ABSTRACT AND REFERENCES

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DEVELOPMENT OF THE MODEL OF THE ANTAGONISTIC AGENTS BEHAVIOR UNDER A CYBER CONFLICT (p. 6-19)

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The results of the development of the model of the antagonistic agents behavior in a cyber conflict are presented. It is shown that the resulting model can be used to analyze investment processes in security systems, taking into account the assumption that investment processes are significantly influenced by the behavior of parties involved in a cyber conflict.

General approaches to model development are presented. First of all, the system of concepts, assumptions and limitations is formed, within the framework of which a mathematical model of behavior must be developed. Taking this into account, the mathematical model of the conflicting agents behavior, presented in the form of algebraic and differential equations, is developed. The developed model presents both the technical characteristics of the security system and the psychological characteristics of the participants in the cyber conflict, which affect the financial characteristics of the investment processes in cybersecurity systems. A distinctive feature of the proposed model is the simultaneous consideration of the behavior of the parties to a cyber conflict not as independent parties, but as agents mutually interacting with each other. The model also makes it possible to simulate the destabilizing effect of the confrontation environment disturbances on the behavior of the conflicting parties, changing the degree of vulnerability of the cybersecurity system along various attack vectors and the level of their success.

Using the developed model, simulation modeling of the interacting agents behavior in a cyber conflict is performed. The simulation results showed that even the simplest behavior strategies of the attacking side ("the weakest link") and the defense side ("wait and see") make it possible to ensure information security of the business process loop.

The developed model of interaction between the attacker and the defender can be considered as a tool for modeling the processes of the conflicting parties behavior when implementing various investment scenarios. The simulation results enable decision-makers to receive support regarding the direction of investment in the security of the business process loop.

Keywords: behavior models, antagonistic agents, attack tree, business process loop.

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MATHEMATICAL MODELING OF AUTONOMOUS UNDERWATER VEHICLE PROPULSION AND STEERING COMPLEX OPERATION IN OBLIQUE (BEVELED) WATER FLOW (p. 19-26)

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The research of nonlinear hydrodynamic characteristics of the propulsion and steering complex (PSC), which influence the accuracy of the plane trajectory motion of an autonomous underwater vehicle (AUV), is carried out. During the underwater vehicle curvilinear motion, its PSC operates in an oblique incident water flow. This leads to a decrease in the PSC thrust force and negatively affects the controlled trajectory motion of the underwater vehicle. The research was conducted for a specific type of AUV for the plane curvilinear motion mode.

The mathematical modeling method was chosen as the research method. To this end, the well-known AUV motion mathematical model is supplemented by the control system that simulates (mimics) its trajectory motion. The developed model consists of four main units: an AUV improved model; the vehicle speed setting unit; the nozzle rotation angle control unit; the unit containing the AUV pre-prepared motion trajectories.

The research results of the AUV hydrodynamic parameters for several typical trajectories of its motion are presented. The investigated parameters include the following: the required nozzle rotation angle; the vehicle actual motion trajectory; the vehicle velocity; the propeller shaft moment; the propeller thrust force.

As a result of the conducted researches, the dependence diagram of the propeller thrust force on the AUV nozzle rotation angle in the speed range from 0.2 m/s to 1 m/s and during the nozzle rotation in the range of up to 35° was constructed. A three-dimensional matrix, which describes the dependence of the propeller thrust force on the incident water flow angle and velocity of the vehicle, was created. The obtained dependence can be used in the synthesis of automatic control systems regulators of AUV plane manoeuvering (shunting) motion of increased accuracy.

Keywords: autonomous underwater vehicle, propulsion and steering complex, mathematical modeling, rotary nozzle.

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REFINEMENT OF THE MATHEMATICAL MODEL OF FREQUENCY CONVERTER CABLE BRANCH WITH A SINGLEPHASE SHORT CIRCUIT (p. 27-35)

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The mathematical model of the frequency converter cable branch as a part of the mine section power network with a single phase-to-ground fault is clarified. The model takes into account a discrete nature of the output voltage and power switches commutation inertia of a voltage inverter as a part of the converter. A technique is proposed for the formation of a mathematical model of a cable line with distributed parameters as a set of differential equations of state and algebraic coupling equations in matrix form. In this case, the cable is divided into three-phase elementary sections, for a set of typical equivalent circuits of which a graph is built, the matrix of the main sections and the matrix coefficients of the equations are calculated. The latter are solved by numerical methods. This allows to take into account the wave processes in the cable for a high-frequency pulse-width modulated output voltage of the frequency converter. Also the asymmetry of the insulation ground resistance, accompanying a ground fault, is taken into account. The matrix-topological approach allows to avoid operations with partial derivatives with respect to geometric coordinates of the cable. The relevance of the research resulted from the neglect of significant factors in known models, which reduces the accuracy of the analysis. In particular, the influence of the discrete nature of the output voltage of the frequency converter, the distributed nature of the cable line insulation parameters and the transverse asymmetry in emergency mode on the instantaneous values of the ground fault current are not taken into account. As a result of numerical simulation for the network of specific configuration, it was found that the occurrence of ground fault through a human body in the cable branch of the frequency converter is characterized by an unacceptably high probability of fatal electrocution. The monitoring method of the insulation resistance of the power network branch, equipped with the semiconductor frequency converter, is proved. The implementation of the method will improve the electrical safety of underground electrical networks due to the timely detection of insulation damage of the frequency converter cable branch and the transmission of a signal to turn off the supply voltage.

Keywords: frequency converter, ground fault, autonomous inverter, state variables, electrocution.

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QUALITY ASSESSMENT OF MEASUREMENT INSTRUMENT SOFTWARE WITH ANALYTIC HIERARCHY PROCESS (p. 35-42)

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A comparative analysis of the results of conformity assessment of software for measuring instruments (MI) was carried out. For comparative evaluation, eight MI software with built-in and universal computers were selected. Selected MI software was preliminarily evaluated by methods and algorithms that are based on the requirements of national standards and documents of international and regional legal metrology organizations OIML and WELMEC. Based on the results of the analysis of the requirements of the WELMEC guidelines for testing MI software, generalized and particular indicators were selected for assessing the quality of MI software. Expressions to obtain the numerical value of each partial indicator for each generalized indicator was generated.

For comparative evaluation, the analytic hierarchy process (AHP) was chosen, since it allows comparing and quantifying alternative solutions. For the purpose of relevant comparison, when evaluating a specific MI software, all compared elements were taken into account. The latter were grouped into generalized indicators, each of which was evaluated separately. Pairwise comparisons and all other stages of assessment using AHP were carried out on the basis of generalized indicators. For pairwise comparison of all quantitative and qualitative indicators with the presentation of the equation in a quantitative form, the Saati scale was used. The weight coefficients of each partial indicator were determined by the expert method.

The main indicators for MI software with a built-in and universal computer were determined, which have the greatest impact on the results of conformity assessment. It was found that without the presentation of documentation and identification of MI software with built-in and universal computers, it is impossible to begin the conformity assessment procedure in accordance with the requirements. The test indicator of storage devices and the special test indicator of software for particular MI are some of the significant indicators. At the same time, the reading test indicator and the test indicator of software separation levels are practically not applicable and can be neglected.

Keywords: software, measuring instrument, quality assessment, analytical hierarchy process.

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DEVELOPMENT OF THE METHOD OF STRUCTURAL AND PARAMETRIC SYNTHESIS OF THE QUANTON DIAGNOSTIC AND HEALTH COMPLEX (p. 42-51)

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The synthesis method based on the use of information invariants is proposed, and structural-parametric synthesis of the Quanton diagnostic and health complex is performed. Structural and parametric optimization of the complex is carried out according to the performance criterion. As information invariants, complete (within the accepted classification) sets of methods to obtain the functional properties of the complex, phase cycles of the life cycle, structures of technical subsystems and methods for controlling the technicalization levels, productivity and energy efficiency of processes are used. The sets of methods to obtain the functional properties of the complex and phase cycles of the life cycle are formed by elementwise complication of the corresponding attributes. The set of structures of technical subsystems corresponding to certain levels of technicalization of functions is determined on the basis of the periodic system of technical elements. Complete sets of possible structural solutions for methods of controlling the productivity and energy efficiency of processes are obtained by the topological product of the sets of

types of objects by the types of methods for ensuring the required properties or qualities of objects. For each structurally different variant, the usual object parameterization procedure and the system of dependencies of the deductive parametric optimization problem are applied. The system of dependencies is a specific case of parametric information invariants. The dependencies are specified using the information about the necessary source data and target transformations occurring in the Quanton complex during the interaction of subsystems. The algorithm for finding an extremely effective solution is step-by-step. This algorithm assumes a step-by-step determination of the optimal process performance parameters within the limiting contours and subsequent improvement of energy efficiency and quality. Due to the use of complete sets of process structures, elements and discrete-continuum procedure of search for the optimal solution, the integration of the optimization of technical innovation is achieved.

Keywords: parametric synthesis, Quanton complex, non-invasive diagnostics, spectral method, high-frequency therapy.

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METHOD FOR DETERMINING ELEMENTS OF URBAN INFRASTRUCTURE OBJECTS BASED ON THE RESULTS FROM AIR MONITORING (p. 52-61)

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The study proposes a two-stage method for determination of elements of urban infrastructure objects in images made by air monitoring systems. The first stage implies determining the contours of objects in images. The advanced Canny method was selected as the contour determination method. We considered the main stages of the advanced Canny method for determination of contours of objects in images made by air monitoring systems. The application of the Hough transform at the second stage was proposed.

The paper reports features in the method for determination of elements of urban infrastructure in color images made by air monitoring systems. In contrast to known methods, the method takes into account features of formation of images made by air monitoring systems. It highlights color channels and marks out contours and geometric primitives in each color channel; it re-integrated color channels and determines elements of urban infrastructure objects in the space of an output image.

The study presents the results of applying the method for determination of elements of urban infrastructure objects in a standard color image acquired from an air monitoring system. We defined elements of urban infrastructure objects, such as roads, houses, streets, building elements and others, as an example.

A visual evaluation of the quality of processing of a typical color image made by an air monitoring system was performed. We calculated errors of the first kind and the second kind. It was established that application of a two-stage method for determination of elements of urban infrastructure objects in an image made by an air monitoring system improves the quality of processing of optoelectronic images. Moreover, errors of the first kind and the second kind in determination of elements of urban infrastructure objects reduced by 13 % on average.

Keywords: air monitoring system, element of an urban infrastructure object, Canny method, Hough transform.

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