Analysis of Solver Rule Construction Methods and Their Working Algorithms

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Abstract: This article mainly analyzes the heuristic and statistical methods of building a decision rule, as well as their performance algorithms, and their advantages and disadvantages are extensively analyzed.

Keywords: heuristic and statistical methods,

The decision rule is built based on the training sample extracted from it, and not for the entire set of objects. The reason for this is that the number of objects in the initial set may be large and very close to each other, and it makes the construction of a decision rule more complicated in practice.

Therefore, the educational sample should be selected in such a way that it sufficiently represents the main set when solving the given problem.

As we mentioned at the beginning of this article, the quality of the decisive rule is determined by evaluating the probability of loss. To determine this probability, a test sample of objects is drawn from the master set. When the test sample is extracted, the researcher knows in advance which object in it belongs to which class, and with the help of the built-in decision rule, the test sample objects are examined and the number of correct image detections is found. The probability of loss is calculated relative to the number of correct detections.

In addition, there are certain requirements for training and examination selections. For example: it is better that the objects to be examined do not participate in the educational selection.

In general, there are several decision rule methods for image recognition [12], but none of them can be single-valuedly good. Because a rule that works well for certain problems may give completely unsatisfactory results for others. The reason is that the decisive rule directly depends on the problem, the mutual location of classes and objects, and many other indicators.

1. Heuristic methods of constructing a decision rule

Let us be given a study sample:

$X = \bigcup_{p=1}^{r} X_p,\ \ X_k \cap X_j = \varnothing, k \neq j,\ k,j = \overline{1,r}$, here $X_p - p$ - class. r -number classes.

$x_{pi} = \left(x_{pi}^1, x_{pi}^2, \ldots, x_{pi}^N\right) \in X_p \subset R^N \ \left(i = \overline{1, m_p}\right),\ m_p$ - X_p number of class objects.

We introduce the following notation:

$$\bar{x}_p = \frac{1}{m_p}\sum_{i=1}^{m_p} x_{pi},\ p = \overline{1,r}$$

$\bar{x}_p$ - X_p a centralized object in the class.

Below are some crucial rules construction and operation principles

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1.1. ‚Benchmark method.

In this section, a decisive rule is made regarding benchmarks. The average object of each class was considered as a benchmark.

In constructing a decisive rule $\Re(x, \bar{x}_p) = \left|x - \bar{x}_p\right|$ we use. Here $\bar{x}_p$ - X_p $\left(p = \overline{1,r}\right)$ class reference, x and unknown object.

If $\min\limits_{p} \Re(x, \bar{x}_p) = \min\limits_{p=\overline{1,r}} \left|x - \bar{x}_p\right| = \left|x - \bar{x}_k\right|$ if, then $x \in X_k$ will be.

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If $\min_{p} \Re(x,\bar{x}_p) = \min_{p=\overline{1,r}} \left|x-\bar{x}_p\right| = \left|x-\bar{x}_k\right| = \left|x-\bar{x}_l\right|$, $k \neq l, k,l \in \{1, 2, ..., N\}$ if , the unknown object is considered undefined.

The advantage of this method is that it is much simpler and the number of calculations is small (the number of calculations does not exceed). If the objects within each class are located in an ellipsoidal shape, the probability of detecting an unknown object by the benchmark method is high.

Algorithm for processing the decision rule:

1 step. Given values: $\bar{x}_p$ - X_p class standard $p=\overline{1,r}$; r number of classes; x - unknown object.

2 step. All $p=\overline{1,r}$ for $\Re(x,\bar{x}_p)=\left|x-\bar{x}_p\right|$ is considered.

3 step. $k=1$ we can say

4 step. $\Re(x,\bar{x}_k)=\left|x-\bar{x}_k\right|=\min_{p}\Re(x,\bar{x}_p)$ we can say

5 step. $\Re(x,\bar{x}_k)>\Re(x,\bar{x}_{k+1})$ the condition is checked.

6 step. If 5 is done $k=k+1$ is taken as and returns to 4.

7 step. $\Re(x,\bar{x}_k)=\left|x-\bar{x}_k\right|=\min_{p}\Re(x,\bar{x}_p)$

8 step. If $\Re(x,\bar{x}_k)=\Re(x,\bar{x}_p)$ If so, the problem has no solution.

9 step. $x \in X_k$ output parameter.

1.2. The method of dividing standards

In this method, we take average objects of each class as benchmarks.

We assume $S(X_p)=\max_{i}\left|\bar{x}_p - x_{pi}\right| = r^{p}_{\max}$ $(p=\overline{1,r})$ let it be. Optional, small enough, $\varepsilon>0$ we construct the following conditions for the quantity:

$$S_p = \{ x \in X : \left|x-\bar{x}_p\right| \le r^{p}_{max} + \varepsilon \} \ (p=\overline{1,r}).$$

$S_p \cap S_q = S_{p,q}$ $(p,q=\overline{1,r})$ for a set can be one of the following:

а) $S_{p,q}=\varnothing$,

б) $S_{p,q}=\{x:\ x\in X_p\}$ or $S_{p,q}=\{x:\ x\in X_q\}$,

в) $S_{p,q}=\{x:\ x\in X_p \vee X_q\}$.

The decisive rule for cases a) and b) is clear. We will dwell on the principle of operation of this rule after considering case

c). $S_{p,q}$ $\bar{x}_{p_1} = \frac{1}{|S_{p,q}\cap X_p|}\sum_{x\in S_{p,q}\cap X_p} x$ and $\bar{x}_{q_1} = \frac{1}{|S_{p,q}\cap X_q|}\sum_{x\in S_{p,q}\cap X_q} x$ we introduce standards.

We will build the following spheres just like above
:

$$S_{p_1}=\{x:|x-\bar{x}_{p_1}|\le r^{p_1}_{\max}+\varepsilon\},\ S_{q_1}=\{x:|x-\bar{x}_{q_1}|\le r^{q_1}_{\max}+\varepsilon\}.$$

$S_{p_1}\cap S_{q_1}=S_{p_1,q_1}$ we check the set, if c) as in the first step, we continue the above process again. Until this process is like a) or b) or

$\exists k\in \mathrm{N},\ \bar{x}_{pk}=\bar{x}_{qk}$ and $r^{pk}_{\max}=r^{qk}_{\max}$ ends at

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If condition a) or b) is applicable x^* for unknown object $x^* \in S_{pk}$ and $x^* \notin Sq_t$ $(k, t \in \mathrm{N}$, $q \in \{1, 2, ..., p\text{-}1, p+1,...r\})$ will be $x^* \in X_p$ be .step. $x^* \in S_{i_l}$, all $\overline{x}_{i_l}$ and equal to $r_{\max}^{i_l}$ if generic, the object is not defined and goes to step 9.

8 step. x^* for the respective spheres $l = l + 1$ and return to step 6.

9 steps. Output parameter $x^* \in X_k$ or x^* not identified.

1.3. Linear solver rule method.

If you have different class objects $D(\overline{x}) = \sum_{i=1}^{N} a_i x_i + a_0$ if it is possible to separate them from each other using hyperplanes, then such separation is called a linear decision rule. It is known that each constructed hyperplane separates two classes, and if the number of classes is large, then the number of hyperplanes also increases.

Generally speaking, if the number of classes is large, the class boundary consists of broken hyperplanes.

Suppose that the number of classes is two,

$X = X_1 \bigcup X_2$. Then it is unknown x^* the following is appropriate for the object:

$$D(x^*) = \begin{cases} > 0, & \text{агар } x^* \in X_1 \\ < 0, & \text{агар } x^* \in X_2 \end{cases}.$$

The advantage of the mentioned method does not depend much on the location of objects within the classes. The disadvantage is strongly related to the geometric position of the classes, and at the same time, if the number of classes is large, the problem of determining the hyperplanes separating the boundaries of different classes, that is, the coefficients of linear functions, increases.

1.4. Nearest neighbor method.

This method is the simplest of the decision rules, and it is recommended to use when the number of objects in the training sample is not very large, especially when the objects within the class are mutually compact.

In general, this method is used when the arrangement of objects has a complex geometric structure.

To implement this method, it is required to store all the objects in the training sample in memory. To find out which class an unknown object belongs to, first the distances between the unknown object and all the objects in the training sample are calculated, and if the distance with the object of the class is the smallest, then the unknown object is also considered to belong to this class.

In this method, the number of calculations is equal to the number of objects participating in the training sample.

If the objects of different classes are located close to each other, the level of informativeness, that is, the effectiveness of this method will decrease sharply.

Therefore, there is a generalized version of this method, which is the nearest neighbor method. In this case, all the objects in the training sample are remembered, a hypersphere with a radius centered on an unknown object is obtained, and the objects in it are analyzed. If the number of objects belonging to a class is large, the unknown object is also considered to be in that class. Here, the built-in resolver is determined when the rule is analyzed.

Algorithm of operation of the method of nearest neighbors.

1 step. Given values: $x_{pi} \in X_p$ objects $\left(i = \overline{1, m_p};\ p = \overline{1, r}\right)$ and x^* unknown object.

2 step. Each x_{pi} $\left(i = \overline{1, m_p};\ p = \overline{1, r}\right)$ for $\left\| x_{pi} - x^* \right\|$ distances are considered.

3 step. If $\min_{p,i} \left\| x_{pi} - x^* \right\| = \left\| x_{qk} - x^* \right\|$ if, $x^* \in X_q$ and goes to 5 steps.

4 step. If $\min_{p,i}\|x_{pi}-x^*\| = \|x_{qk}-x^*\| = \|x_{th}-x^*\|$ so, x^* not identified.

5 step. Output parameter $x^* \in X_q$ or x^* not identified..

Conclusion

1. Methods and algorithms for constructing a decision rule, which are widely used in solving practical problems and at the same time perform one of the main tasks of the problem of image recognition, are presented. The advantages and disadvantages of the decision rule, which is built according to the geometrical location of the educational selections and objects, were shown.

2. In the case of image identification, the methods and recommendations for constructing an informative symbol space for the case where the funds allocated for character identification are limited have been presented.

3. Based on the analysis of the methods of selection of informative signs and construction of the decisive rule, the purpose and main issue of the article was fully explained

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