STRATEGY FOR CREATING AN EXPERT SYSTEM BASED ON FUZZY LOGICAL INCLUSION OF MAMDANI TYPE

ORCID ID: 0000-0002-6441-3467   **Olena Viktorivna Skakalina**
Ph.D. technical Sciences, associate professor,
Associate Professor
of the Department of Computer and Information Technologies and Systems
National University « Yuriy Kondratyuk Poltava Polytechnic»

UKRAINE

It is known that quantitative data (knowledge) can be inaccurate, while there are quantitative estimates of such inaccuracy (confidence interval, significance level, degree of adequacy, etc.). Linguistic knowledge can also be inaccurate. The theory of fuzzy sets is used to account for the inaccuracy of linguistic knowledge. . The use of fuzzy sets allows one to describe fuzzy concepts and knowledge, operate with this knowledge and draw fuzzy conclusions. A prerequisite for the use of fuzzy models is the presence of uncertainty due to the lack of information or the complexity of the system and the availability of qualitative information about the system. The advantages of fuzzy systems include their universality [1].

The beginning of the practical application of the theory of fuzzy sets can be considered 1975, when E. Mamdani built the first fuzzy controller. The success of the first industrial controller based on fuzzy linguistic rules "If - then" led to a surge of interest in fuzzy set theory among mathematicians and engineers [2].

The possibility of using fuzzy logic is based on the following results.

The advantages of fuzzy systems include their versatility. According to [3], any continuous function can be represented by a fuzzy model with any given accuracy. The special qualities of systems with fuzzy logic make it possible to synthesize an object model based on heuristic information received from an expert or as a result of an experiment. At the same time, fuzzy systems have such disadvantages as the lack of algorithms for the synthesis of stable models and the low speed of the latter with a large number of control rules.

In 1992 Wang (L.Wang) showed that the fuzzy system is a universal approximator, so that it can approximate whether a non-interrupted function with sufficient accuracy, as a victorious set of n (n → ∞) rules of the form " If - then", Gaussian functions, compositionality in the appearance of product, the implications of the Larsen form and the centroidal method of reduction to clarity [4].

In 1995 Castro (J. Castro) showing that the logical controller Mamdani is also a universal approximator with symmetric triangular membership functions, composition with multiple operations at least, the implications of the Mamdani form and the centroid method are reduced to clarity [5].

Systems with fuzzy logic can be stagnant for folding processes, if there is no simple mathematical model, as well as expert knowledge about the object or about the process, it is possible to formulate only in a linguistic form.

Systems, which are based on fuzzy logic, can achieve an underestimated as necessary result, may be rejected by some other (standard) way, or else for the object or the process, an adequate and easily completed mathematical model has already been found.

To implement the strategy of creating an expert system according to the type of logical inference of the Mamdani type, an applied problem has been solved for

assigning the number of microbes for a cleaning machine, which analyzes the importance and the confusion of textile fibers. The range of stagnation is 0 to 100. The range of variables is 0 to 100. The Matlab package is in the capacity of the logging software tool [6].

Coordinates of the fuzzy logical inference system

Incoming:
1. Weight of products.
2. Contamination of products.
data-out:
Amount of detergent.

Linguistic variables

Input coordinates:
1. Weight of products (Weight): Change range: [0-100]
Number of terms: 4
("Very Light" (VL), "Light" (L), "Heavy" (H), "Very Heavy" (VH))
Shape of membership functions: Triangular, trapezoidal.
2. Dirtiness: Change range: [0 100]
Number of terms: 4
("Clean" (C), "Slightly Dirty" (LD), "Dirty" (D), "Very Dirty" (HD))
Form of membership functions: Gaussian
Output coordinate:
Amount of detergent (Washing_powder): Change range: [0 100]

Number of terms: 5 ("Very little" (VL), "Little" (L), "Many" (M), "Very much" (VM), "Most" (X))

Shape of membership functions: Triangular, trapezoidal, Gaussian. The rule base is shown in Table 1.

Table 1

The rule base

Weight Dirtiness	VL	L	H	VH
C	VL	L	M	M
LD	L	L	M	VM
D	M	M	VM	X
HD	VM	M	VM	X

[author's development]

The creation of an expert system in the MatLab environment took place using the Fuzzy Tools block.

Using the "View\Surface" menu item, characteristic surfaces of the expert system are constructed for decision-making based on a fuzzy logical conclusion (Fig. 1 - 2):
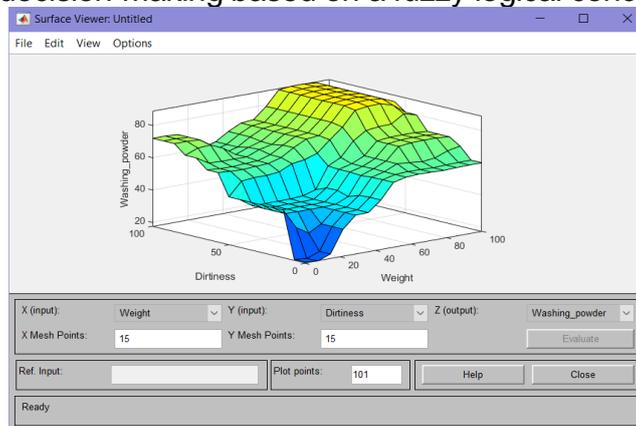

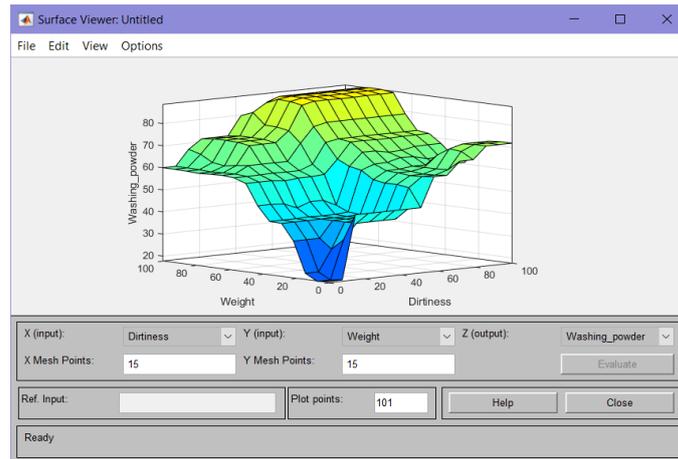Fig. 1**. Dependence of the amount of detergent on the contamination of the products**

Fig. 2. **Dependence of the amount of detergent on the weight of the products**

Conclusions. An expert Mamdani-type inference system was developed to determine the amount of detergent for a washing machine.

Analyzing the weight and soiling of textile products, the system determines the amount of the required detergent, using the rules made up of the following input data parameters for calculations:

Product weight (Weight): Change range: [0 - 100]

Number of terms: 4

("Very light" (0-30), "Light" (15-45), "Heavy" (25-70), "Very heavy" (60-100)).

Dirtiness: Change range: [0 - 100]

Number of terms: 4

("Clean" (0-20), "Slightly dirty" (10-50), "Dirty" (40-80), "Very dirty" (70-100)).

Amount of detergent (Washing_powder): Change range: [0 - 100]

Number of terms: 5

("Very little" (0-40), "Little" (20-60), "A lot" (50-70), "Very much" (65-80), "The most" (75-100)).

References:

[1] Fuzzy logic. Vagueness of knowledge [Electronic resource]: article. – Access mode: https://sites.google.com/site/ne4itkalogika/osnovi-teoriie-necitkih-mnozin/ne4itkist-znan (access date: 17.03.2023)

[2] Mamdani E.H. (1974) Application of fuzzy algorithms for control of simple dynamic plants // Proc. Inst. Elect. Eng. – Vol.121, № 12. – P. 1585-1588.

[3] Takagi T., Sugeno M. (1985) Fuzzy identification of systems and its applications to modeling and control // IEEE Trans. Syst., Man. Cybern. –Vol.15, № 1. – pp. 116-132.

[4] Yu L., Wang S., Lai K.K. (2009) An Intelligent-Agent-Based Fuzzy Group Decision Making Model for Financial Multicriteria Decision Support: The Case of Credit Scoring. European Journal of Operational Research, vol. 195, iss. 3, pp. 942-959.

[5] Bart Kosko and John C. Burgess (1998) Neural Networks and Fuzzy Systems Bart Kosko and John C. Burgess Citation: The Journal of the Acoustical Society of America 103, 3131; doi: 10.1121/1.423096

[6] Sivanandam S.N., Sumathi S., Deepa S.N. (2007) Introduction to fuzzy logic using Matlab . – Berlin: Springer – 430 p.