Research Group Nonlinear Systems Control and Analysis

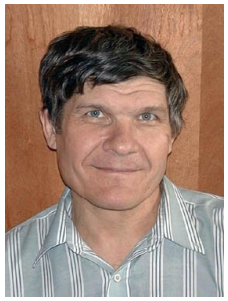
Bauman Moscow State Technical University

Mathematical Modeling Department

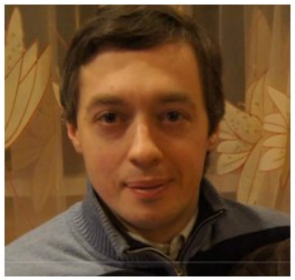
Group Members

- **4 Full professors**
- **6 Associate professors**
- **3 PhD students**









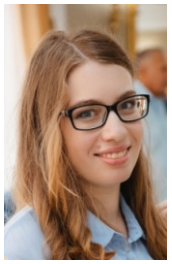

<u>Group leader:</u>

Prof. Alexander P. Krishchenko

Doctor of Physical and Mathematical Sciences, Corresponding Member of the Russian Academy of Sciences

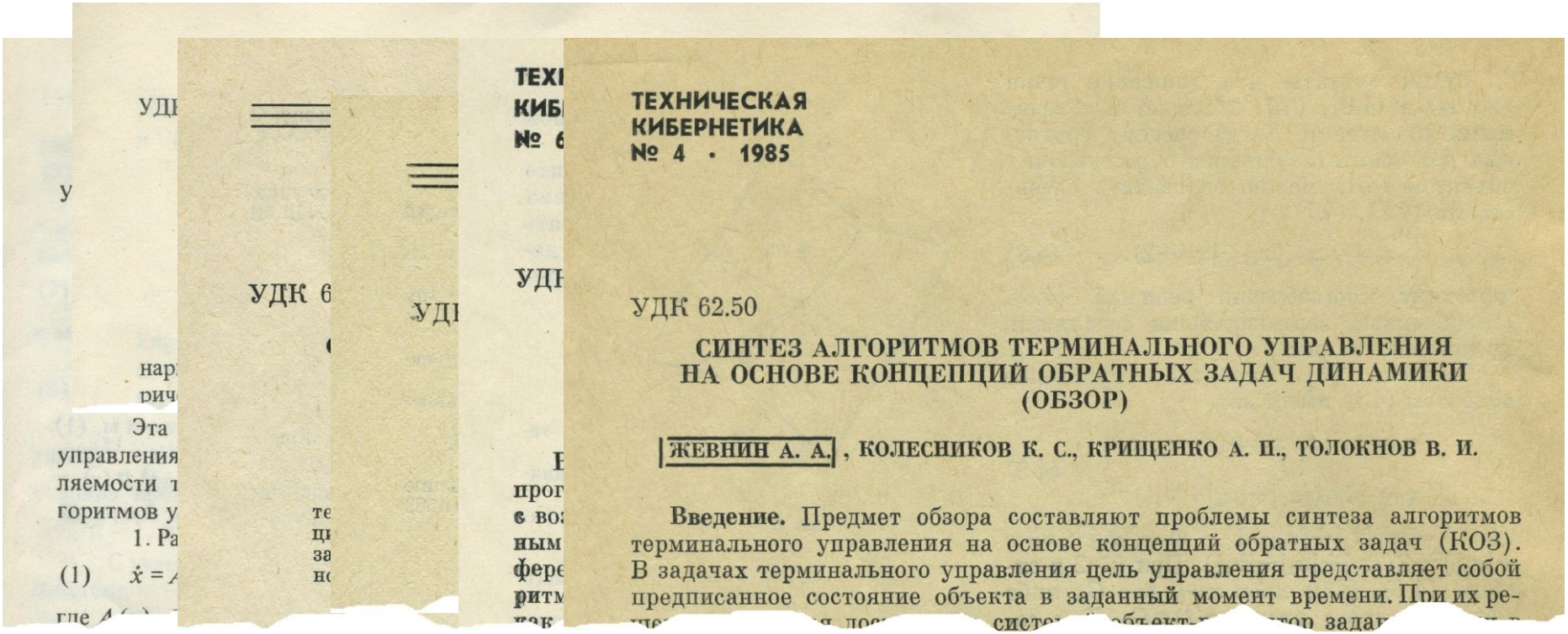






Group's Birth

The history of research team comes back to early 80's and started with the differential - geometric approach to nonlinear terminal control problems



ТЕХНИЧЕСКАЯ
КИБЕРНЕТИКА
№ 4 · 1985

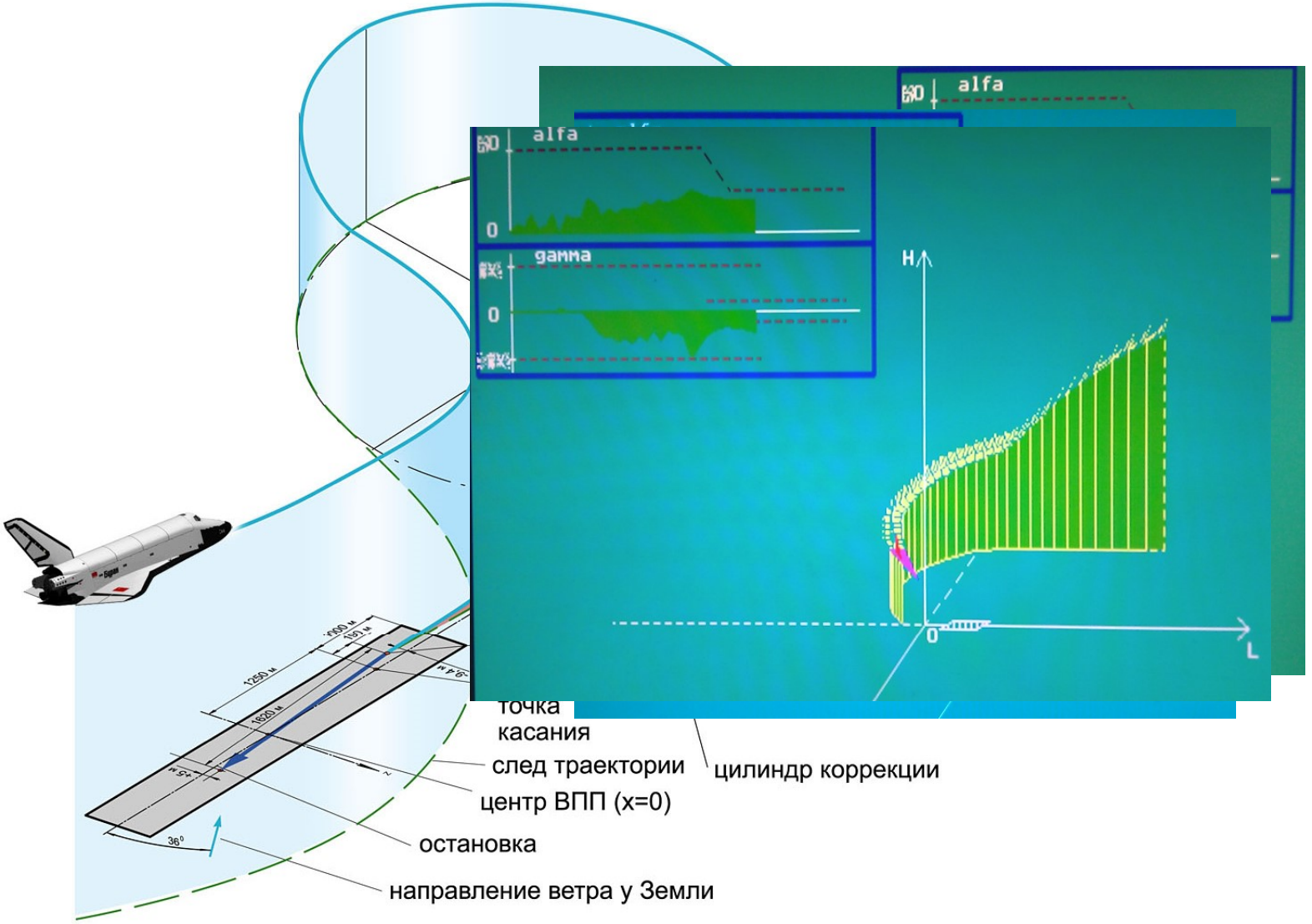
УДК 62.50

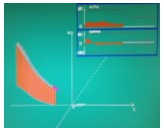
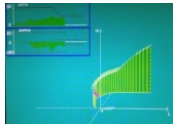
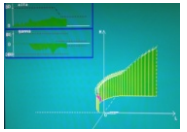
СИНТЕЗ АЛГОРИТМОВ ТЕРМИНАЛЬНОГО УПРАВЛЕНИЯ
НА ОСНОВЕ КОНЦЕПЦИЙ ОБРАТНЫХ ЗАДАЧ ДИНАМИКИ
(ОБЗОР)

ЖЕВНИН А. А., КОЛЕСНИКОВ К. С., КРИЩЕНКО А. П., ТОЛОКНОВ В. И.

Введение. Предмет обзора составляют проблемы синтеза алгоритмов терминального управления на основе концепций обратных задач (КОЗ). В задачах терминального управления цель управления представляет собой предписанное состояние объекта в заданный момент времени. При их ре-

Applied Project Example:
Space Shuttle “Buran” Admissible Trajectories



Research Focus in the 90s

Theoretical results on

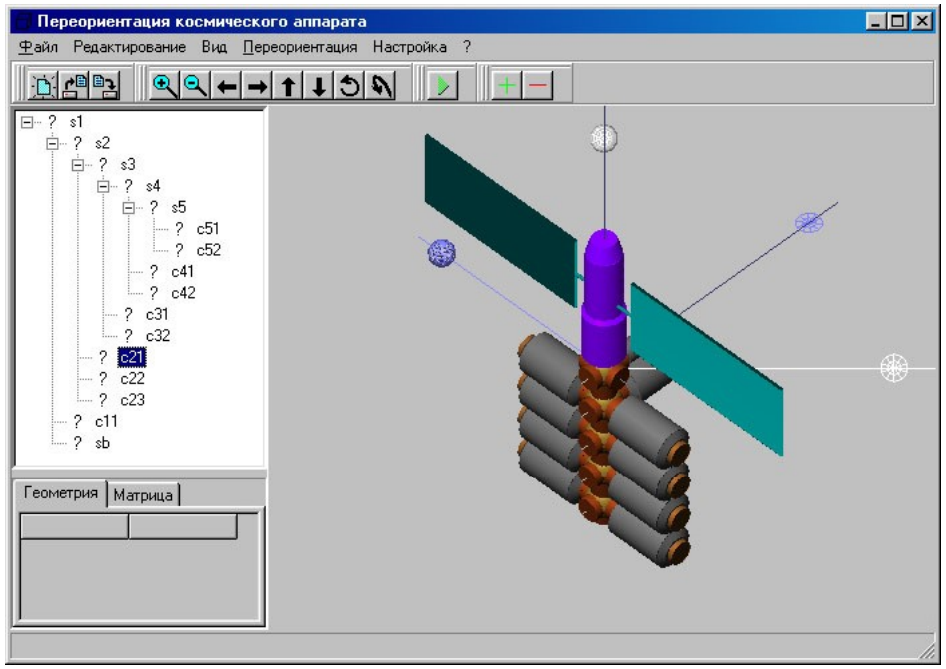
- state feedback linearization and symmetries of control affine dynamical systems
- nonlinear state observer design based on the duality of controllability and observability properties
- control of spacecraft rotational motion
- stabilization of systems with chaotic dynamics

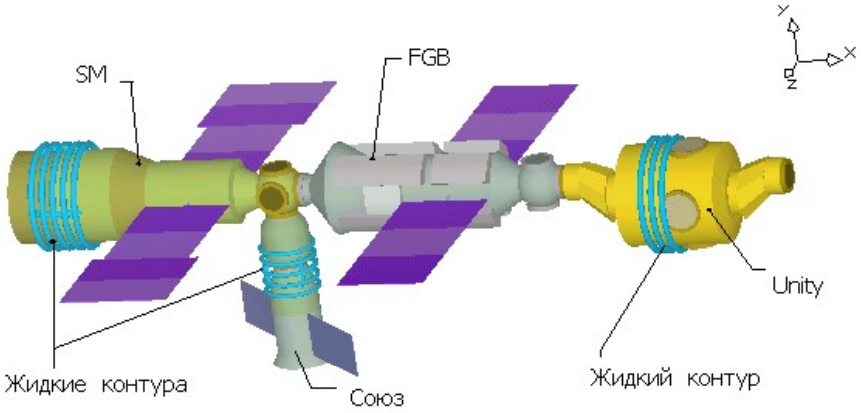
The localization problem is formulated and pioneer key results are conceived for periodic trajectories to start off a new approach in the qualitative analysis theory

Some key publications of the 90s

- *Krishchenko A.P. Synthesis of terminal control algorithms for nonlinear systems // Izvestiya Akademii Nauk. Teoriya i Sistemy Upravleniya. 1994. V.1. pp. 48-57*
- *Krishchenko A.P. Transformation of multidimensional affine controlled dynamic systems // Computational Mathematics and Modeling. 1994. V. 5, No 1. pp. 1-9*
- *Krishchenko A.P., Tkachev S.B. Nonlinear k(x)-dual systems // Avtomatika i Telemekhanika. 1995. V. 2. pp. 21-35*
- *Krishchenko A.P. Stabilization of equilibrium points of chaotic systems // Physics Letters A, V. 203 No. 5-6. pp. 350-356*
- *Krishchenko, A.P. Estimations of domains with cycles // Computers and Mathematics with Applications. 1997. V. 34, No 2-4. pp. 325-332.*
- *Kanatnikov A.N., Krishchenko A.P. Symmetry of affine systems // Computational Mathematics and Modeling. 1998. V. 9, No 1. pp. 64-75.*

Applied Project Example: Space Station Constructor





Research Focus in the 00s

- Research on UAV admissible trajectories generation is continued
- Theoretical results on control of non-minimum phase systems and output feedback are addressed
- The localization approach is extended to compact invariant sets of dynamical systems

Some key publications of the 00s

- *Kanatnikov A.N., Krishchenko A.P. Terminal control of spatial motion of flying vehicles // Journal of Computer and Systems Sciences International. 2008. V. 47, No 5, pp. 718-731*
- *Golubev A.E., Krishchenko A.P., Tkachev S.B. A Separation Principle for Affine Systems // Differential Equations. 2001. V. 37, No 11. pp. 1541-1548*
- *Golubev A.E., Krishchenko A.P., Tkachev S.B. Stabilization of nonlinear dynamic systems using the system state estimates made by the asymptotic observer // Automation and Remote Control. 2005. V. 66, No 7. pp. 1021-1058*
- *Krishchenko A.P., Panfilov D.Yu., Tkachev S.B. Global stabilization of affine systems via virtual outputs // Differential Equations. 2003. V. 39, No 11. pp. 1585-1592*
- *Krishchenko A.P. Localization of invariant compact sets of dynamical systems // Differential Equations. 2005. V. 41, No 12. pp. 1669-1676*

Applied Project Example: Computation of Permissible Flight Trajectories

COMPUTATION
OF PERMISSIBLE
FLIGHT TRAJECTORIES

Project purposes

- Development of algorithms for real-time calculation of the helicopter spatial flight trajectories from the specified initial and final states
- Real-time calculation of the controls realizing the constructed helicopter spatial flight trajectory
- Analysis of the developed control algorithm's characteristics

play previous next

Research Focus in the 2010s

- **Control Systems and Applications**
  - Differential flatness of nonlinear systems
  - Input-output systems and Backlund transformations
  - Orbital decompositions of control systems
  - Invertible linear ordinary differential operators and their generalizations
  - Input-dependent time scalings
  - Trajectory generation methods for dynamical systems
  - Output feedback, nonlinear state observer and passivity-based designs
  - Control of quadrotors and mobile robots

Research Focus in the 2010s (continued)

- **Localization Method and Applications**
  - Localization method for discrete-time systems
  - Stability criteria and Lyapunov function design
  - Separating simple and complex dynamics of nonlinear systems
  - Trajectory behavior classification
  - Studies of tumor dynamics and treatment, cancer and behavior of various populations

2020s: Some recent publications in Control Systems and Applications

- *Golubev, A.E., Utkina, N.V. Stabilization of passive dynamical systems with actuator and sensor disturbances // IFAC-PapersOnLine. 2020. V. 53(2). p. 5807-5812*
- *Chetverikov V.N. Orbital Decompositions of Control Systems and Multivector Fields // Differential Equations. 2020. Vol. 56, № 11. C. 1502–1512*
- *Fetisov D.A. A-Orbital feedback linearization of multiinput control affine systems // International Journal of Robust and Nonlinear Control. 2020. Vol.30, Issue 14. P. 5602-5627*
- *Chetverikov V.N. Invertible linear ordinary differential operators and their generalizations // Journal of Geometry and Physics. 2020. Vol. 151. Art. no. 103617*
- *Chetverikov V.N. Coverings and multivector pseudosymmetries of differential equations // Differential Geometry and its Applications. 2021. Vol. 74. Art. no 101705.*
- *Golubev A.E. Construction of programmed motions of constrained mechanical systems using third-order polynomials // Journal of Computer and Systems Sciences International. 2021. V. 60, No 2. P. 303–314*

2020s: Some recent publications in Localization Method and Applications

- *Krishchenko A.P., Starkov K.E. Convergence dynamics in one eco-epidemiological model: Self-healing and some related results // Communications in Nonlinear Science and Numerical Simulation. 2020. Vol. 85. Art. no. 105223*
- *Starkov K.E., Krishchenko A.P. Stabilization in a 3D eco-epidemiological model: From the complete extinction of a predator population to their self-healing // Mathematical Methods in the Applied Science. 2020. Vol. 43, Issue 18. pp. 10646–10658*
- *Starkov K.E., Kanatnikov A.N., Andres G. Ultimate tumor dynamics and eradication using oncolytic virotherapy // Communications in Nonlinear Science and Numerical Simulation. 2021. Vol. 92. Art. no 105469*
- *Krishchenko, A.P., Starkov, K.E. 5D model of pancreatic cancer: Key features of ultimate dynamics // Communications in Nonlinear Science and Numerical Simulation. 2021. Vol. 103. Art. No 105997*