ADJUSTMENT OF THE GENERALIZED LOGICAL MODEL OF COMPOUND SYSTEMS DIAGNOSTING ACCORDING TO THE SITUATION

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Abstract: The adjustment procedure of intelligent model of compound technical system diagnosing according to the situation within the researched object at the moment of diagnosing has been described.

Keywords: logical model, compound systems, system diagnosing, adjustment of generalized logical model.

Introduction

Usage and maintenance of the modern compound technical systems under any conditions requires providing them with high-quality technical diagnosing. Usually compound technical system comprises large number of the interrelated components and is characterized by large set of variable and parameters determining its condition (Nechyporuk, 2013a). As a rule not all of these parameters may be controlled due to specific conditions of functioning and usage of the system. Besides, the process of information collection about the current conditions of the technical system is subjectively influenced by the human factor. This determines one of the basic requirements to the diagnosing system namely provision of reliable functioning of the object under the conditions of incomplete, inaccurate and often contradictory information. Many negative influences resulting in technical systems’ defaults are of concealed nature and may be revealed in advance only in case of implementation of efficient processing methods for observation data on controlled variable and parameters. In particular this problem may be solved with the purpose of increasing efficiency of technical systems maintenance related to the technological processes and their current repair and modernization.

Analysis of the comprehensive research within the field of the mentioned challenges shows the disadvantages related to the efficient and timely reveal of the abnormal behavior of the compound technical system, search and identification of the allocation point and nature of the system default under the uncertainty conditions of different level and nature. Maintenance efficiency and usage safety depend on the quality of technical system condition prognostication.

Task

This research is aimed at increasing the quality of diagnosing and revealing combinations of the defaults/defects of the compound technical systems by adjustment intelligent diagnosing models to the situation occurring in the researched object at the moment of diagnosing.

Main

Compound object diagnosing model is formed from the logical statements each of which correlates to one of the possible ways of influencing the diagnosed object (Nechyporuk, 2013b).

\[ L_k \rightarrow V_k \]  \quad (1)

\[ k \in K_i (d_i) ; \quad i = \overline{1,m_i} ; \quad t = \overline{1,n} , \]

where \( L_k \) – is a compound logical statement specifying \( k \)-th way of influencing the diagnosed object and conditions of its applicability;

\( V_k \) – is a compound statement describing possible consequences of practical implementation of \( k \)-th way of influencing the diagnosed object.
Adjustment of diagnosing model to the situation shall be defined as taking of its general form (1) to the particular form adequate to the situation occurring in the diagnosing system at the moment of diagnosing.

Diagnosing model is adjusted in two stages. Firstly the truth values of the logical statement $P_i(d_i)\,\, P_j(d_i),\,\, S_k(d_i),\,\, U_{ki} $ and $ F_{ki}(d_i) $ included into the general model (1) are determined. Then from the diagnosing model specified as it has been mentioned above the statements are chosen correlating with the diagnosed object influencing methods that may be practically implemented under the current situation. These statements in their set form the particular (i.e. tuned to the situation) diagnosing model on the basis of which the combinatory model of search decision development is formed.

Statement $P_i(d_i) $ is considered to be true if at the moment of diagnosing there is possibility to practically implement $j$-th search operation in relation to $d_i$ element, otherwise $P_j(d_i) $ is false; $t = 1, n, \, \, j \in J_k(d_i) ; \, k \in K_i(d_i) ; \, i = 1, m_i $

The truth values of the statements $P_j(d_i) ; \, t_i \in T_k^1 ; \, k \in K_i(d_i) ; \, j \in J_k(d_i) ; \, t = 1, n ; \, i = 1, m_i $ are determined analogically.

Statement $S_k(d_i) $ is true if between the elements $d_i $ and $d_j $ are interrelated in such way and parameters that allow implementing k-th way of the diagnosed object influencing, otherwise $ S_k(d_i) $ is false; $ k \in K_i(d_i) ; \, t_i \in T_k^1 ; \, t = 1, n ; \, i = 1, m_i $

Statement $U_{ki} $ is true if under occurring situation implementation of the k-th way of the diagnosed object influencing may result in indirect change in $i$-th feature of the element’s condition $d_i$, otherwise $ U_{ki} $ is false; $ k \in K_i(d_i) ; \, i_i \in I_k(d_i) ; \, t = 1, n ; \, i = 1, m_i $

Statement $ F_{ki} (d_i) $ is true if k-th way of the diagnosed object influencing implementation results in indirect change in $i$-th feature of the state of the element $d_{t_2} $ related to $d_i$, otherwise $ F_{ki}(d_{t_2}) $ is false; $ k \in K_i(d_i) ; \, t_2 \in T_k^2 ; \, i_2 \in I_k(d_{t_2}) ; \, t = 1, n ; \, i = 1, m_i $

Determination of the truth values for the logical statements $P_i(d_i) $ and $ P_j(d_i) $ directly before the search decision making may be performed automatically on the basis of the analysis of the current state of the diagnosing processes and tracing the resources usage and if impossible this may be performed on the basis of the experts’ poll.

Statements $S_k(d_i), U_{ki} $ and $ F_{ki}(d_{t_2}) $ reflect structural features of the diagnosed object as the integral set of the interacting elements. If these features don’t change in time and don’t depend on the diagnosed object condition then the values of these statements may initially be determined in the general model (2.1) or be generated by special subprogram on the basis of the diagnosed object structure description and functional interdependencies of the features of its element. Otherwise the truth values of the considered statements are interactively determined by the experts.

After the general diagnosing model (1) is tuned the further consideration is required only for those diagnosed object influencing methods that may be practically implemented under the current situation. The set $K_h^0(d_i) $ of such ways aimed at direct change in $h_i(d_i) $ feature value is determined by the formula:

$$K_h^0(d_i) = \{k \in K_i(d_i) : T_k^1 \land Q_k^0 = 1\} ;$$

$$ t = 1, n, \, i = 1, m_i ,$$

where $ Q_k^0 $ –is compound statement reflecting possible mutual implementation of the set of diagnosing operations envisaged by k-th method of the diagnosed object influencing in relation to the element $d_i$;

$$ Q_k^0 = \bigwedge_{j=a_i(d_i)} P_j(d_i) ;$$
\( Q_i \) –is a compound statement reflecting presence of the links between \( d_i \) and other diagnosed object elements necessary for implementation of the k-th method of diagnosed object influence as well as the possibility of common implementation in relation to these elements envisaged by the diagnosing operations sets:

\[
Q_i^1 = \bigwedge_{j \in J_k(d_i)} S_k(d_i) \land P_j(d_i).
\]

\( K^H(d_i) \) set of the ways of influencing \( d_i \) element of the diagnosed object that may be implemented under current situation shall be determined by the formula

\[
K^H(d_i) = \bigcup_{i=1}^{m_i} K_i^H(d_i); \quad t = 1, n,
\]

and the set \( K^H \) of all the ways of influencing the diagnosed object remaining in the consideration field after the diagnosing model is tuned to the given situation is determined by the formula:

\[
K^H = \bigcup_{i=1}^{n} K_i^H(d_i).
\]

Let \( T^H \) be the set of numbers of the diagnosed object elements for which there are direct influence methods under current situation:

\[
T^H = \{ t : [1 \leq t \leq n] \land [K^H(d_i) \neq \emptyset] \},
\]

And \( I^H_i \) –is the set of the number of characteristics of \( d_i \) element condition for which there are methods of making direct changes to their values under current situation:

\[
I^H_i = \{ i : [1 \leq i \leq m_i] \land [K_i^H(d_i) \neq \emptyset] \}, \quad t \in T^H.
\]

As a result of adjustment to the situation the general diagnosing model (2.1) is transformed into the following system of logical statements:

\[
L_k^H \rightarrow V_k^H ;
\]

\[
k \in K^H(d_i); \quad i \in I^H_i ; \quad t \in T^H.
\]

Statement \( L_k^H \) describes the set of diagnosing operations that shall be performed according to the k-th method of the diagnosed object influencing (but without conditions of their applicability):

\[
L_k^H = L_k^{H0} \land L_k^{H1},
\]

where

\[
L_k^{H0} = \bigwedge_{j \in J_k(d_i)} O_j(d_i);
\]

\[
L_k^{H1} = \bigwedge_{t \in T_k^H} \bigwedge_{j \in J_k(d_i)} O_j(d_i);
\]

\[
k \in K^H(d_i); \quad i \in I^H_i ; \quad t \in T^H.
\]

Statement \( V_k^H \) reflects the consequences of practical implementation of the k-th method of the diagnosed object influencing under current situation. In general case

\[
V_k^H = V_k^{H0} \land V_k^{H1} \land V_k^{H2},
\]

where

\[
V_k^{H0} = V_k^0 = Z(c_{k,i});
\]

\[
V_k^{H1} = \bigwedge_{i \in I_k^H(d_i)} Z(c_{k,i});
\]

\[
V_k^{H2} = \bigwedge_{i_2 \in I_k^H(d_i)} \bigwedge_{i_3 \in I_k^H(d_i)} Z(c_{k,i_2,i_3});
\]

\[
k \in K^H(d_i); \quad i \in I^H_i ; \quad t \in T^H.
\]
Here \( T_k^{H^2} \) is the set of numbers interacting with \( d_t \) elements of the diagnosed object, features of the conditions under which the values will be changed as a result of the \( k \)-th method of the diagnosed object influencing implementation:

\[
T_k^{H^2} = \left\{ t_2 \in T_k^2 : \bigvee_{i \in I_k(d_t)} F_{ki_2}(d_{t_2}) = 1 \right\}
\]

\( I_k^H (d_t) \) – is the set of numbers of the features of the condition of the \( t \)-th element of the diagnosed object which along with \( h_t(d_t) \) will change their values under this situation as a result of \( k \)-th the diagnosed object influencing method implementation.

\[
I_k^H (d_t) = \left\{ i \in I_k(d_t) : U_{ki} = 1 \right\}
\]

\( I_k^H (d_t) \) – is the set of the number of features of \( d_{t_2} \ (t_2 \neq t) \) element state which under current situation will change their values as a result of \( k \)-th the diagnosed object influencing method implementation.

\[
I_k^H (d_t) = \left\{ i \in I_k(d_t) : t_2 \in T_k^{H^2} \right\}; \quad k \in K_i^H (d_t); \quad t \in T^H.
\]

Let \( K_i^{H^2}(d_t) \) be the set of indirect influence methods to the feature \( h_t(d_t) \) of the first rate remaining in the consideration field after adjustment of the diagnosing model (2.1)

\[
K_i^{H^2}(d_t) = \left\{ k \in K_i^H (d_t) : U_{ki} = 1 \right\},
\]

be the set of the ways of indirect influence on the same feature of the second rate that may be practically implemented:

\[
K_i^{H^2}(d_t) = \left\{ k \in K_i^H (d_t) : F_{ki}(d_{t_2}) = 1 \right\}; \quad t_2 \in T_k^{H^2} ; \quad i = \overline{1, m_t} ; \quad t = \overline{1, n}.
\]

Then complete set \( K_i^{H^2}(d_t) \) of the the diagnosed object influencing methods that may be implemented for direct or indirect change in value of the feature \( h_t(d_t) \) under current situation will be determined according to the formula

\[
K_i^{H^2}(d_t) = K_i^H (d_t) \cup K_i^{H^1}(d_t) \cup K_i^{H^2}(d_t)
\]

\[
i = \overline{1, m_t}; \quad t = \overline{1, n}.
\]

Specified diagnosing model (2) is the basis for development of the combinatorial model of search decision making adequate to the situation occurring within the system (Lytvynenko, 2002, 2004).

**Conclusions**

Combinatorial nature of the task of determination of the combinations of the defaults/defects within the compound technical system allows implementation of the directed choice of variables to its solution. This requires development of the rules for combinatorial model formation adequate to the intelligent diagnosing model in the form it is acquired after being tuned to the situation. As the diagnosing task is not optimizing one, such combinatorial model becomes in general the system of non-linear equations with Boolean variables.

**References**


