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POSSIBILITY OF USE OF FUZZY LOGIC IN MANAGEMENT

PORTIK Tamás PhD student
University of Debrecen, Doctoral School of Informatics;
portik@citromail.hu

POKORÁDI László, professor
University of Debrecen;
pokoradi@mk.unideb.hu

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Abstract*:*
The fuzzy logic is the most suitable device to describe this area with mathematical formulas seeing that in management there are in use a lot of so-called linguistic variable, which are or can be used getting ready in decision-making. Currently in management, the one of the most general acceptable application is the quality insurance. Further, other applications are available and possible even in group decision-making, strategic planning, supply chain management and any other important business improving. The aim of the author is with this paper to present the possibility application of fuzzy logic in area of management, also with this to provide encouragement for managers and leaders to try to apply and use these new fuzzy devices in management.

1. Introduction

Nowadays, the fuzzy logic and measure have become researchers' area of interest especially in wide range of applications. So, engineering management cannot be an exception, for example for sale in a Japanese market engineering goods like wash machine, camera and so on, which do not contain fuzzy logic based adjuster systems, those goods are unmarketable. This is one of causes because of production of these engineering goods should be prefer the fuzzy logic based adjuster system if it is possible to use that. On the other hand, the fuzzy logic is the most suitable device to describe this area with mathematical formulas seeing that in management there are in use a lot of so-called linguistic variables, which are or can be used getting ready in decision-making. Currently in management, the one of the most general acceptable application is the quality insurance. Further, other applications are available and possible even in group decision-making, strategic planning, supply chain management and any other important business improving.

To provide a short overview about applications according to the subjective selection of publications therefore the benefit of researches will be presented in latter sections. To have a good introduction in fuzzy logic Ross wrote a well useable book about the fuzzy set theory and logic with engineering application (Ross, 2010). A hard counting process will given in reliability, which is a part of maintenance management, by (Lindstedt & Sudakowski, 2007) and for condition based maintenance it was provided a fuzzy based model by (Kothamasu & Huang, 2007). For risk assessment, (Ngai & Wat, 2005) developed fuzzy based decision support system in E-commerce. Pokorádi has a publication about risk assessment based on the fuzzy set theory in real life environment (Pokorádi, 2010). In fuzzy FMEA (Failure Mode and Effect Analysis), a new method was developed which is called Fuzzy Risk Priorization Numbers (FRPNs) by (Wang et al., 2009). A

fuzzy linguistic decision was applied to understand the selecting of costumers between the market-bundle mechanism strategies – like bundled money back, unbundled money back, guarantee, information transmission and promotion propaganda – in their several purchasing type by (Lin & Yeh, 2010).

The aim of the author is with this paper to present the possibility application of fuzzy logic in area of management, also with this to provide encouragement for managers and leaders to learn, try to apply and use these new fuzzy devices in management.

The rest of the paper is organized as follows: The second section shows a short overview about fuzzy set theory especially on using of linguistic variables. The third section has written for currently applications in management. A summation, conclusion and future work provide in the fourth section.

2. Fuzzy set theory

The fuzzy set theory is the starting basis for the following problem, given a heap of sand, if a sand-grain is get lost, the heap of sand is still remaining, however, if two or three grains of sand will no longer be a sand-heap. Whether, can we resolve the paradox, how much sand-grains are remaining a sand-heap? The secret of resolving of paradox is in the linguistic definition because this definition has linguistic uncertainty.

Uncertainty can be represented in many forms like fuzzy (not sharp, unclear, imprecise, approximate), vague (not specific, amorphous), ambiguous (too many choices, contradictory), ignorance (dissonant, not knowing something), natural variability (conflicting, random, chaotic, unpredictable) and it is possible to use many other linguistic labels (Ross, 2010). In the classical set theory, if an element belongs or does not belong in the universe, it is unambiguous; but in fuzzy sets, it is not so clear because bounders of the crisps are fuzzy and vague. To describe this kind of uncertainty one should use so-called membership functions. The membership function represents and measures how close an element is to the given sharp crisp boundary. Taking notice, if the value of membership is zero then that element is not in the fuzzy set else if the value of membership is 1 then that element is totally in the fuzzy set – with sharp boundaries are working like a classical set (according to the classical set theory).

Some fuzzy set operations will be shown like union, intersection and complement. Let it be given the next membership functions (Figure 1.)

$$\mu_A : X \to [0;1];\ \mu_B : X \to [0;1] \quad , \tag{1}$$

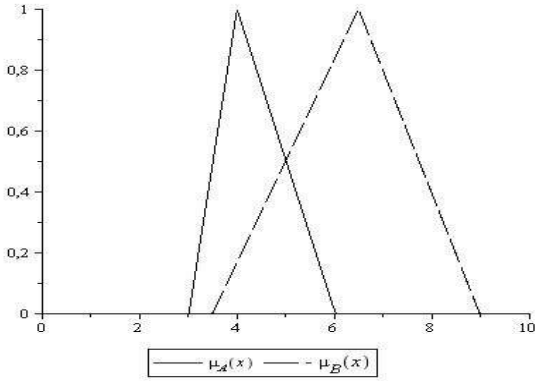

Figure 1. Two Triangular Membership Functions

where: A and B are fuzzy sets over the universe X, then the union and the intersection (Figure 2.) are

$$\mu_{A\cup B}(x) = \mu_A(x) \vee \mu_B(x) \quad , \tag{2}$$

$$\mu_{A\cap B}(x) = \mu_A(x) \wedge \mu_B(x) \quad . \tag{3}$$

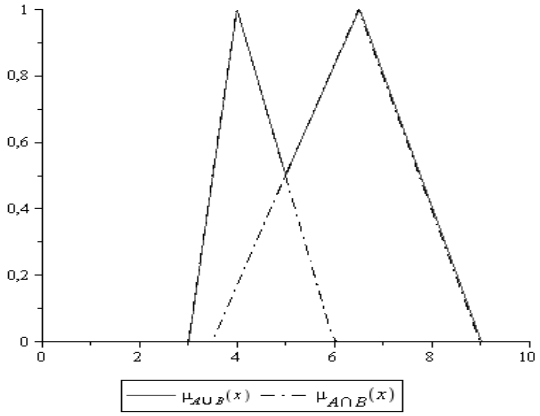

Figure 2. The Union and the Intersection

The complement (Figure 3.) is

$$\mu_{\bar{A}}(x) = 1 - \mu_A(x) \quad . \tag{4}$$

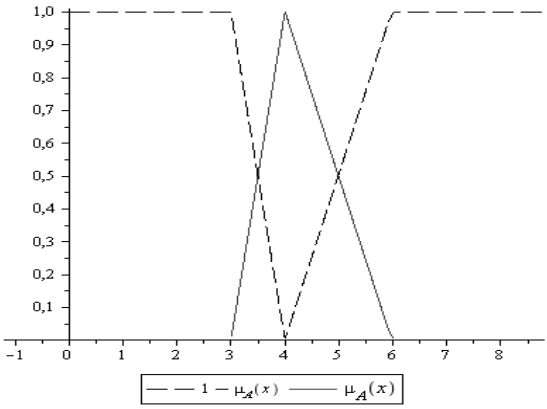

Figure 3. The Complement

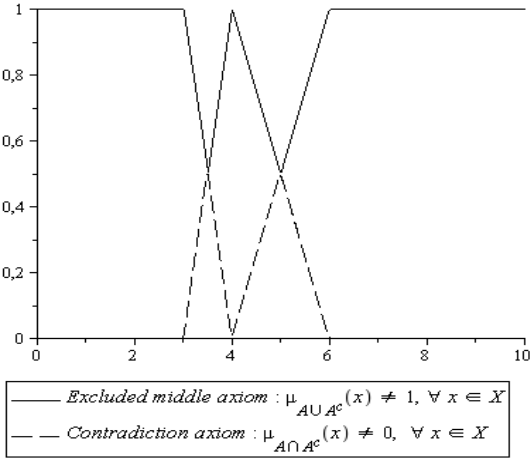

Figure 4. The Excluded Middle Axioms Do not Work in Fuzzy Logic

Of course, De Morgan's principles are hold for fuzzy sets too but axioms of the excluded middle $A \cup \overline{A} = X$ and the contradiction $A \cap \overline{A} = 0$ are not valid for fuzzy sets (Figure 4). Because of the validation of excluded middle axioms is not working therefore this logical system is applicable to do right conclusions whereas the classical logic has been provided several antagonisms. Given universes X and Y, Cartesian product is defined in the same way as in classical relations theory. A subset of the Cartesian product is called relation. Membership function is used describing of this mapping from Cartesian space to the interval [0; 1], where it measures the strength of mapping for ordered pairs from the two universes or. Now, operations will be shown on fuzzy relations. Let R and S be fuzzy relations on the Cartesian space $X \times Y$. Then the following operations are described:

The union

$$\mu_{R \cup S}(x, y) = \max(\mu_R(x, y), \mu_R(x, y)) \quad . \tag{5}$$

The intersection

$$\mu_{R \cap S}(x, y) = \min(\mu_R(x, y), \mu_R(x, y)) \quad . \tag{6}$$

The complement

$$\mu_{\overline{R}}(x, y) = 1 - \mu_R(x, y) \quad . \tag{7}$$

The containment (inclusion)

$$R \subset S \Rightarrow \mu_R(x, y) \leq \mu_S(x, y) \quad . \tag{8}$$

Of course, the next step is to define the fuzzy composition for fuzzy relations; it will be done as in the classical set theory but using of max-min composition with membership functions. Let relations $R \subset X \times Y$, $S \subset Y \times Z$ and $T \subset X \times Z$ be; then the fuzzy composition has the following form:

$$T = R \circ S \,;\; \mu_T(x, z) = \bigvee_{y \in Y} (\mu_R(x, y) \wedge \mu_S(y, z)) \quad . \tag{9}.$$

It should be pointed out; in general, neither crisp relations nor fuzzy relations are commutative. In general practice and applications, it is usually used trapezoidal or triangular membership function to simplify the counting. It is mentioned above that the linguistic uncertainties can be described with fuzzy set theory, to do that; we need to use so-called linguistic variables. The linguistic variable is a collection of fuzzy IF–THEN rules. Its domain is words and membership functions are mapped to those words or those words are mapped to membership functions. This mapping always depends on cognoscenti because of their knowledge will be appeared on membership functions according to their real life experiences. The specific evaluation of the linguistic variable is called proposition. IF–THEN rules are created from propositions in the following way:

IF <proposition (one or more connected with conjunction or disjunction)> THEN <proposition>.

All of IF–THEN rules together are an algorithm and the name of the complete evaluation-procedure is inference. For inference, all data should be fuzzy but normally data are from statistic or from measurement or both of them or from somewhere else that are not fuzzy. Therefore, all of these data should be fuzzified.

If a proposition has an evaluation in a specific case then this result should be converted to a real number or crisp because the result is fuzzy number. That procedure, where the fuzzy number is converted back to real number or crisp, is called defuzzification. To do complete this small introduction in fuzzy set theory see (Ross, 2010).

3. Fuzzy Application in Management

In this section, the authors will provide and show some possible application for managers and leaders from part of management and other areas. In maintenance management, the reliability is very important. In classical method to predict reliability one use hard counting process like in (Lindstedt & Sudakowski, 2007) where data based on basis diagnostic information.

In condition based maintenance management, adaptive Mamdani model is used in (Kothamasu & Huang, 2007) where they have shown an application of the neuro-fuzzy model. The benefit of this method was the follows:

- Rule-based model is close to human heuristic decisions and conclusions therefore it is possible to directly contributing to model building.
- The rule-based description transmits to integrate data-driving modelling with physics based modelling.
- The rule-based model is clear to the user. Because of decision-making can be explained clearly therefore, the user trust is increasing quickly in the system.
- The system can adapt to changing environment because approximation is a parametrical computational approach and that will be able to do automatic parameter tuning.

Next publication is about fuzzy decision support system (FDSS) for risk analysis in E-commerce (EC) development (Ngai & Wat, 2005). The FDSS is developed for project managers to identify the possible hazard factors in EC on the web with the corresponding hazard rates. Benefits of results are the following:

- Priorization is necessary to keep focus on important risks. The most serious risks will be catch first.
- The system transmits more natural model by fuzzy risk model, which is systematic, when evaluators is used for check out the EC development risk level.
- Evaluators can keep on top for currently risk level in EC development therefore managers and/or leaders can predict the overall risk before start the implementation.
- EC project managers or leaders can have information and be able to recognize hazards in EC development.

This study according to the authors has only one big disadvantage it was not tested in the real-life EC projects.

Another study is the risk evaluation using fuzzy weighted geometric mean in FMEA by (Wang el al., 2009). This describing includes new kind of FMEA, whose name is Fuzzy Risk Priority Numbers (FRPNs). This new method has some important advantages that are the following:

- Any IF-THEN rule base is not necessary to create which is time-, cost saving and of course subjective.
- FRPNs are applicable for any number of risk factors.
- Failure modes are prioritized completely according to FRPNs, and they separate them clearly from each other and from others.
- Risk factors and their relative important weights are counted in linguistic manner therefore the assessment is easier carried out.
- The relative importance takes into consideration in priorization of failure modes; therefore, FRPNs are more realistic, flexible and practical.
- The centroid formula, based on α-level sets, is a good decision support to compare FRPNs with fuzzy numbers whose membership functions are not known just their α-level sets are available.
- The fuzzy weighted geometric mean was at first in use in such interpretations.

Of course, the study has a disadvantage it did not test in real life environment.

A fuzzy linguistic decision applied to understand the selecting of costumers between the market-bundle mechanism strategies – like bundled money back, unbundled money back, guarantee, information transmission and promotion propaganda – in their several purchasing type by (Lin & Yeh, 2010). This study has some benefits:

- Fuzzy approach can effectively reduce costumers' purchase uncertainties.
- Fuzzy approach can represent costumers' subjective judgements in their purchases.
- According to costumers, generally, bundled money back, promotion propaganda and guarantee have the highest importance in quality, the lowest seriousness in risk and the highest confidence in reliability.
- The linguistic expressions can handle properly with fuzzy linguistic variables so it more realistic to choose the optimal market bundle mechanism strategies.

The study has an advantage that the market-bundle mechanism strategies have investigated themselves in point of view of costumers. Of course, this study has some other benefits too but the authors concentrate on fuzzy tools associated with applications.

4. Conclusions and Future Works

Authors provide a short introduction in fuzzy set theory and some benefits of some subjectively selected applications have been shown. All of these examples have a common sense, which is the useable of linguistic variables because of implications in fuzzy set and logic theory is much closer to the human thinking and decision-making. The classical (Archimedean) logic cannot handle properly linguistic uncertainties and has its own limits. In this paper is shown some results and benefits from applications in some part of management where fuzzy tools seem to be useful, time-, cost saving and much more practical than other techniques. In the future, the authors would like to investigate and develop new fuzzy tools for management decision-making methods.

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