The Express Method for Pattern Recognition in Production and Maintenance of Electronic Devices

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Abstract – **A pattern recognition method with statistical row, which is got with designed experiment, is offered in this paper. The row processing is used for determination of given specimen to one of ranks formed in training.**

Keywords – **Recognition, statistical row designed experiment, training, ranks, electronic devices**

Pattern recognition is used in manufacturing, management, medicine, criminology and other branches of the science. The requirements for recognition reliability are in wide limits and first of all are depends on formulation of the task.

The offered express method might be used in production and maintenance of electronic devices. The training for forming the ranks is made with representative sample from general collection. A statistical row, developed with design on experiment, is used for the recognition. To define proximity of tested specimen to corresponding rank, the members of the row are processed by an algorithm.

The purpose of training is to form the necessary number of specimen ranks. It can make in relation to one or more parameters of the device. In the second case the task is complicated and the decision is made with help of experts, who know the devices of recognized type.

In cases with one parameter, the creation of ranks can make with representative sampling from general collection. Depending on the purpose of the recognition, the number of ranks and extreme values are defined. In the simplest case they are two – with a sharp limit or with a limit strip between ranks.

The sorted by ranks specimens, are tested with full factorial design, fractional factorials or with saturated designs [3]. Parameter's values are averaged for each rank for respective trials. Thus the patterns-samples are forming and they are used in recognition.

The trials are reduced by means of design of experiments, and are definite combinations of measurements of the factors (variables), which are controlled variables. Their influence over the parameter is reported for each trial. For instance controlled variables might be – the values of passive elements of the electronic device, power supplies, external influences and other factors, and parameters are – gain coefficient, actuation threshold, cut-off frequency etc.

The output parameter's values which are got from trials, forms a statistical row which is processed by different ways depending on formulated task.

For recognition of a specimen from given device are necessary analogous trials as these which are made for forming the ranks (training). The statistical row, which is got, and statistical rows of patterns-samples are compared and according to the established proximity, the decision for pertaining of recognized specimen to a respective rank is made.

The proximity might be established by different methods. For the purposes of express analysis the using of rank correlation, created by Spearman is offered. It is not necessary to know distributions of actions and reactions for it application. And when are the small number of statistical rows' members, the estimations are very simple, since is operated with small integers. This convenience is a premise for simplifying of operations and their registration

The assessment of rank correlation is reduced to:

1. The members from both statistical rows are compared for each separate trial.
2. The members from one of the rows (in this case the row of the pattern!) are arranged by ascending or descending order, and the rank for each member is assigned by ascending order.
3. The ranks for the other row are assigned in the same way, but the correspondence of the members from both rows by trials is preserved.
4. The rank correlation coefficient R is defined by:

$$R = 1 - \frac{6\sum_{u=0}^{n}(x_u - y_u)^2}{n(n^2-1)}, \qquad (1)$$

when x and y are the ranks of the two rows for separate trials, n is number of members for each of the rows.

Depending on the R value the following stages of correlation are differed:

a) $R = 0.7 - 0.9$ – high;
b) $R = 0.5 - 0.7$ – noticeable;
c) $R = 0.3 - 0.5$ – moderate;
d) $R = 0.1 - 0.3$ – weak.

For recognition the high stage is preferable. Since the method is statistical, factors' values have accidental kind and

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probability of occurrence in the high stage reduces with decreasing of the number of trials. On the other hand in electronics the measurements are rather precision, these ensure the appropriate linear models [3].

The method and algorithm are illustrated by following example. Amplifier with powerful integrated circuit is the object. Controlled parameters (factors) are the load resistance R_L and the power supply E. The output power P_L is the parameter. In the training stage the full factorial design is used. It has $N = 2^2 = 4$ trials, also the trial in the "central" point is added, and it corresponds to the nominal values of R_L and E. In the other four trials two settings are given for the factors. For the R_L the nominal value is $R_{L0} = 4\ \Omega$ and the two settings are about 10% above and below it, i.e. $\Delta R_L = 0.5\ \Omega$. The standardized value is signed with x_1 and is as follows:

$$x_1 = \frac{R_L - R_{L0}}{\Delta R_L}. \qquad (2)$$

When $R_L = R_{L0} + \Delta R_L - x_1$ is set to 1, and when $R_L = R_{L0} - \Delta R_L - x_1$ is respectively (-1). The power supply E is standardized in the same way and is signed with x_2. The design matrix is given, in table 1.

Table 1.

Trial	Factors		P_L, W	P_L, W	P_L,W	P_L,W
	x_1	x_2	Pattern	Sample 1	Sample 2	Sample 3
0	0	0	6.00	6.10	5.95	4.80
1	1	1	5.40	5.30	5.35	5.20
2	1	-1	5.30	5.40	5.40	5.60
3	-1	1	6.90	6.50	6.85	6.20
4	-1	-1	6.70	6.80	6.75	6.90

The first for P_L column corresponds to the pattern's statistical row. It is created by averaging of the representative sample.

The next three columns contain statistical rows made by measuring of three samples. The recognition is made with two ranks. The first one is with the high correlation between the pattern and verified sample. In the second rank are the samples, for which $R < 0.7$.

Recognizing the first sample (Sample1), the rows of the pattern and Sample1 with the ranks in increasing order are as follows:

P_L, Pattern	6.00	5.40	5.30	6.90	6.70
Rank	3	2	1	5	4

P_L, Sample 1	6.10	5.30	5.40	6.50	6.80
Rank	3	1	2	4	5

The coefficient R is estimated through Eq. (1) with $n = 5$:

$$R = 1 - \frac{6[(1-2)^2+(2-1)^2+(3-3)^2+(4-5)^2+(5-4)^2]}{5(5^2-1)}$$

$R = 0.8$.

By the same way R is estimated for the second sample (Sample 2) and is $R = 0.9$. Therefore the both samples belong to the first rank, which consists of a population with the near to the pattern's qualities (characteristics).

But the third sample (Sample 3) is different. The recognition of it shows that:

P_L, Pattern	6.00	5.40	5.30	6.90	6.70
Rank	3	2	1	5	4

P_L, Sample 3	4.80	5.20	5.60	6.20	6.90
Rank	1	2	3	4	5

$$R = 1 - \frac{6[(1-3)^2+(2-2)^2+(3-1)^2+(4-5)^2+(5-4)^2]}{5(5^2-1)}$$

$R = 0.5$.

When the respective sample (Sample3) belongs to the second rank, its population consists of disqualified elements or with elements which don't meet the requirements.

Conclusion

The offered method is economical; its procedure is compact and is suitable for automatic monitoring. These and other advantages make it suitable for other applications.

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