# ТЕХНИЧЕСКИЕ НАУКИ

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# ON ONE PROBLEM OF DEVELOPING EXPERT SYSTEMS FOR THE STUDY OF COMPLEX OBJECTS

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The article discusses the construction of expert systems based on the study of complex objects. Also, the linguistic approach provided by logical aproximation procedures is studied.

***Key words:*** *term-set, knowledge, universal set, membership functions, expert systems.*

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**1. Statement of the problem.** At present, the concept of expert systems has clearly defined the tendencies for their structural and functional realization. Further efforts in this direction are concentrated mainly on the development of situation-oriented systems, such as dynamic, distributed and others, as well as on solving conceptual problems. The obvious relationship between the above problems and the understanding that the creation of an intelligent system is rarely carried out on a standard methodological basis has led to the need for appropriate research. Orientation of expert systems in these systems to a specific problem area is complicated by a large amount of information in the current situation or context. This requires consideration of other knowledge without affecting their methods of analysis and formation [1].

**2. Analysis of recent research and publications.**

Existing expert systems are conventionally divided into two classes: systems designed to upgrade the level of different specialists, including expert diagnostics, consulting, and other systems, as well as systems developed and trained for high-level specialists. The latter-class expert systems have the ability to include, modify and remove connections between knowledge base openness, information units, and other features. At the same time, arbitrary expertise is based on the study of problematic field objects in the form of information provision, the main components of which are considered as knowledge obtained from experts or as a result of modification of data on a certain scheme. Within a certain formal system, data is considered to be an ordinary set of information, and knowledge is considered to exist in different spaces with transition conditions from one of them to another [6].

Existing types of knowledge can be represented in the form of three components: declarative, procedural and managerial, and the functioning scheme, as in Fig. 1.

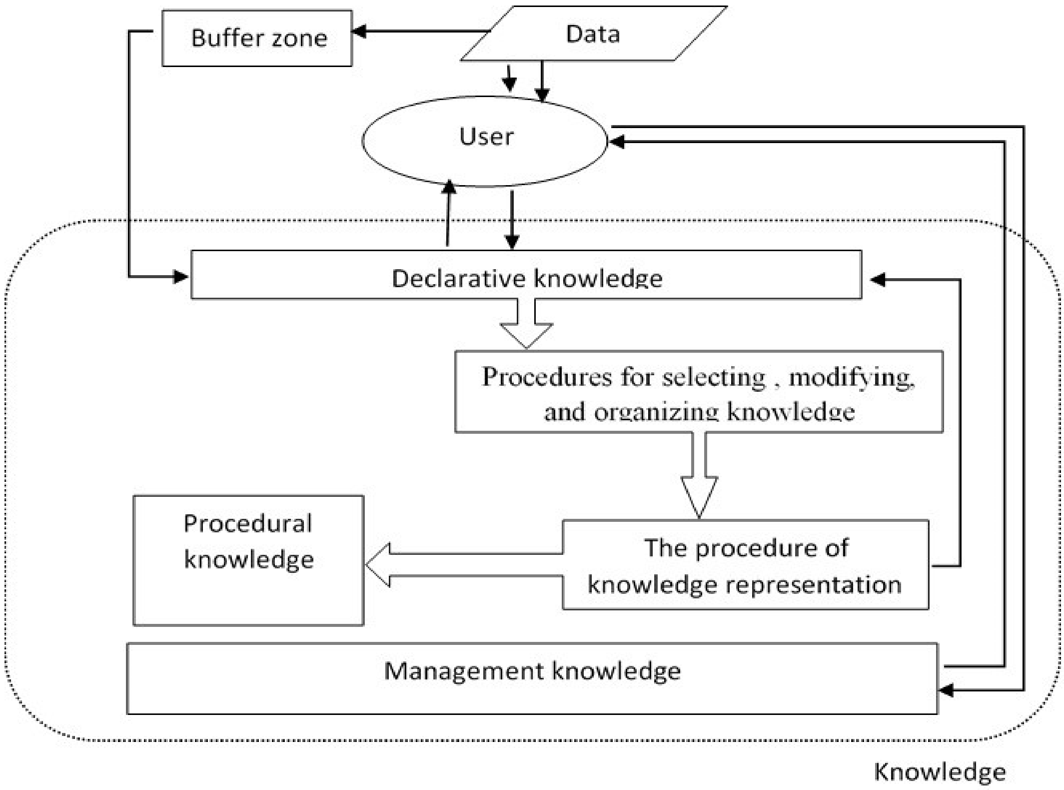


Fig. 1. The scheme of functioning of knowledge [2]

**3. Purpose of article.**

Let the problem area of the expert system be determined by a certain space R, whose center is denoted by M and we assume that at the moment of time $T_0$ M corresponds to properties $F=\{f_i\}(i=\overline{1,n})$. Let also the procedure and scale of measurement of T be Pi and Si – respectively, and n – the number of measurements. Then we will understand by $f_i$ signs of properties, $P_{f_1}.......P_{f_n}$ – procedures, and $S_{f_1}.........S_{f_n}$ – scales of their measurement. They are $f_1(M,T_0), f_2(M,T_0),..........f_n(M,T_0)$ interpreted as property values. Since $M \in R$ it is considered a formal static point $R$ , and arbitrary points $R$ can also be considered such, $R$ it will be called a formal space in the notation $R^F$ . It should be borne in mind $f_1.......f_n$ that operating properties are considered on the basis of which can be obtained other properties $\varphi_1.........\varphi_m$ .

**Presentation of the source material**

The study of the problem area is closely related to the definition of its objects and their characteristics. Since it is $R^F$ understood as a formal space, the subspaces allocated on it in a certain way can be considered as objects $R^F$ , the study of which is of particular importance in formalizing the knowledge base. In this case, the most important solution is considered to be the linguistic approach, which assumes the representation of criteria and binary relations by means of fuzzy logic with truth values of a linguistic nature. Research shows that the use of this approach requires solving problems related to the construction of membership functions and mechanisms for implementing pragmatic operations on fuzzy sets and numbers.

The construction of membership functions is the most important task of fuzzy set theory , since, as a characteristic function, it is based on the methods of formalization of fuzziness. At the same time, the membership function itself can be constructed based on considerations of the adequacy of the context essence based on the methodology for understanding fuzziness. Thus, the complexity or inaccuracy of measuring the intensity of a certain property of an object directly affects its setting, regardless of the objective reasons for the perception of this property by experts. Thus, the complexity or inaccuracy of measuring the intensity of a certain property of an object directly affects its setting, regardless of the objective reasons for the perception of this property by experts.

The assignment of the membership function is based on its existing properties, first of all, monotonicity, symmetry, continuity of the first derivative, etc., as well as the characteristics of uncertainty, the object's blurriness index, and functional dependence. In many cases, the characteristic function is built in conditions of lack of information , ambiguity and inconsistency, in others, the set of its level $\alpha$ is set , and the degrees of membership of elements to an odd set are calculated based on the probabilities of selecting objects for the specified $\alpha$ -levels. The membership function is also built on the basis of a sample and a priori information containing restrictions that characterize it. If there is insufficient data, heuristic methods are used to determine the optimal properties of functions, and their feasibility is investigated by experimental approaches.

Let R have a set of objects $A=\{\alpha_1,\alpha_2,.......\alpha_n\}$, to which properties $S_1,S_2.....S_n$ are assigned and thus A can be represented as a rectangular matrix $S=\lfloor\alpha_{ij}\rfloor: x_{ij}\in P_j : i=\overline{1,n};\quad j=\overline{1,m}$ , where is the $\alpha_{ij}$ $-j-$ th attribute of the $i$ object, $P_j$ - attribute and property, setting the restriction of changes to the $j$ -property.

Let's introduce a linguistic variable, its terms: Number (very small, small, medium, large, very large) and their notation: $c(c_1,c_2,c_3,c_4,c_5)$. Let also the original property series be a ranked series and constitute a universal set X on which fuzzy subsets are defined. The domain of the values of the membership functions is the segment [0;1] and we assume that a fuzzy set is characterized by the case S of fuzzy sets given by a pair (X, M), where $\mathrm{M}:\mathrm{X}\rightarrow\ \mathrm{S}$. Here, as a finite linearly ordered set, we will take an extended or compressed list of terms of the linguistic variable «Number». Let's make an $\{\mathrm{f}_\mathrm{k}\}$ estimate based on the assignment of membership functions, which can be performed, for example, by exponential functions of the form:

$$\mathrm{M}_{\text{small}}(X)=1-exp\left[-\left(\frac{0.25}{|-0.4-x|}\right)^{2.5}\right],$$

$$\mathrm{M}_{\text{medium}}(X)=1-exp\left[-5|x|\right],$$

$$\mathrm{M}_{\text{large}}(X)=1-exp\begin{cases}0, x<a\\0,\ x>b\end{cases}\left[1-\left(\frac{(x-a)^2}{(b-a)^2}\right)^{2.5}\right],\ a\le x\le b$$

Since the membership functions obtained in this way must have certain properties, the goal – like nature of their modification is obvious. For this purpose, we will consider the linguistic approximation of sets, which is understood as the definition of such values of the linguistic variable Ck € Ck, for which the similarity measure $\eta_b$, with fuzzy corresponds to $\mu_b$*€ T($k^e$ ), describing the vector of values of a linguistic variable $C^*=(C_1^*,.......C_e^*)$ is the maximum , here $C_k\Leftrightarrow\eta_{ck}:Y_k\rightarrow[0;1]$ fuzzy subsets corresponding to the values of a linguistic variable $C_k$.

Consider an approach based on approximating the universal set of truth values $x=0+0.1+......+0.9+1$ by fuzzy subsets , and the term set consists of three elements T(true)=true+untrue, but not false+false. Fuzzy subsets true and false are defined by values

TRUE = 0.5/0.7+0.7/0.8+0.9/0.9+1/1
False= 0.5/0.3+0.7/0.2+0.9/0.1+1/0

And their definition, taking into account only the main elements

Not true = 0.5/0.7+0.3/0.8+0.1/0.9+0/1
Not False =0.5/0.3+0.3/0.2+0.1/0.1+0/0

To form term sets, it remains to calculate the value of the subset not true, but not false. Because,

True ⋀ not true =0.5/0.7+0.3/0.8+0.1/0.9+0/1
False ⋀ Not False =0.5/0.3+0.3/0.2+0.1/0.1+0/0

and the law of contradiction in fuzzy logic is generally not fulfilled, as evidenced by elements 0.5/0.7 and 0.5/0.3, the corresponding associated terms , then we can a priori assert that they, in turn, are elements of the desired subset, as well as 1/0. 5 as a consequence of the unimodality and normality of the central linguistic term. Keep in mind that the first two elements correspond to the transition points of the specified set , while the third one corresponds to its cross section , whose intermediate values are defined as the static average of the previously calculated 1/0. 5, 0.5/0.3 and 1/0. 5, 0.5/0.7 ( due to the symmetry of unimodal membership functions)

$$(1+0.5)/2 = 0.75 \approx 0.8$$

The main elements of the «not true, but not false» subset : 0.8/0.4 and 0.8/0.6.

Let now 1/0.5 for the Central element 1 and a zero change in the degree of membership, then 0.8/0.4 second element with a membership value of 0.2 less than the previous 0.5/0.3 third, the value of which is 0.3 less, etc. We get

(1-0.2-0.3-0.4)/0.2+(1-0.2-0.3)/0.3+(1-0.2)/0.4+(1-0)/0.5+(1-0.2)/0.6+(1-0.2-0.3)/0.7+(1-0.2-0.3-0.4)/0.8=
=0.1/0.2+0.5/0.3+0.8/0.4+1/0.5+0.8/0.6+0.5/0.7+0.1/0.8 [1].

**4. Conclusions.** Within a given formal space, research objects are defined, which are considered on a linguistic basis due to the linguistic variable number and its term set. In this case, the use of membership functions is justified, which can be represented by exponential functions and approximated in order to bring them to a certain form.

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## О ПРОБЛЕМЕ РАЗРАБОТКИ ЭКСПЕРТНЫХ СИСТЕМ ДЛЯ ИЗУЧЕНИЯ СЛОЖНЫХ ОБЪЕКТОВ


В статье рассматривается построение экспертных систем, основанных на исследовании сложных объектов. Также изучается лингвистический подход, обеспечиваемый логическими процедурами аппроксимации.



***Ключевые слова:*** *набор терминов, знания, универсальный набор, функции принадлежности, экспертные системы.*




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