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APPLICATION OF THE THEORY OF FUZZY SETS IN THE ANALYSIS OF FACTORS AFFECTING THE STAFF DECISION

Zastosowanie teorii zbiorów rozmytych w Analizie czynników wpływających na decyzje personalne

Summary:
The authors present the possibility of using fuzzy set theory in the analysis of factors influencing personal decisions. The study includes the description of the difficulties in forming the features and the language ontology. There are also a presentation of the analysis of work environment, a description of a student and, finally, a short evaluation of the usefulness of the research method.

Key words: Theory of fuzzy sets, language on-

Streszczenie:
Autor przedstawia możliwość zastosowania teorii zbiorów rozmytych w analizie czynników wpływających na decyzje personalne. W opracowaniu zostały zawarte także problemy przy formułowaniu cech oraz ontologii języka. Dokonana została analiza środowiska pracy, opis ucznia i ocena przydatności metody.

Słowa kluczowe: Teoria zbiorów rozmytych, ontologia języka, decyzje personalne, logika

tology, personnel decisions, fuzzy logic.

JEL codes: A1,A2,A3,C0, C1, C2, C3, C4, D0, D2, D8, L7, P0, P1.

rozmyta.

Kody JEL: A1,A2,A3,C0, C1, C2, C3, C4, D0, D2, D8, L7, P0, P1.

INTRODUCTION

Artificial intelligence methods are used in attempt to describe reality in a human-reasoning-imitating manner. Their aim is to overcome the drawbacks of traditional computer algorithms, which fail especially in situations where the person is able to solve the problem brought without much difficulty. In the real world, many phenomena are described in a very vague way. This is expressed in statements as substantially, a lot, most, etc., in sentences such as commodity price far exceeds 1000 zl or inventory status almost reaches zero. People are able to interpret such statements and use knowledge to solve problems posed to them. These determinations are very difficult to define in a machine language. Their vagueness is the cause of the difficulties sufficiently accurate to determine the values of all occurring variables. The problem is to determine what „almost" or „significantly" actually means. This kind of lack of precision is called „blur". The fuzzy set is defined by a function that takes the value of (0.1).

The creation of interesting and fast developing field of fuzzy mathematics and technology is owed to Lotfi A. Zadeh, who introduced the basic concepts of the theory. Year 1964 is the year of its birth and the moment when Lotfi Zadeh defined the concept of fuzzy set. The concept of fuzzy set is a generalization of the concept of a sharp set, which is based on admission of the characteristic function (membership) of the set to take, next to the marginal states, 0 and 1 intermediate values. This allows to move away from the binary view of the world. In contrast to the sharp sets, which are only an approximation of the real world phenomena. Fuzzy sets model these phenomena more faithfully and accurately.

Significant milestones in the development of this theory are:

- the concept of a fuzzy set,
- fuzzy sets and the measure of probability,
- linguistic variables and approximate reasoning,
- fuzzy dynamic programming and decision-making,
- fuzzy interpretation of the language,
- fuzzy algebra,

- fuzzy stochastic processes, and other mathematical work.

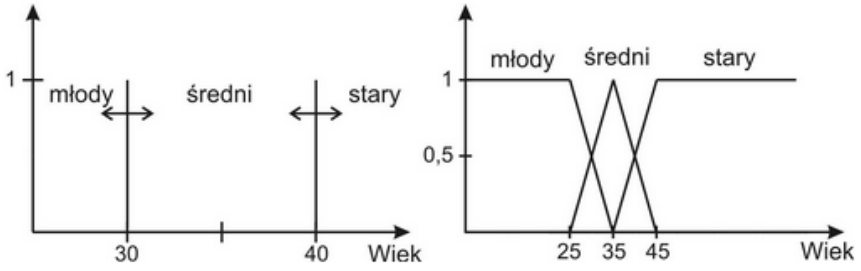
The creators of fuzzy logic refer to the Polish mathematician Lukasiewicz who first introduced the multi-valued logic. Practical application of fuzzy logic idea came after ten years of Zadeh's historical work. We owe Mamdani, who in 1975 built and described a simple control system. From that moment a lot of theoretical work on the design and selection of control rules and parameters of the controller have commenced. Self-organizing systems, human-machine systems were created ex: voice-controlled helicopter built by the Japanese, which understands commands such as fly a little higher, turn slightly to the left, etc.

Fuzzy logic is also gradually coming to household appliances such as washing machines, vacuum cleaners, radios and television. Focusing system of some Cannon camera models manages the fuzzy system, which on its own decides what is the object of shooting and adjusts the focus. In 1988-90, the Japanese (Omron Company) developed and introduced the first fuzzy chip FP1000. Since then fuzzy integrated circuits more boldly have been making their way to the market, although with some difficulty to spread, because engineers do not know the basics of the new technology.

In classical set theory, among others, two laws are valid: the law of contradiction and the law of excluded middle. In other words, each element belongs to the set, or to its complement. It can not belong to both at the same time. If we have, for example, concepts of day and night, they are mutually exclusive. The surrounding's temperature can only be either negative, or not.

The fuzzy set theory assumes that an element may partially belong to the set and its complement. Degree of membership of x to A defines a function of belonging, usually denoted m A (X), with values in the interval [0, 1].

Fuzzy sets describe the most common linguistic terms often used in everyday life, such as cold, hot or young, medium, old in determining age.



Pic.1. Example of membership function for fuzzy set.

Source: Own development.

As shown in the example, the value of the variable x may belong to several fuzzy sets, with varying degrees of belonging. The process of determining the names of sets and degrees of membership for a given x is called the fuzzyfication. Similarly, human growth, the water level in the tank, can be treated as a linguistic variable bringing linguistic values: low, medium, high and specifying the appropriate membership functions.

FUZZY SET THEORY IN THE PROCESS OF PROBLEM ANALYSIS

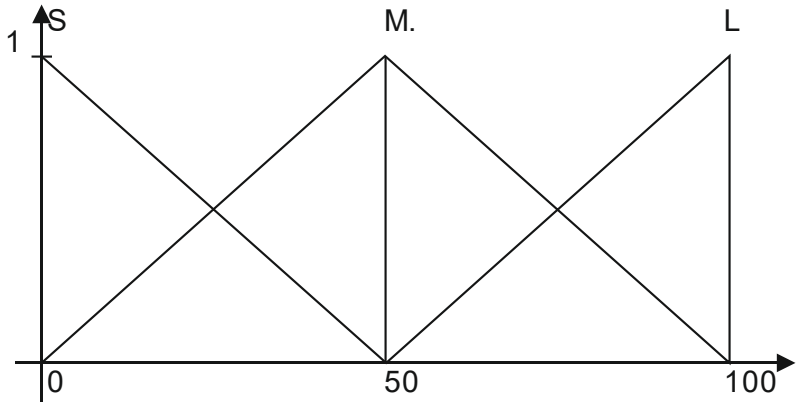
As mentioned above, fuzzy knowledge-based modelling can be particularly useful where the relations between the components of problem are not exactly known or where there are insufficient data for statistical analysis

The variables "distance from school", "average income" etc. are linguistic variables. The terms "short", "long" etc. are defined in the form of fuzzy sets . It should be noted that the formulation of these linguistic rules and the definition of fuzzy sets have a subjective character. Using one of the fuzzy inference methods one can compute output values for certain input values. The input values can take crisp or fuzzy set form. Linguistic terms (represented by fuzzy sets) are also allowed for the input. The output values have the form of a fuzzy set. Then this fuzzy set can be transformed into a numerical value (defuzzification process) or approximated to one of the linguistic terms we have defined for the output variable. This so-called linguistic approximation can be accomplished by means of the calculation of the distance between fuzzy sets.

Tab. 1. The linguistic values for distance from the school

Input data	Linguistic form
0	short
50	medium
100	long

Source: Own development.



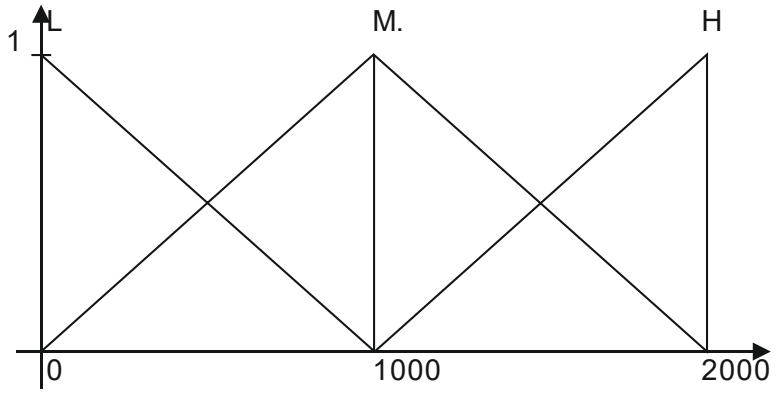
Pic. 2. The affiliation function for distance.

Source: Own development.

Tab. 2. The linguistic values for average income

Input data	Linguistic form
0	low
1000	medium
2000	high

Source: Own development.



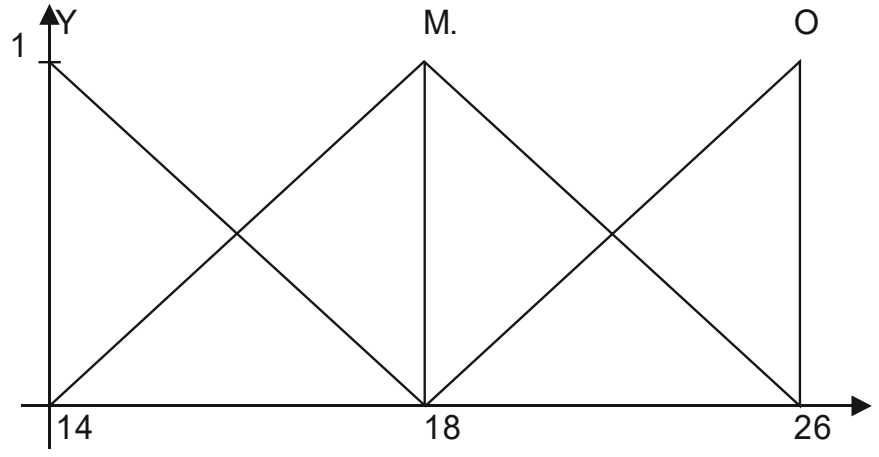
Pic. 3. The affiliation function for average income.

Source: Own development.

Tab. 3. The linguistic values for age.

Input data	Linguistic form
14	Young age
18	Middle age
26	Old age

Source: Own development.



Pic. 4. The affiliation function for age.

Source: Own development.

In order to generate a rating list of criteria, a table with combinations of linguistic values of distance, average income and age has been developed and presented in Table 4.

Tab. 4. The ranking list of all combinations.

Object	Distance	Average income	Age	Ranking (R_k)
1	0	0	14	9
2	0	0	18	8
3	0	0	26	7
4	0	1000	14	26
5	0	1000	18	23
6	0	1000	26	22
7	0	2000	14	27
8	0	2000	18	25
9	0	2000	26	24
10	50	0	14	6
11	50	0	18	5
12	50	0	26	4
13	50	1000	14	20
14	50	1000	18	13
15	50	1000	26	12
16	50	2000	14	21
17	50	2000	18	17
18	50	2000	26	16
19	100	0	14	3
20	100	0	18	2
21	100	0	26	1
22	100	1000	14	18
23	100	1000	18	11
24	100	1000	26	10
25	100	2000	14	19
26	100	2000	18	15
27	100	2000	26	14

Source: Own development.

In order to define values of conclusions for obtained rules, the method of equal differences has been used. In this way 26 differences have been obtained.

Tab. 5. The rate attractions for generated rules.

Rules	attractions
R1	1,00000
R2	0,961538
R3	0,923077
R4	0,884515

R5	0,846154
R6	0,807692
R7	0,769231
R8	0,730769
R9	0,692308
R10	0,653846
R11	0,615385
R12	0,576923
R13	0,538462
R14	0,500000
R15	0,461538
R16	0,423077
R17	0,384615
R18	0,346154
R19	0,307692
R20	0,269231
R21	0,230769
R22	0,192308
R23	0,153846
R24	0,115385
R25	0,076923
R26	0,038462
R27	0,000000

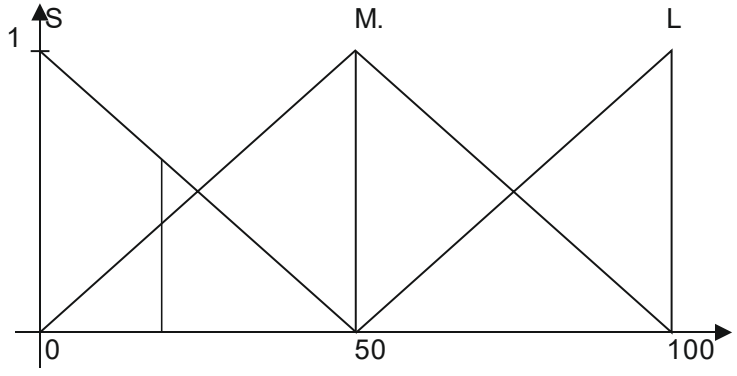
Source: Own development.

Tab. 6. Attributes of one person.

Object	Distance	Average income	Age
P_1	20	1200	14

Source: Own development.

Example: Person P_1

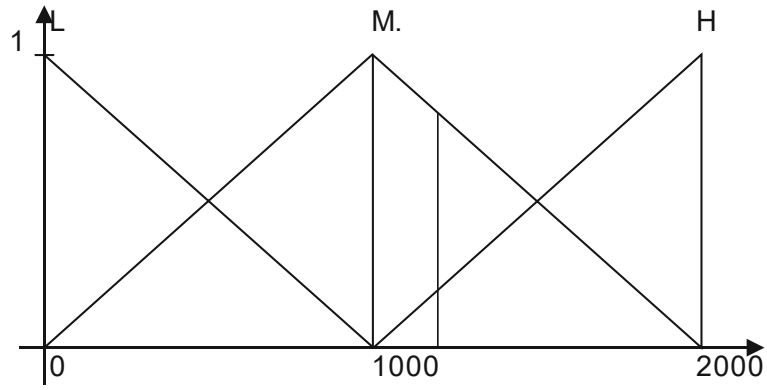


Pic. 5. The affiliation function for distance.

Source: Own development.

$$\mu_{\sim 0}(20) = \frac{50-20}{50} = \frac{30}{50} = \frac{3}{5}$$

$$\mu_{\sim 50}(20) = 1 - \frac{3}{5} = \frac{2}{5}$$

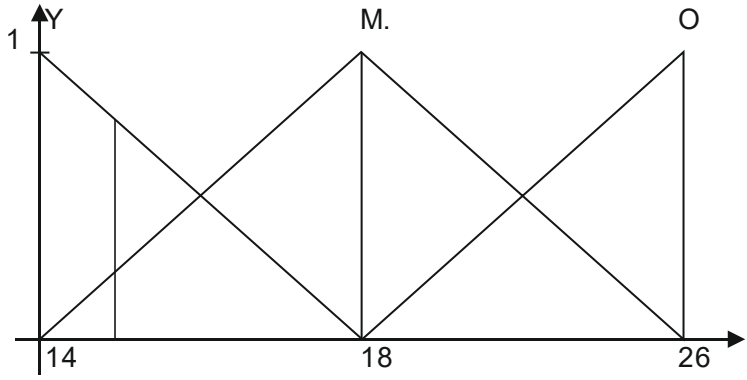


Pic. 6. The affiliation function for average income.

Source: Own development.

$$\mu_{\sim 1000}(1200) = \frac{2000-1200}{1000} = \frac{800}{1000} = \frac{4}{5}$$

$$\mu_{\sim 2000}(1200) = 1 - \frac{4}{5} = \frac{1}{5}$$



Pic. 7. The affiliation function for age.

Source: Own development.

$$\mu_{\sim 1000}(1200) = \frac{18-15}{18} = \frac{3}{18} = \frac{1}{6}$$

$$\mu_{\sim 2000}(1200) = 1 - \frac{1}{6} = \frac{5}{6}$$

$$TR_K = \mu_D * \mu_{AI} * \mu_A$$

$$TR_K = \frac{3}{5} * \frac{4}{5} * \frac{1}{6} = - = 0{,}08$$

Tab. 7. Grades of truth of promises.

Rules Rk	Grades of truth of premises (TRk)
R13	
R17	
R20	
R21	
R23	
R25	
R26	0,08
R27	

Source: Own development.

$$AKR_K = KR_K * TR_K$$

Tab. 8. Grades of truth of promises.

Rules R_k		(TR_k)	AKR_K
R_{13}	0,538462		
R_{17}	0,384615		
R_{20}	0,269231		
R_{21}	0,230769		
R_{23}	0,153846		
R_{25}	0,076923		
R_{26}	0,038462	0,08	0,003077
R_{27}	0,00000		
	sum		

Source: Own development.

Fuzzy interpretations of data structure and a fuzzy representation of expert knowledge are a very natural and intuitively plausible way to formulate and solve some uncertainty problems in environmental data analysis. Heterogeneous and often imprecise data and vague expert knowledge can be integrated more effectively using the fuzzy approach.

The main application areas of the fuzzy set theory are data analysis, knowledge-based modelling and decision making. The number of these applications is constantly growing. Increasing interest in applications of the fuzzy expert systems in environmental management and engineering can be expected in the near future. The development of easy-to-use tools for research or for practical tasks is very important for the promotion of fuzzy logic applications.

CONCLUSIONS

Set theory was proposed as a tool for the analysis of granular information. Granularity of information can cause inconsistency in the description of objects, and this theory provides more precision. The theory is based on the assumption that with the information represented by attributes and their values on objects, it is possible to determine the relationship between these objects. Objects having the same description, expressed as attributes, are indistinguishable because of the available information. We assume that information about facilities is available in a form of an information board. In the case of supervised teaching

for classification of information objects can be expressed as a decision attribute. This leads to a representation in a form of a decision-making board. Set theory is used to vary degrees, both in the induction rules and the initial data processing. As a result, many algorithms rule induction were proposed using the elements of sets.

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