IMPROVING THE QUALITY OF DECISION MAKING, IN THE STATISTICAL RECOGNITION SYSTEM BASED ON A COMPREHENSIVE CONSIDERATION IN THEIR DECISIVE RULES, ALL THE INFORMATION FROM THE MATRIX OF THE PROBABILITY OF RECOGNIZING THE OBJECT'S CLASS AND THE DEGREE OF INFORMATIVITY OF SIGNS.

Valery Timkov, Gennady Bratchenko, Vladimir Zhukov

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Timkov V.F.
The Office of National Security and Defense Council of Ukraine
Bratchenko G. D.
Odessa State Academy of Technical Regulation and Quality
Zhukov V. A.
Research and Production Enterprise "TZHK"

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Annotation

In the vast majority of the existingstatistical systems of recognition, decisions are made based on the probability of correct recognition of object classes, and the probability of their mixing up is not taken into account or taken into account not comprehensively, partially or indirectly.

To recognize the object classes it is offered options of integrating recording of all the information that is contained in the matrix of conditional probabilities of recognition.

Keywords: statistical recognition, detection probability matrix, the probability distribution function, informativity of signs, rules for descision-making, the weighting coefficient.

В.Ф. Тимков
Аппарат Совета национальной безопасности и обороны Украины
Г. Д. Братченко
Одесская государственная академия технического регулирования и качества
В.А. Жуков
Научно-производственное предприятие «ТЖК»

ПОВЫШЕНИЕ КАЧЕСТВА ПРИНЯТИЯ РЕШЕНИЙ В СТАТИСТИЧЕСКИХ СИСТЕМАХ РАСПОЗНАВАНИЯ НА ОСНОВЕ КОМПЛЕКСНОГО УЧЕТА В ИХ РЕШАЮЩИХ ПРАВИЛАХ ВСЕЙ ИНФОРМАЦИИ ИЗ МАТРИЦЫ ВЕРОЯТНОСТЕЙ РАСПОЗНАВАНИЯ КЛАССОВ ОБЪЕКТОВ И СТЕПЕНИ ИНФОРМАТИВНОСТИ ПРИЗНАКОВ

Аннотация

В подавляющем большинстве существующих статистических систем распознавания решения принимаются на основе вероятности правильного распознавания классов объектов, а вероятности их перепутывания не учитываются, или учитываются не комплексно, частично или косвенно.
Для распознавания классов объектов предлагаются варианты комплексного учета всей информации, которая содержится в матрице условных вероятностей распознавания.

Ключевые слова: статистическое распознавание, матрица вероятностей распознавания, функции распределения вероятностей, информативность признаков, правила принятия решений, весовые коэффициенты.

1. Introduction

At the initial stage of designing a statistical system of object recognition it is necessary to select and optimize: the composition of the classes of objects for recognition, the composition and structure attributes of recognition, the rules for decision-making [1,2].

The decision about a class object in a statistical pattern recognition is based on well-known (for example, learning results) probability distribution functions of characteristic values [2], and its quality depends on the completeness of the information used in decision-making algorithms.

In the process of recognition on the basis of received (measured) values of the characters and their distribution functions, matrix of conditional probabilities of detection is constructed. On the main diagonals of the matrix there are the probabilities of correct recognition of object classes, and other elements - are the probability of mixing up of object classes.

2. The comprehensive record of all the information from the matrix of conditional probabilities of detection

We believe that for recognizing selected set $A = \{a1, a2, ..., an\}$, consisting of the $n$classes of objects ai, where$i = 1, 2, ..., n$. Let's use, for identifying classes of objects, k attributes, which have different physical nature, and recognition of object classes is based on the received in the learning process of recognition system statistical characteristics of selected features, for example, the probability distribution function of attribute values or the probability density function of characteristic values upon which it is determined the probability of correct recognition and the likelihood of mixing up of object classes. Namely, recognition of object classes consists of k measuring channels. Each channel has $n$outputs, each output corresponds to one of the $n$classes of recognized objects. With such statistical method of object recognition based on a variety signs which have different physical nature, for the decision to classify them it is convenient to use statistical collective voting rules [1,2]. Among these rules the most common is the rule of simple vote when in the final rules of the system of recognition all voting signs have a weight equal to unity, and the rule of weighted voting, which takes into account additional information about recognized object, such as the degree of informativity of signs, and the voices of features have weight coefficients which differ from unity.

We denote the probabilities in the matrix of conditional probabilities of recognition:

P_{ii}- probability of correct recognition of the object of i-class, $i = 1, 2, ..., n$;

P_{it}- probability of mixing up of objects$i$-th and t-th classes, $i, t = 1, 2, ..., n; i \neq t$.

The integration of all the information which is contained in a matrix of probability of recognition can be carried out if the process of recognition of object classes with each sign is presented as a model, based on the solution of a system of n linear equations, in which the known values are the set values of free members, and the probability of correct recognition and the mixing up from the probability matrix recognition, and unknown quantities are some hypothetical information flows, which are essentially informativity of signs for each class of objects. Such model is convenient to present and implement in the form of informational and electrical scheme. Then, at the output of all measurement channels k we construct informational and electrical schemes, consisting of n outlines, each element of which is the probability of correct recognition and the likelihood of mixing up of object classes of A. In each contour hypothetical thread I_{ii}, $i = 1, 2, ..., n$-th proceeds with informativeness of m, $m = 1, 2, ..., k$ and operates external sign, such as the unit (by virtue of equally signs) E.M.F.E_i, $i = 1, 2, ..., n$. If you know the degree of informativity of signs, the numerical values of the external E.M.F. may be different from unity. The direction of action of an external E.M.F. in each outline is opposite to the thread direction of informativeness. It is connected to the fact that each external E.M.F. is equal to sum of the product of probability of correct recognition and the probability of mixing up of object classes to the relevant threads of informativity of plurality $\bar{A}$, which is the complement of $A$to the complete set U, i.e.: $U = A \cup \bar{A}$. In other words, for example, if A - is a set of selected for detecting Air objects, $\bar{A}$ - is a set of all the rest "that flies."

Let's for each m-th, $m = 1, 2, ..., k$ characteristic (assuming that such reasoning is valid for all signs, the upper index m further drop) call the product $P_{ii}I_{ii}$as potential of correct recognition of the object of i-Class, and the product $P_{it}I_{it}$as potential of mixing up of objects i-th and t-th classes where $i, t = 1, 2, ..., n; i \neq t$. Moreover, the information thread I_{it}equals the difference between information flows in adjacent contours i and t, i.e.: $I_{it} = I_{ii} - I_{tt}$.

Let's by analogy to electrical circuits call $P_{ii}I_{ii}$as capacity of correct recognition of object i-th class using the m-th, $m = 1, 2, ..., k$ sign and $P_{it}I_{it}$as power of mixing up of objects i-th and t-th classes, $i, t = 1, 2, ..., n; i \neq t$by using the m-th, $m = 1, 2, ..., k$ characteristic.

For informational-electrical scheme, and existing in this scheme informational thread, in analogy to electric scheme, Kirchhoff's laws are valid:

1. The algebraic sum of informational threads converging at any nodes of informational and electrical scheme is equal to zero:

$$\sum_{i=1}^{n} I_{ii} = 0;$$

2. The algebraic sum of the potentials of recognition and mixing up in any closed contour of informational and electrical scheme is the algebraic sum of the EMF acting in the outline, and in their absence is equal to zero:

$$P_{ii}I_{ii} + \sum_{\substack{i,t=1 \\ i \neq t}}^{n} P_{it}I_{it} = \sum_{r=1}^{b} E_r = E_i,$$

where b is the amount of E.M.F. in each of the contours, and r is current value of b.

Let's set up a system of equations of informational equilibrium of constructed scheme:

$$\left.\begin{array}{l} P_{11}I_{11} + P_{12}I_{22}+\ldots+ P_{1n}I_{nn} = E_1 \\ P_{21}I_{11} +P_{22}I_{22}+\ldots+ P_{2n}I_{nn} = E_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ P_{n1}I_{11} + P_{n2}I_{22}+\ldots+P_{nn}I_{nn} = E_n \end{array}\right\}$$

Solutions for this system (for example, by Cramer's rule) are of the form:

$$I_{ii} = \frac{1}{\Delta}\begin{vmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{vmatrix},$$

where the i-th column of the matrix system is replaced by a column free members, and Δ - is the main determinant of the matrix system.

The decision on the recognition shall be awarded to a class of objects which potential or the capacity of correct recognition is the highest, i.e.:

$$d = \text{argmax} P_{ii}I_{ii}, \quad \text{or:} d = \text{argmax} P_{ii}I_{ii}^2.$$

Information thread I_{ii} is actually informativeness signs. This thread takes into account the composition of the whole structure of the matrix of conditional probabilities of recognition, which greatly increases recognition quality. Especially it concerns the situation, where a number of the class of n recognized objects is growing, and probability of their correct recognition are significantly close to each other.

Besides taking into account the probability of mixing up of object classes, further improvement of quality of recognition can be achieved by eliminating use in the system of recognition the rule of simple voting and take a decision there on the basis of weighted voting rules. During the operation of the recognition system it will be determined the degree of informativeness of signs. Further, on the basis of informativity of signs, it can be found weights coefficients of the rules of weighted voting.

3. Methods of redistributing the weight coefficients for weighted voting rule

Along with the proposed, it is also possible other easier way to record a priori information stored in a matrix of conditional probabilities of recognition $\|P_{mit}\|$, for recognition system with k measuring channels, $m = 1, 2, ..., k$. We believe that each measuring channel based on measurement of unique value of each feature for known priori probabilities of the emergence of the i-th object class using the Bayesian formula can be obtained in the form of column vector of estimates of posterior probabilities of hypotheses:
$\mathbf{H}_m(n) = (h_{m1}\ h_{m2}\ h_{m3}\ ...\ h_{mn})^T$ m about belonging to one of the object classes $i = 1, 2, ..., n$. For taking into account priori information, stored in the k matrices $\mathbf{P}_m(n,n) = \|P_{mit}\|$, generally, different for each m-th information channel, and reallocation of weight coefficients for weighted voting rule, it is proposed to modify the weights of these channels by multiplying their weighting coefficients on the vectors $\mathbf{P}_m(n,n)\mathbf{H}_m(n) = \mathbf{H}'_m(n)$. Obtained m vectors $\mathbf{H}'_m(n)$ below can also be used as signs in algorithms of rules of simple or weighted voting.

Conclusions

The suggested method of detection is based not only on the probabilities of correct recognition of object classes, and their likelihood of mixing up and degree of informativeness of signs, and presentation of informativeness in the form of informational thread makes it possible to produce a process of recognition, based on the classical analysis of electrical circuits. Presenting probabilities of correct recognition, and the mixing up in the form of nonlinear functions that depend, for example, on observing conditions of object classes, we obtain the nonlinear electronic circuits and, accordingly, the nonlinear system of equations of informational balance.

We also considered an easier way of adjusting the posterior probabilities of hypotheses, considering a matrix of conditional probabilities of recognition.

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