ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL – 2016, Vol.5, No.4, 55-60

INFORMATION TECHNOLOGY FOR TREATMENT OF RESULTS EXPERT ESTIMATION WITH FUZZY CHARACTER INPUT DATA

Yu. Ulianovskaya

University of Customs and Finance, Dnipro, Ukraine; e-mail: uyv@rambler.ru

Received September 23.2016: accepted November 24.2016

Annotation. The questions of processing expert information provided by the group of experts are considered. In the treatment group of expert opinion there is a problem obtaining a generalized result. It is assumed that the information is a set of qualitative and quantitative features (alternatives), described by linguistic concepts. Statistical methods of expert's data processing are quite complicated when the expert's answers have form of ranking or separation, and quite simple, if the answers are the results of independent pairwise comparisons. In this article are proposed to carry out processing of expert information by methods of the fuzzy sets theory. Using this theory are developed a method for determining the qualifications of the expert based on his length of service and number of expertise conducted by him, the results of which are accurate. The developed method is based on the construction of a system on fuzzy logic with fuzzifikator and defuzzifikator. For processing expert's estimates are suggested each alternative presented in the linguistic variable form and evaluate it by assigning a group of experts of membership functions each term by the direct method. Obtaining a generalized assessment based on all expert's estimates going on with regard to their competence. In this paper a method of ranking fuzzy alternatives are propose. Based on the developed methods of data processing was designed an automated system that allows to determine the experts qualification, generalized result of expert group evaluation and of ranking alternatives. The developed technology is applicable to any subject area, where it is necessary to analyze alternatives for many of the criteria based on processing of expert estimations.

Key words: expert information, linguistic variable, fuzzy logic, ordering alternatives, qualification of experts, information technology.

INTRODUCTION

Decigion making by man in most areas of activity in which he has some knowledge and experience, requires a deep understanding of various properties of the considered system. Necessary information may be absent or its getting too expensive, then decigion making takes place with the use of intelligent decision support systems [1, 2].

In these systems, to analyze and propose different methods of data mining, knowledge discovery in databases and knowledge, and other techniques developed within artificial intelligence [3, 4]. Systems built by combining the databases and fuzzy logic can significantly extend the functionality and range of tasks of data mining. The theory of fuzzy databases is not yet complete from a mathematical point of view, and there are still many issues that require resolution [5]. The formation of databases intelligent systems takes place on the basis of expert information. Much attention is paid to the problem of the choice of methods for presenting expertise and processing this information [6-7]. At the same time there is a problem processing a group of expert opinions and getting the generalized results of the expert assessment. Improper use of the results of expert assessment can lead to erroneous conclusions.

Expert information often is a combination of qualitative and quantitative traits can be expressed in terms of a natural language, can possess incompleteness and unclearness. Classical statistical methods does not always give an adequate result, when applied to this type of data. In particular, problems arise when trying to averaging the opinions of experts. Statistical methods of processing depend on the mathematical nature of the experts' answers. The choice of method is determined by the nature of the information in question.

Today there are many methods for processing quantitative expert data, as opposed to qualitative. Therefore, an important task is to combine the theory of classical processing methods quantitative expert information with processing techniques qualitative data.

Analyzing the above, we can conclude that in spite of the extensive development of methods of expert assessments, a number of issues related to the fuzzy expert estimations remain open. Not sufficiently developed methods for comparative assessment of expert evaluations, processing and obtaining the views of the group, as well as methods for ranking fuzzy alternatives when they are formulated as fuzzy linguistic concepts. The results obtained in the form of a generalized opinion must take into account the competence of the experts. With a large number of experts and a large variety of alternatives there is a necessity in the use of computer technology for the storage, retrieval and processing of expert information.

THE ANALYSIS OF RESENT RESEARCHES AND PUBLICATIONS

Processes application of computer and telecommunications equipment for the storage, retrieval, transmission and processing data forms information technology [8]. Let's consider the existing methods of experts' data processing. Methods of expert evaluations are scientific methods of analyzing complex problems. Experts conduct an intuitive and logical analysis of the problem with quantification of judgments and with the formal processing of the results Their general opinion obtained as a result of the processing of individual assessments is adopted as a solution to the problem. To receive qualitative evaluations are used pairwise comparisons, multiple comparisons, ranking methods, etc. For obtain quantitative estimates are used direct numerical evaluation of the alternatives, method Churchman-Akoff and others [9-11]. These methods allow using the experience and knowledge of a person compensate the incompleteness of the information when obtaining it by other means is problematic, demands enough long period, and is quite expensive.

For information, expressed in terms of a natural language and having fuzziness, are developed the methods based on Bayesian probability, confidence coefficients, fuzzy logic and others [12, 13]. It is experimentally shown that fuzzy control gives better results compared with those obtained by conventional control algorithms. For example, fuzzy logic controllers used in various control systems, are an important application of fuzzy set theory. These controllers use the experts' integrated knowledge and describe them by linguistic variables and fuzzy sets [14].

Confidence to results of expert evaluation largely depends on the competence of the experts. This problem can be solved by using an interpolation process. The main idea of this calculation is the suggestion that the competence of the experts must be assessed on the degree of coordination of their evaluations with the group evaluation of objects [15]. The problem of definition of experts' competence can be solved on the basis of the axioms of unbiasedness. But this approach is very cumbersome to calculate and can be implemented only by using an automated system. It is not an absolute full as well as all other methods for assessing subjective characteristics [16].

OBJECTIVES

The aim of this work is to develop information technology for generalization of the results of the expert evaluation, which includes the processing method of fuzzy expert information with expert's qualifications for ranking alternatives according to several criteria and automated information system implementing the developed methods.

THE MAIN RESULTS OF THE RESEARCH

Suppose there are k experts $X = \{x_l\} = \{x_1, x_2, \ldots, x_k\}$. The experts were asked to evaluate a set of alternatives $A = \{a_i\} = \{a_1, a_2, \ldots, a_n\}$, determining their by values term–set $T = \{t_j\} = \{t_1, t_2, \ldots t_m\}$.

The expert in this case indicates the number of μ in the interval [0, 1], which characterizes the degree of compliance by alternative a_j to the selected term t_j. In this case, we get a discrete membership function, built by the direct method for the expert group. Expert opinions in this case may coincide or be not concordant. Consider the method received data processing.

In work [17] it is proposed to form the opinions of all experts, obtained by this method about each an alternative a_i, in form next matrix:

$$\mathrm{M}(a_i) = \begin{array}{c|ccc} & t_1 & \ldots & t_m \\ \hline x_1 & \mu_1^1(a_i) & \ldots & \mu_m^1(a_i) \\ x_2 & \mu_1^2(a_i) & \ldots & \mu_m^2(a_i) \\ \ldots & \ldots & \ldots & \ldots \\ x_k & \mu_1^k(a_i) & \ldots & \mu_m^k(a_i) \end{array} \qquad (1)$$

where: $x_1, \ldots, x_k$ – experts, t_j - the term from term-set of linguistic values, describing the alternative, $\mu_j^l(a_i)$ - an membership function alternative a_i to the term t_j in accordance with the opinion of the expert x_l.

With this approach it is necessary to take into account the competence of the experts, however, in direct methods of building membership functions for the expert group there is one delicate question: who assigns weights to the experts estimates [13].

To solve this problem in work [20] a method was proposed for determining the competence of the expert (*W*) on the basis of its work experience (*S*) and frequency correct evaluation results (*P*) by means of constructing a system of fuzzy logic inference type Mamdani with fuzzifikator and defuzzifikator [18, 19].

A linguistic variable is defined by the five attributes:

$$\langle x, T, U, G, M \rangle,$$

where: x - a variable name; T - term-set, each element which (term) is represented as a fuzzy set on a universal set U; G - syntax rules, often in the form of a grammar, generating the name terms; M - semantic rules that define the membership functions of fuzzy terms supplies generated by syntactic rules of G [13, 18].

Let's consider variable S. We define it five attributes:

$$\langle s, T_s, U_s, G_s, M_s \rangle,$$

where: s - "work experience" (hereinafter referred - experience), $T_s = \{t_s^1, t_s^2, t_s^3\}$={"small", "medium", "high"}, U_s = {0, 1, ..., 50}, G_s - syntax rules, generating new terms with quantifiers "no", "very" and "more or less", M_s - trapezoidal membership function, an analytical expression for which has the following form:

$$\mu(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases} \qquad (2)$$

where: the parameters [a, b, c, d] has values t_s^1 = [-18, -2, 5, 20], t_s^2 = [5, 20, 30, 45], t_s^3 = [30, 45, 52, 68].

Consider variable P. We define it five attributes:

$$\left\langle p, T_p, U_p, G_p, M_p \right\rangle,$$

where: p - "frequency of positive results" (for simplicity - frequency), $T_p = \left\{t_p^1, t_p^2, t_p^3\right\}$ = {"rare," "medium frequency", "often"}, U_p = [0 ... 1], G - syntax rules, generating new terms with quantifiers "no", "very" and "more or less", M_s - trapezoidal membership function, an analytical expression for which is given by equation (1). The parameters [a, b, c, d] is t_p^1 = [-0.4, -0.1, 0.1, 0.4], t_p^2 = [0.1, 0.4, 0.6, 0.9], t_p^3 = [0.6, 0.9, 1.1, 1.6].

The output variable W define the five attributes:

$$\left\langle w, T_w, U_w, G, M_w \right\rangle,$$

where: w - level expert competence, U_w = [0,…,1], $T_w = \left\{t_w^1, t_w^2, t_w^3, t_w^4, t_w^5\right\}$ = {"low", "below average", "average", "above average", "high"}, G_w - syntax rules, generating new terms with quantifiers "no", "very" and "more or less", M_w - triangular membership function, an analytical expression for which has the following form:

$$\mu(x) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ \dfrac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{cases}, \tag{3}$$

where: the parameters a, c - the ends of the carrier corresponding fuzzy set linguistic variable value, b - value, in which the membership function takes a value of 1. For the elements of the set T, these parameters have the following values:

t_w^1 : a=-0,25, c=0,25, b=0,

t_w^2 : a=0, c=0,5, b=0,25,

t_w^3 : a=0,25, c=0,75, b=0,5,

t_w^4 : a=0,5, c=1, b=0,75,

t_w^5 : a=0,75, c=1,25, b=1.

One of the main methods of knowledge representation in fuzzy logic systems are production rules that allow to get closer to the style of human thinking.

Usually, these production rules are given as operator logical expression IF – THEN:

$$\text{IF } x_1 \in F_1^{\,p} \text{ and... and } x_n \in F_n^{\,p} \text{ THEN } y \in G^p, \tag{4}$$

where: the rule's condition (logical expression) is a statement about the content of the knowledge base, and the consequence (operator) suggests what we should do when this production rule is activated [14]; $F_1^{\,p}$ and G^p – fuzzy sets; $\bar{x} = (x_1, \ldots, x_n)^T \in X$ and $y \in Y$ – variable inlet and outlet, respectively; $p = \overline{1, m}$.

We form the fuzzy rule system in accordance with the expression (4):

$$\begin{aligned} &\Pi 1\text{: IF } S = t_s^1 \text{ AND } P = t_p^1 \text{ THEN } W = t_w^1; \\ &\Pi 2\text{: IF } S = t_s^1 \text{ AND } P = t_p^2 \text{ THEN } W = t_w^1; \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ &\Pi 10\text{: IF } S = t_s^3 \text{ AND } P = t_p^3 \text{ THEN } W = t_w^5. \end{aligned} \tag{5}$$

The value of the output variable is found by using the method of defuzzification according to the center of gravity [13, 18, 21]. In the application of the proposed method with next input data: the experience of work is 34 year and the probability of a correct answer is 0.3, according to the method of defuzzification by center of gravity the expert's qualification are estimated by coefficient equal 0,488.

The weight of expert x_l is denoted by w_l, wherein $0 \le w_l \le 1$.

Generalized evaluation of the membership function of each term t_j for alternative a_i may be to compute with the help of expression:

$$\mu_{ij} = \frac{\sum_{l=1}^{k} w_l \mu_j^l(a_i)}{k}, i = 1, \ldots, n, j = 1, \ldots, m, \tag{6}$$

where: k – number of experts , $\mu_j^l(a_i)$ is identified in matrix (1).

As each alternative has its own matrix (1) after its treatment with the expression (6) we obtain a representation of an alternative in the form:

$$a_j = \{<\mu_{j1}/t_1>, <\mu_{j2}/t_2>, \ldots, <\mu_{jk_j}/t_{k_j}>\}. \tag{7}$$

Processing results for each of the alternatives defined in the form (7) can be grouped into the next matrix:

$$A_{proc} = \begin{array}{c|cccc} & t_1 & t_2 & \ldots & t_k \\ \hline a_1 & \mu_{11} & \mu_{12} & \ldots & \mu_{1k} \\ a_2 & \mu_{21} & \mu_{22} & \ldots & \mu_{2k} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ a_n & \mu_{n1} & \mu_{n2} & \ldots & \mu_{nk} \end{array} \tag{8}$$

where: μ_i- affiliation function of alternative a_i to term t_j.

For each linguistic value t_j let's construct non-decreasing sequence alternatives $\{a_i\}$, such that:

$$\forall a_i \in \{a_i\}_{i=1}^{n} : a_i \ge a_{i+1} \leftrightarrow \mu_{ij} \ge \mu_{i+1j}. \tag{9}$$

In constructed in this way sequence in the first place will be alternative a_i that has the maximum value membership function μ_{ij} to term t_j. Let's form matrix $KOL = \{kol_j(a_i)\}$, j=1,2,…,m, i=1,2,…,n with help of variable $kol_j(a_i)$ equal to the number of occurrences of alternative a_i in the j-th place in this sequence. Let's denote $kol^{\max}$ the maximum value of the variable $kol_i(a_i)$ in each column:

$$kol_j^{\max} = \max_i kol_j(a_i), \quad j = 1,\ldots,m. \tag{10}$$

We arrange alternatives as follows. Through r_i denote rating alternatives a_i. Establish a one-to-one correspondence between the sequence $\{r_i\}$ and $\{a_i\}$ as follows:

$$r_i = a_i \leftrightarrow kol_j^{\max} = kol_j(a_i). \tag{11}$$

Thus, it is necessary to repeat this comparison is not all alternatives will be ordered.

Let, for clarity, there are six alternatives $A = \{a_i\} = \{a_1, a_2, \ldots, a_6\}$ and six term-sets of linguistic values $T = \{t_1, t_2, \ldots, t_6\}$. Let's write this alternatives and values of membership functions in the next matrix:

A=

	t_1	t_2	t_3	t_4	t_5	t_6
a_1	0,5	0,6	0,7	0,8	0	0,1
a_2	0,4	0,2	0	0,3	0	0,4
a_3	0,1	0,5	0	0,2	0,9	0,6
a_4	0	0,1	0,9	0,3	0,2	0,5
a_5	0,7	0,2	0,2	0,3	0,4	0,7
a_6	0,1	0,9	0,4	0,3	0,8	0,6

Carry out a ranking for each of values of the term-set by ordering all alternatives in descending respective values membership function:

t_1: < a_5>, < a_1>, < a_2>, < a_3,a_6>, < a_4>
t_2: < a_6>, < a_1>, < a_3>, < a_2,a_5>, < a_4>
t_3: < a_4>, < a_1>, < a_6>, < a_5>, < a_2,a_3>
t_4: < a_1>, < a_2, a_4, a_5, a_6 >, < a_3>
t_5: < a_3>, < a_6>, < a_5>, < a_4>, < a_2,a_1>
t_6: < a_5>, < a_6, a_3>, <a_4>, < a_2 >, < a_1>

The numbers appearance of alternatives in each column are given in next matrix:

KOL =

	kol_1	kol_2	kol_3	kol_4	kol_5
a_1	1	3	0	0	2
a_2	0	1	1	2	2
a_3	1	1	2	1	1
a_4	1	1	1	1	2
a_5	2	1	1	2	0
a_6	1	3	1	1	0

After analyzing the resulting table, we order the alternatives in order to increase the rating. The strongest is the alternative a_5, because it takes the maximum value of the membership function for two terms (kol_1 = 2), so it has the highest rating, and is ranked first in ordering. Alternatives a_1 and a_6 have the same value of the variable kol_2 = 3, which indicates that these alternatives for three terms have value of membership function following after the maximum value. And for the one term they have maximal meaning. However alternative a_6 has one in a neighboring column to the right, therefore we assume it stronger than alternative a_1, and a_6 in the ranking stands before a_1.

After similar analysis of all columns of the matrix all alternatives will be arranged in order descending of values of the evaluated characteristics as follows:

$$a_5,\ a_6,\ a_1,\ a_3,\ a_2,\ a_4.$$

An integral component of information technology is the use of computer technology for data processing and usage. Consider a software implementation of the proposed approaches. The proposed information system, in accordance with the considered the methods of processing expert information, performs the following functions: input of information about experts, formation of alternatives and terms, input of expert estimations, calculation of the experts qualification, ranking alternatives, viewing and saving the results work of the system, saving (in the case of need) input data to a file for later reference.

Let's illustrate the work of system. On the Fig. 1 is shown program screen shot for the process determining the qualifications of experts. Values of the variable *S* (experience) and *P* (positive frequency of results) are introduced by the system user, value of qualification (*W*) is calculated by the system.

At the same time we have the opportunity to see the right side of the screen the rules of the system (5) that have been used in concrete case (the degree of the truth of the rule is greater than zero).

Vector degrees of competence for the three experts in this example was calculated program way accordance to methods described above and has next values:

$$W = \{w_1; w_2; w_3\} = \{0{,}307;\ 0.095;\ 0.92\}.$$

On Fig. 2 illustrated process the formation the matrix (1) experts estimates for three alternatives, which serve famous higher educational institutions of city Dnepr: the Dnepr National University named after Honchar (DNU), the National Mining University (NGU) and the Dnepr Medical Academy (DMA).

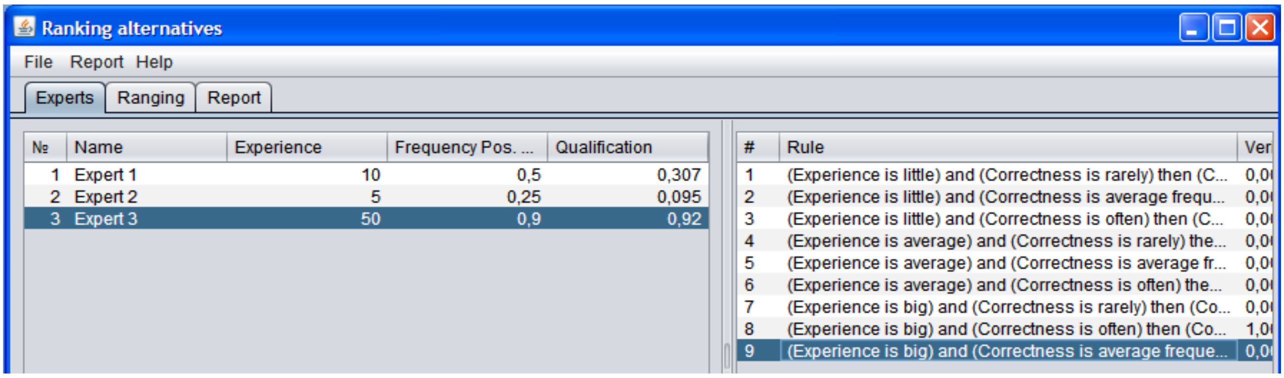

Fig. 1. Program screen form for expert's qualification definition

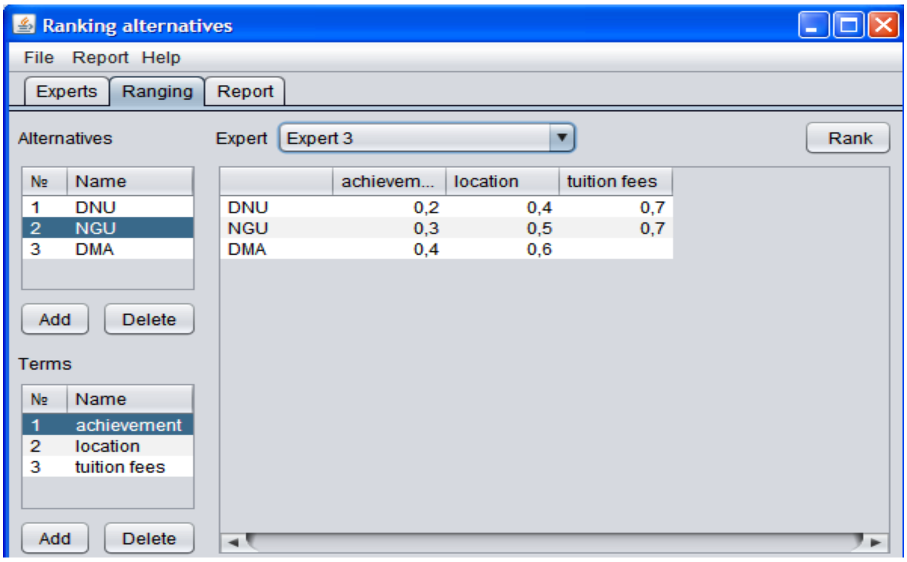

Fig. 2. Program screen form for formation of expert estimates

According to the introduced in this article notations we have a set X that consists of three experts. Set A includes three alternatives:

$$a_1 = \text{DNU},\ \ a_2 = \text{NGU},\ \ a_3 = \text{DMA},$$

which to be ranked according to expert estimates of the terms from the set

$$T = \{t_1;\ t_2;\ t_3\},$$

where: t_1 = «Permormance rating», t_2 =«Location», t_3 =«Training Price».

On the basis of imposed expert assessments obtain a matrix estimates for each alternative. Then weight's vector of expert's competence

$$W=\{w_1;\ w_2;\ w_3\}=\{0{,}307;\ 0,\ 95;\ 0{,}92\}.$$

Let's apply formula (6) to the obtained data of expert evaluations, we obtain an overall assessment, which allows to record every alternative in accordance with expression (7) as a fuzzy variable:

$$a_1=\{<0{,}09/t_1>,\ <0{,}19/t_2>,\ <0{,}3/t_3>\},$$
$$a_2=\{<0{,}13/t_1>,\ <0{,}24/t_2>,\ <0{,}24/t_3>\},$$
$$a_3=\{<0{,}17/t_1>,\ <0{,}24/t_2>,\ <0{,}14/t_3>\}.$$

After applying to alternatives the method of ranking which is proposed in this article and specified by the expressions (9) - (11) we obtain ordering the alternatives that given in Table. 1.

Table 1. Ranging alternatives

Terms	Alternatives		
Permormance rating	<DSMA>	<NSU>	<DNU>
location	<NSU, DSMA>	<DNU>	
Price of training	<DNU>	<NSU>	<DSMA>

This paper presents a software product AltRanging, which is written in object-oriented style of the Java programming language. All objects are described by classes. Each class is stored in separate file with the name of the class. Classes are grouped into packets. This software product has two packages: com.acsu.altranging - contains the basic classes, program logic and GUI, com.acsu.fuzzy - classes and fuzzy logic libraries, which are used to determine the qualifications of the experts. In addition to standard Java packages also applies package org.json , which provides a library JSON. JSON - text format, completely independent of the implementation language, but it uses the agreements, programs on C-like languages, such as C, C++, C#, Java, JavaScript, Perl, Python and many others. These properties make JSON ideal language data exchange [22].

CONCLUSION

1. The information technology is to combine the author previously developed methods of processing expert information provided by the group of experts and the methods for determining the qualifications of experts in a single systematic approach to the treatment of expert information for the purpose of ranking of alternatives and automate this process with the help of an automated information processing system. The disadvantage of this approach is the need for statistical data on the activities of the people taking part in the expertises.
2. The scientific value of the proposed approaches consist in improving the previously known methods for determining the competence of experts and ranking of alternatives by using elements of fuzzy sets theory.
3. The practical significance of the results consist in the possibility of processing a large enough array of expert data and obtaining generalized results of the expertise. This eliminates the possibility of subjective influence some experts to the opinion of others.
4. Information technology, developed by the author, is applicable for any number of experts and any subject area, a description of which is formulated in linguistic terms.

REFERENCES

1. **Angeli C., 2010.** Diagnostic Expert Systems: From Expert's Knowledge to Real-Time Systems, TMRF e-Book Advanced Knowledge Based Systems: Model, Applications & Research. Vol. 1, 50–73.
2. **Lytvyn V., 2013.** Design of intelligent decision support systems using ontological approach. ECONTECHMOD. An international quarterly journal Vol. 2, №1. 31-37.
3. **Korneev V., Gareyev A., Vasjutin S., Reich V., 2000.** *Databases. Intelligent processing of information*. M.: Knowledge, 352. (in Russian).
4. **Kaklauskasa A., Zavadskasbc E., Gargasaited L., 2004.** Expert and knowledge systems and databases of the best practice. Vol. 10, 88-95.
5. **Filatov V., 2014**. Fuzzy models presentation and realization by means of relational systems. ECONTECHMOD. An international quarterly journal Vol. 3, №3. 99-102.
6. **Ivanek J., 1991.** Representation of expert knowledge as a fuzzy axiomatic theory. International Journal of General Systems. Vol. 20, 55–58.
7. **Gong J., Liu L., 2010.** Representing and measuring experts knowledge based on knowledge network. Studies in Science of Science. 28 (10), 1521–1530.
8. **Daintith J., 2009.** IT. A Dictionary of Physics, Oxford University Press, retrieved 1 August 2012.
9. **Orlov A., 2004.** Applied Statistics. M.: Exam, 656. (in Russian).
10. **Ryabushkin T., Baklanov G., Volkov A., 1997.** Statistical methods of analysis of expert estimations. Proc. Sciences. Art. Scientific notes on statistics. Vol. 29. M.: Science, 385. (in Russian).
11. **Litvak B., 1982.** Expert information: Methods for the preparation and analysis. M.: Radio and Communications, 184. (in Russian).
12. **Hughes C., 1989.** The representation of uncertainty in medical expert systems. Medical Informatics. Vol. 14, 269-279.
13. **Melihov A., Bernstein L. and Korovin S., 1990.** Situational advising system with fuzzy logic. M.: Science. 272. (in Russian).
14. **Kovalyshyn O., Gabriel Yu., 2014.** Development of a management systems model of automatic control by using fuzzy logic. ECONTECHMOD. An international quarterly journal. Vol. 3, №. 4. 87-90.
15. **Pavlov A., Sokolov B., 2005.** Methods of processing expert information: study guide. St. Petersburg: State University of Aerospace Instrumentation. 42. (in Russian).
16. **Snityuk V., Rifat Mohammed Ali, 2000.** Model methods for determining the competence of experts on the basis of the axioms of unbiasedness. Bulletin of Cherkasy Engineering and Technological Institute. №4, 121-126. (in Russian).
17. **Ulianovskaya Yu., 2013.** Ranking method of fuzzy alternatives in processes of transfer and information processing in computer systems. Herald of Khmelnytskyi national university. №1(197), 130-134. (in Russian).
18. **Shtovba S., 2007.** Design of fuzzy systems by means of MATLAB. M.: Hotline – Telecom, 288. (in Russian).
19. **Zadeh L., 1976.** The concept of linguistic variable and its application to take close resheniy. -M.: Mir, 165. (in Russian).
20. **Ulianovskaya Yu.**, **2014**. Method for determination of qualifications of the experts participating in the expert survey. Herald of Kherson national technical university. № 1(48), 96-101. (in Russian).
21. **Rybytska O., Vovk M., 2014.** An Application of the Fuzzy Set Theory and Fuzzy Logic to the Problem of Predicting the Value of Goods Rests. ECONTECHMOD. An International Quarterly Journal. Vol. 3, №2, 65-69.
22. Introducing JSON. Available online at: <http://json.org/>