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ON PATHOLOGICAL SOLUTIONS TO AN OPTIMAL BOUNDARY CONTROL PROBLEM FOR LINEAR PARABOLIC EQUATION

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Introduction: In this paper we study an optimal control problem associated to a linear parabolic equation with mixed Dirichlet-Neumann boundary conditions. We adopt as a control the measurable influence imposed on part of boundary. The optimal control problem is to minimize the discrepancy between a given distribution and the solution of the corresponding initial-boundary value problem. The characteristic feature of this problem is the fact that the matrix of coefficients in the main part of elliptic operator is non-symmetric and its skew-symmetric part is unbounded. As a result, the existence, uniqueness, and variational properties of the weak solutions to such problems usually are drastically different from the corresponding properties of solutions to the parabolic problem with bounded matrices in coefficients. In most cases, the situation can change dramatically for the matrices with unremovable singularity. Typically, the boundary value problems of indicated type may admit infinitely many weak solutions which can be divided into two classes: approximable and non-approximable solutions. A solution is called an approximable if it can be attained by weak solutions to the same problem with bounded approximated matrix of coefficients. However, there is another type of weak solutions, which cannot be approximated in such way. It means that the corresponding optimal control problem may also possess the same properties, i.e. it can admit the so-called pathological solutions when none of such solutions can be attained by optimal solutions to regularized optimal control problems with bounded matrices in coefficients of parabolic equation.

The purpose of this work is to give the example of an optimal control problem for parabolic equation with unbounded coefficients such that its unique solution has special singular properties. We show that because of these properties, a numerical simulation for a given class of optimal control problems is getting non-trivial.

Results: We prove that under special choice of the matrix of coefficients in an elliptic operator and the special construction of the right-hand side of the linear parabolic equation, a unique solution to the original optimal control problem has a singular character and it cannot be attainable through the solutions of the similar optimal control problems with bounded coefficients.

Conclusions: We give an example of optimal control problem for which its unique optimal pair has pathological properties, and show that because of this the approximation of such solution becomes non-trivial.

Keywords: parabolic equation, optimal control, variational solution, unbounded coefficient, existence result.

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REGULARITY INVESTIGATION FOR MULTIDIMENSIONAL SYSTEM IDENTIFICATION PROBLEM BY THE FREQUENCY METHOD

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Introduction: System identification problems are often ill-posed. Under certain conditions system identification problems are not well-posed in that the solution is highly sensitive to changes in the final data This property is the fundamental characteristic of this class of problems, and holds irrespective of the solving method. It is studied in detail, for solving by frequency identification method.

Purpose: The purpose of research is to establish and investigate the conditions of ill-posed system identification problem rising and propose a regularization procedure for selected frequency identification method. Method includes the steps of structural and parametrical identification. The regularization procedure should provide a suitable choice of the model structure so that the problem of identification in certain conditions would be well-posed.

Results: For the method used, it has been shown how the errors in the initial data affect the accuracy of the models. On the basis of numerical experiments it was found, that the main factor affecting the accuracy of the solution is the matrix condition number of frequency equations. There has been established a conditionality limit above which makes the problem of identifying an ill-posed even for exact original data.

For frequency identification method the problem regularity testing procedure has been proposed. It is based on parameter variation estimation, and carried out through randomization. It doesn't requires any additional experiments. On the basis of the results obtained during the last time segment of the experiment, a variation area of estimating the eigenvalues of the model are constructed.

Depending on the condition number and the experiment duration, the domains of well-posed and ill-posed problems have been obtained. Getting into the zone of stability ensures that the problem of constructing a model in these conditions is well-posed. Getting into the transition zone requires verification test. In the zone of instability model is rejected.

Conclusions: The problem of identification of multidimensional systems can be well- or ill-posed, depending on what is used for baseline data. If the identification is performed by the frequency method, the main characteristics of the data are the duration of the experiment and error value. It has been shown that for a well-posed problem formulation it is necessary that model complexity be consistent with the error in the initial data. Error value of source frequency data determines the dimensionality of the models, which can be constructed correctly. Regularization parameter in this method is the dimension of the model, or, more correctly, the condition number of the corresponding system of frequency equations.

***Keywords*:** System identification, ill-posed problem, regularization.

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INTERNAL AND EXTERNAL CONFLICTS IN KNOWLEDGE-BASED DISTRUBUTED CONTROL SYSTEMS

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Introduction: Main directions in the development of information and communication systems are both their very fast technological advance and essential increase in the variety as well as complexity of the tasks they deal with. But in spite of the tremendous growth of scientific publications in this area, a lot of important theoretical and practical issues have not been solved yet.

Purpose: Examination of conceptual issues as well as practical ways and means for most appropriate usage of modern information and communication technologies to support solving intelligent tasks in the conditions of conflict.

Methods: Artificial intelligence methods, man-machine theory, organismic conflict resolution theory, theory of deterministic chaos, methods of chaos synchronization and control.

Results: The principal goal of man-machine interaction is providing support for intelligent activity in the specific problem domain. This requires elaboration of efficient algorithms for formation, modification and application of both explicit and implicit fragments of knowledge. Advanced network technologies could be used for the creation of effective procedures of configuring and integrating of various knowledge elements distributed over time and space. System paradigm based on a net-centric concept allows an examination and effective modeling of both man-machine and internal applied processes. Such an approach also gives a possibility for display and examination of essential components for different types of internal as well as external conflicts within a wide range of situation's variables and parameters. It is essential that the development of distributed intelligent systems should take into consideration not only formalized procedures of examination and solving of typical conflict situations, but also experience and skills of effective actions in unexpected environmental conditions.

Conclusion: Development of intelligent systems requires, as a first step, elaboration of consistent methodology as well as feasible procedures for generation and structuring of knowledge related to both external and internal elements of conflict situation. The next step is an efficient integration of these elements into a single goal-directed system. The promising method to cope with this problem is the implementation of a net-centric paradigm in combination with the usage of various types of current situation's informational images. The proposed approach also allows an efficient modeling and examination of different kinds of applied processes.

Keywords: control, distributed system, conflict situation, applied process, knowledge formation, man-machine system, net-centric concept, integration.

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PREPARING MEDICAL IMAGES FOR PROCESSING IN LARGE INFORMATION STORAGES

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Introduction: Improvement of working with medical images is one of the urgent tasks of practical healthcare. Diagnostic equipment provide image in digital form that require storing, processing and analysis in order to be used by medical personnel.

Development of information systems has caused occurrence of many data storage systems such as GRID and cloud, which are not only limited to storing digital medical images but also allow to process and analyze them. Special-purpose systems such as PACS (Picture Archiving and Communication System) are widely used as temporary digital images storage. PACS is a medical imaging technology which provides economical storage of and convenient access to images from multiple modalities. Electronic images and reports are transmitted digitally via PACS. The universal format for PACS image storage and transfer is DICOM (Digital Imaging and Communications in Medicine).

At the present time use of such systems in Ukrainian healthcare practice is extremely limited. This is due to the problem of switching from paper to electronic workflow that is not implemented healthcare facilities.

The purpose is in determination of main conditions, selection of methods and means of preparing (processing, storing, transmitting and analyzing) medical images for usage in big information storages on the example of GRID.

Method: In this work the method of hierarchical clustering is used.

Result: Preparing medical images for GRID-environment processing contains two processes. The first is about organization of software and technical system for image sharing inside the healthcare facility and for image transmission to GRID. The second process lies in medical images pre-processing.

Three-level medical images processing system based on diagnostic and treatment system and temporary storage system in healthcare facility and GRID-system for long-term storage and analysis has been presented. Level functions were defined, scheme for image transmission and processing in the GRID has been suggested.

Method of scintigraphic kidney image analysis has been chosen and tested. Several patients' kidney scintigraphic images have been processed by the means of hierarchical clustering to classify patients by the value of pixel data of the selected fragments of images.

Conclusions:

Suggested three-level system allows regulating medical data of images for usage in diagnostic and treatment process and transmitting depersonalized medical images to GRID.

The chosen method of hierarchical clustering could be used as one of the stages of automated images analysis for grouping of series of patients images by diagnostically informative attributes.

By analyzing the mean pixel value of five patients' renal parenchyma and pelvis scintigraphic image segments authors could divide patients into three subgroups according to the functional state of the parenchyma and into three subgroups according to the functional state of the renal pelvis.

Keywords: medical images, GRID, storage and processing, DICOM.

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MODELLING OF HIDDEN FRAGMENTS POLAROGRAPHIC INVERSION CHRONOPOTENTIOGRAM OF TWO HEAVY METALS

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Introduction: Progressing process of environmental pollution by heavy metals harmful affects on human health. That is why the measurement of the mass concentration of heavy metals in the environment is an actual task. Currently one of the most common polarographic methods of measuring of the mass concentration of heavy metals is the method of inversion chronopotentiometry. To reduce the error introduced into the method that is associated with the error

determination of the mass concentration of heavy metals at their joint inversion is required to be able to model the hidden fragments intensity curves inversion of heavy metals. The article considers issues related to the modelling of hidden fragments of intensity curves inversion of heavy metals.

The purpose of the research is to obtain a model that can more accurately determine the concentration of each heavy metal in the sample.

The task is to develop a simulation algorithm, which will ensure equality of area under the original curve of inversion intensity sum of the areas under the modelled curves for the area joint inversion of the two metals.

Methods: To achieve our purpose we apply the numerical integration methods (for example, using the trapezoid rule) and linear extrapolation on hidden areas.

Results: The algorithm to approximate simulation of hidden fragments of inversion chronopotentsiometric process of joint measurement of the mass concentration of the two heavy metals is obtained which allows realizing an approximate separation of their mass concentration.

Conclusions: Task of constructing an algorithm measuring the concentration of each of the two heavy metal with overlapping inversion ranges can be solved only if the following two assumptions, namely: the nature of the inversion processes of each heavy metal remains unchanged; displacement of the ends of each of the intensity curve inversion relative to the ordinate axis is equal. This allows to provide the approximate equality between the area under the original curve inversion intensity and the sum of area under the model curves for the plot joint inversion of the two metals.

Proposed approach to the construction of the algorithm allows practice the approximate separation of the mass concentrations of two heavy metals on the plot of their joint inversion and to evaluate the quantitative value of each metal as on the plot their joint inversion and in the sample as a whole.

Developed algorithm allows to estimate the proportion of concentration on the hidden plots inversion curve of each of the two heavy metals, thereby increasing the accuracy of measuring the concentration of each metal.

Keywords: polarography, polarographic chronopotentiogram, modelling, hidden fragments, heavy metal.

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SYNCHRONIZATION OF BIOLOGICAL TISSUES WITH COMPLETE MIXING ENVIRONMENT AS A JUSTIFICATION FOR THE SPATIALLY INHOMOGENEOUS ELECTROMAGNETIC FIELD DURING IRRADIATION OF TUMORS

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Introduction: Condition of homeostatic functions of biological fluids is provided by almost perfect mixing of dissolved components. Violation of tissue homeostasis or synchronization often leads to the appearance and progression of tumors. The missing of synchronization often leads to the appearance tumor cells which have different structures and functional activity. It makes malignant tumors resistant to chemo- and radiotherapy. One of the methods of regulation of local and regional blood flow and effective perfusion of biological tissues, including tumor is nonequilibrium reasonable electromagnetic hyperthermia. It does not increase the temperature of more than 1.5°C, and not have a direct cytotoxic effect.

Based on a percolation theory, the choice of the external physical factors spatial inhomogeneity is justified; this factor allows the improvement in perfusion of biological tissues. In the applied aspect, the results of the work theoretically justify the spatially inhomogeneous radiofrequency electromagnetic field at a moderate hyperthermia of the malignant tumours.

The purpose of the paper is to rationalise the choice of the most efficient spatial inhomogeneity of the electromagnetic irradiation of tumour during a combined therapy based on the change in the tissues' perfusion.

Materials and Methods: Lower limit of the spatial inhomogeneity of the external physical factor is estimated based on the evaluation of the characteristic radius of diffusion of biological cells metabolites, while for the upper one it is based on percolation theory and corresponding simulation. When simulating perfusion of tissues biological fluid depends on: the number of blood vessels, area of tissue, volumetric blood flow, penetration factor of fluid from the blood vessels into the tissue, spatial temperature gradient of tissue. The spatial distribution of the electromagnetic field which causes the heating was set sinusoidal function.

Results: The results of simulating showed that the more expressed spatial heterogeneity of external electromagnetic field during moderate hyperthermia of tissue the more increased perfusion. It is shown that the lower limit of the spatial inhomogeneity of the external physical factors is determined by the metabolites diffusion coefficient and their effective generation frequency, which geometrically corresponds to 10^{-2}–10^{-1} cm distances. The upper limit of the clusters' (patterns') geometric dimensions and their number of external fields on the basis of percolation theory and simulation is characterized by the total clusters area (volume) of 5–45 % useful space of irradiation, provided that there are more than three clusters.

Conclusions: For a fixed volume flow effective tumor perfusion increases with the number of blood vessels, as well as in enhancing the spatial inhomogeneity of the external electromagnetic fields. Increased blood flow or fluid velocity through the vessels uniquely characterizes the change in tissue perfusion.

The simulation shows that to increase the effective perfusion effect of the external physical factors "force" diffusion (random) component of the fluid in the tissues must be commensurate with the *forces* of directional movement.

Keywords: spatially inhomogeneous field, electromagnetic fields, synchronization, perfusion, percolation, a malignant tumor.

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MONITORING AND CORRECTION OF STUDENTS' FUNCTIONAL STATE BY THE INFORMATION TECHNOLOGY TOOLS

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Introduction: The functioning of the educational system is aimed at the professional development of young people, the formation of highly qualified specialists in conjunction with the preservation of their health. For a full and adequate assessment, monitoring and timely correction of students' functional state (FS) it is necessary to use new information technologies.

The purpose is the analysis of information technology developed for monitoring the functional state of students to form differentiated programs of psychological support in the learning process.

Results: The basis of information technology (IT) is the formed hierarchical information model of a students' functional state including intellectual, emotional, and personality-motivational components. Normalized assessments of all levels of the hierarchical information model were generated. The study of the developed information model with two groups of students with different learning load was conducted. Testing was conducted four times a year, at the beginning and the end of each two terms. As changes in the individual functional state of students were present in all components of functional state in varying degrees the problems of the additional psychological support were arisen. The task of automating the formation of differentiated psychological support groups is solved by using the developed algorithm, which allows us to analyze the students' functional state based on a hierarchical information model.

Set of differentiated programs for psychological support was developed, the elements of which were trainings aimed at the intellectual, emotional, motivational aspects of psychical activities. Using this psychological training set allowed to form effecting by a program for each particular group of additional psychological support, taking into account the need to correct the state of certain functions of the intellectual, emotional or personality-motivational components.

Using this set allowed us to form effecting by a program for each particular group of additional psychological support, taking into account the need to correct the state of certain functions of the intellectual, emotional or personality-motivational components.

Based on the developed models, a set of criteria classification, algorithms for determining the normalized estimates and forming groups of psychological support the information technology for monitoring and correction of students' functional state in the learning process was developed. Information technology includes three major stages: monitoring the functional state, the classification of this state and on

the basis of obtained estimates formation of differentiated programs of psychological support and its correcting.

Conclusions: Monitoring functional status using the developed information technology can detect the need for additional psychological support. The results show a mosaic combination of psychological functions states that require correction forming the basis of the formation of differentiated programs of the psychologist' additional work. Evaluation of the results of the students' functional state correction indicates an improvement in functional reserves for the improve of the efficiency of the educational process.

Keywords: information technology, student's functional state, monitoring and correction of students' functional state, differentiated programs of psychological support.

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