Algorithms For Solving Problems Of Reliability Of Complex Systems

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Abstract: - Offshore drilling platform is a complex object, including a comprehensive automation system, each element of which is the source of the risk of accidents. Realization of these risks can lead to catastrophic consequences. To minimize the risks and their consequences, a method is required to identify and assess the risks of technological operations. Decision Support System implemeting the method and having been designed as an add-on for the centralized automated rig control system will allow to provide an increase in process efficiency due account of the probability of risks while they are managed.

Key-Words: - Technological operations; offshore; drilling platform; Amphion; Cybershot; risk management

1 Introduction

Modern offshore drilling platforms (ODP) are completely self-contained objects consisting in terms of automation of a variety of complex subsystems, each of which has, in turn, their own local control and central management for the entire complex. In fact, each of these subsystems, starting from elementary sensors and ending with central control units, is a set of critical components as potential sources of unwanted processes scenarios in the system and, consequently, the cause of the failure. Thus, modern offshore drilling platforms are characterized by a high level of automation of core processes with the congregation of the local automatic control subsystems into a common set of controlled automation systems such as «Amphion», «Cybershot», etc. In general, the ODP is a complex system that operates in non-deterministic conditions associated with low predictable drilling conditions, and the occurrence of an emergency with a high degree of probability can lead to catastrophic consequences.

In such complex systems, it is impossible to predict all the possible options for the development of processes, but the main reasons for the development or updating of risks such as lack of information, lack of time and mismanagement can be called.

Risk management involves the creation of the environment of proactive or reactive (but with higher reaction rate) decision-making within the target ODP system prone to the risks able in real time to identify the possibility of a continuous (i.e. to predict) under these conditions scenarios, within which this process can go down the wrong path.

2 Risks associated

The difference between the proactive risk management from the reactive one is that with the reactive management overcoming the erroneous scenario begins at its climax, while managing proactively the prediction of occurrence of erroneous scenario is made in the judgment of any prerequisites for its development. Thus, with proactive management the focus is given not only to the prevention of the development of emerging adverse scenario plans, but also to the methods of early identification of the latter and the effective prevention by all available means, before the scenario starts to be implemented, and its effects have begun to acquire the critical scale.

Such a basis may be realized with the use of diagnostic models based on precedents [1-4]. Practice shows that to identify the risks of emergency operation of the ODP systems it is usually needed to handle large volumes of input data, i.e. the data samples from various types of sensors and subsystems of the ODP, which leads to significant expenses of time for processing data and require significant amounts of memory of the computing device. In this context, it becomes an urgent task to reduce the dimension of the data samples [3-5]. The most widely used approach is to use methods of selection of the informative features [3-10], removing the least informative signs from the initial set as well as methods of designing features [5, 6], which replace the original set of attributes with a set of artificial signs with less dimensions calculated on this basis.

3 Method of formation

The purpose of this paper is to develop a method of formation, and the reduction of initial samples among excess amounts and representative samples of the reduced dimensions.

Statement of the research problem. Suppose, we have the initial fetch $X = \langle x, y \rangle,$ S is a set of precedents by dependency $y(x), x = \{x^s\}, y = \{y^s\}, s = 1, 2..., S,$ which are characterized by a set N of the input features $\{x_j\}, j = 1, 2, ..., N,$ where j is a number of a feature, and output feature y.

Development of sampling method and preservation of samples, located on the borders of the classes. In order to detect samples which are situated on the borders of the classes, it is necessary to solve the problem of cluster analysis. This requires determining the distances between all the samples in the sample feature space, which, in turn, requires either download the entire sample in a computing device memory, or perform multiple passes needed by the original sample. As a rule, the former becomes impossible due to the limited volume of memory, the latter–due to the considerable time expenditure. Furthermore, this approach leads to the necessity of storing and processing the distance matrix between instances of large dimension.

To address the shortcomings outlined above, it is proposed to replace processing of the vector description samples for processing of their descriptions in the form of numeric scalars. Recent instances characterize the situation in the feature space. Replacing the samples characterized by N signs for the scalar image, thus, we display the N-dimensional feature space in the one-dimensional space.

The sample displayed in one-dimensional space allows allocating intervals of its values on the axis of the measurement corresponding to clusters of different classes in the original space N measurements. Defining the beginning and end of each range of values at one-dimensional axis, you can select items that are in the vicinity of the edge of intervals.

To solve the outlined problems the modified multi-level model of the argument group accounting method is used that provides identification of the structure of combinatorial model. Flowchart of the combinatorial model of the argument group accounting method where the following symbols are adopted:

1 – Start.

2 – The input of the experimental data, evaluation of the response function values by the experimental data Y_i and values of the model arguments X_{ij} (i = 1,..., N; j = 1 ,..., M); N is the number of measurements; M is the number of output values of the model.

3 – Ranking of the points $\{Y_i\}$ by dispersion; segregation of training $\{YB_i\}$ and testing $\{YA_i\}$ sequences; $\{YB_i\}$ are points with smaller values of output dispersion; $\{YA_i\}$ is a point with its larger value.

4 – Evaluation of a number of particular descriptions K:

$$K = C_m^2 = \frac{M!}{2!(M-2)}.$$

5 – Start of the cycle by the selection rows: S = 1.

6 – Start of the cycle by the particular descriptions.

7 – The selection of the structure for 2 variables of the G-description.

8 – Start of the cycle by the structures: L = 1.

9 - The calculation of the parameters for model least square method with the G – th description for $\{YA_i\}$ (A_a) и $\{YB_i\}$ (A_b) calculation of $\eta_{\tilde{n}m}$ the G – th description.

10 – (L = 1)?, if «Yes» jump to 11, otherwise to 13.

11 – Establishment of the criteria, the G – th description: $KR_G = \eta_{\tilde{n}i}$; $L = L + 1$.

12 – Amplification of the structure. The end of the cycle, return to 9.

13 – $(KR_G \le \eta_{\tilde{n}m})$? , if «No» jump to 11, otherwise to 14.

14 – As the G – th description we take the structure, corresponding to $(L-1)$ cycle, the calculation of the variable for the G – th description Z_{qi} (i = 1,...,N); in the next row of selection $\{Z_{qi}\}$ they are the arguments for partial descriptions

15 - ($G = K$)?, if «No» return to 7, if Yes, jump to 16.

16 - $G = G + 1$.

17 – Selection of M best partial descriptions for *min* KR_G ; $KR1_S = \min\ KR_G\,(1,\ldots, K)$.

18 - (S = 1)?, if «Yes» jump to 19, otherwise to 20.

19 - $S = S + 1$ and return to 6.

20 - $(KR1_S < KR1_{S-1})$? , if «No» jump to 21, otherwise return to 19.

21 – The establishment of the optimal structure of the model: the structure of the optimal complexity is referred as to the structure of the model with the least value of the selection criterion in the previous (S - 1) - m selection row.

22 – The end.

Let us take as an example the control system for the processes of the underwater quarrying of the shell deposits in the Sea of Azov. Let us represent the combinatorial model of group method of data handling of the control system as a tuple:

$$\sum = \langle T, I, W, D_I, D_X, Z, V, P, X, Q, \Theta, \varphi \rangle ,$$

where T are arrays of time points; I is information about the state of the object under the control; W is information about the ambient environment; D_I is an array of admissible values for the state of the object under the control; D_X is an array of the admissible control operations; Z - is the array of the operational targets; V are capabilities of the computing tools; P is information about the systems of priorities; X are arrays of the control operations; Q is an array of links between I and X ; Θ is an array of regularities in the object performance; φ are images that characterize the process of decision search.

4 Phased math blocks

In order to realize $\varphi : I \to X$, it is proposed the following order of the logic and mathematical stages in the decision-making process:

1. Statement of the problem situation S:

$$\varphi_1 = \langle T, I, D_I, W, Z, S \rangle, \quad (1)$$

2. Classification of situations:

$$\varphi_2 = \langle S, K_1, K_2, P_1 \rangle, \quad (2)$$

where K_1, K_2 и P_1 are arrays of the situation classes respectively, classification rules and expert preferences during the situation assessment $(P_1 \in P)$

3. The selection of the strategy for decision search (for problem statement)

$$\varphi_3 = \langle S, Q, \Theta, R, P_2 C \rangle, \quad (3)$$

where R are resources to settle the problem situation; P_2, C are arrays of preferences while selecting the strategies and strategies for search of the control decisions (adjustment of the production plans, replacement of resources) respectively.

4. Design of the decision search model

$$\varphi_4 = \langle S, K, C, P_3, M \rangle, \quad (4)$$

where P_3, M are arrays of the preferences of the decision-maker while modelling and during formation of the models.

5. Creation of the decision search procedure

$$\varphi_5 = \langle M, V, P_4, A \rangle, \quad (5)$$

where V, P_4, A are arrays respectively capabilities of the means of the computing system (models, algorithms, modules, communication means, etc.), advantages of the decision-maker during creation of the decision search procedure and algorithm procedures of the decision search.

6. Statement of the decision variant

$$\varphi_6 = \langle M, A, X, F, P_5 \rangle, \quad (6)$$

where F is an array of criteria for assessment of the decision utility.

7. Decision choice

$$\varphi_7 = \langle M, F, P_6, X^* \rangle, \quad (7)$$

where P_6 is an array of benefits (of informal character) during decision-making; X^* is the best solution made by the decision-maker based on the assessments.

The above stages for decision search make possible to state the problem of adaptation which involves the statement of the procedure of search A of the control operations X regarding the state of the object I and impact of the ambient environment W. The process of the alternatives search consists of three essential functional blocks:

Block **1** - the statement of the situation S - designed to reveal and describe in certain terms the situation S of the state of the object I under the control and the ambient environment W, the decision-maker's experience, functioning of this block including the stages φ_1 and φ_2 may be expressed as follows :

$$\psi_1 : I \times W \times P \to S, \quad (8)$$

Block **2** – designing of the model M - aimed at creating the logic and mathematical models for search the models of the decision alternatives to settle the current problem situation; and at functioning of this block comprising the stages φ_3 and φ_4, may be expressed as follows:

$$\psi_2 : S \times C \times P \to M. \quad (9)$$

Block 3 – statement of the search procedures A - designed to state and select the alternative operations based on model M, procedures for searching the alternatives for decision A and the system of the decision-maker's advantages.

Functioning of this block involving the stages φ_5, φ_6 and φ_7 may be written as:

$$\psi_3 : M \times A \times P \to X \quad (10)$$

In general the adaptive model to search the alternatives of decision is as follows: $I \to S \to M \to X$ $\uparrow Y_1 \uparrow Y_2 \uparrow Y_3$, where Y_1, Y_2, Y_3 are functions according to the description of the situation in a certain language; its transformation into the formal model and the statement of the procedure of decision-making.

The above stages of functioning are capable to adapt to the situation due to the designing and adjusting the elements of the decision alternatives search (models, strategies, algorithms).

The process of formalizing the decision of tasks in a particular domain can be represented in a model, expressed the set of arrays $M = \langle X, A, Y, F \rangle$, where X, A, Y are arrays of respective control, fixed and controlled parameters of the environment; F is an array of functional dependencies which link the elements of arrays X, A, Y. In order to realize the dialogue in a better way, let us introduce brief verbal characteristics of the relevant parameters in arrays X, A, Y. In this case arrays X and Y will be represented as set of the following regular pairs: $X = \{(h_i, x_i), i \in I = \overline{1,n}\}$; $Y = \{(h_i, Y_i), j \in J = \overline{1,m}\}$, and arrays A are a set of following regular triplets $C = \{(h_\ell, a_\ell, a_\ell^R), \ell \in L = \overline{1,L}\}$, where h_i, h_j, h_ℓ are titles of the relevant parameters; x_i, y_j, a_ℓ are their type codes; a_ℓ^R - are known quantitative values for the fixed parameters.

5 Conclusion

The model of this type displays the basic laws of the particular environment and dependencies $Y_j = f(x_1, x_2, ..., x_n, a_1, ..., a_n)$, by which they are linked. On the other hand, the model allows forming interactive various settings of various decision-making problems of a certain class. Comparative evaluation of the quality of decision support system developed using system and using traditional approaches has shown that the use of SPRUV allows to improve the quality and effectiveness of decision support system in production management, so it can be recommended as an auxiliary component, which consists of tools for modeling decision-making and control of the operation process of decision support system. The model allows stating the various tasks interactively.

Comparative evaluation of the quality of decision support system developed using system and using traditional approaches has shown that the use of system allows improving the quality and decision support system efficiency in controlling PVDPI. Therefore, it could be recommended as an auxiliary component, which consists of means for decision modeling, and controls the decision support system operational process.

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