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General Algorithm on Fuzzy Subclasses of K-Valued Logic for Some Issues

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Abstract: The aim of the research is to study the models, rules, and fuzzy inference engines, which occupy the main place in the knowledgebase, and models of the logic inference engines and simulation modeling, focused on supporting the adoption of semi-structured decisions under uncertainty. This implies the relevance of the task of developing theoretical and methodological tools that provide automation of the processes of fuzzy inference systems. Research methods are the theory of fuzzy sets and fuzzy logic. New scientific results are the design and formation of a set of production rules from a given set of admissible ones, with specific values of conditions and conclusions for describing three types of fuzzy models of the processes and tasks under study. Using modules of standard algorithms and programs, algorithms and a program for solving problems of fuzzy inference systems and making semi-structured decisions based on the constructed fuzzy logic model were developed. This problem is solved by formalization methods based on the theory of algorithmization, fuzzy sets, and fuzzy inference.

Keywords: process, problem, requirements of qualification, study and methodic – study literatures, quality of military education, list of professors, fuzzy algorithm.

If we have a finite set of evaluation values in each node of the model tree k , then we can represent the information aggregation operator as some function of k - valued logic. If the number of node inputs is equal to n , then one of the k - valued logic functions of n variables can be used as an aggregation operator in it. Denote the set of all such functions by P_n^k.

There are a lot of such functions (k^{k^n}). The problem arises: how to choose one of them to use as an information aggregation operator? Usually an expert can determine the value of a function on some sets of its arguments. In this case, we are talking about a partially defined function. Let the values of the function on t sets be known. Denote the class of such functions by$P_{n,t}{}^k$. The number of such functions with a large difference k^n- t is also boundless. If an expert can formulate substantive conditions on the behavior of the desired function such as “When the first argument increases strongly, the value of the function decreases slightly”, “When arguments 3 and 5 increase together, the value of the function increases greatly”, etc., we can talk about fuzzy subclasses k - valued logic [1].

Consider $P_{n,t}{}^k$and denote by S *the* set of fuzzy conditions on the behavior of functions from$P_{n,t}{}^k$. The following tasks can be formulated.

Problem 1. Are the conditions S on the behavior of a particular function $f \in P_{n,t}{}^k$compatible or inconsistent?

Problem 2. If the conditions are not contradictory, is it possible to somehow describe the class of functions S $(P_{n,t}{}^{k})$ that satisfy them? In particular, is it possible to propose a procedure for calculating the degree of membership of any $f \in P_{n,t}{}^{k}$fuzzy conditions S ?

Problem 3. If the conditions S *are* inconsistent, is it possible to formulate conditions $S(S \subset S)$*that are* maximally similar to S and are consistent?

These tasks are interrelated. The solution of problems 1 and 3 can be obtained as some properties of the solution of problem 2.

This relation is defined on the Cartesian square of the domain of the function and describes the behavior of the function that satisfies it on neighboring values of the domain of definition. We will not dwell on its complete solution in detail, but consider its simplest case only for clarity.

Let us have one fuzzy condition on the behavior of a function of one variable. The fuzzy relation $\tilde{S}$,, corresponding to the fuzzy condition S , describes the belonging of a function to a given class based on the values of the function at points i and $i+1$ $(1 \leq i \leq k-1)$. The value $\mu_{\tilde{S},}(p,q)$ is the degree of membership of a function in a given class, provided that $f(i) = p, f(i+1) = q$ $(0 \leq p,q \leq -1)$. Let us give examples of such a formalization of ordinary and fuzzy conditions [2].

Example 2.1. Consider the usual, not fuzzy, condition for the function to increase. It breaks down into the following local requirements:

$$\forall i\ (1 \leq i \leq k-1)\ f(i) < f(i+1).$$

The matrix describing this condition is as follows:

$f(i)\backslash f(i+1)$	0	1	2	3	4	5
0	0	1	1	1	1	1
1	0	0	1	1	1	1
2	0	0	0	1	1	1
3	0	0	0	0	1	1
4	0	0	0	0	0	1
5	0	0	0	0	0	0

The outer row and column contain all possible values of the function at two neighboring points (i and $i+1$). At the intersection of the p -th row and the q -th column of the matrix, there is a number from {0,1} characterizing the degree of membership of the function in the described class, provided that $f(i) = p, f(i+1) = q$. It is clear that such a matrix can also be constructed for the condition of decreasing function [3-4].

Example 2.2. Consider the following fuzzy condition *"When as* x *increases, the function* $f(x)$ *increases slightly* . The matrix describing this condition may look like this:

$f(i)\backslash f(i+1)$	0	1	2	3	4	5
0	0.6	1	0.6	0.2	0	0
1	0	0.6	1	0.6	0.2	0
2	0	0	0.6	1	0.6	0.2
3	0	0	0	0.6	1	0.6
4	0	0	0	0	0.6	1
5	0	0	0	0	0	0.6

As in the previous example, the outer row and column contain all possible values of the function at two neighboring points (i and $i+1$). At the intersection of the p -th row and the q -th column of the matrix, there is a number from [0,1], which characterizes the degree of membership of the function in the described class, provided that $f(i) = p, f(i+1) = q$.

A function satisfies a fuzzy condition if it satisfies it for all values $i\,(1 \leq i \leq k-1)$. Thus, according to the fuzzy relation matrix, the $\tilde{S}$ degree of belonging of any function $f \in P_1^k$ to this condition is uniquely calculated. It will be equal to some t -norm of the corresponding degrees of membership from the matrix:

$$\mu_S(f) = \mathop{\mathrm{T}}_{i=1}^{k-1} \mu_{\tilde{S}}(f(i), f(i+1)). \qquad (2.2)$$

Example 2.3. Consider two functions: increasing and “similar” to increasing (f_1 and f_2 respectively):

x	f_1	f_2
0	0	0
1	1	1
2	2	2
3	3	2
4	4	4
5	5	5

We take multiplication as the t *-norm*. This seems convenient, since in this case, when calculating the membership degree of a function, we will take into account its behavior at all neighboring points [5-6]. Let S_1 be the condition of strict increase of the function (table from example 2.1), S_2 - the condition “slightly increasing”, given by the table from example 2.2. Then

$$\mu_{S_1}(f)=\mu_{\tilde{S}_1}(0,1)\cdot\mu_{\tilde{S}_1}(1,2)\cdot\mu_{\tilde{S}_1}(2,3)\cdot\mu_{\tilde{S}_1}(3,4)\cdot\mu_{\tilde{S}_1}(4,5)=1\cdot1\cdot1\cdot1\cdot1=1;$$

$$\mu_{S_1}(f_2)=\mu_{\tilde{S}_1}(0,1)\cdot\mu_{\tilde{S}_1}(1,2)\cdot\mu_{\tilde{S}_1}(2,2)\cdot\mu_{\tilde{S}_1}(3,4)\cdot\mu_{\tilde{S}_1}(4,5)=1\cdot1\cdot0\cdot1\cdot1=0;$$

$$\mu_{S_2}(f_1)=\mu_{\tilde{S}_2}(0,1)\cdot\mu_{\tilde{S}_2}(1,2)\cdot\mu_{\tilde{S}_2}(2,3)\cdot\mu_{\tilde{S}_2}(3,4)\cdot\mu_{\tilde{S}_2}(4,5)=1\cdot1\cdot1\cdot1\cdot1=1;$$

$$\mu_{S_2}(f_1)=\mu_{\tilde{S}_2}(0,1)\cdot\mu_{\tilde{S}_2}(1,2)\cdot\mu_{\tilde{S}_2}(2,2)\cdot\mu_{\tilde{S}_2}(3,4)\cdot\mu_{\tilde{S}_2}(4,5)=1\cdot1\cdot0\cdot1\cdot1=0.$$

An interesting practical result would be to establish a possible relationship between the degree of fuzziness of a relation that expresses some kind of fuzzy condition on the behavior of a function, and the class defined by this fuzzy relation [6-7]. Then we could predict in advance how clear and, accordingly, **reducing the uncertainty of the output, which is important for applications,** the choice of the information aggregation operator we need will be.

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