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AUTOMATIC SEARCH OF BREAKS WITH STEP-by-STEP VARIATIONS OF PARAMETERS OF TESTS IN COMMUNICATION SYSTEMS

Торошанко Я. І., Шматко В. С. Автоматичний пошук відмов з покроковими змінами параметрів контролю в гнучкій програмі пошуку в комунікаційних системах. Розроблено гнучку систему пошуку відмов, несправностей і аварійних режимів з покроковим уточненням апріорної імовірності відмови елементу, який піддається контролю. Для забезпечення задовільного значення достовірності розпізнавання відмови елементів застосований багатократний контроль. Розроблено структуру алгоритму пошуку відмов з двокроковою процедурою випробування, коли спочатку знаходиться несправний блок, а потім знаходиться несправний елемент в тому блоці.

Ключові слова: автоматизована система контролю, покрокова корекція, багатократний контроль, апріорна ймовірність, достовірність розпізнавання.

Торошанко Я. И., Шматко В. С. Автоматический поиск отказов с пошаговыми изменениями параметров контроля в гибкой программе поиска в коммуникационных системах. Разработана гибкая система поиска отказов, неисправностей и аварийных режимов с пошаговым уточнением априорной вероятности отказа контролируемого элемента. Для обеспечения удовлетворительного значения достоверности распознавания отказа элементов применен многократный контроль. Разработана структура алгоритма поиска отказов с двухшаговой процедурой испытания, когда сначала находится неисправный блок, а затем неисправный элемент в том блоке.

Ключевые слова: автоматизированная система контроля, пошаговая коррекция, многократный контроль, априорная вероятность, достоверность распознавания.

Toroshanko Ya. I., Shmatko V. S. Automatic search of breaks with step-by-step variations of parameters of tests in communication systems. The flexible program of search of breaks, disrepairs and malfunctions with step-by-step correction of a priori probability of break of inspected element was developed. The multiple test of serviceability was applied for providing of satisfactory value of recognition authenticity. The structure of algorithm of search of breaks with two-step procedure of test, when the failed block is searched at first, and then faulty element in that block is detected.

Keywords: automated test system, step-by-step correction, multiple test, a priori probability, recognition authenticity

I. Introduction. The automated test systems (ATS) of complex dynamic objects complete functions of information pickup, measurement and repair. It dissolves such problems:

- determining of technical state of object;
- decision-making regard of serviceableness of object to completing of its functions;
- localisation of fault and definition of reasons of faults;
- trouble shootings;
- initial data collection for prognosis of technical state of object;
- data collection for analysis of influence of exploitation conditions on object functionality;
- data collection for analysis of the degree of perfection of construction and production technology of object.

The list of mentioned problems and quality of their dissolving depend from the goal of testing, type of tested object and economical charges. Automatic search of breaks, disrepairs and malfunctions of communication equipment plays very important role in the complex of measures

for maintenance of needed level of reliability of communication systems. The choice of the strategy of faults search is realised on some program, which is constructed on the basis of statistical data and the results of analysis of the structure of tested object.

In first case are used the following principles of construction of the program:

- receipt of maximum of information (at implementation of control operation) for every subsequent test;
- analysis and estimation of degree of reliability of elements of the controlled object;
- use of positions of successive analysis for determination of order of Boolean operations at the search of disrepair.

In second case at drafting of the program of search it is possible to come from:

- analysis of differential equalizations determining basic correlations of parameters of the system in the dynamic mode;
- analysis of transmission functions of elements of the system;
- logic analysis of structure of the controlled system.

II. Principles of search program construction. Each of principles of construction of the program of search of disrepair, based on the use of statistical data, has the application domain depending on the structure of object of control and component his elements, used signs for recognition of refusal, possibilities of systems of testing and diagnostics etc.

For the special case (all tests have a normalized single cost, probabilities of errors 1st and 2nd kind equal to zero) in [1] the program of search, based on maximisation on every step of the expected (from test) information about a defective element, is considered.

In [2] the algorithm of search of disrepair is offered, developed with the use of criterion of informative sensibility taking into account expenses on conducting of tests. Expression looks like for a criterion:

$$\gamma_k = \frac{\Delta I_k}{C_k} = \frac{-P_k \log P_k - (1-P_k)\log(1-P_k)}{C_k},$$

where P_k is a priori probability of that during testing of k-th element the refusal will not be exposed; C_k – value of expenses necessary for conducting of this test.

The sequence of tests of elements is determined by maximal value of the expected value γ_k.

The programs of search more perfect in the technical reason are developed, giving the effect of optimum on one or another index. Such programs, in particular, may be referred to following programs on the basis of the use [3, 4]:

- optimum homogeneous Markovian strategies;
- method of step-by-step approximations;
- recursive decision of task of search.

Realization of the mentioned programs runs into difficulties in analytical form of decision rule, by complication of calculable procedures with the use of the linear and dynamic programming, by a necessity to have the large volume of input data.

Let's consider the program fulfiling conditions of the most complete statistical optimisation of process of control of operability and search of disrepair, and which takes into account:

- cost of tests;

- a priori probability of refusal in the checked elements up;
- authenticity of estimation (errors of the first and second kind) of the state of elements.

The program of conducting of successive tests is offered in work [5]. It allows exposing failed element at the least average cost of test of all system (estimation on middle expenses is determined from random character of appearance of disrepair).

This two-stage program of search (firstly test is carried out in the blocks of the system, and then in the elements of failure block) is developed at the following basic data:

- in the complex system consisting of the N blocks, each of which contains n_i, $i=\overline{1,N}$ elements, the refusal of only one element happened (hence the proper block);
- a priori probabilities of refusals are known; the occurs of refusals of elements are independent (determination of operability or refusal of any element does not influence on probability distribution of other elements);
- the errors of the first and second kind are taken into account in the algorithms of search;
- every step of test has the cost, which comprise time, necessary for the receipt of results of control, apparatus constituent etc.

III. Optimum test procedure. Optimum procedure of test is taken to the following rule: sequences in the search of disrepair must be such that on every step of test such terms were executed:

for blocks:
$$A_i = \max_i \frac{p_i(1-q_i^{(1)})}{c_i + q_i^{(2)} T_i}; \qquad \textbf{(1)}$$

for elements:
$$A_{ki} = \max_{ki} \frac{p_{ki}(1-q_{ki}^{(1)})}{c_{ki} + q_{ki}^{(2)} \rho_{ki}}, \qquad \textbf{(2)}$$

where p_i and p_{ki} are probabilities of refusal i-th of block and k-th element of i-th block; c_i and c_{ki} are the proper costs of single test of block and element; $q_i^{(1)}$ and $q_{ki}^{(2)}$ are probabilities of errors of the first kind (probabilities of acceptance of failure block (element) for in good condition one); $q_i^{(2)}$ and $q_{ki}^{(2)}$ are probabilities of errors of the second kind (probabilities of false acceptance of the operable tested object failure one); T_i are middle expenses on the search of refusal i-th capable of working block:

$$T_i = \sum_{ki=1}^{n_i} \left(c_{ki} + q_{ki}^{(2)} \rho_{ki} \right);$$

ρ_{ki} is the cost of repair or replacement of k-th element of i-th block.

The parameters, which comprise in the parameters (1) and (2) of the algorithm of search, have to be corrected for every step of inspection. It's necessary for providing of needed level of search authenticity. The procedure of correction comprises of two steps:

- a priori probabilities of failure occurrence of failure in tested element (block) are changed by a posterior values;
- if the error of estimation of element (block) state doesn't satisfies to needed level of search authenticity, the additional multiplicity of inspection is included.

IV. Algorithm of flexible search of failures. A priori values of probabilities of refusal of p_i and p_{ki} in blocks and elements, the included in the programs of search (1), (2) and at determination of threshold on the Bayesian criterion of the decision rule at recognition and subsequent determination $q^{(1)}$ and $q^{(2)}$, must be adjusted after every step of search in accordance with the results of test. Strict strategy of search when the sequence of verification is determined a priori and is not depended on the intermediate results of control becomes flexible, because every subsequent step of search requires the account of change of probabilities and errors, and multiple declaration of terms of inequality. Although the algorithm of search becomes complicated, efficiency of procedure of finding of disrepair rises (time of search grows short etc.).

Conditional probabilities $P^*_{r(s)}$ in accordance with [14] are determined as follows.

If at test of r-th object disrepair found out,

$$\left.\begin{aligned} p_r^* &= \frac{p_r(1-q_r^{(1)})}{[q_r^{(2)}(1-p_r)+(1-q_r^{(1)})p_r]}, \\ p_s^* &= \frac{p_s q_r^{(2)}}{q_r^{(2)}(1-p_r)+(1-q_r^{(1)})p_r}. \end{aligned}\right\} \quad r \neq s \qquad \textbf{(3)}$$

If at at test of r-th object a disrepair not found out,

$$\left.\begin{aligned} p_r^* &= \frac{p_r q_r^{(1)}}{(1-q_r^{(2)})(1-p_r)+q_r^{(1)}p_r}, \\ p_s^* &= \frac{p_s(1-q_r^{(2)})}{(1-q_r^{(2)})(1-p_r)+q_r^{(1)}p_r}. \end{aligned}\right\} \quad s \neq r \qquad \textbf{(4)}$$

Errors of recognition of the first kind in (1) and (2) result in that in the process of the first cycle of search can be not found out a disrepair.

For the increase of authenticity of discovery of disrepair there is the necessity of conducting of repeated and subsequent cycle of search is the same verification is conducted once or twice.

It is possible not to detect a breaking element in the i-th block, in two cases: either at testing of i-th block we get a result with probability $q_i^{(1)}$ or test of block shows a disrepair, and test of failed k_i-th element shows a result with probability $q_{ki}^{(1)}$.

Thus, probability of non-coverability of defect in i-th block is described by expression

$$P_i = q_i^{(1)} + (1-q_i^{(1)})\sum_{ki}^{n_i} p_{ki} q_{ki}^{(1)}.$$

Probability of missing of failure for the first cycle of verification is equal

$$P = \sum_{i=1}^{N} p_i \left[q_i^{(1)} + (1-q_i^{(1)})\sum_{ki}^{n_i} p_{ki}^{(1)} q_{ki}^{(1)} \right]. \qquad \textbf{(5)}$$

On the Fig. 1 the chart of algorithm of flexible search of disrepair is represented.

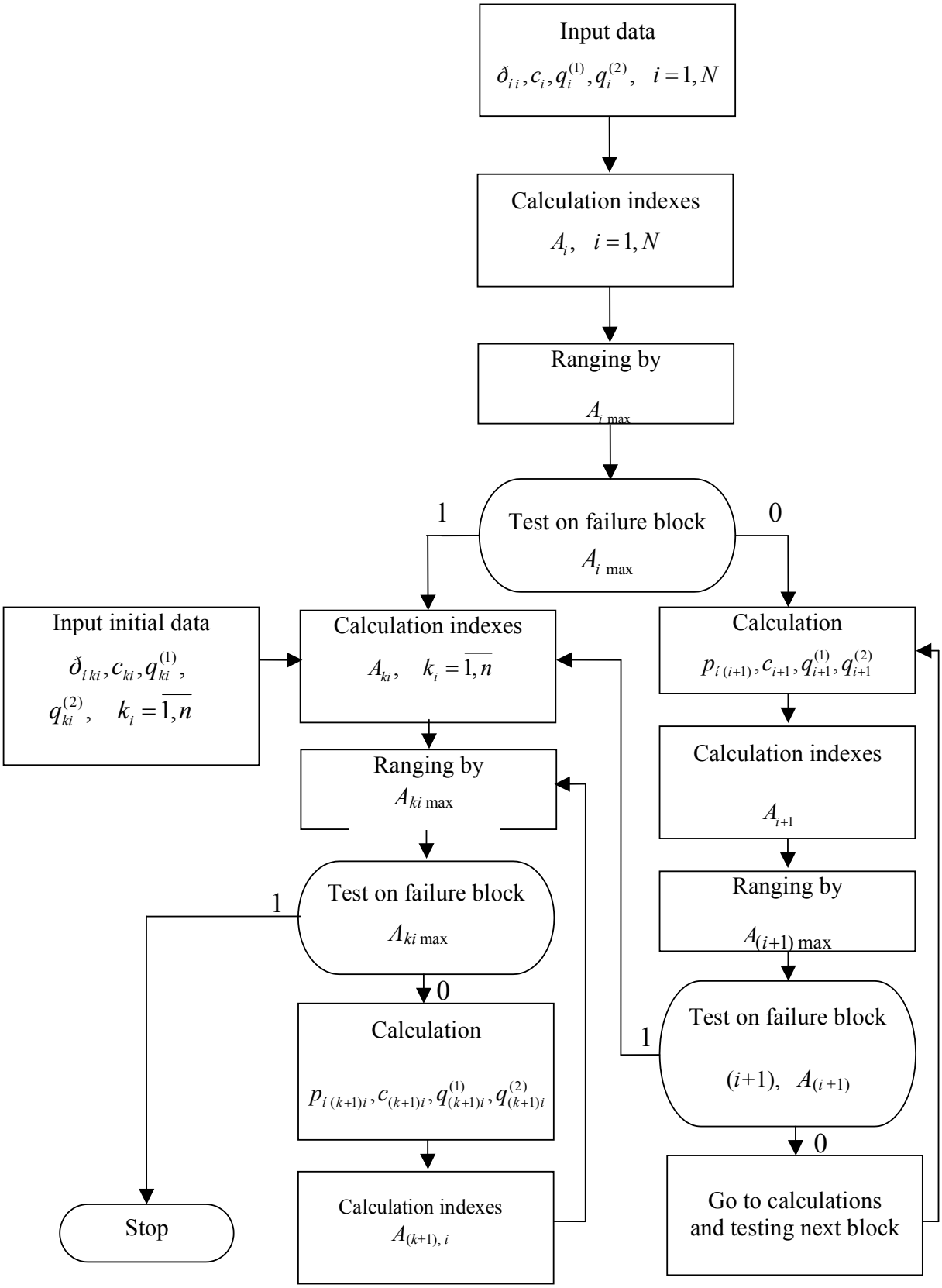

Fig. 1. Algorithm of flexible search of disrepair

On the basis of study of tested object, estimation of possibility of test system, used for recognition of signs, time norms, authenticity of estimation of the state of object and failure detection the $A_{i(ki)}$ indexes are determined, ranging which on a maximum determines the sequence of block (elements) check.

After the first step of test in the case of no discovery of disrepair there is adjustment of indexes of the program of search.

The decision making about authenticity of object state estimation is executed in appliance with expression (5).

V. Conclusions. In the set of tasks of tests of the complex dynamic systems the location disrepair is one of basic for achievement of the required reliability of the system and possible information and economic losses.

As the program of search of disrepair the two-stage search optimum on minimum mean time expended on the discovery of refusal is chosen. The errors of the first and second kind at recognition of the state of object are taken into account in the indexes of the program.

For the increase of authenticity of determination of disrepair the multiple of verification of elements is offered. The chart of rational correlations of time of supervision is given after a process and probabilities of missing of disrepair.

The algorithm of the flexible program of search of disrepair is offered, taking into account adjustment of probabilities of refusals of elements after every step of search.

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