

CONTENTS AND ABSTRACTS

RADIO ENGINEERING AND COMMUNICATION SYSTEMS

S. N. Kirillov, A. A. Lisnichuk, P. S. Pisaka, K. V. Gribko. MULTI-CRITERIA APPROACH TO SELECT THE PROCEDURE OF TELEMETRIC RADIO SIGNALS CODING IN COMPLEX TECHNICAL OBJECTS

Key words: radio signal, telemetry information, error-correcting coding, multi-criteria approach, complex technical object.

The issues of improving the quality of the results in telemetric information processing are considered in the interests of an objective assessment of the state of complex technical objects (STO) in the process of testing. The aim of the work is to develop a multi-criteria procedure for choosing an encoder (decoder) of telemetric radio signals of a service station, which ensures resistance to the influence of interfering factors in transmission channel. Comparison of known encoders efficiency is made according to the following criteria: the ratio of radio signal energy per one message bit to the average value of noise power E_b/N_0 with undetectable error rate after decoding less than 10^{-9} , the delay (in bits) between the moment when a source bit appears in channel encoder and the moment of bit reproduction in a decoder neglecting transmission delay, the number of computational operations per bit during decoding, the amount of memory (in Kbits) required to decode a code of a certain type. Multi-criteria approach has shown that a compromise between increased error correction of telemetric radio signals and reduced requirements to hardware costs for decoding requires the application of CC (3.1 / 2), CC (5.1 / 2), LDPC codes (128, 64) and LDPC (256,128), providing the decrease in indicator value E_b/N_0 on 3.8-9.9 dB relative to uncoded channel.

DOI: 10.21667/1995-4565-2021-75-3-14 3

E. P. Vasiliev, Nguyen Dang Hop, Lyu Thanh Dat. BANDPASS FILTER ON CONNECTED MICROSTRIP LINES WITH TWO SECTOR RESONATORS

Key words: bandpass filter, sector resonator, coupled microstrip lines, electrodynamics and circuit simulation, machine experiment, S-band.

The design of compact bandpass filter based on half-wave resonator with two barrage poles provided by two sector resonators open at the end is considered. A study of the proposed filter design is carried out using analytical relations obtained on the basis of circuit theory and matrix analysis as well as electrodynamics methods of Green's function and finite elements. The aim of this work is to study the original design of bandpass filter with improved quality indicators (compensation of parasitic band at doubled central frequency and increase in stop level and band). The correctness of modeling results is confirmed by a comparative analysis of the data from machine experiment obtained using circuitry and electrodynamics modeling in S-band. The possibility of using the filter in infocommunication systems of space communication is substantiated.

DOI: 10.21667/1995-4565-2021-75-15-23 15

O. V. Kosarev, E. G. Dementieva, E. V. Katuntsov, Y. A. Luntovskaya, D. A. Katelevsky.
ALGORITHM OF TWO-DIMENSIONAL IMAGES MATCHING BY CONTOUR ANALYSIS METHODS

Key words: image matching, contour analysis, vector-contour in complex-valued space, slam-method, scanner, point cloud, two-dimensional image, ultra-sound scanning.

The problem of two-dimensional images matching obtained by successive scanning of internal surface of premises (internal surface of partially enclosed space) is considered. The aim is to obtain an algorithm for matching of two consecutive images by plane coordinates and rotation angle in the conditions of an error in scanner movement and the absence of position correction signals from external sources. A two-dimensional image is formed by a scanner as a cloud of interference boundary points (points of reflection of scanner signal from the walls of the room). Two consecutive images are shifted and rotated relative to each other by the values different from a scan step. The area of intersection of two images is determined and two auxiliary subsets of points are formed. Each auxiliary subset of points is transformed into a difference vector-contour in complex-valued space. Contour analysis methods determine the angle of mismatch between two images and their relative shift in plane coordinates. Based on this information, a subsequent image is combined with the previous one, considering the compensation of scanner movement error.

DOI: 10.21667/1995-4565-2021-75-24-33 24

**MATHEMATIC AND SOFTWARECOMPUTER SYSTEMS
 AND COMPUTER NETWORKS**

M. V. Ushakova, Y. A. Ushakov. RESEARCH OF VIRTUAL INFRASTRUCTURE NETWORK
 OF DATA PROCESSING CENTER WITH HYBRID SOFTWARE-CONFIGURABLE
 SWITCHING

Key words: modeling, OpenFlow, switch, traffic, QoS.

Modern trends in the development of information technology have led to the fact that entire infrastructure is gradually becoming software-controlled. Modern hyperconverged solutions use software-defined networking and soft switches for a hypervisor networking subsystem. The aim of the work is to study traffic processing in hyperconverged structures with software switching based on traditional approaches and OpenFlow. The features in the implementation of hyperconverged solutions network infrastructure are considered, approaches to the study of software-controlled environments are described. A model of internal structure of converged node traffic processing combining the functions of hypervisor, storage system and switch is proposed. Interface models that reproduce traffic switching in usual way and with higher-level OpenFlow processing are developed. The approaches to the implementation of developed models based on experimental studies of network equipment are described. The results of an experimental study of network node and a synthesized model showing the possibility of implementing the proposed approaches within the specified accuracy are presented.

DOI: 10.21667/1995-4565-2021-75-34-43 34

A. A. Spitsyn. ALGORITHM FOR CONFIGURING CLOUD COMPUTING SCHEDULE PARAMETERS BASED ON PARTICLE SWARM OPTIMIZATION

Key words: IaaS cloud, workflow, scheduling, quality of service, data transfer time, reliability, heterogeneous centers, execution time.

Infrastructure as a service (IaaS) clouds offer huge opportunities for solving large-scale tasks. Running workflows in such environments can be time-consuming if they are not properly scheduled. Although workflow planning in industry is widely studied, most approaches are focused on two user requirements for the quality of service, namely, execution time and cost. It is also necessary to take into account other important features of cloud computing, heterogeneous cloud data centers. The aim is to optimize data transfer time while minimizing execution time and improving reliability. Based on the simulation, the results show significant improvement in terms of execution time, transmitted data, and reliability compared to the proven HEFT (Heterogeneous Earliest Execution Time) method for reference workflows.

DOI: 10.21667/1995-4565-2021-75-44-52 44

D. A. Trokoz. SOFTWARE MODULE FOR SUPPORTING THE ALGEBRA OF HYPERDIMENSIONAL VECTORS

Key words: software module, time series, hyperdimensional vector algebra, service-oriented approach, position-independent coding, invariant representation, wide neural network, parametric model.

The paper proposes an architectural solution for a software module to support the algebra of hyperdimensional binary vectors. This module allows converting the values of target problem parameters into a hyperdimensional representation, which is more efficient in a number of mathematical models in comparison with classical position-dependent representation of data. The algorithm of such a transformation is based on the method of invariant data representation, using the algebra of hyperdimensional binary vectors, which allows performing position-independent encoding of arbitrary data structure.

The module uses a service-oriented approach, which greatly simplifies its use, due to the unification of the protocol for interaction of the module with external systems, which is described in detail in the work. In addition, since vector operations are intensively used in the algorithm for transforming data into hyperdimensional representation, the authors have proposed to use graphics accelerator instead of general-purpose processor as the main computing device of the module, which will tenfold increase the execution of such operations.

DOI: 10.21667/1995-4565-2021-75-53-62 53

V. V. Filimonov, V. V. Suskin. INCREASED PERFORMANCE OF MULTIPROCESSOR COMPUTING SYSTEMS THROUGH BALANCED LOAD AND OPTIMUM MEMORY ACCESS

Key words: performance of computing systems, optimization methods, multiprocessor computing systems, performance evaluation, efficiency of multiprocessor computing systems, performance improvement, parallelism, parallel computing.

Methods for evaluating performance and the possibility to use these methods for the development of parallel highly efficient algorithms running on multi-core processors and multi-processor computing systems are considered. The aim of this work is to study the existing methods for assessing performance to be used in choosing the optimal power of hardware for the implementation of computational tasks. The urgency of the problem lies in continuous growth of the amount of information that must be quickly processed

and used to make key decisions in many technological areas. The paper considers the most important laws on which performance assessment is based, a numerical and graphical comparison of assessment methods is carried out, graphs of effective dependence of algorithms on hardware are obtained, and mathematical description of ensuring balanced load and optimal memory access is formulated.

DOI: 10.21667/1995-4565-2021-75-63-70 63

INTELLIGENT INFORMATION SYSTEMS AND TECHNOLOGIES

I. Yu. Kashirin. NEURAL NETWORKS WITH KNOWLEDGE FOR BIG DATA ANALYSIS

Key words: knowledge models, big data, artificial intelligence, neural networks, ICF ontology, ontological taxonomies, hierarchical numbers, software tools, measure of concept semantic similarity, Semantic Web technology, Python, Anaconda, generic and causal relationships.

The most important task to design learning algorithms for mining big data, including neural network, is considered. To improve their efficiency, taxonomies for artificial intelligence knowledge models are used. It is proposed to use ICF contiguous inheritance relation as basic taxonomy relationship. This approach makes it possible to effectively design general and applied ontologies to solve artificial intelligence problems. The article uses mathematical apparatus of hierarchical numbers allowing to analyze applied ICF ontologies by calculating the main characteristics of taxonomic hierarchies. Such characteristics include, for example, a measure of concepts semantic similarity or the complexity of structural path in taxonomic hierarchy between two concepts. As an example that confirms the possibility of effective use of ICF taxonomies in solving real problems of data analysis, we propose the solution of clustering and classification problems in «Reducing churn and attracting customers of telecommunication company» subject area. For this problem the possibility of interdependent design of neural networks and applied ontologies with a priori libraries of causal taxonomies, for example, in Semantic Web technology, is shown. In the experimental part, to test the capabilities of information retrieval in global networks based on Semantic Web technology using ICF taxonomy, an experimental bench program for data mining methods (ESMIAD v.12.02.2021) is considered, which allows by placing fragments of program text in comments or vice versa perform experiments for analytical algorithms with training samples. The experimental stand is implemented in Python v.3.7 in Anaconda v.3.0 development environment. The purpose of this stand is to analyze the effectiveness of data mining methods using knowledge representation models.

The aim of the work is to analyze design features of learning algorithms for data analysis using general and applied ICF ontologies with the apparatus of hierarchical numbers to efficiently solve urgent problems of clustering and classification.

DOI: 10.21667/1995-4565-2021-75-71-84 71

K. V. Bukhensky, A. N. Konyukhov, A. B. Dubois, K. V. Anisimov. ON FUZZINESS OF MAMDANI RULE AS A BINARY RELATION OVER FUZZY NUMBERS

Key words: fuzzy relation, LR-type fuzzy number, membership function, shape function, index of fuzziness, antecedent, consequent, Mamdani rule.

The aim is to investigate fuzziness of binary fuzzy relation (FR) expressing Mamdani rule (implication) in dependence on its constituent fuzzy sets (FSs) given as LR-type fuzzy numbers (FNs). This work is the proceeding of the former investigation of fuzziness transformations on linear and nonlinear operations with FNs. As a measure of math fuzziness the Yager index of fuzziness with linear Hamming metric was used. Cases of FNs relations for same and different classes were investigated. Formulas for Mamdani rule FR index of fuzziness in general case of unimodal and polymodal (fuzzy interval) LR-type FNs were obtained.

DOI: 10.21667/1995-4565-2021-75-85-98 85

K. A. Maikov, A. N. Pylkin, S. N. Kuzmenko, A. A. Teplov. MODELING AND ANALYSIS OF FRACTAL GROWTH PATTERNS FROM MATERIAL POINT

Key words: fractal growth, geometric fractals, stochastic fractals, algorithms for constructing fractals, analysis of building fractals.

The growth of fractals from a material point is modeled using single-phase and multi-phase algorithms for linear fractals and polygonal fractal forms. The connection of fractal growth processes with the phenomena of formation in nature is considered. A method for analyzing growth processes and their characteristics is proposed. Growth laws of fractals metric characteristics and their transformation when changing growth algorithm are revealed. A growth path of fractal points and the distribution of slope angles of their elements are analyzed. The influence of stochastic fluctuations in the length of fractal elements on the process of its growth is modeled. It is shown that the algorithms and methods used for analyzing growth processes have great potential for modernization and adaptation to a wide range of tasks.

DOI: 10.21667/1995-4565-2021-75-99-112 99

E. V. Borisova. DESCRIPTION OF BASIC MATHEMATICAL MODELS IN QUANTUM CRYPTOGRAPHY

Key words: qubit, qudit, quantum cryptography, ensemble density matrix.

Quantum cryptography is one of the three parts that form interdisciplinary field of research-quantum computer science. In addition to quantum cryptography, quantum information science includes research on quantum computers and quantum communication theory. Since quantum informatics originated at the intersection of various disciplines, its understanding requires, first of all, the knowledge of languages and methods of quantum theory as well as classical information theory [1].

This article discusses quantum cryptography, on the one hand, as quantum communication, in particular, quantum key distribution, and on the other hand, quantum computing, which poses a threat to classical cryptography and to public key data transfer protocols. Both are essentially different branches of quantum computer science – the science of how information can be transmitted and transformed using quantum systems. The concept of a qubit is defined as a simple two-dimensional quantum state, the basis of which is a logical zero and a logical unit. In this paper, we will define the concept of qubit as a two-dimensional quantum system, i.e., a superposition of two basis vectors: 0 and 1, with coefficients C_0 and C_1 being complex.

The aim of this paper is to present a mathematical description of qubit, qudit, N-qubit system, and ensemble density matrix. In this paper, we define the concept of qubit as a quantum system with two well-distinguishable orthogonal quantum states. Qubits are shown to move on to qudits, i.e., to d-dimensional system, which, respectively, will be described by $2d-2$ number of parameters, the possibility to move to N qubit system, the dimension of which, in general, growing exponentially is also proved. In case when the system is factorized, it grows linearly.

DOI: 10.21667/1995-4565-2021-75-113-120 113

D. G. Rodionov, E. A. Konnikov, T. V. Tenishev. METHODOLOGY FOR ASSESSING THE IMPACT OF DIGITAL TRANSFORMATION ON BANK ORGANIZATIONAL ACTIVITIES

Key words: digitalization, bank, banking sector, net profit, tonality, financial technologies, fintech.

At the moment, the digitalization process has become ubiquitous at all levels of management decision-making. The consequence of this process is the transformation of both information consumption process and business processes of enterprises in all sectors of the economy. One of the most sensitive to this transformation is a banking sector due to information specifics of the services provided. Thus, the efficiency and competitiveness of a modern banking organization is largely determined by the efficiency of digitalization process. The aim of this work is to analyze the impact of digital transformation indicators on technical and economic indicators of banking enterprises. As part of this study, a regression analysis was carried out, the result of which is mathematical formalization of the impact of identified and quantified indicators of digital transformation on net profit of key representatives of banking sector. Also, a significant scientific result is a quantification algorithm for the analyzed indicators of digital transformation, described in this article. The results obtained allowed us to identify the most significant indicators of digital transformation and formulate generalized recommendations for banking enterprises, which would potentially increase their competitiveness in the context of widespread digitalization.

DOI: 10.21667/1995-4565-2021-75-121-132 121

SYSTEM ANALYSIS, MANAGEMENT AND INFORMATION PROCESSING

S. V. Spitsyn, S. A. Tikhomirov. ON-BOARD DATA CLASSIFIER MODEL OBTAINED FROM ROCKET AND SPACE EQUIPMENT VEHICLE ON THE BASIS OF IMPLICIT FEATURES OF TRAJECTORAL DEVIATIONS

Key words: information and measurement support of rocket launches, trajectory measurements, machine learning, system analysis, telemetry information.

The paper considers on-board data classifier model obtained from rocket and space equipment vehicle on the basis of implicit features of trajectorial deviations. The proposed classification model is based on specific binary classification algorithm in terms of modern and perspective machine learning methodology algorithms such as decision tree and random forest. The aim of the work is to find a generalized algorithm for determining the occurrence of abnormal and emergency onboard situations in complex multiparametric objects (rocket and space equipment vehicle) based on trajectory data analysis. The trajectory data is obtained by polygon measuring instruments as part of general flow of onboard telemetry information during flight experiment. The paper presents a step-by-step process of constructing effective classifier model for normal and abnormal on-board states. The model is based on modern methods of data mining and

machine learning, which are currently not widely used in technological processes of rocket and space industry.

DOI: 10.21667/1995-4565-2021-75-133-141 133

PHYSICAL ELECTRONICS AND NANOELECTRONICS

V. K. Fedyaev, N. M. Marankin. DIODE GENERATOR OF PLANAR CONSTRUCTION

Key words: microwave generator, efficiency, diode, diotron, gap, generation zone, convection current, saturation mode, spatial charge mode, cathode current cut-off mode.

A brief review of publications on single-cavity microwave generators of straight-through type (diode, monotron, two-gap resonator in generation modes) is given. The aim of this work is to study interaction processes and electron efficiency of a diode generator (diotron) of planar construction in various modes including cathode current cut-off mode by numerical simulation. Based on the model of an electron beam consisting of large particles and the solving the equations of particle motion by the Runge-Kutta third order method, the ways to calculate the efficiency by energy method and calculate the shape of convection current pulses using charge conservation law are developed. The authors have shown that the result of speed modulation under the influence of alternating voltage are bunches of electrons being formed that at certain transit angles fall into negative half-waves of alternating voltage leading to the formation of generation zones. Without cutting-off cathode current in case of particle charge equality (electrons enter high-frequency gap from external cathode or diode cathode operates in saturation mode) efficiency values in the center of zones were 12 % for the first zone, 8,3 % for the second and 6,1 % for the third at transit angles, respectively, 4,8 rad, 9 rad and 13,3 rad. In case of particle charge dependence on AC voltage phase, maximum efficiency decreases to 2,4 % for the first zone, 5,3 % for the second and 4,3 % for the third. The decrease is mainly due to the fact that the center of initial bunch formed at cathode and the center of bunch formed by subsequent grouping are shifted in phase by $0,5\pi$. Cathode current cut-off mode did not give expected efficiency increase as in klystron operating in this mode.

DOI: 10.21667/1995-4565-2021-75-142-152 142

M. A. Reginevich, S. M. Karabanov. STUDYING THE INFLUENCE OF INTERMEDIATE HYDROGEN PLASMA TREATMENT ON AMORPHOUS SILICON LAYER PROPERTIES IN TWO-STAGE DEPOSITION

Key words: silicon crystalline solar cells, HJT, amorphous intrinsic silicon layers, PECVD, hydrogen plasma treatment.

The aim of this work is to investigate the effect of hydrogen plasma treatment of layers of amorphous hydrogenated silicon on their defectiveness in the manufacture of heterojunction solar cells. Hydrogen plasma treatment after deposition of the first layer of amorphous hydrogenated silicon with thickness of 5-6 nm allows passivation of defects in layer volume and, due to surface hydrogenation, creates conditions for defect-free growth of next layer to total thickness of 10 nm. The lifetime of minority charge carriers increases from 3.5 to 5 ms. The parameters of treatment with hydrogen plasma are determined, which makes it possible to reduce the level of defectiveness of intrinsic hydrogenated amorphous silicon layers in the production of high-efficiency solar cells. .

DOI: 10.21667/1995-4565-2021-75-153-158 153

M. A. Reginevich, S. M. Karabanov. PROCESS TECHNOLOGY IMPACT ON DEFECT FORMATION IN AMORPHOUS SILICON LAYERS FOR HETEROJUNCTION SOLAR CELLS

Key words: silicon crystalline solar cells, amorphous intrinsic silicon layers, PECVD, hydrogen plasma treatment.

The aim of this work is to study the influence of process step factors on the formation of defects in amorphous silicon in the manufacture of heterojunction solar cells (HJT). Defects of layers in amorphous hydrogenated silicon, their appearance and changes in the structure of layers in the process of manufacturing a solar cell are studied. The change in amorphous silicon structure after hydrogen plasma treatment and annealing after the process of transparent conducting oxide deposition is carried out. The parameters of the processes that allow reducing the level of defectiveness in the production of high-performance solar cells have been determined.

DOI: 10.21667/1995-4565-2021-75-159-164 159