ABSTRACT AND REFERENCES

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MODELING THE CONVEYOR-MODULAR TRANSFER OF MULTIMEDIA DATA IN A SENSOR NETWORK OF TRANSPORT SYSTEM (p. 6–14)

Victor Tikhonov
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-4415-5234

Olena Tykhonova
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-0921-422X

Oleksandra Tsyra
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-3552-2039

Olga Yavorska
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-1790-7472

Abdullah Taher
Islamic University, Najaf, Iraq
ORCID: http://orcid.org/0000-0002-5916-0055

Oksana Kolyada
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-4256-5205

Svetlana Kotova
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-8276-018X

Oksana Semenchenko
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-9004-2575

Evgeniya Shapenko
National Transport University, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-0937-9400

The paper studies the issues of distributed sensor networks interaction based on the Internet of Things architecture in the context of automated control systems design for dynamic objects of transport infrastructure. The properties of multimedia streams like digital telemetry exchange and packet data delivery between the sensor controllers of urban transport network are analyzed. A method of modifying the standard Ethernet network interface at the logical link control (LLC) sublayer on Raw Socket technology for joint transmission of multi-channel telemetry and packet data is proposed. A software simulator has been developed for conveyor-modular transfer in Python codes for Linux Ubuntu operating system based on the dynamic data structuring by the markup tags. The relevance of this work is due to the need to further improve the open system interoperability when building heterogeneous Internet of Things. As a result of the studies conducted, the use of conveyor-modular transfer (CMT) for telemetry data exchange with limited latency in urban control systems of transport safety is substantiated. The tests of the conveyor-modular simulator confirmed the relevance and logical consistency of the basic principles of encoding, transmitting and decoding multimedia data in the communication channel of the Internet of Things. The obtained results create scientific and methodological prerequisites for replenishing the existing TCP/IP stack with a new internetworking protocol with limiting delays, which can be used in conjunction with the IP protocol in real-time applications of the Internet of Things, and above all, in urban transport safety management systems.

Keywords: sensor network, Internet of Things, real-time interaction, latency control, conveyor-modular transfer.

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DESIGN OF THE ARCHITECTURE OF AN INTELLIGENT SYSTEM FOR DISTRIBUTING COMMERCIAL CONTENT IN THE INTERNET SPACE BASED ON SEO-TECHNOLOGIES, NEURAL NETWORKS, AND MACHINE LEARNING (p. 15–34)

Vasyl Lytvyn
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-9676-0180

Victoria Vysotska
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0001-6417-3689

Andrii Demchuk
Ukraine National Paralympic Commitee, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-5710-9347

Ihor Demkiv
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0003-4015-8171

Oksana Ukhanska
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0003-4408-5491

Volodymyr Hladun
IT Academy "STEP", Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-4337-8869

Roman Kovalchuk
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
ORCID: http://orcid.org/0000-0001-8337-8591

Oksana Petruchenko
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
ORCID: http://orcid.org/0000-0003-2304-8149

Lyudmyla Dzyubyk
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
ORCID: http://orcid.org/0000-0001-6942-9436

Nataliia Sokulska
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-3425-5517

We have considered a task on designing an intelligent system of commercial distribution of informational products using a personalized approach to visitors based on the categories and tags of content that interests visitors. A general standard architecture of appropriate system has been developed using methods and personalization tools in the Internet environment with a core of automated recommendation of tags (categories) in the form of a neural network with controlled training. A personalized approach to the web site user results in a higher rate of sales. The system that was developed on the basis of modern SEO technologies considering the metrics for assessing the operation of an information and search module in the system makes it possible to select relevant content according to the user's personalized interests. The system has classes and subclasses that include real commercial informational products, interrelated by the built logical links, whose application promotes the intelligent supply of content based on the personalization of needs and interests of the user. In addition, based on modern methods of Machine Learning, the designed system learns to refine the results from searching the content in demand according to the personalized user's preferences. Personalization algo-

rithms make it possible to associate each user with a list of products that are most likely to be of interest, and can predict what customers may want to see even if they are not aware of it yet. The aim of the intelligent system of e-commerce is to represent unique content based on the personalization approach and the use of tags. In addition to a standard text introduction of categories and tags based on images and product descriptions, the designed automation process defines tags and product categories. Recognition of context using deep neural networks now provides a technology for automated addition of tags to the description of goods at e-commerce web sites. The methods can be used to categorize facial expressions and recognize emotions.

Keywords: commercial content, personalization, Machine Learning, SEO-technology, search metrics, e-commerce, NLP.

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SYNTHESIS OF A FRACTIONAL-ORDER PI$^{\lambda}$D$^{\mu}$-CONTROLLER FOR A CLOSED SYSTEM OF SWITCHED RELUCTANCE MOTOR CONTROL (p. 35–42)

Valerii Tytiuk
Kryvyi Rih National University, Kryvyi Rih, Ukraine
ORCID: http://orcid.org/0000-0003-1077-3288

Oleksii Chornyi
Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchug, Ukraine
ORCID: http://orcid.org/0000-0001-8270-3284

Mila Baranovskaya
Kryvyi Rih National University, Kryvyi Rih, Ukraine
ORCID: http://orcid.org/0000-0002-8082-1305

Iurii Zachepa
Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchug, Ukraine
ORCID: http://orcid.org/0000-0003-4364-6904

Serhii Serhiienko
Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchug, Ukraine
ORCID: http://orcid.org/0000-0002-3977-5239

Leonid Tsvirkun
National Technical University Dnipro Polytechnic, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-5568-5516

Vitaliy Kuznetsov
National Metallurgical Academy of Ukraine, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0002-8169-4598

Nikolay Tryputen
National Technical University Dnipro Polytechnic, Dnipro, Ukraine
ORCID: http://orcid.org/0000-0003-4523-927X

The relevance of creating high-quality control systems for electric drives with a switched reluctance motor (SRM) was substantiated. Using methods of mathematical modeling, transient characteristics of the process of turn-on of SRMs with various moments of inertia were obtained. Based on analysis of the obtained transient characteristics, features of the SRM turn-on process determined by dynamic change of parameters of the SRM during its turn-on were shown.

Low accuracy of SRM identification using a fractionally rational function of rat34 class was shown. Regression coefficient of the resulting model was 85 %. Based on analysis of transient characteristics of the SRM turn-on process, a hypothesis was put forward about the possibility of identifying the SRM by means of a fractional-order transfer function. Using the methods of mathematical modeling, transient

characteristics of the process of turning-on the SRMs with various moments of inertia were obtained. Using the FOMCON MATLAB Toolbox, identification of the SRM turn-on process with the help of a fractional-order transfer function of second order was performed. Regression coefficient of the resulting model was 93–96 %.

For the obtained fractional-order transfer functions, a method of synthesis of a fractional-order $PI^{\lambda}D^{\mu}$ controller optimized in terms of minimum integral square error of the transition function of the closed system of fractional-order control of objects was implemented. The FOMCON MATLAB Toolbox was used for synthesis of the $PI^{\lambda}D^{\mu}$ controller.

Comparative analysis of the SRM turn-on processes in both open and closed control systems with a classical integer-order PID controller and with a fractional-order $PI^{\lambda}D^{\mu}$ controller was made. Use of the fractional-order $PI^{\lambda}D^{\mu}$ controller in comparison with the classical integer-order regulator makes it possible to reduce overshoot from 13.3 % to 2.64 %, increase speed of the closed ACS, decrease regulation time from 1.48 s to 0.53 s while reducing variability of transient characteristics. The study results can be used to improve performance of closed systems for controlling angular velocity of the SRM.

Keywords: switched reluctance motor, identification, fractional-order transfer function, control quality, fractional-order controller.

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DETERMINING THE INFLUENCE OF PARAMETERS FOR GAS-AIR FLOWS ON THE THERMAL PROCESS OF PRODUCING IRON ORE PELLETS (p. 43–54)

Vyacheslav Lobov
Kryvyi Rih National University, Kryvyi Rih, Ukraine
ORCID: http://orcid.org/0000-0001-6833-2819

Karina Lobova
Kryvyi Rih National University, Kryvyi Rih, Ukraine
ORCID: http://orcid.org/0000-0003-3848-6707

Oleksandr Mytrofanov
Kryvyi Rih National University, Kryvyi Rih, Ukraine
ORCID: http://orcid.org/0000-0003-4093-8223

We present the results of the study on changes in temperature of gas-air flows at the outlets from calcination zones and recuperation zones of a conveyor-calcination plant. We determined the influence of these temperatures on other technological zones.

We showed that that the average volume temperatures of gas-air flows from calcination and recuperation zones are the exponential dependences on temperatures of gas-air flows above a layer of pellets in these zones. It was established that an increase in the speed of movement of calcination carts from 0.011 m/s to 0.06 m/s leads to a decrease in the average volume temperature of a heated gas-air flow by 1.7 times. An increase in the height of a pellet layer on calcination carts by 30 percent with constant gas permeability of this layer leads to an exponential decrease in the average volume temperature of a gas-air flow by 2.5 times at the outlet from the calcination and recuperation zones. The average volume temperatures of gas-air flows decrease at the outlet of a pellets layer up to three times at a change in the pressure by 20 % in the calcination zone and at the constant movement speed of calcination carts of 0.049 m/s, the height of a pellets layer of 450 mm and the porosity of a pellets layer of 0.45 m^3/m.

We used a mathematical model to analyze a temperature mode of a gas-air flow at the outlet of the pellet calcination zone. The basis of the mathematical model was the relation between the inlets and outlets of technological zones of the plant by equations of gas dynamics and heat exchange and mass transfer.

The study made it possible to develop and present an automated control system for a smoke exhauster for average volume temperatures of gas-air flows at the outlet from the technological zones of calcination and recuperation of the plant. It is possible to use it under industrial conditions.

It improves thermal and gas-dynamic operation of technological zones of a conveyor calcination plant.

Keywords: conveyor plant, calcination zone, pellet layer, temperature, pressure, gas-air flow control.

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IMPROVEMENT OF THE INVERSE DYNAMICS METHOD FOR HIGH-PRECISION CONTROL OF NONLINEAR OBJECTS UNDER CONDITIONS OF UNCERTAINTY (p. 55–62)

Oleksandr Blintsov
Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0003-0426-1219

Zhanna Burunina
Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0001-7631-7213

Andrii Voitasyk
Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine
ORCID: http://orcid.org/0000-0002-9409-6108

Synthesis of automatic control systems (ACS) of nonlinear objects is a well-known scientific problem. The method of inverse dynamics makes it possible to synthesize high-precision ACSs of nonlinear objects. However, under conditions of uncertainty, control quality is significantly compromised and ACS does not fulfill the set task. The result of present research is the further elaborated method of inverse dynamics for the synthesis of high-precision ACS of nonlinear objects under conditions of uncertainty. We have synthesized a generalized structure of the inverse control law as a basis for control of nonlinear objects under conditions of uncertainty. Under this structure, the inverse control law is built based on an imprecise inverse model of the object of control and contains an uncertain component of controlling influence to compensate for uncertainties. We have synthesized a law to compensate for uncertainties based on the method of minimizing local functionals. It includes an imprecise model of the object of control and ensures that its output approaches the controlled magnitude. The compensation law makes it possible for ACS to operate under conditions of uncertainty and, at the proper choice of reference models, to provide for a high dynamic accuracy in control over a nonlinear object. We have synthesized ACS of the vertical movement of a tethered remotely operated underwater vehicle. The synthesis was implemented based on an imprecise model of the object of control. The model's order was one order of magnitude less than the object's order; part of the model responsible for generating a controlling force was considerably simplified; the disturbing influences of a tether-cable were not taken into consideration. Thus, the structural and parametrical uncertainties were accounted for. The dynamics of ACS transient processes were studied based on computer implementation of the model of one-dimensional motion of a remotely operated underwater vehicle as a third-order object taking into account the disturbing influence of a tether-cable. Results of computer experiment showed high dynamic accuracy of ACS under conditions of structural and parametrical uncertainties of the control object's model under the influence of uncertain disturbances of a tether-cable.

Keywords: automatic control system, method of minimization of local functionals, tethered underwater vehicle.

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SYNTHESIS AND IMPLEMENTATION OF FRACTIONAL-ORDER CONTROLLERS IN A CURRENT CURCUIT OF THE MOTOR WITH SERIES EXCITATION (p. 63–72)

Victor Busher
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-3268-7519

Lubov Melnikova
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-1732-1930

Vasiliy Horoshko
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-7265-2513

We have synthesized and investigated fractional-order regulators, which provide for a series of technological processes the best indicators for the quality of transient process, specifically DC motors with series excitation. Given the dependence of magnetic flux on the armature current and saturation of the magnetic system, a motor armature circuit turns into a system with significant nonlinear properties under static and dynamic modes. However, it can be described with high accuracy by the transfer function of fractional order. Owing to the appropriate fractional integral-differentiating regulators, it becomes possible to obtain the quality of transient processes that is better than when using classic methods.

We have considered standard methods to synthesize the coefficients of regulators and established that such settings result in deterioration of transients due to the saturation of regulators, caused by power supply voltage limitation. Therefore, it has been proposed, for a closed circuit with different structures of fractional regulators, to use a genetic algorithm for determining the optimal values of the coefficients of regulators based on the criterion for the shortest time of first harmonization and minimum overshoot.

Experimental study into different structures of regulators has been performed conducted for settings on the module optimum and a fractional order of astatism from 0.35 to 1.5. Based on the results obtained, it can be argued that the best indicators are demonstrated by regulators at astatism $1+\mu_{co}$, 1.5. The overshoot is then actually less than 2 %. It has been also shown that astatism $1+\mu_{co}$ ensures high-quality of transient processes in the unsaturated zone of magnetic system as well.

The research results could be used primarily in the systems of closed control in DC motors with series excitation, as well as with objects in which power laws are observed.

Keywords: fractional calculus, regulators with fractional order of differentiation and integration, series excitation motor.

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EVALUATION OF DYNAMIC PROPERTIES OF GAS PUMPING UNITS ACCORDING TO THE RESULTS OF EXPERIMENTAL RESEARCHES (p. 73–81)

Mykhailo Gorbiychuk
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-8586-1883

Olena Zamikhovska
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0003-0775-0472

Leonid Zamikhovskyi
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-6374-8580

Serhii Zikratyi
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-8004-3339

Lidiia Shtaier
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0003-1013-9869

Experimental studies of the dynamic properties of gas pumping units (GPU) of various types, which allowed us to obtain GPU acceleration curves and determine the parameters of the transfer function through various transmission channels of input effects, are conducted. For this, a method and a software product were developed for implementing the procedure for determining the areas of the k orders through the moments of the auxiliary function. As a result of the experiments performed on operating GPU, the acceleration characteristics of the selected signal transmission channels were obtained. To identify the dynamic properties of the GPU, a software product was developed in the MatLab environment, which in iterative mode allows each acceleration curve to be approximated by the transfer function, the order of which is selected by the user. The iterative mode allows the user to select the order of the polynomials of the numerator and denominator of the transfer function, and also to calculate the numerical values of the parameters of the selected transfer function. The software product was tested on industrial data obtained during normal start-up of the GPU. The obtained results can be used in the development of a new method for monitoring the reliability and diagnosing the technical state of automatic control systems (ACS) of the gas pumping units and its components. The essence of the method is that a change in the technical state of the ACS or GPU affects their dynamic properties, and this, in turn, causes a change in the parameters of the transfer functions, which can be recorded after a certain period of time. Determining the ranges of values of the transfer function coefficients for various technical states of different types of ACS and GPU, it will be possible to predict the period of their operation in the future.

Keywords: gas pumping units, experimental studies, acceleration characteristic, area method, technical condition, software product, transfer functions.

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