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Conceptual Model of Presentation of Fuzzy Knowledge

Volodymyr Polishchuk[1]
Miroslav Kelemen[2]
Iwona Włoch[3]
Andriy Polishchuk[1]
Yurii Mlavets[1]
Marianna Sharkadi[1]

[1] Uzhhorod National University, Ukraine
[2] Technical University of Kosice, Slovak Republic
[3] c Rzeszow University of Technology, Poland

Speaker: Volodymyr POLISHCHUK

Introduction

Is conducted a study of the current problem of developing a conceptual model of fuzzy knowledge, using one-dimensional and multidimensional membership functions, taking into account any type of input data, as well as designing innovative software as a means of technical support to systems analysts and its implementation in the learning process. For the first time, the study proposed a conceptual model consisting of five stages. Approaches to the formalization of qualitative and hybrid data are demonstrated by examples. The most common types and kinds of membership functionof one variable which can identify a set of criteria of internal and external factors of influence for various applied problems are resulted. Modeling of uncertainties of different types on the basis of multidimensional membership functions is also investigated. An experiment was performed on the example of presenting fuzzy knowledge for the problem of complex evaluation of startup projects. Innovative software in the form of a web application - "Information modeling of fuzzy knowledge", which will find application in systems analysts and implemented in the learning process.

Formal problem statement and input data

A system set-theoretic model of the problem of representing fuzzy knowledge can be represented as follows:

$$\{X, K_{FK}, M_{FK}, Z_{FK} | Y\} \quad (1)$$

Where:

- X – research object or set of research objects;
- K_{FK} – information model of criteria (groups of criteria) for evaluating the properties of the object of study on various factors of influence, based on data sets (expert knowledge, quantitative data);
- M_{FK} – a model for constructing membership functions to evaluate the object of study;
- Z_{FK} – model of aggregation of initial estimates.

As a result, we obtain an aggregate initial estimate Y of the object of study X.

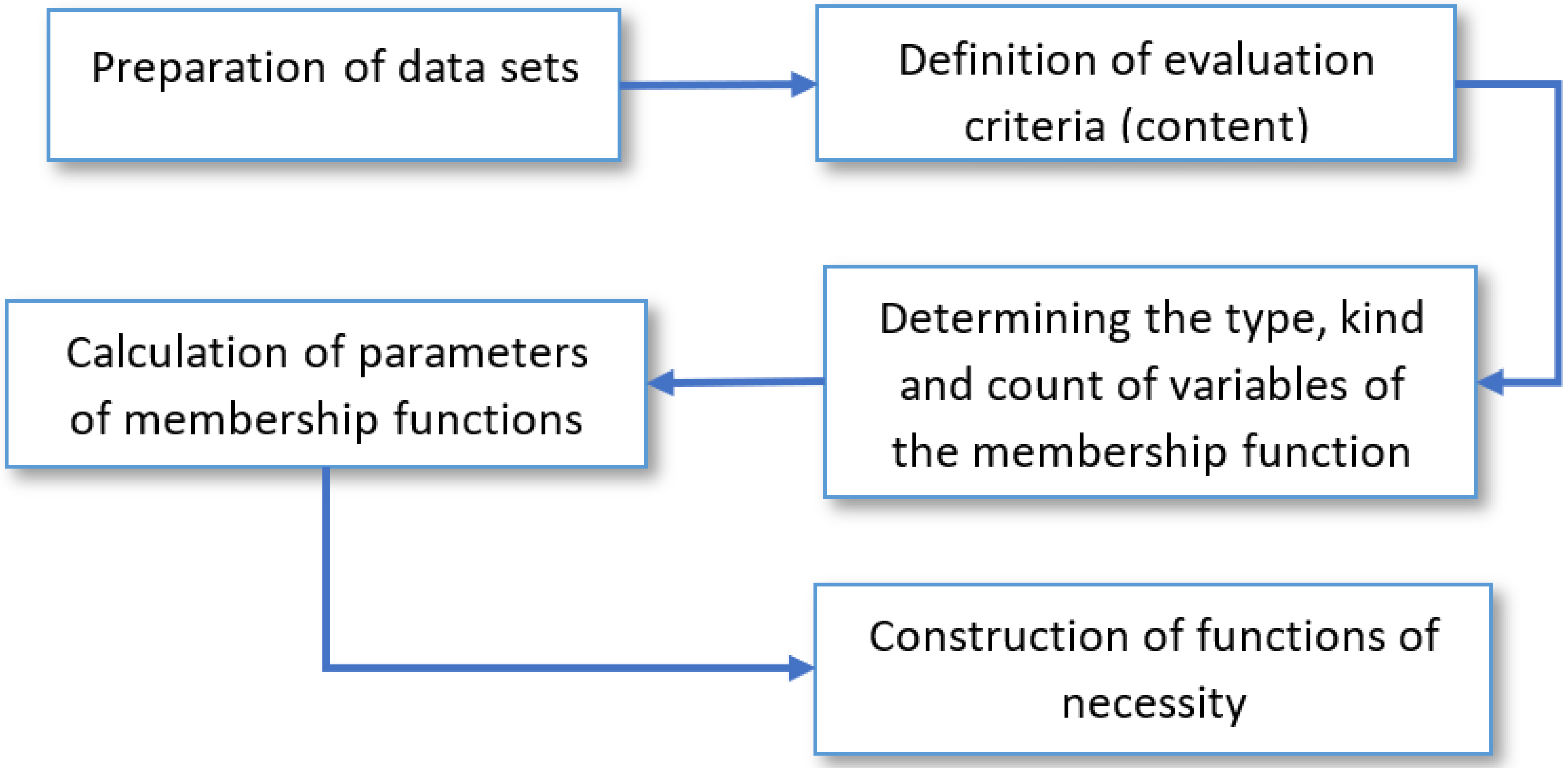
Formal problem statement and input data

Without reducing the generality, we propose the following formal classification of data sets:

- quantitative – all data sets by different criteria, the object of study are quantitative statistical sets or large data sets obtained by technical means;
- quality (expert knowledge) – all data sets have a linguistic representation of some term set $T = \{T_1;\ T_2; \dots;\ T_l\}$. For example, they are evaluated by an expert (group of experts) using a linguistic variable, based on experience and knowledge of the object of study X, analyze it, draw conclusions and make one linguistic assessment of each indicator K;
- hybrid – all datasets are evaluated in a hybrid way, based on the analysis of quantitative datasets, to which linguistic assessments are added, for example using the experience of experts.

Formal problem statement and input data

Figure shows the steps of the method of presenting fuzzy knowledge for the formation of membership functions based on the data of the object of study, obtained experimentally.



Formal problem statement and input data

As can be seen from Figure, the first step is to prepare datasets specific to the universal set of membership functions: statistically large data sets (eg. collected from different sensors), expert (judgments about the relevant indicator for the object of study), or hybrid. The received information is analyzed, its content is evaluated and evaluation criteria are based on them. Next, the type, kind and count of variables of the membership function are determined. This is followed by the calculation of parameters and the construction of the membership function to represent fuzzy knowledge.

Conceptual model of presentation of fuzzy knowledge

At the first stage, preparatory work is carried out on the sets, namely: the objects of research are identified, data are collected, processed, classified, etc.

In the second stage, the evaluation criteria (content) are determined.

Based on the collected data, information models of criteria (groups of criteria) for evaluating the properties of the object of study are built.

In the third stage it is necessary to determine the type, kind and count of variable membership functions.

In the fourth stage, the parameters of the membership function are calculated.

This is a very important stage and is a difficult task, the solution of which depends on the adequacy of information modeling of fuzzy knowledge. Different mathematical or expert approaches can be used in different situations.

Conceptual model of presentation of fuzzy knowledge

In the last ***fifth stage***, membership functions are built by formalizing fuzzy inputs. The result is a matrix of formalized data according to the constructed membership functions.

After disclosure of uncertainty, processing and formalization of data sets using membership functions, it is necessary to obtain an aggregate initial estimate Y_j by researched objects x_j. For this purpose, a model of aggregation of initial estimates using different convolutions is proposed.

Results

Consider an example of presenting fuzzy knowledge for the task of comprehensive evaluation of startup projects.

Let the set of startup projects be considered $S = \{s_1, s_2, \ldots, s_5\}$, which are evaluated by the following models: M_1 – model for evaluating startup projects in conditions of information uncertainty; M_2 – model of information technology risk assessment of project financing; M_3 – information model for evaluation and ranking of startup project development teams.

The projects were evaluated according to the models and received aggregate evaluations, table 1. The process of obtaining aggregate evaluations is described in detail in the work Model of evaluation and selection of start-up projects by investor Goals.

RESULTS

Table 2. Input data for startup projects

Evaluation models	s_1	s_2	s_3	s_4	s_5
M_1	0,87	0,82	0,6	0,77	0,69
M_2	0,66	0,83	0,71	0,98	0,91
M_3	0,78	0,4	0,54	0,85	0,82

The task is to aggregate the knowledge about the object of study to build a ranking of startup projects and select the most promising for funding. To do this, we use the model to represent fuzzy knowledge based on multidimensional membership functions. For example, it is appropriate to use the cone-like membership function:

$$\mu(\overline{x_j}) = \begin{cases} 1 - a_j, \ if \ a_j < 1, \\ 0, otherwise. \end{cases}$$

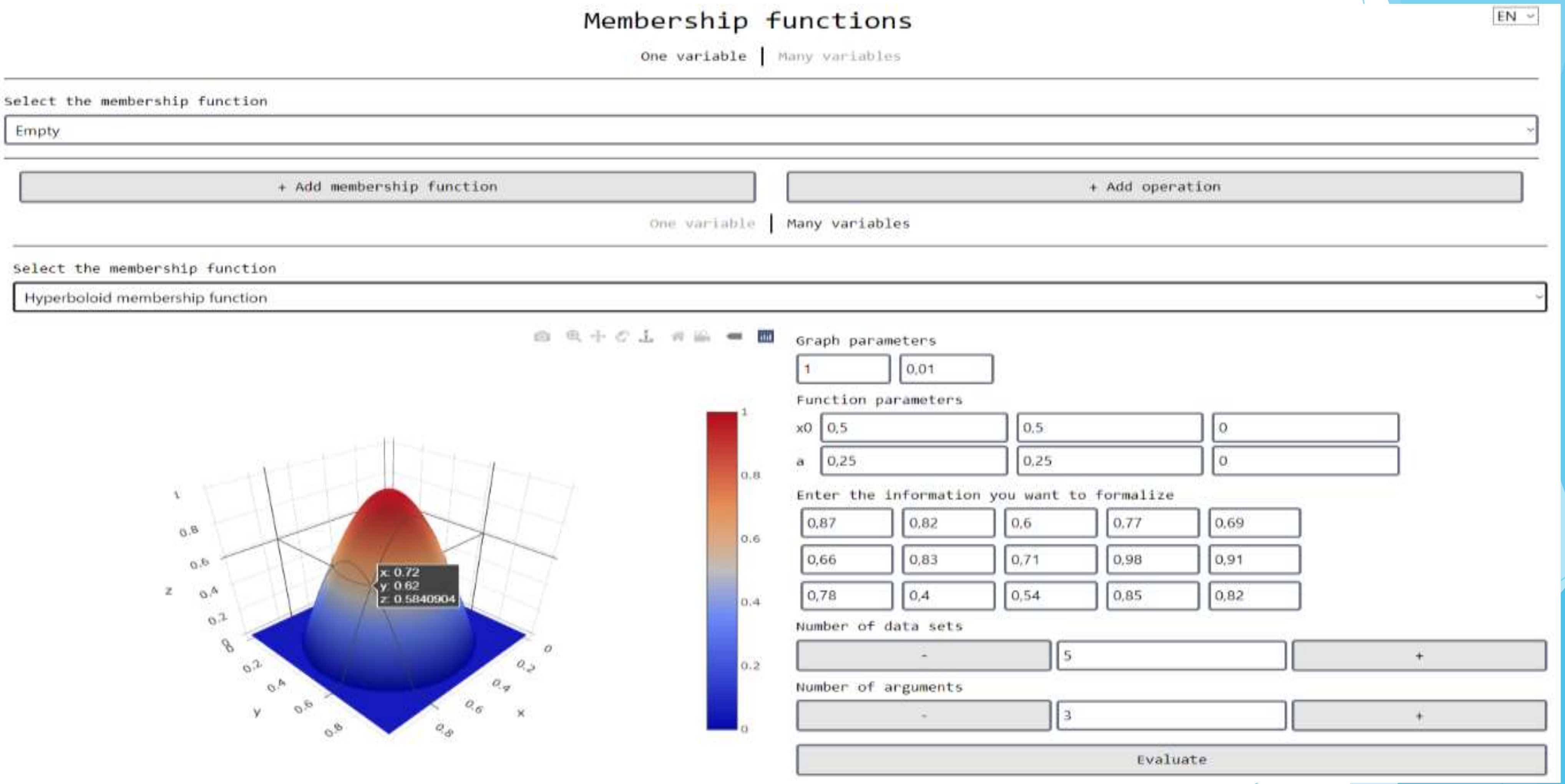
where: $a_j = \sqrt{(x_{1j} - 1)^2 + (x_{2j} - 1)^2 + (x_{3j} - 1)^2}, j = \overline{1,5}.$

Results

Based on the obtained estimates, we can build a ranking of startup projects (s_4; s_5; s_1; s_3; s_2).

The developed software, as a tool for modeling fuzzy knowledge, is a useful tool for systems analysts, who not only has the opportunity to get rid of routine calculations, but also has the opportunity to visualize the processed data. In addition, the web application is planned to be implemented in the educational process of Uzhhorod National University as a means of supporting data processing for master's and PhD students. The main window is divided into two categories regarding the dimensionality of membership functions: "One variable" and "Multiple variables", fig. 2.

RESULTS


Membership functions
EN
One variable | Many variables
Select the membership function
Empty
+ Add membership function
+ Add operation
One variable | Many variables
Select the membership function
Hyperboloid membership function
x: 0.72
y: 0.62
z: 0.5840904
Graph parameters
1
0,01
Function parameters
x0
0,5
0,5
0
a
0,25
0,25
0
Enter the information you want to formalize
0,87
0,82
0,6
0,77
0,69
0,66
0,83
0,71
0,98
0,91
0,78
0,4
0,54
0,85
0,82
Number of data sets
-
5
+
Number of arguments
-
3
+
Evaluate

Discussion

Building a conceptual model of fuzzy knowledge has a number of advantages, namely: accuracy, work with abstractions, transfer of information in a logically uniform way and increase the objectivity of expert and quantitative assessments, reveals the subjectivity of experts, quantifies informal tasks. The disadvantages of this approach include the use of different models of membership functions and the definition of their parameters, which can lead to ambiguity of the final results.

CONCLUSION

Conducted a study of the current problem of developing a conceptual model of fuzzy knowledge, using one-dimensional and multidimensional membership functions, taking into account any type of input data, as well as was designed innovative software as a means of technical support for systems analysts and implementation in the learning process. In the first time the following results have been obtained:

- the conceptual model of representation of fuzzy knowledge on the basis of membership function of estimations on criteria, one and many variables, taking into account any type of input data, and their possibility of application for various applied problems is offered;
- the formal classification of data sets is given taking into account the type of input data, namely: quantitative, qualitative and hybrid. The known approaches of convolutions of receiving the aggregate initial estimation on objects of research are resulted;

CONCLUSION

- an experiment was performed on the example of presenting fuzzy knowledge for the problem of complex evaluation of startup projects, using the data obtained with the help of: model of evaluation of startup projects in the conditions of information uncertainty; models of information technology risk assessment of project financing; information model for evaluation and ranking of startup project development teams;
- Innovative software in the form of a web application called "Information modeling of fuzzy knowledge" is designed on the basis of the developed conceptual model. This tool for modeling fuzzy knowledge, as a practical result of the study, will be used by systems analysts and implemented in the educational process of Uzhhorod National University for master's and PhD students.

Thank you!

Question please:

volodymyr.polishchuk@uzhnu.edu.ua

Assoc. Prof. Mgr. Volodymyr POLISHCHUK, PhD.