СИСТЕМНИЙ АНАЛІЗ І ТЕОРІЯ ПРИЙНЯТТЯ РІШЕНЬ

СИСТЕМНЫЙ АНАЛИЗ И ТЕОРИЯ ПРИНЯТИЯ РЕШЕНИЙ

SYSTEM ANALYSIS AND DECISION-MAKING THEORY

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IDENTIFICATION OF PROBLEM SITUATIONS IN FUNCTIONAL DIAGNOSTICS OF INTELLIGENT BUSINESS SYSTEMS

The paper discusses the issues of increasing the efficiency of production activities of an intelligent business system operating in a dynamic environment by reducing its losses by creating a subject technology for reliable identification of problem situations in the process of functional diagnostics of a business system. The object of the research is an intelligent business system of the IT industry, which produces intelligent products, the results of which depend on the mental abilities of its personnel, who own effective intelligent information technologies. The problem-containing environment was chosen as the basis for analyzing the problem situation, in the depths of which the problem situation arises, develops and manifests itself. A problem-containing environment is characterized by structure and behavior. The behavior of the problem-containing environment is determined by the multidimensionality of the ongoing business processes, their interaction and dynamics. To identify deterministic and non-deterministic problem situations, it is proposed to set them by bipartite graphs and use the technology of inference based on precedents, which has serious advantages over the method of inference based on knowledge. In this work, a cognitive method is used to analyze problem situations of an intelligent business system. The basis of cognitive analysis is formed by the problem-containing environment, in the depths of which the problem situation arises. To study the problem-containing environment, the method of analysis of hierarchies is used, the basis of which is a hierarchy which is a system of levels, each of which consists of elements, factors of the problem-containing environment and an intelligent business system. A complex of models has been developed to construct a bipartite graph of a problem situation and to analyze its problem-containing environment. On the basis of a complex of models, a subject technology for identifying problem situations arising in the process of functional diagnostics of intelligent business systems has been created. The results obtained can be used as a theoretical platform for creating an information technology for functional diagnostics of intelligent business systems operating in a dynamic environment.

Keywords: intellectual business system, functional diagnostics, identification of the problem situation, algorithmic model, hierarchy analysis method, base of precedents

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ІДЕНТИФІКАЦІЯ ПРОБЛЕМНИХ СИТУАЦІЙ ПРИ ФУНКЦІОНАЛЬНІЙ ДІАГНОСТИЦІ ІНТЕЛЕКТУАЛЬНИХ БІЗНЕС СИСТЕМ

У роботі розглядаються питання підвищення ефективності виробничої діяльності інтелектуальної бізнес-системи, що функціонує в умовах динамічного зовнішнього середовища, за рахунок зниження її витрат шляхом створення предметної технології достовірної ідентифікації проблемних ситуацій в процесі функціональної діагностики бізнес-системи. Об'єктом дослідження є інтелектуальна бізнес-система IT-індустрії, яка виробляє інтелектуальну продукцію, результати діяльності якої залежать від розумових здібностей її персоналу, що володіє ефективними інтелектуальними інформаційними технологіями. В якості основи для аналізу проблемної ситуації обрано проблемомісне середовище, в надрах якого проблемна ситуація зароджується, розвивається і проявляється. Проблемомісне середовище характеризується структурою і поведінкою. Поведінка проблемомісного середовища визначається багатоаспектністю протікаючих бізнес-процесів, їх взаємодією і динамікою. Для ідентифікації детермінованих і недетермінованих проблемних ситуацій пропонується задавати їх двочастковими графами і використовувати технологію виводу, заснованого на прецедентах, який має серйозні переваги в порівнянні з методом виводу, заснованого на знаннях. У роботі для аналізу проблемних ситуацій інтелектуальної бізнес системи застосовується когнітивний метод. Основу когнітивного аналізу утворює проблемомісне середовище, в надрах якого зародилася проблемна ситуація. Для дослідження проблемомісного середовища використовується метод аналізу ієрархій, основою якого є ієрархія – система рівнів, кожен з яких складається з елементів, факторів проблемомісного середовища та інтелектуальної бізнес-системи. Розроблено комплекс моделей, необхідних для побудови двочасткового графа проблемної ситуації і аналізу її проблемомісного середовища. На основі комплексу моделей створена предметна технологія ідентифікації проблемних ситуацій, що виникають в процесі функціональної діагностики інтелектуальних бізнес систем. Отримані результати можуть бути використані в якості теоретичної платформи для створення інформаційної технології функціональної діагностики інтелектуальних бізнес-систем, що функціонують в умовах динамічного зовнішнього середовища.

Ключові слова: інтелектуальна бізнес-система, функціональна діагностика, ідентифікація проблемної ситуації, алгоритмічна модель, метод аналізу ієрархій, база прецедентів

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ИДЕНТИФИКАЦИЯ ПРОБЛЕМНЫХ СИТУАЦИЙ ПРИ ФУНКЦИОНАЛЬНОЙ ДИАГНОСТИКЕ ИНТЕЛЛЕКТУАЛЬНЫХ БИЗНЕС СИСТЕМ

В работе рассматриваются вопросы повышения эффективности производственной деятельности интеллектуальной бизнес-системы, функционирующей в условиях динамичной внешней среды, за счёт снижения её потерь путем создания предметной технологии достоверной идентификации проблемных ситуаций в процессе функциональной диагностики бизнес-системы. Объектом исследования является интеллектуальная бизнес-система IT-индустрии, производящая интеллектуальную продукцию, результаты деятельности которой зависят от умственных способностей её персонала, владеющего эффективными интеллектуальными информационными технологиями. В качестве основы для анализа проблемной ситуации выбрана проблемосодержащая среда, в недрах которой проблемная ситуация зарождается, развивается и проявляется. Проблемосодержащая среда характеризуется структурой и поведением. Структурными элементами её являются элементы функциональных зон, компоненты корпоративной, конкурентной функциональных стратегий, бизнес-процессы рассматриваемой бизнес системы. Поведение проблемосодержащей среды определяется многоаспектностью протекающих бизнес-процессов, их взаимодействием и динамикой. Для идентификации детерминированных и недетерминированных проблемных ситуаций предлагается задавать их двудольными графами и использовать технологию вывода, основанного на прецедентах, который имеет серьезные преимущества в сравнении с методом вывода, основанного на знаниях. В работе для анализа проблемных ситуаций интеллектуальной бизнес системы применяется когнитивный метод. Основу когнитивного анализа образует проблемосодержащая среда, в недрах которой зародилась проблемная ситуация. Для исследования проблемосодержащей среды используется метод анализа иерархий, основой которого является иерархия – система уровней, каждый из которых складывается из элементов, факторов проблемосодержащей среды и интеллектуальной бизнес-системы. Разработан комплекс моделей, необходимых для построения двудольного графа проблемной ситуации и анализа её проблемосодержащей среды. На основе комплекса моделей создана предметная технология идентификации проблемных ситуаций, возникающих в процессе функциональной диагностики интеллектуальных бизнес систем. Полученные результаты могут быть использованы в качестве теоретической платформы для создания информационной технологии функциональной диагностики интеллектуальных бизнес-систем, функционирующих в условиях динамичной внешней среды.

Ключевые слова: интеллектуальная бизнес-система, функциональная диагностика, идентификация проблемной ситуации, алгоритмическая модель, метод анализа иерархий, база прецедентов

Introduction. The intensive formation of the information society is accompanied by the creation of global network technologies, cognitive business systems, the emergence of e-business, cognitive business management, etc. The change in the "material" economy based on physical labor, mechanization, automation, "intellectual" economy, characterized by a significant increase in the role of human and social capital, innovation, information and knowledge, creative labor, creative activity in various fields, represents a global structural shift. which, covering all spheres and branches of the post-industrial economy, changes its scale, dynamics, and internal content. The ongoing shift determines the relevance of revising the old methods of management and organization, the creation of effective methods of strategic management not only of tangible assets, resources, cost, but also the management of intangible assets, intellectual capital. Effective management of strategy implementation presupposes systematic diagnostics of the state of intelligent business systems, one of the components of which is functional diagnostics [1]. In this regard, the purpose of the work is to increase the efficiency of economic activity of an intelligent business system by creating a subject technology for identifying problem situations in functional diagnostics (FD) of intelligent business systems.

Formulation of the problem. The main trends in the development of the world system indicate that the main property of the business system of the future is its constant adaptation to a dynamic external environment. At the same time, the business system should be characterized by great organizational flexibility, inclination to individuals, predominant use of teams, accumulated knowledge, high internal competitiveness, a desire for diversification, etc. [1]–[6].

The strategy of the business system should determine, in a dynamic internal and external environment, a long-term, qualitatively defined direction of development towards a fixed target state. At the same time, the business system remains free of choice, taking into account changes in the external environment. The strategy, ensuring the implementation of the tree of goals of the business system, must contain a corporate, competitive and functional strategy [5, 6]. These strategies implement the structural elements of a business system (BS) that form its functional zones, which determine the purpose of these zones (marketing, production, personnel, finance, management, foreign economic activity, etc.) [5, 6].

In the course of the functioning of the BS, the structural elements of its functional zones perform separate components of the strategy. This ensures the realization of the goals of the BS goal tree, and, thereby, its movement in a given direction [5]. The description of the BS as a functional system makes it possible to represent it as an integral organism, the effective functioning of which is the main task of the control system of the BS control loop.

FD is intended for reliable assessment of the state of the functional areas of the BS, the state of the processes of implementation of corporate, competitive, functional strategies and their components. In the process of FD, the mechanisms of interaction of functional zones (FZ) and the component of the BS strategy are revealed, when it moves in a given direction, emerging problems are analyzed, influencing factors, the main aspects of the relationship between problems, the implementation of the goal tree, and the results of the BS activity are identified. Thus, the object of FD is the organizational structure of the BS, its FZ, BS strategies and their components. FD of the current state of the BS is directed to the following [1]:

1. Analysis of the degree of achievement of the goals of the BS goals tree at the strategic, tactical, functional levels of strategy implementation management.
2. Early detection of problem situations in the process of strategy implementation.
3. Identification and analysis of the root internal causes that worsen the BS activity.
4. Creation of a scenario of BS actions aimed at updating the functions and structure of the BS, ensuring overcoming the problem situation that has arisen.
5. Introduction into practice at a new qualitative level of the adopted management decisions and control over their implementation.

In the process method of managing the implementation of the strategy, the BS is considered as a complex of interacting business processes (basic, supporting, business processes of management, development), forming a defining structure designed to actively achieve the target state with a given efficiency [7].

At the stage of formation of the knowledge economy, special attention is paid to human capital, the creation of such a developed infrastructure that would make it possible to use the accumulated experience and knowledge in the field of production and consumption, and would contribute to their further development. Lagging in the process of mastering and creating new knowledge, as a rule, leads to a loss in the competitive struggle [2], therefore, when managing the functioning and development of BS, it is necessary to take into account the most essential features of the knowledge economy. The first of these is the discreteness of knowledge as a product. Specific knowledge is either created or not. The second feature of knowledge is that it is similar in nature to other public goods: once created, they become available, in principle, to everyone, without any discrimination. The information society, by its very nature, ensures an even distribution of knowledge among its members. The third feature of knowledge is that, behind its nature, knowledge is an information product. It does not disappear after consumption, like an ordinary material product. The noted features make significant adjustments to the BS management process. Production base stations are highly dependent on their technical equipment (production capital). This feature significantly affects the methods of managing them. Intelligent BS (IBS) is completely dependent on the mental abilities of personnel with the latest intelligent information technology. It is assumed that IBS creates intelligent products that meet the requirements of efficiency, predictability, reliability, safety [2].

Since the processes of demand, supply, production, consumption, exchange, and distribution of intellectual products are largely determined by humans, the "blind" application of methods for managing production BSs to managing IBS may not be effective. For ischemic heart disease, it is advisable to apply methods of cognitive (knowledge-based) management, taking into account the specific features of the existing technological and human limitations. The basis of cognitive management, as a rule, is the technology of situational management, which provides for making managerial decisions not as planned, but as problem situations (PS) arise, characterized by the presence of a significant gap between the selected and actual directions of development of the BS. PS is called deterministic (routine) if a way to close the gap is known. Deterministic PSs are typical for production BSs. IBS is characterized by non-deterministic PS. In this regard, for the functional diagnosis of ischemic heart disease there is an urgent problem of identification of PS using the positive experience accumulated in the situational management of production BS [8, 9, 10].

Subject technology of identification of PS. When controlling the process of implementing the IBS strategy, it is important not so much the high accuracy of the performance of individual works, but rather finding out how the implemented strategy corresponds to the internal and external conditions of the IBS functioning and to what extent the actual direction of development is able to bring the IBS to the target state. If the detected deviation poses a significant threat to the achievement of the target state, then they speak of the occurrence of PS. The importance of the PS is estimated by the amount of IBS losses due to the non-detection of the PS, or not eliminating it. All PSs are divided into three following classes [7];

1. Resource PS, due to the disproportion of resources, which determines the "bottlenecks" in the process of implementing the strategy.
2. Structural PS, caused by the inconsistency of the structure of the BS with the structure adequate to the implemented strategy.
3. Informational PS caused by the lack of information and knowledge about PS and ways to overcome it.

The selected classes of PS, complementing each other, form a PS system, which is a complex of interacting PSs that form a certain structure that actively opposes the process of achieving the target state of the BS. The complexity of the analysis of PSs that arise during the implementation of the strategy is conditioned by the variability of processes in time, the lack of quantitative information and knowledge about the dynamics of processes, the complexity of the PS system and their mutual influence. To analyze PS, two methods are used - informational and cognitive (knowledge-based). The information method is effective in the analysis of deterministic PSs arising under standard conditions. For IBS, problematic situations, as a rule, are not deterministic, informational and the cognitive method is used to analyze them. The basis of cognitive analysis is formed by the problem-containing environment (PCE), in the depths of which PS is generated. PCE is characterized by structure and behavior. The structural elements of the PS are structural elements, functional areas of the IBS, components of corporate, competitive, functional strategies, business processes, incipient, operating, fading PS, etc.

The purpose of the PS analysis is to find, by immersion in the PS, an answer to the complex question: what factors, under the influence of what forces and circumstances, guided by what objects and pursuing what goals, led to the emergence of PS.

The behavior of the PCE is determined by the multidimensional nature of the business processes associated with the PCE, their relationship, dynamics. This causes the emergence of new discrete structures of the PCE, which have a new quality, determine the dynamics of the change in the gap between the selected and actual directions of the IBS movement. To study such PCE, it is advisable to use the method of analysis of hierarchies (MAH). The basis of the MAH is a hierarchy − a system of levels [11], each of which is made up of elements, factors of PCE and IBS. The task in the language of hierarchy is to determine the intensity of the influence of elements of lower levels on the focus of the problem. In the process of implementing the strategy, IBS PS arises as a result of the activity of the structural elements of the FZ participating in the implementation of the strategy components. Therefore, each PS is characterized by a certain interaction between the FZ and the strategy components. If $F = \{f_i\}$ is the set of FZs, $f_i, i = \overline{1, N}$ of the considered IBS and $S_0 \subset S$ is the set of S_j, $j = \overline{1, M}$ strategy components, then $F_0 \subset F$ is the set of FDs associated with the PCE, and $S_0 \subset S$ is the set of strategy components associated with the PCE. The binary relation $R_0 \subset F_0 \times S_0$ defines the interaction between the selected objects of the PCE generated by the emerging PS. The $< f_i, s_j > \in R$ ordered pair indicates that the FZ f_i is involved in the implementation of the s_j IBS strategy component. The bipartite digraph, the set of vertices of which splits into two sets F_0 and S_0. No vertices from the same set are connected by oriented edges, determines the structure of the PCE. Each ordered pair $< f_i, s_j > \in R$ (an edge of a bipartite graph) defines some variable (concept) that sets a joint influence f_i and s_j on the emergence and development of PS, on the change in the gap. This U_{ij} influence can be significant and insignificant and is determined by the $U_{ij} = \alpha_i + \beta_j$ formula, where α_i is the significance of the f_i influence on the focus of the problem, and β_j is the significance of the s_j influence. To determine the α_i and β_j significance, a hierarchical model is considered, where an increase in the gap between the chosen and actual directions of development is considered as the focus of the problem (upper level). The size of the break is determined at time t by the value of the angle $\alpha(t)$ between the selected and actual directions. The cosine of the angle $\alpha(t)$ is determined by the expression

$$\alpha(t) = \boldsymbol{x'}_b, \boldsymbol{x'}_\phi(t) / \left|\boldsymbol{x'}_b, \boldsymbol{x'}_\phi(t)\right|, \qquad (1)$$

where

$$\boldsymbol{x'}_b = \left(x_b^1, \dots, x_b^j, \dots, x_{\ b}^{\ p}\right) \qquad (2)$$

is the vector that specifies the chosen direction of development,

$$\boldsymbol{x'}_\phi(t) = \left(x_\phi^1(t), \dots, x_\phi^s(t), \dots, x_\phi^p(t)\right) \qquad (3)$$

is the vector that determines the actual direction of development. Violation of inequality $\cos\alpha(t) \geq 1 - \varepsilon$, where ε is the permissible error, indicates the occurrence of PS. The $x^j(t), j = \overline{1, p}$ variable determines the current state of the ischemic heart disease. At the second level of the hierarchy are the systemic characteristics of the functioning and development of IBS, which affect the changes in the gap. This can be income, IBS costs, losses due to risks, etc. At the third level of the hierarchy are $f_i \in F$ FZ. The fourth (lower) level of the hierarchy contains the $s_j \in S$ components of the strategy. As a result of the implementation of the MAI expert procedure, the global priorities α_i^0 of all f_i FZs and the global priorities β_j^0 of all components s_j of the IBS strategy are found. To select a set of essential FZs, they are ranked by decreasing α_i^0 and a set F_0 is formed from the first elements of the resulting series

$$F_0 = \left\{ f_{sj} \in F : \sum_{i=1}^{\rho_0} \alpha_{s_i} = 0.8 \pm \varepsilon \right\}, \qquad (4)$$

where ε is the permissible error, ρ_0 is the cardinality of the F_0 set. To highlight the essential s_j, they are ranked by decreasing β_j^0 and the S_0 set of the first elements of the resulting series is formed:

$$S_0 = \left\{ s_{lj} \in S : \sum_{j=1}^{g_0} \beta_{l_i} = 0.8 \pm \varepsilon \right\}, \qquad (5)$$

where g_0 is the cardinality of S_0. The resulting priorities

$$\alpha_{si}^0,\ i = \overline{1, \rho_0},\ \beta_{lj}^0,\ j = \overline{1, g_0} \qquad (6)$$

normalize and receive the a_{si} significance of the essential FZ and the β_{lj} significance of the essential components of the strategies associated with the PCE of the current PS in the formula (7).

$$\alpha_{si} = \frac{\alpha_{si}^0}{\sum_{i=1}^{\rho_0} \alpha_{si}^0},\ \beta_{lj} = \frac{\beta_{lj}^0}{\sum_{j=1}^{g_0} \beta_{lj}^0}. \qquad (7)$$

A bipartite digraph, defined on the set of vertices F_0 and S_0, defines the structure of the PS, serves as a structured description of the current PS. The concepts corresponding to the edges of a bipartite digraph have the following properties:

1. The weight of the $< f_{si}, s_{lj} >$ concept is determined by the sum of $\alpha_{si} + \beta_{lj}$ significances
2. $R_0 \subset F_0 \times S_0 \subset F \times S$
3. The f_{si} FZ is involved in the implementation of the s_{lj} component of the IBS strategy.

The $R_0 = S_0 \times \Phi_0$ binary relation characterizes a lot of essential, difficult to formalize relationships that significantly affect the increase in the gap, which determines the mechanism of influence of the PS on the process of implementing the IBS strategy.

When resolving PS, it is proposed to use the precedent-based inference method, which has significant advantages over the knowledge-based inference method. It is especially effective when the following conditions are met:

1. The main source of knowledge about PS is experience, not theory;
2. The managed solution is not unique for a specific software system, but can be used in other cases;
3. The goal is not a guaranteed correct solution, but the best possible [8, 9].

The use case provides a description of a variety of sequences of actions, including the options performed by IBS, to overcome the arisen PS. It includes a description of the PS, the scenario for permitting the PS, the result (validity) of the application of the management decision to resolve the PS. The problem of setting a precedent is the problem of choosing information and knowledge to be included in the description of a precedent, finding a structure that defines the content of a precedent, organizing and identifying a precedent knowledge base (PKB), which ensures efficient search and reusable use. At the same time, one should distinguish procedural knowledge (“dissolved” in algorithms) from knowledge that is separate from algorithms [12]–[14].

The use case knowledge base should contain the following:

1. All known precedents of resolved PS.
2. Adopted management decisions to resolve emerging PS, available recommendations and other experience.
3. The results of the research carried out on the identification, identification, and resolution of PS.

PKB reduces the degree of uncertainty in the formation of management, reduces the risks of making wrong decisions. It is an effective tool for managing knowledge about use cases and how to resolve them by means of the following:

1. New information about similar precedents and experience in resolving their PS.
2. Information on the results of conducted and ongoing research of the precedent, PS, PCE.
3. Information on the results of the resolution of the PS of various precedents.

Since the PCE is constantly updated due to its maintenance, its information can be used to identify PSs that correspond to the same precedent, but do not repeat exactly, which is typical for IBS PS [12].

Setting a precedent should be consistent with the goals and technology of functional diagnostics of IBS. If the precedent with the number e corresponds to q PS forming the $T_e = \{PS_{er}, r = \overline{1, q}\}$ set, then it can be specified by a reference PS_E, reflecting the invariant properties of all $PS \in T_e$ and their PCE. The binary relation

$$R_{0r} \subset F_{0r} \times S_{0r},\ F_{0r} \in F,\ S_{0r} \in S \tag{8}$$

is given for each $PS_r \in T_e$. For the reference PS_E it is necessary to determine

$$R_{0E} \subset F_{0E} \times S_{0E},\ F_{0E} \in F,\ S_{0E} \in S. \tag{9}$$

Let's assume that $R_{0E} = \bigcup_{r=1}^{q} R_{0r}$. For each $< f_i, s_j >\in R_{00}$ concept, it determines the ρ_{ij} value, which is the number of occurrences of the concept in the R_{0r} binary relation. It's obvious that $\rho_{ij} < q$. To determine R_{0E} the $< f_i, s_j >$ concepts are ranked in descending ρ_{ij} and the R_{0E} set of the first elements of the resulting series is formed in the formula (10):

$$R_{0E} = \left\{ < f_i, s_j >\in R_{00}: \sum_{< f_i, s_j >\in R_{0E}} \rho_{ij} = h_e \cdot \rho_0 \pm \varepsilon_0 \right. \\ \left. \rho_0 = \sum_{< f_i, s_j >\in R_{00}} \rho_{ij}, 0 \le h_e \le 1 \right\}, \tag{10}$$

where ε_0 is the permissible error, and the h_e threshold value for each precedent with the number e is found considering the historical experience of the formation of the T_e class. In particular, if $R_{0r} = R$ for all $r = \overline{1, q}$, then $R_{00} = R_0$ and $h = 1$. Therefore, for deterministic PS the value is close to unity. For non-deterministic PS, the value of h decreases. $h = 0.8$ is taken as an initial approximation. The sets

$$F_{0E} = D_l(R_{0E}), S_{0E} = D_n(R_{0E}) \tag{11}$$

are determined by the left and right regions of the R_{0E} binary relation defining the bipartite graph of the reference PCE of the precedent with the l number. If the current problem situation of the PS_T is determined by the

$$R_{0T} \subset F_{0T} \times S_{0T}, F_{0T} \in F, S_{0T} \in S \tag{12}$$

binary relation, then to assess its belonging to the class T_e it is necessary in the case when h satisfies the

$$\frac{|R^0|}{|R_{00}|} \ge h_e \pm \varepsilon \tag{13}$$

condition, where ε is the permissible error, $|R^0|$ is the cardinality of the $R_0 = \bigcap_{r=1}^{q} R_{or}$ set, $|R_{00}|$ is the cardinality of the set R_{00} check the fulfillment of two conditions:

$$R_0 \subset R_{0T}, \frac{|R^0|}{|R_{00}|} \ge h_e \pm \varepsilon. \tag{14}$$

If the conditions are true, then PS_T belongs to the class T_e. Otherwise, it is referred to a different use case. If PS_T is a deterministic PS belonging to the T_e class, then the managerial decision to overcome the PS_T is determined by the reference PS of the T_e class. If PS_T is a non-deterministic PS belonging to the T_e class, then the management decision on its resolution is determined by one of $PS_r^0 \in T_e$. To find PS_r^0, the set of

$$Q_e = \{g_j,\ j = \overline{1, k_e}\} \tag{15}$$

segments g_j of the knowledge base is selected, containing information about the PCE of the precedent with the number e, k_e is the cardinality Q_e.

For each (g_j, PS_r) pair, the probability m_{ir} was obtained expertly that the knowledge segment g_j can be used to reliably describe the PS_r. The degree of similarity between PS_i and PS_s can be estimated by the value

$$\delta_{is} = \frac{|G_s \cap G_i|}{|G_s \cup G_i|},\ 0 \le \delta_{is} \le 1, \tag{16}$$

where G_s is the set of $q_j \in G_e$ that reliably describe PS_s, G_i is the set that reliably describes PS_i. When $\delta_{is} = 1$ the degree of similarity according to the selected criterion is the greatest.

To reduce the Q_e power, determine the average value m_{jr}, which is equal to $\bar{m}$

$$\bar{m} = \frac{\left(\sum_{j=1}^{K_e} \sum_{r=1}^{q} m_{jr}\right)}{K_e} \cdot q \tag{17}$$

and build a generalized similarity table $PS_r \in T_e$. Matrix columns $PS_r \in T_e$ are defined, rows are $g_j \in G_e$. At the intersection of the j-th row and the r-th column, the $\overline{m_{jr}}$ value is recorded determined by the formula (18):

$$\overline{m_{jr}} = \begin{cases} 1, \overline{m_{jr}} \ge \bar{m} \\ 0, \overline{m_{jr}} < \bar{m} \end{cases}. \tag{18}$$

Simultaneous similarity of all $PS_r \in T_e$ is estimated by the value

$$\delta = \frac{\left|\bigcap_{r=1}^{q} G_r\right|}{\left|\bigcup_{r=1}^{q} G_r\right|},\ 0 \leq \delta \leq 1. \tag{19}$$

The value $\delta = 1$ is achieved when the $G_r = G$, $r = \overline{1, q}$ condition is met. The $G \in Q_e$ set is obtained by successive deletion of the rows of the generalized similarity table containing the largest number of zero elements, until a column of the matrix containing only zero elements appears. The remaining rows of the table without zero columns are determined by the Q_{0e} set of $g_j \in Q_e$ knowledge segments that provide the greatest degree of similarity $PS_r \in T_e$. On the basis of $g_j \in Q_{0e}$ knowledge segments, the vector of x_j^e informative features used for $PS_r \in T_e$ task is formed:

$$\boldsymbol{x}'_e = \left(x_1^e, \dots, x_j^e, \dots, x_{n_e}^e\right). \tag{20}$$

To determine PS_r^0, find the smallest d_{T_r} which is Euclidean distance from the current PS_T problem situation to $PS_r \in T_e$.

The problematic situation m determines the management decision recommended for the resolution of the current PS [15]–[17].

The described process of identifying problem situations defines a subject technology containing a sequence of stages.

Stage 1. Identification during the monitoring of the functioning of the IHD of the arisen PS.

Stage 2. Construction of a bipartite graph defining the current PS and the formation of its two-dimensional image.

Stage 3. Selecting a use case to which the current software belongs.

Stage 4. Identification of the current PS.

Stage 5. Formation of a management decision recommended for the resolution of the current PS.

Conclusions. As a result of the research, a subject technology for identifying problem situations arising in the process of functioning of intelligent business systems has been developed.

The created subject technology can serve as a scientifically grounded platform for the development of information technology for functional diagnostics of intelligent business systems.

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