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Fuzzy methods in decision making process - A particular approach in manufacturing systems

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Abstract. We are living in a competitive environment, so we can see and understand that the most of manufacturing firms do the best in order to accomplish meeting demand, increasing quality, decreasing costs, and delivery rate. In present a stake point of interest is represented by the development of fuzzy technology. A particular approach for this is represented through the development of methodologies to enhance the ability to managed complicated optimization and decision making aspects involving non-probabilistic uncertainty with the reason to understand, development, and practice the fuzzy technologies to be used in fields such as economic, engineering, management, and societal problems. Fuzzy analysis represents a method for solving problems which are related to uncertainty and vagueness; it is used in multiple areas, such as engineering and has applications in decision making problems, planning and production. As a definition for decision making process we can use the next one: result of mental processes based upon cognitive process with a main role in the selection of a course of action among several alternatives. Every process of decision making can be represented as a result of a final choice and the output can be represented as an action or as an opinion of choice. Different types of uncertainty can be discovered in a wide variety of optimization and decision making problems related to planning and operation of power systems and subsystems. The mixture of the uncertainty factor in the construction of different models serves for increasing their adequacy and, as a result, the reliability and factual efficiency of decisions based on their analysis. Another definition of decision making process which came to illustrate and sustain the necessity of using fuzzy method: the decision making is an approach of choosing a strategy among many different projects in order to achieve some purposes and is formulated as three different models: high risk decision, usual risk decision and low risk decision - some specific formulas of fuzzy logic. The fuzzy set concepts has some certain parameterization features which are certain extensions of crisp and fuzzy relations respectively and have a rich potential for application to the decision making problems. The proposed approach from this paper presents advantages of fuzzy approach, in comparison with other paradigm and presents a particular way in which fuzzy logic can emerge in decision making process and planning process with implication, as a simulation, in manufacturing - involved in measuring performance of advanced manufacturing systems. Finally, an example is presented to illustrate our simulation.

1. Introduction and related work

The concept of fuzzy sets developed by Zadeh [1] handle with impreciseness and incertitude, uncertainty, tangled in all decision making aspects. The fuzzy set theory has been derived from the probability theory and is more suitable to modeling any real life phenomena.
Starting with ’80, a large number of researchers applied fuzzy set concepts to solve many problems in Engineering and Management.

One of the most representative concept of fuzzy theory is represented by the adaptive model based on free estimation.

Some techniques related that the Intelligent Systems adaptively estimate continuous functions from data without specifying mathematically how the results are depend on initial dates are presented in [2]. In this example, this refers to the ability of fuzzy systems to map an initial dates domain X e.g., denote to an results dates range Y e.g., judgments/decisions without denoting the function f: X → Y. Anyway, mathematically it has been demonstrated that fuzzy systems are universal approximations of continuous functions of an approximately general class [3]. Due to the universal approximations, modeling techniques based on fuzzy models have a native freedom from a priori assumption of the type of relationships that may exist through different variables. Usually an universal approach places no theoretical limits on the modeling capabilities of fuzzy systems, in practice, although to optimally construct a model for a given data set to achieve the full modeling strength of the approach is still an open question [10]. Convert and Crager [4] show how fuzzy sets can be used to capture linguistic values such as high and low in variables related to human performance such as job or task experience and performance. According to this, the variable performance can be captured by specifying a finite universal set that consists in levels of performance using three fuzzy sets such as high, moderate, and limited efficiency.

Noteworthy, the concept of fuzzy set is equivalent with early psychometric ideas; for instance Thurstone [5] has the idea that an individual's opinion could be characterized by more than a single point estimate response as suggested by Hesketh and Hesketh [6].

Newell and Simon [7] have been demonstrated that much of human problem solving could be expressed as if-then types of production rules.

Moreover, expert and other Intelligent systems have been implemented to model, capture, and support human decision processes. These usually rule-based systems allow different points, including the fact that human experts are often needed to articulate propositional rules, that the symbolic processing normally used prevents direct application of mathematics and that traditional rule-based systems require a large number of rules that are often friable and thus they are not rough to the required novel set of data inputs.

The advantages of modeling decision making process are numerous, nevertheless a short analysis of traditional modeling papers, for instance linear regression shows a number of factors suggesting that inquiry on alternative methods is warranted.

These factors include the use of idealistic, orthogonal judgment response, arising from the difficulty in analyzing inter-correlated responses with multiple regression [8]; reliance on linear models even though the cited pervasiveness of linearity may be more reflective of a lack of research on alternative models [9]; and limited selection of methods for eliciting participants verbal descriptions of their judgment policies.

2. Aspects of decision making process

One of the application of the theory of decision is to determine some optimal strategies where a decision is faced with different decision alternatives and an uncertain pattern of next events.

For example, a manufacturer of a new product which will be launched (or will be used in different build) can think to manufacture a wide number of pieces of the product if the consumer acceptance and consequently demand for the product intent to increase. Withal, the producer would like to produce a small number of pieces if the market requirement for that product are going to be low.

Unfortunately, the launching of a certain product which will use the product discussed require to the producer to create a production quantity decision before the demand is actually know. The new acceptance of actual consumer for a certain product will not be determined until the items have been placed in the stores and the consumers have had the opportunity to purchase them.
The selection of the best production volume decision from among several production volume alternatives when the decision Filter is faced with the uncertainty of future demand is a problem for the theory of decision. The theory of decision commences with the assumption that regardless of the type of decision involved, all the Decision making process problems have certain common characteristics which are briefly enumerated below:

The filter of decision. This refers to individual or a group of individuals responsible for making the choice of an appropriate course of action amongst the available course of action. Courses of Action: The courses of action or strategies are the acts that are available to the decision Filter. The Decision Analysis involves a selection among two or more courses of action and the problem is to choose the best of these variants, as a final purpose to achieve an objective.

Many different people have take a decision about the similar situation and then trade potential cognitive interference aimed at improving decision making process outcomes. Some the commonly argued cognitive biases are selective search for evidence; premature stops of search for evidence; inertia; selective perception; wishful thinking or optimism bias; choice supportive bias; Recency; repetition bias; anchoring and adjustment; source credibility bias; incremental Decision making process; attribution symmetry; role fulfillment; underestimating uncertainty and the illusion of control.

Nowadays, in our fields as business or industry, we need rational decision making process. If we have to define a decision, we can use a simple one, an if-then action or the selection from two or more courses of action.

Decision making process can be regarded as a consequence of mental processes that are fundamental cognitive in nature leading to the selection of a course of action among several alternatives. Every decision making process causes a final selection [8]. The result can be an action or an view of choice. Decision making process is vital for all categories of problems which may be either long-range or short-range in nature; or the problem may be at relatively high or low level managerial responsibility. The inherent analysis in the theory of decision is a discipline providing various tools for modeling different decision situations in view of explaining them or prescribing actions increasing the coherence between the possibilities offered by the situation, and goals and values systems of agents involved. Decision making process for human performance represented a topic of active research from several point of views. From a psychological point of view, it is necessary to examine individual decisions in the context of preferences and needs that an individual had and values he looking for. From a cognitive point of view, the decision making process process must be regarded as a continuous process integrated in the interaction with the environment. From a normative point of view, the analysis of individual decisions is thoughtful with the logic of decision making process and rationality and the invariant choice it leads to [10]. At another level, it might be regarded as a problem solving activity which is finished when a satisfactory solution is set out. Therefore, decision making process is a reasoning or emotional process which can be rational or irrational, for the main based on explicit hypothesis or tacit hypothesis.

3. A case study: The distribution of tasks application

The term fuzzy suggests an image of a boundary zone, rather than an abrupt frontier. The set relations are being considered as relations composed of crisp sets, to distinguish them from fuzzy set relations. As with set relations, we are only guided by intuition in deciding which objects are members and which are not; a formal basis for how to determine the membership grade of a fuzzy set relation is absent. The membership grade is a precise, but arbitrary measure as it rests on personal opinion, not reason. The range of values of membership grade is $0 \leq \mu \leq 1$, the higher the value, the higher the membership grade.

The members of fuzzy relations are taken from a universe of discourse which comprises of all objects that can be taken into consideration and generally depends on the context.

There are two ways to represent a membership function viz., continuous or discrete. A continuous fuzzy relation $A$ is defined by means of a continuous membership function, $\mu_A(x)$. 


A trapezoidal membership function is a linear parts, and a continuous function, directed by four parameters such as, $a$, $b$, $c$, $d$ [11]:

$$
\mu_{\text{trapezoid}}(x; a, b, c, d) = \begin{cases}
0, & x \leq a \\
\frac{x - a}{b - a}, & a \leq x \leq b \\
1, & b \leq x \leq c; \quad x \in \mathbb{R} \\
\frac{d - x}{d - c}, & c \leq x \leq d \\
0, & d \leq x
\end{cases}
$$

(1)

To achieve a discrete triangular membership function from the trapezoid membership function let us assume that the universe is a vector $U$ of 7 elements. Each membership value corresponds to one element of the universe, with the universe in the bottom row, and the value for a membership for the top row. As a rule of thumb, the continuous form is more computing increased, but a storage demanding smaller than the discrete form.

In real application, the problem is often intricate and elaborate due the fact that resources may be limited or the set of tasks may not be known exactly, and the set of tasks may change in time. Generally resource allocation algorithms could not handle in a proper manner the constrained situations, especially the uncertainty in the environment and their dynamics.

For an example we consider a repartition of tasks between the members of a team to accomplish a mission in an activity. We now consider another decision-making problem of allocating a particular job to the best possible person who fulfills the requirements of the job.

Let $U = \{p1, p2, p3, p4, p5, p6\}$ be the crisp set of five persons for the job.

Let $E = \{\text{enterprising}, \text{average}, \text{confident}, \text{confused}, \text{yes risks}, \text{no risks}\}$ be the set of parameters.

Let $(F1, A1) = \{F1 (\text{enterprising}) = \{p1/0.5, p2/0.7, p3/0.3, p4/0.1, p5/0.8, p6/0.9\}, F1 (\text{average}) = \{p1/0.3, p2/0.1, p3/0.5, p4/0.8, p5/0.05, p6/0.7\}$ be the set describing the enterprising qualities of the person.

Again $(F2, A2) = \{F2 (\text{confident}) = \{p1/0.6, p2/0.8, p3/0.5, p4/0.2, p5/0.9, p6/0.8\}, F3 (\text{confused}) = \{p1/0.3, p2/0.1, p3/0.7, p4/0.9, p5/0.5, p6/0.6\}$ be the set describing the confidence level of the person.

Similarly, $(F3, A3) = \{F3 (\text{yes risks}) = \{p1/0.7, p2/0.8, p3/0.5, p4/0.2, p5/0.6, p6/0.5\}, F1 (\text{no risks}) = \{p1/0.3, p2/0.07, p3/0.65, p4/0.95, p5/0.1, p6/0.6\}$ be the set describing the willingness level of the person.

Let us assume that the particular job requires an enterprising, confident person who is yes risks.

Our problem (Table 1) is to find the candidate who best suits the requirements of the job. To solve this problem we use the definition of a fuzzy relation $(R, C)$ of the fuzzy sets $(F1, A1)$, $(F2, A2)$, $(F3, A3)$ of all candidates who are enterprising, confident, yes risks.

By definition, $(R, C)$ is given by $(R, C) = \{p1/0.21, p2/0.45, p3/0.08, p4/0.05, p5/0.43, p6/0.36\}$.

From the relation it is evident that the most suitable candidate for the job is $p2$ who possesses the greatest membership value in the relation $(R, C)$.

Now, we present the probability and possibility distributions for the above problem corresponding to one specific parameter. Considering the risk taking parameter, eg. yes risks from the parameter set $E$ we have the following probability distribution $\text{prob}$ for the persons $PT_i; i = 1,\ldots,6$ from the set.
Table 1. Probability risk taking parameter (PT).

| Tasks Person | Prob (PT) |
|--------------|-----------|
| 1,00         | 0,25      |
| 2,00         | 0,55      |
| 3,00         | 0,10      |
| 4,00         | 0,10      |
| 5,00         | 0,00      |
| 6,00         | 0,00      |

Probability values of person PTi with respect to risk taking parameter. Again, a fuzzy set expressing the risk taking attitude of the persons pi; i = 1,………,6 from the set U may be the expressed using the following possibility distribution π,

Table 2. Probability values of person Pti.

| Tasks Person | Π (PTi) |
|--------------|---------|
| 1,00         | 1       |
| 2,00         | 1       |
| 3,00         | 1       |
| 4,00         | 1       |
| 5,00         | 0,8     |
| 6,00         | 0,7     |

Possibility values of person Pti with respect to risk to take attitude.

It is to be noted that each possibility is at least as high as the corresponding probability. Further, the sum of prob (Pti – table 2) is always equal to 1 but π (pi) may be equal to, greater or less than 1. As it is obvious from the above discussion that it is much easier to represent a large amount of information viz., different parameters using the fuzzy relations which is the prime requirement in most decision making situations, because the final decision to the problem is dependent on various associated parameters. Besides this, using probability and possibility distributions only a partial representation of the information is possible, which leads to final decision results which are inaccurate and incomplete. Finally, the solution to the problem is obtained with minimal computational effort using fuzzy relations.

4. Conclusions

As a conclusion, the paper use some notions important for planning and decision: we are using the fuzzy concepts and process of decision making.

Firstly, the utility of fuzzy logic is due to the inference structure that enables the human reasoning capabilities to be applied to artificial knowledge-based systems. Fuzzy logic theory plays an important role in inference mechanism, learning, adaptation, fault tolerance, parallelism, and generalization, is generally used in cognitive uncertainty or computational neural networks.

Secondly, the process of making decisions is the fundamental activity of human beings. In other words, decision making represent an important field in all aspects of life. In any decision process we consider the information about the outcome and choose among two or more alternatives for subsequent action. If good decisions are made, then we may get a good expected output. Decision making is defined to include any choice or selection alternatives. A decision is said to be made under
certainty, where the outcome for each action can be determined precisely. A decision is made under risk when the only available knowledge concerning the outcomes consists of their conditional probability distributions.

The uncertainty existing is the prime domain for fuzzy decision making.

Nowadays, our world is furthermore based on the use of electronics and computers to control the behavior of real-world resources, and in this case, we can see the utility of fuzzy aspects in real-life, usually in process of decision.

Related to the future work, we want to investigate the distribution of tasks application considering another value which is important when we are talking about uncertainty, the time. Another idea of future work is to use intelligent agents.

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