ISSN 2224-087X. Електроніка та інформаційні технології. 2019. Випуск 12. С. 20–29
Electronics and information technologies. 2019. Issue 12. P. 20–29

UDK 004.8: 004.89: 519.7 DOI: https://doi.org/10.30970/eli.12.2

GENERATION OF ELEMENTARY SIGNS IN THE GENERAL SCHEME OF THE RECOGNITION SYSTEM BASED ON THE LOGICAL TREE

I. Povhan

Department of software systems,
State High School "Uzhgorod National University",
st. Zankovetska №89B, 88000 Uzhgorod, Ukraine
igor.povkhan@uzhnu.edu.ua

In this work consider an important problem of simple and effective generation of elementary features in the general scheme of the approach – branched feature selection in the construction of tree-like schemes of recognition of discrete objects. Since the correct choice of features in the process of constructing the recognition system affects the simplicity and efficiency of the resulting scheme, a simple method of generating elementary features is proposed and several simple algorithmic implementations effective in terms of memory saving and performance are given on the basis of it.

Key words: elementary feature, recognition system, training sample, discrete object.

Introduced.

As you know from the scheme, distributed choice signs that detail has been considered in [1,2,3] process of incremental construction of the General result tree recognition meets the faster, the better will be elected subatomic signs at each step [4.5].

A key, requirement which is imposed on the elemental sign is its simplicity. The latter means that the elementary sign should represent, simple scheme (formula). Let G set $n-$dimensional arithmetic vectors, that is, sequences of real numbers $f(y_1, y_2, ..., y_n)$. Then each elemental sign on the G set represents a predicate $f(y_1, y_2, ..., y_n)$. Simple predicates in this case would be the following:

$$1)\ f(y_1, y_2, ..., y_n) = \begin{cases} 1,\ if\ \sum_{i=1}^{n} a_i y_i + b \geq 0 \\ 0,\ if\ \sum_{i=1}^{n} a_i y_i + b < 0 \end{cases}; \tag{1a}$$

$$2)\ f(y_1,y_2,...,y_n)=\begin{cases}1,\ if\ \sum_{i=1}^{n}(y_i-a_iy)^2-b\le 0\\ 0,\ if\ \sum_{i=1}^{n}(y_i-a_iy)^2-b>0\end{cases};\tag{1b}$$

$$3)\ f(y_1,y_2,....,y_n)=\begin{cases}1,\ if\ \ a_i\le y_i\le b_i,\ \ (i=1,2,...,n)\\ \quad 0,\ else\end{cases}.\tag{1c}$$

Features (1) have the general scheme: is a function $\varphi(x_1,x_2,...,x_n)$ that accepts a valid value. The function $\varphi(x_1,x_2,...,x_n)$ sets the following sign:

$$f_{\varphi}(y_1,y_2,...,y_n)=\begin{cases}1,\ if\ \ \varphi(y_1,y_2,...,y_n)\ge 0\\ 0,\ if\ \ \varphi(y_1,y_2,...,y_n)<0\end{cases}\tag{2}$$

Sign (2) depends on the complexity of the function $\varphi(y_1,y_2,...,y_n)$. In the case of (1.a) function $\varphi(y_1,y_2,...,y_n)$ is linear, as in the case of (1.b) quadratic.

In general as a function $\varphi(y_1,y_2,...,y_n)$ can be considered a random polynomial $\sum_{i_1,...,i_n} a_{i_1i_2....i_n}y^{i_1}y^{i_2}...y^{i_n}$.

The complexity of this polynomial, you can estimate the number of factor needed to ask. From this point of view the most simple polynomials are polynomials $y_i+a,(i=1,2,....,n)$ where $a-$ is a real number.

These polynomials representing the signs of the following:

$$\varphi(y_1,y_2,...,y_n)=\begin{cases}1,\ \ if\ \ y_m\ \ge\ a\\ 0,\ \ if\ \ y_m\ <\ a\end{cases},\tag{3}$$

where $m-$ a fixed number of sets of numbers $\{1,2,....,n\}$.

Note that in the case where G is a set of zero-vectors $x_1,x_2,....,x_n$, i.e., $x_i\in\{0,1\}$, $(i=1,2,...,n)$, then feature (1.1) can also be taken as elementary.

Features of the form (1.1) in the theory of two-digit functions are also called threshold function.

Let set some staff training picks and some system L - elementary features. The question arises how from L you can select elementary characteristic φ, that the best way approximarely training data.

If the number of plural features set L is not very large, then the best feature from L with can be chosen by a finite search. The latter means that for all features $\varphi_1,\varphi_2,...,\varphi_n$ of the set L it is possible to calculate the efficiency $W_M(\varphi_i),(i=1,2,....,n)$ and select the feature $\varphi_m,(1\le m\le n)$, for which the condition $W_M(\varphi_m)=\max_{1\le i\le n}W_M(\varphi_i)$ [4] is satisfied.

But only, that this situation is not very common in practice. More often, there is a situation when the set L is large enough or even infinite. For example, the set of all features of the form (1.1) is not only infinite, but also continuous. It is clear that in this situation, other approaches should be used to select elementary features.

Let us proceed directly to the consideration of the ways of choosing elementary features in the set G of $n-$ dimensional arithmetic vectors.

The general scheme of the generation elementary features.

Let us present a test sample (TS) as follows:

$$(x_1, f_R(x_1)),...,(x_M, f_R(x_M)), \quad (4)$$

where $x_i \in G$, (G - some set), $f_R(x_i) \in \{0,1,2,...,k-1\},(i=1,2,...,M)$ and accordingly $f_R(x_i)=l,(0 \le l \le k-1)$ means that $x_i \in H_l, H_l \subset G$. Here f_R is some finitely significant function that specifies the partition R of a set G, that consists of subsets (images) $H_0, H_1, H_2,..., H_{k-1}$.

Thus, it can be concluded that TS is a set (or rather a sequence) of some sets, and each set is a set of values of some features and values of some functions on this set. We can also say that the set of feature values is a certain image, and the value of the function relates this image to the corresponding image (class).

Let (4) the training sample, in which there are only two images H_0, H_1, that is $f_R(x_i)$ - takes only two values 0 and 1, and the objects x_i belong to the set G, that is have the form $y_1^i, y_2^i,...., y_n^i$, $(i=1,2,...,M)$. Consider the classes:

$$G_m = \{x_i / f_R(x_i) = m\}, \ (m=0,1). \quad (5)$$

Note that if the voters (4) have l pairs $(x_i, f_R(x_i))$, that satisfy the ratio $x_i = x$ and $f_R(x_i)=m,(0 \le m \le 1)$, it is considered that the object x is included in the class G_m - l times. Through n_0 and n_1, accordingly, denote the number of objects in the classes G_0, G_1. The choice of features, which are shown below, is based on the assumption (hypothesis) of compactness of classes G_0, G_1. The latter means that the objects of each class G_0, G_1 are grouped around some points, which are the centers of mass of these classes. As these centers, it is natural to choose the arithmetic mean of classes G_0, G_1, that is:

$$Z_0 = \frac{\sum_{x_i \in G_0} x_i}{n_0}, \quad Z_1 = \frac{\sum_{x_i \in G_1} x_i}{n_1} \quad (6)$$

Let $Z_0 = (Z_1^0,....,Z_n^0)$ and $Z_1 = (Z_1^1,....,Z_n^1)$. Z_0 and Z_1 can be interpreted as the centers of mass of images H_0, H_1 and the number n_0, n_1 - the mass of these images.

Let the component $r,(1 \le r \le n)$ satisfy the relation:

$$\left|Z_r^0 - Z_r^1\right| = \max_{1 \le i \le n}\left|Z_i^0 - Z_i^1\right| \quad (7)$$

It can be concluded that with the help of components Z_r in some sense the images H_0 and H_1 are separated in the best way. Now you need to find a point a_r on the component y_r that would be a feature of the form:

$$\varphi(y_1,\dots,y_n)=\begin{cases}1, & if\ y_r \ge a_r\\ 0, & if\ y_r < a_r\end{cases}, \tag{8}$$

the best way to share the images H_0 and H_1. It is permissible for certainty that $Z_r^0 < Z_r^1$. If only the centers of mass are known Z_0 and Z_1 then the best thing we can do is choose as the number a_r of the form:

$$a_r = \frac{Z_r^0 + Z_r^1}{2}. \tag{9}$$

If in addition to centers Z_0 and Z_1, to take into account the mass n_0 and n_1, then it is natural to assume that:

$$a_r = \frac{n_1 Z_r^0 + n_0 Z_r^1}{n_0 + n_1}. \tag{10}$$

Formula (10) follows from the following considerations. Let the points are located in this way – Fig. 1.

Fig. 1 the location of the mass centers of the classes

If we assume that the masses of images H_0 and H_1 are distributed evenly by the argument y_r, then a_r we should choose such a way that the ratio is executed:

$$\frac{a_r - Z_r^0}{Z_r^0 - a_r} = \frac{n_0}{n_1}. \tag{11}$$

Note that the formula (10) can be obtained from (11).

Algorithm for selection of elementary features for discrete objects.

Thus, it is possible to suggest the following algorithm of selection of the elementary features of the form (3).

On the sample (4) we calculate the centers of mass of classes Z_0 and Z_1, mass n_0 and n_1 images H_0 and H_1.

According to the formula (7) select the component y_r and the formula (10) is determined a_r. Feature (8) will be the result of the selection process just specified. And this choice will be the better, the more the images H_0 and H_1 are spaced on the component y_r. After selecting the attribute (8), all points x whose component $r-$ does not exceed the number a_r, refer to the image H_0, and all other points – to the image H_1.

The advantage of this algorithm is that it has elementary features of a fairly simple form. Indeed, to represent signs of the form (3), only one number a_r should be stored in memory.

An important property of this algorithm is that the calculation of the centers Z_0 and Z_1, masses n_0 and n_1 can be performed sequentially in the order of receipt of pairs TS (4). Thanks to the latter, it is not necessary to store the entire sample (4) in the computer memory.

The above algorithm can also be used in the case when the sample (4) is not stored in the external memory, and at each step of constructing a logical classification tree is fed in a new way. In the latter case, the sample (4) should be worked out until the values Z_0 and Z_1 begin to stabilize for some numerical values.

The above algorithm can be modified as follows:

1) Calculate according to (6) centers $Z_0(z_1^0,...,z_n^0)$ and $Z_1(z_1^1,...,z_n^1)$, masses n_0 and n_1.

2) For each component y_i was calculated as follows, two numbers b_i^0 and b_i^1, $(i=1,2,...,n)$.

Let us suppose for definiteness that $z_i^0 \le z_i^1$.

Define classes:

$$G_0^i = \{(y_1,...,y_n)/(y_1,...,y_n) \in \text{G}_0, y_i \ge Z_i^0\},\ G_1^i = \{(y_1,...,y_n)/(y_1,...,y_n) \in \text{G}_1, y_i \ge Z_i^1\} \quad (12)$$

Through $\overline{G_m^i}$ denote the projection of the G_m^i class on the $i-$ component. Then b_i^m we calculate as follows:

$$b_i^m = \frac{\sum_{y \in g_m^i} y}{\left|\overline{G_m^i}\right|}. \quad (13)$$

Where $\left|\overline{G_m^i}\right|$ is the number of $\overline{G_m^i}$ class objects.

Note that some objects in the $\overline{G_m^i}$ class can be repeated several times. From (13) you can see what b_i^m is the arithmetic mean of the classes $\overline{G_m^i}$. Clearly, $b_i^0 \ge z_i^0$ and $b_i^1 \ge z_i^1$. Among all components y_i we find a component y_r for which the difference $c_r = b_r^1 - b_r^0$ is the greatest. If $c_r \ge 0$, then impose:

$$a_r = \frac{b_r^1 + b_r^0}{2}. \quad (14)$$

If $c_r < 0$, then a_r it is calculated by the formula (9). After that, in accordance with (8) we construct an elementary feature φ. Note that the number b_i^0 indicates the range of masses of the image H_0 to the right of the point z_i^0, number b_i^1 of the range of masses of the image H_1 to the left of the point z_i^1.

This algorithm has such a drawback that you first need to calculate the numbers $Z_i^0, Z_i^1, (i=1,2,...,n)$, and then calculate the numbers $b_i^0, b_i^1, (i=1,2,...,n)$.

We draw attention to the fact that this procedure actually needs at every step of the proposed algorithm of the actual double processing of the test sample of the form (4).

Modification of algorithms of formation of the basic characteristics of discrete objects. Given all the above, we propose a modification of the last algorithm, in which TS of the form (4) at each step is processed only once. For ease of recording, we fix the image (class) H_0 and the first component of the $n-$dimensional vector $x=(x_1,x_2,...,x_n)$. Let $(x_i f_r(x_i))$ - couple from TS (4). Next, the first component of an arbitrary vector will be denoted by $x_i^`$.

For certainty, we assume that all pairs $(x_1 f_r(x_1)),(x_2 f_r(x_2)),...,(x_{n_0} f_r(x_{n_0}))$ and only these pairs belong to the image H_0.

At each step i of the algorithm we will calculate the number d_i,z_i,h_i,l_i^- and l_i^+, $(i=1,2,...,n_0)$. Let $x_1^` \le x_2^`$. Then you can put:

$$d_2 = x_1^`, z_2 = \frac{x_1^` + x_2^`}{2}, h_2 = x_2^`, l_2^- = 1, l_2^+ = 1. \quad (15)$$

If $x_2^` < x_1^`$, then in (15) $x_1^`$ is replaced by $x_2^`$, and $x_2^`$ on $x_1^`$.

Suppose that we have calculated the number of d_i,z_i,h_i,l_i^- and l_i^+. On the $i+1$ step lay:

$$z_{i+1} = \frac{i*z_i + x_{i+1}}{i+1} = z_i + \frac{x_{i+1} - z_i}{i+1}.$$

Check the condition $z_i \le x_{i+1}+1$. If $z_i \le x_{i+1}$ we have the following:

$$h_{i+1} = \frac{l_i^+ * h_i + x_{i+1}}{l_i^+ + 1} = h_i + \frac{x_{i+1} - h_i}{l_i^+ + 1};$$

$$l_{i+1}^+ = l_i^+ + 1, l_{i+1}^- = l_i^-, d_{i+1} = d_i.$$

If $x_{i+1} < z_i$, then put:

$$h_{i+1} = h_i, l_{i+1}^+ = l_i^+, l_{i+1}^- = l_i^- + 1;$$

$$d_{i+1} = \frac{l_i^- * d_i + x_{i+1}}{l_i^- + 1} = d_i + \frac{x_{i+1} - d_i}{l_i^- + 1}.$$

Based on (15), it is i easy to prove the following relation by induction:

$d_i \le z_i \le h_i, l_i^+ \le i, l_i^- \le i$ for all $(i=2,...,n_0)$.

Then put $d_1^0 = d_{n_0}, z_1^0 = z_{n_0}, h_1^0 = h_{n_0}$. Similarly, we calculate the number d_j^0 of components $(j=2,3,...,n)$. Thus, as above, you can calculate the numbers z_j^1, d_j^1, h_j^1, here $(j=1,2,...,n_1)$ for the image (class) H_1. Next, we expect the following:

$$c_i^` = \frac{z_i^0 + z_i^1}{2} \quad (16)$$

$$c_i^{``} = \begin{cases} \frac{d_i^0 + h_i^1}{2}, & if \;\; z_i^1 \le z_i^0; \\ \frac{d_i^1 + h_i^0}{2}, & if \;\; z_i^1 > z_i^0. \end{cases}$$

Here $(i=1,...,n)$. So in the end we will consider the following features:

$$\varphi_i^{``}(y_1,...,y_n) = \begin{cases} 1, & if\ y_i \geq c_i^{``}; \\ 0, & if\ y_i < c_i^{``}. \end{cases} \qquad (17)$$

Here, $(i = 1,...,n)$ too.

Among the signs (17) at the stage of the exam is selected and the feature φ, for which the value $W(\varphi)$ will be the greatest.

In addition to features (17), you can check the following features. But first, let the $j-$ coordinate of the vector x_i, that is included in the sample $(x_i, f(x_i))$ pair (4) be denoted by $(x_i)^j$. Next, the ratio $f_R(x_i) = m, (m = 0,1)$ is presented in the form $x_i \in H_m$. Calculate the values:

$$L_j^m = \min_{x_i \in H_m}(x_i)^j, R_j^m = \max_{x_i \in H_m}(x_i)^j. \qquad (18)$$

Here $(m = 0,1; j = 1,2,...,n)$. Next, calculate the following:

$$D_j = \begin{cases} \dfrac{L_j^0 + R_j^1}{2}, & if\ R_j^0 \geq R_j^1; \\ \dfrac{L_j^1 + R_j^0}{2}, & if\ R_j^0 < R_j^1. \end{cases} . \qquad (19)$$

After that, based on (19), we construct the following features:

$$\varphi_i^{```}(y_1,...,y_n) = \begin{cases} 1, & if\ y_i \geq D_i; \\ 0, & if\ y_i < D_i. \end{cases} \qquad (20)$$

Among the signs of the form (20) and (17) at the stage of the exam, you can choose the sign for which the value $W(\varphi)$ will be the greatest.

The characteristic of type (8) can be summarized as follows. Let $a_1, a_2, ..., a_S$ some numbers the same $a_1 \leq a_2 \leq .... \leq a_S$. Then as a sign we can take the following:

$$\varphi(y_1,...y_n) = \begin{cases} 0, & if\ y_r \leq a_1; \\ 1, & if\ a_1 < y_r \leq a_2; \\ .... \\ .... \\ .... \\ i, & if\ a_i < y_r \leq a_{i+1}; \\ .... \\ .... \\ .... \\ \text{S-1}, & if\ a_{S-1} < y_r \leq a_S; \\ \text{S}, & if\ a_S \leq y_r. \end{cases} . \qquad (21)$$

Here $(r = 1,2,...,n)$.

The following procedure is used to construct the attribute of the form (21). For each component x_i, $(1 \le i \le n)$ we calculate two numbers E_i^+ and E_i^- such that $E_i^+ \ge E_i^-$. As E_i^+ and E_i^- you can take these numbers:

$$E_i^+ = \max(z_i^0, z_i^1)\,;\; E_i^- = \min(z_i^0, z_i^1)\,. \tag{22}$$

Here z_i^0, z_i^1, respectively, the coordinates of the centers of mass of images (classes) H_0 and H_1. As E_i^+ and E_i^- can take the values:

$$E_i^+ = \max(h_i^0, h_i^1)\,;\; E_i^- = \min(d_i^0, d_i^1)\,. \tag{23}$$

Here $(i = 1,...,n)$ and $h_i^0, h_i^1, d_i^0, d_i^1$ - the values that appear in the ratio (16).

If the images H_0 and H_1 not much "scattered", then as E_i^+ and E_i^- you can take the following values:

$$E_i^+ = \max(R_i^0, R_i^1)\,;\; E_i^- = \min(L_i^0, L_i^1)\,. \tag{24}$$

For certainty, we fix the first coordinate (that is, we put $i = 1$). Let N - it be some positive integer. Divide the segment into equal parts:

$$\Delta^j = \{x_i \,/\, E_1^- + \delta * j < x_i < E_1^- + \delta(j+1)\}\,.$$

Here $(j = 0,1,3,...,N-1; i = 1,2,...,n_0)$ and $\delta = \dfrac{E_1^+ - E_1^-}{N}$. Through λ_{1j}^0 denote the number of pairs $(x_i f_r(x_i))$ with TS (4) that satisfy the ratio $(x_i)^1 \in \Delta^j, f_R(x_i) = 0$.

Similarly λ_{1j}^1, denote by the number of pairs $(x_i f_r(x_i))$ (4) that satisfy the relation $(x_i)^1 \in \Delta^j, f_R(x_i) = 1$. Here $(x_i)^1$ we denote the first coordinate of the vector x_i.

Divide the numbers $0,1,...,N-1$ into two groups Q_0 and Q_1. We define them as follows:

$$Q_0 = \{i \,/\, \lambda_{1i}^0 \ge \lambda_{1i}^1\}\,;\;\; Q_1 = \{i \,/\, \lambda_{1i}^0 < \lambda_{1i}^1\} \tag{25}$$

It is clear that $Q_0 \cap Q_1 = \varnothing$. If the ratio $(i \in Q_0 \wedge j \in Q_0) \vee (i \in Q_1 \wedge j \in Q_1)$ is satisfied for the numbers i and j, this fact is denoted by $i \approx j$. If the ratio $i \approx j$ does not take place then this fact is denoted by $i \overline{\approx} j$.

Let $j_0 < j_1 < ... < j_S$, $(j_0 = 0)$, be all such numbers $\{0,1,...,N-1\}$, that satisfy the relation:

if $j_r \le j < j_{r+1}$ then $j_r \approx j$ and $j_{r+1} \overline{\approx} j$;

if $j_S < j$ then $j_S \approx j$.

Here $(r = 0,1,...,S-1)$, and as the numbers $a_1, a_2, ..., a_S$, that are included in (21), you can take the following values:

$$\begin{aligned} a_1 &= E_1^- + \delta * j_1 \\ a_2 &= E_1^- + \delta * j_2 \\ &\ldots\ldots\ldots\ldots \\ a_S &= E_1^- + \delta * j_S \end{aligned} \tag{26}$$

Note that similar values can be calculated for all other coordinates.

The calculation of values (26) for all coordinates in direct program implementation may not be optimal from the point of view of performing a large number of operations. Therefore, among all the coordinates for the calculation of values (26) it is appropriate to choose one or more coordinates that have some features. For example, among all coordinates, you can select the coordinates i for which the value $E_i^+ - E_i^-$ is the largest.

And finally, we note that the last feature selection algorithm can be applied in the case when the images (classes) H_0 and H_1 are not related.

Result.

The paper proposes general algorithms for the formation of elementary features and schemes for their optimization in the design of discrete object recognition systems.

In this case, an attempt is made to take into account the resource features of implementations (memory, performance), as well as the main requirement for elementary features – its general simplicity.

The latter means that the elementary feature should be represented as simple as possible by a scheme (or formula).

References

1. *Povhan I.* Conceptual framework of recognition systems based on the method of extensive array of features / Povhan I., Vasilenko Yu., Vasilenko E. // Scientific and technical journal “European Journal of Enterprise Technologies”. – 2004. –№7[1]. – P. 13-15.
2. *Povhan I.* Method of extensive choice of signs in the mathematical construction of multilevel systems of pattern recognition / Povhan I., Vasilenko Yu., Vasilenko E. // Scientific and technical journal “Artificial Intelligence”. – 2003. – №7. – P. 246-249.
3. *Povhan I.* Definition of the concept of a sign in the theory of pattern recognition / , I., Vasilenko, Yu., Vassilenko, E. // Scientific and technical journal “Artificial Intelligence”. – 2002. – №4. – P. 512-517.
4. *Povhan I.* Calculation of the importance of discrete traits (analysis of some approaches) / Povhan I., Vashchuk F., Vasilenko Yu., Povhan L. // East European journal of advanced technologies. ─ 2010. ─ No. 5/4 (47). - P. 71-75.
5. *Povhan I.* Group and individual assessment of the importance of Boolean arguments / Povhan I., Vasilenko Yu., Vashchuk F., Polischuk V. // Bulletin of national technical University "Kharkiv Polytechnic Institute". – 2011. – No. 53.– P. 57-64.

ГЕНЕРАЦІЯ ЕЛЕМЕНТАРНИХ ОЗНАК У ЗАГАЛЬНІЙ СХЕМІ РОЗПІЗНАВАННЯ НА ОСНОВІ ЛОГІЧНОГО ДЕРЕВА

І. Повхан

Кафедра програмного забезпечення систем,
ДВНЗ “Ужгородський національний університет”,
вул. Заньковецкої №89Б, 88000 Ужгород, Україна
igor.povkhan@uzhnu.edu.ua

Робота піднімає важливе питання в теорії розпізнавання дискретних об‘єктів пов‘язане з загальною схемою генерації елементарних ознак при побудові результуючого логічного

дерева класифікації. Так представлення навчальних вибірок (дискретної інформації) великого об‘єму у вигляді структур логічних дерев має свої суттєві переваги в плані економічного опису даних та ефективних механізмів роботи з ними. Покриття навчальної вибірки набором елементарних ознак у випадку логічного дерева, породжує фіксовану деревоподібну структуру даних, яка в якісь мірі забезпечує навіть стиск та перетворення початкових даних навчальної вибірки, а отже дозволяє суттєву оптимізацію та економію апаратних ресурсів інформаційної системи. Отже представлення результуючої схеми розпізнавання на основі логічного дерева, дозволяє забезпечити мінімальну форму системи розпізнавання та високу якість класифікації.

В роботі пропонується загальна покрокова схема побудови елементарних ознак для такого логічного дерева, та дається схема модифікації даного алгоритму в плані економії пам‘яті та процесорного часу. Так, здатність логічних дерев виконувати одномірне розгалуження для аналізу впливу (важливості, якості) окремих змінних дає можливість працювати зі змінними різних типів у вигляді предикатів.

В даній роботі розглядається важлива проблема простої та ефективної генерації елементарних ознак в загальній схеми підходу – розгалуженого вибору ознак при побудові деревоподібних схем розпізнавання дискретних об‘єктів. Відмітимо, що галузь застосування концепції логічних дерев в даний час надзвичайно об‘ємна, а множина задач та проблем, які розв‘язуються даним апаратом може бути зведена до наступних трьох базових сегментів – задачі опису структур даних, задачі розпізнавання та класифікації, задачі регресії. Так як правильний вибір ознак в процесі побудови системи розпізнавання впливає на простоту та ефективність отриманої схеми, пропонується простий метод генерацій елементарних ознак та на основі нього приводяться декілька простих алгоритмічних реалізацій ефективних з точки зору економії пам‘яті та швидкодії.

Ключові слова: елементарна ознака, система розпізнавання, навчальний зразок, дискретний об’єкт.

Стаття: надійшла до редакції 29.09.2019,
доопрацьована 11.10.2019
прийнята до друку 12.10.2019.