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SPACE QUALITY INDEXES OPTIMIZATION FOR SYSTEMS OF A COMPLEX OBJECTS TECHNICAL STATE RECOGNITION

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Аннотация. В статье рассматривается задача оптимизации пространства показателей качества для систем распознавания технического состояния сложных объектов. При этом предлагается целевая функция задачи оптимизации, для построения которой обосновано использование меры разрешимости уравнений обшей задачи распознавания, в частности задачи диагностики технических объектов.

Анотація. В статті розглядається задача оптимізації простору показників якості для систем розпізнавання технічного стану складних об'єктів. При цьому пропонується цільова функція задачі оптимізації, для побудови якої обгрунтовано застосування міри розв'язуваності рівнянь загальної задачі розпізнавання, зокрема задачі діагностики технічних об'єктів.

Abstract. In a paper the task of space quality indexes optimization for systems of a complex objects technical state recognition is considered. Thus the goal function of the optimization task is offered. for which construction the use of the task recognition equations solvability measure, in particular for the task of diagnostics technical objects.

Key word. Diagnosing, space of diagnosing parameters, diagnostics equation, solvability measure.

STATEMENT OF THE TASK

Now theory of recognition quickly develops, one of the basic directions of which use is diagnostics of complex objects and processes. In particular, to raise quality and reliability of products of the radio-electronic equipment, systems of processes diagnosing of their manufacture widely take root. The designing of such systems is rather complex procedure and requires the system approach. The realization of such approach is connected to construction of mathematical model of system, which is gradually specified, forming, thus, optimum space of parameters of diagnosing.

Generally, for the decision of tasks of diagnostics today allocate two basic approaches, in which basis the methods of functional diagnosing and methods based on decomposition of objects lay. In last the decomposition of objects can be carried out at various levels of detailed elaboration, where fragments of decomposition can be both complex, and elementary components.

At functional diagnosing defects are determined as a result of the decision of the equations of diagnostics made in space of generalized parameters of diagnosing. Thus the high reliability of the control is provided, as the area of serviceability of objects is described by functional dependences of parameters an elementary component [1]. However, the given methods are characterized by low depth of localization of defects occurrence place, as the equations of diagnostics, generally, have not the decision concerning parameters an elementary component.

For methods based on decomposition of objects, resolution of the diagnostics equation the above, than above level of detailed elaboration of decomposition fragments. In a limiting case, at decomposition of objects at a level an elementary component of the diagnostics equation will be solved a rather elementary component, that there corresponds to depth localization of defects at a level an elementary component. However, thus, the reliability of acceptance of the decision owing to rough approximation of objects serviceability area by the independent admissions on meanings of parameters an elementary component is reduced [1].

It is obvious that to supply high reliability of the control with localization of defects at a level an elementary component the combined approach will allow only. Thus, the basic task is the synthesis of the equations of diagnostics in some optimum space of parameters of various levels of detailed elaboration of objects.

SOLUTION OF THE TASK

Generally any task of optimization assumes presence of some constructive (diagnostic) variety. In this case such diagnostic variety can be served by system of the diagnostics equations, which is made for objects represented by multilevel mathematical model of spatial decomposition [2]:

$$\mathrm{Y} = \mathrm{F}(\mathrm{X}, \mathrm{R}). \tag{1}$$

In the given expression a component $\mathrm{X} = \left\{ \mathrm{X}^{\nu} = \left\{ \mathrm{X}_j^{\nu} \right\} \right\}$ - vector of test signals influences, $\mathrm{Y} = \left\{ \mathrm{Y}^{\nu} = \left\{ \mathrm{Y}_j^{\nu} \right\} \right\}$ - vector of object reactions on these influences, and $\mathrm{R} = \left\{ \mathrm{R}^{\nu} = \left\{ \mathrm{R}_j^{\nu} \right\} \right\}$ - vector of diagnosing parameters. The top indexes $\nu = \overline{1,\mathrm{E}}$ in the specified vectors determine horizontal levels of objects spatial model. Their meanings designate accordingly functional $\nu = 1$, fragmentary $\nu = \overline{2,\mathrm{E}\text{-}1}$ and elementary $\nu = E$ levels of decomposition. The vertical levels of spatial model are determined by the bottom indexes $j = \overline{1, m^{\nu}}$, where m^{ν} - capacity of fragments (elements) set of at the appropriate levels of decomposition.

The system of the diagnostics equations (1) generally is superfluous, as each elementary component of object has repeated representation according to number of decomposition levels. It predetermines in (1) presences of the dependent equations. From here task of optimization will consist in, that by exception of (1) dependent equations to make such system of the diagnostics equations, deciding which it is possible to locate a place of malfunctions occurrence at a level an elementary component, providing, thus, maximum accessible reliability of decisions acceptance.

First of the specified conditions imposes restriction on quantitative structure of system of the equations and consists in, that the number of the equations was equal to number of parameters an elementary component. The second condition establishes restriction on qualitative structure of diagnosing parameters set. To satisfy it, is necessary at formation of required equations system to prefer the equations, which are described in more generalized parameters. The put task can be solved, being based on results of the analysis of resolution of the initial diagnostics equations. Thus we shall proceed from the following reasons.

Generally, for any unelementary horizontal level of spatial model of object $\mu = \overline{1, E-1}$ the diagnostics equation can be described both in space of parameters R^{μ}, and in space of parameters R^{η}, where $\eta = \overline{2, E}$, $\eta > \mu$. It is possible to estimate resolution of the given equations, it is accepted with which to consider number variable, included in the decision [3], under the formula:

$$\lambda^{\mu}\left(\aleph^{\mu}\,\mathrm{R}^{(\cdot)}\right) = \sum_{j=1}^{m^{(\cdot)}} \left(n_j^{(\cdot)} \textit{-rank}\ \mathrm{M}\left[\aleph_j^{\mu}, \mathrm{R}_j^{(\cdot)}\right]\right) \equiv n^{(\cdot)} \textit{-rank}\ \mathrm{M}\left[\aleph^{\mu}, \mathrm{R}^{(\cdot)}\right], \tag{2}$$

where $(\cdot) = \mu, \eta$; $\mathrm{M}\left[\aleph_j^{\mu}, \mathrm{R}_j^{(\cdot)}\right]$ - test matrixes formed with the help of matrixes of the individual derivative initial equations in some range of definition of test signals parameters $\aleph_j^{\mu}$ [3]; $n^{(\cdot)}$ and $n_j^{(\cdot)}$ - accordingly common number of diagnosing parameters and number of diagnosing parameters of a fragment j of a horizontal section $(\cdot)$.

For the equations of diagnostics in space of parameters R^{μ} characteristic is that always it is possible to choose such set of test signals, that the given equation will have the unique decision, and the solvability measure will be equal to zero. For the equations of diagnostics in space of parameters R^{η}, thus a set of test signals, the meaning of a test matrix rank will not change. Thus owing to validity of an obvious inequality $n^{\eta} \geq n^{\mu}$, the diagnostics equation, generally, will not have the unique decision, and the solvability measure will not be equal to zero. From here it is obvious, that to satisfy the certain above conditions, the required equations system should contain all equations in space of parameters R^{μ}, and should be complemented by the equations in space of parameters R^{η}, which number will be determined by meaning of a measure $\lambda^{\mu}\left(\aleph^{\mu}\,\mathrm{R}^{\eta}\right)$.

Proceeding with above stated, it is possible to offer such procedure of a choice of parameters diagnostic optimum space in systems of the combined diagnosing.

Since a level $\mu = E-1$, for each of horizontal levels $\mu = \overline{1, E-1}$ diagnostics equations in space of parameters $R^{\mu+1}$ are formed and the solvability measure is determined:

$$\lambda_*^{\mu}\left(\aleph_*^{\mu} R^{\mu+1}\right) = n^{\mu+1} - \max_{\aleph_*^{\mu} \in \aleph^{\mu}} rank\ M\left[\aleph^{\mu}, R^{\mu+1}\right]. \tag{3}$$

The meanings of the received measures will determine for the appropriate levels of capacity of a diagnosing parameters subset:

$$R_*^{\mu+1} = \left\{R_{*p}^{\mu+1}\right\};\ p = \overline{1, \lambda_*^{\mu}\left(\aleph_*^{\mu} R^{\mu+1}\right)}. \tag{4}$$

Upon termination of such consecutive analysis the required optimum space of parameters of diagnosing will be defined(determined) by set of sets of parameters received on (4), together with set of parameters of a functional level, which capacity will be defined(determined) by the maximal meaning(importance) of a rank of a test matrix of a level $\mu = 2$:

$$R_*^1 = \left\{R_{*k}^1\right\};\ k = \overline{1, \max_{\aleph_*^1 \in \aleph^1} rank\ M\left[\aleph^1, R^2\right]}. \tag{5}$$

From here is simple to generate equation of diagnostics for system of the combined diagnosing as:

$$\begin{gathered} Y_* = F\left(X_*, R_*\right); \\ R_* \subset R;\ Y_* \subset Y;\ X_* \subset X; \\ (\cdot)_* = \left\{(\cdot)_*^1, (\cdot)_*^2, \ldots, (\cdot)_*^E\right\}. \end{gathered} \tag{6}$$

The process of diagnosing, thus, will be carried out in two stages. At the first stage the equations system (6) is solved, are checked on the admission of coordinate of a vector of parameters R_*, and by results of the control on the admission is made a decision on serviceability of object diagnosing. If the object is faulty, at the second stage the localization of a defects occurrence place is carried out which consists in the decision of system of the equations $R_* = \Phi\left(R^E\right)$ and check on the admission of coordinates of parameters vector R^E. Those elements will be faulty, which parameters leave for allowable limits.

Thus, proceeding from above stated, for restrictions determined by the requirement maximum accessible reliability of the control and maximum accessible localization of defects, the criterion function of optimum synthesis of the diagnostics equation can be described by expressions of a kind:

$$\lambda_*\left(\aleph, R\right) = n - \max_{\aleph_* \in \aleph} rank\ M[\aleph, R], \tag{7}$$

where

$$n = \sum_{\mu=1}^{E-1} \sum_{j=1}^{m^{\nu}} \left(\max_{\aleph_*^1 \in \aleph^1} rank\ M\left[\aleph^1, R_j^2\right] + n_j^{\mu} \right) - n^E; \tag{8}$$

$$rank\ M[\aleph, R] = \sum_{\mu=1}^{E-1} \sum_{j=1}^{m^{\nu}} rank\ M\left[\aleph_j^{\mu}, R_j^{\mu+1}\right]. \tag{9}$$

CONCLUSIONS

The approach, offered in the given paper, formalizes the task of the combined diagnosing systems synthesis. Thus, the optimum combination of their effectiveness and functionalities is ensured, as the solution of the task of diagnosing parameters space optimization reduces simultaneously and in an optimum choice of means for deriving an a posteriori information. It is necessary to mark, also, that the given approach can be applied to the most various tasks, for example, in medical diagnostics, systems of a discernment, control, decision making etc.

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