On a Model of Forming the Optimal Parameters of the Recognition Algorithms

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***Abstract*— In this work, we present solutions of two problems. First, the representation of pattern recognition problem in the standard T_{nml} table of the algorithm estimate calculation was considered. Second, the problem of finding the model, consisting of the optimal parameters of an algorithm was considered. Such procedure is carried out by the selection optimal values of the parameters of extreme algorithms. This serves to reduce the number of calculations in the algorithms of estimate calculation and to increase the quality of recognition process. The algorithmic data base of the developed system was based on mathematical apparatus of pattern recognition.**

***Index Terms* - pattern recognition, algorithms of estimate calculation, algebraic approach.**

I. INTRODUCTION

IT is considered the problem of finding the optimal in some sense, the algorithm for the standard recognition problem. Algorithm of estimate calculation (AEC) is one of the most important classes of algorithms used in recognition tasks. It is known that a recognition algorithm contains a recognizing operator and decision rule [1],[2],[3]. Let's $AEC = \langle S, \Gamma, A \rangle$. In AEC, a recognizing operator converts the standard description of the object $S_i = (x_{i1}, x_{i2}, ..., x_{in}), (x_{ij} \in M_j)$ subject to recognition into the set of numerical estimates $(\Gamma_1(S), \Gamma_2(S), ..., \Gamma_\ell(S),)$, where ℓ is the number of classes. A decision rule helps us construct the information vector $(\alpha_1^A, \alpha_2^A, ..., \alpha_\ell^A) \in \{0,1,\Delta\}$ from this set. Here $\alpha_j^A = 0$ if the algorithm does not assign object ***S*** to ***j*** class; $\alpha_j^A = 1$ if the algorithm assigns object ***S*** to ***j*** class; and $\alpha_j^A = \Delta$ if the algorithm cannot classify object ***S.***

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II. FORMULATION OF THE PROBLEM

The construction of extreme algorithms lies in finding the optimal parameter of $A = \{k, w_{\tilde{\omega}^k}, \varepsilon, \varepsilon_i, p_i, \gamma_j, v_l, r, \delta_1, \delta_2\}$ for this model recognition algorithms, this ensures that the condition $\varphi(A^*) = \underset{A^* \in \{A\}}{extr}\, \varphi(A)$.

III. METHOD OF SOLUTION

The estimate $\Gamma_j(S), (j = \overline{1,\ell})$ of the object S in regard to ***j*** class is calculated as follows:

$$\Gamma_j(S) = \frac{1}{N} \frac{1}{|M_j|} \sum_{S \in M_j} \gamma(S') \sum_{\tilde{\omega} \leftrightarrow \Omega \in \Omega_A} p(\tilde{\omega}) B_{\tilde{\omega}}(S, S') \qquad (1)$$

where N is the normalizing factor; M_j is the set of objects from ***j*** class; Ω_A is a system of support set; $B_{\tilde{\omega}}(S,S')$ is the proximity function; $\gamma(S')$ is the weight of the precedent S'; and $p(\tilde{\omega})$ is the weight of the support set Ω with characteristic vector $\tilde{\omega}$.

The setting of all these parameters – the system of support sets, a proximity function, weights of precedents and features, and a decision rule – specifies the recognition algorithm in the AEC model.

In the applied problems, where the number of precedents is large and the power of a system of support sets is high, the calculation of estimates by (1) may be very complicated and sometimes impracticable. The most complicated task here is the calculation of the sum [2],[4]:

$$\sum_{\tilde{\omega} \leftrightarrow \Omega \in \Omega_A} p(\tilde{\omega}) B_{\tilde{\omega}}(S, S') \qquad (2)$$

This complexity depends on the choice of the system of support sets Ω_A and on the type of the proximity function $B_{\tilde{\omega}}(S,S')$.

As a result the challenge arises to get efficient formulas for the estimations of calculations without exhaustive search for all support set of (2) and, thus, a combinatorial. complexity of calculating the value of (2) is replaced by the complexity which is proportional to the size of the learning table.

There are a lot of works dealing with generation of efficient formulas for AEC. They differ both in approaches to the task and in degree of generality.

In this work, we consider developing algorithm A^* for optimal formulations parameters software of recognition systems.

The recognition process in many models of computing estimates assumes knowledge of the numerical model parameters (weight characteristics, weight standards, the threshold parameters, etc.). Their values can be chosen directly by the user based on the content or heuristic arguments, since many parameters have a natural interpretation. Basically the same approach to their calculation is a process of learning or optimization models. Desired outcome in both cases is to find such values of parameters which will be provided with high accuracy.

Parameter set recognition algorithms can be assigned as $\{A(y), y \in D\}$ and it defines the real functional $\varphi(A)$ quality of the algorithm. There is a need to find an algorithm in which the functional attains its extremum:

$$\varphi(A^*) = \underset{A \in \{A\}}{extr}\, \varphi(A) \quad (3)$$

Standard functional quality of recognition is the functional:

$$\varphi(A) = \frac{1}{q\ell} \sum_{i=1}^{q} \sum_{j=1}^{\ell} \left| \alpha_{ij} - \alpha_{ij}^{A} \right| \quad (4)$$

For example, the model calculation of assessments with the methods of execution steps (a system of support sets, a proximity function, weights of precedents and features, and a decision rule) is the following parametric family of algorithms [5],[6].

General parameters of AEC:

$$A^* = \{k, w_{\tilde{\omega}^k}, \varepsilon, \varepsilon_i, p_i, \gamma_j, v_l, r, \delta_1, \delta_2\} \quad (5)$$

here k - length of the voting kits, $w_{\tilde{\omega}^k}$ - information weight of the reference set, ε - general threshold, ε_i - threshold for feature, p_i - information weight traits, γ_j - information weight of objects, v_l - information weight classes, r - threshold for the parts of votes, δ_1, δ_2 - threshold decision rules.

Search parameters as the process of "learning with teacher" are used in neural network approaches, the method of potential functions, constructing linear separating hyper planes. We specify the initial value of parameters by iteration methods. Algorithm is applied to one of the learning objects, whose class is known. The correct recognition of each object is checked by (3). The process continues until the extreme reduction of the total number of errors and the improvement of recognition quality.

More general statement of "tuning" of algorithms is related to solving a standard optimization problem of optimization models. We developed the software package PRASK-2 on the principle of AEC [7].

IV. EXPERIMENTAL RESULTS

The PRASK-2 uses the parameters of Table 1:

$$A^* = \{k, \varepsilon, \varepsilon_i, \delta_1, \delta_2\} \quad (6)$$

It is important to determine min and max values of ε_i - threshold, one of the main parameters of A^* algorithm. This, in turn, serves to solve the problem of the recognition problem based A^* algorithm qualitatively. Finding ε_i -threshold, necessary for A^* algorithm is carried out by calculating the following (7), (8) and (9) formulas:

$$\begin{cases} MinX_i^{\ell} = \min\limits_{i,j} x_{ij}^{\ell}, \\ MaxX_i^{\ell} = \max\limits_{i,j} x_{ij}^{\ell}. \end{cases} \quad (7)$$

$$\Xi_i^{\ell} = \frac{1}{2}(MaxX_i^{\ell} - MinX_i^{\ell}), \quad (8)$$

here $i = \overline{1,n},\ j = \overline{1,m},$ where ℓ is the number of classes.

As the initial values of ε_i, the minimums of the differences obtained by (8) are taken and written as following:

$$\varepsilon_i = \min_{\ell} \Xi_i^{\ell}, \quad (9)$$

here $i = \overline{1,n},$ where ℓ is the number of classes.

In the following table, the results of initial and tuned states of IRIS, WINE and ItBuri data base parameters are demonstrated.

TABLE 1
RESULTS DB OF IRIS, WINE AND ITBURI

DB	N	ℓ	Initial state (%)	QA	RP (%)	TR
IRIS	150	3	94	2	97.3	102,92
WINE	178	3	79,21	3	96,07	281,4
ItBuri	42	2	91	1	95,2	16

(DB- Data Base, N-quantity of objects, ℓ -quantity of classes, QA-quantity of attempts' $\varepsilon, \varepsilon_i$ -stages of tuning of parameters, RP- the results after the tuning of parameters, TR-time of recognition by the seconds).

V. CONCLUSIONS

In this work, we propose one of the possible methods for solving the problem of choice parameters and find optimal values of the state of the art and effective (in particular, correct) algorithm for pattern recognition. After formalizing the notion of the reduction parameters, the effect of recognition and quality recognition increased from 94% to 97.3%, from 79.21% to 96.07% and from 91% to 95.2% in IRIS, WINE and ItBuri respectively.

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