Академик Н. К. Надировтың 90 жылдығына және
академик М. Ө. Өтелбаевтың 80 жасқа толу мерейтойына арналған
«Ғылым, техника және білім берудегі есептеу және ақпараттық
технологиялар» (CITech-2022)
Халықаралық конференциясының

БАЯНДАМА ТЕЗИСТЕРІ

(12-15 қазан 2022 жыл)

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ТЕЗИСЫ ДОКЛАДОВ

Международной конференции,
«Вычислительные и информационные технологии в науке, технике
и образовании» (CITech-2022), посвященной
90-летию со дня рождения академика Н. К. Надирова и
80-летнему юбилею академика М. О. Отелбаева
(12-15 октября 2022 года)

❖

ABSTRACT BOOK

of the International Conference
«Computational and Information Technologies in Science,
Engineering and Education» (CITech-2022)
dedicated to the 90th anniversary of Academician N. K. Nadirov,
to the 80th anniversary of Academician M. O. Otelbaev
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❖

Конференцияның мақсаты - тәжірибе алмасу, ғылымның, техника мен білімнің әр түрлі салаларында есептеу және ақпараттық технологияларды қолдану саласындағы жетекші мамандардың мәселелерін талқылау, іргелі және қолданбалы математикалық зерттеулердің жаңа нәтижелерімен танысу, сондай-ақ халықаралық ғылыми және техникалық ынтымақтастықты кеңейту.

"Computational and Information Technologies in Science, Engineering and Education" (CITech) халықаралық ғылыми-тәжірибелік конференциясы бай дәстүрлерге ие және 2002 жылдан бері тұрақты түрде өткізіледі.

Конференция ресейлік және қазақ ғалымдары арасында тығыз ынтымақтастықта ұйымдастырылды және жалпы талқылау саласы - есептеу технологиялары саласындағы ең озық жетістіктер болды. Конференция географиясы кейінірек кеңейіп, енді оған Еуропа, АҚШ, Жапония, Үндістан және Түркия елдерінің жетекші ғалымдары қатысады.

Конференцияның мақсаты - қатысушылар арасында жаңа білім мен ғылыми жетістіктерді тарату болып табылады. Бұл конференцияның ерекшелігі жас ғалымдарды екі елдің жетекші ғылыми қызметкерлерімен өзара іс-қимыл арқылы ғылыми жетістіктерін бағалауға тарту болып табылады. CITech-ке қатысу қазіргі уақытта осы салада маңызды зерттеулер жүргізіп жатқан жас ғалымдардың қауымдастығын қалыптастыруға көмектеседі.

CITech конференциясы Алматыда (2002, 2004, 2008, 2015, 2020, 2022), Павлодарда (2006) және Өскеменде (2003, 2013, 2018) өткізілді. CITech конференциясын ұйымдастыру және өткізу үшін тұрақты дәстүрлерді қалыптастыруда Новосібір ғылыми мектебінің профессоры Ш. С. Смағұлов, Н. Т. Данаев, Ю. И. Шокин, В. Н. Монахов, Б. Т. Жұмағұлов, Н. М. Темірбеков және т. б. ғалымдардың жеке достық қарым-қатынасы маңызды рөл атқарады.

CITech-2022 конференциясы келесі негізгі бағыттар бойынша жұмыс атқарды:

- Есептеу ғылымдары және жоғары өнімді есептеу;
- Салалар бойынша ақпараттық және коммуникациялық технологиялар;
- Функциялар теориясы және функционалдық талдау;
- Дифференциалдық теңдеулер және басқару теориясы;
- Алгебра, Математикалық логика және геометрия;
- Актуарлық математика және статистика;
- Теориялық және қолданбалы механика;
- Ғарыштық технологиялар және робототехникалық жүйелер;
- Білім берудегі жаңа ақпараттық технологиялар.

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СЕКЦИЯ 1
Вычислительные науки и высокопроизводительные вычисления

❖

SESSION 1
Computational sciences and high-performance computing

IRSTI 27.41.19

MODIFIED VARIABLE-ORDER FRACTIONAL DIFFERENTIAL FILTRATION MODEL

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Keywords: filtration models; numerical method; variable-order fractional derivatives, fluid filtration in media with memory.

Studies of the last two decades show that diffusion in complex heterogeneous media is accompanied by frequent changes in the diffusion regime [1, 2]. In particular, the authors of [3] came to the conclusion that there is another type of memory that manifests itself when the diffusion mode changes. Regarding filtration models, it is known that the order of the fractional derivative is related to the fractal dimension of the porous medium, determined by the Hurst index, which changes with the change in the geometric structure of the medium [4]. The problem when the order of the derivative exhibits a monotonic (linear or non-linear) transition from the initial order to the final one, or when the diffusion regime changes at some point in time is of physical interest. This makes it possible to more accurately reveal the latent effects during fluid flow in a porous medium associated with changes in the properties of the porous medium.

The talk presents a modified nonlinear fractional differential model with variable-order fractional derivatives that takes into account the change in the diffusion regime and the memory effects of a porous medium. The model is based on a fractional differential filtration model with constant orders of fractional derivatives, studied in [5-7]. The model was modified by replacing constant-order derivatives with variable-order derivatives, i.e. functions of time and space $\alpha = \alpha(x,t)$, and, in particular, functions depending on the desired solution $\alpha = \alpha(u(x,t))$. In addition, the equation contains several terms with fractional derivatives of various orders. Moreover, the assumptions adopted when modifying the model are stated.

This research was funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP14972807.

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COMPRESSIBILITY AND NON –EQUILIBRIUM MODIFICATION FOR $k-\omega$ TURBULENCE MODEL

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Keywords: numerical simulation, Navier-Stokes equations, turbulence model, compressibility effect, non- equilibrium modification.

The analysis of the problem of turbulence closure at high speeds with extensive subsonic zones was carried out. It was revealed that using two-parameter turbulence models was insufficient. The main reason is that these models were originally developed for incompressible flows, and then applied to compressible flows. Therefore, today there is an active development of turbulence models taking into consideration compressibility. However, it should be noted that the existing models have shown insufficient efficiency in solving certain problems associated with supersonic flow.

A mathematical model of the spatial supersonic turbulent flow of a multicomponent gas mixture is formulated based on three-dimensional Favre-averaged Navier-Stokes equations closed by a $k-\omega$ model of turbulence. Numerical algorithm based on a high-order accuracy ENO scheme is applied for numerical simulation of the interaction of a jet with a supersonic flow [1].

Compressibility and non –equilibrium modification for $k-\omega$ turbulence model [2] are proposed in this study. A two-parameter $k-\omega$ turbulence model is constructed giving consideration the compressibility effect, characterized by taking into account the work of pressure forces G, pressure dilation Π_d and the baroclinicity effect B_w. The Jones-Launder model [3] is considered for the term corresponding to the work of pressure forces G, based on a hypothesis similar to the Boussinesq hypothesis, as well as the modified Shyy Krishnamurty model [4], which uses the additional hypothesis that fluctuations of thermodynamic quantities are isobaric. For the pressure dilatation term Π_d is considerered the Zeman model [5] based on Rott's assumption about the correlation between pressure fluctuation and velocity fluctuation gradient for an incompressible fluid, as well as its modification proposed by Sarkar. Turbulent diffusion is modeled by the known gradient representation [1]. And an additional hypothesis is given for taking into account compressibility for turbulent quantities (generation and dissipation of turbulence), which characterize the local equilibrium. Additional semi-empirical hypotheses are involved for closing compressibility terms used in construction $k-\omega$ turbulence model. The semi-empirical constants of the turbulence model are determined by comparing numerical experiments with experimental data. The use of the $k-\omega$ turbulence model, giving consideration the effect of compressibility for turbulent parameters characterizing local equilibrium, predicts the flow structure quite accurately and makes it possible to obtain a satisfactory agreement between the results and the calculations of other authors.

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THEORETICAL ESTIMATION OF PARALLEL ALGORITHMS FOR PROBLEMS OF MULTIPHALE FLOW IN POROUS MEDIA

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Keywords: fluid flow models; numerical method; threads; parallel algorithms.

Multiphase fluid flow models are the basis of reservoir simulators used in oil field development, enabling predictive calculations of development performance. Due to the complexity of these models, calculations for one field can take from several hours to several weeks. Despite the fact that high-performance parallel computing has been successfully implemented in all commercial hydrodynamic simulators, research aimed at creating and mathematically justifying parallel algorithms for solving problems of fluid flow in porous media continues to be carried out [1-7].

The paper presents efficient and theoretically substantiated parallel algorithms for solving several classes of problems of fluid flow in porous media that are of great practical importance in the oil industry. Theoretical estimates of the acceleration and efficiency of parallel algorithms are obtained which depend on the execution time of an arithmetic operation, data transfer time and latency. These estimates allow making a conclusion about the scope of the potential parallelism of the algorithms. Programs are developed using CUDA and OpenMP technologies, the dependence of the acceleration of calculations on the number of processors used, the method of implementing communication and other factors is presented, a comparative analysis of the algorithms for each of the problems is given.

Verification of the developed parallel finite element methods for solving fluid flow problems using real geological and laboratory data of oil samples from the fields of the East Kazakhstan region was carried out.

This research was funded by the Ministry of Education and Science of the Republic of Kazakhstan, grant number AP08053189.

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GENERALIZED FRACTIONAL STOCHASTIC MODEL OF FLUID FLOW IN COMPLEX MEDIA

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Keywords: fractional stochastic model, Stokes-Darcy model, fluid flow, complex media

The generalized stochastic Stokes-Darcy model is used to predict processes occurring in oil reservoirs with a cavernous-porous structure, in underground systems of karst aquifers, in problems of interaction between surface and underground flows. In addition, the model is used in forecasting and assessing the risk of flooding of territories as a result of groundwater and surface water. This problem is especially relevant for most of the territories of Kazakhstan.

The study of the stochastic generalization of the Stokes-Darcy model is a fairly new and relevant area in modern computational fluid dynamics. The earliest work in this direction is the work [1], published in 2018. Over the next 3–4 years, interest in this model is growing rapidly [2–6].

The report presents a fractional-stochastic generalization of the model of fluid motion in complex porous media with memory. This is achieved by modifying the stochastic Stokes-Darcy equations by adding terms with fractional derivatives. This modification is carried out with a detailed description of the hypotheses and assumptions under which this model will be adequate. Model input data, such as model coefficients, exposure conditions, region geometry, boundary conditions, initial conditions, were assumed to be random.

This research was funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP14871299.

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COMPUTING SERVICE ARCHITECTURE FOR SIMULATION OF STOCHASTIC FLOW PROCESSES IN COMPLEX POROUS MEDIA

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Keywords: computing service architecture, fractional stochastic model, Stokes-Darcy model, fluid flow, complex porous media

The development of a high-performance cloud computing service for modeling stochastic processes of fluid flow in complex porous media on heterogeneous computing architectures based on the Stokes-Darcy fractional differential filtration model has important scientific, applied and economic significance in hydrology, the oil industry and biomedicine.

There are several examples of high-performance services for modeling highly specialized processes based on stochastic models. For example, the Thorium project [1] for modeling the thermal regime of satellites using the Monte Carlo method on CUDA; geological modeling projects [2]. In addition, there are several libraries for working with stochastic processes. For example, the trading library SpyReaper [3], a package for solving large multi-stage problems of convex stochastic programming SDDP.jl [4], the BioSimulator.jl library [5], stochastic modeling of molecular control networks inside living cells StochPy [6]; packages for solving stochastic differential equations Andata [7], StochasticDifferentialEquations for the Julia language, which allow solving ordinary stochastic differential equations. The implementation of the task considered in the report in these packages is impossible.

In this regard, the architecture of the computing service was determined, a description of its subsystems and a scheme of their interaction, a functioning model were given, a choice of software underlying each of the subsystems was made. The cloud service is organized by the SaaS (software-as-a-service) model. The service is built according to an $N + 2$ branched scheme, in which N high-performance machines, one control server and a cloud database participate.

Due to the need to repeatedly solve a stochastic problem for a comprehensive study of the model, its solution is impossible without the use of parallel algorithms and high-performance heterogeneous computing architectures. The rationale for using the hardware-software architecture of parallel computing CUDA in solving stochastic fractional-differential Stokes-Darcy equations is the occurrence of several terms with fractional derivatives. Since the approximation formulas of fractional derivatives are represented as a linear combination of a function calculated on all previous time layers, their calculation requires large computational resources. The use of CUDA allows distributing the calculation of a linear combination across the GPU cores, which significantly reduces the calculation time. The application of MPI technology to the calculation of fractional derivatives is impractical, since the data transfer time will significantly exceed the calculation time.

This research was funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP14871299.

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DEVELOPMENT OF A CLASSIFIER USING TEXT CLASSIFICATION METHODS

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Keywords: Machine learning, Bayes Classifier, Neural networks, K-Nearest neighbors, Text classifier

Modern computer systems in most cases operate with large amounts of unstructured or less structured data called big data. Such data processing is usually done by software with good horizontal scalability: these systems are a connected network of computing nodes that can be expanded when the load increases. Communication between nodes is carried out using network protocols and programming interfaces for processing parallel computing, such as MPI (Message Passing Interface).

Convolution method, SVM (Support Vector Machine), k-nearest neighbors method - KNN (K-Nearest Neighbors) and Naive Bayes Classifiers are often used to train neural networks for text classification. NBC) is used.

The support vector method is one of the most popular supervised learning techniques used to solve classification and regression problems. The principle of the method is to build a hyperplane that optimally divides the model objects.

The algorithm works on the assumption that the larger the distance (gap) between the dividing hyperplane and the objects of the classes to be divided, the smaller the average error of the classifier. It is the sum of the distances from the two closest points to the hyperplane on opposite sides of it is equal to the maximum. If such a hyperplane exists, it is called an optimal partitioning hyperplane, and the corresponding linear classifier is called an optimal partitioning classifier.

The K-nearest neighbor method belongs to the non-parametric class, that is, it does not require assumptions about which statistical distribution the training data set is drawn from. Therefore, the classification models built using the KNN method are also non-parametric. This means that the structure of the model is not set initially, but is determined based on the data. Since the features can have different physical properties and ranges of values, it is useful to normalize the training data to improve the classification results.

The KNN algorithm uses two phases in its work: training and classification. During training, the algorithm remembers feature vectors of observations and their class labels. Algorithm parameter k is also set, which determines the number of neighbors used during classification. In the classification phase, k closest pre-classified observations are determined for an object without a class label. Then, the class that belongs to most of the k nearest examples-neighbors is selected, and the object to be classified belongs to that class.

The easiest way to classify a text is based on the application of Bayes theorem, which allows to determine the probability of a certain event (A) if another event that is statistically dependent on it (B) has occurred.

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

A Naive Bayesian classifier is used for recognition and classification, corresponding to different variations in image classifiers based on the underlying probability and trueness. Naive Bayes techniques are based on self-defining assumptions.

We used Naive Bayes classifier for text classification, NLP(Natural Language Processing) and packages required for work using NPM(Node Package Manager) in JavaScript programming language. The performance of the model is lower because the data for training is not collected systematically, but already the model is showing good results

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MATHEMATICAL MODEL FOR MEDIUM-TERM COVID-19 FORECAST IN KAZAKHSTAN

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Keywords: Covid-19, ODE, inverse problems, identification.

The paper presents the designed algorithm for calculating the dynamics of detected cases of Covid-19 in Kazakhstan, which is based on the processing and use of epidemiological data, the formulation and solving the inverse problem of identifying unknown parameters of the mathematical model of the spread of infection. The inverse problem was solved by methods of stochastic global optimization (differential evolution algorithm, Parzen's tree-like estimation method), implemented in the Python programming language and the Matlab software package for solving technical computing problems.

As a result of the work, predictive scenarios for the spread of Covid-19 in Kazakhstan using chamber modeling (SIR models) [1-5] are presented based on ordinary differential equations from 07/09/2020 to 07/09/2021, indicating peak rates and the most pessimistic outcomes, in the period from 09/01/2021 to 06/24/2022, as well as in agent-based modeling [6-8] for the baseline scenario and the scenario with increased mobility of citizens in public places during the New Year holidays for the period from 12/1/2021 to 01/18/2022 [9].

To implement the models, data on the infected, PCR tests, recovered, deceased, and the division of the country's population into different age groups of ten years were used.

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NUMERICAL MODELING OF THE BOUNDARY INVERSE PROBLEM FOR THE EQUATION OF ACOUSTICS

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Keywords: Acoustics equation, continuation problem, inverse problems, numerical methods, Landweber methods.

Direct and inverse problems. Consider the inverse problem:

$$u_{tt} = u_{xx} + u_{yy} - a(x,y)u, \quad (x,y,t) \in \Omega, \tag{1}$$

$$u_x(0,y,t) = g(y,t), \quad y \in [0,L_y], t \in [0,2T], \tag{2}$$

$$u(x,y,x) = q(x,y), \quad x \in (0,T), y \in (0,L), \tag{3}$$

$$u(x,0,t) = u(x,L_y,t) = 0, \quad (x,t) \in \Delta(T). \tag{4}$$

Where it is necessary to define $u \in H^1(\Omega)$ by given $a \in C^1((0,T)\times(0,L))$, $q \in H^1((0,T)\times(0,L))$ and $g \in H^1((0,L)\times(0,2T))$. Problem (1)-(4) is called direct [1-4].

The inverse to (1) - (4) problem, in which it is required to define the function $q \in H^1((0,T)\times(0,L))$ from relations (1)-(4) for given functions $a \in C^1((0,T)\times(0,L))$, $q \in H^1((0,T)\times(0,L))$ and additional information on solving a direct problem

$$u(0,y,t) = f(y,t) \quad y \in [0,L_y], t \in [0,2T]. \tag{5}$$

Let's introduce the objective functional

$$J(q_n) = \| Aq_n - f \|^2_{L_2} = \int_0^L \int_0^{2T} [u(0,y,t;q_n) - f(y,t)]^2 \, dydt \tag{6}$$

We minimize the objective functional (6) by the Landweber method.

$$q_{n+1} = q_n - \alpha_n J' q_n \tag{7}$$

$\alpha \in \left(0, 1/\|A\|^2\right)$ - descent parameter [3]. The algorithm of the inverse problem, the Landweber iterative method converges. The value of the functional has decreased to the number $J(q) = 2.33 \cdot 10^{-6}$. The total number of iterations has the value n = 8317.

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STABILITY ESTIMATION OF A FINITE - DIFFERENCE PROBLEM SOLUTION FOR A MIXED TYPE EQUATION

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The problem of determining a function through the integral of a function along the family of curves with a known weight function is considered. Under fairly general assumptions about the family of curves and the weight function, the problem reduces to the inverse problem for a differential equation. The stability and uniqueness of the solution of the discrete analogue of this problem on the space of sufficiently smooth functions is estimated. Due to the absence of a theorem of the existence of a solution, the concept of conditional well-posedness of the problem is used in the work, namely, it is assumed that the solution of a finite-difference problem exists. The results obtained are based on reducing the problem under consideration to a boundary value problem for an equivalent second-order partial differential equation of mixed type. Information about the solution of the set finite-difference problem is given both on the boundary of Γ and in some of its ε - neighborhood, which is due to the presence of certain kinds of singularities. When proving the stated theorem on estimating the solution, a technique is used, which is based on the use of a special factor.

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NUMERICAL IMPLEMENTATION OF THE FICTITIOUS DOMAIN METHOD FOR AN ELLIPTIC TYPE EQUATION

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Keywords: fictitious domain method, elliptic equation, Dirichlet problem, equations with rapidly changing coefficients, computational algorithm, iterative process, boundary conditions.

For the numerical solution of equations of elliptic type in regions of complex shape, it is effective to use the Fictitious domain method. In [1], an economical (in terms of the number of actions) difference scheme of the second order of accuracy, an alternating-triangular scheme, is proposed for the numerical solution of an elliptic equation. In [2], a modified alternating-triangular iterative method with Chebyshev parameters was constructed for solving the Dirichlet difference problem for an elliptic equation of the second order of accuracy. In the monograph by V.I. Lebedev [3] considered applications of the composition method for finding solutions to eigenvalue problems, non-stationary problems, the Dirichlet problem for the biharmonic equation, and grid problems. The paper [4] considers a stationary difference problem for the Poisson equation with piecewise constant coefficients in subdomains. The Poisson equation at the media interface is approximated in a special way, i.e. the coefficients of the difference equation are chosen as the quotient in the denominator, which is the sum of the coefficients in the subdomains. A two-stage iterative process based on the area division method is built.

In this paper, we propose a special method for the numerical solution of an elliptic equation with strongly varying coefficients. The proposed method is based on a special change of variables, which reduces the problem with discontinuous coefficients of the second kind to the problem with discontinuous coefficients of the first kind. An iterative process is constructed with two parameters and taking into account the ratio of the coefficients of the equation in subdomains. A theorem is proved for estimating the rate of convergence of the developed iterative process. A computational algorithm has been developed and numerical calculations have been carried out to illustrate the effectiveness of the proposed method.

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APPROXIMATE SOLUTION OF THE NONLINEAR FREDHOLM EQUATION OF THE SECOND KIND BY THE GALERKIN METHOD WITH BASES IN THE FORM OF MULTIWAVELETS

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Keywords: Nonlinear Fredholm integral equation, multiwavelets, projection methods

Consider the nonlinear Fredholm integral equation of the second kind

$$y(x) - \int_a^b K(x,s)\varphi(s, y\,(s))\mathrm{d}s = f(x),\ x \in [a,b] \quad (1)$$

$K(x,s)$ and $\varphi(s,y(s))$ are continuous in $G = \{a \le x \le b,\ a \le s \le b\}$, $f(x),\ y(s) \in L_2[a,b]$. To solve the equation , we put

$$z(s) = \varphi(s, y(s)), \quad (2)$$

then substituting (1.2) and approximating, we will have

$$z_n(x) = \varphi(x, f(x) + \int_a^b K(x,s)\varphi(s, z_n\,(s))\mathrm{d}s),$$

where $z_n(x) = \sum_{j=1}^n c_j b_j(x)$,

$b_j(x)$ – orthonormal system in $X_n \subset X$, X – Banach space. We find an approximate solution from the expression

$$\left(\sum_{j=1}^n c_j b_j(x)\,, b_i(x)\right) = \left(\varphi\left(x, f(x) + \int_a^b K(x,s)\varphi(s, f(x) + \sum_{j=1}^n c_j b_j(s))\mathrm{d}s\right), b_i(x)\ \right), \quad (3)$$

Let 's introduce the notation $a_{ij} = \int_a^b b_j(x)b_i(x)dx,\ d_j(x) = \int_a^b k(x,s)b_j(x)dx$. A nonlinear system can be solved by Newton's method. To do this, we write

$$g_i(c_1,\ c_2,\ \dots, c_n) = \sum_{j=1}^n c_j a_{ij} - \int_0^1 \varphi(s, f(x) + \sum_{j=1}^n c_j d_j(x))b_i(x)\mathrm{d}x,\ i = 1, \dots, n. \quad (4)$$

Let $\left(\vec{c}^{(m)}\right) = \left(c_1^{(m)}, c_2^{(m)}, \dots, c_n^{(m)}\right)^T$ - the value of the coefficients on the *m*-th iteration. Then

$$\mathrm{G}\left(\vec{c}^{(m)}\right) = \left(g_1\left(\vec{c}^{(m)}\right),\ g_2\left(\vec{c}^{(m)}\right),\ \dots, g_n\left(\vec{c}^{(m)}\right)\right)^T \quad (5)$$

The Jacobi matrix is constructed through derivatives

$$\frac{\partial g_i}{\partial c_l} = a_{ij} - \int_0^1 \frac{\partial \varphi}{\partial c_l}\ (s, f(x) + \sum_{j=1}^n c_j d_j(x))d_l(x)b_i(x)\mathrm{d}x,\ i = 1, \dots, n. \quad (6)$$

The canonical form of Newton's method for solving a system of nonlinear equations with a given initial approximation $\vec{G}^{(0)} \in R^n$

$$\frac{\partial \mathrm{G}\left(\vec{c}^{(m)}\right)}{\partial \mathrm{c}}\left(\vec{c}^{(m+1)} - \vec{c}^{(m)}\right) = -\ \mathrm{G}\left(\vec{c}^{(m)}\right). \quad (7)$$

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DISCRETE ANALOGUE OF THE MULTIDIMENSIONAL GELFAND-LEVITAN-KREIN-MARCHENKO METHOD AND APPLICATION IN GEOPHYSICAL PROBLEMS

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Abstract. In the multidimensional case, the application of the Gelfand-Levitan-Krein-Marchenko (GLKM) method makes it possible to reduce the multidimensional nonlinear inverse problem to a system of linear integral equations of the Volterra type [1-5].

The papers [2; 3] describe the achievements of research in this area. The solution of multidimensional coefficient inverse problems by the GLKM method is well studied at the differential level. In the monograph of Krein M.G. the physical formulation of the problem of string tension and theorems on the solution of the inverse boundary value problem are considered.

For the numerical solution of inverse problems by the GLKM equations, one can use conventional approaches, such as inversion of finite difference schemes, minimization of the residual functional, the Monte Carlo method, the method stochastic iterative projection.

In this paper, we consider the method of Krein M.G. and an algorithm for its numerical implementation. A discretization of the Kerin equations with a block Toeplitz matrix structure is given.

Key words: Inverse problem, direct problem, multidimensional coefficient inverse problem, Gelfand-Levitan-Marchenko-Krein method (GLKM), residual functional, Method M.G. Krein in 3D, N-approximation of the M.G. Krein in vector form.

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ON THE FOURIER TRANSFORM OF FUNCTIONS FROM A LORENTZ SPACE $L_{\bar{2},\bar{r}}$ WITH A MIXED METRIC

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Keywords: The Lorentz Space, Fourier transform, Bochkarev's theorem

In 2015 we had an analog of Bochkarev's theorem for the Fourier transform of the function in $L_{2,r}(\mathbb{R})$.

Theorem 1 [1]. Let $\Re_N = \{A = \cup_{i=1}^{N} A_i,\ where\ A_i$ are segments in $\mathbb{R}\}$, then there be an inequality for any function: $f \in L_{2,r}(\mathbb{R}),\ 2 < r < \infty$

$$\sup_{N \geq 8} \sup_{A \subset \Re_N} \frac{1}{|A|^{\frac{1}{2}} (\ln (N+1))^{\frac{1}{2}-\frac{1}{r}}} \left| \int_A \hat{f}(\xi) d\xi \right| \leq 23 \|f\|_{L_{2,r}}.$$

The aim of this article is to obtain a two-dimensional analog of the Bochkarev type theorem for the Fourier transform.

Lemma 1. Let $\frac{4}{3} < q_1, q_2 < 2\ \ and\ f \in L_{\bar{q},\bar{2}}(\mathbb{R}^2)$. Then for any measurable sets A_1 and A_2 of finite measure of $\Re_{N,}$ the inequality

$$\sup_{A_1 \subset \Re_N} \sup_{A_2 \subset \Re_N} \frac{1}{|A_1|^{\frac{1}{q_1}} |A_2|^{\frac{1}{q_2}}} \left| \hat{f}(\xi_1, \xi_2) \right| d\xi_1 d\xi_2 \leq$$

$$\leq C \left(\frac{q_1}{2(q_1 - 1)} \right)^{\left(\frac{1}{q_1} - \frac{1}{2}\right)} \left(\frac{q_2}{2(q_2 - 1)} \right)^{\left(\frac{1}{q_2} - \frac{1}{2}\right)} \|f\|_{L_{\bar{q},\bar{2}}}$$

holds.

Theorem 2. Let $\Phi_{m_1,m_2}(x_1, x_2) = \varphi_{m_1}(x_1) \cdot \psi_{m_2}(x_2), m_1, m_2 \in \mathbb{N}$ be an orthonormal system of functions. Then $f \in L_{\bar{2},\bar{r}}[0,1]$ and $2 < r_1, r_2 < \infty$ we have the inequality:

$$\sup_{|A_1| \geq 8} \sup_{|A_2| \geq 8} \frac{1}{A_1 \subset N\ A_2 \subset N} \frac{1}{|A_1|^{\frac{1}{2}} |A_2|^{\frac{1}{2}} (\log_2(|A_1| + 1))^{\frac{1}{2}-\frac{1}{r_1}} (\log_2(|A_2| + 1))^{\frac{1}{2}-\frac{1}{r_2}}} \times$$

$$\int_{A_1} \int_{A_2} \left| \hat{f}(\xi_1, \xi_2) \right| d\xi_1 d\xi_2 \leq \|f\|_{L_{\bar{2},\bar{r}}}$$

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SIMULATION OF FOUR-COMPONENT MIXTURES SEPARATION BY PHASE FIELD AND LB METHODS

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Keywords: four-component fluid, mixtures separation, Cahn-Hilliard equation, free energy, lattice Boltzmann equations method.

The study of the dynamics of multicomponent fluids is of significant scientific and technological interest. Multicomponent fluids are found in many natural and industrial processes, such as oil and gas production, chemical processing of raw materials, fluid mixture flows in boilers and condensers, etc.

There are various models [1–4] that describe processes in multicomponent fluid mixtures. Considering the thickness of the transition layer between the phases, these models can be divided into two groups: sharp interface models (transition layer between phases has zero thickness) and diffuse interface models (transition layer between the phases has a finite thickness). This article uses the diffuse interface model. Van der Waals [5] was the first to consider the transition layer between phases as a layer of finite thickness. At present, the Cahn-Hilliard approach [6] is widely used to describe diffuse interface models.

This work is a continuation of the work we wrote in [7], which describes the process of separating a three-component fluid mixture. This paper presents a mathematical model of the four-component incompressible fluid flow using the phase field method based on solving the Navier-Stokes equations and the Cahn-Hillard convective equation. The numerical model is based on the D2Q9 scheme of the free energy LB method. The separation process of four-component mixtures at different points in time was presented in the form of figures depicting the density contours of the mixture components. Four-component mixture separation was considered in two cases: with and without taking into account the influence of the gravity force. The results obtained determine the correctness of the constructed model for a four-component fluid.

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MATHEMATICAL AND COMPUTER MODELING OF THE PROCESS OF NATURAL GAS TRANSPORTATION THROUGH PIPELINE NETWORKS TO MINIMIZE FUEL COSTS

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Keywords: Natural gas transportation, mathematical modeling, fuel cost minimization problem.

Constant and disordered increase in oil prices as well as the new environmental attitude of various governments to existing high levels of pollution have led to the exploitation of cleaner and more economically attractive fuels, namely natural gas. Unlike oil or coal, it can be used directly as a source of primary clean energy, which causes less emissions. Historically, gas extraction from natural gas transportation systems was carried out by utilities and industrial consumers, whose use was predictable and characterized by small fluctuations in demand. These exemptions are formed using day-ahead contracts for fixed deliveries and implicitly assume that supply and consumption volumes remain almost constant [1]. As a result, optimization approaches for natural gas transportation systems have traditionally been limited to considering stationary models [2].

The new problem formulated above requires new research to develop methods for modeling and optimal control of dynamic compressible gas flows in large pipeline networks (see [3]).

Here is a mathematical model that most fully describes the process of gas movement in a pipe [4]. Newton's equation of motion can be written as follows:

$$\frac{\partial P}{\partial x} + g\rho\frac{dh}{dx} + \frac{\lambda}{2DS^2}\frac{|M|M}{\rho} + \rho\frac{DW}{dt}$$

where P is the pressure, g is the acceleration of gravity, ρ is the density, $\frac{dh}{dx}$ is the slope of the pipeline, λ is the coefficient of hydraulic friction, D is the inner diameter, S is the cross-sectional area, M is mass flow rate, and x is the length of the pipe.

$$\frac{DW}{dt} = \frac{\partial w}{\partial t} + w\frac{\partial w}{\partial x}$$

Continuity equation:

$$S\frac{\partial \rho}{\partial t} + \frac{\partial M}{\partial x} = 0$$

and the energy equation is written in the form for temperature $\theta = \theta(x)$ under the assumption of zero value of the temperature gradient over time. Also the equation of state

$$P = zR\theta\rho,$$

where R is the gas constant and z is the compressibility factor. The coefficient of hydraulic friction can be calculated using Chen's formula, which is often used in practice.

We introduce a model for gas dynamics in natural gas transmission pipelines by crossing-branch method. We present the derivation of the model as well as numerical results illustrating the validity and its properties. Using crossing-branch method by [5] we obtained numerical results for artificial gas transmission network.

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НУМЕРАЦИИ ВЫЧИСЛИМЫХ СЕМЕЙСТВ

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Ключевые слова: теории нумерации, теория рекурсивных функции, алгоритмы и рекурсивные функции

Наиболее «инвариатной» частью для всех существующих в настоящее время в математике уточнений понятия алгоритма является класс частично рекурсивных арифметических функций (под частично арифметической функцией понимается частичное отображение из конечной декартовой степени множества натуральных чисел N в N)- тех и только тех частичных арифметических функции, которые вычислимы в любом из предложенных в качестве уточнения алгоритмической вычислимости. По существу эта инвариантность и позволяет говорить об эквивалентности всех уточнении и укрепляет уверенность в том, что класс всех частично рекурсивных функции совпадает с классом всех частичных арифметических функции, допускающее эффективное вычисление. Поэтому представляется желательным, чтобы все исследования в теории алгоритмов и ее приложениях проводились на основе «общего знаменателя» - класса всех частично рекурсивных функции.

Теория нумерации является разделом теории алгоритмов, призванным решить вопросы, связанным с указанным выше приведением к «общему знаменателю» на основе понятия нумерованного множества. В теории нумерации разрабатывается необходимая система понятий, ставятся и решаются естественные вопросы, такие, как, например, зависимость или независимость тех или иных свойств множества от выбора нумерации, существование (единственность) нумерации множества с заданными свойствами и т.п.

Вычислимые нумерации - это один из наиболее изученных объектов теории нумерации. Можно даже сказать, что разнообразные свойства вычислимых нумерации, обнаруженные в ходе исследовании, создал предпосылку к созданию содержательной общей нумерации и определили основные вопросы дальнейших исследований.

Пусть S – это не более чем счетное множество, тогда сюръективное отображение α натуральных чисел N на множество S называется нумерацией семейства S. Нумерация α называется вычислимой, если отношение $x \in \alpha(y)$ является вычислимо перечислимым. Семейства S называется вычислимой, если существует вычислимая нумерация для семейства S. Подробно о вычислимых нумерациях можно посмотреть, к примеру в [1].

Теорема. Семейства всех вычислимых линейных порядков не является вычислимой.

Теорема. Семейства всех рекурсивных и примитивно рекурсивных множеств является вычислимой.

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ПОСТРОЕНИЕ НЕСТРУКТУРИРОВАННОЙ СЕТКИ МЕТОДОМ ТРИАНГУЛЯЦИИ (МЕТОД ПРОДВИГАЕМОГО ФРОНТА)

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Ключевые слова: метод продвигаемого фронта, триангуляция, корректировка ошибка, эластичные границы

Точность описания процессов и сокращение расчетного времени является одним из приоритетов численного моделирования. Указанные показатели зачастую взаимосвязаны с качеством сеток, используемых для проведения расчетов, которые делятся на две большие группы: структурированные и неструктурированные. Структурированные сетки легки к построению, при этом сравнительно с меньшей точностью описывают места с усложненным течением процесса. Неструктурированные сетки могут иметь сложный способ построения, при этом точнее описывают необходимые участки области.

Среди методов построения неструктурированной сетки одним из распространенных является метод продвигаемого фронта.

Указанный метод представляет собой построение равнобедренных треугольников с определенной площадью, где основанием первого треугольника является ребро с минимальной длиной рассматриваемой многоугольной области. Далее, область треугольника исключается и формируется новый многоугольник посредством удаления ребра с минимальной длиной из первичного многоугольника и добавления в многоугольник в качестве дополнительных ребер двух остальных ребер треугольника. Процедура повторяется до заполнения треугольниками всей площади первичного многоугольника [1]. Узлы сетки нумеруются отдельно, треугольники отдельно [2].

Могут быть случаи, когда вершина противоположная основанию равнобедренного треугольника лежит близко к одной из вершин многоугольника. В данном случае, в целях недопущения чрезмерного уменьшения треугольников, вершина треугольника заменяется вершиной многоугольника.

В случае наличия пересечения треугольника с ребром многоугольника, предполагаемую вершину треугольника заменяет ближайшая к ней вершина многоугольника и треугольник предварительно считается построенным. При этом, построенный треугольник проверяется на предмет того, чтобы он не пересекал ребра многоугольника и целиком лежал внутри многоугольника, т.е. имел положительный векторный обход. В противном случае, в качестве вершины треугольника проверяется следующая близлежащая вершина многоугольника.

Для областей со сложным течением процесса предлагается измельчить каждую построенную треугольную сетку, разделив его на три треугольника. В целях сохранения конформности сеток общей вершиной этих треугольников является точка пересечения трех медиан первичного треугольника.

Также, при моделировании процессов могут быть случаи, когда границы рассматриваемой области являются эластичными и определенная граничная подобласть меняется в сторону увеличения. В данном случае предлагается «отсечь» увеличенную граничную подобласть из остальной области и построить сетку вышеуказанным методом для этой подобласти. При этом, в остальной части области сетка не меняется. Конформность сетки между увеличенной граничной подобластью и остальной частью области не нарушается. Данный подход предлагается в целях возможности сравнения параметров в определенных узлах остальной части области до и после изменения границы области.

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СЕКЦИЯ 2
Салалар бойынша ақпараттық және коммуникациялық технологиялар

❖

СЕКЦИЯ 2
Информационные и коммуникационные технологии по отраслям

❖

SESSION 2
Information and communication technologies by industry

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DEVELOPMENT OF AN ALGORITHM FOR GRAPHICAL VISUALIZATION OF USER RELATIONSHIPS BASED ON SPECIFIED PARAMETERS

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Keywords: visualization, vkontakte, analysis of connections of users, social media algorithm

The object of research is the relationship between users in certain social networks. networks or special programs where users exist.

The purpose of the work is to analyze and study the connections between users according to the given parameters of social networks. networks based on various metrics

Method of work - the structure of social networks is studied in the work, algorithms are applied for divided into communities and users, various metrics for users are calculated. Based on the data obtained, a conclusion is made about the applicability of such applications in education.

Practical application - the results of this thesis can be used for further study of social networks, as well as for finding information about a particular user based on connections between other users, communities.

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DYNAMIC PROPERTIES OF VIBRATION MACHINE DRIVES

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The drives of vibration machines form an important part of their structure. In the analysis of drives of vibration machines, their self-synchronization is of interest. Self-synchronization of vibration exciter drives of vibration machines is the establishment of the same average angular velocity of unbalances, which are not kinematically interconnected. Synchronous rotation of unbalances in a two-shaft mechanical vibration exciter is achieved due to their interaction with a moving carrier body [1,2]. Coordinated rotation of unbalances, despite the differences in parameters, occurs under certain conditions. Self-synchronization is studied on the basis of the nonlinear theory of oscillations.

The dynamics of the vibrating screen model with a self-synchronizing drive is described.

It is shown that the conditions necessary for a stable mode of synchronous-in-phase movements of the rotors are met at all stages of operation with a hinged connection of the screen box with a two-shaft centrifugal vibration exciter. In this case, the time of establishment of synchronous-in-phase movements of the rotors does not exceed 0.5 s.

It was revealed that the mode of stable synchronous-in-phase movements of the rotors is insensitive in the magnitude of the system parameters changing in a certain region. This circumstance can be used in the design of vibration machines for various technological purposes.

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USING MACHINE LEARNING TO IDENTIFY A FAKE ACCOUNT

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Keywords: machine learning, Instagram, dataset, prediction, classification.

Nowadays, online social media is dominating the world in several ways. Day by day the number of users using social media is increasing drastically. The general purpose of social media is to keep in touch with friends, sharing news, etc. This provided a new way of a potential attack, such as fake identity, false information, etc. The objective of this project is the automated recognition of fake accounts, using some Classification Algorithms. In order to achieve the set goal, the possible factors of currently known possible fake accounts were studied. The following detection strategy was used to work with them.

The first stage of the project is the collection of information about the account. For this step, Apify platform was used to collect and automate web pages, which can turn any site into an API.

The projects have 2 datasets: the first with 11 feature is used for the recognition of private accounts, which due to their privacy have a limited amount of information to share, the second with 14 features is used with the public accounts, which thanks to their privacy have more information to work with, such as the date of the post published, which gave the algorithms some information about the index of activity of the account. Every account's feature has been scraped using an Instagram Web Scraper.

Then the two datasets have been subject to a Preprocessing Phase. This phase consists of the standardization and the normalization of the two datasets.

The features, now preprocessed, are taken and given to this Machine Learning Classifier Algorithms:

- Decision tree
- K-Nearest Neighbours (KNN)
- Logistic Regression
- Random Forest
- Support Vector Machine (SVM)

For every algorithm, in addition to the training and the testing phase, has been calculated:

- Confusion Matrix
- Receiver Operating Characteristic / ROC Curve
- Classification Report

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THE ROLE AND INFLUENCE OF ARCHIVAL DATA IN THE LIFE OF THE SCIENTIFIC COMMUNITY. WAYS TO EXPAND ACCESS TO DIGITAL ARCHIVES

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Keywords: Research method, archival system, metadata, research data, research data archives.

As technology develops and changes at a rapid pace, it is easy to damage or change, lose digital information. This problem is important for scientists, students, mass media, scientific organizations. The solution of this problem not only provides free access of the scientific community to the results of research, but also increases the reliability of the archive system. This, in turn, is an opportunity for the implementation of new ideas and innovations.

The main purpose of digital research archives is not only to store materials, but also to provide access to what is stored. When creating the structure of the system, it is necessary to create access to research results with the most open consideration of the legal framework of intellectual property rights and confidentiality rules. Objects of research

- Electronic archive systems;
- collections of scientific papers.

Primary and secondary data will be taken into account by research methods. Primary data is any initial information that is collected to answer a research question (for example, through surveys, observations, and experiments). Secondary data is information that has already been collected by other researchers (for example, during a government census or previous scientific research) [1].

The main goal of the work is to find an answer to the question why archiving plays such an important role in the life of the scientific community and directly affects the quality of current research, as well as whether it is possible to make the archive more accessible.

Like all processes in the world, archiving of research data affects the dynamics of modern information technologies and is therefore subject to rapid changes. Access to the results of research activities implies free access to the public network, which allows the user to read, download, copy, distribute, search or link to the full texts of these articles, scan them.

The digital turn raises the fundamental question of how knowledge is created, evaluated, taught, transmitted and published. When creating an archive, the following problematic points must be taken into account:

- the problem of providing free, remote and direct access to information,
- archives must respond to changes in technology and updates to digital platforms.

To solve access problems, machine learning can be used to unlock archives and make them more accessible, for example, by distinguishing confidential and non-confidential materials or by automatically adding tags and other metadata to facilitate search [2].

The problem of access to digital collections will not be easy to solve. It doesn't make much sense to restrict access to web archives that could potentially yield valuable research results that researchers would then have to publish in open access journals.

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BUILDING A MODEL FOR DETECTING PNEUMONIA USING DEEP LEARNING

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The World Health Organization estimates that more than four million deaths occur annually due to pneumonia and other diseases associated with air pollution, and the latest Covid-19 virus has dramatically increased the percentage of pneumonia cases. Also, there is a shortage of radiologists in both developing and developed countries. Currently, the development of artificial intelligence and machine learning technologies, as well as the collection of a large amount of medical images, make it possible to create automated systems for analyzing medical images. The article presents a simple model for detecting pneumonia based on deep learning methods (convolutional neural networks). 5,863 X-ray images from Guangzhou Women's and Children's Medical Center were used for the model. Neural network training took 12 epochs and 26 minutes. The results obtained in the test data are: recall – 96%, precision – 92%, accuracy – 92%, f1 – 94%. This is no less than the indicators in many popular works. The model significantly reduces the burden on radiologists, helps them make decisions and save time, allows them to evaluate the quality of their work and reduce the likelihood of medical errors.

DEEP LEARNING TECHNIQUES FOR IMAGE SEGMENTATION: A SYSTEMATIC ANALYSIS

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The development of neural network algorithms has revolutionized many areas, especially those related to image mining. The paper considers the problem of image segmentation (search for groups of pixels, each of which characterizes one semantic object). Image segmentation can be used as the first step of algorithms to solve many different computer vision problems, including analysis of medical images, in production to indicate defects in the assembly of parts, as well as for mapping terrain from satellite images, etc. In the last few years, it has been possible to significantly improve the quality of image segmentation through the use of deep convolutional neural networks. Despite this, due to the complexity of the problem and performance requirements, this task cannot be considered completely solved. A comprehensive overview of modern methods of image segmentation using neural networks is given. The interrelationships, strengths and problems of these DL-based segmentation models are investigated, widely used data sets are presented, as well as a comparison of characteristics and promising research directions.

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OVERVIEW OF DEEP NEURAL NETWORK TRAINING METHODS

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Keywords: neural network, machine learning, deep learning.

Deep neural networks are currently becoming one of the most popular approaches to creating artificial intelligence systems, such as speech recognition, natural language processing, computer vision, etc. The article presents an overview of the history of development and the current state of deep neural network training methods. The model of an artificial neural network, neural network learning algorithms, including the error back propagation algorithm used to train deep neural networks are considered [1]. The development of neural network architectures is described: neocognitron, autoencoders, convolutional neural networks, limited Boltzmann machine, deep trust networks, long-term memory networks, managed recurrent neural networks and residual learning networks. Deep neural networks with a large number of hidden layers are difficult to train due to the vanishing gradient problem. The article discusses methods for solving this problem, which make it possible to successfully train deep neural networks with more than a hundred layers [2]. The review of popular libraries of deep learning of neural networks, which made possible the wide practical application of this technology, is given. Currently, convolutional neural networks are used for computer vision tasks, and recurrent neural networks, primarily long—term memory networks and managed recurrent neural networks, are used for processing sequences, including natural language [3].

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INTEGRATED DEVELOPMENT OF AN AUTOMATED TRADE SYSTEM ON THE EXAMPLE OF A DOMESTIC VENDING MACHINE FOR SELLING FLOWERS – A FLOROMAT

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Keywords: Vending machine, Floromat, SolidWorks 2018, Arduino IDE, Mega 2560 PRO MINI, ICT L83, Puloon LCDM-1000

The vending machine for selling flowers belongs to the automated trade equipment and can be used for the sale of flowers by the self-service method. Generally, such an apparatus is given a definition - floromat, sometimes flomat.

Floromats are placed at airports, train stations, supermarkets, theaters, concert halls, and even maternity hospitals. Their more modern models can sell not only flowers, but also gifts, soft toys and other related goods. The advantages of the absence of a seller, a small leasable area and round-the-clock operation of the device make this type of business today one of the fastest paying off.

Currently, only foreign vending machines are presented and used in the domestic market in the field of automated trade, and in the vast majority for the sale of goods such as foods. As practice shows, along with them, the number of operating floromats is single copies.

The concept of the integrated development of a separate automated trading unit, which will be considered using the example of the mentioned floromat, includes the following main successive stages: writing a technical task (functions and tasks of the floromat), calculations and selection of electronic and other components available on the market for assembling the device being created, development of an electrical device circuit, writing a control program code loaded into the microcontroller memory for the implementation of an automated sales process, designing and arranging its design using modern computer-aided design (CAD), analysis and simulation of physical processes (CAE), and finally the development of technical documentation for production.

Today, one of the important criteria in terms of all kinds of payment methods for goods is a digital payment method, for example, payment with a smartphone via a QR code. The emerging relevance of this method of payment also affected the situation with vending machines, which requires the development of completely new algorithms for the integrated operation of a smartphone and the control center of such device – the microcontroller.

The given and analyzed practical experience in creating a simple floromat indicates that the availability and existence on the market of all kinds of electronic and ready-made mechanical components, theoretical knowledge in the field of microcontrollers and practical experience with them, as well as certain skills in performing design work, allow in general to create other types of all kinds of automated sales devices of our own domestic production.

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USING THE PHOTOGRAMMETRIC PROCESSING TECHNOLOGY IN THE ISSUES OF 3D MODELS OF URBAN OBJECTS BUILDING

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Abstract. Currently, the use of three-dimensional modeling in scientific research allows researchers to solve a number of problems from different fields of science. Such important tasks are, for example, the restoration and reconstruction of historical and cultural heritage, the tasks of architecture and construction, the modeling of geophysical processes, the development of topographic maps and plans, etc. It becomes necessary to use modern methods and technologies for modeling 3D objects in search of a solution to such problems. Using a laser scanner or 3D modeling software is usually expensive and requires a high level of knowledge. However, among 3D modeling technologies, there is an image-based photogrammetric data processing method that offers a cheaper alternative and allows you to get a more accurate 3D model of objects. Thus, this article proposes the results of building 3D models of urban objects using photogrammetric data processing technology. The East Kazakhstan Regional Drama Theater of the Ust-Kamenogorsk city acts as an object for 3D modeling. There is presented a mathematical model of nonlinear distortions described using the Brown model. In addition, the article provides a technique for obtaining the necessary photographs for 3D modeling, as well as an analysis and review of modern technologies for photogrammetric data processing for 3D modeling.

Keywords: 3D model, sparse point cloud, dense point cloud, photogrammetry, unmanned aerial vehicles (UAVs).

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THE AGRICULTURE INDUSTRY OF KAZAKHSTAN STATISTICS: INPUT-OUTPUT ANALYSIS

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In this research considers of the problems of (+) over- and/or (–) under- evaluation of aggregated flows in monetary terms of accounts and budgets of the agents of two sectoral economy, – agriculture, hunting, forestry, and fishing industry and the rest of national economics. To achieve the goal of the study, the input-output table statistical data obtained from the reports of the Asian Development Bank for 2007-2020 for the Republic of Kazakhstan at current prices in of U.S. billions of dollars. Here was determined the time phases of divergence, convergence, and equilibrium of the values of such macroeconomic indicators as interindustry Produce / selling and Purchase / buying, Gross value added and Final demand, Imports and Exports. The results obtained based on this systematic research on input-output analysis can be used in decision-making in macroeconomic policy in the face of external challenges and uncertainty.

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QUASI-ANALYTICAL SOLUTION OF DYNAMIC PROBLEMS BY THE PARTIAL DISCRETIZATION METHOD

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Keywords: partial discretization, mathematical model, nonlinearity, vibrations

The work is devoted to the development of the partial discretization method, particularly in solving the nonlinear problems of dynamics system, as well as differential equations with variable coefficients. This method is actively used to obtain an analytical solution of applied problems. It is based on the discretization of individual "uneasy" components of the mathematical models that interfere with obtaining an analytical solution. Discretizable element is represented as a constant at each discretization step. As a result of such partial discretization of the mathematical model, finding a quasi-analytical solution is not difficult.

The purpose of the work is to develop the partial discretization method and the algorithm for constructing its recursive formulas, to substantiate the correctness and accuracy of the solution through verification with known scientific results.

The authors of the paper carried out a discrete partition of the argument of a non-linear function and replaced this function by a discrete representation through the Dirac delta function [1], which belongs to the class of generalized functions. The Dirac delta function characterizes the spatial density of the required value applied or concentrated at one point; moreover, by using this function it becomes possible to record a point action [2].

Generally, integration is used in the process of finding an analytical solution of differential equations. If the partial discretization method was applied before, then the generalized Dirac function is transformed into a piecewise constant Heaviside function.

The authors of the work on the example of the model of the elastic rod vibrations with variable coefficients [3] identified an algorithm of obtaining a recurrent form of an analytical solution with partial discretization. The algorithm is based on obtaining solutions to the equation for the first 4 iterations and applying the method of mathematical induction to derive a recursive formula. The algorithm is of a general nature for such type problems. Some well-known mathematical models [3] - [4] are taken as test examples. For them, according to the developed algorithm, the recurrent formulas of the analytical solution are determined.

The results verification of the obtained studies with the results of work [3] was carried out. The reliability of the algorithm and the accuracy of the obtained solutions were confirmed by verifying the results with the results of [4], as well as the solutions of the Mathieu equation. In these cases, the solution obtained by the partial discretization method and the Runge-Kutta method gives good agreement. The high accuracy of the solution is established. The discrepancies in the calculations, that is, the relative error, do not more than 0.01782.

Graphs of numerical results and calculation errors by various methods are given.

Thus, on separate examples the mechanism of the method application of partial discretization is demonstrated. The accuracy of the partial discretization method was evaluated by comparison with the 4th order Runge-Kutta method on the example of solving of the Mathieu equation using the Python programming language

This method can be applied to a wide class of problems in studying the nonlinear systems dynamics.

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TECHNOGENIC SEISMICITY OF THE SURROUNDING MEDIUM AND ITS MODELING IN DRILLING PROBLEMS

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Keywords: drill string, vibration, seismic waves, mathematical model, nonlinearity

An earthquake is one of the most unpredictable and destructive natural phenomena. About half of all densely populated regions of the Earth are subject to seismic activity; 10-15% of the entire surface can be classified as highly active seismic regions [1]. According to [2] 19% of entire Kazakhstan Republic's territory are counted as seismically active areas. Moreover 40% of whole population lives at these regions, as well as more than 30% of all production and industrial assets of the country are concentrated there. Among the industrial assets located at seismically active areas there are several oil and gas production facilities [2].

The aim of the work is to analyze the impact of technogenic seismicity on the drilling process, to derive a mathematical model of the drill string dynamics taking into account the impact of technogenic seismicity of the surrounding medium.

It is known that drilling of oil and gas producing wells is a complex and high-cost technological process associated with many complicated factors, such as the own weight of the drill string, contact interaction with the walls of the well and bottomhole, stochastic processes, structure heterogeneity of the drill string, etc. In addition to the above and widely represented in the literature complicated factors, the seismicity of the region can be attributed to them. The effect of tectonic instability on drill string dynamics is poorly studied, thus derivation of mathematical models precisely describing such cases is relevant and has scientific and practical interest.

The authors of this work carried out an analysis of the nature of the surrounding medium seismicity. It is noted that the causes of the movement of the Earth's surface can be not only natural, but also technogenic (man-made). The paper considers the main types of waves, reviews materials on the seismicity of the Kazakhstan's territory, observes the data to determine the energy of seismic waves. Based on the previously created nonlinear mathematical model of the vertical rotating drill string dynamics, considering the effect of gas and fluid flows [3-4], a new model has been derived that takes into account the impact of technogenic seismicity of the surrounding medium.

The influence of Rayleigh surface waves on drill string dynamic has been considered. Choice of the surface seismic waves is explained by the greatest danger of this type of waves since its propagation occurs due to the movement of the upper layers of the Earth's surface together with the buildings and underground non-deep structures as non-deep drilling wells located on them.

The mathematical model of drill string dynamics under the impact of the seismicity has been derived by using the Ostrogradsky-Hamilton principle [5]. According to the principle a variation of the difference between the kinetic and potential energies and the potential of external forces was calculated. Seismic energy has been added to the model through its inclusion to the potential of external forces.

The developed technique modeling the influence of seismicity on the drill string dynamics can be successfully applied in the future to the wide range of drill problems.

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OPTIMAL CHOICE OF IT INFRASTRUCTURE FOR EFFECTIVE INTERNAL COMMUNICATION IN THE COMPANY

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Keywords: IT, infrastructure, digital, enterprise, database, information system.

The development of sustainable digital infrastructures is of fundamental importance for ensuring the technological progress of any enterprise [1].

Currently, in order for employees to quickly and efficiently perform their duties and solve numerous business tasks, they need to be provided with a functional information system, since its operational activity itself depends entirely on the capabilities of the organization's IT infrastructure [2].

IT infrastructure can be produced exclusively within the framework of suitable infrastructure support. This term should be understood as the presence of a complex of closely related equipment, systems and communication channels. Such a complex combines separate software and hardware complexes, contributing to the formation of a common interaction environment for all its components. The capacity of the infrastructure support determines the functionality of the applied IT system in terms of processing and transmitting data through communication channels to the required extent. This is what can unite all participants in the data exchange into a common environment for all of them [3].

In order for corporate IT services to work smoothly and develop, they must function on the basis of a modern, flexible and adaptable IT infrastructure to the needs of the company. The same condition is necessary for the ability to effectively test and implement new business applications, observing the plans for the development of the information system in particular and the entire company as a whole. And as you know, the maturation of information technology in any enterprise is based on its business needs. They should be used in the analysis of the IP market for the subsequent selection of the optimal solution [3].

The study examines aspects of the development of digital infrastructure and the problems of its formation in organizations. The necessity of forming a stable and developed technological infrastructure as an important prerequisite for the formation and development of the company's digital infrastructure is substantiated. The most multifunctional computing resources are proposed to improve the process of ensuring the development of digital infrastructure.

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THE PROBLEM OF INTERNAL DIGITAL INFRASTRUCTURE IN THE COMPANY

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The development of sustainable digital infrastructures is important for ensuring the technological progress of any enterprise. Therefore, investments and innovations in digital infrastructure are essential for the global development of an advanced company.

Digital infrastructure includes physical resources to provide the ability to use data, computerized devices, methods, systems, and processes. Digital infrastructure is important for the functioning of not only individual enterprises, but also society as a whole [1].

An effective technological infrastructure is urgently needed to support optimally functioning organizations. Ensuring sustainable development of internal digital infrastructures expands the company's technological capabilities in business, thereby increasing their competitiveness.

Digital infrastructure is an important basis for ensuring digital transformation of organizations that want to expand the potential of new digital technologies. The digital infrastructure consists of technical and organizational components, processes, and networks. It covers the social environment of users of digital tools, as well as designers and developers of systems connected to the infrastructure. In modern scientific literature, digital infrastructure, in contrast to autonomous Information Systems, is conceptualized as the interconnection of various system groups, including software, hardware, standards, the internet, platforms and people [2].

Currently, no company can do without IT infrastructure, and even a small company needs servers or tools that integrate employees' computers into a common network to store databases. In the context of digital transformation, organizations are moving from local IT infrastructures to the use of cloud services. First of all, this is due to reduced risks, time costs, and cost optimization.

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PROJECT MANAGEMENT IN THE FIELD OF BIOTECHNOLOGY

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Keywords: Biotechnology, project management, biotechnology tasks, areas of biotechnology.

Biotechnology is one of the most important modern sciences. This is the science of technology and the use of biological processes in industrial production. It is known that its name comes from the Greek words: bios – life; teken-art; logos - word, teaching, science. Biological processes include substances that use biological objects of various nature (microbial, plant or animal), for example, the production of a number of medical, food and other products — antibiotics, vaccines, enzymes, feed and food proteins, polysaccharides, hormones, glycosides, amino acids, alkaloids, biogas, fertilizers and others [1].

Project management - management is an integral part of the discipline it uses part of its arsenal of tools, its language and basic definitions, and adds its own specific concepts. Project management helps you achieve your goals quickly and efficiently. In addition, in this process, a whole system of complexes is formed, which can be used for the general purposes of any project, and a competent resource allocation scheme is developed. Currently, project management is a whole science with a set of knowledge, rules and standards. The most popular resource is PMBOK. This is a kind of "Knowledge Book" in the field of Project Management, which describes the best practical advice and knowledge in this area [2].

The main prospects for the development of Biotechnology in Kazakhstan are related to the introduction of high-tech technologies into production and competitive products for healthcare, agriculture, and Environmental Protection. We should also mention the food and processing industry, mining and mineral processing (biogeotechnologies in the production of precious metals). These areas are included in the tasks of the National Center for Biotechnology, and there are successful developments in several types of them [3].

The purpose of the work is to analyze the field of biotechnology, project management and identify common features of IT project development. During the analysis of this work, the following information was revealed: the Government of Kazakhstan identified four areas as a priority for the development of biotechnology: pharmaceutical; agricultural; industrial; environmental.

For Kazakhstan, the development of Biotechnology has been identified as the most important scientific priority around the world.

There is a lot of information about the field of Biotechnology. However, this information has not been sufficiently collected and systematized, that is, it has been raised to the project level, and project management has not been mastered. In this case, you can see an unstructured field of knowledge. In this regard, the following needs arise: project management in the field of Biotechnology, data representation at the required level, search tools on a specific topic, management software. Such needs will be an indispensable tool and set of methods for specialists, researchers, and the field of knowledge. It leads to investment and development in the field of Biotechnology for private and state entrepreneurs.

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ИСПОЛЬЗОВАНИЕ АВТОНОМНОЙ НАВИГАЦИОННОЙ СИСТЕМЫ GPS И КОМПЬЮТЕРНОЕ ЗРЕНИЕ ДЛЯ СОВРЕМЕННОГО ДОРОЖНОГО ДВИЖЕНИЯ

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В данной статье рассматривается возможность совершенствования использования навигационных сервисов, и компьютерного зрения, с целью улучшения дорожного движения на перекрестках. Объектом исследования стали статьи указывающие на большой разрыв между фактическими потребностями в навигации и тем, что существует в настоящее время. Предметом исследования является реальные проблемы с регулированиям трафика на дорогах, о которых свидетельствует множество фактов.

По сути, навигационную систему можно рассматривать как сложный вычислительный механизм, облегчающий предоставление навигационных услуг[1]. Типичная навигационная система состоит из географической информации в виде карты, которая предлагает удобный формат чтения географических данных, часто в виде текста. Они также могут использовать различные формы датчиков и другие источники информации, собираемой различными способами.

Из всех форм навигационной системы глобальная система позиционирования (GPS) является наиболее распространенным способом среди глобальных пользователей. GPS использует механизм радионавигации, который предоставляет информацию о времени и географическом местоположении приемнику GPS из любой точки земли. Существуют различные причины для более широкого технического внедрения GPS, поскольку он полностью независим от любых данных, передаваемых пользователем, и может работать самостоятельно [2]. У него нет даже зависимости от приема Интернета или каких-либо телефонных услуг, чтобы функционировать, хотя использование этих услуг обеспечивает большую точность навигации.

Также были выявлены основные причины заторов в урбанизированных городах на примере города Алматы. Рассмотрены следствия таких заторов и к чему они приводят, и почему эти проблемы одни из главных в крупных городах Казахстана. Предложены варианты решения с использованием ИТС (Интеллектуальной транспортной системы).

Проанализировав насущные проблемы связанные с навигацией и регулировкой дорожного трафика, мы проследили основные отклонения в системах наблюдения и GPS навигации. Когда передача данных о дорожном трафике слишком долго доходила до серверов и имела слишком маленькую область применения. На основе этого был предложен новый вариант использование навигационных сервисов и компьютерного зрения для модификации управления дорожным трафиком.

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СЕКЦИЯ 3
Функциялар теориясы және функционалдық талдау

❖

СЕКЦИЯ 3
Теория функций и функциональный анализ

❖

SESSION 3
Function theory and functional analysis

DIRECT AND INVERSE APPROXIMATION THEOREMS FOR A FUNCTION OF TWO VARIABLES BY POLYNOMIALS IN THE WALSH SYSTEM IN SPACE $BVC_p[0,1)^2$ $1 < p < \infty$

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Keywords: Walsh polynomials, Fourier-Walsh series Walsh system.

In this paper, we present direct and inverse theorems of approximation of two variable functions, by polynomials in the Walsh system in space $BVC_p[0,1)^2$ $1 < p < \infty$.

We denote by $E^w_{m,n}(f)_{p,V}$ the best approximation of function $f \in BVC_p[0,1)^2$ by Walsh polynomials of degree at most (m,n) ($m,n \in N$) in the metric $BVC_p[0,1)^2$, $1 < p < \infty$

$$E_{m,n}(f)_{p,V} = \inf_{c_{ij}} \left\| f(x,y) - \sum_{i=0}^{m-1}\sum_{j=0}^{n-1} c_{ij} w_i(x) w_j(y) \right\|_{p,V}.$$

Denote by $S^w_n(f)$ the rectangular partial sum of double Fourier-Walsh series of function $f \in L_1$.

Theorem 1. Let $f \in BVC_p[0,1)^2$, $1 < p < \infty$, $m,n \in N$. Then holds

$$E^w_{m,n}(f)_{p,V} \le K_p \omega_{1-\frac{1}{p}}\left(f, \frac{1}{m}, \frac{1}{n}\right).$$

Theorem 2. Let $f \in BVC_p[0,1)^2$, $1 < p < \infty$, $m,n \in N$. Then holds

$$\omega_{1-\frac{1}{p}}\left(f, \frac{1}{m}, \frac{1}{n}\right) \le K_p E^w_{m,n}(f)_{p,V}.$$

Note that in the case of one variable functions corresponding results have been established by S.S. Volosivets.

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ON BOUNDED DIFFERENTIAL OPERATORS IN WEIGHTED SPACES OF POSITIVE SMOOTHNESS

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Keywords: differential operator, weighted spaces of differentiable functions.

The differential operator

$$L_0 f = \sum_{|\alpha|\le m} a_\alpha(x) D^\alpha f, \tag{1}$$

given in the class of finite functions $C_0^\infty(\Omega)$ are considered, Ω is an arbitrary domain in $\mathbb{R}^n$. The weighted spaces of potentials $H_p^t(\Omega;\rho,v_t)$, the weighted spaces of Besov of a new type $B_p^t(\Omega;\rho,v_t)(t>0, 1<p<\infty)$ are described in the paper. Sufficient and necessary conditions are obtained for the $a_\alpha(x)$ coefficients, under which there are limited continuations of

$$L: H_p^s(\Omega;\rho,v_s) \to H_p^t(\Omega;\rho,v_t)$$

or

$$L: B_p^s(\Omega;\rho,v_s) \to H_p^t(\Omega;\rho,v_t)$$

operators L_0.

To describe these conditions were used theorems on the limitation of multipliers acting in pairs of functional spaces

$$\left(H_p^s(\Omega;\rho,v_s), H_p^t(\Omega;\rho,v_t)\right), \left(B_p^s(\Omega;\rho,v_s), H_p^t(\Omega;\rho,v_t)\right), 1<p<\infty, 0<t<s.$$

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ON ESTIMATES OF S-NUMBERS OF ONE SINGULAR SECTORIAL DIFFERENTIAL OPERATOR

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Keywords: sectorial differential operator, s-numbers, a function of length, closed sectorial extension.

In our work the sectorial operator L_0 generated in the Hilbert space $L_2(\Omega)$ by the singular differential expression

$$lu = \sum_{k=1}^{n} \mathcal{D}_k^{l_k}\left(\rho_k(x)\mathcal{D}_k^{l_k}u\right) + \omega(x)u, u \in C_0^{\infty}(\Omega),$$

was considered, here $\mathcal{D}_k = \partial/\partial x_k, \Omega$ - arbitrary n-dimensional domain, under the following assumptions: $l_k \geq 1 (1 \leq k \leq n), \varkappa = \sum_{k=1}^{n} l_k^{-1} < 2; \omega(x) = \omega_0(x) + i\omega_1(x) (i = \sqrt{-1}), \omega_0, \omega_1 \in L_{loc}(\Omega), \rho_k \in L_{2,loc}(\Omega)$, $\rho_k > 0, \inf_{\Omega} \omega_0 > 0$

Let's put $\bar{\rho} = (\rho_1, \rho_2, \dots, \rho_n), Q(x,h) = \{y \in \mathbb{R}^n : |y_k - x_k| \leq (\rho_k(x)h)^{1/l_k}/2, 1 \leq k \leq n\}$,

$$M_{(\delta)}(x,h;\bar{\rho},\omega_0) = h|Q(x,h)|^{-1/2} \inf_{\{e\}_\delta} \left(\int_{Q(x,h)\setminus e} \omega_0 dy\right)^{1/2}.$$

In (2) $0 < \delta < 1$, inf is taken over the set $e \subset Q(x,h)$ such that the Lebesgue measure $|e| \leq \delta|Q(x,h)|$.

A positive and bounded function $h(x)$ in Ω will be called a function of length in Ω with respect to the pair $(\bar{\rho}, \omega_0)$ if the following conditions are met:

1 $Q(x, h(x)) \subset \Omega, x \in \Omega$,

2 there are $0 < \delta < 1, 0 < \varepsilon < 1$, that $M_{(\delta)}(x, \varepsilon h(x); \bar{\rho}, \omega_0) \geq 1$ in Ω.

The notation $(\bar{\rho}, \omega_0) \in \pi$ will mean that for the pair $(\bar{\rho}, \omega_0)$ there is a function of length $h(x)$ in Ω. The class of functions $\omega_0, \rho_k (1 \leq k \leq n)$ for which $(\bar{\rho}, \omega_0) \in \pi$ is wide enough.

For pairs $(\bar{\rho}, \omega_0) \in \pi$ conditions are formulated under which L_0 has a closed sectorial extension L with a completely continuous inverse operator L^{-1}. Two-sided estimates for the s-numbers of the operator L are obtained.

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ИНТЕРПОЛЯЦИЯ НЕЛИНЕЙНЫХ ОПЕРАТОРОВ

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Пусть (V,ν), (U,μ) измеримые пространства и $Z(U), M(V)$ нормированные пространства ν-измеримых и μ-измеримых функций, соответственно. Пусть $K:\mathbb{R}\times U\times V\to\mathbb{R}$, и оператор $T:Z(U)\to M(V)$ определен следующим равенством: для любых $f\in Z(U)$

$$T(f,y)=\int_U K(f(x),x,y)d\mu,\ y\in V$$

и предположим, что этот интеграл существует и конечен для почти всех $y\in V$. Данный оператор называется интегральным оператором Урысона.

Хорошо известно, что одним из достоинств метода вещественной интерполяции, основанного на свойствах введенного Петре К-функционала, является возможность перенесения основных результатов этого метода, установленных в линейном случае, на некоторые классы нелинейных операторов, например, на класс липшицевых или гельдеровых операторов , т.е. накладывалось условие вида:

$$\| Tf-Tg \|_Y\leq C\ \| f-g \|_X^{\alpha}.$$

Заметим, что оператор Урысона, вообще говоря, не является квазилинейным оператором или гельдеровым оператором, поэтому соответствующие интерполяционные теоремы не применимы к этому оператору.

В данной работе получены интерполяционные теоремы Марцинкевича, Кальдерона и Стейна-Вейса для широкого класса нелинейных операторов. Данные теоремы применимы для ρ-однородных операторов, при $0<\rho<\infty$. Построен интерполяционный метод, охватывающий операторы типа Урысона. В частности, получены следующие утверждения.

Теорема 1. Пусть $\rho>0,1<p_0<p_1<\infty,1\leq q_0,q_1<\infty,q_0\neq q_1,0<\sigma\leq\tau\leq\infty,0<\theta<1$ и

$$\frac{1}{p}=\frac{1-\theta}{p_0}+\frac{\theta}{p_1},\frac{1}{q}=\frac{1-\theta}{q_0}+\frac{\theta}{q_1}.$$

Пусть T оператор Урысона.

Если для некоторых $M_1,M_2>0$ следующие неравенства имеют место

$$\| T(f)-T(0) \|^{\rho}_{L_{q_i,\infty}(V,\nu)}\leq M_i\ \| f \|_{L_{p_i,\sigma}(U,\mu)},\ i=0,1,$$

тогда

$$\| T(f)-T(0) \|^{\rho}_{L_{q,\tau}(V,\nu)}\leq cM_0^{1-\theta}M_1^{\theta}\ \| f \|_{L_{p,\tau}(U,\mu)},$$

где c >0 зависит только от параметров $p_0,p_1,q_0,q_1,\sigma,\tau,\theta$.

Теорема 2. Пусть $0<p_0<p_1<\infty,0<q_0,q_1<\infty,q_0\neq q_1\ 0<\theta<1u$

$$p=(1-\theta)p_0+\theta p_1,\ q=(1-\theta)q_0+\theta q_1.$$

Если T оператор Урысона и для некоторых $M_1,M_2>0$ иметот место неравенства

$\int_V(v_i(y)|T(f,y)-T(0,y)|)^{q_i}d\nu\leq M_i\int_U(w_i(x)|f(x)|)^{p_i}d\mu,\ f\in L_{p_i}(U,w_i,\mu)\ i=0,1,$ mo

$$\| T(f)-T(0) \|^{q}_{L_q\left(V,v_0^{1-\theta}v_1^{\theta},\nu\right)}\leq cM_0^{1-\theta}M_1^{\theta}\ \| f \|^{p}_{L_p\left(U,w_0^{1-\theta}w_1^{\theta},\mu\right)},$$

где c >0 зависит только от $p_0,p_1u\theta$.

Работа выполнена при поддержке Министерства образования и науки Республики Казахстан, грант AP08856479.

О СИСТЕМЕ КОРНЕВЫХ ВЕКТОРОВ ВОЗМУЩЕННОГО РЕГУЛЯРНОГО ДИФФЕРЕНЦИАЛЬНОГО ОПЕРАТОРА ВТОРОГО ПОРЯДКА, НЕ ОБЛАДАЮЩЕГО СВОЙСТВОМ БАЗИСНОСТИ

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Ключевые слова: Дифференциальный оператор второго порядка, интегральное возмущение краевых условий, базисность, корневые векторы, система собственных функций, собственное значение, характеристический определитель, нагруженный дифференциальный оператор, сопряженный оператор.

В статье рассматривается спектральная задача для оператора кратного дифференцирования при интегральном возмущении краевых условий одного типа, являющихся регулярными, но не усиленно регулярными. Ядром интегрального возмущения является функция $p(x) \in L_2(0,1)$. Особенностью рассматриваемой задачи является отсутствие свойства базисности у системы собственных функций невозмущенной задачи. Построен характеристический определитель спектральной задачи. Доказано, что множество функций $p(x)$, для которых система собственных функций возмущенной задачи (1),(4) не образует безусловного базиса в $L_2(0,1)$, является плотным в $L_2(0,1)$. Показано, что сопряженный оператор имеет аналогичную структуру.

Работа выполнена при финансовой поддержке КН МОН РК (грант № AP09260752).

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СЕКЦИЯ 4
Дифференциалдық теңдеулер және басқару теориясы

❖

СЕКЦИЯ 4
Дифференциальные уравнения и теория управления

❖

SESSION 4
Differential equations and control theory

IRSTI 27.25.19

ESTIMATES FOR TRIGONOMETRIC WIDTHS OF THE NIKOL'SKII-BESOV CLASS IN THE ANISOTROPIC LORENTZ-ZYGMUND SPACE

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Keywords: Lorentz-Zygmund space, Nikol'skii-Besov class, trigonometric widths.

Let $\bar{p} = (p_1, \dots p_m)$, $\bar{\tau} = (\tau_1, \dots \tau_m), \bar{\alpha} = (\alpha_1, \dots \alpha_m)$ and $p_j, \tau_j \in (1, \infty), \alpha_j \in \mathbb{R}, j = 1, \dots, m$. We denote by $L^*_{\bar{p},\bar{\alpha},\bar{\tau}}(\mathbb{T}^m)$ the anisotropic Lorentz-Zygmund space of all Lebesgue measurable functions of m variables having a 2π period for each variable with the norm $||f||^*_{\bar{p},\bar{\alpha},\bar{\tau}}$ (see [1], [2], [3]).

We consider an analog of the Nikol'skii-Besov class $S^{\bar{r}}_{\bar{p},\bar{\alpha},\bar{\tau},\bar{\theta}}B$ in the anisotropic Lorentz-Zygmund space (see [3]).

The report presents estimates of trigonometric widths of Nikol'skii-Besov class $S^{\bar{r}}_{\bar{p},\bar{\alpha},\bar{\tau}^{(1)},\bar{\theta}}B$ in the Lorentz-Zygmund space $L^*_{\bar{q},\bar{\beta},\bar{\tau}^{(2)}}(\mathbb{T}^m)$ for different relations between the parameters. In particular, for $\tau_j^{(1)} = p_j = p$, $\tau_j^{(2)} = q_j = q$, $\theta_j = \theta$ for $j = 1, \dots, m$ and $\bar{\alpha} = \bar{\beta} = (0, \dots, 0)$ from the proved statements we obtain the well-known results of E.S. Belinskii, V.N. Temlyakov, A.S. Romanyuk (see bibliography in [4]) .

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AN INITIAL BOUNDARY VALUE PROBLEM FOR A PSEUDOPARABOLIC EQUATION WITH A NONLINEAR BOUNDARY CONDITION

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Keywords: Pseudoparabolic equations, nonlinear boundary conditions, Galerkin method, the existence of a solution, uniqueness of the solution, blow-up of the solution.

An initial-boundary value problem for a quasilinear equation of pseudoparabolic type with a nonlinear boundary condition of the Neumann- Dirichlet type is investigated. By the Galerkin methods to prove the existence of a weak solution. On the basis of a priori estimates, we prove a local existence theorem and uniqueness for a weak generalized solution of the initial-boundary value problem. A special place in the theory of nonlinear equations is occupied by the study of unbounded solutions, or, as they are called in another way, blow-up regimes. Nonlinear evolutionary problems admitting unbounded solutions are globally unsolvable. In this work, sufficient conditions for the blow-up of a solution in a finite time in a limited area with a nonlinear Neumann- Dirichlet boundary condition are obtained. A large number of works are devoted to the study of nonlinear equations of pseudoparabolic type [1]-[6].

Formulation of a problem. We consider the cuasilinear equation

$$\frac{\partial}{\partial t}(u-\chi\Delta u)-\left(a_0+a_1\|\nabla u\|_{2,\Omega}^{2q-2}\right)\Delta u=b(x,t)|u|^{p-2}u+f(x,t),\ (x,t)\in Q_T \tag{1}$$

with the nonlinear boundary

$$\frac{\partial u}{\partial n}+k(x,t)|u|^{\sigma-2}u|_{\Gamma}=0,\Gamma=\partial\Omega\times(0,T) \tag{2}$$

and with the initial conditions

$$u(x,0)=u_0(x),\ x\in\Omega \tag{3}$$

Here $Q_T=\{(x,t)\colon x\in\Omega,\Omega\subset R^n,0<\mathrm{t}<\mathrm{T}\}$ is a cylinder, $\Omega\subset R^n,n\geq 3$ is a bounded domain, with a sufficiently smooth boundary Ω , so p,q,a_0,a_1 and σ are positive constants. The functions $b(x,t),f(x,t),k(x,t)$ and $u_0(x)$ satisfy the following conditions:

$$0<b_0\leq b(x,t)\leq\ b_1<\infty,0<b_t(x,t)\leq\ b_1<\infty,\qquad\forall(x,t)\in Q_T;$$

$$0<k_0\leq k(x,t)\leq\ k_1<\infty,0\leq\frac{k_t(x,t)}{k(x,t)}\leq\ K_1,\frac{|k_{tt}(x,t)|}{k(x,t)}\ \leq\ K_2,\qquad\forall(x,t)\in Q_T;$$

$$\|f(x,t)\|_{2,\Omega}^2\leq\ C_0,\forall t\in[0,T],u_0(x)\in W_2^1(\Omega).$$

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HOMOGENIZATION OF ATTRACTORS FOR GINZBURG–LANDAU EQUATIONS IN PERFORATED DOMAIN

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We consider the complex Ginzburg–Landau equation with rapidly oscillating terms inthe equation and boundary condition, set in a bounded domain with periodic obstacles. On the boundary of obstacles we assume the Robin condition and on the outer boundary

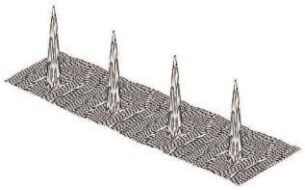

Figure 1: Attractors of the Ginzburg–Landau equation.

the Dirichlet condition to be set. We prove that the trajectory attractors of this problem (see Figure) converge in a weak topology to the attractors of the homogenized problem for the Ginzburg–Landau equation with an additional potential. Moreover we prove the existence of the respective trajectory attractors. Similar problems see in [1].

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HOMOGENIZATION OF ATTRACTORS FOR NAVIER-STOCKES SYSTEM IN PERFORATED DOMAIN

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We consider 2D Navier–Stockes system with rapidly oscillating terms in the equationsand boundary conditions, set in a bounded domain with periodic obstacles (see Figure) On the boundary of obstacles we assume the Robin condition and on the outer boundary

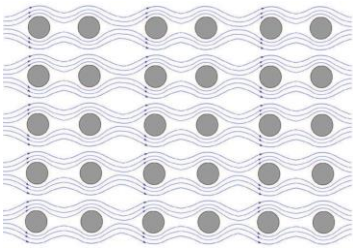

Figure 1 - 2D model of a fluid in a medium with small periodic obstacles.

the Dirichlet condition to be set. We prove that the trajectory attractors of this problem converge in a weak topology to the attractors of the homogenized problem for the Navier– Stockes system with an additional potential. Moreover we prove the existence of the respective trajectory attractors. Similar problems see in [1].

BKA was supported by Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan (grant AP08855579). CGA was supported in part by RSF (project 20-112027

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HOMOGENIZATION OF TRAJECTORY ATTRACTORS FOR REACTION-DIffUSION SYSTEMS IN DOMAINS WITH OBSTACLES

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Keywords: four-component fluid, mixtures separation, Cahn-Hilliard equation, free energy, lattice Boltzmann equations method.

We consider reaction-diffusion systems in perforated domains that contain rapidly os- cillating terms in the boundary conditions and in the equations. In the problems under study, a small parameter ε characterizes the diameter of perforation holes and the oscil- lation rate of coefficients. We do not assume any Lipschitz condition for the nonlinear functions in the equations, so, the uniqueness theorem for the corresponding initial bound- ary value problem may not hold for the considered reaction-diffusion systems. We study the asymptotic behavior of trajectory attractors of the considered inital-boundary value problem as $\varepsilon \to 0+$. We apply homogenization methods and the theory of trajectory attractors.

Attractors describe the behavior of solutions to dissipative nonlinear evolution equa- tions as the time tends to infinity. Attractors show the most important limit objects of the dynamical systems, that is, sets of trajectories characterizing the entire dynamics of the model governed by evolution equations.

We prove that the trajectory attractor of the considered reaction-diffusion system in a perforated domain converge as $\varepsilon \to 0+$, to the trajectory attractor of the corresponding homogenized reaction-diffusion system with an additional “strange term” (potential). For similar results see [1].

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COMPACTNESS OF THE COMMUTATOR FOR THE BILINEAR RIESZ POTENTIAL IN GENERALIZED MORREY SPACES.

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Keywords: generalized Morrey spaces, bilinear Riesz potential, compact, commutator.

In this paper, we give sufficient conditions for the commutator of the bilinear Riesz potential to be compact in generalized Morrey spaces.

Let $1 \le p \le \infty$ and w a non-negative measurable function on (0, ∞). We denote by $M_p^w \equiv M_p^w\left(R^n\right)$ the generalized Morrey space, as of all functions $f \in L_p^{loc}\left(R^n\right)$ with finite quasinorm $\|f\|_{M_p^w} \equiv \sup_{x\in R^n} \left\| w(r)\|f\|_{L_p(B(x,r))} \right\|_{L_\infty(0,\infty)}$, where $B(x, r)$ denotes the ball centered at x and with radius r.

The space $M_p^w\left(R^n\right)$ coincides with Morrey space M_p^λ when $w(r) = r^{-\lambda}$, with $0 \le \lambda \le n/p$, [1]. Suppose that the continuous increasing functions w_1, w_2 in [0; ∞) satisfy the following conditions (j = 1, 2):

a) w_j (0) = 0; b) $\lim_{r\to\infty} \mathrm{wj}\ (\mathrm{r}) = \infty$; c) There exists a constant D, satisfying $1 \le D < 2^n$, such that w_j $(2r) \le Dw_j$ (r) for any r>0; d) $(\mathrm{w(r)})^{1/p} = w_1^{1/p_1}(r)w_2^{1/p_2}(\mathrm{r})$.

For α $(0 < \alpha < 2n)$, let us consider bilinear Riesz potential Iα defined by

$$\mathrm{I\alpha(f,g)(x)} = \iint_{\mathrm{Rn}} \frac{\mathrm{f(y)g(z)dydz}}{(|\mathrm{x-y}| + |\mathrm{x-z}|)^{2\mathrm{n}-\alpha}}.$$

I

The commutator of Riesz potential I_α defined by

$$[\mathrm{I}_\alpha, \mathrm{b}](\mathrm{f,g})(\mathrm{x}) = \iint_{\mathrm{Rn}} \frac{(\mathrm{b(x)-b(y))f(y)g(z)\ dydz}}{(|\mathrm{x-y}|+|\mathrm{x-z}|)^{2\mathrm{n}-\alpha}}$$

The commutator $[\mathrm{I}_\alpha, \mathrm{b}]$ were discussed by some authors, see [1]-[2].

Theorem 1. For $1 < \mathrm{p} < \infty$, $1 < p_1, p_2 < \infty$ $1/p = 1/p_1 + 1/p_{2_1}$.

Suppose w_1, w_2 satisfy the conditions a)-d) and $b \in VMO(\mathrm{R}^n)$. Then Iα(f, g)] is a compact bilinear operator from $M_{p_1}^{w_1} \times M_{p_2}^{w_2}$ to M_p^w,

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THE PERSISTENCE PROPERTY FOR SOLUTIONS OF THE K-GENERALIZED KORTEWEG-DE VRIES EQUATION WITH K=3 IN WEIGHTED SOBOLEV SPACES

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Keywords: Korteweg-de Vries equation, local well-posedness, weighted Sobolev space.

We study the initial value problem for the k-generalized Korteweg-de Vries equation (k-gKdV)

$$\begin{cases} \partial_t u + \partial_x^3 u + \partial_x(u^{k+1}) = 0, & x,t \in \mathbb{R}, \\ u(x,0) = u_0(x), & x,t \in \mathbb{R}, \end{cases} \tag{1}$$

where $u = u(x,t)$ is a complex valued function. Equation (1) contains, for certain choices of the parameters, well-known equations of great relevance, for example, in quantum mechanics or water waves.

Motivated by the seminal work of T. Kato [5], the solvability of many dispersive nonlinear equations has been studied in weighted Sobolev spaces in $H^s(R) \cap L^2(|x|^{2m}dx)$, aiming to control better the decay at infinity of the solutions (see for example [1,2,3,4,8] and the references therein). In particular, for the mKdV and the k-gKdV, for $k = 4$ optimal results in this context were obtained by J. Nahas [7]. Moreover, A. Munoz-Garcia [6] established the local well-posedness of the KdV for with $s > 3/4$ in weighted Sobolev spaces. We continue these investigations for the k-generalized KdV with $k = 3$.

We apply the contraction mapping principle to the integral equation version of the IVP (1) with $k = 3$, i.e.

$$u(x,t) = e^{-it\partial_x^3}u_0 - \int_0^t e^{-i(t-\tau)\partial_x^3}\,\partial_x(u^4)d\tau, \tag{2}$$

where $e^{-it\partial_x^3}$ is the Airy semigroup. We are interested in establishing the best index s for which equation (2) has local well-posedness in $H^s(R) \cap L^2(|x|^{2m}dx)$ with $m \in [0,1/6]$.

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ON THE CONNECTION OF DEGENERATE SECOND-ORDER HYPERGEOMETRIC SYSTEMS WITH ADMISSIBLE EQUATIONS

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Keywords: hypergeometric functions, Laguerre systems, admissible equations

The theory of polynomials of two or more variables orthogonal in a domain with arbitrary weight has been greatly developed in the works of D. Jackson, G.Krall and I.Scheffer, G.Engelis and others. They considered some two-dimensional analogues of classical orthogonal polynomials, which are solutions of linear partial differential equations of the second order. Such equations are called admissible.

This paper is devoted to the study of the connection of some degenerate hypergeometric systems with admissible equations with solutions in the form of Laguerre polynomials of many variables. A number of theorems are proved.

Theorem 1. A linear partial differential equation of the second order

$$x_1 Z_{x_1x_1} + x_2 Z_{x_2x_2} + (\alpha_1 + 1 - 2x_1) Z_{x_1} + (2x_2 + \alpha_2 + 1) Z_{x_2} = 2nZ, \tag{1}$$

obtained by adding two equations of a degenerate hypergeometric system

$$\begin{aligned} &x_1 Z_{x_1x_1} + (\alpha_1 + 1 - x_1) Z_{x_1} - x_2 Z_{x_2} + nZ = 0, \\ &x_2 Z_{x_2x_2} + (\alpha_2 + 1 - x_2) Z_{x_2} - x_1 Z_{x_1} + nZ = 0 \end{aligned} \tag{2}$$

refers to the tenth normal form of an acceptable equation

$$x_1 Z_{x_1x_1} + x_2 Z_{x_2x_2} + (Bx_1 + d_{00}) Z_{x_1} + (Bx_2 + g_{00}) Z_{x_2} = nBZ, \tag{3}$$

with a solution in the form of a generalized Laguerre polynomial of two variables

$$L_{n,n}^{(\alpha_1,\alpha_2)}(x_1, x_2) = \Psi_2(-n; \alpha_1 + 1, \alpha_2 + 1; x_1, x_2) \sum_{m_1,m_2=0}^{n} \frac{(-n)_{m_1+m_2}}{(\alpha_1+1)_{m_1} (\alpha_2+1)_{m_2}} \frac{x_1^{m_1}}{m_1!} \frac{x_2^{m_2}}{m_2!}.$$

Indeed, if we accept $B = -2,\ d_{0,0} = \alpha_1 + 1,\ g_{0,0} = \alpha_2 + 1$, then equation (1) will be represented as (3). This equation is called the Laguerre-Laguerre equation.

Theorem 1 can be generalized to the case of a degenerate Laguerre type system consisting of three equations

$$x_j F_{x_jx_j} + (1 + \alpha_j - x_j) F_{x_j} - \sum_{(k \neq j)} x_k F_k + nF = 0, \quad j = \overline{1,3}. \tag{4}$$

Theorem 2. A linear partial differential equation of the second order

$$x_1 F_{x_1x_1} + x_2 F_{x_2x_2} + x_3 F_{x_3x_3} + (\alpha_1 + 1 - 3x_1) F_{x_1} + (\alpha_2 + 1 - 3x_2) F_{x_2} + (\alpha_3 + 1 - 3x_3) F_{x_3} = 3nF \tag{5}$$

obtained by adding three equations of the system (4), refers to the tenth normal form of the admissible equation (5) with a solution in the form of a generalized Laguerre polynomial of three variables

$$\begin{aligned} L_{n,n,n}^{(\alpha_1,\alpha_2,\alpha_3)}(x_1, x_2, x_3) &= \Psi_2(-n; \alpha_1 + 1, \alpha_2 + 1, \alpha_3 + 1; x_1, x_2, x_3) = \\ &= \sum_{m_1,m_2,m_3=0}^{n} \frac{(-n)_{m_1+m_2+m_3}}{(\alpha_1+1)_{m_1} (\alpha_2+1)_{m_2} (\alpha_3+1)_{m_3}} \frac{x_1^{m_1}}{m_1!} \frac{x_2^{m_2}}{m_2!} \frac{x_1^{m_3}}{m_3!}. \end{aligned}$$

However, the theory of normal forms of admissible equations requires additional research.

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ON INVERSE PROBLEMS FOR A 2-D SYSTEM OF NAVIER-STOKES

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Keywords: Navier-Stokes equations, inverse problem, numerical solution

Let $\Omega = \{|y| < 1\} \subset R^2$ be an open bounded domain with boundary $\partial\Omega$, $Q_{yt} = \Omega \times (0,T)$, $\Sigma_{yt} = \partial\Omega \times (0,T)$. The following inverse problem of determining functions $\{w(y,t), P(y,t), f(y)\}$ is considered:

$$\partial_t w - \nu\Delta w = g(t)f(y) - \nabla P, \qquad (y,t) \in Q_{yt}, \tag{1}$$

$$\operatorname{div} w = 0, \qquad (y,t) \in Q_{yt}, \tag{2}$$

$$w(y,t) = 0, \qquad (y,t) \in \Sigma_{yt}, \qquad w(y,0) = 0, \qquad y \in \Omega, \tag{3}$$

with overdetermination condition:

$$w(y,T) = w_T(y), \tag{4}$$

where $g(t) = \{g_1(t), g_2(t)\}$ and $w_T(y) = \{w_{T1}(y), w_{T2}(y)\}$ are given functions.

For a biharmonic operator in a circle, a generalized spectral problem has been posed. For the latter, a system of eigenfunctions and eigenvalues is constructed, which is used in the report for the numerical solution of the inverse problem in a circular cylinder with specific numerical data. Graphs illustrating the results of calculations are presented.

Some of our results are published in [1]. The report discusses the develop- ment of the obtained results for the nonlinear 2-D system of Navier-Stokes.

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CRITERION FOR MINIMALITY OF THE LAPLACE OPERATOR

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Keywords: minimal operator, maximal operator, Cauchy problem, regular boundary value problem.

This work is devoted to finding a necessary and sufficient condition for the solvability of the overdetermined Cauchy problem, i.e. the Cauchy entire boundary condition for the multidimensional Laplace equation. The proof of the statement is based on the representation of the boundary conditions of the Newtonian (volumetric) potential of the multidimensional Laplace equation, obtained in the work of Kalmenov T.Sh. Suragan D. [1]. It should be noted that in the two-dimensional case, the generating function for the harmonic functions was also found.

In the work of Vishik M. [2], Otelbaev M. [3], Kalmenov T.Sh. [4], by using the solution of the overdetermined Cauchy problem, a description of all regular boundary value problems for the Laplace equation and for other differential equations is given.

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ON FREDHOLM PROPERTY AND ON THE INDEX OF THE GENERALIZED NEUMANN PROBLEM FOR AN ELLIPTIC EQUATION OF HIGH ORDER ON A PLANE

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Keywords: high order elliptic equations, boundary value problem, normal derivatives, Fredholm solvability of the problem, formula for problem index.

For an elliptic operator of order $2l$ with constant (and only leading) real coefficients, we consider a boundary value problem in which the normal derivatives of $(k_j - 1)$, $j = 1,...,l$, where $1 \le k_1 < ... < k_l$ are specified. It becomes the Dirichlet problem for $k_j = j$ and the Neumann problem for $k_j = j + 1$. We obtain a sufficient condition for the Fredholm property of which problem and derive an index formula.

In simply connected region *D* in the plane bounded by the simple smoothcontour Γ, we consider the elliptic equation

$$\sum_{r=0}^{2l} a_r \frac{\partial^{2l} u}{\partial x^{2l-r} u \partial y^r} + \sum_{0 \le r \le k \le 2l-1} a_{rk}(x,y) \frac{\partial^k u}{\partial x^{k-r} u \partial y^r} = f(x,y), \quad (x,y) \in D \qquad (1)$$

with real coefficients $a_r \in R$ and $a_{rk} \in C^{\mu}(\overline{D})$, $\Gamma = \partial D \in C^{2l,\mu}$, $0 < \mu < 1$.

Problem S. The generalized Neumann problem consists in finding thesolution $u(x,y)$ of equation (1) in the domain D by boundary conditions

$$\left. \frac{\partial^{k_j - 1} u}{\partial n^{k_j - 1}} \right|_{\Gamma} = g_j, \quad j = 1,...,l, \qquad (2)$$

where $1 \le k_1 < k_2 < ... < k_l \le 2l$ and $n = n_1 + in_2$ — the unit externalnormal.

For a polyharmonic equation, this problem was studied by A.V. Bitsadze [1]. Another version of the Neumann problem, based on the variational principle, was previously proposed by A.A. Desin [2]. In [3], problem (1), (2) was investigated for $a_{kr} \ne 0$ and $f \ne 0$ in the space of functions $C_a^{2l-1,\mu}(\overline{D})$.

The report established: a sufficient condition for the Fredholm property of problem (1), (2); equivalence of the Fredholm condition of the problem tothe complementarity condition (or Shapiro–Lopatinsky) [4]. A formula for the index of the problem find S is calculated.

The condition of Fredholm property of various problems for equations of the fourth and sixth orders is established in detail, and formulas for the indices of the corresponding problems are described in explicit form.

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ON A BOUNDARY VALUE PROBLEM WITH THE FRACTIONAL LOAD AS A CONFORMABLE FRACTIONAL DERIVATIVE

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Keywords: loaded equation, conformable fractional derivative, integral equation.

In the domain $Q = \{(x,t) \mid x > 0,\ t > 0\}$ find a solution to a problem:

$$u_t - u_{xx} + \{T_{\alpha,t}u(x,t)\}\big|_{x=\gamma(t)} = f(x,t), \tag{1}$$

$$u|_{t=0} = 0, u|_{x=0} = 0, \tag{2}$$

where

$$T_{\alpha,t}u(x,t) = t^{1-\alpha}u_t(x,t)$$

is a conformable fractional derivative of the order $\alpha, 0 < \alpha \le 1$, [1] $\gamma(t)$ is a continuous increasing function, $\gamma(0) = 0$,

$$f(x,t) \in L_\infty(A) \cap C(B), \tag{3}$$

where $A = \{(x,t) \mid x > 0, t \in [0,T]\}, B = \{(x,t) \mid x > 0, t \ge 0\}, T - \text{const} > 0$.

We invert the differential part of problem (1)-(2) by formula [2]

$$u(x,t) = -\int_0^t \int_0^\infty G(x,\xi,t-\tau)\{T_{\alpha,t}u(x,t)\}\Big|_{x=\gamma(t)} d\xi d\tau + \\ + \int_0^t \int_0^\infty G(x,\xi,t-\tau)f(\xi,\tau)d\xi d\tau, \tag{5}$$

where

$$G(x,\xi,t) = \frac{1}{2\sqrt{\pi t}}\left\{\exp\left(-\frac{(x-\xi)^2}{4t}\right) - \exp\left(-\frac{(x+\xi)^2}{4t}\right)\right\}.$$

We take into account relation

$$\int_0^\infty G(x,\xi,t-\tau)d\xi = \operatorname{erf}\left(\frac{x}{2\sqrt{t-\tau}}\right)$$

and introduce the notation

$$\mu(t) = \{T_{\alpha,t}u(x,t)\}\big|_{x=\gamma(t)} \tag{6}$$

and

$$f_1(x,t) = \int_0^t \int_0^\infty G(x,\xi,t-\tau)f(\xi,\tau)d\tau. \tag{7}$$

From (4) we take the conformable fractional derivative of the order $\alpha, 0 < \alpha \le 1$, with respect to the variables t on both sides and put $x = \gamma(t)$. On the left side, we get the function $\mu(t)$ by virtue of the notation (6). We also introduce the notation according to formula (6)

$$f_2(t) = T_{\alpha,t}f_1(x,t)\big|_{x=\gamma(t)}.$$

After that we obtain the integral equation:

$$\mu(t) - \int_0^t K_\alpha(t,\tau)\mu(\tau)d\tau = f_\alpha(t), \tag{22}$$

with the right-hand side $f_2(t)$, defined by formula (15), and the kernel

$$K_\alpha(t,\tau) = \frac{t^{1-\alpha}\gamma(t)}{2\sqrt{\pi}(1+t^{1-\alpha})(t-\tau)^{\frac{3}{2}}}\exp\left(-\frac{\gamma^2(t)}{4(t-\tau)}\right), \tag{23}$$

$$f_\alpha(t) = \frac{f_2(t)}{1+t^{1-\alpha}} \tag{15}$$

Let $\gamma(t) \sim t^\omega$ in the neighborhood of $t = 0$ and $\omega \ge 0$. The following theorem is proven

Theorem. Integral equation (22) with kernel (23) for $0 < \alpha \le 1$ and with $\gamma(t) \sim t^\omega$ in the neighborhood of $t = 0$ is uniquely solvable in the class of continuous functions $C([0;T])$ for any continuous right-hand side $f_\alpha(t) \in C([0;T])$ defined by formula (15), and, if $1 - \alpha - 2\omega > 0$ when $0 < \alpha \le 1$ then the kernel is bounded at $t \in [0,T]$.

It is shown that for values parameters α, ω not under the conditions of the theorem, $\left(\omega = \frac{1}{2}, \alpha = 1\right)$ the function $\mu(t) = t^\beta$ is an eigenfunction for Integral equation (22), where the parameter β is a solution to the equation:

$$\frac{1}{4\sqrt{\pi}}e^{1/8}\Gamma(\beta+1)W_{-\beta-\frac{1}{4},-\frac{1}{4}}\left(\frac{1}{4}\right) = 1,$$

where $W_{a,b}(z)$ is the Whittaker function [3].

In [3], [4] it is also shown that the existence and uniqueness of solutions to the integral equation depends on the order of the fractional derivative in the loaded term and on the nature of the load behavior.

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COMPACTNESS, ESTIMATES FOR THE EIGENVALUES AND SINGULAR NUMBERS (S-NUMBERS) OF A RESOLVENT OF A CLASS OF SINGULAR PARABOLIC OPERATORS

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Keywords: parabolic type operator, an eigenvalues, a singular numbers, separability, an unbounded domain.

In this paper we study the singular parabolic operator

$$Lu = \frac{\partial u}{\partial t} - \frac{\partial^2 u}{\partial x^2} + q(x)u$$

initially defined on $C_{0,\pi}^{\infty}(\bar{\Omega})$where $\bar{\Omega} = \{(t,x): -\pi \le t \le \pi, -\infty < x < \infty\}$. $C_{0,\pi}^{\infty}(\bar{\Omega})$is the set, which consist of infinitely differentiable finite functions with respect to the x and satisfying the condition

$$u(-\pi, x) = u(\pi, x).$$

We assume that the coefficients of L are continuous functions in $R = (-\infty, \infty)$and a strongly growing functions at infinity.

The operator L admits closure in $L_2(\Omega)$and the closure we also denote by L.

In the paper, we have proved that there exists a bounded inverse operator and found a condition on $q(x)$that ensures the existence of the estimate, i.e. separability of the operator L

$$\| \frac{\partial u}{\partial t} \|_{L_2(\Omega)} + \| \frac{\partial^2 u}{\partial x^2} \|_{L_2(\Omega)} + \| q(x)u \|_{L_2(\Omega)} \le c(\| Lu \|_{L_2(\Omega)} + \| u \|_{L_2(\Omega)}),$$

where $c > 0$is any constant.

Example. Let $q(x) = e^{1000|x|}, -\infty < x < \infty$. Then the operator L is seperability.

In addition, we prove the compactness of the resolvent, obtain two-sided estimates for the distribution function of singular numbers, prove the existence of positive eigenvalues, and find two-sided estimates for these positive eigenvalues. An example is given.

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ON THE COMPLETENESS OF THE ROOT VECTORS OF A SINGULAR OPERATOR GENERATED BY THE LINEAR PART OF THE KORTWEG-DE VRIES OPERATOR

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Keywords: singular operator, Korteweg-de Vries operator, boundary value problems.

Considerable literature and papers cited there are devoted to the solvability of boundary value problems for differential equations of odd order and, in particular, for the Kortweg-de Vries equations.

In contrast to some of these papers, in this paper we consider the following operator in $L_2(\Omega)$:

$$(L+\mu I)u = \frac{\partial u}{\partial t} + \frac{\partial^3 u}{\partial x^3} + q(x)u + \mu u \tag{1}$$

initially defined on $C^{\infty}_{0,\pi}(\bar{\Omega})$, where $\bar{\Omega} = \{(t,x): -\pi \le t \le \pi, -\infty < x < \infty\}$, $C^{\infty}_{0,\pi}(\bar{\Omega})$ is a set consisting of infinitely differentiable finite functions with respect to the variable x and satisfying the condition:

$$u(-\pi, x) = u(\pi, x). \tag{2}$$

For this operator with a growing coefficient, the following questions are studied:

- the existence of a resolvent;
- operator separability, i.e. maximum regularity of solutions;
- compactness of the resolvent;
- estimates of singular numbers (s-numbers);
- completeness of root vectors.

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COERCIVE ESTIMATE FOR A SECOND-ORDER DIFFERENTIAL EQUATION WITH UNBOUNDED LEADING COEFFICIENTS

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Keywords: differential equation, strong solution, solvability, maximal regularity.

The work is devoted to the study of the following singular differential equation:

$$-s(x)(\rho(x)y')' + r(x)y' + q(x)y = f(x), \quad (1)$$

where $x \in R = (-\infty, \infty)$, and $f \in L_2(R)$. We will assume that s and ρ are twice continuously differentiable, r is continuously differentiable, and q is a continuous function. The equation (1) is singular in the sense that its coefficients, generally speaking, can be unbounded functions.

We denote by L the closure in $L_2(R)$ of the differential operator

$L_0 y = -s(x)(\rho(x)y')' + r(x)y' + q(x)y$ with $D(L_0) = C_0^2(R)$ ($C_0^2(R)$ is the set of twice differentiable functions with compact support). The function y is called a solution of equation (1), if $y \in D(L)$ and $Ly = f$.

The purpose of this work is to obtain conditions on the coefficients under which

(a) there exists a solution y of equation (1) for any $f \in L_2(R)$,

(b) the solution y of equation (1) is unique,

(c) the following, so-called, coercive estimate holds for y :

$$\|-s(\rho y')'\|_2 + \|ry'\|_2 + \| ry \|_2 \leq C \| f \|_2.$$

where $\|\cdot\|_2$ is the norm in $L_2(R)$.

Moreover, we present the application of estimate (2) to find of compactness conditions of the resolvent L^{-1}.

If $s(x) = \rho(x) = 1, r = 0$, then (1) is the Sturm-Liouville equation. In this case the estimate (2) was stadied by B. Everitt and M. Giertz (the case of smooth $q(x)$), M. Otelbaev, K.Kh. Boimatov (the case of nondifferentiable $q(x)$) and others. In the case $s(x) = \rho(x) = 1$ and $r(x)$ is a weakly oscillating function that does not obey the coefficient $q(x)$, the estimate (2) was obtained in [1].

Example 1. We consider the equation (1), where

$s = |x|^{\varphi}, \rho = |x|^{\psi}, r = |x|^{\theta}$ for $|x| \geq 1$, and φ, ψ, θ are nonnegative and such that $\theta - \varphi - \psi - 2 \geq 0$. Assume that at least one of the following conditions (j) and (jj) holds

(j) $q = -|x|^m (|x| \geq 1, m \geq 0)$, and $\theta \geq m + 2$, or

(jj) $\varphi \geq 1/2, \psi \geq 1, q = -|x|^m (|x| \geq 1, m \geq 0)$, and $\varphi + \psi \geq m + 3/2$.

Then for any $f \in L_2(R)$ there exists a unique solution y to equation (1). Moreover, y satisfies the estimate (2).

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MAXIMAL REGULARITY ESTIMATE FOR A SOLUTION OF A THIRD-ORDER PSEUDOPARABOLIC EQUATION

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Keywords: pseudoparabolic equation, coercive solvability, unbounded region.

Assume $\bar{\Omega} = [0, \omega] \times (-\infty, +\infty)$. Let us consider the following pseudoparabolic equation of the third order

$$u_{xtt} = a_0(x,t)u_{xt} + a_1(x,t)u_x + a_2(x,t)u_t + a_3(x,t)u + f(x,t), \quad (1)$$

where the functions $a_i(x,t)(i = \overline{0,3}), f(x,t)$ are assumed to be continuous and, generally speaking, unbounded on $\bar{\Omega}$.

By $C_*(\bar{\Omega}, R)$ we denote the space of the bounded functions, which are continuous by $t \in R$ for $x \in [0, \omega]$ and uniformly with respect to $t \in R$ continuous by $x \in [0, \omega]$. Let $\| V(x,\cdot) \|_1 = \sup_{t \in R} \| V(x,t) \|$, where $\| V(x,t) \| = \max_{i=1,n} |V_i(x,t)|$. We study the properties of the solution $u(x,t)$ of equation (1) satisfying the conditions

$$u(0,t) = \psi(t), u(x,t), u_x(x,t), u_t(x,t), u_{xt}(x,t), u_{xtt}(x,t) \in C_*(\bar{\Omega}, R). \quad (2)$$

We put $P_{\alpha,\beta}(x,t) = \frac{\alpha(x,t)}{\sqrt{\beta(x,t)}}, \theta(x,t) = \frac{1}{d}\int_t^{t+d} a_1(x,\tau)d\tau$.

Theorem 1. Let functions $a_i(x,t)(i = \overline{0,3})$ in (1) be continuous on $\bar{\Omega}, \psi, \dot{\psi}, \ddot{\psi}$ are continuous and bounded on R and the following conditions are satisfied:

a) $a_1(x,t) \geq \gamma > 0, \gamma$ is a constant;

b) $\frac{a_1(x,t)}{a_1(x,\hat{t})} \leq c$ for $t, \hat{t} \in R: |t - \hat{t}| < d$, where c, d are constants;

c) for any $\varepsilon > 0$ there exists a number $\delta > 0$ such that for all t in R and $x_1, x_2 \in [0, \omega]: |x_1 - x_2| < \delta$ the following inequality holds

$$\left| \frac{|a_1(x_1,t) - a_1(x_2,t)|}{|a_1(x_2,t)|} \right| < \varepsilon$$

d) $P_{a_0,a_1}(x,t) \leq K, P_{a_2,a_1}(x,t), P_{a_3,a_1}(x,t), P_{f,a_1}(x,t) \in C_*(\bar{\Omega}, R)$.

e) $f(x,t), \sqrt{\theta(x,t)}\psi(t), \sqrt{\theta(x,t)}\dot{\psi}(t) \in C_*(\bar{\Omega}, R^2)$.

Then there exists a unique solution $u(x,t)$ of problem (1), (2) and $u_{xtt} \in C_*(\bar{\Omega}, R)$ and the estimate holds

$$\|u_{xtt}\|_1 + \|a_0 u_{xt}\|_1 + \|a_1 u_x\|_1 + \|a_2 u_t\|_1 + \|a_3 u\|_1 \leq C.$$

Here C depends on the norms of functions f and ψ and constants $\gamma, K, c, d, \varepsilon$.

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UNIFORM ESTIMATES FOR SOLUTIONS OF A CLASS OF NONLINEAR EQUATIONS IN A FINITE-DIMENSIONAL SPACE

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In this article, we obtain two theorems on a priori estimates for solutions of nonlinear equations in a finite-dimensional space. These theorems are proved under certain conditions, which are borrowed from the conditions which are satisfied by finite-dimensional approximations of one class of nonlinear initial-boundary value problems.

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ON CORRECT PROBLEMS FOR THE TWO-DIMENSIONAL LOADED PARABOLIC EQUATION

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Keywords: loaded differential equations, parabolic type equations, existence.

Boundary value problems for loaded differential equations, in some cases are correct in natural classes of functions, i.e. the loaded term is interpreted as a weak perturbation. If the uniqueness of the solution of the boundary value problem (1) is violated, then the loading can be interpreted as a strong perturbation. It transpires here that the character of the loading - perturbation (weak or strong perturbation) depends both on the order of derivatives included in the loaded (perturbed) part of the operator (2) and on the manifold on which the trace of the desired function is defined. It should be noted that when studying boundary value problems for loaded differential equations and boundary value problems for parabolic equations in noncylindrical domains, it becomes necessary to solve similar integral equations [1]-[6]

Problem setting

In the domain

$$\Omega = \{(r,t), r > 0, t > 0\}$$

consider the following problem:

$$\begin{cases} \dfrac{\partial u}{\partial t} = \dfrac{\partial^2 u}{\partial r^2} + \dfrac{1-2\beta}{r}\dfrac{\partial u}{\partial r} - \lambda \dfrac{\partial^k u}{\partial r^k}\Big|_{r=t^\alpha} + f(r,t) & (1) \\ u(r,0) = 0; u(0,t) = 0, & (2) \end{cases}$$

where $0 < \beta < 1, \alpha > 0, \lambda \in R$ – spectral parameter, $f(r,t) \in M(\Omega)$ – given function

$$f_k(t) = \left(\frac{\partial^k}{\partial r^k} \int_0^t \int_0^\infty \left[\frac{r^\beta \xi^{1-\beta}}{2(t-\tau)} \exp\left[-\frac{r^2+\xi^2}{4(t-\tau)} \right] I_\beta \left(\frac{r\xi}{2(t-\tau)} \right) \right] \cdot f(\xi,\tau) d\xi d\tau \right) |_{r=t^\alpha} \in M(0,\infty)$$

$$M(\Omega) = L_\infty(\Omega) \cap C(\Omega),\ M(0,\infty) = L_\infty(0,\infty) \cap C(0,\infty).$$

The purpose is to determine for which integer values $k = 0,1,2$ and for which values $\alpha > 0$, $0 < \beta < 1$ the problem (1) – (2) will be correct in other words have a unique solution.

It was concluded that:

Theorem 1. If $k = 1$, then for $0 < \beta \le 1/2$, $\forall \lambda \in R, \forall \alpha > 0, \forall f_1(t) \in M(0,\infty)$ the boundary value problem (1) – (2) has a unique solution $u(r,t) \in M(\Omega)$. And if $1/2 < \beta < 1$, then in order for the boundary value problem (1) – (2) to have a unique solution $u(r,t) \in M(\Omega)$, the following condition must be satisfied:

$$0 < \alpha < \frac{2-\beta}{1-2\beta}.$$

Theorem 2. Let $k = 2$. Under the condition $0 < \alpha < 1/2$, the boundary value problem (1) – (2) $\forall \beta \in (0,1), \forall \lambda \in R, \forall f_2(t) \in M(0,\infty)$ has a unique solution $u(r,t) \in M(\Omega)$.

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MUTUAL REDUCIBILITY OF LINEAR MULTIPERIODIC SYSTEMS

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Keywords: differentiation operator, reducibility, multiperiodicity.

The problem statement is related to the feasibility of conditional-periodic linear systems of ordinary differential equations, the study of the problem is related to points I and II.

I. Necessary concepts, terms and objects:

1. The function $X(t)$ of the vector argument $(t_1,...,t_m,t_{m+1})=(t,\tau)\in R^m\times R=R^{1+m}$ of the period $(\omega_1,...,\omega_m,\omega_{m+1}=\theta)=(\omega,\theta)$ are called multiperiodic, where $\omega=(\omega_1,...,\omega_m)$, $t=(t_1,...,t_m)$. Components of the vector-period (ω,θ) rationally incommensurable.

2. $D=\frac{\partial}{\partial\tau}+D_0$ and $D_0=\left\langle e,\frac{\partial}{\partial t}\right\rangle$ are called differentiation operators, $\left\langle e,\frac{\partial}{\partial t}\right\rangle$ – the scalar product of vectors $e=(1,...,1)$ and $\frac{\partial}{\partial t}=\left(\frac{\partial}{\partial t_1},...,\frac{\partial}{\partial t_m}\right)$.

3. Equations with matrix unknowns X and $\tilde{X}$ of the form

$$DX=P(t,\tau)X,\quad P(t+\omega,\tau+\theta)=P(t,\tau)\in C_{t,\tau}^{(e,0)}(R^m\times R), \tag{1}$$

$$D\tilde{X}=\tilde{P}(t,\tau)\tilde{X},\quad \tilde{P}(t+\omega,\tau+\theta)=\tilde{P}(t,\tau)\in C_{t,\tau}^{(e,0)}(R^m\times R), \tag{2}$$

are called multiperiodic with a differentiation operator D.

4. Equations

$$DY=Q(t)Y,\quad Q(t+\omega)=Q(t)\in C_t^{(e)}(R^m), \tag{3}$$

$$D_0Z=Q(t)Z,\quad Q(t+\omega)=Q(t)\in C_t^{(e)}(R^m) \tag{4}$$

are called multiperiodic with a common matrix $Q(t)$ and various differentiation operators D and D_0. Equation (3) is called autonomous with respect to τ. Solutions of equations with ω-periodic on t initial data at initial $\tau=0$ are considered.

5. Nonsingular solution $X=\Phi(t,\tau)$ (with $\det\Phi(t,\tau)\neq 0$) is called a fundamental.

6. When $\Phi(t,\tau+\theta)=\Phi(t,\tau)\Omega_\Phi(\sigma)$, $\sigma=t-e\tau$ the matrix $\Omega_\Phi(t)$ is called the main one for the solution. In the case of a matricant $\Phi=U(t,\tau)$, it is called a monodromy matrix: $U(t,\theta)=\Omega_U(\sigma)$.

7. The basic matrices $\Omega_X(t)$ and $\Omega_Y(t)$ are called θ-similar if there exists a nonsingular matrix $M(t)$ of the period ω such that $\Omega_X(t)=M^{-1}(t)\Omega_Y(t)M(t-e\theta)$. At the same time we can write $\Omega_X(t)\overset{\theta}{\sim}\Omega_Y(t)$.

8. If there is a transformation $X=T(t,\tau)Y$ with a nonsingular matrix $T(t+\omega,\tau+\theta)=T(t,\tau)\in C_{t,\tau}^{(e,1)}(R^m\times R)$ equation (1) to equation (2), they are called mutually reducible equations. In this case, we can write: (1) $\Leftrightarrow$ (2).

II. The following theorems are proved:

Theorem 1. For (1) $\Leftrightarrow$ (2) it is necessary and sufficient $\Omega_Y(t)\overset{\theta}{\sim}\Omega_U(t)$.

Theorem 2. When $\tilde{P}=P(t-e\theta,\tau)$ follows (1) $\Leftrightarrow$ (2).

Theorem 3. When $\tilde{P}=DU(t,\theta)\cdot U^{-1}(t,\theta)$ follows (1) $\Leftrightarrow$ (2).

Theorem 4. Solutions of equation (4) are solutions of equation (3). Solutions of equation (3) are solutions of equation (4) when $\tau=t_j$, $j=\overline{1,m}$.

Theorem 5. When (1) $\Leftrightarrow$ (3) follows (1) $\Leftrightarrow$ (4) with a transformation matrix $T(t,t_m)$.

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MATHEMATICAL MODELING OF THE EPIDEMIC PROPAGATION WITH LIMITED TIME SPENT IN COMPARTMENTS AND VACCINATION

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Keywords: mathematical model, epidemic, vaccination

The paper proposes discrete and continuous mathematical models of epidemic development. A division of the population into nine compartments is suggested: susceptible, exposed, vaccinated, contact vaccinated, undetected patients, isolated patients, hospitalized patients, recovered and deceased. At the same time, the time spent in exposed and infected compartments is considered limited. According to the assumptions made in the models, a susceptible person can encounter the patient and go into the exposed compartment, and be vaccinated, and then also encounter the infection and go into the contact vaccinated compartment. Exposed people may become ill to any degree of severity or not, returning to the susceptible group. A contact vaccinated either does not become ill or becomes undetected or isolated patient. Every patient can recover. An undiagnosed patient may develop symptoms of the disease, because of which he moves into the isolated compartment. An isolated patient may be hospitalized, and a hospitalized patient may die. In the discrete model, discrete quantitative data for each day of the epidemic are considered, in the continuous one, these indicators are considered continuous functions. The article provides a qualitative and quantitative analysis of the proposed models. The influence of all parameters on the process under study is investigated.

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NEW MULTIDIMENSIONAL HARDY INEQUALITY

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Keywords: Hardy inequality; Symmetric rearrangements; Bessel pairs; Uncertainty principle; Euclidean space, Hyperbolic space; Metric measure spaces.

We establish a new improvement of the classical Hardy inequality on different metric measure spaces, which mainly include Euclidean space, Hyperbolic space, Cartan-Hadamard manifolds with constant curvature, symmetric Model manifolds, Homogeneous groups, etc. In this talk, we will discuss both the subcritical and critical versions of the Hardy inequality. Recently, in [1], there has been a new kind of development of the one-dimensional Hardy inequality, which has an important application in the theory of Schrodinger operators. Using some radialisation techniques of functions and then exploiting weighted symmetric decreasing rearrangement on the real line, we give the new multidimensional version of the Hardy inequality. Some improvement of the Hardy inequality involving the Bessel pair, super weights, and a new version of the uncertainty principle is also discussed. This talk is based on our joint work with Prasun Roychowdhury and Michael Ruzhansky.

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NORMAL-REGULAR SOLUTIONS OF LAGUERRE-TYPE SYSTEM OF *n* EQUATIONS

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Keywords: normal-regular solutions, Laguerre polynomials, system, hypergeometric series.

The paper proves a number of theorems establishing the existence of normally regular solutions [1] of a Laguerre type system, as well as their connection with Laguerre polynomials of many variables.

Theorem 1. Additional system derived from the generalized Laguerre system

$$x_j \frac{\partial^2 W}{\partial x_j^2} + \left(1+\alpha_j - x_j\right)\frac{\partial W}{\partial x_j} - \sum_{(k\neq j)} x_k \frac{\partial W}{\partial x_k} + nW = 0, \quad j = \overline{1,n}, \tag{1}$$

using the conversion

$$W(x_1,...,x_n) = \exp\left(\alpha_{1,0,...,0}x_1 + ... + \alpha_{0,...0,1}x_n\right)U(x_1,...,x_n),$$

when two necessary conditions are met

$$\alpha_{1,0,...,0}^2 - \alpha_{1,0,...,0} = 0,\ \alpha_{0,...,0,1}^2 - \alpha_{0,...,0,1} = 0$$

and

$$f_{0,...,0}^{(j)}(\rho_1,...,\rho_n) \equiv \rho_j\left(\rho_j - 1\right) + \left(1+\alpha_j\right)\rho_j = 0 \quad \left(j = \overline{1,n}\right),$$

has n normally-regular solutions of the form

$$W_{1,j}(x_1,...,x_n) = \exp\left(x_j\right)U_j(x_1,...,x_n), \quad \left(j = \overline{1,n}\right) \tag{2}$$

where $U_j(x_1,...,x_n)$ are hypergeometric series of n variables.

There is a connection between Laguerre polynomials of n variables

$$\Psi_2^{(n)}(-n;\alpha_1+1,...,\alpha_n+1;x_1,...,x_n) = L_{n,...n}^{(\alpha_1,...\alpha_n)}(x_1,...,x_n) =$$
$$= \sum_{m_1,...,m_n=0}^{n} \frac{(-n)_{m_1+...+m_n}}{(1+\alpha_1)_{m_1}...(1+\alpha_n)_{m_n}} \frac{x_1^{m_1}}{m_1!}...\frac{x_n^{m_n}}{m_n!}$$

and the normally regular solutions of (2).

Theorem 2. There are relations

$$\Psi_{2,j}^{(n)}(-n;\alpha_1+1,...,\alpha_n+1;x_1,...,x_n) = \exp\left(x_j\right)U_j(x_1,...,x_n), \quad \left(j = \overline{1,n}\right).$$

Theorem 3. There are relations

$$\exp\left(-x_j\right)\Psi_{2,j}^{(n)}(-n;\alpha_1+1,...,\alpha_n+1;x_1,...,x_n) = U_j(x_1,...,x_n), \quad \left(j = \overline{1,n}\right).$$

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ON ALTERNATIVE CRITERIA FOR BOUNDEDNESS OF ONE CLASS OF MATRIX OPERATORS

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Keywords: matrix operators, boundedness, weighted inequalities, weighted Lebesgue spaces.

Let $1<q,p<\infty$, and $v=\{v_i\}_{i-1}^{\infty}$, $u=\{u_i\}_{i-1}^{\infty}$ be positive sequences of real numbers. Let $\left(a_{i,j}\right)$ be a non-negative triangular matrix with entries $a_{i,i}\geq 0$ when $i\geq j\geq 1$ and $a_{i,i}=0$ when $i<j$. Let $l_{p,v}$ denote the space of sequences of real numbers $f=\{f_i\}_{i-1}^{\infty}$ such that $\|f\|_{p,v}=\left(\sum_{j=1}^{\infty}\left|v_j f_j\right|^p\right)^{\frac{1}{p}}<\infty$, $1\leq p<\infty$.

We will consider inequalities of the following form

$$\|Af\|_{q,u}\leq C\|f\|_{p,v},\forall f\in l_{p,v} \tag{1}$$

for matrix operator

$$(Af)_i=\sum_{j=1}^{i}a_{i,j}f_j,i\in N. \tag{2}$$

In paper [1] R. Oinarov and Zh. Taspaganbetova introduced an extended class of matrices $O_n^{\pm},n>0$ and obtained a criterion for the fulfillment of inequality (1) for matrix operators from these classes. The class O_1^{+} consists matrix $\left(a_{i,j}\right)$ satisfying the following condition: $a_{i,i}\geq 0$ and there exist $d\geq 1$, a sequence of positive numbers $\{\omega_i\}_{i-1}^{\infty}$ and a non-negative matrix $\left(b_{i,j}\right)$, where $b_{i,j}$ is non-decreasing in i and non-increasing in j such that

$$\frac{1}{d}\left(b_{i,k}\omega_j+a_{k,j}\right)\leq a_{i,j}\leq d\left(b_{i,k}\omega_j+a_{k,j}\right) \tag{3}$$

for all $i\geq k\geq j\geq 1$.

Therefore, the main goal of this work is to establish new alternative criteria for the fulfillment of the inequality (1) for matrix operators belonging to the classes O_1^{+} and O_1^{-} when $1<p\leq q<\infty$.

Theorem 1. Let $1<p\leq q<\infty$. and matrix $\left(a_{i,j}\right)$ of operator (2) belong to the class O_1^{+}. Then inequality (1) holds if and only if $B^{+}=\max\{B_1^{+},B_2^{+}\}<\infty$, where

$$B_1^{+}=\sup_{k\geq 1}\left(\sum_{n=k}^{\infty}v_n^{-p'}\left(\sum_{i=n}^{\infty}a_{i,n}b_{i,n}^{q-1}u_i^q\right)^{p'}\right)^{\frac{1}{p'}}\left(\sum_{n=k}^{\infty}b_{n,k}^{q}u_n^q\right)^{-\frac{1}{q'}},$$

$$B_2^{+}=\sup_{k\geq 1}\left(\sum_{n=k}^{\infty}v_n^{-p'}\left(\sum_{i=n}^{\infty}a_{i,n}u_i^q\right)^{p'}\right)^{\frac{1}{p'}}\left(\sum_{n=k}^{\infty}u_n^q\right)^{-\frac{1}{q'}}.$$

Moreover, $C\approx M^{+}$, where C is the best constant in (1).

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THE RIEMANN-HILBERT PROBLEM FOR A MULTIDIMENSIONAL SYSTEM OF FIRST-ORDER DIFFERENTIAL EQUATIONS GENERALISING THE CAUCHY-RIEMANN SYSTEM

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Keywords: Holomorphic vector, Cauchy-Riemann system, Moisil-Teodorescu system, harmonic function, oblique derivative problem, quaternions.

In this paper a five-dimensional analogue of the well-known Cauchy-Riemann system for analytic functions is constructed with the help of quaternions. Representation of solutions of this system in terms of the derivatives of harmonic functions was found. In addition, the Riemann-Hilbert boundary value problem for this system has been investigated, which was reduced to the well-known problem of the oblique derivative for harmonic functions.

It is known that one of the ways to construct an analog of holomorphic functions of a complex variable in the multidimensional case is a generalization of the Cauchy-Riemann conditions [1] - [3]. For example, we consider a system of differential equations in the Euclidean four-dimensional space R^4, which is a four-dimensional generalization of the Cauchy-Riemann system

$$\sum_{j=1}^{4} B_j \frac{\partial U}{\partial x_j} = 0, \tag{1}$$

where $B_j, j = 1,2,3,4$ are matrices of dimension $2 * 2$, whose elements are complex constants, and $U = (u, v)$ is the required complex column vector of complex-valued functions $u = u(x), v = v(x), x = (x_1, x_2, x_3, x_4) \in R^4$. System (1) is called a four-dimensional analogue of the Cauchy-Riemann system if the components u and v for each of its solutions U are harmonic functions. If we denote by $U = (u_1, u_2, u_3, u_4)$ the column vector composed of the real and imaginary parts of the components of the solution $U = (u, v)$ of system (1)

$$u_1 = Re\, u, \qquad u_2 = Im\, u, \qquad u_3 = Re\, v, \qquad u_4 = Im\, v,$$

and perform homotopy classification, we can write the real version of system (1) of the canonical form as in [4]:

$$\begin{aligned} &u_{1x_1} + u_{2x_2} + \rho b_1 u_{3x_3} - \rho b_2 u_{4x_3} - \rho b_2 u_{3x_4} - \rho b_1 u_{4x_4} = 0,\\ &u_{2x_1} - u_{1x_2} + \rho b_2 u_{3x_3} + \rho b_1 u_{4x_3} - \rho b_1 u_{3x_4} - \rho b_2 u_{4x_4} = 0,\\ &u_{3x_1} - u_{4x_2} - \rho b_1 u_{1x_3} - \rho b_2 u_{2x_3} - \rho b_2 u_{1x_4} - \rho b_1 u_{2x_4} = 0,\\ &u_{4x_1} + u_{3x_2} + \rho b_2 u_{1x_3} - \rho b_1 u_{2x_3} + \rho b_1 u_{1x_4} + \rho b_2 u_{2x_4} = 0, \end{aligned} \tag{2}$$

where $b = b_1 + ib_2$ is an arbitrary complex number and $\rho = (b_1^2 + b_2^2)^{-1}$. In this paper solutions to the system (2) were obtained and the Riemann-Hilbert boundary value problem for this system has been investigated, which was reduced to the well-known problem of the oblique derivative for harmonic functions.

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ON SOLUTIONS OF AN INHOMOGENEOUS DEGENERATE HYPERGEOMETRIC SYSTEM RELATED TO HUMBERT FUNCTIONS OF MANY VARIABLES

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Keywords: System, Hypergeometric, Normal-regular, By passage to the limit, Function, Variables.

Formulation of the matter. The possibilities of constructing normally-regular solutions of the inhomogeneous degenerate hypergeometric Horn system are studied: (Φ_3):

$$\begin{aligned} &z_1W_{z_1z_1}+z_2W_{z_1z_2}+(\gamma-z_1)W_{z_1}-\alpha W=f_1(z_1,z_2),\\ &z_2W_{z_2z_2}+z_1W_{z_1z_2}+\gamma W_{z_2}-W=f_2(z_1,z_2). \end{aligned} \tag{1}$$

with the right side

$$\begin{aligned} &f_1(z_1,z_2)=\alpha_{0,0}^{(1)}\exp(\alpha_{1,0}z_1+\alpha_{0,1}z_2)z_1^{\rho_1-1}z_2^{\rho_2},\\ &f_2(z_1,z_2)=\alpha_{0,0}^{(2)}\exp(\alpha_{1,0}z_1+\alpha_{0,1}z_2)z_1^{\rho_1}z_2^{\rho_2-1}. \end{aligned} \tag{2}$$

The solution of the corresponding homogeneous system obtained from (1) at $f_j(z_1,z_2)(j=1,2)$ is the Humbert function. The two Humbert functions (Φ_2) and (Φ_3) are special cases of the introduced by V.I. Khudozhnikov of a new function $\Phi_{B,n}^{k,l}$ obtained by passing to the limit from the Lauricella function F_B [1]. Therefore, the corresponding homogeneous system is a particular case of a degenerate hypergeometric system obtained from the Lauricella system F_B by passing to the limit. A number of theorems have been proved.

Theorem 1. The corresponding homogeneous system obtained from (1) at $f_j(z_1,z_2)=0$ has only one normal-regular solution

$$W_{1,1}(z_1,z_2)=\exp(z_1)\{1-\frac{\gamma-\alpha_1}{\gamma}z_1+\frac{1}{\gamma}z_2-\frac{\gamma+1-\alpha_1}{\gamma(\gamma+1)}z_1z_2+\frac{(\gamma-\alpha_1)(\gamma+1-\alpha_1)}{\gamma(\gamma+1)}\frac{z_1^2}{2!}+ \\ +\frac{z_2^2}{\gamma(\gamma+1)2!}+\ldots\}. \tag{3}$$

Theorem 2. The relation between the functions (Φ_3) and the normal-regular solution (3) is valid: the relation

$$\Phi_3(\alpha_1;\gamma;z_1,z_2)=\exp(z_1)\{1-\frac{\gamma-\alpha_1}{\gamma}z_1+\frac{1}{\gamma}z_2-\frac{\gamma+1-\alpha_1}{\gamma(\gamma+1)}z_1z_2+\frac{(\gamma-\alpha_1)(\gamma+1-\alpha_1)}{\gamma(\gamma+1)}\frac{z_1^2}{2!}+ \\ +\frac{z_2^2}{\gamma(\gamma+1)2!}+\ldots\}.$$

Theorem 3. System (1) with the right side (2) has particular solutions in the form of normal-regular series:

$$W_{\rho_1,\rho_2}(z_1,z_2)=z_1^{\rho_1}z_2^{\rho_2}\sum_{m_1,m_2=0}^{\infty}\frac{(\rho_1+\alpha_1)_{m_1}(1)_{m_2}}{(\rho_1)_{m_1+1}(\rho_1-1+\gamma)_{m_1+1}(\rho_2-1+\gamma)_{m_2+1}}z_1^{m_1}z_2^{m_2}. \tag{4}$$

at $(\alpha_{1,0}=0,\alpha_{0,1}=0)$.

$$W_{\rho_1,\rho_2}(z_1,z_2)=\exp(z_1)z_1^{\rho_1}z_2^{\rho_2}\sum_{m_1,m_2=0}^{\infty}\frac{(-1)^{m_1+m_2}(\rho_1+\rho_2+\gamma-\alpha_1)_{m_1}(1)_{m_2}}{(\rho_1)_{m_1+1}(\rho_1-1+\gamma)_{m_1+1}(\rho_2)_{m_2}(\rho_2-1+\gamma)_{m_2+1}}z_1^{m_1}z_2^{m_2}. \tag{5}$$

The unknown coefficients $\alpha_{0,0}^{(t)}(t=1,2)$ on the right side of (1) are chosen depending on the value of the system roots of characteristic equations [2]. They ensure the compatibility of finding the coefficients of the series of particular solutions (4) and (5). The Frobenius-Latysheva method [2] is used to construct the solution [2].

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WEIGHTED ESTIMATES OF A CLASS OF MATRIX OPERATOR WITH THREE PARAMETERS

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Keywords: Inequality; Hardy-type operator; weights; weighted sequence space; quasilinear operator, matrix operator.

Let $0<q,p,r<\infty$, $\frac{1}{p}+\frac{1}{p'}=1$ and $f=\{f\}_{i-1}^{\infty}$ arbitrary sequence of real numbers. Suppose that $\omega=\{\omega_i\}_{i-1}^{\infty}$, $u=\{u_i\}_{i-1}^{\infty}$ and $v=\{v_i\}_{i-1}^{\infty}$ be positive sequences of real numbers, which will be called weight sequences. We denote by $l_{p,v}$ the space of sequences f of real numbers such that

$$\|f\|_{p,v}=\left(\sum_{j=1}^{\infty}\left|v_j f_j\right|^p\right)^{\frac{1}{p}}<\infty.$$

For any $f\in l_{p,v}$ we consider the following discrete Hardy-type inequalities

$$\left(\sum_{n=1}^{\infty}u_n^q\left(\sum_{k=1}^{n}\left|\omega_k\sum_{i=k}^{\infty}a_{i,k}f_i\right|^r\right)^{\frac{q}{r}}\right)^{\frac{1}{q}}\le C\left(\sum_{j=1}^{\infty}\left|v_j f_j\right|^p\right)^{\frac{1}{p}} \qquad (1)$$

where C is a positive constant independent of f and $(a_{i,k})\,i\ge k$ is a matrix, whose non-negative entries satisfy the discrete Oinarov condition: there exists a constant $d\ge 1$, entries $a_{i,k}$ are almost non-decreasing in i and almost non-increasing in k, such that the inequalities

$$\frac{1}{d}\left(a_{i,j}+a_{j,k}\right)\le a_{i,k}\le d\left(a_{i,j}+a_{j,k}\right),\ i\ge j\ge k\ge 1 \qquad (2)$$

We also need the following quantities: $J_{r,p}^{-}(\alpha,\beta)=\sup_{f\ne 0}\dfrac{\left(\sum_{k=\alpha}^{\beta}\left|\omega_k\sum_{i=k}^{\beta}a_{i,k}f_i\right|^r\right)^{\frac{1}{r}}}{\left(\sum_{j=\alpha}^{\beta}\left|v_j f_j\right|^p\right)^{\frac{1}{p}}}$, $f\in l_{p,v}$.

The purpose of the work is to obtain weighted estimates of inequalities (1) and its dual version for the cases: $1<p\le q<\infty$ and $1<r<\infty$; $p\le q<\infty$, $0<p<1$ and $1<r<\infty$. Similiar integral inequalities were considered in work [1].

Theorem 1. Let $0<p<1$, $p\le q<\infty$ and $1<r<\infty$. Let the entries of the matrix $(a_{i,k})$ satisfy condition (2). Then inequality (1) holds if and only if $B^{+}=\max\{B_1^{+},B_2^{+}\}<\infty$, where

$$B_1^{+}=\sup_{j\ge 1}\left(\sum_{n=j}^{\infty}u_n^q\right)^{\frac{1}{q}}J_{r,p}^{-}(1,j),$$

$$B_2^+ = \sup_{j\geq 1}\left(\sum_{n=1}^{j} u_n^q \left(\sum_{k=1}^{n} a_{j,k}^r \omega_k^r\right)^{\frac{q}{r}}\right)^{\frac{1}{q}} v_j^{-1}.$$

Moreover, $C \approx B^+$, where C is the best constant in (1)

Theorem 2. Let $1 < p \leq q < \infty$ and $1 < r < \infty$. Let the entries of the matrix $\left(a_{i,k}\right)$ satisfy condition (2). Then inequality (1) holds if and only if $M^+ \approx \max\{M_1^+, M_2^+, M_3^+\} < \infty$, where

$$M_1^+ = \sup_{j\geq 1}\left(\sum_{n=j}^{\infty} u_n^q\right)^{\frac{1}{q}} J_{r,p}^-(1, j),$$

$$M_2^+ = \sup_{j\geq 1}\left(\sum_{n=1}^{j} u_n^q \left(\sum_{k=1}^{n} a_{j,k}^r \omega_k^r\right)^{\frac{q}{r}}\right)^{\frac{1}{q}} \left(\sum_{i-j}^{\infty} v_i^{-p'}\right)^{\frac{1}{p'}}.$$

$$M_3^+ = \sup_{j\geq 1}\left(\sum_{n=1}^{j} u_n^q \left(\sum_{k=1}^{n} \omega_k^r\right)^{\frac{q}{r}}\right)^{\frac{1}{q}} \left(\sum_{i-j}^{\infty} a_{i,j}^{p'} v_i^{-p'}\right)^{\frac{1}{p'}}.$$

Moreover, $C \approx M^+$, where C is the best constant in (1)

Remark. The statements of the main results are also given for dual version of the inequality (1).

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СЕКЦИЯ 5
Алгебра, математикалық логика және геометрия

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СЕКЦИЯ 5
Алгебра, математическая логика и геометрия

❖

SESSION 5
Algebra, Mathematical logic and Geometry

IRSTI 27.15.25

COMPANIONS OF FIELDS OF RATIONAL AND REAL ALGEBRAIC NUMBERS

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Keywords: companion, field of rational numbers, real closed field, algebraic field extension, algebraic element, transcendental element.

The theory of existential closure arose in the middle of the twentieth century in the works of one of the recognized classics of model theory Abraham Robinson [1], [2], as well as in the works [3] – [8]. Some properties of existentially closed and forcing companions have been studied [9]. Another promising approach to constructing the theory of existentially closed structures based on Frese's works [6] is developed in [9] - [11].

This study is an example of studying a classical object through an approach developed by Nurtazin A.T. and based on Frese classes.

Let: $\mathbf{Q}$ be the field of rational numbers; $\mathbf{R}$ is a real closed algebraic extension of the field $\mathbf{Q}$; $\mathbf{P}[\bar{x}]$, $\mathbf{P}(\bar{x})$ are, respectively, the ring of polynomials and the field of quotients over the field $\mathbf{P}$ of independent variables $\bar{x}=(x_1,...,x_n)$. Simple algebraic extensions

Let $A_f=\{\ (\bar{a},a)|\ f(\bar{a},a)=0,\ \bar{a},a\in\mathbf{P}\}$ be an annihilator f, where $f(\bar{x},x)\in\mathbf{P}(\bar{x})[x]$, $I(A_f)=\{\ g|g\in\mathbf{P}(\bar{x})[x],\ A_f\subseteq A_g\}$, where $f\in\mathbf{P}(\bar{x})[x]$.

THEOREM 1. Let $f(\bar{x},x)$ be an irreducible polynomial over a field $\mathbf{P}(\bar{x})$. An algebraic extension $\mathbf{P}(\bar{x})[x]/f$ of the field $\mathbf{P}(\bar{x})$ is a companion $\mathbf{P}$ if and only if the ideal $I(A_f)$ is the same as the ideal (f).

THEOREM 2. An algebraic extension $\mathbf{Q}(\bar{x})[y]/f/g$ of a field $\mathbf{P}(\bar{x})[y]/f$ is a companion of $\mathbf{P}$ if and only if the ideal $I(A_{fg})$ is the same as the ideal (f,g).

THEOREM 3. An algebraic extension $\mathbf{P}(\bar{\beta})[\bar{x}_n^{\bar{f}_n}]=\mathbf{P}(\bar{\beta})[\bar{x}_{n-1}^{\bar{f}_{n-1}}][x_n]/\ f_n(\bar{\beta},\bar{x}_{n-1}^{\bar{f}_{n-1}},x_n)$ of a field $\mathbf{P}(\bar{\beta})$ is a companion $\mathbf{P}$ if and only if the ideal $I(A_{\bar{f}_n})$ coincides with the ideal $(f_1,...,f_n)$.

The proof is a general reproduction of the proof of Theorem 5.

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СЕКЦИЯ 6
Актуарлық математика және статистика

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СЕКЦИЯ 6
Актуарная математика и статистика

❖

SESSION 6
Actuarial mathematics and statistics

IRSTI 27.39.15

NONCOMMUTATIVE SYMMETRIC SPACE ASSOCIATED WITH A WEIGHT

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Abstract

Let $\mathcal{N}$ be a semifinite von Neumann algebra on the Hilbert space $\mathcal{H}$ with a faithful normal semifinite trace ν satisfying $\nu(1) = a$. Now let $\varphi(\cdot) = \nu(D_\varphi \cdot)$ be a faithful normal locally finite weight on $\mathcal{N}$ (where D_φ is the Radon-Nikodym derivative of φ with respect to ν, D_φ is is locally measurable). For $1 \leq p < \infty$ and $\alpha \in [0,1]$, define

$$\mathfrak{N}_\alpha^{\frac{1}{p}} = \left\{ x \in \mathcal{N} : D_\varphi^{\frac{\alpha}{p}} x D_\varphi^{\frac{1-\alpha}{p}} \in L_p(\mathcal{N}) \right\}$$

$$\| x \|_{p,\alpha} = \left\| D_\varphi^{\frac{\alpha}{p}} x D_\varphi^{\frac{1-\alpha}{p}} \right\|_p .$$

Then $\left(\mathfrak{N}_\alpha^{\frac{1}{p}}, \|\cdot\|_{p,\alpha} \right)$ is a normed space and its completion is isometrically isomorphic to $L_p(\mathcal{N}, \nu)$ for all $\alpha \in [0,1]$ (see [4]).

In [2], the authors extend this result to the Orlicz space associated with an N-function case. They introduced a class of non commutative Orlicz spaces, associated with arbitrary faithful normal locally finite weights on a semifinite von Neumann algebra $\mathcal{N}$ and showed that this Orlicz spaces can be realized as linear subspaces of the algebra $L_{loc}(\mathcal{N})$ of locally measurable operators affiliated with $\mathcal{N}$. This class of noncommutative Orlicz spaces is extention of the class of noncommutative Orlicz spaces for states in [1]. In [3], some results of [2] have been extended to the weak noncommutative Orlicz space case.

The aim of this talk is to define noncommutative quasi symmetric spaces and noncommutative quasi symmetric Hardy spaces associated with a weight, to extend the results in [2] to the case that E is a separable p-convex symmetric quasi Banach function space on $[0, a)$ for some $0 < p < \infty$.

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INTERPOLATION OF ANISOTROPIC LOCAL MORREY SPACES

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Keywords: anisotropic local Morrey spaces, interpolation theorems

In this paper, anisotropic local Morrey spaces are considered. The properties of Morrey spaces and the operators acting in these spaces have been of great interest in recent decades. To study them, the scale of spaces $LM^{\overline{\lambda}}_{\overline{p},\overline{q}}(\mathbb{T})$ is introduced. Research methods are based on the interpolation properties of these spaces.

Let $k \in \mathbb{Z}$,, denote by G_k the set of all cubes of the form $[0, 2^k)^n + 2^k m, m \in \mathbb{Z}^n$. Let $\mathbb{G} = \bigcup_{k\in\mathbb{Z}} G_k$, $Q \in G_k$. A set of mutually disjoint cubes $\mathbb{T} = \{Q\} \subset \mathbb{G}$ will be a local partition of the space $\mathbb{R}^n$ if $= \overline{\coprod_{Q\in\mathbb{T}} Q}$ and $|\mathbb{T} \cap G_k| < \infty$.

Now let $\overline{n} = (n_1, \dots, n_d)$: $n_i \in \mathbb{N}$, $|n| = n_1 + \cdots + n_d$, $\overline{k} = (k_1, \dots, k_d)$: $k_i \in \mathbb{Z}$. Let $G_{\overline{k}} = \{Q = Q_1 \times \cdots \times Q_d\colon\ Q_i \in G_{k_i},\ i = \overline{1,d}\}$, mutually disjoint cubes $\mathbb{T}_i = \{Q_i\} \subset G_{k_i}$ be a local partition of the space $\mathbb{R}^{n_i}$, the sets $\mathbb{T}_1, \dots, \mathbb{T}_d$ are local partitions of the spaces $\mathbb{R}^{n_1}, \dots, \mathbb{R}^{n_d}$, respectively. A family of mutually non-intersecting parallelepipeds $\mathbb{T} = \mathbb{T}_1 \times \dots \times \mathbb{T}_d$ is called a local partition of the space $\mathbb{R}^{|n|}$.

Consider the vectors $\overline{\lambda} = (\lambda_1, \lambda_2, \dots, \lambda_d)$, $\overline{p} = (p_1, p_2, \dots, p_d)$, $\overline{q} = (q_1, q_2, \dots, q_d)$, $\lambda_i \in \mathbb{R}$, $0 < p_i, q_i \leq \infty, i = \overline{1,d}$. We define the local Morrey space $LM^{\overline{\lambda}}_{\overline{p},\overline{q}}(\mathbb{T})$ as the set of measurable functions f for which

$$\|f\|_{LM^{\overline{\lambda}}_{\overline{p},\overline{q}}(\mathbb{T})} = \left(\sum_{k_d=1}^{\infty} \dots \left(\sum_{k_1=1}^{\infty} \left(2^{-\sum_{i=1}^{d} k_i\lambda_i} \sum_{Q\in\mathbb{T}_{\overline{k}}} \|f\|_{L_{\overline{p}}(Q)} \right)^{q_1} \right)^{q_2/q_1} \dots \right)^{1/q_d} < \infty.$$

Theorem. Let the vectors $\overline{\lambda_0} = (\lambda_1^0, \dots, \lambda_d^0)$, $\overline{\lambda_1} = (\lambda_1^1, \dots, \lambda_d^1)$, $\overline{\theta} = (\theta_1, \dots, \theta_d)$ $\overline{p} = (p_1, \dots, p_d)$, $\overline{q} = (q_1, \dots, q_d), \overline{q_0} = (q_1^0, \dots, q_d^0)$, $\overline{q_1} = (q_1^1, \dots, q_d^1), \overline{n} = (n_1, \dots, n_d)$ such that $0 < p_i \leq \infty$ $0 < q_i^0, q_i^1, q_i \leq \infty$, $-\infty < \lambda_i^0 < \lambda_i^1 < +\infty$, $\theta_i \in (0; 1)$, $n_i \in \mathbb{N}$, $\mathbb{T}$ is a local partition of $\mathbb{R}^{|n|}$. Then

$$\left(LM^{\overline{\lambda_0}}_{\overline{p},\overline{q_0}}(\mathbb{T}), LM^{\overline{\lambda_1}}_{\overline{p},\overline{q_1}}(\mathbb{T})\right)_{\overline{\theta},\overline{q}} = LM^{\overline{\lambda}}_{\overline{p},\overline{q}}(\mathbb{T}),$$

where $\lambda_i = (1 - \theta_i)\lambda_i^0 + \theta_i\lambda_i^1$.

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ON THE INTERPOLATION PROPERTIES OF DISCRETE NET SPACE

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Keywords: Net spaces, discrete Net spaces, Marcinkiewicz type interpolation theorem.

Let S be the set of all finite sets of indices from $\mathbb{Z}^n$. For a fixed set $M \subset S$ we define the space $n_{p,q}(M)$ $(0 < p, q \leqslant \infty)$ as the set of sequences $a = \{a_m\}_{m\in\mathbb{Z}^n}$ with quasinorm for $0 < p < \infty$, $0 < q < \infty$

$$\| a \|_{n_{p,q}(M)} = \left(\sum_{k=1}^{\infty} k^{\frac{q}{p}-1} (\bar{a}_k(M))^q\right)^{\frac{1}{q}},$$

and for $q = \infty$, $0 < p \leqslant \infty$

$$\| a \|_{n_{p,\infty}(M)} = \sup_{1\leqslant k<\infty} k^{\frac{1}{p}} \bar{a}_k(M),$$

where

$$\bar{a}_k(M) = \sup e \in M : |e| \geqslant k \frac{1}{|e|} |\sum_{m\in e} a_m|,$$

where $|e|$ is the number of indices in e.

These spaces were introduced in [4], and they were called net spaces.

Net spaces have found important applications in various problems of harmonic analysis, operator theory and theory of stochastic processes [1, 2, 3]. In this paper, we study the interpolation properties of these spaces. It should be noted here that net spaces are in a sense close to the discrete Morrey spaces:

$$m_p^{\lambda} = \left\{a = \{a_k\}_{k\in\mathbb{Z}}: \quad \sup_{m\in\mathbb{N}} \sup_{k\in\mathbb{Z}} \frac{1}{m^{\lambda}} \left(\sum_{r=k}^{k+m} |a_r|^p\right)^{\frac{1}{p}} < \infty\right\}.$$

In the case when $a = \{a_k\}_{k\in\mathbb{Z}}$, $a_k \geqslant 0$, for $\lambda = n\left(1 - \frac{1}{p}\right)$

$$\| a \|_{n_{p,\infty}(M)} \asymp \| a \|_{m_1^{\lambda}}.$$

The question of interpolation of Morrey spaces was considered in the works [12, 5] and it was shown that this scale of spaces is not closed with respect to the real interpolation method.

In this paper we show that if M is the set of all segments from $\mathbb{Z}$ the scale of spaces is closed with respect to the real interpolation method, i.e. the following relation holds

$$\left(n_{p_0,q_0}(M), n_{p_1,q_1}(M)\right)_{\theta,q} = n_{p,q}(M). \tag{1}$$

Let (A_0, A_1) be a compatible pair of Banach spaces. Let

$$K(t, a; A_0, A_1) = K(t, a) = \inf_{a=a_0+a_1} (\| a_0 \|_{A_0} + t \| a_1 \|_{A_1}), \ a \in A_0 + A_1,$$

be the functional Petre. For $0 < q < \infty$, $0 < \theta < 1$

$$(A_0, A_1)_{\theta,q} = \{a \in A_0 + A_1 : \| a \|_{(A_0,A_1)_{\theta,q}} = (\int_0^{\infty} (t^{-\theta} K(t, a))^q \frac{dt}{t})^{1/q} < \infty\},$$

and for $q = \infty$

$$(A_0, A_1)_{\theta,q} = \{a \in A_0 + A_1 : \| a \|_{(A_0,A_1)_{\theta,q}} = \sup_{0<t<\infty} t^{-\theta} K(t, a) < \infty\}.$$

Acknowledgments

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O'NEIL'S INEQUALITY IN LOCAL MORRY SPACES

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Let $\lambda \in \mathbb{R}$, $0 < p, q \leq \infty$. The Local Morry Space

$$LM^{\lambda}_{p,q} = \left\{ f : \|f\|_{LM^{\lambda}_{p,q}} = \left(\int_0^{\infty} \left(t^{-\lambda} \|f\|_{L_p(B_{t(0)})} \right)^q \frac{dt}{t} \right)^{\frac{1}{q}} < \infty \right\},$$

where $B_t(0) = \{ y \in \mathbb{R}^n : |y| \leq t \}$ is the open ball centered at the point x=**0** of radius $t > 0$, were introduced by Guliyev-Burenkov [1]. In this paper, we introduce spaces that generalize local Morrey spaces.

We study the Riesz operators, which are dedicated in [2,3]. O'Neil-type inequalities are obtained for convolution operators in these spaces. The methods from [4] are used.

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IRSTI 27.25.17

INTERPOLATION METHODS WITH PARAMETRIC FUNCTIONS

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Keywords: Interpolation, interpolation methods, interpolation theorem, Lebesgue and Lorentz spaces.

In this work we construct interpolation methods with parametric functions that can be used to study the interpolation properties of spaces with mixed metrics and obtain an interpolation theorem for Lebesgue and Lorentz spaces with mixed metrics.

Let (A_i^0, A_i^1), i=1,2 be compatible pairs of Banach spaces. Let $A_{00} = (A_1^0, A_2^0)$, $A_{01} = (A_1^0, A_2^1)$, $A_{10} = (A_1^0, A_2^0)$, $A_{11} = (A_1^1, A_2^1)$ be spaces with mixed metric [1].

Let $\sum A = A_{00} + A_{01} + A_{10} + A_{11}$. For $f \in \sum(A)$ and $t > 0$ we define the Petre functional $K(f,t)$ by formula

$$K(f,t) = K(f,t;A_{00},A_{11}) = \inf_{f=f_{00}+f_{01}+f_{10}+f_{11}} \left(\|f_{00}\|_{A_{00}} + t_1\|f_{10}\|_{A_{10}} + t_2\|f_{01}\|_{A_{01}} + t_1t_2\|f_{11}\|_{A_{11}}\right),$$

where $\|f_{11}\|_{A_{11}} = \left\|\|f\|_{A_1^1}\right\|_{A_1^2}$, $\|f_{00}\|_{A_{00}} = \left\|\|f\|_{A_0^1}\right\|_{A_0^2}$, $\|f_{10}\|_{A_{10}} = \left\|\|f\|_{A_1^1}\right\|_{A_0^2}$, $\|f_{01}\|_{A_{01}} = \left\|\|f\|_{A_0^1}\right\|_{A_1^2}$.

Let $1 \le \overline{q} = (q_1, q_2) \le \infty$, $\overline{\phi}(t) = \left(\phi_1(t), \phi_2(t)\right) \ge 0$, $t = (t_1, t_2) > 0$. The space $A_{\overline{\varphi},\overline{q}} = (A_{00}, A_{11})_{\overline{\varphi},\overline{q}}$ are set of all elements for which the following norm is finite

$$\|f\|_{A_{\overline{\varphi},\overline{q}}} = \left(\int_0^\infty \left(\int_0^\infty \left(\frac{K(f,t_1,t_2;A_{00},A_{11})}{\phi_1(t_1)\cdot\phi_2(t_2)}\right)^{q_1} \frac{dt_1}{t_1}\right)^{\frac{q_2}{q_1}} \frac{dt_2}{t_2}\right)^{\frac{1}{q_2}}.$$

We define anisotropic Lorentz spaces as follows:

$$\Lambda_{\overline{q}}(\overline{\varphi}) := \left\{ f: \quad \left(\int_0^{+\infty} \left(\int_0^{+\infty} (f^{*_1*_2}(t_1,t_2)\phi_1(t_1)\phi_2(t_2))^{q_1} \frac{dt_1}{t_1}\right)^{\frac{q_2}{q_1}} \frac{dt_2}{t_2}\right)^{\frac{1}{q_2}} < \infty \right\},$$

where $\boldsymbol{f^{*_1*_2} = f^{*_1*_2}(t_1, t_2)}$ is the nonincreasing permutation of a function $\boldsymbol{f}$ [1]. The paper [2] studies one-dimensional generalized Lorentz spaces.

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ON CONCAVE FUNCTION INEQUALITIES FOR MATRICES OF τ MEASURABLE OPERATORS

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Keywords: normal operator, submajorization; semifinite von Neumann algebra

Let $(\mathcal{M},\tau)$ be a semi-finite von Neumann algebra, $L_0(\mathcal{M})$ be the set of all τ-measurable operators and $\mu_t(x)$ be the generalized singular number of $x \in L_0(\mathcal{M})$. We proved that if $g:[0,\infty) \to [0,\infty)$ is an increasing continuous function, then for normal operators $x_1, x_2, \cdots, x_n$ in $L_0(\mathcal{M})$,

$$\mu(g(|\sum_{k=1}^{n} x_k|)) \leq \mu(g(\sum_{k=1}^{n} |x_k|))$$

holds. As application, we obtained that if x is a matrix of normal operators x_{ij} in $L_0(\mathcal{M})$ and $f:[0,\infty) \to [0,\infty)$ is a concave function, then $\mu(f(|x|))$ is majorized by $\mu(\sum_{i,j=1}^{n} f(|x_{ij}|))$.

Theorem 1. Let $x_1, x_2, \cdots, x_n \in L_0(\mathcal{M})$ Then

$$\mu_t(|\sum_{k=1}^{n} x_k|) \leq \mu_t\begin{pmatrix} \sum_{k=1}^{n} |x_k^*| & 0 \\ 0 & \sum_{k=1}^{n} |x_k| \end{pmatrix}, \qquad t > 0.$$

Theorem 2. Let $x = \sum_{i=1,j=1}^{n} e_{ij} \otimes x_{ij} \in L_0(\mathbb{M}_n(\mathcal{M}))$. If $f:[0,\infty) \to [0,\infty)$ is a concave function, then

$$\mu(f(|x|)) \preccurlyeq \mu\begin{pmatrix} \sum_{i,j=1}^{n} f(|x_{ij}^*|) & 0 \\ 0 & \sum_{i,j=1}^{n} f(|x_{ij}|) \end{pmatrix}.$$

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СЕКЦИЯ 7
Теориялық және қолданбалы механика

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СЕКЦИЯ 7
Теоретическая и прикладная механика

❖

SESSION 7
Theoretical and applied mechanics

IRSTI 41.03.02

LINEAR NON-AUTONOMOUS DIFFERENTIAL EQUATIONS, DETERMINING SECULAR PERTURBATIONS OF EXOPLANETARY SYSTEMS WITH VARIABLE MASSES

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Keywords: dynamical evolution, canonical perturbation theory, variable masses, Poincaré variables, secular perturbations, evolutionary equation.

The study of dynamical evolution of exoplanetary systems is actual topic in astrodynamics and in celestial mechanics. For today, more than 3,700 confirmed exoplanetary systems are known [1], and this list is growing rapidly. Researching of dynamics of exoplanets in the non-stationary stage of its formation gives us the opportunity to determine further evolutionary tracks. The influence of the variability of the masses of celestial bodies is explored on the dynamic evolution of planetary systems, considering that the masses of bodies change isotropically with different velocities.

The problem of many bodies is considered in a relative coordinate system, with assuming that the most massive body - the parent star is located at the origin of this coordinate system. All *n* bodies in the system will interact with each other according to Newton's law. Orbits of *n* planets around the parent star are quasi-elliptical and we believe that they do not intersect. Bodies are considered spherically symmetrical with isotropically varying masses. We consider the laws of the masses to be known and arbitrary functions of time. Differential equations of motion of *n* bodies in the relative coordinate system are given in the works [2-3]. The methods of canonical perturbation theory are used here, which developed on the basis of aperiodic motion over a quasi- canonical section [4] in analogues of the second Poincaré system of variables. The obtained canonical equations of perturbed motion [5] are most convenient for describing the dynamic evolution of planetary systems in the case when analogues of eccentricities and analogues of inclinations of the orbital plane are small enough. The non-resonant case is researched. The Wolfram Mathematica package is used in the expansion of perturbing functions into series. Since we are interested in the evolution of orbital parameters over long periods of time, short-period perturbations associated with the orbital motion of bodies should be eliminated by averaging the perturbation functions by mean longitudes. As a result, we get the secular parts of perturbing functions. Secular perturbations of eccentric and oblique elements are defined as solutions of a system of *4n* linear differential equations.

As an example, we consider the two-planet exosystem *HD 106315* (spectral type *F5 V*) [6] in the non-stationary stage of its evolution. To find secular perturbations, it will be necessary to solve a system of 8 linear non-autonomous differential equations. The obtained equations of secular perturbations are studied by the numerical method.

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TWO SPHERICAL BODIES WITH NON-ISOTROPICALLY VARYING MASSES IN THE PRESENCE OF REACTIVE FORCES

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Key words: two-body problem, variable masses, reactive force, perturbation theory.

Real celestial bodies are unsteady, their masses, sizes, shapes and structures change in the process of evolution. The consequences of the variable masses of celestial bodies, especially during the nonstationary stage of the gravitational system are poorly studied [1, 2].

We considered gravitational system consisting of two spherical celestial bodies with variable masses in the relative coordinate system with the origin in the center of the more massive body. The masses of the bodies decreases due to the separating particles and increases due to the joining (sticking) particles. In this case, in general, the relative velocity of separating particles from the body differs from the relative velocity of joining (sticking) particles to the body. The general case where the body masses do not change isotropically at different rates, in the presence of reactive forces, was studied.

The derived equations of motion of the two-body problem with variable masses in the presence of reactive forces are generally very complicated. Therefore, we investigated the problem by perturbation theory based on aperiodic motion along the quasi-conic section developed for such nonstationary gravitating systems [2, 3]. To study our problem of two bodies with variable masses varying non-isotropically at different rates in the presence of reactive forces in the relative coordinate system, we used the perturbed motion equations in Newton form [4]. In the dynamics of gravitationally-bound systems, during the evolution, the perturbed analogue of the eccentricity of aperiodic motion along the quasi-conic section remains less than unity $e(t)<1$ for a long time. In this case it is convenient to use the following system of oscillatory elements *a, e, i,* π , Ω , λ . Here *a, e, i,* π , Ω , λ are analogs of Keplerian dynamic elements, *a* - analog of the semi-major axis, *e* - analog of eccentricity, *i* - analog of orbit inclination to the plane, π - analog of pericenter longitude, Ω - analog of ascending node longitude, $\lambda = M + \pi$ - analog of mean longitude in the orbit. The obtained equations of perturbed motion, in the form of Newton's equations, in various systems of osculating variables can be effectively used in the study of the dynamics of nonstationary gravitational systems.

Averaging over the mean longitude, we obtained evolution equations of the two-body problem with variable masses in the presence of reactive forces, which are quite simple, easy to calculate.

From the equations for the analogue of the semi-major axis and eccentricity we obtained the exact analytic integral, which has a very simple form $a^3 e^4 = const$.

The derived evolution equations of the two-body problem with variable masses in the presence of reactive forces will be used to study binary systems with variable masses.

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DEVELOPMENT OF HYDROGEOLOGICAL MODELS IN REACTIVE TRANSPORT

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Keywords: in-situ leaching, uranium extraction, hydrodynamic model, key performance indicators, aquifer effect

The article explores the possibility of using HYTEC technology for Katko uranium deposits. The goal is to understand and simulate the physical and geochemical processes occurring during the development of the Muyunkum deposit by the acidic ISR method. This understanding requires detailed identification of these processes, and then prioritization of their contribution (phenomenology).Its main value is to ultimately provide better control of production costs for the operator.

Uranium In Situ Recovery (ISR) is the first uranium mining technique worldwide. It consists in the dissolution of the ore by a mining solution, directly in the deposit. By predicting fluid flow and geochemical reactions in the reservoir, reactive transport simulation is a powerful tool to better understand and pilot ISR uranium production. This paper illustrates the robustness of HYTEC, a coupled reactive transport software, and its added value for the operators.

The purpose of the work is to build a hydrodynamic reservoir model for prediction of zones with the highest concentration of residual oil reserves, and automation of the wells using a script. The relevance of the topic lies in the adaptation and prediction of the three horizons. The hydrodynamic models include a set of available geological, geophysical and field data. This makes it possible to trace in dynamics the depletion of residual hydrocarbon reserves, to forecast oil production more accurately, to model geological and engineering operations (GTM) to enhance oil recovery and field efficiency, to calculate more reasonably the most rational and economically efficient options for developing productive reservoirs. Also with the help of hydrodynamic models it is possible to design wells and determine their potential productivity

Acidification is a simple method to speed up the recovery. Based on the model of Kanzhugan reservoir (M6/M5) done by GEOS department, simulations on HYTEC were performed to evaluate an efficient way of producing blocks in this reservoir. In that study, only the impact of acid was varied and studying. The exercise was done on few blocks with different morphology, gross rock mass (GRM) and reserves of U to understand impact of geology on the acidification process.

As a result of the study, the most effective method of acidification was determined.

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NUMERICAL STUDY OF THE AERODYNAMICS OF HIGH-RISE BUILDINGS

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Keywords: turbulent currents, Reynolds number, wind flow, pressure, Ansys R2022

This paper presents the results of a study using the method of quantifying the process of wind flow of three mutually located high-rise buildings, the geometry of which is a prism. The aerodynamic environment of the pipeline was built in the Ansys Fluent software package. During the numerical experiment, the influence of factors such as the geometry of buildings, the initial wind speed, and the Reynolds number was taken into account.

A 3D model of buildings was first built on the Ansys Fluent platform, and in the course of an experimental study, the process of air flowing through buildings at three different speeds was implemented by conducting a quantitative study:

1. $v = 5m/s$;
2. $v = 10\ m/s$;
3. $v = 15\ m/s$.

It was established how effective the experience was. After three different speeds and times were given, the effect of speed on the building was studied, the maximum and minimum values of speed and pressure were determined. According to the results obtained, it was found that when nearby buildings flow at different speeds, a wind vortex occurs between buildings located at a distance of 10 m. In addition, suction zones were clearly visible behind the buildings.

It was found that vortices caused by an increase in the height of buildings and an increase in wind speed pose a danger to nearby objects in the area. In the report, the data obtained during the quantitative experimental study are presented in tables and depicted in the form of graphs.

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EXPERIMENTAL STUDY OF OIL REMEDIATION IN A POLLUTED POROUS MEDIUM BY DISPLACEMENT WITH A SURFACTANT

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Keywords: porous media, fluid flow, filtration, remediation, non-aqueous phase liquids

The active development of the oil production industry and, as a result, the production, transportation and consumption of all oil and petroleum products have led to a global deterioration in the environmental situation. Due to the leakage of oil from oil storage tanks and oil spills during transportation, underground oil depots are one of the main pollutants of soil and groundwater.

Non-aqueous phase liquids (NAPL) are widely used as solvents and fuels due to their special properties. However, some of those properties make it toxic and removal from soil and groundwater after spillage is problematic.

This paper presents the results of an experimental study of the remediation of a porous medium contaminated with anhydrous phase liquid of high density. In the course of the work, experimental ways of studying the treatment of groundwater contaminated with oil are considered.

As a non-aqueous phase liquids (NAPL) with a high pollutant density for a saturated porous medium in a tank filled with sand, oil and solvents consisting of a mixture of three different types of water and ethanol are used, which wash it away: 100%-Water, 0%-ethanol; 80%-water, 20%-ethanol; 50%-water, 50%-ethanol.

In the course of the experiment, sand was obtained as a porous medium, oil with a density of $1040\text{kg}/m^3$ as a pollutant. The solvent was injected into a porous medium at high speed. In the first experiment, when performing a displacement test only with water, the mobilization of the pollutant along the porous medium was not strongly observed. In the process of rinsing with the second 20% ethanol solvent, it is observed that the oil slowly melts and begins to shift. During a high-speed test with a 50% ethanol solution, it is seen that the contaminant is relatively actively dissolved, forming a significant part of the resulting emulsion.

It was determined how effective the conducted experiment was. According to the results obtained, the most effective way to clean the environment contaminated with dense non-aqueous phase liquid (DNAPL) is to wash it with 50% ethanol solution.

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ЛАСТАНҒАН КЕУЕКТІ ОРТАДАҒЫ МҰНАЙДЫ БЕТТІК БЕЛСЕНДІ ЗАТПЕН ЫҒЫСТЫРУ АРҚЫЛЫ РЕМЕДИЦИЯЛАУДЫ ТӘЖІРИБЕЛІК ЗЕРТТЕУ

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Мұнай өндіру саласының белсенді дамуы және соның салдарынан мұнай және мұнайдан жасалатын барлық өнімдерді өндіру, тасымалдау және тұтыну экологиялық жағдайдың әлемдік тұрғыда нашарлауына әкеліп соқты. Мұнайды сақтау резервуарларынан мұнайдың ағып кетуіне және тасымалдау кезінде мұнайдың төгілуіне байланысты жерасты мұнай базалары топырақ пен жер асты суларының негізгі ластаушыларының бірі болып табылады.

Сусыз фазалық сұйықтықтар (NAPL) ерекше қасиеттеріне байланысты еріткіштер және жанармай ретінде кеңінен қолданылады. Алайда, сол қасиеттердің кейбіреулері оны улы етеді және төгілгеннен кейін топырақ пен жер асты суларынан шығару қиындық тудырады.

Бұл жұмыста тығыздығы жоғары сусыз фазалық сұйықпен ластанған кеуекті ортаның ремедиациясын тәжірибелік зерттеу нәтижелері баяндалады. Жұмыс барысында мұнаймен ластанған жер асты суларын тазартуды зерттеудің тәжірибелік жолдары қарастырылады.

Құммен толтырылған резервуардағы қаныққан кеуекті ортаға ластаушы зат тығыздығы жоғары сусыз фазалық сұйықтық (NAPL) ретінде мұнай және оны шайып өтетін үш түрлі су мен этанолдың қоспасынан тұратын еріткіштер пайдаланылады: 100%-су, 0%-этанол; 80%-су, 20%-этанол; 50%-су, 50%-этанол.

Эксперимент барысында кеуекті орта ретінде құм, ластағыш зат ретінде тығыздығы $1040 кг/м^3$ болатын мұнай алынды. Еріткіш жоғары жылдамдықта кеуекті ортаға енгізілді.

Бірінші тәжірибеде тек сумен ығыстыру сынағын жүргізу кезінде кеуекті орта бойымен ластағыш заттың мобилизациясы қатты байқалмады. Екінші 20% этанол еріткішімен шаю барысында мұнай баяу еріп, ығыса бастағаны байқалады. 50% этанол ерітіндісімен жоғары жылдамдықпен шайы өту сынағы кезінде ластағыштың салыстырмалы түрде белсенді еріп, пайда болған эмульсияның едәуір бөлігін құрайтындығы көрінеді.

Жүргізілген тәжірибенің қаншалықты тиімді екендігі анықталды. Алынған нәтижелереге сай, тығызыдығы жоғары сусыз фазалық сұйықпен (DNAPL) ластанған ортаны тазартудың тиімді жолы 50% этанол ерітіндісімен жуып өту екендігіне көз жеткізілді.

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ТАСЫМАЛДАУ КОНТЕЙНЕРІНЕН ЖҰМЫС КОНТЕЙНЕРІНЕ МИКРОБҰЙЫМДАРЫН ҚАЙТА ТИЕУ КЕЗІНДЕГІ РОБОТ-МАНИПУЛЯТОРДЫҢ ИННОВАЦИЯЛЫҚ ҰСТАҒЫШЫНЫҢ МОДЕЛІ

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Түйінді сөздер: роботтық кешен, манипулятор, шамадан тыс жүктеме, микроатылым, өсімдіктердің микрокөбейтілуі, ұстау күші.

Бұл мақалада өсімдік микроөсірулерін in vitro тасымалдау контейнерінен топырақпен жұмыс істейтін контейнерге олардың микрокөбейту кезінде топырақта бейімделу сатысында жылжытуға арналған қысқышы бар инновациялық роботтың құрылымдық элементтерінің параметрлерін анықтау моделі ұсынылған.

Зерттеудің ғылыми-тәжірибелік нәтижесі өсімдіктердің микро өсінділерін тасымалдау контейнерінен in vitro жағдайында топыраққа бейімделу кезеңінде топырақпен жұмыс істейтін контейнерге ауыстыруға арналған фалангты ұстағышы бар манипуляциялық құрылғының инновациялық роботтық кешенін құру болып табылады. Микроклондық көбею және оның физикалық прототипін сынау 3000 дана сүректі микроөркендерді бейімделген, топырақта тамыры бар өсімдіктер. Алынған зерттеу нәтижелері Қазақстан Республикасындағы ғалымдардың ғылыми-техникалық әлеуетіне және бәсекеге қабілеттілігіне әсер етеді. Қазақстан Республикасында оларды көптеп өндіру үшін өсімдіктерді микроклондық көбейту технологиясын автоматтандыруға байланысты зерттеулер жоқ, оларды қолдану өсімдіктердің көп мөлшерін алуға, отырғызу материалдарының құнын төмендетуге мүмкіндік береді. Сондай-ақ, инновациялық роботтық кешен бойынша зерттеулердің практикалық нәтижелері Қазақстан Республикасының елді мекендерін абаттандыру үшін басқа елдерден ағаш өсімдіктерінің отырғызу материалдарының импортын қысқартуға мүмкіндік береді.

Осыған байланысты ағаш тектес өсімдіктер үшін отандық жоғары сапалы отырғызу материалына деген қажеттілік артады. Қазақстан Республикасының елді мекендерінің аумақтарын көгалдандыру мәселесін шешудің түбегейлі шешімдерінің бірі ағаш тектес өсімдіктерге олардың микроклондық көбеюі арқылы отандық жоғары сапалы отырғызу материалын алу болып табылады.

Роботтар қатысатын ауылшаруашылық міндеттері әртүрлі, бірақ оларды топырақ дайындау, тұқым себу, трансплантациялау, егу, дәл ұрықтандыру, кесу, жапырақты алу, обаны анықтау, жинау, кесу, егінді жою және егін жинаудан кейінгі жұмыстарға топтастыруға болады.

Ауылшаруашылық циклінің негізгі кезеңдері топырақ дайындау, отырғызу, өндіру және жинау болып табылады. Олардың әрқайсысында сіз кейбір тапсырмаларды орындауыңыз керек, олардың кейбіреулері робототехникаға ашық.

Тұтқыштың жұмыс элементтерінің санының ұлғаюы жұмыс элементінің жанасу аймағында деформация мен кернеудің болмауы жағдайында үлкен диаметрлі сақинаны ұстау күштерінің рұқсат етілген мәндерінің ауданын кеңейтуді береді. Сондықтан, бұл зерттеуде өсімдік микробұйқасының сақиналы құрылымдық элементін түсіру жағдайлары фалангалы ұстағыштың жұмыс элементінің ішкі бетінің өсімдік микробұйқасының сыртқы бетімен жанасуының төрт, алты және сегіз нүктелерінде қарастырылады. [5-6]-да жұқа қабырғалы сақинаның ұстау күшінің максималды және ең аз рұқсат етілген мәндерін есептеуге арналған келесі формулалар тұтқаның сенімділігін қамтамасыз ету шарттарынан және серпімді ығысу мәндерінің шамалылығынан негізделген.

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СЕКЦИЯ 8
Ғарыштық технологиялар және робототехникалық жүйелер

❖

СЕКЦИЯ 8
Космические технологии и робототехнические системы

❖

SESSION 8
Space technologies and robotic systems

DEVELOPMENT OF A PARKING SENSOR DESIGN USING AN ULTRASONIC DEVICE FOR A CAR

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Keywords: parking sensor, parkronik, ultrasonic, device, car.

The modern technological process creates all the necessary conditions for motorists to help them solve any tasks facing them. Such new solutions, designed to simplify the task of safe movement, include parkronik. The main part of the parkronics is special sensors installed in the front and rear of the car. The basic principle of this device is to generate signals that reflect various objects and return them to their original state. At the time of Signal Return, you can calculate at what distance the obstacle is located. Parkronik informs the driver that the distance between the car and the obstacle is decreasing.

Parking sensors (also called parking radars) are special equipment that warns the driver of a danger or obstacle on the road, whether it is a large stone, curb, fence or other vehicle. It is also used by students who study the art of safe parking. Parktronic has a different functional orientation. As a rule, the use of parking spaces increases the comfort of using the vehicle, as well as ensures the safety of the car and the safety of its owner. Parking sensors allow you to more accurately control the process of moving the car in close proximity to possible obstacles, for example, when parking in reverse, in other narrow or flooded spaces.

Considering the huge advantages of parking sensors, I also thought about creating a device with a parking sensor. Considering the possibilities available to me, I decided to design the project in the Arduino electronic constructor.

Ultrasonic sensors are mounted on the bumper of the car, and the directional nature of the emitters allows you to form the necessary sensitivity zone. The initial systems had separate emitting and receiving sensors, which were subsequently used to transmit and receive a single piezoelectric element. The high cost of electronics initially led to mechanical scanning of the rear hemisphere using a single sensor. Today, the sensors are mounted permanently, and the absence of dead zones is achieved by installing several sensors. The simplest systems use two sensors. The most common systems use 4 sensors located on the rear bumper at a distance of 30-40 cm from each other. This arrangement of sensors avoids the appearance of "dead zones". In more complex systems, 2 or 4 sensors are installed on the front bumper. Unique systems can use various sensors, as well as sensors located on the side of the car.

Externally, many models of parking sensors are very similar, but they can perform different functions. Choosing this equipment, it is necessary to remember about its main purpose - to provide all conditions for comfortable parking of the car without any obstacles. The options for installing parking sensors depend on the driving experience of the motorist, as well as on his individual needs in terms of parking convenience.

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APPROACH TO MUDFLOW HAZARD PREDICTION AS A RESULT OF CHANGES IN SNOW COVER AND ACTIVE SNOWMELT IN MOUNTAINOUS AREAS BASED ON THE APPLICATION OF REMOTE SENSING TECHNOLOGY

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Keywords: Satellite imagery, Remote sensing data, Precipitation, Hydrological model, Geographic information systems, drone, emergency

The ability to find constructive solutions to prevent emergencies in mountainous terrain will contribute greatly to the management of the field of emergency forecasting. One of such solutions is to find solutions using remote sensing and GIS, as well as the use of digital twin projects. Nowadays, the study of emergencies, forecasting is very important. The occurrence of each emergency in its own way adversely affects the inhabitants of settlements at risk of emergency [1].

Drone imagery and satellite geodetic work, make it possible to determine the regions of Kazakhstan where emergencies may occur. Of course, it is impossible to fly over the entire territory of the Republic of Kazakhstan by drone, but in this matter, we resort to satellite imagery. The essence of the solution is to find a relevant method and do the necessary analysis.

The method of extracting high-precision DEM (digital terrain models), point clouds, 3D models, orthophotomaps, topographic maps from satellite images with high accuracy can get accurate research results in this direction [2].

Disaster prevention is one of the important applications of remote sensing. Natural disasters, climate change and anthropogenic factors can complicate the work of disaster prevention and mitigation teams. With the help of remote sensing, professionals can better prepare and act faster and more accurately [3]. This can save many lives, reduce property damage, and reduce the time and money emergency departments need to do their jobs.

Flood risk modeling shows that cities, city governments, and emergency professionals can take prompt action to reduce flooding [4]. Landslide and avalanche monitoring provides a prediction before landslides occur and gives the public enough time to evacuate.

In carrying out this study, data from open sources were used.

The work identified a specific question of interest about the seasonality of snow cover in the study area and the statistical analysis needed to answer it.

The study area was defined by creating a shapefile to delineate it. A MODIS time series of snow cover products was downloaded from NSIDC, here this would be MOD10A1 or MOD10A2 (depending on the specific question of interest) [5].

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SOLVING THE PROBLEM OF TIGHTLY COUPLED INTEGRATION OF INERTIAL-SATELLITE NAVIGATION SYSTEMS COMPLETED WITH ODOMETER

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Keywords: tight integration, inertial-satellite navigation systems, odometer, nonlinear Kalman filter, continuous-discrete filtering

At present, the leading companies developing and manufacturing integrated navigation systems around the world are actively engaged in the task of close integration of inertial and satellite navigation systems. The task of close integration of inertial (INS) and satellite navigation systems (SNS) arises during the construction of advanced navigation systems, as well as to ensure the functioning of coarse (for example, on MEMS-sensors), redundant INS. A distinctive feature of the task of close integration is the possibility of obtaining integrated solutions when the number of visible navigation satellites is small, when autonomous positioning and velocity satellite navigation solutions are not possible [1,2].

Currently, the development and creation of high-precision positioning systems for moving objects is one of the most important problems in ensuring traffic safety for all types of transport. One of the most promising ways of solving it is close integration of navigation information from SNS with measurements of free inertial navigation system (BINS) of the moving object. At the same time, the development of modern algorithms of integration of inertial-satellite NS implies the use of only linearized equations of BINS (the so-called "error equations") and linearized measurements of SNS, adequate to the real motion only for small time intervals [3], which, in turn, imposes fundamental restrictions on the time of autonomous motion of the object (when the satellite measurement signals disappear).

In this connection there is a problem of developing such an approach, which would allow to solve the problem of close integration of inertial-satellite navigation system in the most general case - without assumptions about the magnitude and nature of measurement errors, about the trajectory of the object, etc., and provided a possibility to generalize.

The obtained results and numerical estimates allow us to conclude both about the theoretical solution of the problem of close integration of the SNS and BINS with the use of other external meters (odometers), and about the possibility of effective practical use of the proposed approach.

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СЕКЦИЯ 9
Білім берудегі жаңа ақпараттық технологиялар

❖

СЕКЦИЯ 9
Новые информационные технологии в образовании

❖

SESSION 9
New information technologies in education

ONTOLOGICAL ENGINEERING FOR STEM EDUCATION IN SCHOOL

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Keywords: STEM, knowledge, school, ontology, ontological engineering, competencies, knowledge base.

The Head of the State Kassym-Zhomart Tokayev emphasizes the need for digitalization of all spheres of life and continuous education of students in the State Program for the Development of Education and Science of the Republic of Kazakhstan for 2020-2025 and in the State Program "Digital Kazakhstan". Digitalization of all spheres of life and economy of Kazakhstan will allow to take leading positions on the global arena and to enhance the quality of life the population and to create favorable conditions for development of entrepreneurship. Digitalization of the education system is not only creation of digital copies of the educational material, digitalization of document flow, and provision of access to high-speed Internet. This is a change of the very approach to teaching schoolchildren, to the content and methods of teaching.

Special attention is currently paid to education in the Republic of Kazakhstan, new approaches are used, and the education system is digitalized. Therefore, it is necessary to develop digital skills in children for further development of their learning skills and personal growth. Schoolchildren need to develop in various key academic fields such as science, mathematics, technologies, and engineering, i.e. in line with STEM, a new education trend [1, 2]. The article discusses a project-based learning method and its application for STEM-education. It determines advantages and ontological engineering stages for STEM-education [3-10]. The article considers development of the ontological model "STEM-education in school". It presents an ontology "STEM-Education in School" generated in Protégé 4 editor that contains necessary classes, relations, properties, and persons involved in the school education process. There are requirements to this ontology. A hierarchy of classes and fragments of the generated ontology are presented.

Enhancement of school education quality can be achieved through the use of the STEM-approach and semantic description of the knowledge about the subject area with the use of ontological engineering methods. Filling of the ontology with actual data of a school will allow creating a comprehensive database of the school. This approach will help to improve efficiency of lesson plan development with the use of the STEM-approach and the learning content.

Currently, professions appear at the confluence of technologies and natural sciences. Implementation of STEM-education from school time will help schoolchildren to adapt themselves more easily in obtaining higher education and future profession. Promotion of STEM-literacy in students will help them to be in demand and able to meet competition in the labour market.

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INTERNET TECHNOLOGIES FOR MANAGING GREENHOUSE COMPLEXES ON THE BASIS OF ENERGY CONSERVATION

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Keywords: energy saving, greenhouse, management, technology.

It is obvious that life is directly related to energy and its consumption. At present, energy conservation has become important because of energy shortages, significant increases in energy prices, and the growing importance of environmental issues such as global warming, ozone depletion, and climate change. Renewable energy technologies are widely seen as reducing global energy costs, in which fossil fuels still dominate, and reducing greenhouse gas emissions through clean energy production. However, recent reports clearly show that renewable energy can provide only 14% of total energy demand. Additional stringent measures are therefore needed to effectively reduce global energy consumption and to stabilize carbon emissions urgently.

Energy saving strategies are important for all types of sectors-from transportation to buildings. However, it can be said that this scenario is much more important for the greenhouse sector, as they currently play an important role in total energy consumption. The growing energy demand in the greenhouse sector is becoming a major challenge to ensure a stable crop. Conventional facade materials used in greenhouse structures currently have thermal insulation properties, so 20-40% of the energy consumption in a conventional greenhouse depends on the greenhouse envelope . The most common facade materials considered in greenhouses are glass polyethylene, semi-rigid plastic and polyethylene film. In addition to insufficient thermal resistance values, which create a significant heating requirement in winter, conventional facade materials have very high shading coefficients, resulting in a significant increase in solar heat in summer, which also plays an important role in greenhouse cooling.

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ONTOLOGICAL ENGINEERING TO DETERMINE REVEAL INTER-SUBJECT RELATIONS BETWEEN MATHEMATICS AND COMPUTER STUDIES

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Keywords: knowledge, school, ontology, ontological engineering, competencies, knowledge base.

The state program for the development of education and science of the Republic of Kazakhstan for 2020-2025 provides for enhancement of the education system and development of the interdisciplinary approach.

In recent years, the school educational process has been actively improved according to current requirements. The substance of computer studies in school has changed. It has become necessary to introduce interdisciplinary approach in education. Therefore, students, from the school-time, must prepare for life and professional activity in the information environment and opportunities of obtaining higher education with the use of modern information technologies.

Implementation of the interdisciplinary approach helps building a comprehensive understanding of natural phenomena and relationships between them, i.e. the knowledge becomes more substantive and can be used in practice. The ontologies for higher educational institutions are developed in the Republic of Kazakhstan. The school ontologies are relevant but not comprehensively developed [1-9].

The article offers an approach to generation of a conceptual model of the curriculum content for schoolchildren in form of a thesaurus and ontology which will allow using an adaptive collation and ordering of teaching information. The article discusses the possibility and experience of using ontological modeling and engineering for the conceptual description of school teaching. It contains description of the stages of building an ontological model of the subject area using interdisciplinary relation between mathematics and computer studies as an example. The article contains examples of classes and individuals of the school educational process and relations between them. It discusses advantages of ontological modeling of a subject area.

Development of the ontological model and entering data into the school database can help to identify interdisciplinary relationship between mathematics and computer studies. The database can be replenished with necessary data on an ongoing basis to keep the school data up-to-date. The application of ontological engineering methods will help to enhance the quality of school education due to semantic description of the subject area knowledge with the use of interdisciplinary approach in teaching.

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METHODOLOGICAL BASES OF TEACHING 3D MODELING IN INSTITUTIONS OF ADDITIONAL EDUCATION

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Keywords: 3D modeling, technology, communication, visualization, information, animation, design.

In the modern world, education is considered as the main factor of stability and development of society. In the new model of progressive development of society, the leading direction will be the development of the quality of human capital (education, professionalism, morality, culture), as well as the quality of education systems [1].

The use of 3D modeling and animation in education provides teachers with new learning tools. These tools help students easily perceive educational material, increase their motivation, and quickly master a large amount of knowledge. In fact, 3D helps to gain experience in several subjects, which makes it necessary for teachers to use new technologies to introduce modeling into the educational process [2].

Education:

Formation of an idea of the basics of 3D modeling;

* Master the basic tools and operations of working in an online 3D modeling environment;
* Study of the basic principles of building three-dimensional models;
* Create models of objects, parts, and assembly structures.

A necessary condition for the implementation of the course is the use of the methodology of project activities with children. The result of the course is the final draft of the 3D model presented in the final lesson.

Expected results:

After completing the course "fundamentals of 3D modeling" at Twinmotion, students should master modeling skills in the Twinmotion environment.

Conclusion:

* Knowledge of the basic principles of three-dimensional design;
* Mastering the skills of creating 3D models;
* Possess planning skills.

Mastering modern knowledge is a successful work in many types of practical and theoretical activities closely related to the management of spatial images. Ideas created on the basis of 3D models have a different psychological character than those created on the basis of the perception of visual images of certain objects.

Technical achievements and social changes in the world engineering service impose new requirements on education.Effective assimilation of educational information, the possibility of practical application in development require an understanding of graphic images of technical objects and processes, the ability to navigate modern technical systems.

The inclusion of the study of the basics of 3D modeling in the general educational process outside of educational activities opens up wide opportunities for students to create fundamentally new products of labor, mastering new peaks in the study of modern technologies. Students gain practical knowledge in the field of modeling and parametric design, develop their own engineering and technical projects, develop engineering and technical abilities and ensure their competitiveness in professional areas of technical orientation. The development of a program for such a course is an urgent need due to rapidly developing, rapidly changing technologies [3].

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TEACHING GEOGRAPHY IN AN INTERACTIVE EDUCATIONAL ENVIRONMENT: OPPORTUNITIES AND DIDACTICS

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Keywords: training, educational environment, interactive teaching methods, geographical education, geographical literacy, interaction, communication.

The article examines the possibilities of interactive education, which is a complex content and didactic system, including interactive strategies, interactive technologies and interactive methods. The purpose of interactive learning is to develop students' interpersonal communication skills. Interactive learning is carried out through interaction and dialogue between participants in the process and between students.

The philosophical foundation of interactive strategies is based on socio-cultural theories of learning, in which constructivism, research approach and cognitive reflection are interrelated and play a priority role. At the same time, the new paradigm, the philosophical basis of which is constructivism and humanitarian education, determines the change in the educational environment, including the argumentation of educational goals and objectives – the teaching methodology (from monologue to dialogue), the change in educational technologies (from stimulus response to interaction), the change in pedagogical dialogue and interaction between teacher and student.

Interactive method means a method of teaching, teaching and learning, which includes methods of interaction of communicators, between them and with the teacher. The essence of interactive teaching methods is based on obtaining new cognitive experience in the process of active and well-organized productive interaction with each other, with teachers, with computers, with nature and with various sources of information on geographical problems of our time.

In our understanding, interactive methods are considered as procedures, systematic methods containing a sequence of common actions to achieve a certain goal in a certain scientific field, in this case in geography.

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DIDACTIC POSSIBILITIES AND ADVANTAGES OF USING THE GOOGLE EARTH PROGRAM IN GEOGRAPHY LESSONS

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Keywords: Google Earth program, geographic information system, spatially oriented learning, spatial analysis, cartographic service, digital atlases, geographical thinking

The article discusses the didactic possibilities and advantages of using the Google Earth learning platform in geography lessons. In accordance with the standard curricula in the subject area of geography, a number of educational goals in the field of information literacy and the use of information skills to achieve subsequent educational goals are provided in grades 7-11 of secondary schools in Kazakhstan.

Geography, as a school discipline, attaches great importance to educational resources and technologies. Thus, geoinformation systems (GIS) with its emphasis on the processing and analysis of digital information can make a significant contribution to the unification of a number of school disciplines that consider spatial trends and elements of the geographical environment. Despite these advantages and didactic opportunities, GIS is still underutilized as an educational technology. Among the many platforms, the Google Earth program can be noted, although it has limited spatial analysis tools compared to real GIS, but it can be effectively used when teaching geography on personal gadgets. It makes it possible to study spatial information and is convenient for students and teachers at all levels of education. Google Earth can also be used to solve problems in various training programs, helping them understand information in a spatial or geographical context.

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TRANSFORMATION OF THE MARKETING CONCEPT AS A RESULT OF THE DEVELOPMENT OF DIGITAL TECHNOLOGIES

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Keywords: digital marketing, innovative products, digital economy, digital marketing tools

Digital marketing is a marketing concept whose goals are achieved through the Internet, computer communication technologies and digital interactive media. Digital marketing uses advanced computer and network technologies to find new markets and new consumers, ensuring maximum economic efficiency.

Previously, digital marketing was considered as a form of individual communication with customers in certain areas of activity, but since 2003, the scale of its application has been increasing. Most forms of marketing in traditional areas (for example, direct marketing, targeted advertising) are switching to digital formats.

Digital marketing is not only a technological revolution, but also a deep conceptual revolution. It is a combination of targeted marketing, direct marketing, decentralized marketing, customer-oriented marketing, two-way interactive marketing, remote or global marketing, virtual marketing, paperless trading and customer-driven marketing. Digital marketing gives marketing a new meaning: its functions include information exchange, online purchases, online publications, electronic money, online advertising, corporate public relations, etc.[1]

In a competitive market, companies can only make normal profits, and if they want to make super profits, they must innovate. Innovation is a new combination of factors of production, which in the economic sense includes not only technological innovations, but also marketing innovations. Among them, digital marketing is a typical innovation.

Digital marketing is inextricably linked with the development of IT technologies. The spread of mobile technologies. Mobile terminals, collectively referred to as "mobile" communication functions, have spread around the world in an explosive way, creating an environment that "can be connected anytime, anywhere." This phenomenon has led to innovative changes in the consumer society. For example, you can use your smartphone to go online, see recipes on the bus and order the products you need for dinner on the Internet. [2]

Diversification of choice, fierce competition among the media. In traditional marketing, the source of customer information was the mass media. Over time, the power of the media has weakened, and the differences between the times have also increased. Currently, consumers' access to mass media has become diverse and takes a lot of time. For suppliers of products or services, such as media companies and advertisers, the so-called "competition of media contact time" is intensifying.

Data marketing collects a large amount of information from consumers, then analyzes and uses it to predict the likelihood that consumers will purchase a certain product, uses tags to accurately describe user images, and then implements personalized and accurate marketing. [3]

Word of mouth marketing is the most cost-effective and trustworthy marketing method, far surpassing the communicative effects of advertising in newspapers on television, outdoor advertising, brand sponsorship, online advertising, advertising using keywords for mobile video.

Digital marketing has many unprecedented competitive advantages: it is able to integrate various marketing activities, such as product description, promotion, customer opinion polling, advertising, public relations, customer service, etc. These marketing activities are not limited by time and geography, they are integrated with text, sound, video, web and audiovisual, dynamic or static display and can be quickly and easily updated, and consumers can also re-view requests.

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DEVELOPMENT OF A ROAD SIGN RECOGNITION SYSTEM

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Keywords: neural network, deep learming, machine learning

In the modern world, a mandatory attribute in the organization of traffic is road signs. They inform drivers about dangerous areas of the road, indicate the direction of movement, indicate dangerous roads where it is forbidden to drive, and oblige them to reduce speed, as well as perform many other useful tasks [1].

Road sign recognition systems are one of the most important tools in road traffic. It plays an important role in many issues, such as self-driving automated cars, traffic regulation, traffic control, accident prevention by warning drivers, warning about road structures and slippery conditions, etc. [2].

Every year, the number of cars in the world is growing dramatically. Driving in an ever-increasing traffic flow is becoming increasingly difficult. Currently, to solve the problem of road sign recognition, commercial closed systems have been developed and used, which are "assembled" by a car. Such systems include "Opel Eye" from Opel, "Speed limit assist" from Mercedes, and "Road sign information" from Volvo. However, most people will not be able to pay for the cost of such cars and, as a result, will not be able to use this technology. The above-mentioned hardware and software complexes are installed on the car as an option and cannot be changed. When analyzing the subject area, it was found that the existing systems mentioned above are not fully satisfied. The relevance of creating a road sign recognition system is due to the increased level of safety on public roads and the extreme importance of information containing road signs. When using the road sign recognition system, it is very important to accurately and timely identify road signs both in urban conditions and when driving on highways [3].

This work contributes as follows. First of all, achieving high-quality recognition of road signs based on modern in-depth training and avoiding mistakes. Secondly, the proposed deep learning algorithms for detecting and recognizing road signs based on multi-stage classification and providing high resistance to noise and various distortions in images.

Thus, this system helps to achieve high-quality recognition of road signs, which is based on in-depth training at the moment.

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WAYS OF DEVELOPING STEM EDUCATION IN KAZAKHSTAN'S SCHOOL

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Keywords: STEM, ethno-education, mathmodel, simulation

This article provides an overview of the international experience in the development of STEM education and provides a general overview of the advantages of implementation and the difficulties identified in the implementation of STEM education in our country. Currently, the STEM education system is actively developing as a direction, the main idea of which is the integration of natural sciences, technologies, modeling, art, mathematics, the usage of interdisciplinary and applied approaches.

At the same time, the main task of education is to develop students ' competencies based on an interdisciplinary, creative, project-based approach to learning. Analysis and study of sources of introduction and development of STEM education, the concept of STEM as a leading and new direction in modern education covers a wide range of psychological and pedagogical concepts and technologies.

The educational and methodological tool can be used for students, undergraduates of specialties "Chemistry", "Biology", who study methodological courses, in independent work tasks, in practical classes. The scientific heritage of Abu Nasr Al-Farabi (about 870-950 y.y.) is diverse and unusually large. He wrote more than 160 treatises in which he developed all known branches of knowledge. Many of the scientist's positions in the field of philosophy, sociology, logic, aesthetics, ethics, natural science had a great influence on the subsequent development of socio-philosophical thought of the peoples of the East and Europe. In this research paper, it is proposed to develop students' project thinking of an interdisciplinary nature. During the project training, parallels of analytical concepts from Al-Farabi's works on natural science will be used to develop students' scientific thinking. This article provides an overview of international experience in the development of STEM education and offers an example of analytical research by using digital technology of Al-Farabi's scientific works on music and poetry.

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