# Systems for identification of diagnostic conditions, which use criteria with minimum difference between the standard and the registered characteristics

Georgi Krastev

***Systems for identification of diagnostic conditions, using criteria with minimum difference between the standard and the registered characteristics:*** *This paper proposes due to the conducted research a newly-developed approach toward algorithmization of the system for technical diagnostics of objects with continuous operation, which is based on the methodology of the statistics theory about the image recognition.*

***Key words:*** *Computer Systems and Technologies, Model, Diagnostics.*

## INTRODUCTION

The effective use of every technical system is unthinkable without the means for maintaining its performance.

The decision to assign the status of the diagnostic object to a certain class is taken on the basis of the measured diagnostic parameters, which indirectly characterize the internal parameters of the object or the parameters of its constructive elements. The diagnostic parameters can be numerically measurable parameters (for example the direct current potentials, the parameters of the form of the output signal, the coefficient of amplification or distortion of the signal etc.) or the continuous functions of some independent argument (for example, the amplitude-frequency characteristic, the phase-frequency characteristic, the transient response, the output signal, etc.) [1, 2, 3, 7, 8]. In many cases by complex and multi-component objects, numerical parameters, as well as characteristics of the types discussed above, are included simultaneously in the multitude of the diagnostic parameters. The choice of the diagnostic parameters is also connected with the desired level of diagnostics. After having chosen the type of the diagnostic parameters, the next step is to find the descriptions of the status classes, which actually is the task of the diagnostic modeling [4, 5, 6, 9, 10, 15].

The diagnostic algorithm is built on the basis of the chosen multitude of diagnostic parameters. It represents an exact description of the type and order of fulfillment of the control-measuring operations of the diagnostic parameters and of the operations of the processing of the obtained information with the purpose for identification the status of the object. The diagnostic algorithm determines the action and the structure of the diagnostic system, which is designed for its automatic implementation.

The paper suggests a system and methodology about identification of the diagnostic statuses, which use criteria with minimum difference between the standard and the registered characteristics.

## PRESENTMENT

The task about the diagnostics of the status is given on the basis of the configuration of some generalized characteristics (amplitude, frequency or temporary characteristics) $y(x)$.

The most typical standard characteristics $y_{ei}(x)$ $(i=1, 2, ..., n)$ is determined for each class. In the general case, every characteristics $y_{ei}(x)$ is determined as a mathematical expectation of the multitude of functions in the process of the statistics processing of the pertaining learning implementations of the temporary characteristics to the discussed class. All the standard implementations $y_{ei}(x)$ $(i=1, 2, ..., n)$ are united in the multitude B. Each class $A_j$ $(j=1, 2, ..., n)$ is analyzed as a multitude, which consists of the different learning implementations of this class.

The principle of comparison is used for the identification of the status of the researched object on the basis of its functional characteristics.

The multitude of the standard images are presented for this purpose via a multitude of points $V_j$ *(j=1, 2, …, k)* in the multidimensional space of the images. The temporary characteristics, which is being researched, is depicted as a point $S_i$ in the same space. The distance between the point $S_i$ and the points $V_j$ is determined. These distances represent the quantity measure about the accordance of the input image with one of the standards. The researched object belongs to this class , about which the distance $L(S_i, V_j)$ is the minimum one.

$$S_i \in W_j, \; ако \; L(S_i, V_j) = \min_r L(S_i, V_j) \tag{1}$$

*The accuracy* of diagnosing according to the discussed methods depends mainly on the choice of the criteria for estimating the difference between the registered characteristics and the standard characteristics.

One of the most appropriate criteria by equal distance of the standards to the borders of the particular classes consists of determining the maximum amplitude difference in the researched interval of values of the argument between the measured and ordinate normalized characteristics $y_н(x)$ of the object and the normalized standard characteristics $y_{ejн}(x)$ *(j=1, 2, ..., n)*. This difference determines the distance between the functions in the functional space:

$$\gamma_j = \max\lfloor y_н(x) - \varphi_{ejн}(x) \rfloor \quad за \quad x \in (x_1 \div x_2) \tag{2}$$

The measured characteristics belongs to this multitude Aj, about which the condition for minimum value of $\gamma_j$, i.e. $y_i(x) \in A_j$, if

$$\gamma_j = \min(\gamma_1, \gamma_2, ...\gamma_k). \tag{3}$$

has been fulfilled.

For some objects it is very appropriate to use the *integral criterion*, defined by the absolute value of the difference between the areas, bounded by the curves $y_{ejн}(x)$ and $y_н(x)$ in the operational interval $\Delta x \in (x_1 \div x_2)$ , i.e.

$$\gamma_j = \int_{x_1}^{x_2} [y_H(x) - y_{ejH}(x)] dx, \quad j = 1,2,...,n \tag{4}$$

In this case the estimation for the belonging of the characteristics to a specific class is also accomplished on the basis of the expression (3). The problem for the identification of the status of the object has a single solution in the case, when the distance $\gamma_j$, determined according to the formula (2) or (4), is significantly smaller than each of the components of the multitude

$$\{\gamma_p\} \quad (p = 1,2,.., j-1, j+1,...n) \tag{5}$$

It is much more difficult to determine the identification of the status of the object in the cases, when the smallest members of this multitude are similar in their values. In such cases, for increasing the accuracy of the identification,

the multitude of distances undergoes an additional estimation via comparison with a system of threshold coefficients, $k_j$ *(j=1, 2, ..., n)*, which are determined in the process of the statistic processing of the masses of input data.

The distances of the multitude $\{\gamma_j\}$ *(j=1, 2, ..., n)* are situated in order according to the absolute values, starting with the most junior members.

The difference G=$\gamma_j$-$\gamma_i$, is determined, as $\alpha_j$ is the first, and $\alpha_l$ - the next member from the row of the distances. The value of G is compared with a certain threshold $R_j$. If $G \geq R_j$, the researched temporary characteristics belongs to the class $A_j$. If $G < R_j$, the following solutions are possible:

- the distance between $y_н(x)$ and $y_{ejн}(x)$ c is determined via other criteria, about which this difference is expressed more strongly, after that analogical checking of the results must be done;

- the indexes of the classes $A_i$ *(i=j, l,…,m)*, are registered, about which the following inequalities are valid:

$\gamma_j < \gamma_l < ... < \gamma_m$.

In such cases the system determines several most likely statuses, or by introducing of additional information in the diagnostic system, then a single solution to this problem can be achieved, as well.

In the cases, when a better differential diagnostics is required, the interval $\Delta x \in (x_1 \div x_2)$ is divided to separate subintervals and for each of them a comparison of the particular parts of the measured and the standard characteristics is made, and finally estimation is made according to the discussed criteria. The final estimation about the belonging of the researched characteristics to the appropriate class can be achieved on the basis of a summary criterion, which takes into account the results, which have been received for the separate parts, as well as the information contents of these parts.

The following sequence of the operations is necessary to be achieved by the program implementation of the method, which is being discussed:

1. On the basis of the research of the object, which is subject to control and diagnostic classification, the classes of the statuses are determined, belonging to the multitude A, as well as the operational interval $\Delta x \in (x_1 \div x_2)$, in which the characteristics *y (x)* contains the largest information about the object.

2. The configurations of the standard characteristics $y_{ej}(x)$ *(за j=1, 2, ..., n)* and the values of the threshold coefficients *(for j=1, 2, ..., n)* are determined as a result to the learning of the diagnostic system.

3. The characteristics $\varphi_i(x)$ of the researched object is registered and after its normalization it is compared with the normalized standard characteristics of the separate classes, and for this purpose the formula (2) or (4) is used according to the type of the diagnostic objects, which are discussed.

4. On the basis of the equation (3) the minimum difference $\gamma_j$ and the next difference in relation to size $\gamma_l$ is determined.

5. The difference $G = \gamma_j - \gamma_l$, is determined, which is compared with the appropriate (for the class $A_j$ ) threshold coefficient $R_j$.

6. If the following is obtained $G \geq R_j$, the status, which is being searched, belongs to the class $A_j$.

7. If $G < R_j$ , the attribution of the sought status to the class $A_j$ can lead to a significant error.

7.1. Additional features or criteria are sought, which can lead to the increase of the difference *G*, so that it may be possible with enough accuracy to accept the availability of the one from the two statuses $A_j$ or $A_l$.

7.2. If such features or criteria miss, then the following ones are sought in the order of the rising increase of the differences of the multitude $\{\gamma_1, \gamma_2, ...., \gamma_n\}$, for which the following conditions are valid $\gamma_j - \gamma_l <,...,< \gamma_m;\ \ \gamma_j - \gamma_m \leq R_j; \gamma_j - \gamma_{m+1} > R_j$ and the appropriate to these differences classes $A_j, A_l, ..., A_m$ are accepted as the most likely ones.

7.3. If in this case a differential diagnostics is also wanted to be achieved, then additional features have to be sought, which can give the possibility for accurate classification of the status of the system to one of the classes $A_j, A_l, ..., A_m$ .

## CONCLUSION

An approach to algorithmization of the system for technical diagnostics of objects with continuous operation has been developed as a result to the research, which has been conducted. It is based on the methodology of the statistics theory of identification of images.

## REFERENCES

[[1] Belozerski, L. A. Basic structure of systems for images identification. Part 1, Donezk, 1997.

[2] Bendat, G., A. Pirsol. Measurement and analysis of random processes. World, M., 2009.

[3] Vilkas, E., E. Z. Maiminas. Solutions, theory, information, modeling. Radio and connections, M., 2001.

[4] Dide, E. Methods of data analysis. Finances and statistics, M., 2005.

[5] Juravlev, J., V. V. Rjazanov, O. V. Senko. Recognition. Mathematical methods. Program system. Practical exercises, Phasis, M., 2005.

[6] Zagoruiko, N. G. Recognition methods and their application. M., Soviet radio, 1972.

[7] Kashjal, R. L., A. R. Rao. Building dynamic models according to experimental data. M, Science, 2003.

[8] Classification and cluster, G. V. Rajzina M., World, 2008.

[9] Marinov, J., E. Ranfelova, V. Dimitrov. Technical diagnostics of radioelectrical systems and devices. Technics, Sofia, 1980.

[10] Nedev, A., K. Tenekedjiev. Technical diagnostics and images identification. Varna-Kassel-Reding, 1994.

[11] Categories and Concepts: Theoretical Views and Inductive Data Analysis. Academic Press Ltd, 2003.

[12] Diday, E. Orders and overlapping clusters by pyramids. In: Multidimensional Data Analysis (eds. J. De Leeu, W. J. Heisen, J. J. Meulman and F. Critchley), DSWO Press, Leiden, pp. 201-234, 2006.

[13] Gonzalez, R., R. Woods. Digital Image Processing. Prentice Hall, 2008.

[14] Harmon, P. Knowledge acquisition tolls //Expert Systems Strategies, vol.5, №7, 2009.

[15] Hayes, M. H. Statistical Digital Signal Processing and Modeling. Johon Wiley & sons, Inc, 2006.

[16] Hofmann, D. Knowledge based quality measurement //Proc. of the XIII IMEKO World Congres (Torino, Sept. 5 - 9, 2004), vol. 3., pp. 2215 – 2221, 2004.

**Contact information:**

assoc. prof. Georgi Krastev, PhD, Department of Computing Systems and Technologies", University of Ruse "Anfel Kanchev", phone.: 082-888 672, e-mail: gkrastev@ecs.uni-ruse.bg

**The paper has been reviewed.**