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DEVELOPMENT OF A DEVICE FOR THE OPTIMAL RECEPTION OF SIGNALS AGAINST THE BACKGROUND OF AN ADDITIVE THREE-COMPONENT INTERFERENCE (p. 6–13)

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We have synthesized the optimal receiver of code signals from an automated locomotive signaling system. The signals are observed against the background of a three-component additive interference. The first component of the interference is pulse, the second component is a continuous sinusoidal disturbance from a power line, the third component is the Gaussian noise. We have implemented a method of joint evaluation of signal parameters and the structurally deterministic interference in the receiver. The proposed method is flexible to the changing parameters of interference. A decision on the form of the received code signal is made based on the criterion of a minimum in the mean square of approximation error. The error of approximation means a difference between the magnitude of the sum of a signal and the structurally deterministic interference components and the magnitude of total voltage at a receiver's input. It has been shown, based on realistic assumptions about the statistical relationships between a signal and the interference components, that the objective function is a sum of the isolated logarithms from the ratios of likelihood and correction functions, taken with an opposite sign. This research has focused primarily on studying a possibility to reduce the impact of structurally deterministic interference. The result is the designed device capable to respond quickly to changes in the parameters of such an interference. We have shown a fundamental possibility to construct an optimal receiver in a modular fashion. In this case, modules can be connected and disconnected according to the a priori defined composition of the interference set, while the «library» of modules can be updated when the new kinds of interference emerge. It has been shown through computer simulation that in the channel, responsible for forming a valid solution, the magnitude of approximation error is about 6 times less than in the other two channels. This ratio holds when the amplitudes of a pulse noise and an interference from a power line have a multiple advantage over the amplitude of the code signal.

The designed device ensures high noise immunity when distinguishing code signals over a wide range of interference parameters. This would make it possible to improve the safety of motion, as well as accuracy in keeping the schedule of trains.

Keywords: structurally deterministic interference, code signal, optimal recognition, multi-extremal objective function.

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DEVELOPMENT OF STRUCTURES OF THE AIRCRAFT FIRE ALARM SYSTEM BY MEANS OF NESTED MODULES (p. 14–23)

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Optimization of structures of information management systems is determined by the choice of such a functional structure that would ensure high reliability of information. When creating complex systems, there is the problem of ensuring high operational reliability of connection of a large number of separate elements into a single monolithic highly efficient information system. This problem is effectively solved by combining the elements of the system of controlled information sensors by means of nested modules.

The mathematical model of parallel information redundancy based on polynomial distribution is developed. This model allows exploring the probability states of the fire alarm system, consisting of n parallel-connected identical sensors. As the state of the fire alarm system, indicators such as probabilities of correct detection, non-detection and false alarm are considered.

On the basis of the proposed model, mathematical dependencies of the basic modules $M_{2,3}$, $M_{2,4}$ are obtained, taking into account the majority factor, and accordingly schematic diagrams of these modules on logic gates are developed.

Mathematical dependences for the first ($N_{6,9}$, $N_{12,24}$) and second ($L_{18,27}$, $L_{48,96}$) hierarchies of connection of fire alarm system sensors, implementing the majority rule « m -out-of- n », taking into account their hierarchy are obtained.

The generalized mathematical formulas for determining the number of logic AND gates in each specific structural circuit for nested modules of the first and second hierarchies, as well as the mathematical formula for n hierarchies, are proposed.

Mathematical dependencies of the total economic gain, which consists in reducing the number of AND circuits for implementing the majority rule « m -out-of- n » using nested modules, are obtained.

It is advisable to introduce structures of fire alarm systems on the basis of nested modules into production, as the

reliability of information increases even with low reliability characteristics of the sensors.

Keywords: fire alarm sensors, event recognition reliability, information parallel redundancy, probability states, nested modules.

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TRAFFIC ENGINEERING IN A SOFTWARE-DEFINED NETWORK BASED ON THE DECISION-MAKING METHOD (p. 23–28)

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One of the main control tasks in a computer network is to organize an effective system of information delivery; this task is of particular relevance in the software defined network. Conventional routing tools do not meet the requirements to service quality and the requirements for equitable distribution of congestion along communication channels. Routing in conventional networks is performed by the shortest path search based on a specified parameter, but these tools do not provide sufficient agility when changing routes in the network. Another drawback is the need to transmit regular updates of routing information by passing the service traffic, thereby dramatically increasing the congestion and reducing the throughput.

At present, the most effective way to ensure the assigned quality of service parameters, as well as a promising solution to organize efficient routing under conditions of uncertainty, is a software defined network. This new networking paradigm makes it possible to simplify the process of managing the network, to significantly enhance the use of network resources, and to reduce operating costs. One of the main advantages of such a network is control at the upper levels of the reference model, which makes it possible to simplify both the process of network management and the process to manage traffic in corporate networks and data center networks.

A new approach to traffic design in a software defined network has been proposed that employs the making-decision theory oriented towards routing exactly in such networks. If there is a «problematic area» and there is the need to overcome it, the decision-making theory under conditions of uncertainty is used, since the probability of selecting the best way to circumvent it accounts for the patterns in transmitted traffic. Such a method makes it possible to reduce the loss of inelastic traffic that is an important component of the overall amount of transmitted information. From a practical point of view, the algorithm constructed in this work, when compared to known algorithms for traffic engineering, improves the quality of service in software defined networks.

Keywords: traffic engineering, software defined network, fuzzy logic, throughput capacity, channels congestion, network reconfiguration.

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LOCALIZATION AND NAVIGATION OF MOBILE ROBOTS IN AN ENVIRONMENT WITH VARIABLE PROPERTIES (p. 29–36)

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A method of localization and navigation of a mobile robot in an environment with variable properties in conditions of limited possibilities was proposed for remote control which provides for a possibility of switching the mode of robot control to a state of autonomous navigation. The method is based on combined application of a fuzzy model and an RL-algorithm that makes it possible to improve the set of fuzzy rules using the signal of reinforcement.

Improvement of the method of localization of mobile objects using iBeacon and NFC technologies in a space with known maps of premises was proposed which enables reduction of the number of transmitters necessary for localization.

The method of identification of mobile object movement routes was modified with the use of the modified Jump Point Search algorithm. Essence of the modification consists in the use of the algorithm of Manhattan distance between coordinates of the route points. This makes it possible to reduce impact of individual surges on the results of calculations compared with the basic algorithm.

The obtained results can be used in mobile robot control systems in an environment with variable properties at limited possibilities for remote control. The results of testing the proposed methods and corresponding computational procedures confirm their performance and prospects of practical application. Application of the above approach makes it possible to take into account obstacle configurations and adjust the navigation strategy to improve the system quality (in 95 % of the test experiments, the mobile robot reached the target in an environment with various types of obstacles).

Keywords: mobile object, localization, autonomous navigation, fuzzy controller, control with reinforcement learning.

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SEGMENTATION OF OPTICAL-ELECTRONIC IMAGES FROM ON-BOARD SYSTEMS OF REMOTE SENSING OF THE EARTH BY THE ARTIFICIAL BEE COLONY METHOD (p. 37–45)

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It was established that it is not possible to apply the known methods of image segmentation directly to segmentation of optical-electronic images of on-board systems of remote sensing of the Earth. We have stated the mathematical problem on segmentation of such images. It was established that the result of segmentation of images of on-board systems of remote sensing of the Earth is separation of an image into artificial objects (objects of interest) and natural objects (a background). It has been proposed to use the artificial bee colony method for segmentation of images. We described the essence of the method, which provides for determination of agents positions, their migration, conditions for stopping of an iteration process by the criterion of a minimum of a fitness function and determination of the optimal value of a threshold level. The fitness function was introduced, which has the physical meaning of a sum of variance brightness of segments of a segmented image. We formulated the optimization problem of image segmentation of an on-board optical-electronic observation system. It consists in minimization of a fitness function under certain assumptions and constraints.

The paper presents results from an experimental study on application of the artificial bee colony method to segmentation of an optical-electronic image. Experimental studies on segmentation of an optical-electronic image confirmed the efficiency of the artificial bee colony method. We identified possible objects of interest on the segmented image, such as tanks with oil or fuel for aircraft, airplanes, airfield facilities, etc.

The visual assessment of the quality of segmentation was performed. We calculated errors of the first type and the second type. It was established that application of the artificial bee colony method would improve the quality of processing

of optical-electronic images. We observed a decrease of segmentation errors of the first type and the second type by the magnitude from 7 % to 33 % on average.

Keywords: remote sensing of the Earth, image, segmentation, artificial bee colony method.

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DEVELOPMENT OF THE MODIFIED METHODS TO TRAIN A NEURAL NETWORK TO SOLVE THE TASK ON RECOGNITION OF ROAD USERS (p. 46–55)

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We have developed modifications of a simple genetic algorithm for pattern recognition. In the proposed modification Alpha-Beta, at the stage of selection of individuals to the new population the individuals are ranked in terms of fitness, then the number of pairs is randomly determined – a certain number of the fittest individuals, and the same number of the least adapted. The fittest individuals form the subset B, those least adapted – the subset W. Both subsets are included in a set of pairs V. The number of individuals that can be selected to pairs is in the range of 20–60 % of the total number of individuals. In the modification Alpha Beta fixed compared to the original version of a simple genetic algorithm we added a possibility of the emergence of two mutations, added a fixed point of intersection, as well as changed the selection of individuals for crossbreeding. This makes it possible to increase the indicator of accuracy in comparison with the basic version of a simple genetic algorithm. In the modification Fixed a fixed point of intersection was established. The cross-breeding involves half the genes – those genes that are responsible for the number of neurons in layers, values for other genes are always passed to the descendants from one of the individuals. In addition, at the stage of mutation there are randomly occurring mutations using a Monte-Carlo method.

The developed methods were implemented in software to solve the task on recognizing motorists (cars, bicycles, pedestrians, motorcycles, trucks). We also compared indicators for using modifications of a simple genetic algorithm and determined the best approach to solving the task on recognizing road traffic participants. It was found that the developed modification Alpha-Beta showed better results compared to other modifications when solving the task on recognizing road traffic participants. When applying the developed modifications, the following indicators for the accuracy of Alpha-Beta were obtained – 96.90 %, Alpha-Beta fixed – 95.89 %, fixed – 85.48 %. In addition, applying the developed modifications reduces the time for the neuromodel's parameters selection, specifically using the Alpha-Beta modification employs only 73.9 % of the time required by the basic method, applying the Fixed modification – 91.1 % of the time required by the basic genetic method.

Keywords: pattern recognition, genetic algorithm, evolutionary algorithm, neural networks, Python, OpenCV, Keras.

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DEVELOPMENT OF METHODOLOGY FOR MODELING THE INTERACTION OF ANTAGONISTIC AGENTS IN CYBERSECURITY SYSTEMS (p. 56–66)

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The basic concepts that form the basis of integrated modeling of the behavior of antagonistic agents in cybersecurity systems are identified. It is shown that the emphasis is largely on modeling the behavior of one of the cyber conflict parties only. In the case when the interaction of all parties to the conflict is considered, the approaches used are focused on solving particular problems, or they model a simplified situation.

A methodology for modeling the interaction of antagonistic agents in cybersecurity systems, focused on the use of a multi-model complex with elements of cognitive modeling, is proposed. For this objective, the main components of cyber conflict are highlighted, the models of which must be developed. Modeling the interaction of antagonistic agents is proposed to be implemented as a simulation of situations. The concept of a situation is formulated and its components are presented.

In the proposed methodology, traditional methods and modeling tools are not opposed, but are considered together, thus forming a unified methodological basis for modeling the antagonistic agents' behavior.

In the proposed multi-model complexes, the individual elements and functions of the entities under study are described using various classes of models at a certain level of detail. Coordinated use of various models allows improving the quality of modeling by compensating for the shortcomings of some models by the advantages of others, in particular, reflecting the dynamics of interaction in system-dynamic and agent-based models, which is difficult in classical models of game theory.

Multi-model complexes allow stating the concept of «virtual modeling». This concept allows simulation using models of various classes. The choice of a class of models should correspond to the goals and objectives of modeling, the nature and structure of the source data.

As a result of research, a methodology is proposed for modeling the interaction of antagonistic agents in cybersecurity systems using methods based on the proposed models of the reflective behavior of antagonistic agents under modern hybrid threats conditions.

Keywords: cybersecurity, antagonistic agents, modeling methodology, system dynamics, reflective agent, multi-agent systems, cognitive modeling.

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DEVELOPMENT OF THE METHOD TO CONTROL TELECOMMUNICATION NETWORK CONGESTION BASED ON A NEURAL MODEL (p. 67–73)

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The circuit of congestion control using feedback by the sign of function of sensitivity to telecommunications network performance was considered. To determine a given function, the use of a simple neural network model of a dynamic system was proposed. Control over the existence or a threat of congestion is executed based on the analysis of the length of a queue at the side of information receiver. To analyze the system, the cost function was determined as the objective function of congestion existence. The proposed algorithm of optimal control ensures the formation of a control signal in such a way that the system output should maximally match the pre-established features – the key indicators for network efficiency. The congestion control circuit with the feedback based on the sign of sensitivity of the function of system performance was developed. The sign of performance sensitivity provides an optimal direction to configure the data source rate.

The neural model for a multi-step prediction of the state of the queue at the side of the telecommunication network receiver was proposed. If the neural network is configured to monitor the dynamics of the system and shows that the quadratic error is negligible, it is believed that the executed step corresponds to the system output, predicted in advance.

The algorithm of additive increase/multiple decrease, which determines the change of the data source rate, depending on the sign of function of sensitivity of performance indicator was proposed. This algorithm is an alternative system of congestion prediction and flow control based on the threshold queue filling.

A comparative analysis of the effectiveness of controlling circuits for congestion detection based on queues and on the function of sensitivity of telecommunication network performance was performed. It was shown that the magnitude of the queue and fluctuation in the source rate is smaller than that for the queue-based circuit.

Results from modeling the performance of the proposed circuit show that the circuit based on a sensitivity function has better key performance indicators in comparison with the conventional circuit of queue threshold selection.

Keywords: telecommunication network, sensitivity function, neural network, dynamic system, queue control.

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DEVELOPMENT OF A METHOD OF INCREASING THE INTERFERENCE IMMUNITY OF FREQUENCY-HOPPING SPREAD SPECTRUM RADIO COMMUNICATION DEVICES (p. 74–84)

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The development of a technique for increasing the interference immunity of frequency-hopping spread spectrum radio communication equipment has been carried out. The essence of the proposed method is the rational distribution of operating frequencies among the frequency-hopping spread spectrum radio communication devices, taking into account the mutual influence of transceivers on each other. The technique takes into account the strategies of the electronic warfare complex, predicts the signal-interference environment, chooses the parameters of the frequency-hopping spread spectrum, depending on the parameters of the frequency range. The existing scientific-methodical apparatus is intended only for use in radio directions and does not take into account a number of important parameters that does not allow it to be used with a lack of radio resources and active electronic countermeasure. According to the results of the research, it has been found that the proposed method allows increasing the interference immunity of frequency-hopping spread spectrum radio communication equipment on average up to 30 %, depending on the state of the channel. However, an increase in computing complexity at the level of 10 % is noted due to the introduction of additional procedures. Additional procedures in the developed method are the distribution of frequencies in the network, calculation of the mutual influence of transceivers of frequency-hopping radio communication devices on each other, prediction of the signal-interference situation and selection of frequency-hopping parameters. It is advisable to use this methodology in radio stations with programmable architecture to increase their interference immunity due to the rational distribution of operating frequencies of frequency-hopping spread spectrum radio communication devices in the network and forecasting of the signal situation.

Keywords: radio communication devices, forecasting, frequency-hopping spread spectrum, electronic countermeasure, interference.

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