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SELECTION OF METHODS FOR DISPLAYING INFORMATION ON THE TECHNICAL CONDITION OF ELECTRONIC APPLIANCES

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ABSTRACT

A geometric interpretation of the processes of recognition and classification of the technical condition of electronic appliances is proposed, which made it possible to solve the problem of displaying information to a decision maker in accordance with the requirements for ensuring the visibility of the process of development of manufacturing defects in electronic devices.
Keywords: figurative analysis, information display, geometric interpretation, technical condition, manufacturing defects.

1. INTRODUCTION

In the process of manufacturing hybrid and integrated structures of functional electronics, integrated circuits and electronic appliances (EAs), a large number of defects occur. There is a system for monitoring manufacturing defects, but despite the large number of methods and means of detecting defects, some of them remain undetected. At the same time, the availability of these tools and their high information content provide a variety of information about the parameters of EA, the use of which makes it possible to improve monitoring and, on this basis, to adjust the technology of EA manufacturing [1,2].

Defects that occur during the implementation of technological processes further develop in accordance with the objective laws of change in the micro and macrostructure of the material environment that make up the elements and devices of the EA [3]. Considering various EA materials and processes of manufacturing defects development, analyzing and generalizing the mechanism of processes, we can conclude that there are three main types of the above changes: diffusion of components, corrosion (chemical, electrical, electrochemical), and evaporation. The kinetics of the processes is determined by the heterogeneity of the internal and external material environment of the EA, due to the internal structure and external conditions of its production and operation.

To ensure timely adjustment of the technology aimed at preventing parametric failures of EA, failure prediction is performed. The forecasting method widely used in testing and maintenance of EA, based on the analysis of random realizations of time functions obtained in the process of monitoring parameters, does not take into account the mechanism of processes leading to a change in state, so the reliability of such information analysis in some cases cannot meet the requirements for solving practical problems of ensuring the quality of EA. Another method, based on the participation of the decision maker (DM), has advantages associated with the possibility of making a guaranteed decision and verifying the forecast.

The main direction of the research adopted in this paper is to solve the problem of displaying information in accordance with the principles of the DMP. The general research methodology is determined by the basic requirements for the implementation of monitoring of production defects, including visual, which corresponds to the principles of figurative analysis, information display, a deterministic process model, and a guaranteed decision on the technical condition of the EA.

2. PRESENTATION OF THE MAIN MATERIAL

The behavior of the ERP and its decisions should be subject to the notion of some deterministic model of the observed process. There is a connection between determinism and obtaining a guaranteed solution, which in this case implies the use of a deterministic model of processes that lead to a change in the technical condition of the EA. It is also important to display information in accordance with the principles of visibility, taking into account the specifics of the EA. It should reflect the essential aspects of the process model, i.e., the changes occurring in the facility and the possibility of making a decision on the state of the EA. This decision should ensure the prediction of parametric failures. Thus, the general research methodology is determined by the basic requirements for the implementation of this approach, including visual, corresponding to the principles of figurative analysis, display of information, a deterministic process model, and a guaranteed decision on the technical condition of the EA.

To display information, it seems promising to use the concept of figurative analysis, which solves the problems of finding informative features and building complex, highly developed structures of experimental data.

It is based on an unconventional division of functions between a person and a computer, in which the machine is used mainly to form various sound, contour and color halftone representations of data, and a person visually or by ear identifies and describes informative features and holistic images of classes, selecting in a dialogue with the computer a representation that provides a solution to the problem [4]. The fundamental difference between this approach and the most common automatic methods is that a computer is used not to replace a person, but to effectively use its unique capabilities of recognizing and describing images. As practice, as well as experimental and theoretical studies have shown, image-based methods significantly expand the range of feasible tasks for analyzing experimental data and significantly reduce the cost of solving them.

To search for similarities and differences between classes, various representations of them in the form of curves in rectangular argument-function coordinates have been and are most widely used: oscillograms, spectra, correlograms. Such curves show only relatively simple differences between classes, reduced to a small set of easily observable features, such as significant differences in their dynamics, obvious periodicities, individual outliers, etc. The main criterion for choosing a display method is the degree to which a given class representation is used in the verbal and figurative hierarchy of human descriptions of images of the real world. This criterion is a direct consequence of the already mentioned requirement: in the case of a priori unknown and equally probable informative features, to provide RPOs with the possibility of visual comparison of as many feature characteristics as possible for each of their representations. The more familiar images the display contains, the easier it is to fulfill this requirement.

Oscillograms and other curves in rectangular coordinates are not the best way to represent classes in terms of this criterion. Indeed, due to their unambiguity, they form a one-dimensionally ordered sequence of extrema, kinks, and other simple local features along the abscissa axis. Such an arrangement of even quite diverse local features does not allow associating their groups with most images of the real world. The inapplicability of the natural image hierarchy to curves and the practically unacceptable complexity of visual comparison of a large number of curves by a variety of local features forces us to compare various averaged characteristics of these curves (envelopes, dynamics, dispersion, etc.). Such indicators have little to do with the original local features, i.e., they ignore most of the original information. To solve complex tasks, it is necessary to represent signals that allow using the upper levels of the hierarchy of natural images for their description and operational perception Since the vast majority of objects usually fit entirely in the field of view, psychology has long experimentally established the fact of the difficulty of visual recognition of even a well-known image represented by a sequential change of its parts. In our case, the ODA needs to identify the difference between entire classes of images as a result of comparative analysis. Since it is quite difficult to compare unfamiliar images from memory, it is necessary to simultaneously present in the field of view holistic images of a certain set of features from at least two classes.

The geometric interpretation meets this criterion [5]. Almost any analyzed parameter can be described with any accuracy by a finite (although it can be very large) set of numbers. By choosing a description system and plotting the value of each parameter along the corresponding axis of a multidimensional space of the desired dimension, any signal is assigned a certain point in this space, and each class of signals - a certain region of this space. As a result, the problem can be interpreted as the problem of finding a separating surface that separates regions of different classes with a given quality. Further, the problem of dividing into two classes, or, as it is also called, the problem of dichotomy, is almost always considered. This does not narrow the generality of consideration, since any multi-class classification problem can be easily reduced to a sequence of dichotomies.

The geometric interpretation of the problem allows us to give the following illustration (Fig. 1) [5]. Areas 0 and 1 are the classes of signals that need to be distinguished, but about which there is information in the form of a final training sample of signals that are known to belong to class 0 (dots) and class 1 (crosses).

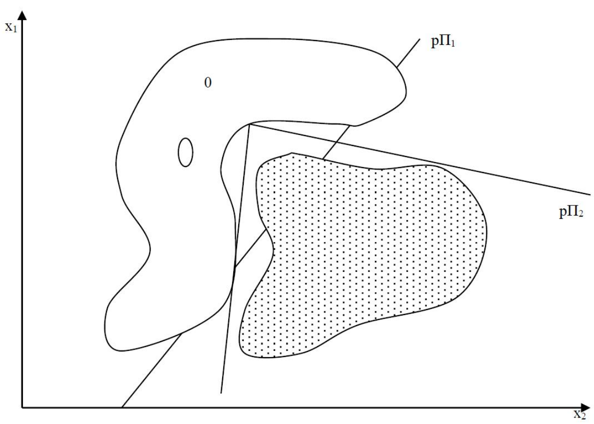

Figure 1 - Geometric interpretation of the pattern recognition task

The situation that arises during limit tests is similarly displayed. In this case, the region of permissible parameter values (q - dimensional rectangle bounded by hyperplanes with equations of the form $y_i = const$) corresponds to the limit state (image) of the EA. These hyperplanes correspond to the separating function used to divide the feature space. As a result of changing the parameters, it is possible to display a set of points with the position in the feature space determined by the values of the parameters at specified moments of time. Observation of the EA makes it possible to obtain values y_i^j at the time moments t_i. The area occupied by these points is perceived as the actual state (image) of the EA and is bounded by hyperplanes, the position of which is determined in accordance with the accepted model of the process of changing the state of the EA.

Obviously, observing the dynamics of this area's development over the time δt_p, it is possible to obtain useful information about the change in the state of the EA. Thus, the position of this area relative to the boundaries of the object characterizes the state of the EA in terms of the possibility of its failures and makes it possible to make appropriate decisions within the framework of a deterministic representation.

The solution to the recognition problem here includes the following provisions. Let the set of A objects ω consists of two groups of objects $A = A_1 \cup A_2$, wherein $A_1 \cap A_2$ in the general case is not empty. Object ω has a description $\{\omega_1, \omega_2, \ldots, \omega_n\}$. Then the recognition system that performs the given classification can be represented as a model, the block diagram of which is shown in Fig. 2.

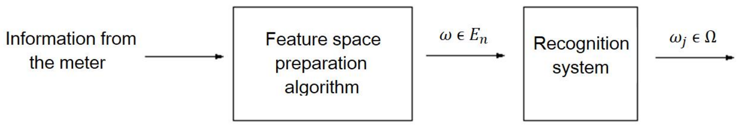

Рисунок 2 – Блок схема моделі системи розпізнавання

The input device describes the object ω according to some algorithm for preparing the feature space, and then the algorithm that implements the decision-making procedure determines which class ω_j the object under study belongs to.

The description of an object ω in an n-dimensional Euclidean space E_n corresponds to a point $(\omega_1, \omega_2, \ldots, \omega_n)$ or vector $\omega = \omega_1 e_1 + \omega_2 e_2 + \ldots + \omega_n e_n$. The work of the classifier at $n = 2$ is as follows. The system that implements the classifier must determine, based on the description of the object $\omega(\omega_1, \omega_2)$, to which class it belongs. Thus, the classifier must realize the mapping of the initial feature space defined on the set A into the production of solutions Ω. It is necessary to find a certain surface (nonlinear, multidimensional in general) that separates subsets of the set A from each other, it is called a separating surface. In our problem, this surface will limit the domain of change of EA parameters. The solutions obtained in $E_2 \supset \omega$ the subdomains R_1 and R_2 correspond to the solution domains. With an optimal (in a certain sense) drawing of the dividing surface, the solution domain R_1 includes all points (“most” points) of the first class (A_1) and there are no points in it (there are “minimum” points) of the second class.

There are various methods for determining the separating surface - one of them is the method of discriminant functions, when the concept of a class membership function, or discriminant function, is introduced to determine the separating surface. Functions of membership $g_j\{\omega_1, \omega_2, \ldots, \omega_n\}$ to the classes $A_j (j = 1,2,\ldots,J)$ have the property

$$g_j(\omega) < g_i(\omega), \quad (1)$$

if $\omega \in A_i (J = 1,\ldots,J, j \neq i, \forall i \in \{J\})$.

In our problem, these functions reflect the resource characteristics of the EA. Then the equation of the surface separating the i-th and j-th classes is $G_{ij}(\omega) = g_i(\omega) - g_j(\omega) = 0$ or $G_{ij}(\omega) = 0$.

The separating function is negative in the domain of solutions of class j and positive in the domain of solutions of class i. The points at which $G(\omega) = 0$, are considered to be neither the first nor the second class.

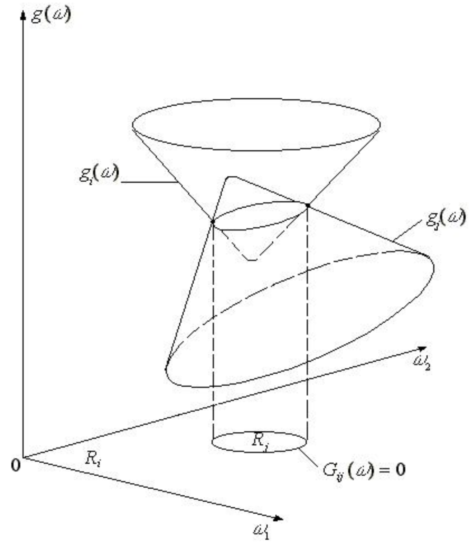

Figure 3 - View of the surface equation separating the *i-th* and *j-th* classes

If the method of geometric interpretation of pattern recognition and classification processes is used to solve the problem of displaying information about the process of development of production defects of EA, it is possible to observe the state of EA with a high degree of clarity. It displays the feature space and areas corresponding to the boundary and real controlled values of the EA parameters, during the production and operation of the EA, the configuration of the area changes, there is a change in the size and shape of this area, as well as its movement in a certain direction [6].

On the monitor screen, the most visual is the display of two-dimensional space. The task arises of mapping a multidimensional feature space into a two-dimensional one and observing the latter on the monitor screen. This problem is solved by linear mapping of *q*-dimensional vector of parameters *Y* with components y^{β}, $\beta = 1...q$ into a two-dimensional vector *X* with components x^i, $i = 1,2$, what is directly observed

$$x^i = a^i_{\beta} y^{\beta}, \tag{2}$$

where a^i_{β} – components of the weights matrix.

The name of the matrix components, the weighting coefficients, reflects their physical essence, since their value corresponds to the contribution of the corresponding parameter to the vector *X*. The choice of these coefficients determines the effectiveness of reflecting the situation and the basis for solving the problem of mapping a multidimensional feature space into a two-dimensional one.

Since at the limit value of the parameter $y^j_{гр}$ end of the vector *X* must be on the border of the working area, it is necessary that the equality is fulfilled

$$x^i{}_{гр} = a^i_j y^j{}_{гр}. \tag{3}$$

The main recommendations for choosing the *X* vector are that its components should be highly informative with respect to typical EA defects and reflect a situation approaching a critical one.

We can assume that an additional selection criterion may be the correlation coefficient r_{ij} between the parameters. Since the minimum correlation coefficient provides the maximum amount of information [5]

$$J(y^j) = H(y^j) - H\left(y^j / y^i\right), \tag{4}$$

obtained by measuring the parameter y^j. Here $H(y^j)$ is an initial uncertainty (information entropy); $H\left(y^j / y^i\right)$ – conditional entropy of the object after measuring the parameter y^i. The use of binary correlation algorithms [7,8] makes it possible to formalize and automate the processes of inputting, processing, and recognizing the resulting image with the participation of the DMP.

In addition to formal ones, heuristic methods of parameter selection can be proposed, including:

- selection of control points for digital EA based on the use of prototypes of basic logic elements [9];
- selection of controlled parameters based on information priorities [10];
- input of information based on the priority of diagnostic features [11].

Thus, the use of a geometric approach to pattern recognition in solving the problem of displaying information about the process of development of manufacturing defects makes it possible to observe the state of the EA with a high degree of clarity. It displays the feature space and areas corresponding to the boundary and real controlled values of the EA parameters, during the production and operation of the EA, the configuration of the area changes, there is a change in the size and shape of this area, as well as its movement in a certain direction. Observing the dynamics of the development of this area, it is possible to obtain useful information about changes in the parameters of the EA. Thus, the position of this area relative to the boundaries of the object characterizes the state of the EA in terms of the possibility of failures and makes it possible to make appropriate decisions on adjusting technological processes within the framework of a deterministic representation. On the monitor screen, the most visual is the display of two-dimensional space. The task arises of mapping a multidimensional feature space into a two-dimensional one and observing the latter on the monitor screen. Recommendations for choosing a two-dimensional vector of controlled EA parameters are determined.

3. CONCLUSIONS

Thus, the use of the principles of figurative analysis in solving the problem of displaying information on the development of manufacturing defects makes it possible to observe the state of the EA with a high degree of clarity. It displays the feature space and areas corresponding to the boundary and real values of the EA parameters, during the production and operation of the EA, the configuration of the area changes, there is a change in the size and shape of this area, as well as its movement in a certain direction. Observing the dynamics of the development of this area, it is possible to obtain useful information about changes in the parameters of the EA. Thus, the position of this area relative to the boundaries of the object characterizes the state of the EA in terms of the possibility of failures and makes it possible to make appropriate decisions about adjusting technological processes within the deterministic view.

On the monitor screen, the most visual is the display of two-dimensional space. The task of displaying a multidimensional feature space in two dimensions and observing the latter on the monitor screen arises. Recommendations for choosing a two-dimensional vector of controlled EA parameters are determined, since its components should be highly informative in relation to typical EA defects and reflect a situation approaching a critical one.

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