ABSTRACT AND REFERENCES

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RAY TRACING SYNTHESIS OF SPATIAL CURVE IMAGES BUILT BY THE SPHERICAL INTERPOLATION METHOD (p. 4-9)

Vladimir Gusiatin
National University of Radio Electronics, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-4201-2398

Maksim Gusiatin
National University of Radio Electronics, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7884-8613

Oleg Mikhal
National University of Radio Electronics, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-5977-3177

The problem of visualization by ray tracing of spatial curves specified by interpolation points and smoothed by the method of spherical interpolation was solved. The method of spherical interpolation was developed mainly for interpolation of a triangulated surface with the purpose of further visualization of this surface by the method of ray tracing. This method is universal and enables the construction of flat and three-dimensional smooth curves drawn through arbitrarily set points. The paper presents analytical relationships for realization of each stage of construction of a spatial curve by this method. To visualize a spatial curve, an iterative process (IP) was developed for calculation of a point in the projection ray (PR) closest to some point of a mathematical spatial curve. To establish correspondence of the curve point to a pixel in a computer monitor screen, position of this point was determined relative to the space region bounded by the pyramid of pixel visibility. The proposed IP has a potential of wide parallelization of computations. An algorithm for constructing points of a spatial curve was developed with its step coinciding with the step of the iterative calculation process, which allows one to perform visualization algorithm and plot a curve point in a single pass of the IP. To this end, the point in the PR and the direction vector of the curve lie in the same plane perpendicular to the interpolated segment in each iteration step. This approach enables determination of the directing vector modulus for the subsequent stage of this iteration step. The proposed interpolation algorithm is based on the simplest algebraic surface, sphere, and does not use algebraic polynomials of the third and higher degrees. The results of the studies were confirmed by simulation of the visualization process using the Wolfram Mathematica software package. The problem of combining new methods for constructing smooth geometric shapes of spatial curves defined by straight lines and the method of ray tracing which on the whole will increase realism of the synthesized scenes in computer graphics was solved.

Keywords: ray tracing, projection ray, modeling of curves and surfaces, quadrics, spherical interpolation.

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DEVELOPMENT OF A SET OF METHODS FOR PREFORECASTING FRACTAL TIME SERIES ANALYSIS TO DETERMINE THE LEVEL OF PERSISTENCE (p. 10-17)

Vitaliai Kropyvnytska
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-5231-7104

Lev Kopystynskyy
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0002-3196-1213

Georgiy Sementsov
Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-8976-4557

A set of methods for the pre-forecasting fractal time series analysis to determine the levels of persistence of chaotic information flows in the well-drilling control system is proposed. Based on this methodology, the values of the Hurst exponent H, fractal dimension D, spatial dimension n and correlation measure C are obtained for six time series. Since the Hurst exponent H for all the signals is greater than 0.5, the conclusion about a chaotic nature of the studied time series is made. However, the dynamics of these signals will not change and it can be predicted that it will evolve in the same direction as in the past. This allows using the obtained results for forecasting and early detection of deviations of the drilling process from the norm. Since the oil and gas well drilling process is a complex stochastic process proceeding in conditions of a priori and current uncertainty under the influence of immeasurable disturbances, calculation of the Hurst exponent H contributes to solving the forecasting problems in the automated support system of decision-making regarding well-drilling process control.

Keywords: persistence, Hurst exponent, time series, fractal dimension, sequential R/S analysis.

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A STUDY OF SYNCHRONIZATION PROCESSES OF NONLINEAR SYSTEMS IN THE DIFFERENCE SPACE OF PHASE VARIABLES (p. 17-24)

Leonid Politansky
Yuriy Fedkovych Chernivtsi
National University, Chernivtsi, Ukraine
ORCID: http://orcid.org/0000-0001-8045-7630

Ruslan Politanskyi
Yuriy Fedkovych Chernivtsi
National University, Chernivtsi, Ukraine
ORCID: http://orcid.org/0000-0003-0015-7123

Valentin Lesynsky
Yuriy Fedkovych Chernivtsi
National University, Chernivtsi, Ukraine
ORCID: http://orcid.org/0000-0002-1259-1974

The analysis of trajectories in the phase space of the systems of ordinary differential equations has been made. Classification of phase trajectories has been developed.

Synchronization in Rössler systems, coupled by the scheme "main-controlled" system, has been studied. In the controlled system, variables in the right –hand side are replaced by functions of time, which are solutions to the main system.

The analysis of processes in nonlinear systems was made by means of replacement with the help of synchronization matrix and transfer to the linearized system of variables equal to the difference of phase variables of the main and controlled systems. As a result of this analysis, there have been set the values of the synchronization matrix elements in which there occur different types of synchronization: complete, phase and topological. It is shown that even in the absence of communication between Rössler systems in the difference space of phase variables of the main and controlled systems with nonlinear dynamics, there occurs topological synchronization and there is formed an attractor with low spatial complexity that is an open trajectory of limited values. The criterion for the absence of synchronization of nonlinear systems is the unlimited growth of the difference of phase variables.

Keywords: Rössler system, attractor, solutions of ordinary differential equations, matrix synchronization, complete, phase and topological synchronization.

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METHOD OF FINDING EQUILIBRIUM SOLUTIONS FOR DUOPOLY OF SUPPLY CHAINS TAKING INTO ACCOUNT THE INNOVATION ACTIVITY OF ENTERPRISES (p. 25-30)

Yulia Kurudzhi
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-0939-593X

Iryna Moskvichenko
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0001-5223-1212

Mykhaylo Postan
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-4891-3063

We developed and analyzed an economic-mathematical model of duopoly of industrial enterprises-manufacturers with similar nomenclature of products taking into account innovation activity in the field of technologies. It is assumed that enterprises are the links in supply chains, that is, in addition, we examined delivery of the finished goods to the points of consumption. In contrast to the micro-economic theory of the firm, here price competition is investigated at the operational level, that is, when making up plans for the output of products and their delivery to destination points. Innovation activity implies that enterprises invest part of their profit into improvement of the technological process, and, in this case, production expenses of enterprises are the assigned decreasing functions of the investments indicated. In line with the classical theory of the firm, it is considered that the demand function in each point of delivery of finished goods linearly depends on the summary volumes of these goods, delivered from both enterprises. Optimality criterion for supply chains of both plants is the maximum of summary profit, obtained from the sale and delivery of finished products to the points of consumption taking into account expenditures for innovative solutions.

We found equilibrium solutions of duopoly by Cournot and Stackelberg. Numerical illustration of the obtained results is given. The obtained results could be used in the process of joint development of marketing, logistic and innovation strategies of enterprises.

Keywords: industrial enterprises, optimal output plan, supply chain, innovation activity, competition, duopoly, equilibrium solutions by Cournot and Stackelberg.

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CALCULATION OF THROUGHPUTS OF INTERMEDIATE CENTERS IN THREE-INDEX TRANSPORTATION PROBLEMS (p. 31-37)

Lev Raskin
National Technical University
"Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-9015-4016

Oksana Sira
National Technical University
"Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-4869-2371

Viacheslav Karpenko
National Technical University
"Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-8378-129X

A transportation problem of linear programming with intermediate centers was considered. For cases where throughputs of intermediate centers are not specified, a problem of calculating rational distribution of the total throughput in order to minimize the average value of total transportation costs has been stated. Several options of constructing the method for solving the problem were proposed. The first option implements the iterative procedure of successive improvement of the initial distribution of throughputs of the centers by the Nelder-Mead method. Increase in speed of this method was achieved using the duality theory. The second option is based on a preliminary solution of the problem of finding optimal routes for all pairs "supplier-consumer" taking into account a possible intermediate center. In this case, the usual two-index transportation problem of delivering products from the system of suppliers to the system of consumers arises. The optimal plan of this task contains necessary data to calculate required throughput for each of the intermediate centers. Advantage of this method consists in the possibility of its effective propagation for solving problems with a multilayered structure of intermediate centers.

Keywords: transportation problem with intermediate centers, calculation of throughputs of intermediate centers.

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A METHOD OF BUILDING TYPE-2 FUZZY LOGIC SYSTEMS IN MULTIDIMENSIONAL OBJECTS IDENTIFICATION PROBLEMS (p. 38-45)

Natalia Kondratenko
Vinnytsia National Technical University, Vinnytsia, Ukraine
ORCID: http://orcid.org/0000-0002-4450-1603

Olha Snihur
Vinnytsia National Technical University, Vinnytsia, Ukraine
ORCID: http://orcid.org/0000-0002-9268-6876

A generalized method for developing partially formalized objects identification fuzzy models by direct rule generation based on experimental data is formulated. Models built according to this principle have the intrinsic ability to operate in accordance with the observation data. Under the condition of the initial experimental data set being representational enough, they may not even require additional tuning of the membership functions parameters.

Still, systems developed based on experimental data are often redundant, and may require corrections of the input feature set magnitude. An approach for modifying the number of model inputs is proposed. It allows to do so without the model losing its capability to adequately reflect the subject area.

In order to develop a fuzzy logic system, which would reflect the subject area in an adequate manner, an optimization criterion is proposed, measuring the increase in mutual information reflecting from a fuzzy logic system's inputs to its outputs. Under the condition of maintaining the system's capability for adequate decision making, a sequence of steps required for developing a type-2 fuzzy logic system, optimal according to the considered criterion, is shown.

This paper provides justification for type-2 fuzzy sets being appropriate for use in mathematical models dealing with uncertain input data. The justification is performed theoretically, based on information theory considerations, and confirmed experimentally.

The proposed method enables solving applied problems of identifying multidimensional objects, such as an environmental system.

Keywords: type-2 fuzzy logic system, type-2 fuzzy sets, interval membership function, optimization criterion.

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SPLINE-APPROXIMATION-BASED RESTORATION FOR SELF-SIMILAR TRAFFIC (p. 45-50)

Irina Strelkovskaya
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-2717-5014

Irina Solovskaya
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-9904-5692

Nikolay Severin
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-2706-5205

Stanislav Paskalenko
O. S. Popov Odessa National Academy of Telecommunications, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-2045-7265

The work considers the queuing system of the G/M/1/K with the Weibull distribution. The model for self-similar traffic was created within the Matlab Simulink software environment. Restoration of the self-similar traffic was obtained with the help of the spline approximation using linear and cubic splines. In this research, it has been discovered that the obtained self-similar traffic is characterized by "bursts", "pulsations", and the long-term dependence between arrivals. Linear and cubic spline approximations have been suggested to restore traffic. The approximations with the linear and cubic splines were used to restore smoothly changing self-similar traffic.

The obtained results of the self-similar traffic restoration allow planning buffer capacities for NGN networking devices at the stages of design and further operation in order to avoid network overloads, excessive time delays and jitter for the case of packet traffic with bursts.

The wavelet approximation is recommended for the accurate restoration of the self-similar traffic.

Keywords: self-similar traffic, Weibull distribution, queuing system, restoration, spline functions.

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SYNTHESIS OF OPTIMAL CONTROL OF TECHNOLOGICAL PROCESSES BASED ON A MULTIALTERNATIVE PARAMETRIC DESCRIPTION OF THE FINAL STATE (p. 51-63)

Dmitriy Demin
National Technical University
"Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-7946-3651

A method is proposed to establish control of technological processes that would be optimal in terms of speed and final state on the basis of analyzing the solution of a system of stochastic differential equations (SDEs), which is a mathematical model of a controlled process. The results of the numerical modeling have proved that, being sufficiently simple, the proposed method helps obtain solutions that are completely consistent with the results obtained using the Pontryagin maximum principle for the speed problem. It has been shown that such an approach to the search for optimal control of technological processes opens up additional opportunities in solving the task of retaining the parameters of the technological process within a given area. Two alternatives of the control implementation are proposed and justified, differing in the principle of selecting control switching times.

It has been shown that the determining factor for the choice of optimal control is the initial state of the system, described by the position of the phase space point characterizing the actual initial state relative to the final state line. If the final state is described by the equation of the straight line, it is proposed to reduce it to its normal form and to calculate the corresponding deviation of the point of the preceding state from this straight line, which uniquely determines the sign of control. It has been proved that the problem of finding the optimal control of technological processes must be preceded by the problem of obtaining a mathematical description of the final state, based on the construction of regression equations in which the output variable can be the quality of the finished technological product.

It is proposed to obtain a multialternative parametric description of the final state for the search for optimal control of the technological process using a ridge analysis. It has been shown that each of the alternatives represents a set of suboptimal values of the output variable, which provides optimal values of the output variable describing the quality of the finished technological product in the chosen sense. Due to this approach, it is possible to synthesize the optimal control in terms of the speed and final state of technological processes in conditions of a multialternative description of the final state of the technological system.

Keywords: optimal control of technological processes, Pontryagin's maximum principle, speed, final state line, multialternative description of the final state, ridge analysis.

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