XIV International Conference "Stability and Oscillations of Nonlinear Control Systems"(Pyatnitskiy's Conference)

Abstracts

Plenary lectures

Input-to-State Stability of systems with Complex Dynamics

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The Input-to-State Stability framework allows studying several systems' theoretic concepts such as robust stability and stabilization, but also detectability and minimum-phase properties, for nonlinear systems subject to input disturbances. The original, simplest notion applies to systems defined on Euclidean space and globally asymptotically stable at the origin. We present recent extensions that allow much richer dynamical behaviors, such as oscillations, multi-stability, and systems defined on manifolds. Two approaches will be discussed and characterized, involving almost global stability notions or global attractivity. Remarkably the latest developments seem to allow a systematic extension of the tools developed for the classical case.

Lyapunov Functions of Discontinuous Systems

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The primary concern of the talk is a systematic construction of Lipschitz continuous (possibly, non-differentiable) Lyapunov functions of discontinuous systems with the focus on variable structure systems. To begin with, basic paradigms such as Filippov and Aizerman-Pyatnitskiy solution concepts as well as the equivalent control method are recalled with special attention to peculiar sliding and Zeno motions. Constructive Lyapunov functions are then introduced in terms of the augmented state vector which is composed not only of the original state components

but also of their fractional degrees. An explicit sufficient condition of such a Lyapunov function to possess a negative definite time derivative, computed along the system trajectories, is derived thereby ensuring the asymptotic stability of the underlying discontinuous system. Once the system is verified to be homogeneous of a negative degree, its finite time stability is additionally established. Arsenal of the proposed stability tools of discontinuous systems is illustrated with simple benchmark applications.

Analysis of Nonlinear Systems by the Localization Method

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The method of localization of compact invariant sets is proposed for the qualitative analysis of nonlinear systems. Using this method, a finite family of embedded localizing sets is constructed. The qualitative behavior of any trajectory is indicated outside the smallest localizing set. The sets that have a nonempty intersection with any compact invariant set of the system are found. The illustrative examples are given.

Road Map in the Control Theory. Mathematical Problems

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The lecture is dedicated to the general duality principle for the problems of control design and guaranteed estimation under wide range inputs from analytical functions to higher-order generalized pulses. Appropriate classes of mathematical problems are presented.

Plasma Control in Tokamaks

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Magnetic and kinetic plasma control in tokamaks is one of the

central fundamental challenges of theoretical and experimental study of thermonuclear fusion and a project of transition to the fusion power engineering. Some experience in application of plasma control systems for various thermonuclear installations in computer simulations and physical experiments was accumulated in V.A. Trapeznikov Institute of Control Sciences of the Russian Academy of Sciences. The beginning of this work was connected with suppression of plasma flute instability in experiments on the Ogra-3 open magnetic trap in Kurchatov Institute. Then the work was transferred to tokamaks. That led to the development of a series of control systems of various classes installed into physics experiments practice of tokamaks TO-1, T-7, T-10, TVD (Kurchatov Institute, Moscow), Tuman-3 (Ioffe Institute, S. Petersburg). Further, some work was done regarding design and simulation of plasma control systems for the projects of T-14 (TRINITI, Troitsk, Moscow region) and T-15 (Kurchatov Institute), ITER (France) as well as for the operating Globus-M spherical tokamak (Ioffe Institute). The survey on plasma control in tokamaks was issued in "Control Sciences" journal, 2018, No. 1-2. The operating tokamaks with vertically elongated cross-sections having the most advanced plasma control systems are shown in the presentation. The results of plasma control systems design for the projects of ITER and T-15 tokamaks as well as for the operating Globus-M tokamak are presented.

Optimal Motion Control for a Two-Body System

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Process of control for a planar motion of a two-body system is considered. The system consists of a rigid body and a point mass that interact with each other. Two time-optimal control problems for the system are stated, and their explicit analytical solutions are obtained.

Regular talks

Systems with Regime Switching on Manifolds

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We propose an extension of the stochastic dynamical systems whose trajectories belong to a given manifold. This extension is the stochastic systems with regime switching, namely the systems with a random structure (switching diffusions). The description and analysis problems for such systems are considered.

Motion Control of a Nonhomogeneous Rod with a Boundary Load

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In this paper, a hybrid vibrational system is considered. It consists of a transversally oscillating nonhomogeneous rod with a boundary load at the end, and distributed control is applied to the system. It is required to transfer the system from some initial state to the desired one without excitation of vibrations. We suggest to implement this motion with the help of slow finite control functions after preliminary damping of highest modes.

On the Triaxial Stabilization of a Rigid Body under an Evolution of Dissipative Torque

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The problem of triaxial orientation of a rigid body under the action of restoring and dissipative torques is considered. It is assumed that the dissipative torque evolves as time increases. Both the cases of unboundedly increasing and vanishing dissiparion are considered. Conditions are determined under which one can guarantee asymptotic stability of a programmed motion of the body dispite the evolution of the dissipative torque.

Construction of Lyapunov–Krasovskii Functionals for a Class of Nonlinear Difference Systems with Delay

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Nonlinear systems of difference equations with delay and nonlinearities of a sector type are considered. New constructions of Lyapunov–Krasovskii functionals are proposed. With the aid of these functionals, conditions guaranteeing asymptotic stability and ultimate boundedness of solutions of considered systems for any value of delay are obtained.

Optimum Control of One-dimensional Structures on Longitudinal Periodic Excitation

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The damping of one-dimensional structure's oscillations under the action of variable periodic excitation, which arises during the safety (emergency) braking of the mine rope, is considered. The speed-in-action problem of an object's control described by the Mathieu equation is solved under conditions of limited longitudinal control action. A numerical method for calculating the switching times of piecewise constant control under conditions of a stable mode of oscillation of the structure is proposed. Numerical examples of damping of the oscillations of a skip hoist with different number of control stages and a different direction of the control action are presented.

Control Problem for Evolutionary Systems with Incomlete Information

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In this paper, evolutionary control systems in Hilbert space are considered. The state of the system is unknown, but there is an equation of measurement in discrete times. The initial state and disturbances

are restricted by joint integral constraints. According to measurements, the informational set is introduced that contains the true state of the system. The preliminary aim of control consists in minimization of the terminal criterion depending of the informational set. We suggest some statements of the problem based on the separation of control and observation processes. The optimal instants of transition from estimation to control are looked for as well. The approach is applied to systems with the deviation of time of retarded and neutral types, to parabolic and hyperbolic partial differential equations.

Bringing a Cart into a Given State in the Presence of Perturbations

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A control problem for a cart that moves along a horizontal straight line under a bounded steering force in the presence of unknown small perturbation is considered. Two linear oscillators are attached to the cart. Only the coordinate of the cart is observed, while the phase states of the oscillators are unknown. A control law which in a finite time stops the cart at a given terminal state and then holds it there is proposed.

Bifurcations of Solutions of Impulsive Differential Equations

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Impulsive differential equations demonstrate rather more complex behavior of solutions than ordinary differential equations. This complexity is due to discontinuities of the integral curves at the moments of impulse actions. In this paper, bifurcations of periodic solutions of impulsive systems are studied.

On Motion Stabilization of a Mechanical System with Cyclic Coordinates

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In this paper, mechanical systems with cyclic coordinates are considered. Such systems admit the existence of steady and unsteady motions (stationary and generalized stationary), in which the positional coordinates are constant and the cyclic ones change in time according to linear or nonlinear laws. The problems of complete and partial stabilization of such motions are solved using only (all or positional) generalized coordinates measurements. The solutions to the various problems on the motion stabilization of a rigid body and robot manipulators are given.

Nonlinear Regulators in the Trajectory Tracking Control Problem of a Mobile Robot

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In this paper, the trajectory tracking control problem of a mobile wheeled robot is considered. An analysis of the known results on the problem solution for a dynamical model of the robot is given. The results on the construction of various types of robust nonlinear continuous and discrete-time regulators without velocity measurement are presented.

Suboptimal Anisotropy-based Control Design for Discrete-time Linear Systems with Norm-bounded Parametric Uncertanties

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The paper is dedicated to the suboptimal anisotropy-based control for linear discrete-time systems with norm-bounded parametric uncertainties. State-feedback and static output feedback control design procedures,

that guarantee desired disturbance attenuation level, are derived in terms of convex optimization.

Decomposition Synthesis of Invariant Systems with Nonlinear Local Feedbacks

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In this paper, the procedure of feedback decomposition synthesis, providing stabilization of output variables with the given accuracy is developed for a nonlinear plant which model contains external unmatched disturbances and is presented in the input-output block form with stable inner dynamic. Such approach does not require parametric certainty of the plant and introduction of dynamic models of external disturbances. It satisfies restrictions on state variables during a control process by using smooth, bounded S-shaped sigma-functions.

On Possibility of the Quadratic Lyapunov Function Use for Stability of Delay-Differential Systems Study

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The problem of possibility of quadratic Lyapunov function use when studying the stability of delay-differential systems is examined. Quadratic Luapunov functions are chosen to satisfy the limitation of the first derivative over some system without delay.

Multiphase Filtration in Anisotropic Porous Media

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A differential-geometric description of the models of multiphase filtration in anisotropic porous media is proposed. The concept of the anisotropy metric is introduced. A generalization of the Buckley-Leverett model for anisotropic media is constructed.

Pareto Optimal Control of the Rotor Motion in Electromagnetic Bearings

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Two-criteria control problems for a vertically rotating rotor in active magnetic bearings are considered. The centralized and decentralized Pareto optimal controls are synthesized and compared.

Evasion from Pursuers in the Problem of Group Pursuit with Fractional Derivatives and Phase Constraints

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In this paper we consider the evasion problem from the group of pursuers in the finite-dimensional Euclidean space. The motion is describe by the linear system of fractional order $\alpha \in (0, 1)$ with Caputo derivative and a simple matrix. The initial positions are given at the initial time. The set of admissible controls of all players is a convex compact. It is further assumed that the evader does not leave the convex polyhedron with nonempty interior. In terms of the initial positions and the parameters of the game, sufficient conditions for the solvability of the evasion problem are obtained.

Solution to the Natural Stabilization Problem for the Oscillation of Weakly Coupled Systems

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Considered is the autonomous model containing coupled subsystems with ordinary differential equations as subsystems. Each subsystem is supposed to admit a family of oscillations with the period depending on a single parameter. The problem of natural stabilization is solved: couplings that ensure both existence of an oscillation and its asymptotic

stability are found.

About Controllability and Observability of Stage by Stage Changing Linear Non-Stationary Dynamic Systems

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Questions of controllability and observability of stage by stage changing linear non-stationary systems are considered. Necessary and sufficient conditions for complete controllability and observability of stage by stage changing linear non-stationary systems are obtained, which are comparable with the known conditions for ordinary systems. These conditions are expressed through integral matrices of controllability and of observability of stage by stage changing systems.

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With the help of Hamiltonian normal form the generating solutions with specific symmetry of the perturbed Kepler problem are computed. The conditions on continuation of such solutions up to periodic orbits of planar circular Hill problem are given.

Controller Design via Time-Scale Separation Technique for Inverter of Photovoltaic System

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The problem of controller design for three-phase inverter of photovoltaic system is discussed where direct current of photo-electric cells (Solar Electric or PV modules) is transformed to three-phase voltage system of alternating current. This inverter is an example of dynamic system with the pulse-width modulator (PWM) in a control loop. The proposed controller design methodology is based on singular perturbation method (time-scale separation method) where the controller parameters are

selected such that two-time-scale motions are artificially induced in the closed-loop system. The presented approach gives the possibility to achieve a high accuracy of three-phase voltage generation.

Problem of Choice of Eigenvalues Based on Adjusted Degree of Stability

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In this paper, we aim to minimize control resources in the problem of modal control for a given degree of stability of a closed system. The proposed approach to the solution of the problem described above is based on the block approach procedures in the control and use of unitary transformations preserving the norm of the feedback matrix.

On Motions of a Carrier with a Mobile Load along a Horizontal Plane

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Motions of system consisting of a carrier and a load are considered. The carrier moves from the state of rest translationally along a rectilinear trajectory on a rough horizontal plane. The Coulomb dry friction model is applied. The load moves according to predetermined law in a curvilinear channel located in a vertical plane passing through the trajectory of the carrier. The influence of parameters of the system and the medium on the carrier motion is investigated. The results of computational experiments are presented.

Mixed and Combined Inverse Problems of Heat and Mass Transfer and Friction Control on Hypersonic Aircraft Permeable Surfaces

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The heat and mass transfer and friction in laminar boundary layer on

hypersonic aircraft permeable cylindrical and spherical surfaces effective control mathematical modeling problems are considered. The mixed and combined inverse problems statements are given. The computation experiments results are discussed.

The New Approach to the Analysis of Linear Control Systems

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In this paper the σ-entropy of input signal is introduced. The considered approach to the analysis of linear control systems is based on using the σ-entropy norm, which is defined as the maximum of the ratio of L_2 norm of the system output to that of the input wherein the σ-entropy of input signal does not exceed a given value s.

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Limiting performance analysis is performed for protection of an object from short-duration shock excitations by means of an active isolator with anticipating control. For optimal controls obtained previously for given shock pulses, the worst disturbances and the respective values of the maximum peak displacement of the object relative to the base are found.

Minimization of Switching in Optimal Control Problems for Hybrid Continuous-Discrete Systems

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We consider the optimal control of a system whose continuous state variation is described by differential equations, and instantaneous jumplike changes of state (switching) - by recurrent equations. Switching moments, as well as their number, are not specified in advance. The problem of finding the least number of switching is solved, in which the value of the control quality index is not worse than the permissible value.

The Core in Two-Stage Network Game with Pairwise Interaction

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The cooperative two-stage network game with pairwise interactions is considered. First stage is a network formation stage. On the second stage players play bimatrix games with neighbours in formed network. The characteristic is defined in two-stage game and also in one-stage subgame on the network formed on the first stage. As solution concept the core is introduced. It is proved that both, the two-stage game and one-stage subgame are convex. This guarantees that in both cases the core is not empty and the Shapley-value belongs to the core.

Chameleon Systems of Automatic Control

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It is now well known that dynamical systems can be categorized into systems with self-excited attractors and systems with hidden attractors. A self-excited attractor has a basin of attraction that is associated with an unstable equilibrium, while a hidden attractor has a basin of attraction that does not intersect with small neighborhoods of any equilibrium points. Recently, researchers have discovered the so-called "chameleon systems". These systems were so named because they demonstrate self-excited or hidden oscillations depending on the value of parameters. The present paper offers a simple algorithm of synthesizing one-parameter chameleon systems. The evolution of the Lyapunov exponents and the Kaplan-Yorke dimension of attractors of such systems with a parameter change are traced.

On Stabilisation of Steady-state Motions of Two-link Manipulator

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In this paper the problem on stabilisation of states and steady-state rotation motions of a two-link manipulator is considered in non-linear formulation using PI- and PID-regulators.

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In this paper the energy optimal control of harmonic oscillator is found. The solution is compared to the solution of the time optimal nulling of harmonic oscillator's energy. The results of the modelling of the oscillator's full energy from given control time T and phase coordinates are shown.

Modeling of Dynamics of a Wind Powered Boat

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Dynamical model of a wind powered boat is introduced. The boat is equipped by the wind-receiving propeller. Mechanical energy is transmitted from the propeller to the screw by the connecting shaft. The regime of motion directly against the wind flow is discussed. The experiments with the laboratory model are described.

Motion Control of the Quadcopter in the Horizontal Plane

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The problem of tracking the reference position of a quadrocopter in the horizontal plane without using the linearization of the equations

of motion in the vicinity of Krylov zero angles is considered. For the synthesis of control, the feedback linearization method is used. Strategy for controlling the plane motion with restrictions on the orientation of the apparatus are proposed.

Support of the Space Robot Motion Stability at Manipulation Functioning

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It is considered of the space manipulation robot (SMR) function in the regime of a free drift at which the task of control by a manipulator is solved in the class of systems with feedback and with using of measuring of the distance between the manipulator end point's from the goal. Analysis of the plane motion mathematical model at manipulation functioning of the free flying SMR which consists of the main body and joining to it manipulator with three link showed that variability of the object's coefficients caused by their dependence from the angular position of the main body and hinge angels can be the cause of the instability of the system motion. It is defined the region of stability on the plane with the coordinates of the manipulator's angles at which the motion of the SMR is unstable. These results are taken into consideration at the control algorithms synthesis. It is derived the structure of the SMR adaptive control system which has a subsystem of stability and algorithms adaptive correction of the control law coefficients.

Rational Combination of Aerodynamic and Reaction Controls of a Vehicle

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The problem of the mixed control is considered by a unmanned vehicle which is equipped by aerodynamic and reaction controls. The basic criteria of formation of control are formulated. The generalized estimation of efficiency of functioning of the channel of reaction control is resulted at the problem decision damping the oscillatory processes caused by nonlinear characteristics in the channel of aerodynamic control.

On the Influence of Mounting Stiffness Upon Dynamics of a Double Aerodynamic Pendulum

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A double pendulum is considered, the second link of which carries a thin wing with symmetrical airfoil. Both joints of the pendulum are equipped with linear spiral springs. Experiments with such pendulum are performed in the wind tunnel of the Institute of Mechanics of Lomonosov MSU. Dependence of amplitude and frequency of self-sustained oscillations are studied for different wind speeds and different locations of the wing with respect to the second link.

Six-Legged Robot Transporting a Cargo on a Raft over a Small Body of Water

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The motion of an insectomorphic robot that allows to transport a cargo on a rectangular raft during the robot's crossing to the bounding shore of a small body of water was constructively designed and worked out by means of software package "Universal Mechanism". The simplest case is studied, when then robot performs an initial push from the shore of departure.

Cylinder Grasping By a Two-finger Manipulator

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We consider the problem of rough cylinder grasping by the fingers of the robot-manipulator. Each finger contacts the cylinder in a single supporting point. Using numerical simulations and analytically, possible locations of contact points on the cylinder, for which there is a kinetostatics problem solution when the cylinder is moved by two fingers, are received.

Estimating the number of almost periodic solutions of ordinary differential equations

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The paper deals with the existence and stability of almost periodic solutions of ordinary differential equations and estimates the number of these solutions.

On Nonlinear Oscillations of a Single Distributed System

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A mathematical model of the transverse auto-oscillations of a single distributed system (boring bar, intended for boring deep holes) is described. Analytic expressions for the amplitudes of self-oscillations obtained and the conditions under which soft and rigid modes of excitation of self-oscillations are possible, as well as the results of numerical experiments with different values of the geometric and technological parameters of the mathematical model, are presented.

On a Class of Inverse Control Problems

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The paper considers the problem of describing the reachable set for a nonlinear control system under constraints on the values of the integral functional of the control and the trajectory of the system. This problem can be interpreted as an inverse problem for the optimal control problem. It is proved that any admissible control that steers the trajectory of the system to the boundary of the reachable set is a local solution of some optimal control problem with a given integral functional under controllability assumptions for the linearized system.

Educational Device for Studying Nonlinear Aeroelastic Oscillations

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We describe a modification of the Flexy device, originally developed at the Slovak University of Technology. With our version of it, developed at the Institute of Control Sciences, students can study aeroelastic oscillations (flutter) using cheap and freely available components. Flex sensor (tensoresistor) changes its electrical resistance proportionally to its bending. The plastic thin plate (attached to the resistor) plays the role of a wing in the flow generated by a small fan. Both fan and tensoresistor are connected to an Arduino microcontroller and it is possible to obtain and analyze experimental data from the device on a personal computer.

Nonconvex Quasidifferentiable Piecewise-linear Lyapunov Functions

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We consider stability analysis of the piecewise-affine dynamical systems using nonsmooth nonconvex polyhedral Lyapunov functions. Such function is defined as a Minkowski function of its level set, which is a star-shaped nonconvex polytope. To compute its Dini derivative, we employ the d.c. decomposition of the function using linear programming.

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In this paper we examined the problem of trajectory motion control of quadrotor transporting rigid body on hinge fixed cable. 2D motion equations were obtained using Lagrange equations of the second kind. Oscillations of rigid body appeared with a change of fly direction, so the system could become unsustainable. We created a regulator based on structural synthesis method to decrease this oscillations.

Autonomous Discrete Riccati Operator Equation in the Problem of Optimal Stabilization of Linear Periodic Systems with Aftereffect

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We consider the problem of optimal stabilization of linear periodic systems with aftereffect. Admissible controls are formed on the principle of feedback in functional state space. We assume piecewise constant periodic dependence of controls on time. An equivalent discrete problem of optimal stabilization in a functional space is autonomous. A representation of solutions of autonomous discrete operator Riccati equation is found.

On Implementation of Tactile Feedback Using a PZT Actuator

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Lack of tactile feedback during lapaeoscopic operations often leads to increase in complexity and duration of the operation. in the present paper, a system providing such feedback based on a piezoelectric actuator is considered. In order to describe the actuator, a phenomenological model is used, parameters of which are determined based on performed experiments. It is shown that the system allows distinguishing objects with different stiffness characteristics.

On Obtaining the Stationarity Conditions in an Optimal Control Problem for a Trajectory with a Smooth Contact with the Phase Boundary on the Single Boundary Arc

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We consider a class of optimal control problems with a scalar state constraint. For a trajectory with a smooth contact with a single boundary

subarc, we first obtain, using a special technique (two-stage var iation approach), optimality conditions in the form of Gamkrelidze, and then obtain the full set of optimality conditions in the Dubovitskii-Milyutin form, including the nonnegativity of the measure density and its atoms at the junction points.

Stabilization of a Multiply Connected Dynamical System Using Piecewise Constant Control

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The problem of motion stabilization of the manipulator gripper along a given trajectory in space is studied on the basis of the stabilization conditions of multiply connected dynamical systems. The manipulation system is represented as a multiply connected discrete-continuous system for which stabilizing control is constructed and the limiting quantization step is determined. An algorithm for the numerical solution of the stabilization problem is developed and a series of computer experiments is performed.

Optimal Control of the Deterministic Queuing System in the Stationary Mode

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The paper considers a deterministic service system, which receives requests for services from three streams. The service system is characterized by the intensity and speed of service, these stable and do not depend on time. The main purpose of the work is to find the duration of continuous application service for each stream (system operation mode), in which the total queue length consisting of service requests for each stream was minimal.

The Point Mapping Method for Studying Strongly Nonlinear (Shock-Vibrating) Systems with a Nonanalytic Poincare Surface

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The dynamics of novel types of multi-pulse shock-vibrating mechanisms is studied, accounting for the properties of the processed medium, mathematical models of which are substantially nonlinear systems with a variable structure. A dynamic analysis of the model is done using the point mapping of a two-dimensional nonanalytic Poincare surface into itself. The dynamics of the complex periodic and stochastic moving regimes is studied using numerical experiments on personal computers with a software complex developed in the Borland C++ Builder 6 medium, which made it possible to describe possible qualitative changes in the motion modes of such mechanisms, based on bifurcation diagrams.

The Stabilization and Control for Three Links Robot-Manipulator with Non Rigid Connection

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The manipulator has a drive only for the first link. The state and output feedback control design problem, providing stabilization of the given position at action of the uncertain bounded perturbations and under constraints on control is solved.

Asymptotic Method for Solving a Singularly Perturbed Linear-Quadratic Optimal Control Problem

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The problem of minimization of the integral quadratic functional on the trajectories of a linear singularly perturbed system subject to linear

terminal constraints is under consideration. Asymptotic approximations to the optimal open-loop and optimal feedback controls for this problem are constructed. The main advantage of the proposed algorithms is that the original optimal control problem is split into two unperturbed problem of smaller dimensions.

On the Stability of Third Order Differential Equations

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In this paper, we study the problem of stability of the equilibrium of nonlinear ordinary differential equations by the method of semi-definite Lyapunov's functions. We have identified third order equations for which the choice of a semi-definite function does not present difficulties. For such equations, sufficient conditions of stability and asymptotic stability (local and global) are obtained. It is shown that the use of semi-definite positive functions can give advantages in comparison with the classical method of applying Lyapunov's definite positive functions.

Tsypkin's Criterion and Other Stability Conditions for Discrete Switched Systems

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The notion of connected switched systems is generalized from continuous-time systems for discrete-time ones. Necessary and sufficient existence conditions of common quadratic Lyapunov function for such systems are obtained as a frequency-domain stability criterion. Connected systems with switching among two and three subsystems are considered in more detail. An example of a third-order connected system is presented.

New Criteria of Equilibrium Points Stability for Discrete-Time Systems

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An investigation of the equilibrium points stability of dynamical systems is based on the analysis of the linear approximation or on the construction of a Lyapunov function. However, the first method is not applicable in the degenerate case, and the second one requires a construction of functions of a special kind, which is not always possible. At the same time, the Lyapunov function method is based on the notion of an invariant set. Therefore, an idea arises to analyze the stability of the equilibrium point by direct verification of the invariance of certain sets in phase space. In this paper, we establish criteria for stability and asymptotic stability of equilibrium points of autonomous discrete systems in terms of invariant sets. We also suggest methods for verifying the criteria conditions.

Navigation in the Field of a Point Magnetic Dipole from Measurements of the Field Gradient Parameters

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In the field of a point magnetic dipole the measurements of a magnetic gradiometer are considered to be used for solution of the navigation problem of a moving object. We suggest a nonlinear algorithm for solution of an inverse problem — source parameters detection from the field parameters measurements. The algorithm allows calculation of the relative position with respect to two dipole sources of alternating magnetic field.

Role of Rayleigh Function in the Constructing Motion of Equations by Given Properties

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The inverse problem of dynamics is considered - the problem of constructing the equations of motion from given properties. The method of link stabilization is used. It is analyzed how the stabilization coefficients of bonds affect the dissipative function. Thus, equations are constructed that have the stability property of a numerical scheme.

Construction of Bifurcation Diagrams of Periodic Motions of an Aerodynamic Pendulum via the Method of Iterative Averaging

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Periodic motions of an aerodynamic pendulum are studied. The bifurcation diagram of such motions depending on the viscous friction coefficient is constructed via the new iterative method based on the averaging procedure and the energy balance.

Synthesis of the Outer Cascade for Plasma Magnetic Control in the Globus-M Tokamak by Using Linear Matrix Inequalities Method

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For a multi-loop control system of the Globus-M tokamak was synthesized an outer controling cascade with a static regulator by state estimation. Matrices of regulator and observer are synthesized by using method of linear matrix inequalities (LMI), with placing poles of a closed system in $\mathbb{D}$-region. This made it possible to significantly reduce the oscillation index and transition time, in comparison with a system without an outer cascade.

Control Systems Synthesis of Technical and Industrial Plants by State via Linear Matrix Inequalities

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By method of linear matrix inequalities with use of generalized Lyapunov theorem, the problems of controlling the ship steam boiler and the industrial system for controlling the tension of the material in the zone of its transportation in the production line are solved. In particular, a robust controller was synthesized that preserves poles of the system in a given $\mathbb{D}$-region for given perturbations of the plant model.

Protection of an Object From Impacts by Means of Anticipating Control Under Uncertain Disturbances

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The protection of an object on a movable base from impacts by means of a shock isolator with constrained anticipating control is addressed. The impact disturbance is represented by the time history of the acceleration of the base, which is assumed to be constant in direction. For an uncertain disturbance, of which the duration and the integral with respect to time are know, a guaranteeing anticipating control designed for the worst disturbance is constructed.

Modelling and Optimization of Controlled Longitudinal Motions for an Elastic Rod Based on the Ritz Method

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A generalized formulation of the optimal control problem for the motion of an elastic rod is considered. Based on the Ritz method, a finite element algorithm is developed to find displacement, momentum, and stress fields. The aim of control is to define the boundary force

that depresses elastic vibrations in the rod and minimizes its average mechanical energy during a fixed time interval. The results of numerical simulation for the inhomogeneous distribution of mechanical parameters are presented.

On Polyhedral Estimates of Reachable Sets of Linear and Bilinear Discrete-Time Systems with Integral Constraints on Additive Terms

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Linear and bilinear discrete-time systems are considered under integral non-quadratic constraints on additive terms. Algorithms for constructing external polyhedral (parallelepiped-valued) estimates of reachable sets are proposed.

Development of Extreme Maintenance System of Required Paraglider Flight Altitude

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In this paper the extreme managment of maintenance required altitude problem is considered. The extreme function of paraglider L/D ratio is constructed.Based on synchronous detection method peak-seeking algorithm is applied.The efficiency of algorithm is applied the numerical experiment result.

The Control of Induction Motor under Uncertainty Condition

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In the paper the tracking problem for a given velocity is considered for induction motor under influences of uncertainty of parameters of the mathematical model, as well as the presence of external uncontrollable

disturbances. An original discontinuous control law is proposed, which ensures the asymptotic convergence of the tracking error to zero.

Mathematical and Computer Modeling of the Dynamics of the Delta Robot.

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Proceeding from the method proposed by M. Zavatsky for describing the kinematics of the delta robot, a method is developed for modelling its dynamics in the form of Lagrange equations of the second kind. For the generalized coordinates, the angles of rotation of the output shafts of the drives are selected. The stabilization problem of the set position of the working element of the delta-robot with the DC motor is solved.

Synthesis of the Robust Control System of the Robot-Manipulator under Incomplete Measurements

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The procedure for decompositional synthesis of the robot manipulator control system with electric actuators has been developed. The procedure ensures the exponential convergence of generalized coordinates to given trajectories under the action of external unmatched disturbances and the uncertainty of the parameters of the mechanical subsystem. It is supposed to use discontinuous controls and organization of sliding modes in the virtual space of mixed variables (functions of state variables, external influences and their derivatives). A method for the synthesis of a lower order observer with piecewise linear correcting actions is presented. The observer makes it possible to estimate the mixed variables from measurements of only tracking errors under conditions of uncertainty of the input channels.

Cascade Design of Disturbances Observers for Non-linear Control Plants of General Form

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The paper deals with non-linear control plants under external disturbances. For the purposes of combined control and current diagnostics cascade design procedures of dynamics observers for estimating external disturbances and their derivatives are developed based on virtual dynamic models.

On the Possibility of Stabilizing the Equilibrium Position of a Holonomic System on a Quickly Vibrating Base

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In this paper a holonomic system on a translationally vibrating base is considered. The conditions of existence of a directional vector of vibrations have been obtained at which the equilibrium position that the system has without vibrations is preserved as frequency of the vibrations tends to infinity. It is shown that in the nondegenerate case this equilibrium position of the limit system can be made stable always.

Variational Approach for Modeling Oscillations of Living Systems

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Variational principle for the behavior of living systems is proved. The principle allows us to find the motion of living systems, like the variational principles of mechanics. Modeling periodic oscillations observed in the behavior of aquatic organisms, is based on this principle.

Control System for Unstable Vertical Plasma Position in Globus-M Tokamak with Actuator on the Base of Current Inverter

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The analytical research of the control system for unstable vertical plasma position in Globus-M tokamak is presented in this paper. The requirement for auto-oscillations existence in the system is obtained. The equilibrium limits for the control system is derived. Optimal control algorithm for the control system is proposed. The results of the system's experimental testing are presented.

Existence of Liouvillian Solutions in The Problem of Motion of a Rotationally Symmetric Body on a Sphere

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The problem of rolling without slipping of a rotationally symmetric rigid body on a sphere is considered. The rolling body is assumed to be subjected to the forces, the resultant of which is directed from the center of mass G of the body to the center O of the sphere, and depends only on the distance between G and O. In this case the solution of this problem is reduced to solving the second order linear differential equation over the projection of the angular velocity of the body onto its axis of symmetry. Using the Kovacic algorithm we search for liouvillian solutions of the corresponding second order differential equation in the case, when the rolling body is a dynamically symmetric ball.

The Application of a Method of Dynamic Programming for the Determination of the Possibility for Fuel Economy During Interregional Flights

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The comparison of the time-optimal and fuel-optimal trajectories of the medium-range aircraft was carried out. The optimization was implemented for the flight as a whole, without the decomposition into the sections of the climb, maintaining the flight level and descending. The mathematical model is realistic enough and involves numerous limitations on the phase coordinates and control parameters.

A Model of the Impact of Information about Tax Audits on the Risk Statuses of Taxpayers

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We consider a model of tax control which includes a process of propagation of information to stimulate the tax collection. Every agent chooses her behavior depending on her own risk propensity, information received from her contact network, economic environment. We formulate an evolutionary model of tax control and analyze the behavior of agents based on stochastic evolutionary dynamics and Markov process. Series of experiments illustrate different economic scenarios.

Construction of M-strongly Time-Consistent Subcore in the Game with Spanning Tree

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In the paper the multistage N-person minimum cost spanning tree game is considered. The cooperative behavior of players is defined. Selecting strategies, players build a minimum cost spanning tree at each stage. On the bases of values of characteristic function, a new

characteristic function $\hat{V}$ is constructed for each coalition in subgames. The function $\hat{V}$ is defined as in [L. A. Petrosjan, Y. B. Pankratova, 2017]. With the help of this newly constructed characteristic function, an analogue of the core is defined. This analogue of the core can be considered a new optimality principle. It is proved that this constructed optimality principle has the property of M-strongly time-consistent in the game with spanning tree.

Looking Forward Approach for Dynamic Cooperative Advertising Game Model

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In this paper we examine a dynamic cooperative advertising game model where each firm's market share depends on its own and its competitors' advertising decisions. Looking Forward Approach is applied to the initial game in order to construct model where information about the game updated dynamically.

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The paper considers the hub location-allocation problem based on the analysis of statistical data characterizing the functioning of the company engaged in the transportation of goods. The number of distribution centers is not fixed in advance. The network of distribution centers is built on the basis of the demand for services in the terminals. The paper suggests a statistical criterion for selecting the number of distribution centers in the network, based on the application of the network robustness principle to the disturbances in the demand for services in each terminal. Demand distortions are proposed to be carried out by taking into account the forecasting of future trends in demand.

Modelling and Analysis of LbL Structure Stability

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The article develops a differential-geometric approach to the modeling of residual stresses in layered (LbL) structures obtained as a result of successive curing of thin layers of material and analysis of their stability.

Deep Learning Algorithms for Estimating Lyapunov Exponents from Observed Time Series in Discrete Dynamic Systems

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This paper demonstrates possible uses of deep neural networks for estimating Lyapunov exponents in discrete dynamic systems from their observable trajectories in the extended state space. We have studied the functional mechanisms of using deep neural networks in said application. The proposed approach has been tested in simulations with different topologies and attractor complexities. The study shows that our analyzer can be used to investigate the structure of time series.

Optimal Geopolitical Interaction in Case of Limiting Factors

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A wide range of real processes can be formalized within the theory of hybrid systems and toggled systems. So geopolitcal interaction can be represented as a scheme. In the nodes of such formal scheme are geopolitical actors, that realize the system of geopolitical actions. For geopolitical actions implementation it is necessary serial functioning of activities-component (i.e. the organization of the information impact process on all of the geopolitical region). Such of this actions can be realized either successfully or without any success. The models of such type are formalized and investigated in this paper. The numerical

examples are given.

Control Design with Compensation of Unknown Inputs

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A way for the synthesis of a regulator in the combined feedback form is proposed, which provides the H_∞-property of rejection of initial deviations and uncertain bounded external disturbances for time-varying continuous lipschitz systems with compensation of unknown inputs, estimated by observer.

On Dynamics of a Wheeled Cart Driven by Savonius Rotor

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A mechanical system consisting of a wheeled cart with inslalled Savonius rotor is considered. The rotor axis is connected with wheels and drives them. It is assumed that wheels can slip. Conditions of existence and asymptotic stability of steady motions of the system are obtained. Properties of motion of the cart for different wind speeds are studied. Numerical simulation of the system is performed.

Estimates of the Trajectory Tubes of Impulsive Control Systems

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The reachable sets estimation problem for the impulsive control system with uncertainty in the initial data is considered. Impulsive controls in a dynamical system are vectors and belong to the generalized ellipsoid in the space of functions of bounded variation. Algorithms for constructing ellipsoidal estimates of reachable sets for such control

systems and results of numerical simulation are presented.

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A multi-loop plasma position and current control system has been developed and modelled on a new evolution plasma code. Robust PID controllers in the plasma position control loops are tuned by QF theory based on the identified linear model of a single-phase thyristor current inverter as self-oscillating actuator.

Control of a Simplified Model of Bispiner with a Displaced Center of Mass

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In this paper, we propose a mathematical model describing the motion of bispiner with a displaced center of mass, fixed to a special type of cardan. For the proposed model we build a bounded control law that guarantees the rotation of the aircraft with a given angular velocity and small fluctuations in height. Comparative analysis of discontinuous and smooth control laws is made.

On the New Class of Reducible Linear Time-Varying Systems

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The new class of reducible linear time-varying (LTV) systems with control and observation is described. The reducing transformation of LTV system is proposed. The LTV system's observability and controllability tests are formulated based on the reduced system. The estimation and control algorithm is constructed.

Control of Dynamical Objects and Constraints Stabilization

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The control problem for a system with desired kinematic properties is investigated. The constraints stabilization that define the purposes of the control, is achieved by the appropriate construction of the dynamic equations of the extended system. Dynamical properties, which provide the necessary precision in the execution of the constraints equations are defined.

Analysis of the Influence of Time Scaling on Relative Degree of Affine Systems with Scalar Output

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In this paper conditions for increasing of relative degree of affine dynamical systems with scalar output using time scaling are obtained. All possible time scales transforming the third-order system to the canonical form are determined.

A Descent Mode of the Finned Body with Asymmetrical Pitch Angles of Blades

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The descent of a finned heavy body in the air is studied .The body has four identical blades. Two cases are compared:,the case when all pitch angles are equal to each other and the case when one or two of the pitch angles differ from the others.

Optimal Stabilisation of a Quasilinear Stochastic System with Controllable Parameters

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In this paper we construct necessary conditions for the infinite horizon optimal stabilisation problem of a quasilinear stochastic system with controllable parameters. We propose that matrices in system and criterion (in general non-linearly) depend on vector parameter to be chosen. A particular case of this problem is LQG-problem for linear system with multiplicative noise and information constraints.

Stochastic Game of Data Transmission in the Presence of Buffers of Finite Capacity

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The game-theoretic model of data transmission in a network of a given topology is presented. Two players (network nodes) tend to send as many random data packages as possible to the final nodes through one common node. Each player has a finite capacity buffer for storing data packages. A system of costs for sending and storing data packages and rewards for the successful delivery of packages is introduced. A dynamic conflict-controlled process is modeled as a stochastic game with a finite set of states. The existence of Nash equilibrium is proved, as well as a cooperative solution, in which players maximize the total expected payoff. The price of anarchy in the network is calculated. The price compares the players' payoffs in the Nash equilibrium and cooperative solution.

Robust Stabilization of Nonlinear Mechanical Systems by Using an Integral Control

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In this paper the position stabilization and trajectory tracking control

problems are considered for nonlinear mechanical systems with unknown parameters by constructing integral control. Nonlinear modifications of PI and PID controller are constructed. The solution of the problems is obtained on the basis of the construction of the Lyapunov vector-function and the comparison system.

Attraction Domain Estimate for a Normal Form of Multi-input Nonlinear Affine Systems with Constrained Control

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For a normal form of a multi-input nonlinear affine system with constrained control resource closed by a feedback of special form, the problem of finding an estimate of the attraction domain of an equilibrium state is posed. The estimate is sought as a Cartesian product of invariant ellipsoids of the subsystems composing the system. The proposed method relies on results of absolute stability theory and reduces construction of the estimate to solving an LMI system.

Multiple Capture of the Given Number of Evaders in the Example of L.S. Pontryagin

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In the finite-dimensional Euclidean space, a generalized example of L.S. Pontryagin with many participants is considered with the same dynamic and inertial capabilities of all players. The aim of the group of pursuers is to catch at least q evaders, and each pursuer must catch at least r pursuers. Assuming that evaders use program strategies, and each pursuer catches no more than one evader, sufficient conditions are obtained for the solvability of the pursuit problem.

New Characteristic Function for Multistage Dynamic Games

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The finite stage dynamic n-person game with transferable payoffs is considered. The cooperative version of the game is defined and the new approach for constructing characteristic functions in multistage games based on characteristic functions defined in stage games is proposed. The conditions are derived which guarantee that this new approach leads to time-consistent and in some cases strongly time-consistent solutions.

On the Domain of Dependence for Scalar Conservation Laws

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An upper estimate for the domain of dependence of a scalar multidimensional conservation law is constructed. This estimate is given by a controllability set of a certain differential inclusion. Its prove is based on the modified version of the classical Kružkov uniqueness theorem.

On the Property of Proportional Local Controllability of the Lyapunov Exponents of Discrete-Time Systems

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We investigate the question of the proportional local controllability of the Lyapunov exponents of every system belonging to the Bebutov shell of a given linear control system with discrete time. We have obtained conditions that ensure the equivalence of the uniform complete controllability of a given system and the proportional local controllability of the Lyapunov exponents of each system from the Bebutov shell.

Unique Weak Solvability of a Hyperbolic Systems with Distributed Parameters on the Graph

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Existence and uniqueness of the solution are proved for hyperbolic system in weak formulation with distributed parameters on the graph. The general scheme of classical studies: selected functional space in which solves initial-boundary value problem and special basis of space; for approximation of the solution of the problem are set a priori estimates of the energy type inequalities; shows weak compactness of the approximations family, unity and continuity of the solution on the source data. The results are fundamental in the study of problems of optimum control of a net-like industrial designs.

Semi-definite Relaxation for Optimization of the Set of the Satellite Navigation Signals

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There are multiple navigation satellite systems, including GPS, GLONASS, Galileo, Beidou, QZSS. Overall number of the range signals can exceed several tens. On the other hand, only few of them are sufficient for precise positioning. To reduce computational cost of positioning, the optimal choice of signals should be performed. Semi-definite relaxation approach to solution of this optimization problem is proposed.

Semidefinite Relaxation and New Conditions of Signdefinitness of Quadratic Forms under Quadratic Constraints

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Using the semidefinite relaxation allows one to derive the S-procedure from duality conditions. However, the S-procedure gives only sufficient

conditions for sign definiteness of the quadratic form under quadratic constraints in the general case, while giving necessary and sufficient conditions for the relaxed problem. In this paper the new approach is proposed, allowing for establishing of conditional sign definitenes in some cases, when the S-procedure doesn't give the answer. Results are illustrated by an example.

Adaptive control of wheeled mobile robot with differential drive

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The path following problem of tracking a given trajectory for nonholonomic wheeled mobile robot with DC motors as actuators. The synthesis of an adaptive control law is conducted on the basis of the block approach and sliding mode. The simulation results verify the proposed approach.

The Effect of Loss of Traction under Asymmetric Vibrations of the Drive Wheels of the Vehicle

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The effect of a significant and sudden loss of traction during acceleration of the vehicle with asymmetric (or asynchronous) vibrations of the wheels. The effect appears on vehicles with inter-wheel differential under intense start with slipping. This can be dangerous when the car enters a highway or crosses intersections. The project is aimed at studying this phenomenon and developing modes of optimal acceleration of the vehicle, provided that the undesirable effect described above does not appear.

Modeling the Movement of a Wheel with a Pneumatic with a Slip and Detachment

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A mathematical model of a wheel with a pneumatic tire has been created. The model takes into account the radial and torsional stiffness of the tire, as well as the effect of radial deformation on the torsional stiffness and vice versa. Numerical simulation of controlled wheel motion with slip at the start and detachment from the surface. The results will be used when examining the conditions for the occurrence of undesirable vibrations of the wheels of vehicles.

Application Of Hybrid Random Search Method To Optimal Control Of Trajectory Bundles In Nonlinear Deterministic Systems

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In this paper the application of hybrid random search method to optimal control of trajectory bundles in nonlinear deterministic systems with incomlete data is examined. The hybrid random search method is a combination of the Luus-Jakola random search method, adaptive random search method and best trial method.

Development of a Control Unit for Compressors of Inflatable Pneumatic Bbuildings

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The unit has been created to control air compressors. It can fast and autonomous organize inflatable air buildings: temporary shops, halls, field hospitals. The control unit consists of a gauge of overpressure, a programmable microcontroller, relays, power supplies, etc. Operating temperature range from -50 to +60 degrees Celsius.

Kinetics of Collisionless Continuous Medium for Non-maxwellian Initial Density

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Being periodically under gravitational force field, collisionless ideal gas in a rectangular parallelepiped performs the non-equilibrium irreversible cycles. We prove, that for any initial probability distribution density this system irreversibly tends to the Maxwell distribution on the velocities, and uniform distribution on the coordinates.

Necessary Optimality Conditions for Optimal Impulsive Control Problems with Hysteresis

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In this paper an optimal control problem for measure-driven differential equations with rate independent hysteresis is considered. The hysteresis is modeled by an evolution variational inequality equivalent to the action of play operator generalized to the case of discontinuous inputs of bounded variation. Necessary optimality conditions are obtained.

Approximation Results for an Impulsive Control System with Hysteresis

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In this paper an impulsive control system described by measure-driven differential equations with rate independent hysteresis is examined. The hysteresis is modeled by an system of variational inequalities equivalent to the action of the play operator generalized to the case of discontinuous inputs of bounded variation. Approximation results for impulsive processes are presented.

The Method of Integrodifferential Relations and the Projection Technique in Control Problems of an Elastic Body Motion

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The possibility of reducing the initial-boundary value problem formulated initially in partial derivatives to a system of ordinary differential equations with small dimension is investigated. The properties of various quadratic energy relations arising in various problems of mathematical physics are studied and discussed.

Control Model of Opinion Dynamics in a Social Network with Two Centers of Influence

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We consider an opinion dynamics model in a social network with two centers of influence. The centers can select their levels of influence on other members of the network pursuing certain goals. Considering this model as a 2-person noncooperative dynamic game and choosing the Nash equilibrium as its solution, we find the equilibrium levels of influence for each center.

On Sufficient Conditions for Exponential Stability of Delay Nonlinear Systems

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The stability problem for a nonlinear delay system is studied. Sufficient conditions for exponential stability in terms of linear matrix inequalities are discussed. These conditions are obtained using the Lyapunov-Razumikhin method, under the assumption that the system is represented as a linear system with bounded state-dependent coefficients. The cases with both bounded and unbounded variable delay are considered. Some semidefinite programs are formulated that make it possible to obtain

guaranteed estimates of some stability-like properties of the system, in particular, the upper bound on the time-delay preserving stability, the sets of initial functions corresponding to exponentially decreasing solutions, etc. Some possibilities of using structural features of the system for obtaining simpler and more flexible conditions for exponential stability are studied.

The Limit Periodic Solutions of Multifrequency Systems Described by the Volterra-type Integrodifferential Equations

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The analytical systems of n order with n pure imaginer roots of a characteristic equetion are investigated. The equations of the systems depend on a small limit periodic perturbation in a form of a function exponentially approaching to a periodic function as independent variable grows. If all frequencies of the system are commensurable, the existence conditions of the limit periodic solutions (for the system of 4 order) are given by basing on the terms of third degree of the equations.

The Perron Stability and the Simplified Vinograd–Millionshchikov Central Exponents

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For the first time the Perron stability is defined as the property of a differential system solution to be returned by all closely related perturbed solutions. This property is similar to the Lyapunov and Poisson stability, but it is related to the Perron exponents. The rough Perron stability or instability of a linear system is given by its central exponents, which are provided here with the simplified formulas.

Theory of Parametric Resonance: New Results

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Linear dynamical systems with many degrees of freedom with periodic coefficients also depending on constant parameters are considered. Stability of the trivial solution is studied with the use of the Floquet theory. First and second order derivatives of the Floquet matrix with respect to parameters are derived in terms of matriciants of the main and adjoint problems and derivatives of the system matrix. This allows to find the derivatives of simple multipliers, responsible for stability of the system with respect to parameters and predict their behavior with a change of parameters. It is shown how to use this information in gradient procedures for stabilization or destabilization of the system. As a numerical example, the system described by Carsson-Cambi equation is considered. Then, strong and weak interactions of multipliers on the complex plane are studied, and geometric interpretation of these interactions is given. As application of the developed theory the resonance domains for Hill's equation with damping are studied. It is shown that they represent halves of cones in the three-parameter space. Then, parametric resonance of a pendulum with damping and vibrating suspension point following arbitrary periodic law is considered, and the parametric resonance domains are found. Another important application of damped Hill's equation is connected with the study of stability of periodic motions in non-linear dynamical systems. It is shown how to find stable and unstable regimes for harmonically excited Duffing's equation. Then, linear vibrational systems with periodic coefficients depending on three independent parameters: frequency and amplitude of periodic excitation, and damping parameter are considered with the assumption that the last two quantities are small. Instability of the trivial solution of the system (parametric resonance) is studied. For arbitrary matrix of periodic excitation and positive definite damping matrix general expressions for domains of the main (simple) and combination resonances are derived. Two important specific cases of excitation matrix are studied: a symmetric matrix and a stationary matrix multiplied by a scalar periodic function. It is shown that in both cases the resonance domains are halves of cones in the three-dimensional space with the boundary surface coefficients depending only on the eigenfrequencies, eigenmodes and system matrices. The obtained relations allow to analyze influence of growing eigenfrequencies

and resonance number on resonance domains. Two mechanical problems are considered and solved: Bolotin's problem of dynamic stability of a beam loaded by periodic bending moments, and parametric resonance of a non-uniform column loaded by periodic longitudinal force.

On the Bohl – Perron theorem on the asymptotic stability of hybrid systems

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We consider an abstract hybrid system of functional differential equations (FDEs). One equation with respect to a part of the variables is FDE, on the other part of variables — difference equation, the second equation with respect to the part of the variables is a difference equation, in the other part of the variables, the FDE. There is a system of two equations with two unknowns. Two model equations are studied: one is a system of FDEs, the second is a system of difference equations. Solutions spaces are studied. The Bohl – Perron theorem on the asymptotic stability for the hybrid system of FDES equations was obtained.

Asymptotic Behavior of Singularly Perturbed Systems with Periodic Nonlinearities

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In this paper phase systems with external forces are considered. The sistems are described by integro-differential Volterra equations with positive parameter at the higher derivative. The conditions for the external disturbances and the transfer function are established which guarantee the gradient-like behavior of the system for any sufficiently small value of the parameter.

Problems of Adaptive Optimal Robust Control with Linear Performance Criteria

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This paper addresses problems of adaptive optimal robust control where control criteria are linear or linear-fractional functions of unknown and non-identifiable parameters of linear discrete-time systems under uncertainty and bounded external disturbance. Optimal set estimation of unknown parameters for such systems is reduced to recurrent linear programming and is computationally tractable in the case of a small number of estimated parameters.

On Numerical Modeling of the Dynamics of the Electric Power Object by Volterra Polynomials

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This work addresses the numerical modeling of systems of automatic control of nonlinear dynamics of electric power object. The apparatus of Volterra integral power series is applied to describe the dynamic characteristics of the investigated object of the "input-output" type. We consider mathematical model of a wind power plant with a horizontal axis of rotation as a simulation model.

Robust Economical Digital Control of an Information Satellite Orientation in Initial Modes

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We present algorithms of the robust economical digital attitude control for an information satellite in initial modes – beginning from separation from the launch vehicle up to the stabilization of its given angular position in the orbital reference frame. We have presented results on computer simulation of the initial orientation modes for a land-survey satellite in sun-synchronous orbit.

Energy-Saving Digital Control of Magnetic Actuator at an Emergency Orientation Mode of a Satellite in Sun-Synchronous Orbit

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We present algorithms of economical digital attitude control for an information satellite at an emergency mode. We have presented results on parametric analysis of nonlinear spatial angular oscillations for an emergency orientation of land-survey satellite in sun-synchronous orbit.

Principles of Clustering in Healthcare Systems

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Complex systems demand for a special analytical tools. We present a research on visualisation of health care time series of Russia. It is needed to detect a structure and anomalies. Visualisation is performed through cluster analysis. Special dissimilarity measures are used to accomplish clustering of time series.

Robust Stability Analysis of Electrical Drive System

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A type model of electrical drive system is suggested, controling system and motor inclusive. Getting general transfer function the system under investigation seqular equation symbolically. Analysis has been performed on root locus seqular equation coordinates. Constructed stability boundary the four centers lie in a different planes.

Ellipsoidal Approximation of Reachability Sets of the Class of Nonlinear Systems Represented by Takagi-Sugeno Fuzzy Models

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The approach that allows approximating reachability sets of the class of nonlinear systems under external restricted perturbations is presented. The application of the approach consists of two stages. The first stage is the transition to fuzzy description. Nonlinear system is replaces by the Takagi-Sugeno fuzzy model. At the second stage the estimation of the system reachability set based on the generalization of invariant ellipsoid technique is performed. The numerical experiment results that allow estimating the persistence of received estimations are shown.

Synthesis of Semi-Transparent Screen's Impedance for the Design of High-Precision GNSS Antennas Issue

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The diffraction problem of a weakly directional source of radiation over a semi-transparent screen with a variable impedance profile is discussed. The main interest is to achieve the desired radiation pattern with a sharp drop (cut-off) in the shadow domain. The problem of reconstruction of the screen impedance distribution providing a desired total field in the far zone, refers to the solution of non-linear inverse problem of electrodynamics. The original formulation is equivalent to solving the Fredholm integral equation of the second kind. The scheme of the impedance synthesis based on the numerical solution of integral equation by the method of moments is constructed. As the first step of the synthesis scheme the analytical solution is proposed under the assumption of geometric optics. Numerical optimization methods is then used. Minimizing a quadratic penalty function for the deviation of the radiation pattern from the desired shape is employed. To eliminate heavily oscillating solutions a Tikhonov regularization method is used.

For the purposes of trying to search the global minimum, the heuristic algorithms (PSO) were used, which further complemented by quasi-Newton algorithm to refine the solution at the last step. The positive results of the synthesis is achieved, which confirms the appropriateness of the selected scheme. Numerical estimations are discussed for the different geometrical sizes of the screen.

Vibration Damping for the High-Rise Buildings by Means of Synthesis of Hybrid Systems with a Dynamic Dampers Using Methods of Pattern Recognition

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New statistical approach to the synthesis of non-fragile robust control systems with given properties and the specific features of its application to the problem of vibration damping for the high-rise buildings by means of synthesis of hybrid systems with a dynamic dampers are discussed in this paper. As an illustration, an analysis of the possibilities of using such control systems for damping vibrations of a 24-storey building is cited.

Analysis of the Relationship Between Transport Network Development and the Areas via Probabilistic Modelling

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We consider the problem of forecasting passenger traffic under transformation of the transport network structure. Modelling of passenger traffic in transformed network based on Markov chains with incomplete transitional probabilities. Estimation of transition probabilities is performed via the original networks traffic and patterns of passenger preferences.

Generalized Dynamic Model and Control of Supply Chain

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The report considers a generalized dynamic model, which consists of several subsystems that describe the various processes in the supply chain (SC). The control problem of such a SC is considered in the presence of incoming information about the state of the system at fixed moments of time and under conditions of limited external influences on it. An algorithm for constructing control is proposed.

Stability of Collinear Libration Points in the Photogravitational Three-Body Problem with Two Radiation Masses

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A photogravitational restricted circular three-body problem is considered in which both main gravitating bodies are also sources of light energy radiation. The collinear libration points located on a straight line passing through the main bodies are studied. The Lyapunov stability of such relative equilibrium in a plane problem is proved.

On Stabilization of Pendulum Oscillations of a Rigid Body

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For a heavy rigid body with a fixed point, the problem of stabilizing Mlodzievsky's pendulum oscillation is posed. A small smooth autonomous control is used, which corrects the model and introduces dissipation into the vicinity of the oscillation.

Group Pursuit Problem with Impulse Constraint Leader

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We consider group pursuit problem, in which among pursuers there are object-leader with impulse control and objects, which are follow by it. These follower-objects and evader have controls with geometrical constraints. We found a criterion for convergence of a linear combination of phase vectors of the group of pursuers with evader at a given time moment and constructed according optimal controls of pursuers. Such the capture condition, with proper selection of the coefficients of the linear combination, can be interpreted as a condition for the convergence of the convex hull formed by the phase vectors of the pursuers with the phase vector of the evader.

Stabilization of an Electromagnetic Suspension System with State-Space Constraints

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We consider an output-feedback stabilization problem with state-space constraints. The solution based on the method of Lyapunov functions and linear matrix inequalities. The sufficient conditions for existence of controllers are obtained.

Orbital Linearizability Condition for Single-Input Control Affine Systems

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In order to transform an affine system to a linear controllable system, we extend state feedback linearization by input-dependent changes of the independent variable. We prove the linearizability condition for single-input control affine systems.

Estimates of Reachable Sets of a Nonlinear Dynamical System with Impulsive Vector Control and Uncertainty

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The problem of estimating the reachable sets of a nonlinear control dynamical system with uncertainty with respect to initial data is studied. It is assumed that the dynamic system has a special structure in which the nonlinear terms presented in dynamical equations are determined by quadratic forms with respect to the state coordinates, and we assume also that unknown initial states of the system belong to a given ellipsoid. It is assumed that in the system there are both classical measurable controls and generalized controls corresponding to the related vector measures. To estimate the reachable sets of a control system of this type and the reachable sets of the corresponding generalized nonlinear differential inclusions with vector measures, we use the results of the ellipsoidal estimation theory and the results of the theory of evolution equations for set-valued states of dynamical systems under uncertainty. Methods and algorithms for estimating reachable sets of a non-linear control system of the studied type are given in the paper; the results are illustrated by examples.

Nash Equilibrium in a Quasi-linear Stochastic System that Operates on an Infinite Time Interval

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The method of optimal control synthesis for a quasi-linear dynamic system that operates on an infinite time interval is generalized to a gaming problem with a vector optimality criterion for which Nash

equilibrium conditions are obtained.

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The stabilization problem of the discrete-time bilinear control system is considered. Using the linear matrix inequality technique and quadratic Lyapunov functions, an approach is proposed to the construction of the so-called stabilizability ellipsoid such that the trajectories of the closed-loop system starting from any point inside this ellipsoid asymptotically tend to the origin. The proposed approach is easy implemented numerically. It allows to construct the nonconvex approximations to stabilizability domains of discrete-time bilinear control systems, and can be extended to robust formulations of the problem, where the system matrices are subjected to structured uncertainty.

On Control of Dynamical Systems with Various Types of Feedbacks.

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In this paper, the finite-dimensional dynamical control systems with various types of feedbacks are considered. The feedbacks defined either as functions of states or as functionals of trajectories are applied. The feedbacks depending on trajectories are more preferable than the feedbacks depending on states although they provide less accuracy of control.

Sufficient Conditions for Relative Minimum in Quasi-Linear Stochastic Optimal Control Problem

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In this work we consider the optimal control problem for quasi-linear dynamical stochastic systems, whose coefficients are nonlinear functions of control vector. We develop an extension of Lagrange-Pontryagin method formulated by V. F. Krotov and V. I. Gurman for deterministic

problem and use it for construct sufficient conditions for strong and weak relative minimum.

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The paper considers a linear discrete time-invariant system with the parametric unstructured linear-fractional uncertainty bounded in spectral norm. The system input is fed by a random sequence, its measured output is distorted by an additive noise. It is supposed that the disturbances are the statistically uncertain signals with bounded level of the mean anisotropy. First time the problem of estimating the output (or state in particular) of the uncertain system by its measured output by means of the suboptimal anisotropic filter (estimator) is stated and solved. The estimator ensures the anisotropic norm of the matrix transfer function from the statistically uncertain disturbance to the estimation error to be bounded.

First Integrals of the Systems with Three Degrees of Freedom with Dissipation

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In this work, the integrability of some classes of dynamic systems on tangent bundles of three-dimensional manifolds is demonstrated. The corresponding force fields possess the so-called variable dissipation and generalize those considered earlier.

Stabilization of the Linear Milling Model

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Under consideration is the problem of optimal stabilization of the linear milling model. Admissible controls are formed on the principle of feedback. Canonical state space decomposition is used to replace the initial problem in Hilbert space by the finite dimensional approximative stabilization problem. Then piecewise constant controls are used to solve

the approximative problem. The corresponding discrete time periodic Riccati equation is solved numerically.

Time-scale Separation Approach to PWM-nonlinear Control System Design

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The stabilizing and tracking control problems of nonlinear systems with pulse-width modulated (PWM) control variable are discussed. Filippov's averaging approach is used to get the equivalent continuous-time dynamics of a high-frequency pulse-width modulated (PWM) nonlinear system. The unified methodology is proposed for controllers designed based on singular perturbation method (time-scale separation method) where the controller parameters are selected such that two-time-scale motions are artificially induced in the closed-loop system. Stability conditions imposed on the fast and slow modes and sufficiently large mode separation rate between fast and slow modes can ensure that the full-order closed-loop nonlinear system achieves the desired properties in such a way that the almost perfect output tracking and external disturbance rejection are provided.

Multiplicative–Noise System Performance in Anisotropy–Based Theory

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In this paper the multiplicative–noise discrete system is considered. The sufficient condition for boundedness of anisotropic norm for the system is formulated in terms of matrix inequalities. Based on this condition there two control laws for multiplicative–noise system are designed. First control law operates state–space and the second one uses output of the system.

Anisotropy-Based Controller Design for Time–Invariant Systems with Moments Constraints

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In this paper the suboptimal anisotropy–based output regulator synthesis formulae are given. It is assumed that mean anisotropy of input is bounded by certain value. The first and the second moments of input are obeyed to some constraints. It is shown that anisotropy–based regulator design can be formulated in terms of convex optimization.

On the Stability of Discontinuous Solutions of Nonlinear Systems with Impulse Action and Delay

Nonsmooth Optimization of Bodies Flow in Hydrodynamics

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The problem is to optimize energy consumption for overcoming the resistance of a fluid in the translational motion of a solid body from one phase state to another during a given time. Necessary optimality conditions are obtained that generate the displacement of the body, accompanied in the general situation by an unsteady fluid motion. The construction of such a displacement is connected with the solution of a two-point boundary value problem for a system of Navier-Stokes equations and having a similar structure of the conjugate system. Such a problem can not be solved analytically, and therefore the question of the structure of optimal control for nonstationary flow remains open even in the case of rigid bodies of simple form. The hypothesis of quasistationary flow allows us at the preliminary stage of research to use the appropriate analytical technique and analyze such problems at a qualitative level.

Uniform Global Asymptotic Stabilization of Bilinear Non-Homogeneous Periodic Discrete-Time Systems

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For a bilinear non-homogeneous periodic system with discrete time, new sufficient conditions are obtained for uniform global asymptotic stabilization of the zero equilibrium by state feedback.

On Spectrum Assignment by Static Output Feedback for Linear Continuous-Time or Discrete-Time Systems with Time Delays in State Variables

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For linear time-invariant continuous-time or discrete-time control systems with several non-commensurate delays in state, we study a spectrum assignment problem by linear static output feedback with delays. Sufficient conditions are obtained for solvability of the arbitrary spectrum assignment problem.

On the Stability of Discontinuous Solutions of Nonlinear Systems with Impulse Action and Delay

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The property of stability and asymptotic stability for nonlinear systems with impulse action and delay is investigated. Sufficient conditions for stability and asymptotic stability are obtained.

Features of Motion Control of a Spacecraft in Photogravitational Fields

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In the general classification the photogravitational problem deals with the specifics of control of solar sail spacecraft (SC), which takes into account the translational and rotational motion of the whole structure. To control the motion of the SC, it is necessary to change the dimensions, properties, or orientation of the sail relative to the rays of the Sun. For heliocentric flight to planets, asteroids or the Sun in a first approximation we can consider only central photogravitational field of the Sun and additional driving force of light pressure of his rays on the sail. The equations of motion taking into account the perturbations can be presented in different forms based on models of the problem of two or three bodies while using convenient coordinate systems and main parameters.

Identification of quadrocopter dynamics

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This paper describes the identification of quadcopter dynamics using Elman's recurrent neural network. The Kalman filter was used to configure this network. The results of the network operation were presented using harmonic input signals.

Robust Output Stabilization of a Class of Continuous and Impulsive Uncertain Systems

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An uncertain n-dimensional system is considered, whose l coordinates are observable ($l < n$) and l controls are present. By constructing an observer and a quadratic Lyapunov function, and by using the backstepping method we build a robust continuous or impulsive control that globally stabilizes the system.

Motion planning in the presence of obstacles under higher-order controllability conditions

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Issues of motion planning and stabilization for essentially nonlinear systems are among the central problems in modern control theory because of significant mathematical challenges and numerous engineering applications. The complexity of several motion planning algorithms has been thoroughly studied for nonholonomic systems whose vector fields satisfy the Lie algebra rank condition at each point of the state space. The presence of obstacles significantly increases the complexity of steering and motion planning problems. An efficient approach for solving these problems is based on the generation of admissible trajectories by using the gradient flow of an auxiliary potential function. Up to now, the construction of potential functions has been addressed only for particular classes of nonlinear systems. In this talk, we consider a general class of control-affine systems under controllability conditions with iterated Lie brackets and present a control algorithm, which ensures the collision-free motion of the system and stabilizes the dynamics at the target point. The proposed class of control functions is based on a recurrent construction of the control functions as trigonometric polynomials depending on time. A rigorous analysis of the solvability of the collision avoidance problem within the above class of controllers is presented together with the convergence proof.