DEVISING A METHOD FOR THE ESTIMATION AND PREDICTION OF TECHNICAL CONDITION OF SHIP COMPLEX SYSTEMS (p. 4-11)

Vladimir Vychuzhanin, Nikolay Rudnichenko, Victor Boyko, Natalia Shibaeva, Sergii Konovalov

In the course of devising and examining a method for the estimation and prediction of technical condition of ship CTS, operated under conditions of unpredictable extreme and technogenic impacts, we received new theoretical and practical results. A place in the hierarchy and topology of the FIIS elements of ship CTS is defined based on the characteristics of the energy, material and information resources used by the systems in the devised method for the estimation and prediction of technical condition of CTS.

The most vulnerable elements of FIIS of ship CTS are found with regard to their weight values in the systems, obtained by cognitive imitation and fuzzy simulation. The CTS elements, prone to failures, are determined by their advance detection by modeling the processes of decision making support in the search for reasons of failures. The strategy of restoring the FIIS elements of ship CTS with decision making support when searching for the reasons of their failures is based on the prediction of change in the probability of losing working ability and risk of failures of the elements. The obtained results improve reliability of ship CTS in the operation under conditions of extreme and technogenic impacts.

Keywords: complex technical systems, risk of failure, estimation of technical condition, prediction of technical condition, cognitive models.

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DEVELOPMENT OF THE DYNAMIC TENSOR MODEL FOR TRAFFIC MANAGEMENT IN A TELECOMMUNICATION NETWORK WITH THE SUPPORT OF DIFFERENT CLASSES OF SERVICE (p. 12-19)

Oleksandra Yeremenko

A model of traffic management, based on the tensor generalization of nonlinear differential equations of network state was proposed. This made it possible to obtain coordinated solution of the problems of routing and link resource allocation between the flows of different classes. The solution makes it possible to provide the Quality of Service by the parameters of the average packet transmission rate and the packet delay, including the nonstationary operating mode of the network routers interfaces. The coordinate system of interpolar paths and internal node pairs was used in the tensor geometrization of the network structure. This made it possible to provide the solution, in which the QoS requirements were satisfied not only along the basic paths, but also on the entire set of calculated routes. The problem of traffic management in the telecommunication network was set as the problem of optimization. In this case, it was necessary to calculate sets of control variables of two types, responsible for flow routing and for determining the order of the link resource allocation in the network in the course of minimization of the quadratic criterion of optimality. The selection of the criterion of quadratic form was determined by the fact that its use contributes to obtaining solutions of the balanced use of available network resources. On the other hand, the consideration of the state dynamics of network interfaces over time made it possible to provide meeting the requirements on the packets transmission rate and the average delay not in a specific moment of time, but throughout the entire routing table update timer.

Keywords: Quality of Service, traffic management, telecommunication network, tensor, dynamic model, routing, interface.

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ANALYSIS OF MATHEMATICAL MODELS OF CHANGING THE VESSEL'S COURSE WHEN TURNING (p. 20-31)

Yevgeniy Kalinichenko, Igor Burmaka

Mathematical models of changing the course of a vessel when turning without taking into account the duration of putting the rudder blade over are presented. All in all, three models of different degree of adequacy to the actual turning process were explored, and the correspondence of mathematical models to the experimental field observations of specific vessels was revealed. Analytical expressions for calculating the duration of both phases of a turn by the method of simple iterations were obtained.

An analysis of mathematical models under consideration was conducted for the purpose of identifying the model, most adequate to the actual process of the vessel's turn. As a result of the imitation simulation of the vessel's turn to 90°, whose inertial characteristics of turning ability were obtained from the field observations, it was established that when using mathematical model of the first type for the prediction of the curvilinear section, the trajectory error was 150÷200 m, for the second type of the model this value was 35÷40 m, and for the third type – 25÷30 m. The mathematical model of the vessel's turning ability of the third type proved to be the most acceptable, since along with sufficient simplicity it possesses the required accuracy (maximum divergence of experimental and model trajectories is 25÷30 m.

Results of the study can be used in navigation information systems for developing the function of calculation of parameters of the vessel's turn for the assigned initial data.

Keywords: provision of navigation safety, motion control, vessel's turn, dynamic models of turning ability.

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DEVELOPMENT OF ADAPTIVE EXPERT SYSTEM OF INFORMATION SECURITY USING A PROCEDURE OF CLUSTERING THE ATTRIBUTES OF ANOMALIES AND CYBER ATTACKS (p. 32-44)

Valeriy Lakhno, Yuliia Tkach, Taras Petrenko, Sergey Zaitsev, Volodymyr Bazylevych

The paper presents results of the research aimed at the further development of models for the intelligent systems of recognition of cyber threats, anomalies and cyber attacks.

A structural scheme of adaptive expert system (AES) of informa-tion security, capable of self-learning, is proposed, which takes into account potential errors of the third kind, which may arise and ac-cumulate while training a system of intelligent detection of complex targeted cyber attacks and preliminary process of splitting a space of attributes of the objects of recognition. We developed a model for calculating information criterion of functional effectiveness, based on entropic and distance criteria of Kullback-Leibler in the course of clustering the attributes of objects of recognition in computer systems, which allows obtaining input fuzzy classification training matrix. A procedure for the operation of AES as an element of the system for intelligent recognition of cyber threats (SIRCT) was explored in the training mode by a priori classified training matrix that allowed us to build correct decisive rules for the recognition of cyber attacks.

We designed AES "Threat Analyzer" and conducted its test research under conditions of real CoS performance at several enter-prises. It was found that the proposed model of AES learning makes it possible to achieve results of the recognition of the standard classes of cyber attacks at the level from 76.5 % to 99.1 %, which is at the level of recognition effectiveness by the best hybrid neural networks and genetic algorithms.

Keywords: recognition of cyber attacks, expert system, cluster-ing of attributes, functional effectiveness.

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THE THEORY OF PARALLEL CRC CODES BASED ON AUTOMATON MODELS (p. 45-55)

Vasyl Semerenko

A theoretical representation of the CRC codes with the aid of the finite automata in the Galois fields is proposed linear finite-state machine (LFSM). We examined three types of LSC, which are distinguished by its characteristic matrices: type 1, type 2, and type 3. Three methods of the parallel CRC computation are proposed.

The theorems are proven about the estimation of duration of the CRC computation by tuple-parallel method for three types of LFSM. We presented algorithms for the CRC tuple-parallel computation by the tables lookup for different types of LFSM and demonstrated their hardware implementation. For the symbolic-parallel and symbolic-tuple-parallel methods of CRC computation, symbolic LFSM over the non-binary Galois fields are applied.

In contrast to the known approaches, which consider the problem of high speed only, present article stresses the need for taking into account a capability to detect errors with the aid of generator polynomials of the CRC codes. We proposed the Hamming codes and the Abramson codes in the binary and non-binary Galois fields for this purpose.

Within the framework of single mathematical apparatus – theory of LFSM – it is possible to solve two important tasks simultaneously: to carry out mathematical substantiation of performance efficiency of the methods for parallel CRC computation and to estimate the detection and correction capability of the CRC codes based on LFSM graph models.

Such comprehensive approach is relevant in the practice of various data transmission, storage and compression systems.

Keywords: CRC codes, checksum, linear finite-state machine (LFSM), tables lookup.

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CRITERIA FOR THE EVALUATION OF MODEL'S ERROR FOR A HYBRID ARCHITECTURE DSS IN THE UNDERWATER TECHNOLOGY ACS (p. 55-62)

Alexander Trunov

On the examples of successful implementations of technologies in the projects of unmanned (U) tethered and autonomous underwater vehicles (AUV), we demonstrated effectiveness of the automated control systems (ACS) with a hybrid decision support system (DSS). A generalized DSS structure is formed, for which the fundamental elements that provide for the quality of control are the selection criteria for models, algorithms and formation of operating rules. The main ones of the properties of criteria are simplicity, accuracy, and evaluation speed, which also enables full account of the models' properties.

We explored a generalized mathematic model of UAUV. The problem on analytical determination of dependence of the estimation error in the predicted behavior of model on the properties of AUV and process parameters was formulated and solved. Based on general analytical solutions, which were obtained by the methods of finite-integral transforms, we examined the properties of such evaluations by using numerical experiments. According to results of analysis of the obtained data, it was established that a factor of the quantity of own numbers for the formation of kernels of integral transformations is more significant and it first of all determines the magnitude of error when modeling the processes. Analyticity of expressions for the estimation of error in the predicted model's behavior makes them fit for simple rapid calculations. The latter provides for the advantage of such estimations when selecting them as the criteria for DSS of hybrid architecture as a quantitative criterion for the choice of alternative model, algorithm in the course of functioning of the underwater technology ACS.

Keywords: coordination control, evaluation of model's error, hybrid DSS, underwater technology ACS.

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DEVELOPMENT OF DIRECT METHOD OF DIRECTION FINDING WITH TWO-DIMENSIONAL CORRELATIVE PROCESSING OF SPATIAL SIGNAL (p. 63-70)

Vitaliy Tsyporenko, Valentyn Tsyporenko

The development of the direct digital method of correlative-interferometric direction finding with two-dimensional correlative processing of the reconstructed complex spatial signal in the aperture of linear antenna array was conducted. The estimations of directions towards the radio sources are obtained through the use of a two-dimensional frequency domain of determination and a two-stage processing, which enables the direct correlative analysis with minimal computing expense. At this point, the direct estimation of directions towards the sources of casual radio emissions, which spectra are fully overlapped by frequency, is performed in real time by reconstructing of the complex spatial analytical signals, their spatial selection and dispersive-correlative processing.

As a result of simulation, the dependence family of mean square deviation of estimation of direction from the direction of the source of radio radiation for different signal/noise ratios is obtained. The analysis showed that the examined method provides a higher accuracy of direction finding in comparison with the known method in a wide sector of directions, but it has lower computation costs and provides a significant speed increase of direction finding.

It is shown that the direction finding in the sector 360 degrees with an error of less than 0.04 degrees, when the input signal/noise ratio of 0 dB, is possible by using two antenna arrays. The possibility to ensure the resolution of 8 degrees or less at a signal/noise ratio of 0 dB, which is an important advantage in a complex electromagnetic environment is also shown.

Keywords: direct digital method; correlative-interferometric direction finding; reconstructing of the spatial analytical signal.

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