ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS APPLIED ASPECTS

ON A STRATEGY FOR OPERATIONAL PLANNING MODES PUMPING STATION (p. 4-9)

Andrei Tevyashev, Olga Matviyenko

Most pumping stations in urban water supply systems in Ukraine are not equipped with adjustable drive, and traditional turning on/off of pumping units and repositioning the adjustable valves are used as an operational control of pumping station modes. Moreover, even in large cities, centralized water supply systems management is carried out manually.

With this approach, there are significant energy losses, pumping unit capacity is not used efficiently. The paper proposes a strategy to optimize the operating modes of pumping station with multi-type pumping units based on a stochastic model of quasi-stationary regimes in water supply and distribution systems, taking into account both the stochastic nature of water consumption processes, and the statistical properties of the model parameters.

This strategy is resource-and energy-saving and allows to:

• minimize the mathematical expectation of PS energy expenditure on the planning interval (day);

• obtain an optimal solution, sustainable to the estimated level of stochastic perturbations by the flow and the head at the PS outlet with a probability not below the given;

• minimize the number of PU switching.

The problem of planning the pumping station modes with one-day anticipation is formulated and solved. Solving this problem has allowed to find the optimal structure of working pumping units, flow rate for each pumping unit and the position of the adjustable valves for four pumping station modes, planned during the day.

Keywords: pumping station, pumping unit, quasi-stationary regime, stochastic model, optimization potential.

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SERVICE WAITING TIME AND FACTOR USE IN QUEUING SYSTEMS OF MARKOV TYPE (p. 10-15)

Semen Bronza, Olga Goncharova, Nataliya Yurchak, Murad Ovchiev

In many cases two variables such as utilization ratio (relative characteristic) and queuing time (absolute characteristic) are enough to assess the efficiency of a queuing system. The literature contains formulas for calculating utilization and downtime ratios as constants.

In the paper, queuing time and utilization ratio are obtained as a function of time. This allows to investigate them in dynamics.

For the queuing system S, set as a Markov chain with continuous time and finite number of states $E_i \quad i = 1,2,...,n,$ where n is the number of system state, the formulas for calculating the queuing time (downtime) in any state are obtained. Queuing time in the i-th state for the time interval (τ_1, τ_2) can be calculated using the formula:

$$P_i(\tau_1, \tau_2) = \int_{\tau_1}^{\tau_2} \left(Nq_i(t) + c_i\lambda_{ii}\right)dt ,$$

and for the time

$$t\,P_i(t) = \int_0^t \left(Nq_i(t) + c_i\lambda_{ii}\right)dt .$$

The formulas for calculating the time of appearance and disappearance of queues, time intervals of the queue existence in any state of the system are obtained. The formulas for calculating the time of the beginning, end and duration of service in any state are obtained. The formulas of dependencies of utilization ratio of any system state on the time are obtained.

Calculating the above functions for the unloading terminal of freight rail hub is given as an example of using the obtained formulas.

Keywords: queuing system, Markov chain, queuing time, downtime, utilization ratio of states.

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MEDICAL DECISIONS UNDER UNCERTAINTY (p. 16-20)

Helena Vysotskaya, Aleksandr Dounar, Anna Pecherska

The paper proposes a solution to the patients’ differential diagnosis problem by a combined application of the basic game theory, linear programming, and the conjugate gradient method. Based on the clinical research, a differential diagnosis of diseases such as atopic dermatitis, dermatitis herpetiformis, drug disease, psoriasis, eczema, scleroderma, lupus erythematosus, mycosis in 590 patients was carried out. Serum levels of T-lymphocytes, T-helper lymphocytes, cytotoxic T-cells; B-lymphocytes; s5 – interleukin 2; interleukin 6, endothelin-1 polypeptide; the percentage of segmented neutrophils in a leukogram; the serum IgA level; the se-

rum IgM level; the serum immunoglobulin G level, s12 – the serum total immunoglobulin E level were considered informative features.

As a result of applying the proposed method not only the patient's diagnosis was determined, but also the doctor was given the opportunity to weigh the probability of possible medical diagnostic errors.

Using the approach, proposed by the authors to differentiate diagnoses with similar clinical implications, allows improving the efficiency of medical decision-making.

Keywords: decision-making, differential diagnosis, game theory, conjugate gradient method, linear programming.

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PREDICTING THE COURSE OF ATOPIC DERMATITIS IN CHILDREN USING DISCRETE SIMULATION OF DYNAMIC SYSTEMS (p. 21-25)

Helena Visotskaya, Andrey Porvan, Yury Bespalov, Konstantin Nosov, Victoria Klimenko, Alexei Trubitsyn

The authors propose an approach to predicting the course of atopic dermatitis (AD) using discrete simulation of dynamic systems (DSDS) based on the previously selected informative features, which allows to reveal hidden relationships between them and determine the nature of the AD course in children. For this, an array of observations is formed of prognostic factors, such as itch intensity, severity of the morphological elements of rash, prevalence of skin formations, ranked IgE index value. After that, the Spearman's correlation matrices between the parameters of the array of observations and rows of the minor of the dynamic system trajectory array are calculated. Then, the value of the function of distance between objects is minimized, the conditional-reference trajectory of the system for each parameter is built. Further, the system change pitch, which characterizes the patient's condition control points is found. Later, during individual examination of patients, their prognostic factors are recorded and compared with conventional-reference trajectory, defining the site, corresponding to the patient's condition at a certain time. The data-based trajectory allows to select a prognostic working hypothesis and determine the amount and mode of treatment for children with AD.

Keywords: predicting, atopic dermatitis, dynamic system, discrete simulation, Spearman's correlation matrices.

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CONFIDENCE INTERVAL OF NONLINEAR REGRESSION OF TIME RESTORE FUNCTIONALITY OF NETWORK TERMINAL DEVICES (p. 26-31)

Sergiy Prykhodko, Lidiia Makarova

Building confidence interval of the nonlinear regression equation and estimating the restoration time of devices play an important role in the practical tasks of terminal network control. Restoration time is non-Gaussian random variable, which depends on the distance between the service center and the terminal network device. For more reliable estimation of restoration time, it is necessary to have the confidence interval of its non-linear regression.

In the case of Gaussian random variable, it is possible to apply linear regression equation and build the confidence interval for it by traditional method using the Student's t-distribution. This method does not take into account many features of the empirical data distribution, for example, its asymmetry. In the case of non-Gaussian random variable, it is difficult to build the confidence interval of the nonlinear regression equation without the assumption of normality.

Applying linearizing transformations is reduced to obtaining a linear regression model from the original non-linear by replacing variables and coefficients. This substitution leads to the model simplification and data loss, associated with nonlinearity.

Using the normalizing transformations allows to proceed to linear regression of the normalized data, build the confidence interval for it by the traditional method, and finally, by applying the relevant transformation, pass to non-linear regression and its confidence interval. Johnson transformation is used as normalizing transformation because it provides the best results as compared to other known transformations.

Keywords: confidence interval, nonlinear regression, normalizing transformation, Johnson transformation, terminal network.

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METHOD OF OUTLIERS REMOVAL BASED ON THE WEIGHTED TRAINING SAMPLES OF W-OBJECTS (p. 31-36)

Elena Volchenko

The problem of preprocessing training samples to improve the efficiency of trainable recognition systems is considered in the paper. A new method for solving the problem of outliers removal based on constructing weighted reduced samples of w-objects is proposed. The wGridDC method for constructing the weighted sample of w-objects by superimposing the grid features on the space and constructing weighted objects of new sample by analyzing the contents of cells is used as a basis for the proposed method.

Within the proposed method, two outliers removal algorithms are developed. The algorithm for constructing the weighted training sample of w-objects with simultaneous outliers removal at a given filtering threshold is focused on the use in the tasks that require not only filtering the original data, but also controlling the size of the sample. Herewith, filtering threshold is user-defined. The algorithm for constructing the weighted training sample of w-objects with simultaneous outliers removal at automatic filtering threshold detection is focused on the tasks that require constructing samples, providing the highest efficiency of the system. Analysis of the effectiveness of the proposed method has shown that the main advantage of the threshold filtering algorithm is the ability to control the size of the sample. The main advantage of the non-threshold filtering algorithm is the ability to automatically select the value of the filtering threshold that provides the greatest efficiency of the recognition system as a whole. Thus, the proposed method in general and both its constituent algorithms allow to obtain the samples, providing high efficiency of trainable recognition systems.

Keywords: training sample, data filtering, outlier, w-object, decision rule, generating set.

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ASSESSMENT OF DYNAMIC EFFORTS TO BODIES OF WAGONS AT TRANSPORTATION WITH RAILWAY FERRIES (p. 36-41)

Alyona Lovskaya

In order to ensure traffic safety of cars during rail-ferry transportations, assessment of forces, acting on them in conditions of rough sea is necessary. Regulations that reflect these issues include values of loads, which are unique to the Caspian Sea. In this regard, mathematical models that allow to get accelerations, acting on the support structure of car bodies for the given waters, such as rail ferry and technical characteristics of the car are developed.

Due to the variety of rail-ferry routes, structures and processing technologies of ferries, as well as increased technical and economic parameters of cars, these studies are relevant.

The paper presents the results of studies of dynamic features of car bodies during their transportation by rail ferries in the waters of the Black Sea. The values of the inertial loads, acting on the car bodies are determined. These studies can be taken into account when designing the new generation cars on carriage works, which will allow to improve sea traffic safety of cars.

Keywords: car, car dynamics, structural load, rail-water transport, rail-ferry transportations.

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MATHEMATICAL MODEL OF A BLOOD VESSEL IN CASE OF LOSS OF INTEGRITY OF ITS WALL (p. 42-48)

Sergey Vladov, Oleg Avrunin, Vladislav Mospan, Alexey Yurko

A mathematical model of a blood vessel in case of the wall integrity loss was developed in the paper. It was based on the electrical analogy of blood circulation through vessels and current flow within a circuit unit. In general, the basis of the developed model is the model of a human blood circulatory system in the form of an inhomogeneous long line matched with distributed constants. The constructed mathematical model allows solving urgent problems of investigating the process of blood circulation through vessels in case of the wall integrity loss and determining the location, the conditional diameter of the wall hole and the influence of the loss of the vessel wall integrity on the pulse wave shape and blood pressure. The process of blood circulation in the femoral artery under normal blood circulation and taking into account the occurred loss of the vessel wall integrity was studied in the paper.

Keywords: blood vessel, loss of integrity, pulse wave, blood pressure, long line, four pole.

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MATHEMATICAL MODEL OF THE PROCESS ESTIMATION OF THE DEFORMATION OF THE ROAD SURFACE (p. 49-54)

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A method of estimating the stress-strain state of road pavements resulting from the effect of operating loads was developed. For solving the above mentioned problem, mathematical models of deformation, which are based on solving the classical Boussinesq problem, were used. The formulae for calculating six components of a tensor of mechanical stresses in road pavements for estimating the depths at which stresses have maximum values were studied. A scheme of traffic loads during the active road transport movement for different number of vehicles was proposed. Based on this scheme the formulae for determining all components of the stress tensor were suggested.

For implementing the developed models and algorithms, the software systems were created. In addition, the model and practical computations for real road sections with different types of pavement were carried out.

The possibility of considering the peculiarities of spatial configuration of highway sections and, in particular, their curvature radii while estimating the stress-strain state of these sections, was studied. This approach will allow working out software systems for estimating and predicting the road pavements state, based on the traffic analysis and studying physical and mechanical properties of the materials, which the pavements were made of. The further coordinates for studying the problem were defined.

Keywords: road pavement, stress state, strain state, Boussinesq problem, curvature radius.

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