuzzy measure (see 3.3), the same approach can be applied by only changing the expression $\Delta\mu_{(i)}^k$ in (3) that becomes (see the proof in the appendix):

$$\Delta\mu_{(i)}^k = v_{(i)} + \frac{1}{2} \sum_{j>i} I_{(i)(j)} - \frac{1}{2} \sum_{j<i} I_{(j)(i)} \quad (7)$$

where, $v_{(i)}$ is the overall importance of criterion $c_{(i)}$ and $I_{(i)(j)}$ are the interaction between criteria $c_{(i)}$ and $c_{(j)}$.

Now, turning over to our application, we add other information of existence of interactions between the criteria based on the decision maker knowledge. He considers that the criterion c_2 (SE) being the most important in this kind of festival, and the criterion c_1 (SC) and c_3 (AC) are both less important in the same level so that: $v_1 = 0.3, v_2 = 0.4, v_3 = 0.3$. There exists a positive synergy between criteria c_1 and c_2 , i.e. $I_{12} = 0.4$: simultaneous high scores for them provide a

higher improvement of the aggregated score than simultaneous high score for c_1 and c_2 (in other words, for a given film, a good scenario with a good special effects, will improve the overall quality of the film). And the same for c_1 and c_3 ; $I_{13} = 0.2$ and for c_2 and c_3 , $I_{23} = 0.1$.

We know (formula (3)) that: $\forall k=1,2,3$:

$$C_\mu(s^k) = \sum_{i=1}^3 \Delta\mu_{(i)}^k \cdot x_{(i)}^k, \text{ where } \Delta\mu_{(i)}^k \text{ is given by formula (7). So, for } s^1 = (x_1^1, x_2^1, x_3^1) = (0.7, 0.95, 0.65) \text{ we have, } 0.65 = x_{(1)}^1 \leq 0.7 = x_{(2)}^1 \leq 0.95 = x_{(3)}^1:$$

$$\Delta\mu_{(1)}^1 = v_{(1)} + \frac{1}{2}(I_{(1)(2)} + I_{(1)(3)}) = v_1 + \frac{1}{2}(I_{12} + I_{13}) = 0.45$$

$$\text{And } \Delta\mu_{(2)}^1 = 0.4, \Delta\mu_{(3)}^1 = 0.15; \text{ so } C_\mu(s^1) = 0.715.$$

Same computations are done for s^2 and s^3 , we find that $\Delta\mu_{(1)}^2 = 0.65, \Delta\mu_{(2)}^2 = 0.2, \Delta\mu_{(3)}^2 = 0.15$, and $\Delta\mu_{(1)}^3 = 0.45, \Delta\mu_{(2)}^3 = 0.4, \Delta\mu_{(3)}^3 = 0.15$; finally, $C_\mu(s^2) = 0.74$; $C_\mu(s^3) = 0.665$.

The fact of considering the interactions between criteria has changed the preference order of solutions, one sees that it is now the solution s^2 which is preferred collectively. Now, we will highlight the potentials which lead to this preference, as seen in the preceding section.

In terms of the absolute elucidation, it is noted that the absolute potential related to the criterion $c_{(1)} = c_2$ (SE) ($\Delta\mu_{(1)}^2 \cdot x_{(1)}^2 = 0.65 * 0.7 = 0.455$), is the largest. In the second rank, one finds the absolute potential $\Delta\mu_{(3)}^2 \cdot x_{(3)}^2 = 0.15 * 0.9 = 0.135$, related to the criterion c_3 (AC), and finally, that of c_1 (SC) ($\Delta\mu_{(2)}^2 \cdot x_{(2)}^2 = 0.15$).

In terms of the relative elucidation, the preference of s^2 over s^1 is due, primarily, to the relative potential $R_{(1)}^{2,1} = \Delta\mu_{(1)}^2 \cdot x_{(1)}^2 - \Delta\mu_{(1)}^1 \cdot x_{(1)}^1 = 0.1625$ w.r.t c_2 (SE). Same conclusion for to the superiority of s^2 over s^3 .

For the last level of argumentation, it is noted, that the mean potential $\bar{R}_{(1)}^{-1} = (2 * 0.455 - (0.27 + 0.2925)) = 0.3475$ w.r.t. criterion (SE) c_2 ; which makes the difference, in the superiority of s^2 over the other solutions.

5 Conclusion

In this paper, within the framework of project management, we have been interested in elucidative functionalities of fusion systems using fuzzy integral aggregation operators. The proposed functionalities allow to explain why a specific solution has been elected by a collective of people. Two main prospects are in progress.

An important postulate in the elucidation procedure is that a strategy has already been identified under the definition of a fuzzy integral operator C_μ . The other possibility would be to define a strategy *a posteriori* solely for purposes of argumentation. On completion of the project, a solution s^k is adopted and this choice is then justified on the basis of the knowledge collected via the RKB. The problem is thus to identify a strategy that confirms the "superiority" of the elected solution s^k over the other candidates. In a second time, after having determined the potentials of scores in the argumentation phase, we can determine on which criteria, one should improve the scores of a given solution in order to obtain the highest possible improvement in its global evaluation.

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Appendix

We give in this annex the demonstration of the formula (7): $\Delta\mu_{(i)}^k = v_{(i)} + \frac{1}{2} \sum_{j>i} I_{(i)(j)} - \frac{1}{2} \sum_{j<i} I_{(j)(i)}$. Firstly, let us recall some results established in [8].

Definition 3. Let μ be a fuzzy measure on C, the Möbius transform (MT) m of μ is a set function on C defined by :

$$m(A) = \sum_{B \subset A} (-1)^{|A/B|} \mu(B), \quad \forall A \subset C.$$

This transformation is invertible, and μ can be recovered from m by: $\mu(A) = \sum_{B \subset A} m(B)$, $\forall A \subset C$.

Lemma. The fuzzy measure μ is 2-additive, if its MT $m(A) = 0$, whenever $|A| > 2$, $\forall A \subset C$, and we have the results $\mu_i = m_i = m(\{c_i\}) \quad \forall c_i \in C$, and, $I_{ij} = m_{ij} = m(\{c_i, c_j\})$, also, $v_i = m_i + \frac{1}{2} \sum_{j \neq i} m_{ij}$, where v_i and I_{ij} are the Shapley and interaction indices defined in section 3.3.

Let us recall that in (3), we have $\Delta\mu_{(i)}^k = \mu(A_{(i)}^k) - \mu(A_{(i+1)}^k)$, so $\Delta\mu_{(i)}^k = \sum_{B \subset A_{(i)}^k} m(B) - \sum_{B \subset A_{(i+1)}^k} m(B)$. Using the lemma, $m(B) = 0$; when $|B| > 2$, then

$$\mu(A_{(i)}^k) = \sum_{j=i}^n m(c_{(j)}) + \sum_{\substack{j,k \neq i \\ j \neq k}}^n m(c_{(j)}, c_{(k)}), \quad \text{and}$$

$$\mu(A_{(i+1)}^k) = \sum_{j=i+1}^n m(c_{(j)}) + \sum_{\substack{j,k=i+1 \\ j \neq k}}^n m(c_{(j)}, c_{(k)}) \quad \text{then}$$

$$\Delta\mu_{(i)}^k = m(c_{(i)}) + \sum_{j>i} m(c_{(i)}, c_{(j)}).$$

Finally, using the relations given in the lemma, we get the desired result.