УДК 681.3

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MEMBERSHIP FUNCTIONS OF MODIFIED TERMS OF LINGUISTIC VARIABLES AND THEIR ANALYSIS

The work offers semantic procedures to find out membership functions of modified terms of linguistic variables that correspond to such words as "very", "more or less", "much more" or "much less", and provides formulas to account for them. The work features peculiarities of fuzziness indexes of the above words. It also analyses how the fuzziness indexes change and provides corresponding formulas.

Introduction. The major difficulty in decision making comes with the factors as uncertainty in information, multicriteriality of a problem, impossibility to cardinally measure certain partial factors of decisions or difficulties in their evaluating; time limitations to make immediate decisions; human factor in decision making; impossibility to do objective experiments to check efficiency of various decisions; risk related to any decision. That is why systems of decision support have been developed for a vast range of problems, the most effective of them being systems of decision support with fuzzy logic [1, 2, 3, 4, 5]. The strong appeal of fuzzy logic for systems of decision support lies in its closeness to real speech. It makes the process of creating both data base and interface easy, as statements of a human expert may be directly translated into mathematical formulas of fuzzy logic and the other way round. Data base of such systems may be used basing on composition rules with fuzzy linguistic expressions. At that it is possible to use modified terms of linguistic variables. The work lays emphasis to the significance of the problem as there is no unified methodology to determine the functions of membership of modified terms or of their analysis. The purpose of this articles is to develop semantically the procedure to determine the membership function of modified terms of linguistic variables that correspond to such words as "very", "more or less"," much more" or "much less" and so on; to have formulas to work out the corresponding membership function and their analysis.

Main results. System of decision support will be analyzed in its narrow sense of the word as "intellectual " software that uses experts' knowledge and expertise (knowledgebase) as well as information about an object of decision making and "understanding" the person, who makes decisions (PMD) in his field (database). On the basis of processing them optimal resolutions are worked out (algorithm of fuzzy output operation), control signals are developed (fig. 1).

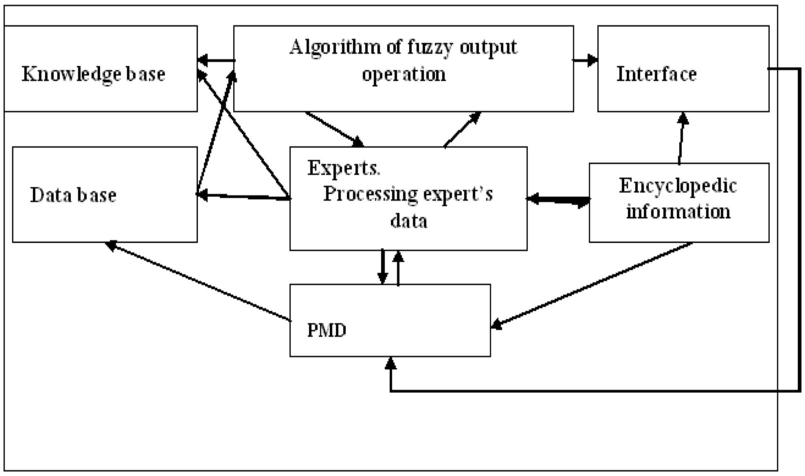

Fig. 1. Main elements of managerial decision support system and links between them

By intellect we understand ability to adapt to new information that is characterized by new external conditions and new objects of decision making.

The system is supposed to have 3 modes of operation: receiving expert's knowledge (creating data base), receiving data about the situation and object of decision making (creating a data base) and the mode of logic output, basing on which decisions are made.

In many cases the data base is defined by a system of fuzzy production rules as shown in [2, 3]:

$$\text{If } \nabla_k \mathrm{A}_\mathrm{i}^\mathrm{L}, then \nabla_l B_i^L; i = \overline{1,n}, \tag{1}$$

where $\nabla_k \mathrm{A}_\mathrm{i}^\mathrm{L}; i = \overline{1,n},$ – linguistic expression of the type $\mathrm{A}_\mathrm{i}^\mathrm{L} = E_j$ which is the antecedent with term modifier ∇_k; *E* – name f linguistic variable; E_j – one of its terms; $\nabla_l B_i^L$ - fuzzy linguistic expression with term modifier ∇_l, which is the consequent of fuzzy production.

For instance, the indistinct linguistic expression $\mathrm{A}_\mathrm{i}^\mathrm{L} = E_j$ – "The installation has very low reliability level" has a linguistic variable *E* "Installation reliability", one of the term of which is E_j – "Low reliability level". Modifier of the term ∇_1 – is expressed by the word "Very". Another indistinct linguistic expression $\nabla_2 B_1^L$ "There needed parallel connection of much higher than average number of such installations" uses linguistic variable E "Number of parallel installations", one of the term of which is E_j "Average number of installations". Modifier of the term $\nabla_2 B_1^L$ – is defined by the words "much higher", which in this case is equivalent to modifier "Very".

As the semantic procedures of forming the modifiers and corresponding formulas of determining membership functions of the terms with linguistic variables with modifiers do not exist, so this work is going to consider this task, too.

Further in the work there will be used terms A^L for linguistic variables as fuzzy variables with trapezoidal function of membership, that are featured by 4 numbers: $A^L=\langle a:b:c:d\rangle$, in which the carrier of fuzzy variables $s=d-a$, and kernel $r=c-b$ (fig. 2). The work [7] shows that setting up side branches of membership functions as linear ones doesn't lower the generality of the evaluation task, but all the mathematical operations on fuzzy variables are becoming significantly simpler.

The left branch of the trapezoidal membership function takes the form:

$$\mu_л(x)=\frac{x-a}{b-a};\ x\in[a;b], \tag{2}$$

the right branch –

$$\mu_п(x)=\frac{d-x}{d-c};\ x\in[c;d]. \tag{3}$$

For defuzzification of such a fuzzy variable using the method of gravitation center it is convenient to use the formula [6]:

$$x_{ц.т.}=\frac{\int_{-\infty}^{\infty} x\cdot\mu(x)dx}{\int_{-\infty}^{\infty}\mu(x)dx}=\frac{d^2+c^2+dc-a^2-b^2-ab}{3(d-a+c-b)}. \tag{4}$$

For fuzzy numbers (b=c) formula (4) becomes even more simple:

$$x_{ц.т.}=\frac{a+b+d}{3}. \tag{5}$$

When using various modifies the following transformations of membership function of the term of linguistic variable or fuzzy variable are possible:

1. Extension of the membership function, when the left branch of membership function moves left and the right one – right, which corresponds to such modifies ∇_1, as "more or less";

2. Contraction (concentration) of the membership function, when the left branch of membership function moves right and the right one – left, which corresponds to such modifies ∇_2, as "about", "nearly";

3. Reduction of the fuzzy variable, when both the left and right branches of membership function move right, which corresponds to such modifies ∇_3, as "much less ", "very little";

4. Increase of the fuzzy variable, when both the left and right branches of membership function move left, which corresponds to such modifies ∇_4, as "much more", "very big".

Determining trapezoidal membership function of modified terms of linguistic variable $\nabla_j A_i^L=\langle a_m;b_m;c_m;d_m\rangle$ is suggested as follows (fig. 2).

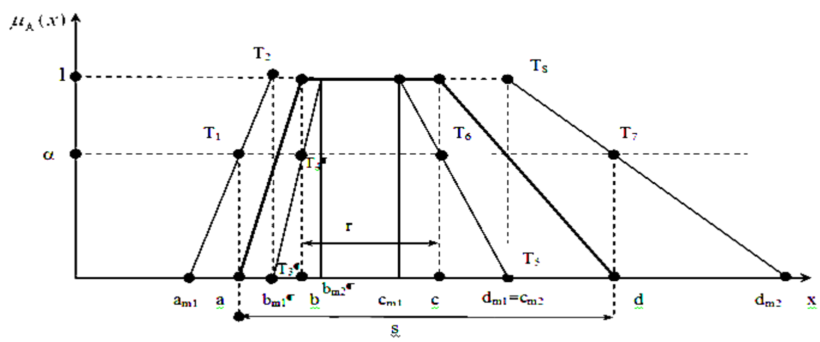

Figure 2. Diagram of determining membership function of modified terms of linguistic variables

When the left branch of membership function moves left, then points T_1 and T_2 can be determined as shown in fig. 2. The left branch of the corresponding modified term is drawn through these points. When using (2), we get for this branch:

$$b_{m1}=a+\beta(b-a); \tag{6}$$

$$a_{m1}=\frac{a-\beta b_{m1}}{(1-\beta)}, \tag{7}$$

where $\beta\in(0;1)$ – is an index, that characterizes the stage (power) of action of the corresponding modifier.

When β=0, the left branch of membership function gets vertical $(b_{m1}=a_{m1}=a)$ and when β =1, it turns into infinite horizon $(-\infty;b)$. When β ≥0.5, the carrier of the modified term changes at larger rate than its kernel.

When the left branch of membership function moves right, then points T_3 and T_4 are found as shown in fig. 2. A new left branch of modified term is drawn through them. When using (2), we get:

$$a_{m2} = a + \beta(b-a); \quad (8)$$

$$b_{m2} = \frac{b-(1-\beta)a_{m2}}{\beta}. \quad (9)$$

When $\beta = 0$, the left branch of membership function turns into infinite horizon $(a;\infty)$, and when $\beta = 1$, it becomes vertical ($b_{m2} = a_{m2} = b$).

When the right branch of membership function moves left and through point's T_5 and T_6, then using (3), we get the following:

$$d_{m1} = d - \beta(d-c); \quad (10)$$

$$c_{m1} = \frac{c-(1-\beta)d_{m1}}{\beta}, \quad (11)$$

When the right branch of membership function moves right and through points T_7 and T_8, then using (3), we get the following:

$$c_{m2} = d - \beta(d-c); \quad (12)$$

$$d_{m2} = \frac{d-\beta c_{m2}}{1-\beta}. \quad (13)$$

From formulas (6), (8) and (10), (12) we get that $b_{m1} = a_{m2}$; and $d_{m1} = c_{m2}$.

This result corresponds to graphic finding these points as shown in fig. 2.

Index α is supposed to provide the condition

$$b_{m2} \le c_{m1}, \quad (14)$$

at which the use of modifier ∇_2 will not lead to subnormal status of membership function.

When plugging (9) and (11) in (14), we find a condition for choosing index *β* :

$$\beta \ge \frac{\nu - \sqrt{\nu^2 - 4}}{2},$$

where

$$\nu = \frac{2(d-a)-(c-b)}{(d-a)-(c-b)}. \quad (15)$$

To evaluate the variation of membership function of terms of linguistic variable or fuzzy variable we offer to use index of fuzziness k_p as a functional that is analogous to Shannon entropy [5]:

$$k_p = -\int_{-\infty}^{+\infty} \mu_A(x) \ln \mu_A(x) \cdot dx,$$

where $\mu_A(x)$ – of membership function of fuzzy variable *A*.

The index of fuzziness has the following properties.

Property1. Index of fuzziness k_p of any normal continuous fuzzy variable (FV) is directly proportional to the difference between its carrier s and kernel r of the fuzzy variable:

$$k_p = K(s-r), \quad (16)$$

where K– fixed coefficient [7].

For the linear side branches as show in work [7], K=0.25 and changes irrelevantly, if side branches of the membership function are non-linear.

Property 2. When shifting the membership function of FV along the X axis index of fuzziness does not change. In other words, if

$$k_{pA} = -\int_{-\infty}^{\infty} \mu_A(x) \ln \mu_A(x) \cdot dx,$$

then

$$k_{p\tilde{A}} = \int_{-\infty}^{\infty} \mu_A(x-l) \ln \mu_A(x-l) \cdot dx = k_{pA}.$$

Proving is done by changing the variables in the integral.

Property 3. When extending the membership function of FV the membership function of FV along *x* axis in the way that the carrier and kernel grow by one and the same value *L*, index of fuzziness does not changes.

Indeed, according to (16), we have

$$k_p = K \cdot (s + L - r - L) = K(s-r).$$

Property 4. When membership function of FV along *x* axis is extended n times, so is changed the index of fuzziness by n times, too.

Indeed, when the membership function of FV along *x* axis is extended n times so is changed the carrier and kernel by n times, too. According to (16), we have

$$k_{pA} = K \cdot (ns - nr) = Kn(s-r).$$

Property 5. When only kernel r is extending n times, the index of fuzziness changes.
Indeed, according to (16), we have

$$\Delta k_p = k_{pA} - k_{p\breve{A}} = K \cdot r(n-1);$$

Property 6. When only carrier r is extending n times, the index of fuzziness grows.
Indeed, according to (16), we have

$$\Delta k_p = k_{p\breve{A}} - k_{pA} = K \cdot s(n-1).$$

When evaluating the index of fuzziness of FV it is convenient to utilize the following theorems.

Theorem1. The index of fuzziness k_{pA} of a sum of fuzzy variables $A_\zeta, \zeta = 1,...\tau$, equals a sum the indexes of fuzziness $k_{p\xi}$ of these variables:

$$k_{pA} = \sum_{\xi=1}^{\tau} k_{p\xi}.$$

Proving is done by mathematic induction method.

Theorem2. The index of fuzziness k_{pA} of difference between two FV equals a sum of indexes of fuzziness of these variables:

$$k_{pA} = k_{p1} + k_{p2}.$$

Proving. In accordance with generalization principle [1] the membership function of difference between two FV is defined as four numbers $\langle a_1 - d_2, b_1 - c_2, c_1 - b_2, d_1 - a_2 \rangle$. Then

$$k_{pA} = K(s-r) = K\left(d_1 - a_2 - (a_1 - d_2) - (c_1 - b_2) - (b_1 - c_2)\right) =$$
$$= K\left(d_1 - a_1 - (c_1 - b_1) + d_2 - a_2 - (c_2 - b_2)\right) = K\left(s_1 - r_1 + (s_2 - r_2)\right) = k_{p1} + k_{p2},$$

as was to be proved.

Utilizing (16), we will determine the expressions for kernel $r_{\nabla i}$, carrier $s_{\nabla i}$ and index of fuzziness $k_{p\nabla i}$ for various modifiers.

1. For the modifier of extension "more or less" ∇_1, when the left branch of the membership function moves left and right one – right, the modified term $\nabla_1 A^L = \langle a_{m1} : b_{m1} : c_{m2} : d_{m2} \rangle$ has the following formulas:

$$r_{\nabla 1} = c_{m2} - b_{m1} = \beta r + (1-\beta)s = \beta(c-b) + (1-\beta)(d-a); \quad (17)$$

$$s_{\nabla 1} = d_{m2} - a_{m1} = \frac{s - \beta r_{\nabla 1}}{1-\beta} = \frac{d - a - \beta((1-\beta)(d-a) + \beta(c-b))}{1-\beta}; \quad (18)$$

$$k_{p\nabla 1} = K(s_{\nabla 1} - r_{\nabla 1}) = K(d_{m2} - a_{m1} - c_{m2} + b_{m1)} = K\frac{s - r_{\nabla 1}}{1-\alpha}. \quad (19)$$

2. For the modifier of contraction "about" or "nearly" ∇_2, when the left branch of the membership function moves right and right one – left, the modified term $\nabla_2 A^L = \langle a_{m2} : b_{m2} : c_{m1} : d_{m1} \rangle$ has the following formulas:

$$s_{\nabla 2} = d_{m1} - a_{m2} = \beta r + (1-\beta)s = \beta(c-b) + (1-\beta)(d-a); \quad (20)$$

$$r_{\nabla 2} = c_{m1} - b_{m2} = \frac{r - (1-\beta)s_{\nabla 2}}{\beta} = \frac{c - b - (1-\beta)(d_{m1} - a_{m2})}{\beta}; \quad (21)$$

$$k_{p\nabla 2} = K(s_{\nabla 2} - r_{\nabla 2}) = K(d_{m1} - a_{m2} - c_{m1} + b_{m2}) = K(c_{m2} - c_{m1} + b_{m2} - b_{m1}). \quad (22)$$

3. For the modifier of reduction "much less", "very little" ∇_3, when both the left and the right branches of the membership function move left, the modified term $\nabla_3 A^L = \langle a_{m1} : b_{m1} : c_{m1} : d_{m1} \rangle$ has the following formulas:

$$s_{\nabla 3} = d_{m1} - a_{m1} = d - \beta(d-c) - \frac{a - \beta b_{m1}}{1-\beta}; \quad (23)$$

$$r_{\nabla 3} = c_{m1} - b_{m1} = \frac{c - (1-\beta)d_{m1}}{\beta} - a - \beta(b-a); \quad (24)$$

$$k_{p\nabla 3} = K(s_{\nabla 3} - r_{\nabla 3}) = K(d_{m1} - a_{m1} - c_{m1} + b_{m1}) = K(s_{m1} - r_{m1}), \quad (25)$$

where $s_{m1} = d_{m1} - a_{m1}; r_{m1} = c_{m1} - b_{m1}$.

4. For the modifier of increase "much more", "very big" ∇_4, when both the left and the right branches of the membership function move right, the modified term $\nabla_4 A^L = \langle a_{m2} : b_{m2} : c_{m2} : d_{m2} \rangle$ has the following formulas:

$$s_{\nabla 4} = d_{m2} - a_{m2} = \frac{s - \beta r_{\nabla 1}}{1-\beta} = \frac{d - a - \beta((1-\beta)(d-a) + \beta(c-b))}{1-\beta}; \quad (26)$$

$$r_{\nabla 4} = c_{m2} - b_{m2} = \beta r + (1-\beta)s = \beta(b-a) + (1-\beta)(d-a); \quad (27)$$

$$k_{p\nabla 4} = K(s_{\nabla 4} - r_{\nabla 4}) = K(d_{m2} - a_{m2} - c_{m2} + b_{m2}) = K(s_{m2} - r_{m2}), \quad (28)$$

where $s_{m2} = d_{m2} - a_{m2}; r_{m2} = c_{m2} - b_{m2}$.

As we see with (17) and (20), $r_{\nabla 1} = s_{\nabla 2}$.

When using various modifiers, the indexes of fuzziness change:

$$\nabla k_{p\nabla 1} = k_{pA^L} - k_{p\nabla_1 A^L} = K(s - r - d_{m2} + a_{m1} + c_{m2} - b_{m1}); \quad (29)$$

$$\nabla k_{p\nabla 2} = k_{pA^L} - k_{p\nabla_{21} A^L} = K(s - r - d_{m1} + a_{m2} + c_{m1} - b_{m2}); \quad (30)$$

$$\nabla k_{p\nabla 3} = k_{pA^L} - k_{p\nabla_3 A^L} = K(s - r - d_{m1} + a_{m1} + c_{m1} - b_{m1}); \quad (31)$$

$$\nabla k_{p\nabla 4} = k_{pA^L} - k_{p\nabla_{41} A^L} = K(s - r - d_{m2} + a_{m2} + c_{m2} - b_{m2}); \quad (32)$$

At α=0.5 the index of fuzziness while using the modifiers ∇_1, ∇_3 and ∇_4 does not change in comparison with the index of fuzziness of the starting term, as the kernel and carrier change by one and same value (properties 3). Hence, in practice, if it meets the requirements (15), it is better to choose *β* = 0.5.

In the end, we will give an illustrational example of using the offered method of defining the membership function of modified terms of linguistic variables that are used in decision making support on the basis of fuzzy logic system and their analysis.

Example. Given term of linguistic variable $A^L = \langle a : b : c : d \rangle = \langle 2;4;8;10 \rangle$. We will find modified terms and make their analysis.

Solution. If coefficient *β* = 0.5. It meets the requirement (15).

Indeed, $$\beta \ge \frac{\nu - \sqrt{\nu^2 - 4}}{2} = \frac{3 - \sqrt{9-4}}{2} = 0.38,$$

where $\nu = \dfrac{2(d-a)-(c-b)}{(d-a)-(c-b)} = \dfrac{2(10-2)-(8-4)}{(10-2)-(8-4)} = 3.$

By using formula (6)–(13), we find:

$$b_{m1} = a + \beta(b-a) = 2 + 0.5(4-2) = 3;\ a_{m1} = \frac{a - \beta b_{m1}}{(1-\beta)} = \frac{2 - 0.5*3}{1-0.5} = 1;\ \ a_{m2} = a + \beta(b-a) = 3;$$

$$b_{m2} = \frac{b - (1-\beta)a_{m2}}{\beta} = \frac{4 - (1-0.5)3}{0.5} = 5;\ d_{m1} = d - \beta(d-c) = 10 - 0.5(10-8) = 9;$$

$$c_{m1} = \frac{c - (1-\beta)d_{m1}}{\beta} = \frac{8 - (1-0.5)9}{0.5} = 7;\ c_{m2} = d - \beta(d-c) = 10 - 0.5(10-8) = 9;\ d_{m2} = \frac{d - \beta c_{m2}}{1-\beta} = \frac{10 - 0.5*9}{1-0.5} = 11.$$

Then the membership functions are shown as the following trapezoid:

$$\nabla_1 A^L = \langle a_{m1}; b_{m1}; c_{m2}; d_{m2} \rangle = \langle 1;3;9;11 \rangle;\ \nabla_2 A^L = \langle a_{m2} : b_{m2} : c_{m1} : d_{m1} \rangle = \langle 3;5;7;9 \rangle;\ \nabla_3 A^L =$$
$$\langle a_{m1} : b_{m1} : c_{m1} : d_{m1} \rangle = \langle 1;3;7;9 \rangle;;\ \nabla_4 A^L = \langle a_{m2} : b_{m2} : c_{m2} : d_{m2} \rangle = \langle 3;5;9;11 \rangle.$$

Using formula (16) or formulas (19), (22), (25), (28) we find the indexes of fuzziness of modified terms:

$$k_{p\nabla 1} = K(s_{\nabla 1} - r_{\nabla 1}) = 0.25(11 - 1 - (9-3)) = 1;\ k_{p\nabla 2} = K(s_{\nabla 2} - r_{\nabla 2}) = 0.25(9 - 3 - (7-5)) = 1;$$

$$k_{p\nabla 3} = K(s_{\nabla 3} - r_{\nabla 3}) = 0.25(9 - 1 - (7-3)) = 1;\ k_{p\nabla 4} = K(s_{\nabla 4} - r_{\nabla 4}) = 0.25(11 - 3 - (9-5)) = 1.$$

As mentioned above, at β =0.5, the indexes of fuzziness for different modifications of the term are identical. But at different β these indexes will be different. So if the index of fuzziness of terms $A^L = \langle 2;4;8;10 \rangle$ equals $k_{pA^L} = K(s - r) = 0.25(10 - 2 - (8-4)) = 1$, then it does not change at any modification.

Let us analyze how the defuzzification variables change when modifying the terms. We use formula (4) and get:

$$x_{ц.м.A^L} = \frac{d^2 + c^2 + dc - a^2 - b^2 - ab}{3(d - a + c - b)} = \frac{100 + 64 + 80 - 4 - 16 - 8}{3(10 - 2 + 8 - 4)} = 6;$$

$$x_{ц.м.\nabla_1 A^L} = 6;\ x_{ц.м.\nabla_2 A^L} = 6;\ x_{ц.м.\nabla_3 A^L} = 5;\ x_{ц.м.\nabla_4 A^L} = 7;$$

As we see, the use of modifiers ∇_1 and ∇_2 didn't change defuzzification meaning of the term, but it is only real for symmetrical the trapezoid t membership functions. It is natural, that the use of modifier ∇_3 has diminished defuzzification meaning of the term, but the use of modifier ∇_4 has enlarged it.

When we take coefficient *β*=0.6, then we find:

$$b_{m1} = 3.2;\ a_{m1} = 0.35;\ a_{m2} = 3.2;\ b_{m2} = 4.53;\ d_{m1} = 8.8;\ c_{m1} = 7.46;\ c_{m2} = 8.8;\ d_{m2} = 11.8.$$

Then the membership functions of modified terms are determined by the following trapezoids: $\nabla_1 A^L = \langle 0.35;3.2;8.8;11.8 \rangle$; $\nabla_2 A^L = \langle 3.2;4.53;7.46;8.8 \rangle$; $\nabla_3 A^L = \langle 0.35;3.2;7.46;8.8 \rangle$;; $\nabla_4 A^L = \langle 3.2;4.53;8.8;11.8 \rangle$.

The index of fuzziness of modified terms:

$$k_{p\nabla 1} = 0.25(11.8 - 0.35 - (8.8 - 3.2)) = 1.46;\ k_{p\nabla 2} = 0.67;\ k_{p\nabla 3} = 1.05;\ k_{p\nabla 4} = 1.08.$$

As we see, these indexes are already different from the index of fuzziness of the non – modified term A^L:

$$\nabla k_{p\nabla 1} = k_{pA^L} - k_{p\nabla_1 A^L} = 1 - 1.46 = -0.46;\ \nabla k_{p\nabla 2} = 0.33;\ \nabla k_{p\nabla 3} = -0.05;\ \nabla k_{p\nabla 4} = -0.08.$$

Conclusions. 1. The work offers the method of determining the membership functions of modified terms of linguistic variables, that are used in knowledge base of decision making support systems and shows the formulas obtained. 2. The properties the index of fuzziness of fuzzy variables and terms of linguistic variables are given. 3. The work outlines two theorems for the index of fuzziness of fuzzy variables and terms of linguistic variables that can be convenient to use when analyzing the sensitivity of decision making support systems based on fuzzy linguistic expressions. 4. The formulas have been obtained to evaluate the index of fuzziness for various modifiers of the term of linguistic expressions and their defuzzification. Their analysis is given.

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Стаття надійшла до редколегії 24.02.15

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ФУНКЦІЇ НАЛЕЖНОСТІ МОДИФІКОВАНИХ ТЕРМІВ ЛІНГВІСТИЧНИХ ЗМІННИХ ТА ЇХ АНАЛІЗ

У роботі запропоновані семантичні процедури знаходження функцій належності модифікованих термів лінгвістичних змінних, які відповідають таким словам , як "дуже", "більш – менш", "значне більше" або "значне менше" та отримані формули для їх розрахунків. Приведені властивості показників розмитості термів лінгвістичних змінних (нечітких змінних). Проведено аналіз змін коефіцієнтів розмитості цих функцій належності та отримані відповідні формули.

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ФУНКЦИИ ПРИНАДЛЕЖНОСТИ МОДИФИЦИРОВАННЫХ ТЕРМОВ ЛИНГВИСТИЧЕСКИХ ПЕРЕМЕННЫХ И ИХ АНАЛИЗ

В работе предложены семантические процедуры нахождения функций принадлежности модифицированных термов лингвистических переменных, которые соответствуют таким словам как "значительно", " более – менее", "существенно больше" или "существенно меньше" та получены формулы для их расчетов. Приведены свойства показателей размытости термов лингвистических переменных (нечеткие переменные). Приведен анализ изменений коэффициентов размытости этих функций та получены соответствующие формулы.

ОВСІЄНКО СЕРГІЙ АДАМОВИЧ (01.05.1953 – 25.01.2016)

Сергій Адамович Овсієнко народився у старовинному селі Германівка (у 1944–87 рр. – село Красне-2) Обухівського району Київської області. Його батьки – за освітою філологи – рано помітили математичні здібності сина і всіляко сприяли їх розвиткові. У 1967 р. Сергій вступає до Республіканської фізико-математичної школи-інтернату при Київському державному університеті ім. Т. Г. Шевченка, яку закінчує в 1970 р. із золотою медаллю. Його вчителем математики у ФМШ був В. А. Вишенський. У шкільні роки Сергій брав активну участь в Українських та Всесоюзних математичних олімпіадах для школярів, завжди був серед переможців.

У 1970 р. С. А. Овсієнко вступає на механіко-математичний факультет Київського університету. Уже з першого курсу, насамперед, під впливом професора Л. А. Калужніна, починає активно цікавитися алгеброю. Після закінчення з відзнакою в 1975 р. механіко-математичного факультету Сергій Адамович вступає до аспірантури Інституту математики АН УРСР (науковий керівник – доктор фізико-математичних наук, професор А. В. Ройтер), де в 1978 році успішно захистив кандидатську дисертацію на тему "Квадратичні форми в теорії зображень". У 1978–1982 рр. працює в Інституті математики, спочатку інженером, потім молодшим науковим співробітником. У 1982 р. С. А. Овсієнко повертається на механіко-математичний факультет, з яким більше не розлучається. Спочатку він працює в науково-дослідній частині університету на посадах молодшого і згодом старшого наукового співробітника, а потім стає завідувачем лабораторії. У 1988 р. С. А. Овсієнко переходить на викладацьку роботу на кафедру алгебри і математичної логіки, де пройшов усі щаблі: асистент, доцент, професор. Він був яскравим і неординарним педагогом, багато колишніх студентів механіко-математичного факультету з вдячністю згадують його лекції з алгебри і теорії чисел, лінійної алгебри, прикладної алгебри, різноманітних спецкурсів, які він читав з натхненням, ентузіазмом і глибоким почуттям гумору.

У 2006 р. Сергій Адамович успішно захистив докторську дисертацію на тему "Категорні методи в теорії зображень" (науковий консультант – доктор фізико-математичних наук, професор Ю. А. Дрозд). До сфери його наукових інтересів насамперед належала теорія зображень – він був одним із провідних представників добре відомої в математичному світі Київської школи з теорії зображень. Разом із Ю. Дроздом і В. Футорним він увів новий