

ICR 2026

XI International Conference on
Interactive Collaborative
Robotics

ICR 2026

Conference Programme and Abstracts

August 17-20, 2026
Vladivostok, Russia



Organizers

- Far Eastern Branch of the Russian Academy of Sciences, FEB RAS, Vladivostok, Russia
- Saint-Petersburg branch of the Russian Academy of Sciences, SPbRAS, St. Petersburg, Russia
- Institute of Automation and Control Processes Far Eastern Branch of the Russian Academy of Sciences, IACP FEB RAS, Russia
- St. Petersburg Federal Research Center of the Russian Academy of Sciences, SPC RAS, Russia

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- Andrey Ronzhin, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), Russia

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- Saul de la Rosa, National Autonomous University of Mexico (UNAM), Mexico

Organizing Committee Members

- Alexander Zuev, Institute of Automation and Control Processes Far Eastern Branch of the Russian Academy of Sciences, (IACP FEB RAS), Russia (Co-Chair)
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- Inna Uzinger, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), Russia

Conference at a glance

Monday, August 17, 2026			
14:00-16:00	Registration (for on-site participants)		
Tuesday, August 18, 2026			
09:00-09:30	Registration (for on-site participants)		
09:30-10:00	Opening Ceremony: https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Roman Romashko, Andrey Ronzhin		
10:00-11:00	Plenary Session 1: https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Valeria Gribova, Roman Meshcheryakov		
11:00-11:30	Coffee Break and Exhibition On-line Joint Photography of Conference Participants		
11:30-14:00	<table border="0"> <tr> <td> Oral Session 1: Manipulator Control https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Alexander Zuev, Dmitry Dobrynin </td> <td> Oral Session 2: Robot Navigation https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Mikhail Medvedev, Konstantin Yakovlev </td> </tr> </table>	Oral Session 1: Manipulator Control https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Alexander Zuev, Dmitry Dobrynin	Oral Session 2: Robot Navigation https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Mikhail Medvedev, Konstantin Yakovlev
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15:00-18:00	<table border="0"> <tr> <td> Online Session 3: Water Robotics Vehicles https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Oleg Stepanov, Anton Gubankov </td> <td> Online Session 4: Robot Navigation https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Petr Trefilov, Ekaterina Cherskikh </td> </tr> </table>	Online Session 3: Water Robotics Vehicles https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Oleg Stepanov, Anton Gubankov	Online Session 4: Robot Navigation https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJdDz09 Chairs: Petr Trefilov, Ekaterina Cherskikh
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18:00-21:00	Gala Dinner and Closing Ceremony		
Thursday, August 20, 2026			
09:00-15:00	Sightseeing Tour		

The time of the video conference is specified in the time zone of Vladivostok, Russia (UTC + 10): <https://www.worldtimebuddy.com/utc-to-russia-vladivostok>

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	<i>Mikhail Medvedev, Stepan Dergachev, Konstantin Yakovlev.</i> Empirical Evaluation of Priority-Based Planners for Multi-Agent Path Finding with Elevators.
	<i>Marat Agranovskiy.</i> Path Planning with Motion Primitives in Dynamic Environments: SIPP on Lattices.
	<i>Kirill Muravyev, Dmitry Vtorushin.</i> Robust and Effective Semantic-aided Point Cloud Matching for Mobile Robot Navigation.
	<i>Dmitrii Kostin, Valeria Gribova.</i> CGAN Model for Building Layout Plans Generation.
	<i>Liudmila Steshina, Igor Petukhov, Daniil Galkin, Ildar Grigorev.</i> Hybrid Forest Mapping for Robotic Navigation under GNSS Uncertainty.
	<i>Wei Zhang, Ziwen Qu, Xusheng Yang, Minglei Fu, Wen-An Zhang, Yuke Ji, Haoning Zhang.</i> A Robust RTK Navigation and Positioning Method for a Quadruped Robot in Complex Dynamic Environments.
	<i>Yuqiang Jin, Shaoqing Xu, Xusheng Yang, Wen-An Zhang.</i> Robust Geometric Filtering with Gain Constraints on Lie Groups.
	<i>Nikolai Kolesov, Alexander Gruzlikov, Yuri Skorodumov, Viktor Tiulnikov.</i> Application of Three-Dimensional Graph Modeling for the Investigation of Multipath Data Routing Algorithms in Underwater Acoustic Networks of AUVs.
	<i>Alexander Scherbatyuk.</i> On a Method of Increasing the Accuracy for AUV Group Positioning by Use of SBL APS.
<i>Petr Trefilov, Roman Meshcheryakov.</i> Adaptive Navigation Method for a Robotic System with Discrete Mode Switching Based on Environmental Uncertainty Assessment.	
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	<i>The Tien Nguyen, Huu-Hung Nguyen, Xuan Tung Truong.</i> An Efficient Camera-LiDAR-Based 3D Human Detection and Tracking Algorithm for Socially Aware Mobile Robot Navigation Systems.
	<i>Phạm Trần Quyển Anh, Trương Xuân Tùng.</i> Density-Aware Layered Social Costmaps for Context-Aware Navigation of Omnidirectional Robots.
	<i>Sergey Jatsun, Oksana Emelyanova, Alexander Pechurin, Oksana Loktionova.</i> Development of a Method and Algorithm for Determining the Reaction Forces of the Joints of the Patient's Lower Extremities.
	<i>Andrei Malchikov, Anastasiya Kisele, Evgeny Politov.</i> Modeling the Dynamics of a Collaborative Parallel Kinematic Robot with Elastic Actuators for Automated Periorbital Massage.
	<i>Alexandr Korchemnyi, Anatoly Onishchenko, Eva Bakaeva, Alexey Kovalev, Aleksandr Panov.</i> HELP: Hierarchical Embodied Language Planner for Household Tasks.
<i>Yaroslav Turovsky, Roman Meshcheryakov, Nikita Solopanov.</i> Interface for Controlling a Group of Unmanned Aerial Vehicles, Taking into Account the Operator's Characteristics.	

	<i>Victor Naumov, Alexandr Anochshenko, Matvei Chernyshov.</i> Safe Use of Artificial Intelligence and Robotics: Issues of Legal Terminology.
	<i>Elvira Chebotareva, Renat Abdulganeev, Timur Minullin, Edgar Martinez-Garcia, Evgeni Magid.</i> Monocular Depth-Based Object Localization for Collaborative Robotic Grasping.
	<i>Sergey Jatsun, Dmitry Efremov, Gavriil Fursov, Roman Derevyanko.</i> Autonomous Control of a Medical Stand for Urological Surgeries.
	<i>Arkady Yuschenko.</i> Interactive Collaborative Robotics (ICR) Ergonomic Research and Design on the Fuzzy Logic Base.
	<i>Olga Ergunova, Andrey Somov, Irina Karabulatova.</i> Neurocognitive Risk Management of Human Capital in Human–Robot Collaborative Organizations: A Neural Network Framework for Metropolitan Digital Economies.
	<i>Mohammad Alwardat, Hassan Alwan.</i> Real-time Link-level Obstacle and Singularity Avoidance for a Robotic Manipulator using PID-controlled DLS and Null-space Projection.
	Online Session 2: Ground Robotics https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chairs: Marina Barulina, Tatyana Yermolenko
	<i>Hoang Duc Long, Vu Xuan Duc, Le Van Tung.</i> A Fixed-Time Adaptive Barrier-Based Integral Super-Twisting Sliding Mode Control for Uncertain Wheeled Mobile Robots.
	<i>Maksim Romanenko.</i> Towards Latency-Stable Robotic Perception Pipelines in ROS 2: Eliminating Non-Maximum Suppression for Real-Time Target Tracking and Distance Estimation.
	<i>Ilya Kovalenko, Eugenia Ahremenko, Alexandr Andreev, Danila Apushkin, Marina Barulina.</i> System Analysis of Video Stream Coherence in the Design of Hybrid Behavior Recognition Models.
	<i>Elvira Chebotareva, Nail Bikmullin, Tatyana Tsoy, Mikhail Svinin, Evgeni Magid.</i> Monocular Vision-Based Positioning System for Object Localization in Collaborative Conveyor Applications.
15:00-19:00	<i>Vladimir Dashevsky, Yuri Galykin, Andrey Ronzhin.</i> Autonomous Service Platform for Spraying UAVs: System for Mixing Solutions.
	<i>Andrei Shevkunov, Anna Shirokova, Sofia Dzhatdoeva, Azret Kochkarov.</i> AI-Driven Trichome Quantification for Robotic Phenotyping Systems.
	<i>Vitaly Bondarenko, Tatyana Yermolenko, Andrey Grabarchuk, Egor Moroz.</i> Testing Methodology for a Computer Vision System for Glass Container Quality Control on a Robotic Conveyor.
	<i>Sergey Okunkov, Marina Barulina, Ivan Ulitin.</i> Comparative analysis of AI model robustness in color image classification tasks with respect to synthetic data.
	<i>Anna Nelyubova, Victor Zhoga.</i> Controlling the Movement of Hybrid Parallel-Serial Manipulator with Passive Link.
	<i>Vladislav Danilchenko, Philip Bulyga, Elmar Kuliev, Daria Zaruba.</i> Intelligent Decision Support System for Wind Farm Maintenance Based on Hybrid Bio-Inspired Optimization.
	<i>Ilya Afanasyev.</i> Neuro-Symbolic Enhancement of the Geometric Dual Quaternion Observer for 6DoF Pose Estimation in Autonomous Robotic Systems.

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	<i>Minglei Fu.</i> High-precision Positioning and Navigation of Intelligent Robots in Complex Dynamic Environments
	<i>Du Libin.</i> Research Progress on Marine Environment Perception and Intelligent Detection Robots
11:00-11:30	Coffee Break and Exhibition
11:30-14:00	Oral Session 3: Robot Control https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJkdz09 Chairs: Nikolay Sharonov, Victor Kazantsev
	<i>Mikhail Medvedev, Vyacheslav Pshikhopov, Ilya Medvedev.</i> Method of Adaptive Control of Pure Feedback Plants Based on the Actor-Critic Framework.
	<i>Denis Bordyugov, Evgeniy Briskin, Nikolay Sharonov, Aleksey Prokopov.</i> Control of Mobile Robots with Load-Bearing Supports Discretely Interacting with the Supporting Surface.
	<i>Olga Zarina, Alexey Bobtsov.</i> An Adaptive State Observer for a Class of Time-variant Bilinear Systems Under Condition of Partial Parametric Uncertainty.
	<i>Sofya Devyataya, Olga Zarina, Alexey Bobtsov.</i> Velocity observer design via reducing to linear regression for the Euler-Lagrange systems class.
	<i>Oleg Stepanov, Alexey Isaev.</i> Recursive Batch Gaussian Sum Filter for Single-Beacon Navigation Problem.
	<i>LiBin Du, Zhen Zhu, Vladimir Filaretov, Dmitry Yukhimets, ChengGang Wang, Di Tian, YunLi Nie.</i> Hydrodynamic Performance Analysis of Rim-Driven Propeller Based on CFD
	<i>Iliia Mitin, Victor Kazantsev, Sergey Lobov, Susanna Gordleeva.</i> Study of Energy Efficiency of Thunniform Locomotion Using a Robotic Fish Example.
<i>Waleed Khalid, Victor Kazantsev.</i> Numerical Simulation of Dynamics Deformation of Bio-Inspired Robotic Wing.	
11:30-14:00	Oral Session 4: Service Robots https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJkdz09 Chairs: Igor Petukhov, Alexey Kashevnik
	<i>Igor Petukhov, Liudmila Steshina, Dimiter Velez, Plamena Zlateva.</i> Effects of Simulator Training Duration on Early-Stage Control Performance of Mobile Vehicle Platforms.
	<i>Anatoly Kalyaev, Dina Orda-Zhigulina.</i> Design of Heterogeneous Robotic Warehouse Systems Based on an Intelligent Zone-Based Multiagent Dispatching Method.
	<i>Alexey Yakushev, Alexey Kashevnik.</i> Lightweight Multi-Task Emotion Recognition for Human-Robot Interaction.

	<i>Hao Chen, Weihua Chen, Li Zhang, Fan Ye, Minglei Fu.</i> A Cloud-Edge Collaborative Framework for Personnel Identification via Wearable Smart Glasses.
	<i>Anton Gubankov, Aleksander Zuev, Vladislav Gorin, Dmitriy Yukhimets, Anastasia Serdyukova.</i> Development of a Method for Synthesizing Adaptive Control Systems for Unmanned Aerial Vehicles.
	<i>Dmitry Yukhimets, Anton Gubankov.</i> Development of Control System Synthesis Method for Unmanned Aerial Vehicles Moving in a Group.
	<i>Yunli Nie, Zihao Zhang, Yizhe Huang, Jiahao Du, Vladimir Filaretov, Dmitry Yukhimets, Libin Du.</i> Design of Intelligent Weighing System Based on Multi-Sensor Information Fusion.
	<i>Vladimir Malyshev, Roza Mikhailenko, Alexey Martynov, Nikita Zatsepin, Georgy Piskunov.</i> Robotics in Environmental Monitoring of Surface Water Bodies.
14:00-15:00	Lunch
	Online Session 3: Water Robotics Vehicles https://us06web.zoom.us/j/83782678933?pwd=SE9EULhxdnpsbWVENEJ2aEhRWXJDdz09 Chairs: Oleg Stepanov, Anton Gubankov
	<i>Pham Van Gioi, Hoang Duc Long, Le Van Tung.</i> Adaptive Energy-Shaping Error-Dynamics Control for Omni-Mecanum Mobile Robots.
	<i>Aws Ahmad, Arkady Yuschenko.</i> Fuzzy Logic Application for Underwater Robot with Undulating Fin Control.
	<i>Le Van Nghia, Andrey Ronzhin, Tran Van Tuyen, Nguyen Huy Liem.</i> Analysis of Deep Learning Methods in Video Analytics, Robotic Monitoring, and Aquaculture Management with an Empirical Comparison of Lightweight YOLO Models for Fish Detection.
15:00-18:00	<i>Firas Houssein, Mikhail Medvedev.</i> A Communication-Efficient Modified Consensus-Based Auction Algorithm for Distributed AUV Task Allocation.
	<i>Iuliia Zaitceva.</i> Synthesis of Robust Controller based on Stability Criterion of Forced Oscillations.
	<i>Andrey Maevskiy, Vladimir Ryzhov, Alexander Zinoviev, Igor Kozhemyakin.</i> PathFormer: A CNN–Transformer Architecture for Autoregressive Path Planning of Unmanned Surface Vehicles in Current-Affected Waterways.
	<i>Tatiana Fedorova, Vladimir Ryzhov, Igor Kozhemyakin, Ekaterina Strelets.</i> An Analytical Approach to Evaluating the Lifetime and Energy Efficiency of a Hybrid Underwater Wireless Sensor Network with a Mobile Gateway.
	<i>Vagif Abdullayev, Kamil Aida-zade, Vugar Hashimov.</i> Synthesis of Control of the Movement of Measurement Points of the State and Power of Heat Sources at the Ends of the Rod.
	<i>Kamil Aida-zade, Samir Guliyev, Seymur Mirzabayov.</i> Feedback Control of a Discrete System with Memory within the Class of Zonal Control Actions.

	<p>Online Session 4: Robot Navigation https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chairs: Petr Trefilov, Ekaterina Cherskikh</p>
	<p><i>Doan Van Dung, Do Duy Khanh, Lan Anh Nguyen, Xuan-Tung Truong, Le Quy Don Technical University, Hanoi, Vietnam.</i> An Efficient Navigation System for Autonomous Mobile Robots on Rough Terrain Environments</p>
	<p><i>Phuc Nguyen Xuan, Thanh Nguyen Canh, Huu-Hung Nguyen, and Xiem Hoang Van.</i> Mitigating Tracking Failures in Sparse-View Gaussian SLAM via Feature-Guided Initialization.</p>
	<p><i>Cong Binh Nguyen, Xuan Chiem Nguyen, Pavel Obukhov, Pham Duy Thái.</i> Adaptive Nonlinear Hierarchical Control Based on RBF Neural Networks for Line-Following and Obstacle-Avoiding Mobile Robots under Dynamic Model Uncertainties.</p>
15:00-18:00	<p><i>Thong Pham Duc, Dmitry Tarlakovskii.</i> Onboard Vehicle Detection for Autonomous UAV Reconnaissance under Degraded Visual Conditions.</p>
	<p><i>Satenik Akopyan, Gleb Kiselev.</i> Informed Reinforcement Learning for Mobile Robot Planning and Control Tasks based on the D*-Lite Algorithm.</p>
	<p><i>Bushra Ali, Hani Khalil, Riham Saad, Igor Smirnov.</i> Real-Time Stereo-Vision Semantic Navigation for Apple Orchards Using YOLOv5.</p>
	<p><i>Gleb Dudyrev, Gleb Kiselev.</i> Differentiable LQR as a Structured Policy Output Layer for Mapless Goal-Reaching Navigation of a Mobile Robot.</p>
	<p><i>Mikhail Stepanyov, Anton Saveliev, Ekaterina Cherskikh, Konstantin Krestovnikov.</i> Autonomous Flight System for UAVs to Selected Objects.</p>
	<p><i>Boris Lebedev, Oleg Lebedev, Andrey Sukhanov.</i> Methods of Collecting Information using Unmanned Aerial Vehicles for Monitoring Difficult and Remote Areas.</p>
	<p><i>Kristina Obukhova, Kirill Nikitin, Anton Saveliev, Ekaterina Cherskikh.</i> UAV Stabilization System Based on Machine Vision and Inertial Sensors.</p>
	<p><i>Mohammad Issa.</i> Toward Cognitive and Energy-Aware Multi-Agent UAV-UGV Collaboration under Limited Communication.</p>
18:00-21:00	Gala Dinner and Closing Ceremony
Thursday, August 20, 2026	
09:00-15:00	Sightseeing Tour

The time of the video conference is specified in the time zone of Vladivostok, Russia (UTC + 10): <https://www.worldtimebuddy.com/utc-to-russia-vladivostok>

Abstracts

Plenary Session 1



Igor Bychkov, Director of the Matrosov Institute for System Dynamics and Control Theory, Deputy Chairman of the Siberian Branch of the Russian Academy of Sciences (SB RAS) for Scientific Work – Scientific Supervisor of the Irkutsk Branch of SB RAS, Irkutsk, Russia.

Plenary Speech: Adaptive Control Strategies for Autonomous Robot Groups Operating in Obstacle-prone Environments

Abstract: One of the fundamental tasks in group control of autonomous mobile robots is the efficient routing of a group while performing a given set of distributed tasks. The presence of unaccounted physical obstacles in this context can disrupt communication within the group, creating a risk of losing one or multiple robots. This is especially important when the group moves in a specific formation, the choice of which is determined by the current task and the surrounding environment. To compensate for insufficient situational awareness, various solutions are used, including additional observer robots that form a higher-level group, which possesses enhanced situational awareness and is capable of maintaining communication with the lower-level group within line of sight. The talk presents original control strategies for groups of autonomous robots that enable decentralized adaptation of formations and interaction modes in multi-level groups in response to environmental dynamics and squad changes. Unlike centralized solutions, the proposed methods do not rely on a single leader or a global coordinator. Instead, each robot independently makes decisions based on local information from neighboring agents and environmental conditions. This ensures scalability, robustness to individual robot failures, and adaptability to dynamically changing environments.



Konstantin Yakovlev, Leading Researcher, Federal Research Center «Computer Science and Control» of the Russian Academy of Sciences, Moscow, Russia, Docent, Saint Petersburg University, St. Petersburg, Russia.

Plenary Speech: Multi-agent Path Finding: Algorithmic and Learning-based Solutions

Abstract: Coordinating a team of mobile robots that simultaneously move and accomplish tasks in a shared environment (e.g., wheeled robots in a warehouse, driverless cars in a parking lot, etc.) is a challenging problem that comes in different flavors. The Multi-Agent Path Finding (MAPF) formalism provides a fundamental abstraction for this problem, enabling the development of algorithms with strong theoretical guarantees. Heuristic search has been highly successful in this domain, producing optimal or bounded-suboptimal solutions with proven guarantees. Rule-based solvers and optimization techniques have also proven to be effective tools to tackle MAPF by providing high-quality solutions within a much lower computational budget. Still, most of the modern search-based and rule-based MAPF solvers intrinsically assume that the multi-agent system is controlled in a centralized fashion and it is not trivial to adapt them to real-world constraints like partial observability and limited communication. This is where ML-based approaches may come on stage and overcome the limitations of conventional planning-based methods. This talk explores how heuristic search may be integrated with machine learning (i.e. deep reinforcement learning, imitation learning, transformers, large-scale learning) to create new generation of (decentralized) MAPF solvers.

Plenary Session 2



Minglei Fu, College of Information Engineering, Zhejiang University of Technology, Hangzhou, China

Plenary Speech: High-precision positioning and navigation of intelligent robots in complex dynamic environments.

Abstract: The problems of high-precision positioning and navigation of intelligent ground robots under dynamic interference conditions (tree canopy shading, multipath effects, and onboard electromagnetic interference) are considered. Limitations of the classical EKF approach with direct fixing of dual-frequency ambiguities are shown. A robust RTK method combining wide-lane tracking and a progressive Gaussian filter is proposed. Real experiments with quadruped ground robotic platforms in a real environment demonstrate a reduction in horizontal trajectory error to 0.13 m and vertical error to 0.18 m. The developed solutions are intended for navigation of autonomous robots in shaded and industrial environments.



Du Libin, Executive Dean of College of Ocean Science and Engineering, Shandong University of Science and Technology, Qingdao, China

Plenary Speech: Research Progress on Marine Environment Perception and Intelligent Detection Robots.

Abstract: High-precision marine environmental perception and intelligent detection serve as an essential foundation for deep-sea resource development, ecological environment protection, marine scientific research, and marine security guarantee. Aiming at prominent problems such as insufficient detection accuracy, poor sensor stability, and limited autonomous operation capability of robots under complex ocean disturbances and extreme deep-sea working conditions, this report focuses on two core components: high-precision marine sensor technology and intelligent detection robots, and systematically reviews the latest research progress and application achievements of relevant technologies. Firstly, it elaborates on the technological breakthroughs of high-precision marine hydrological sensors in terms of high-precision acquisition, noise suppression, and product development. Secondly, it summarizes the technological iteration achievements of underwater intelligent operation robots and agile detection robots in multi-source sensor information fusion, anti-interference perception in complex sea areas, high-precision autonomous navigation, and intelligent operation. Finally, it prospects the development trends of this field. In the future, marine perception technologies will achieve continuous breakthroughs in the directions of high-precision integration of sensors, deep-sea adaptation of detection equipment, high-precision collaborative detection of robot clusters, and long-term stable autonomous operation, providing theoretical reference and technical support for the iterative upgrading of high-precision marine perception technologies, the optimization and upgrading of intelligent detection robots, and their engineering implementation.

Oral Session 1: Manipulator Control



Vladimir Filaretov, Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia.

Michail Belousov, Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia; Far Eastern Federal University, Vladivostok, Russia.

Igor Gornostaev, Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia; M.D. Ageev Institute of Marine Technology Problems FEB RAS, Vladivostok, Russia; Admiral Nevelskoy Maritime State University, Vladivostok, Russia.

Lecture Title: Target Designation Method Using Underwater Video Camera Calibrated with Multi-link Manipulator.



Abstract: The paper focuses on developing a method for creating accurate target designations for a multi-link manipulator installed on AUV for various technological operations. These target designations consist of spatial straight lines passing through observed points on work object surfaces, created with the help of underwater monocular video cameras mounted on the AUV. The protective housings of these video cameras consist of thick glass that separate different media due to environment high external pressure, and usually introduce significant optical distortions in the captured images. To correct these distortions, a new calibration method for underwater video cameras is proposed. This method uses a known ray-tracing approach to account for light refraction at media boundaries (with unknown pre-determined refractive indices: air-glass-water) and eliminate lens distortions. This method is applicable for calibrating video cameras with glass of various shapes (flat, cylindrical, etc.). It not only enables accurate determination of the spatial line parameters on which a visible point of an observed object lies but also – after camera calibration – ensures accurate designation targeting of working tools of these manipulators to target work points. The effectiveness of this method has been confirmed by experimental results.



Ivan Grigorev, Academician M. D. Ageev Institute of Marine Technology Problems FEB RAS, Vladivostok, Russian Federation; Institute of Automation and Control Processes FEB RAS, Vladivostok, Russian Federation.

Dmitry Yukhimets, Academician M. D. Ageev Institute of Marine Technology Problems FEB RAS, Vladivostok, Russian Federation; Institute of Automation and Control Processes FEB RAS, Vladivostok, Russian Federation.

Lecture Title: Method for identifying elastostatic parameters of a multi-link manipulator using a three-axis accelerometer.



Abstract: The elastostatic (compliance) parameters of an industrial manipulator (IM) are used to calculate its deformations under its own weight or external forces. The calculated deformations are compensated by the manipulator control system, which allows to increase positioning accuracy in absolute coordinate system. However, the compliance parameters are usually unknown. This article proposes a method for identifying these parameters based on a consumer-grade three-axis accelerometer mounted on the IM flange and operating in inclinometer mode. During data collection for identification, the IM is moved to several positions and loaded with a known mass in each position. In each position, the accelerometer measures the flange tilt angle before and after loading.

	<p>Numerical optimization methods are then used to find elastostatic parameters that accurately predict the IM deformations when an external force is applied to its flange. The proposed method, unlike existing methods, does not require expensive or bulky high-precision measuring equipment and lends itself well to automation. Furthermore, the method allows the use of uncalibrated consumer-grade microelectromechanical accelerometers, which are very inexpensive and widely available. The results of mathematical modeling confirm the method's feasibility.</p>
	<p>Vladimir Filaretov, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation.</p>
	<p>Alexander Zuev, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation; Institute of Marine Technology Problems named after Academician M.D. Ageyev, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation.</p>
	<p>Aleksander Timoshenko, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation.</p>
	<p>Alexander Protsenko, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation.</p> <p>Lecture Title: Development of an Algorithm for Solving the Inverse Dynamics Problem for Underwater Manipulators.</p> <p>Abstract: The paper discusses the development of a new method for calculating load moments for all joints of underwater multi-link manipulators installed on unmanned underwater vehicles. By introducing additional terms into the equations of motion, it takes into account all the key features of the interaction of the manipulator links with a viscous medium, including the effects of currents. To achieve this, the attached masses and moments of inertia are represented as symmetric positive-definite matrices with constant coefficients. This distinguishes the proposed approach from known methods that use variable coefficients dependent on the instantaneous velocity and direction of motion. This representation ensures the linearity of the dynamic model with respect to the identifiable hydrodynamic parameters, creating the basis for their subsequent precise determination. To account for constant underwater currents in the proposed modified algorithm, the linear velocity of the manipulator base is assumed to be equal to the difference between the vehicle speed and the current velocity, allowing for the determination of the longitudinal and transverse components of the viscous friction forces and moments. Furthermore, a correction is introduced into the expressions for the acceleration of the link's center, accounting for the constant current velocity. This corrects the calculation of the forces and moments due to the attached masses and moments of inertia. Thanks to these modifications, the proposed algorithm enables the correct modeling of the manipulator's dynamics in a real underwater environment, where the presence of currents is a significant factor influencing the formation of moments in the joints.</p>



Irina Naidanova, Anton Gubankov, Institute of Automation and Control Processes, Vladivostok, Russia; Admiral Nevelskoy Maritime State University, Vladivostok, Russia.

Lecture Title: Method of Tracking Underwater Moving Objects by means of Unmanned Surface Vessels in Marine Environments.

Abstract: The paper considers a method of forming and tracking trajectories of underwater moving objects (trajectory processing) by means of a small unmanned surface vessel, taking into account external disturbing effects from the marine environment. The proposed method is based on the processing of data received from a hydroacoustic station mounted on an unmanned surface vessel, and can be applied when it is not possible or impractical to deploy stationary hydroacoustic stations or when it is necessary to promptly complete a mission to track underwater objects in the water area where there is no appropriate infrastructure. Fuzzy logic methods are used to track moving objects, in particular to associate their measurements, an extended Kalman filter is used to estimate the position and velocity of underwater objects, and elementary rotation matrices are used to account for the varying orientation of a small unmanned surface vessel. In addition, this method takes into account the time delay in the propagation of the hydroacoustic signal. The simulation results confirmed the operability and effectiveness of the proposed method of tracking underwater objects.



Milana Krivova, HSE University, Moscow, Russia.

Konstantin Yakovlev, HSE University, Moscow, Russia; FRC CSC RAS, Moscow, Russia.

Lecture Title: Graphs of Convex Sets for Lifelong Manipulation Motion Planning.

Abstract: Manipulation has great potential not only for industrial settings with predefined trajectories, but also for tasks such as human-robot interaction, where more sophisticated planning methods are required. One promising direction is planning with Graphs of Convex Sets (GCS) in the configuration space. This approach has been shown to be effective on many robotic manipulation tasks, but it still has a major bottleneck: constructing convex sets in high-dimensional setups is computationally expensive. Moreover, obtaining a sufficiently good decomposition of the whole scene in advance can be difficult and time-consuming. To this end, in this paper we focus on the online planning setup in which goal states are sent to the system iteratively. Instead of requiring a good decomposition of the entire scene beforehand, we refine and expand the graph of convex regions only when needed, as new goal states arrive. In this way, the decomposition is built incrementally rather than fully precomputed. We evaluate our approach on different planning scenes and compare it with sampling-based and optimization-based baselines in terms of planning time and trajectory quality. The results show that our method is faster while remaining competitive in trajectory quality.





Roman Vasilenko, Academician M. D. Ageev Institute of Marine Technology Problems Far Eastern Branch of RAS, Vladivostok, Russia.

Alexander Konoplin, Academician M. D. Ageev Institute of Marine Technology Problems Far Eastern Branch of RAS, Vladivostok, Russia.

Lecture Title: Positioning System for Autonomous Underwater Vehicles Equipped with Multilink Manipulators Near Work Objects.

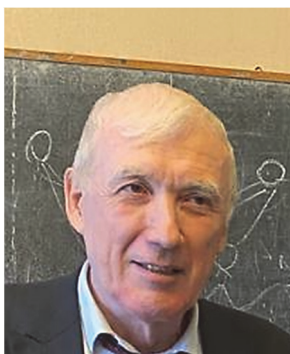
Abstract: Autonomous underwater vehicles (AUVs) are designed for efficient long-distance travel. When equipping such vehicles with multilink manipulators (MMs), it is necessary to select a vehicle position and orientation near the work object (WO) that will allow it to be stabilized and ensure the successful and safe mission execution. This paper proposes an approach to the synthesis of positioning systems for AUVs equipped with MMs near WOs during manipulation operations in the presence of underwater currents. This approach consists of the following main components: estimation of the underwater current velocity vector based on the analysis of visual navigation system data in the area near the WO; using flow simulation, the heading angles are determined at which propulsion and steering complex (PSC) capabilities are sufficient to stabilize the AUV under the effects of currents; the AUV with MM position relative to the target WO is determined, taking into account the onboard technical vision system (TVS) field of view and the boundaries of the MM workspace; simplified operation execution modeling is performed to assess the MM's effects on the AUV; the target position and orientation of the AUV near the WO are selected based on a quadratic quality criterion.



Elizaveta Shmalko, Askhat Diveev, Federal Research Center "Computer Science and Control" of the Russian Academy of Sciences, 119333 Moscow, Russia.

Lecture Title: Stabilization System Quality in Synthesized Optimal Control.

Abstract: Stability is crucial for practical implementation of computed optimal controls onboard, as it compensates for discrepancies that arises, as a result, of objectively existing differences in the models used during control design and the real objects. The synthesized control approach solves optimal control problems by strategically placing stable equilibrium points in state space, activated at equal time intervals. However, stability alone proves insufficient for maintaining optimal performance; equilibrium points must also exhibit specified quality characteristics to minimize sensitivity to external disturbances and model uncertainties. Stable equilibria can be classified as aperiodic or oscillatory. Near oscillatory points, the system's differential equations fail to ensure strict contractivity in state space mappings, potentially causing unpredictable error growth between the actual object state and its model-based estimate. Thus, oscillatory equilibria are undesirable for control synthesis. This paper imposes additional quality requirements on the stabilization dynamics approaching equilibrium points namely to the object's movement to the stability point. A numerical approximation method is proposed for synthesizing stabilization systems meeting these criteria. Optimal trajectories are first generated around the target equilibrium for various initial conditions via optimal control solutions. Symbolic machine learning then serves as a universal function approximator, trained on these supervised trajectories to minimize approximation error across the trajectory set. A computational experiment demonstrates stabilization synthesis for a differential-drive mobile robot using symbolic regression, a form of evolutionary machine learning. Results confirm that high quality stabilization system is little sensitive to disturbances.





Dmitry Dobrynin, Federal Research Center «Computer Science and Control» of the Russian Academy of Sciences, Russia, Moscow.

Yulia Zhiteneva, State University of Humanities and Technology, Russia, Orekhovo-Zuyevo.

Lecture Title: Simulation of Static Interactions of a Leg with a Support for a Walking Robot.

Abstract: One of the main limitations when using walking robots is the limited capacity of the power supply. At the design stage of a robot, a detailed analysis of how to reduce energy consumption is required. This requires an analysis of the robot's energy consumption in static and dynamic operating modes. This article discusses the interaction of the robot's foot with the support surface in a static mode when the robot is stationary is investigated. The design of the leg of a four-legged walking robot is described. A mathematical model of the robot's leg is given, which is used to calculate the moments acting on the robot's leg drives. The data for calculating the static moments of the robot's drives when the robot is not moving relative to the support surface are presented. Criteria for minimizing the energy consumed by a walking robot in this mode have been obtained. The experiments carried out on the stand with a prototype of a walking robot leg showed a good qualitative agreement between the experimental results and the simulation results. This allows you to significantly reduce the energy consumption of a walking robot in static mode.



Dobrynin Dmitry, Federal Research Center «Computer Science and Control» of the Russian Academy of Sciences, Russia, Moscow.

Lecture Title: Short-range 3D Scanning System for Home Walking Robot.

Abstract: This paper presents a prototype of a short-range vision system for a domestic quadruped robot. The vision system generates a grid of distances to the supporting surface and the nearest obstacles in locations where the robot's legs might be positioned. Scanning along the robot's path is performed using a laser lidar. The lidar is rotated by an additional servo drive. The proposed prototype system utilizes an inexpensive 2D lidar. The design of the scanning system is presented, and options for using laser scanners are proposed. A mathematical model of the scanning system for converting lidar data into the walking robot's coordinate system is presented. The mathematical model is used to construct an obstacle height map in the robot's near field. The height map can be used to detect obstacles in front of the robot and plan movements on complex surfaces. This paper discusses lidar data processing, which enables the required scanning accuracy to be achieved. Testing on an experimental setup confirmed the key parameters for scanning accuracy. The proposed scanning system reduces the cost of the control system, lowers computing power requirements, and increases the battery life of a domestic walking robot.

Oral Session 2: Robot Navigation



Mikhail Medvedev, HSE University, Moscow, Russia.

Stepan Dergachev, HSE University, Moscow, Russia; Federal Research Center for Computer Science and Control of Russian Academy of Sciences, Moscow, Russia.

Konstantin Yakovlev, HSE University, Moscow, Russia; Federal Research Center for Computer Science and Control of Russian Academy of Sciences, Moscow, Russia.

Lecture Title: Empirical Evaluation of Priority-Based Planners for Multi-Agent Path Finding with Elevators.

Abstract: This work studies multi-robot navigation in multi-floor facilities equipped with elevators. The baseline mathematical model is Multi-Agent Path Finding (MAPF) in a discrete space-time environment. Unlike the classical single-floor MAPF setting, multi-floor warehouses include vertical transport resources (elevators) with limited throughput and nonzero travel time between floors. In the existing literature, elevator-control tasks and MAPF tasks are usually considered separately: elevator papers do not account for detailed coordination of many mobile agents, while MAPF papers assume single-level geometry or simplified vertical transitions. The goal of this study is to formalize MAPF for multi-floor environments with elevators, and to adapt and evaluate existing cooperative planning algorithms under elevator-specific constraints.



Marat Agranovskiy, Markov Lab, Saint-Petersburg University, Russia.

Lecture Title: Path Planning with Motion Primitives in Dynamic Environments: SIPP on Lattices.

Abstract: Autonomous navigation in dynamic environments is a critical challenge, particularly when spaces are shared with other mobile agents whose future trajectories are known. While traditional grid-based planners efficiently find collision-free paths, their reliance on stop-and-turn mechanics over 2^k -connected grids produces piecewise-linear trajectories that are kinodynamically highly sub-optimal for differentially constrained robots. In this paper, we present an adaptation of Safe Interval Path Planning (SIPP) that operates on state lattices, utilizing precomputed, kinodynamically smooth motion primitives. To efficiently handle dynamic environments, we rasterize the spatiotemporal swept volumes of moving obstacles directly onto the grid, treating grid cells as atomic units of space, whose resolution is typically dictated by inherent localization noise. We perform a comprehensive comparative analysis between our lattice-based approach and 2^k -connected grid planners across diverse topological environments. Our evaluation considers a broad spectrum of performance metrics, including planning time, path angularity, cumulative heading change (angle-over-length), and bending energy. The results demonstrate that while the expanded state space of lattice-based search increases computational overhead, it yields trajectories with significantly superior kinodynamic properties. Specifically, our method achieves a reachability comparable to highly connected grids while ensuring smooth, continuous, and physically executable paths ready for real-world deployment.

	<p>Kirill Muravyev, Federal Research Center “Computer Science and Control” of Russian Academy of Sciences, Moscow, Russia.</p> <p>Dmitry Vtorushin, National Research University “Higher School of Economics”, Moscow, Russia.</p> <p>Lecture Title: Robust and Effective Semantic-aided Point Cloud Matching for Mobile Robot Navigation.</p> <p>Abstract: Navigation of a mobile robot is a challenging task which requires precise localization of the robot to plan routes and follow them. Localization refinement is commonly done by matching data from the robot's LiDAR sensors and corresponding area of the map. Conventional geometry-based methods of point cloud matching may fail with shapeless objects (e.g. trees) or with weakly overlapped scans. Addition of semantic features to geometric ones may help to address this issue. However, semantic segmentation models may produce segmentation errors, so additional techniques are required to handle these errors while matching. In this paper, we propose a robust and computationally efficient point cloud matching method based on 2D projection of semantic data and iterative filtering of extracted features. Usage of 2D projections makes our method memory- and computationally-effective, whereas clusterization and integration of RANSAC technique keeps robustness to segmentation errors. We test our approach in a simulated indoor environment and on real outdoor data, comparing it with state-of-the-art semantic-free point cloud matching methods. The experimental results show that our approach outperforms competitors on both memory consumption and matching precision, and works with proper speed for real-time operation.</p>
	<p>Dmitrii Kostin, Valeria Gribova, Institute of Automation and Control Processes Far Eastern Branch of the Russian Academy of Sciences, Russia.</p> <p>Lecture Title: CGAN Model for Building Layout Plans Generation.</p> <p>Abstract: The task of layout planning is a fundamental challenge in developing site masterplans, governed by spatial and architectural constraints. Automating plan generation can greatly reduce the effort required to produce design alternatives. While shape grammars and genetic algorithms have been used for this purpose, they require manual adjustment of transformation rules and optimization criteria for each new case. In contrast, deep learning methods can identify patterns and generate designs based on existing developments. Conditional Generative Adversarial Networks (CGANs) allow constraints to be incorporated by using label maps as input. In this work, the Pix2PixHD model – featuring one generator and two discriminators – is applied to the problem. Building layout plans are generated for sites in Vladivostok, Saint Petersburg, Sochi, Seoul, and San Francisco, and the results are compared using numerical image similarity metrics. The primary metrics are Fréchet Inception Distance (FID) and Structural Similarity Index (SSIM), chosen for their ability to compare distributions. The key advantages and limitations of the model are discussed. The paper concludes with an assessment of the applicability of this deep learning approach to solving the layout planning problem in architectural design. Directions for future research have been identified, including the use of hybrid models as well as addressing the need for training on giant datasets.</p>



Liudmila Steshina, Igor Petukhov, Daniil Galkin, Ildar Grigorev, Volga State University of Technology, Russia, Yoshkar-Ola.

Lecture Title: Hybrid Forest Mapping for Robotic Navigation under GNSS Uncertainty.



Abstract: This paper examines the problem of constructing a navigation-oriented spatial model of a forested area under conditions of limited satellite navigation accuracy. In dense forest stands, GNSS observations are subject to significant errors, which distorts the spatial structure and reduces the distinguishability of objects. A hybrid method is proposed based on the integration of global coordinates obtained using GNSS devices and local geometric measurements of distances and directions. The method incorporates polar measurements relative to control points, as well as inter-object distances, forming a graph model of the spatial structure. Coordinate reconstruction is performed within the framework of a weighted optimization problem, taking into account the heterogeneity of the initial data accuracy. Additionally, the model incorporates contextual environmental factors, including undergrowth, windfall zones, and topography, which affect the observability of objects and the quality of measurements. Numerical simulations with 250 objects under three GNSS uncertainty scenarios showed that the hybrid reconstruction reduced RMSE by up to 33.91% under severe GNSS degradation and decreased the risk of object ambiguity according to the proposed distinguishability index. This improves the applicability of the method in real-world operating conditions of forestry machines and robotic systems. The proposed approach is shown to restore a geometrically consistent site structure, improve object distinguishability, and be robust to GNSS observation errors. The method is implemented using readily available measurement tools and can be applied to both field mapping and forestry machine automation systems.



Wei Zhang, Ziwen Qu, Xusheng Yang, Minglei Fu, Wen-An Zhang, Yuke Ji, Haoning Zhang, College of Information Engineering, Zhejiang University of Technology, Hangzhou, China; Zhejiang Key Laboratory of Intelligent Perception and Control for Complex Systems, Hangzhou, China.

Lecture Title: A Robust RTK Navigation and Positioning Method for a Quadruped Robot in Complex Dynamic Environments.

Abstract: A quadruped robot requires continuous, stable, and high-precision positioning for autonomous navigation in complex dynamic environments. However, its onboard GNSS observations are easily affected by tree canopy blockage, near-ground multipath, and endogenous electromagnetic interference from the platform. As a result, traditional dual-frequency RTK methods often suffer from long float periods, unstable ambiguity fixing, and poor trajectory continuity in complex scenes. To address this problem, this paper proposes a robust RTK positioning method that integrates wide-lane guidance constraints with a progressive Gaussian filtering update mechanism. The proposed approach follows a procedure of wide-lane guidance, progressive float estimation, and narrow-lane stepwise fixing. Based on dynamic experimental data collected from a quadruped robot in a campus environment, this paper compares the proposed AGF-WLL1 method with the conventional EKF-L1L2 method. The results show that the proposed method reduces the horizontal and vertical errors from 0.221 m and 0.319 m to 0.128 m and 0.178 m, respectively. The narrow-lane fixed-solution ratio increases from

	<p>67.054% to 77.286%, and the float-solution ratio decreases to 16.836%. The experimental results demonstrate that the proposed method enhances fixed-solution stability, trajectory continuity, and positioning robustness for quadruped robot navigation in environments with blockage and interference.</p>
	<p>Yuqiang Jin, Shaoqing Xu, Xusheng Yang, Wen-An Zhang, College of Information Engineering, Zhejiang University of Technology, Hangzhou, China; Zhejiang Key Laboratory of Intelligent Perception and Control for Complex Systems, Hangzhou, China.</p> <p>Lecture Title: Robust Geometric Filtering with Gain Constraints on Lie Groups.</p> <p>Abstract: Geometric filtering provides a principled way to preserve the intrinsic structure of systems evolving on Lie groups, but its performance may deteriorate when the assumed model differs from the true dynamics. This paper develops a robust geometric filtering framework based on linear constraints imposed on the correction gain. For group affine systems, we first examine how model errors enter the invariant error dynamics and how they are further amplified through the recursive filtering update. This analysis clarifies why conventional geometric filters, including the invariant extended Kalman filter, may become sensitive to persistent model deviations. Motivated by this observation, we introduce a constrained gain design that restricts the correction action along prescribed mismatch directions in the Lie algebra. The resulting filter suppresses the leading effect of model mismatch while keeping the state estimate on the underlying Lie group through the standard geometric update. The proposed formulation preserves the recursive structure and computational simplicity of Kalman type geometric filters, which makes it suitable for real time estimation tasks. Simulation results on INS and GNSS integrated navigation show that the proposed method achieves more reliable estimation performance than the standard invariant extended Kalman filter under representative model mismatch conditions.</p>
	<p>Nikolai Kolesov, Alexander Gruzlikov, Yuri Skorodumov, Viktor Tiulnikov, Concern CSRI Elektropribor, JSC Saint Petersburg, Russian Federation.</p> <p>Lecture Title: Application of Three-Dimensional Graph Modeling for the Investigation of Multipath Data Routing Algorithms in Underwater Acoustic Networks of AUVs.</p> <p>Abstract: This paper examines a class of telecommunication networks with mobile nodes, an important subclass within which is the so-called geography-aware networks. Their distinguishing feature is the availability of information about the geographic coordinates of all nodes in the network to each individual node, whereby each node is aware of the complete topology of the network graph, which enables rapid identification of the required number of information transmission routes between any two nodes. The purpose of this article is to investigate multipath routing algorithms. To this end, we propose a method for the automatic synthesis of adequate test models capable of representing networks of virtually unlimited complexity. The proposed solution is based on a compositional approach, in which a relatively simple network fragment that satisfies given constraints is first formed, and then the resulting model is constructed as a composition of copies of this fragment. To investigate the efficiency of multipath routing algorithms, we propose a compositional method for the random synthesis of test models of</p>

	<p>complex networks that satisfy constraints on distances between the vertices. This method was applied to the investigation of two routing algorithms, resulting in a large body of illustrative model data. The obtained results, presented in the form of graphs, demonstrate an increase in the gain in message transmission time as the queue length in the target flow grows. While the efficiency of multipath routing is insignificant under low network load conditions, its usefulness increases with growing network load. A similar increase in efficiency is demonstrated when transitioning from an algorithm that does not allow intersecting paths to an algorithm that allows such intersections.</p>
	<p>Alexander Scherbatyuk, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russian Federation.</p> <p>Lecture Title: On a Method of Increasing the Accuracy for AUV Group Positioning by Use of SBL APS.</p> <p>Abstract: This article proposes a cost-effective solution to the problem of simultaneously determining the coordinates for a group of inexpensive autonomous underwater vehicles (AUVs). It is assumed that each AUV does not have expensive precision time system and absolute velocity sensor onboard. The presented method of providing navigation support for a group of AUVs is based on use of a short-baseline acoustic positioning system (SBL APS), that includes two receiving antennas onboard each AUV and one emitting beacon with a known location. The navigation task is solved by measuring the difference in the signal arrival times for each cycle at the SBL receiving antennas, the difference in the signal arrival times for two consecutive cycles at one receiving antenna, and measuring the frequency of the signal received onboard the AUV. An algorithm for estimating the AUV's position based on a particle filter is described. It is designed for operation onboard each AUV in real time. The results of the proposed algorithm operation, obtained in the process of computer modeling, are presented, which confirmed its higher accuracy, compared to the version of the algorithm in which the difference in the signal arrival times for two consecutive cycles is not used.</p>
 	<p>Petr Trefilov, Roman Meshcheryakov, V. A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia.</p> <p>Lecture Title: Adaptive Navigation Method for a Robotic System with Discrete Mode Switching Based on Environmental Uncertainty Assessment.</p> <p>Abstract: The paper considers the problem of generating a navigation solution for a robotic system operating under changing environmental conditions, degradation of measurement channels, and incomplete a priori information about the current situation. It is shown that single-mode navigation algorithms with a fixed measurement processing structure do not always provide the required state estimation quality when the availability and reliability of navigation sources change. An adaptive navigation method based on discrete switching of operating modes depending on an integral uncertainty estimate is proposed. Within the method, diagnostic features are formed to characterize the consistency of measurements with the predicted state, the level of estimation uncertainty, and the structural availability of navigation channels. Based on these features, an integral uncertainty index is calculated and used to select one of the predefined processing modes: nominal data fusion, partial degradation of</p>

measurement information, or limited correction. To prevent false transitions, the selected mode is confirmed over several consecutive steps. Numerical simulation results show that the proposed approach reduces the influence of degraded measurements on state estimation and decreases the position error compared with a baseline single-mode algorithm.

Online Session 1: Human-Robot Interaction



The Tien Nguyen, Huu-Hung Nguyen, Xuan Tung Truong, Le Quy Don Technical University, Hanoi, Vietnam.

Lecture Title: An Efficient Camera-LiDAR-Based 3D Human Detection and Tracking Algorithm for Socially Aware Mobile Robot Navigation Systems.

Abstract: Reliable and real-time perception of surrounding humans is essential for mobile robots operating in dynamic human-populated environments. However, existing human perception approaches often rely on a single sensing modality or computationally demanding 3D detection pipelines, which can limit robustness and onboard deployment in practical navigation tasks. This paper presents an efficient camera-LiDAR-based 3D human detection and tracking algorithm for socially aware mobile robot navigation systems. The proposed method combines RGB observations from an Azure Kinect camera with 3D point clouds from a Velodyne LiDAR to improve robustness and spatial localization accuracy. Humans are first detected and tracked in the image domain using a vision-based multi-object tracking method. LiDAR points are then projected onto the image plane and associated with the tracked detections to estimate human positions in 3D space. To improve temporal consistency and maintain stable trajectories under noise, partial occlusions, and intermittent detection, a Kalman filter-based temporal state estimation module is employed. The resulting 3D human states are subsequently integrated into a mobile robot navigation framework, enabling the robot to perceive nearby humans and adapt its motion accordingly. The proposed system is implemented on a real mobile robot platform using ROS and operates at approximately 15Hz. Experimental results in multiple real-world scenarios demonstrate stable 3D human tracking performance and improved robustness compared with single-sensor perception approaches, highlighting its practical suitability for deployment in socially aware mobile robot navigation systems.



Pham Tran Quyen Anh, Truong Xuan Tung, Le Quy Don Technology University, Hanoi, Vietnam.

Lecture Title: Density-Aware Layered Social Costmaps for Context-Aware Navigation of Omnidirectional Robots.

Abstract: The problem of navigating robots in shared spaces with humans requires both geometric feasibility and socially acceptable behavior. However, in many existing ROS systems, social signals remain fragmented between perception and navigation, making consistent integration into layered costmaps difficult. This paper presents a contribution towards system integration: a unified interface `social_msgs/SocialState` for transmitting individual, group, human-object interaction, emotion, and local density information; and a density-aware cost modulation mechanism to reduce costmap saturation in crowded areas. On an omni-robot platform, we integrate the Proxemic, Passing, HumanGroup, HumanObject, and Emotion layers in the same ROS pipeline `/social_state` \rightarrow `costmap_2d` \rightarrow `/move_base`. The evaluation was conducted in a unified simulation environment, following a sequential

	<p>waypoint protocol with seven tasks (T1–T7) and a two-axis ablation matrix based on SocialState completeness and density channel. Metrics included GPA, objective completion rate, SII, SGI, travel time, and distance. Within the scope of the current simulation setup and logging, the results at the system comparison level show that density-aware modulation is related to the ability to maintain planning in congested situations, and clarify the trade-off between navigation feasibility and social-intrusion proxies.</p>
 	<p>Sergey Jatsun, Oksana Emelyanova, Aleksander Pechurin, Oksana Loktionova, Southwest State University, Kursk, Russia.</p> <p>Lecture Title: Development of a method and algorithm for determining the reaction forces of the joints of the patient's lower extremities.</p> <p>Abstract: This paper proposes a method and algorithm for determining the reaction forces occurring in the hip and knee joints, as well as the interaction forces between the musculoskeletal system and the external environment, using mathematical modeling. This allows for the assessment of movement dynamics and load distribution across the joints, muscles, and bone structures of the musculoskeletal system to analyze the patient's functional state and subsequently restore lower extremity motor function. The diagnostic and rehabilitation device is presented in this work as a crank-slider mechanism equipped with a linear drive, ensuring linear motion of the patient's heel. The mathematical model of the patient's lower limb motion in this device is based on the solution of a direct kinematics and dynamics problem and is represented as Newtonian and Lagrange differential equations of the second kind for a constrained mechanical system. These equations allow for the active and reactive forces acting on the thigh, lower leg, and heel, depending on the driving force generated by the electric drive. The aim of the study is to develop a method and algorithm for determining reaction forces in the hip and knee joints to assess the dynamics of movements and diagnose the condition of the patient's joints, as well as to analyze the distribution of loads on the elements of the musculoskeletal system when it interacts with the external environment. Graphs were constructed showing the dependence of forces occurring in the hip and knee joints, heel pressure on the support surface, and frictional forces (over time) on the hip rotation angle. It was established that rheological parameters μ_i of the lower limb muscular system significantly influence the force responses in the hip and knee joints: their increase leads to increased joint loads. Monitoring the duration of the muscle contraction phase and the nature of limb control provides an objective assessment of the effectiveness of rehabilitation measures, which allows for the optimization of recovery programs for patients with affected joints.</p>



Andrei Malchikov, Anastasiya Kisele, Evgeny Politov, South-West State University, Kursk, Russia.

Lecture Title: Modeling the Dynamics of a Collaborative Parallel Kinematic Robot with Elastic Actuators for Automated Periorbital Massage.

Abstract: This paper presents the development of a dynamic model of a collaborative robotic system based on parallel kinematics with series elastic actuators (SEA) for automated periorbital massage. The proposed system is intended for rehabilitation and therapeutic applications, including meibomian gland dysfunction treatment and postoperative recovery. A mathematical model of the delta manipulator dynamics is developed, incorporating actuator dynamics, SEA elasticity, and contact interaction with soft tissues. Three control strategies are compared through computational simulation: rigid positioning (high-stiffness SEA), passive compliance (soft SEA without force feedback), and active compliance (hybrid position–force control with trajectory correction based on contact force measurement). The simulation results demonstrate that the hybrid controller significantly reduces peak contact force and force tracking error compared to both rigid and passive compliance modes, while maintaining acceptable position accuracy for periorbital massage. The proposed active compliance approach effectively limits interaction force to a specified safe level, ensuring patient safety even under large-amplitude motions. The developed model provides a foundation for designing SEA-based collaborative robots for delicate facial massage procedures.



Alexandr Korchemnyi, Anatoly Onishchenko, Eva Bakaeva, CogAILab, Moscow, Russia.

Alexey Kovalev, and Aleksandr Panov, CogAILab, Moscow, Russia; MIRAI, Moscow, Russia.

Lecture Title: HELP: Hierarchical Embodied Language Planner for Household Tasks.

Abstract: Embodied agents tasked with complex scenarios, whether in real or simulated environments, rely heavily on robust planning capabilities. When instructions are formulated in natural language, large language models (LLMs) equipped with extensive linguistic knowledge can play this role. However, to effectively exploit the ability of such models to handle linguistic ambiguity, to retrieve information from the environment, and to be based on the available skills of an agent, an appropriate architecture must be designed. We propose a Hierarchical Embodied Language Planner, called HELP, consisting of a set of LLM-based agents, each dedicated to solving a different subtask. We evaluate HELP on a household task and perform real-world experiments with an embodied agent. We also focus on the use of open source LLMs with a relatively small number of parameters, to enable autonomous deployment.



Yaroslav Turovsky, Roman Meshcheryakov, Nikita Solopanov, V. A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia.

Lecture Title: Interface for Controlling a Group of Unmanned Aerial Vehicles, Taking into Account the Operator's Characteristics.

Abstract: This article examines the problem of controlling a swarm of unmanned aerial vehicles (UAVs) operating in a changing environment, with degraded communication quality and incomplete a priori information about the current situation, potentially leading to communication loss. It



is shown that requirements must be imposed on the swarm of UAVs themselves, on the operator who controls the swarm and monitors its movements, as well as on the types of interfaces and their qualitative characteristics. A method for studying operator capabilities is proposed, based on determining the time characteristics of switching operating modes depending on observed phenomena and control capabilities. As part of the study, various methods of information processing are identified and their quality assessed. Based on these characteristics, the feasibility of controlling a swarm of UAVs and preventing loss of control over the swarm is assessed. To prevent false alarms, a justification for the most important characteristics is proposed. Modeling results show that the proposed approach reduces the impact of possible distractions to maintain control over the swarm of UAVs.



Victor Naumov, Alexandr Anochshenko, Matvei Chernyshov, Kutafin Moscow State Law University (MSAL), Moscow, Russia.

Lecture Title: Safe Use of Artificial Intelligence and Robotics: Issues of Legal Terminology.

Abstract: This article addresses the issues of developing legal terminology in the field of regulatory governance of safe artificial intelligence and robotics use. The authors argue that the absence of an adequate conceptual framework constitutes a fundamental obstacle to the effective regulation of relations concerned with the safe development and deployment of AI systems. Particular attention is given to the situation in the Russian Federation, where dedicated legislation remains at the drafting stage. The article conducts a comparative analysis of legislative approaches to the definition of artificial intelligence in the different jurisdictions and classifies the identified approaches into two broad categories: the «anthropomorphic» approach and the «technical» approach. Drawing on this analysis, the authors propose an original conceptual framework of legal definitions for Russian AI legislation. A novel legal definition of «artificial intelligence» is formulated, reflecting its dual nature as both a technology and a scientific discipline. The article substantiates the need for statutory recognition of the categories of «trusted» and «prohibited» AI systems. A three-tier model of legal subjects is proposed, comprising the AI system developer, operator, and user. The authors conclude that the establishment of a sound and coherent terminological foundation is a necessary precondition for safeguarding the rights and safety of individuals in the context of advancing artificial intelligence and autonomous robotics technologies.



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Edgar A. Martinez-Garcia, Department of Industrial Engineering and Manufacturing, Institute of Engineering and Technology, Autonomous University of Ciudad Juarez, Chihuahua, Mexico.

Evgeni Magid, School of Electronic Engineering, Tikhonov Moscow Institute of Electronics and Mathematics, HSE University, Moscow, Russian Federation.

	<p>Lecture Title: Monocular Depth-Based Object Localization for Collaborative Robotic Grasping.</p> <p>Abstract: This paper investigates the application of monocular depth estimation for 3D object localization in collaborative robotic manipulation tasks. We propose a method for converting relative depth maps obtained using the Depth Anything V2 Small model into metric depth maps by employing small 5×5 cell ArUco markers with a physical size of 3×3 cm, which do not obstruct the operator or reduce the available workspace. Pre-calibration on 10-30 images achieves a diameter measurement accuracy with a mean absolute error (MAE) of 0.307–0.671 cm (relative error 3.6–7.9%) and height measurement accuracy of 1.73–2.13 cm MAE (relative error 14.6–16.7%). The full processing cycle for a single frame takes 1.19 seconds on a mid-range laptop without a dedicated GPU, which confirms the method's suitability for operation under modest frame rate requirements. The proposed approach is applicable in collaborative scenarios with low-speed object motion and can be recommended for robots equipped only with an RGB camera, provided that pre-calibration is performed. The method is characterized by its ease of implementation, low cost, and the absence of a need for specialized hardware, making it attractive for a wide range of human-robot interaction tasks in constrained spaces.</p>
	<p>Sergey Jatsun, Dmitry Efremov, Gavriil Fursov, Roman Derevyanko, Southwest State University, Kursk, Russian Federation.</p> <p>Lecture Title: Autonomous control of a medical stand for urological surgeries.</p> <p>Abstract: This article discusses the development of a medical stand for automated retrograde intrarenal surgery. An analysis of the possibilities for automated ureteroscopy control using the medical stand is conducted. Alternative developments in this area are considered. The kinematics of a ureteroscope in the surgeon's hands are examined, and its kinematic diagram is provided. The process of tracking the trajectories of the ureteroscope and the surgeon's hand during surgery is conducted. The relationship between the movement of the surgeon's hand and the rotation of the ureteroscope is determined. The range of motion sufficient for performing surgery using the medical stand is determined. Based on the obtained data, the parameters of the medical stand are determined. An algorithm for operating the stand during retrograde intrarenal surgery is proposed. The algorithm includes: defining the workspace by processing an X-ray image, constructing a graph in this space using Delaunay triangulation, and planning the shortest trajectory of movement of the distal end of the ureteroscope towards the stone using Dijkstra's algorithm. The advantages of using the selected methods to solve this problem are revealed. A system for controlling the stand in remote control mode using console handles, depending on the handle rotation speed, is proposed. Graphs of the voltage and rotation speed of the ureteroscope handle versus time during console handle rotation are presented, obtained experimentally using a stand prototype. The data obtained may further assist in the development of a medical stand for retrograde intrarenal surgery.</p>



Arkady Yuschenko, Moscow Bauman State Technical University N.E. Moscow, Russia.

Lecture Title: Interactive Collaborative Robotics (ICR) Ergonomic Research and Design on the Fuzzy Logic Base.

Abstract: The human – robot interaction is a modern trend of robotics as a way toward a society of new technologies. The area of Interactive Collaborative Robotics (ICR) application is rapidly expanding. Collaborative Robotic Systems have now become interactive and «intelligent». This is really a new class of technical systems combining the capabilities of both humans and robots. That is why the problem of such systems design seems relevant today. The problem is to present a satisfactory mathematical model for both partners – robot and human to determine a procedure of investigation and design of such systems. An approach to solve the problem with Fuzzy Logic theory firstly proposed by L. Zadeh is the subject of this paper. The main idea of the theory is formalization of human perception and reasoning. We suppose that it may be a base for ergonomic research and design of ICR systems as a process of coordination between capabilities of human and an «intelligent» robot.



Olga Ergunova, Andrey Somov, Higher School of Industrial Management, Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russia.

Irina Karabulatova, Higher School of Journalism, Communication and Film, Hainan Normal University, Haikou, China; Laboratory of Neurocognitive and Digital Humanitarian Technologies «Harmony+», Haikou, China.

Lecture Title: Neurocognitive Risk Management of Human Capital in Human–Robot Collaborative Organizations: A Neural Network Framework for Metropolitan Digital Economies.



Abstract: The integration of artificial intelligence (AI) and collaborative robots into organizational work produces a new class of human capital risks that conventional human resource (HR) analytics fails to capture. This paper proposes a neurocognitive risk-management framework for human–robot collaborative (HRC) organizations, operationalized as a multimodal neural network that jointly models cognitive-load signals, behavioural telemetry, psychometric indicators, and HR information-system records. Grounded in four theoretical constructs – *riskogenic substitution*, *cascading human capital risks*, *latent competency degradation*, and the *strategic competency adaptation window* – the model computes a Human Capital Vulnerability Index (HCVI) and forecasts four adverse trajectories: cognitive-load overflow, skill atrophy, trust miscalibration, and algorithmic-management burnout. Evaluation was conducted on 1,847 knowledge workers across 18 organizations in three metropolitan digital economies, with predictor streams temporally separated from label windows to reduce target leakage. A hybrid LSTM–attention–transformer architecture attained 87.3% accuracy (95% CI: 85.1–89.4%) and AUC of 0.903, detecting adverse trajectories on average 34 days in advance. SHAP- and LIME-based explanations were rated actionable by HR managers in 94% of audited cases. Attention patterns were reported as *consistent with*, not as direct evidence of, the theoretical constructs.



Mohammad Alwardat, Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia.

Hassan Alwan, Department of Mechanical Engineering, University of Technology, Baghdad, Iraq.

Lecture Title: Real-time link-level obstacle and singularity avoidance for a robotic manipulator using pid-controlled dls and null-space projection.

Abstract: This study investigates safe motion control for a six-degree-of-freedom robotic manipulator operating in a confined workspace containing obstacles and near-singular configurations. We propose an integrated control strategy that couples Cartesian-space PID tracking with damped least-squares (DLS) inverse kinematics and null-space projection for secondary objectives. Collision avoidance is implemented via an artificial potential field (APF) that generates repulsive Cartesian velocity components computed at the link level, rather than only at the end-effector. In addition, the damping factor is adapted based on a manipulability measure, improving numerical robustness close to kinematic singularities while maintaining smooth joint motions. Simulation results for two representative scenarios show that the manipulator reaches the goal with a residual positioning error below 0.05 m, maintains a minimum clearance above 0.18 m from the closest obstacle, and keeps the Yoshikawa manipulability index above approximately 0.8 throughout the motion. The obtained behaviour is stable and collision-free, indicating that the proposed framework is suitable for real-time applications.

Online Session 2: Ground Robotics



Hoang Duc Long, Vu Xuan Duc, Le Quy Don Technical University, Hanoi, Vietnam.

Le Van Tung, Thanh Dong University, Hai Phong, Viet Nam.

Lecture Title: A Fixed-time adaptive barrier-based integral super-twisting sliding mode control for uncertain wheeled mobile robots.

Abstract: This paper develops a fixed-time adaptive barrier-based integral super-twisting sliding mode controller for uncertain wheeled mobile robots affected by wheel slip, lateral skidding, and external disturbances. The main objective is to obtain accurate trajectory tracking while preserving error constraints and reducing chattering in the control input. In contrast to prescribed-performance schemes that require an explicitly designed performance envelope, the proposed approach uses a barrier-type error transformation to keep the tracking error inside an admissible region. An integral sliding variable with fractional nonlinear terms is then constructed so that the reaching phase is removed and the transient response is improved. A super-twisting component is combined with an adaptive disturbance-compensation mechanism to handle unknown matched uncertainties without assuming that their upper bounds are available. Fixed-time convergence of the sliding variable and tracking errors is established through Lyapunov analysis, and sufficient gain conditions are provided. Comparative simulations for straight-line and U-shaped reference trajectories show that the proposed method yields smaller tracking errors, faster convergence, and smoother responses than conventional sliding mode control, non-singular fast terminal sliding mode control, fixed-time non-singular fast terminal sliding mode control, and fixed-time prescribed performance sliding mode control under the same disturbance and slip conditions.



Maksim Romanenko, ANO HE «Innopolis University», Russia.

Lecture Title: Towards Latency-Stable Robotic Perception Pipelines in ROS 2: Eliminating Non-Maximum Suppression for Real-Time Target Tracking and Distance Estimation.

Abstract: Visual perception is a fundamental component of autonomous navigation in mobile robotics. However, for real-time control loops such as Proportional-Integral-Derivative (PID) or Model Predictive Control (MPC) systems, temporal determinism is as critical as spatial accuracy. Traditional object detectors rely on Non-Maximum Suppression (NMS), a post-processing stage whose execution time depends on scene complexity. This dependency introduces stochastic inference latency, commonly referred to as latency jitter. Such temporal instability propagates through the perception pipeline, degrading multi-object tracking consistency and significantly impairing monocular distance estimation, ultimately leading to unstable robotic control behavior. This paper proposes a latency-stable perception pipeline implemented in Robot Operating System 2 (ROS 2) that fundamentally eliminates the NMS bottleneck. By integrating an NMS-free detector (YOLOv10) with the ByteTrack tracking algorithm inside an asynchronous multithreaded ROS 2 node, computational workloads are isolated from communication callbacks, preventing head-of-line blocking and artificial latency variance. Experimental validation conducted in a dynamic Gazebo simulation environment demonstrates a 78.2% reduction in latency standard deviation (from 18.22 ms to 3.97 ms) compared to a classical baseline pipeline (YOLOv8 + SORT). The improved temporal stability directly enhances geometric consistency: the root mean square error (RMSE) of monocular distance estimation decreases from 1.710 m to 1.449 m, while the proposed system maintains errors below 1.5 m in 61.3% of frames versus 26.1% for the baseline. The results confirm that eliminating NMS is a key requirement for reliable deployment of vision-based perception systems in real-time robotic platforms.



Ilya Kovalenko, Eugenia Ahremenko, Faculty of Chemistry, Perm State University, Perm, Russia; Institute of Physics and Mathematics, Perm State University, Perm, Russia.

Alexandr Andreev, Danila Apushkin, Faculty of Chemistry, Perm State University, Perm, Russia.

Marina Barulina, Institute of Physics and Mathematics, Perm State University, Perm, Russia.

Lecture Title: System Analysis of Video Stream Coherence in the Design of Hybrid Behavior Recognition Models.

Abstract: Designing video analytics systems under small-data conditions requires accounting not only for the target recognition task but also for the acquisition regime of the sensor. In this study, a two-stream CNN-ViT model with time-color coding is used as an experimental instrument to analyze two contrasting observation conditions: a static camera, where spatial and temporal representations remain mutually consistent, and active tracking, where camera stabilization introduces decoherence between these streams. The experiments show an inversion of generalization behavior across these regimes. In the coherent setting, the higher-capacity configuration provides the best recognition performance. In the decoherent setting, reducing model capacity by 62.5% prevents collapse of generalization and improves accuracy by 61.2 percentage points. In addition, removing a low-consistency class from the tracking

	<p>domain, which reduces the dataset by 15%, further improves system performance by 6.9 percentage points. These results indicate that, under small-data conditions, the admissible capacity of the computational core should be selected with respect to sensor behavior and the consistency of the observed motion patterns rather than from task complexity alone.</p>
	<p>Elvira Chebotareva, Nail Bismullin, Tatyana Tsoy, Intelligent Robotics Department, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russian Federation.</p> <p>Mikhail Svinin, Graduate School of Information Science and Engineering, Ritsumeikan University, Osaka, Japan.</p> <p>Evgeni Magid, School of Electronic Engineering, Tikhonov Moscow Institute of Electronics and Mathematics, HSE University, Moscow, Russian Federation.</p> <p>Lecture Title: Monocular Vision-Based Positioning System for Object Localization in Collaborative Conveyor Applications.</p> <p>Abstract: This paper presents a monocular vision-based relative localization system for a collaborative robotic cell comprising a mobile conveyor and an industrial robot. The main challenge is that movement of the conveyor and/or the robot may disrupt traditional camera-robot calibration, which requires time-consuming manual readjustment. The proposed solution enables a camera, statically mounted on the conveyor frame, to detect a calibration ArUco marker attached to the robot base with known coordinates, compute the camera's position relative to the robot, and then determine the coordinates of a target object on the conveyor within the robot base coordinate system. The key advantage of this approach is that calibration is performed online in each frame, allowing the conveyor and the robot to be repositioned independently between production cycles without requiring manual recalibration. A mathematical model of coordinate transformation, including rotation matrices and homogeneous transformations, is developed. The system is integrated with a real KUKA KR3 robot. The experiments demonstrated a mean absolute error in the XY plane of 2.4 mm for the X-axis and 3.1 mm for the Y-axis, which is acceptable for most object grasping tasks. These findings confirm the system's functionality and suitability for flexible manufacturing cells with frequently changing layouts.</p>
 	<p>Vladimir Dashevsky, Yuri Galykin, Andrey Ronzhin, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia.</p> <p>Lecture Title: Autonomous Service Platform for Spraying UAVs: System for Mixing Solutions.</p> <p>Abstract: Maintenance of agricultural spraying drones (UAVs) currently requires manual dosing of highly concentrated and toxic products (with dilution ratios of 1:100 and higher), which is not always performed with sufficient accuracy. The developed multi-channel modular system for mixing working solutions is designed for the automated preparation of liquids and refueling of UAVs. The developed system ensures versatility due to the ability to prepare solutions in a wide range of required dilution ratios from 1:10 to 1:1000 and higher while maintaining high dosing accuracy. A fundamental distinction of the developed system is the inclusion of dosing modules of two different designs, each optimized for a specific range of dosing volumes and concentrate dilution ratios. The system fully automates the preparation and refueling process, eliminating the need for the operator to be constantly present in the hazardous area near operating UAVs and minimizing their exposure to highly concentrated toxic substances. The system is designed for use as part of mobile or stationary autonomous service platforms for servicing UAV fleets.</p>



Andrei Shevkunov, Anna Shirokova, Sofia Dzhatdоеva, Azret Kochkarov, Federal Research Centre «Fundamentals of Biotechnology» of the Russian Academy of Sciences (Research Centre of Biotechnology RAS), Moscow, Russia.

Lecture Title: AI-Driven Trichome Quantification for Robotic Phenotyping Systems.

Abstract: This paper addresses the challenge of accurately quantifying basil (*Ocimum basilicum*) leaf glandular trichomes in the context of rapidly expanding urban vertical farming, where optimized monitoring of plant traits is essential for improving essential-oil yield and quality. To overcome the limitations of manual counting, we developed an automated approach using deep-learning object detection. Basil plants of the «Queen of Sheba» cultivar were grown under controlled LED lighting with varying spectral compositions, and microscope leaf images were acquired, annotated, and used to train YOLO models. Automated trichome detection revealed significant differences between their quantities on adaxial and abaxial leaf surfaces and demonstrated that different lighting treatments resulted in various trichome quantities. Moreover, correlations between essential oil yield and trichome quantity can be observed. Deep learning enabled fast, objective, and reproducible quantification of basil microstructures. The developed method represents a promising tool for integrating AI-based phenotyping into city farm monitoring and robotized automatization systems, supporting the optimization of cultivation parameters and receiving of high-yielding plants.



Vitaly Bondarenko, Tatyana Yermolenko, Andrey Grabarchuk, Egor Moroz, Institute of Artificial Intelligence Problems, Donetsk, Russia.

Lecture Title: Testing Methodology for a Computer Vision System for Glass Container Quality Control on a Robotic Conveyor.

Abstract: This paper presents a comprehensive testing methodology for a prototype cascaded computer vision system deployed on a robotic conveyor mockup for automated quality control of glass containers. The work extends previously proposed approaches to synthetic training data generation by shifting the focus to empirical validation of deep learning algorithms on real product samples using low-power edge platforms. The physical experimental setup is implemented on a laboratory belt conveyor equipped with a Raspberry Pi 5 single-board computer, a Hailo-8L NPU accelerator, a Raspberry Pi AI Camera (IMX500) sensor and a programmable LED ring light. A real COCO-compatible dataset with key classes of industrial defects is collected and a structured test protocol is developed. The system is evaluated in terms of detection accuracy, inference performance, thermal stability under long-term load, and robustness to motion blur and illumination changes. Experimental results confirm that the proposed architecture achieves industrial-level inspection performance on edge devices: mAP reaches 0.95, the false positive rate does not exceed 5%, and the processing speed consistently exceeds 30 FPS. This demonstrates the feasibility of integrating such hardware–software complexes directly into real-time production conveyor lines.



Sergey Okunkov, Marina Barulina, Ivan Ulitin, Institute of Precision Mechanics and Control, Russian Academy of Sciences, Saratov, Russia; Perm State National Research University, Perm, Russia.

Lecture Title: Comparative analysis of AI model robustness in color image classification tasks with respect to synthetic data.

Abstract: In most cases, when solving tasks using machine learning and deep learning methods and algorithms, poor performance metrics can often be attributed to the low quality of the initial dataset. This includes factors such as limited data volume, class imbalance, and insufficient coverage of potential cases by existing examples. One of the simplest and most cost-effective solutions to address many of these challenges is to augment the dataset with new synthetic data generated from the original dataset using augmentation techniques. However, this method is not universally applicable due to the limited understanding of its impact on different neural network architectures. The goal of this study is to explore the following aspects of data augmentation: identifying the optimal percentage of synthetic data, where the optimal percentage is defined as the point at which performance metrics begin to degrade; assessing the impact of synthetic data on different neural network architectures; and investigating the effect of adding synthetic data only to specific classes, using the task of multi-class classification for color medical images as a case study. To achieve this goal, the following neural network architectures were trained: ResNet34, ResNet50, DenseNet121, DenseNet201, ViT, DeiT, and ConvNeXT. All training datasets were derived from a highly imbalanced dataset, where synthetic data were added to the minority classes, while original data were used for the majority classes. A separate validation dataset was employed to confirm the results, and experiments were repeated on this dataset. The study revealed that determining a universal optimal percentage of augmentation is infeasible, as models, even within the same family, exhibit varying degrees of robustness to synthetic data. Transformer-based and hybrid models demonstrated greater robustness, exhibiting clear and consistent patterns. In contrast, convolutional networks failed to exhibit any consistent trends, which could be attributed to their high sensitivity to random biases in the data.

Anna Nelyubova, Victor Zhoga, Volgograd State Technical University, Volgograd, Russia.

Lecture Title: Controlling the Movement of Hybrid Parallel-Serial Manipulator with Passive Link.

Abstract: A new hybrid parallel-serial manipulator with passive link with 4 degrees of freedom (DOF) is proposed. In the article the design of new hybrid manipulator is introduced. Hybrid manipulator based on a tripod with the additional of passive link. The advantages of the new design of the hybrid manipulator with the passive link are an increase in the rigidity of the structure and an increase in functional capabilities compared to existing solutions. This manipulator has a high stiffness and high dexterity. The kinematics analysis of this manipulator is carried, solutions to direct and inverse kinematics, and a solution to the problem of positioning the end-effector. For solving the direct and inverse kinematics a geometric approach is used, design constraints in ball joints and conditions of intersection of design elements are taken into account. The trajectory of the end effector's motion along a straight line is obtained. A description of the manipulator's dynamic model is provided, with the

	<p>dynamic equations presented in matrix form. A description of the manipulator actuator control system for the end-effector's straight-line motion is provided. The control system regulates the position of the manipulator actuators with the required accuracy.</p>
	<p>Vladislav Danilchenko, Philip Bulyga, Elmar Kuliev, Daria Zaruba, ICTIS, Southern Federal University, Taganrog, Rostov Region, Russia.</p> <p>Lecture Title: Intelligent Decision Support System for Wind Farm Maintenance Based on Hybrid Bio-Inspired Optimization.</p> <p>Abstract: The automation of wind turbine maintenance processes aimed at improving the operational efficiency of wind farms through timely diagnosis of structural condition and optimization of inspection mission planning represents a critical challenge under conditions of increased operational loads and meteorological instability. The present study proposes an intelligent decision support system architecture integrating two complementary functional modules. The routing module implements a hybrid three-stage trajectory planning procedure combining the A* algorithm for discrete path construction, B-spline smoothing for angular deviation elimination, and a modified ant colony optimization algorithm incorporating an adaptive pheromone evaporation rate that dynamically responds to objective function dynamics, preventing premature convergence and expanding the solution space exploration under search stagnation conditions. The visual diagnostics module is based on a modified YOLOv3 architecture augmented with an adaptive feature fusion mechanism providing dynamic redistribution of weight coefficients across feature map hierarchy levels, and a bio-inspired anchor frame optimization module implemented through hybrid interaction of a genetic algorithm and a modified grey wolf optimizer featuring differentiated agent position updates via a binary search activity mode indicator, dynamic leadership redistribution based on a weighted ranking criterion, and adaptive population diversity restoration. Computational experiments confirmed a 15-20% reduction in route length and energy consumption with stable algorithm convergence, a 50% increase in the F1 detection metric relative to the baseline YOLOv3 implementation while maintaining an inference rate of 42 frames per second, and an 11-13% improvement in average anchor IoU coverage with a 46% reduction in anchor parameter variance relative to k-means initialization. The obtained results confirm the practical feasibility and integration potential of the developed architecture for predictive maintenance and lifecycle management of wind energy infrastructure.</p>
	<p>Ilya Afanasyev, Innopolis University, Innopolis, Russia.</p> <p>Lecture Title: Neuro-Symbolic Enhancement of the Geometric Dual Quaternion Observer for 6DoF Pose Estimation in Autonomous Robotic Systems.</p> <p>Abstract: Accurate and reliable 6DoF pose estimation is a critical prerequisite for the safe navigation and control of autonomous unmanned vehicles and mobile robotic systems. This paper presents a novel hybrid approach to pose estimation by combining manifold-aware geometric filtering with evolutionary artificial intelligence technologies. While the Geometric Dual Quaternion Observer (GeoDQ) provides robust orientation and position tracking for mobile robots, it remains susceptible to inertial integration drift during sparse or interrupted visual odometry updates. To mitigate this vulnerability, we employ Cartesian Genetic Programming (CGP) to automatically discover interpretable symbolic</p>

mathematical expressions that model error dynamics directly from raw inertial measurement unit (IMU) data. Evaluated on the standardized RoNIN dataset, the evolved correction term is seamlessly injected into the GeoDQ velocity estimation loop. Experimental batch validation across 35 distinct tracking trajectories demonstrates the viability of this neuro-symbolic sensor fusion approach for dynamic robotic applications. Although the global average precision remained comparable to the baseline, the proposed hybrid filter successfully achieved measurable drift reduction in 51.4% of the highly dynamic scenarios. These findings highlight the potential of evolutionary algorithms to synthesize explicit error compensation models for complex autonomous navigation systems without relying on unpredictable black-box neural networks.

Oral Session 3: Robot Control



Mikhail Medvedev, Vyacheslav Pshikhopov, Ilya Medvedev, Southern Federal University, Rostov-on-Don, Russia.

Lecture Title: Method of Adaptive Control of Pure Feedback Plants Based on the Actor-Critic Framework.

Abstract: This article proposes a backstepping-based method for design of adaptive control for uncertain pure feedback nonlinear systems using reinforcement learning. Pure feedback nonlinear systems describe classes of electromechanical systems, mobile robots, and moving objects. When setting the problem, the constraints on control and state variables of the plant were taken into account. The adaptive control problem is solved using the one-step Actor-Critic method. Radial basis functions are used to approximate the control policy. To estimate the value of a state, an analytical expression is used that depends on the control error at two time steps. A new algorithm for updating weight coefficients and parameters of radial basis functions is proposed. The article demonstrates the effect of increasing the accuracy of a closed-loop system by dynamically adjusting the parameters of radial basis functions. The proposed algorithm does not contain uncertainty in calculating the increments of weight coefficients. The closed-loop Lyapunov stability property of the system is demonstrated. The theoretical analysis is supported by numerical simulation examples.



Denis Bordyugov, Evgeniy Briskin, Nikolay Sharonov, Aleksey Prokopov, Volgograd State Technical University, Volgograd, Russia.

Lecture Title: Control of Mobile Robots with Load-Bearing Supports Discretely Interacting with the Supporting Surface.

Abstract: A schematic of a two-section mobile robot of the «robo-train» type is presented. The robot is equipped with braking supports that interact discretely with a flat surface and with a linear actuator. Its motion is achieved by extending or retracting the rod of the linear actuator: one section remains stationary due to the interaction of all its deployed supports with the supporting surface, while the other section is in a free state and performs rotational motion about a vertical axis passing through a single fixed support. The motion principle of the two-section robot is based on the alternation of fixation and displacement phases of the sections. This enables the «robo-train» to follow a prescribed trajectory with minor deviations and to achieve high maneuverability. It is established that the motion pattern is determined by the geometric parameters of the system, the operating modes of the linear actuator, and the control algorithm governing the interaction of the deployable braking supports with the supporting surface. To evaluate the motion performance



of the «robo-train», the concept of «dimensional passability» is introduced, which refers to the robot's ability to move within narrow curvilinear regions bounded by rigid walls. The design and operating principle of a mobile robot with deployable supports and a rotating internal body are also considered; such a robot can be incorporated into the «robo-train» as a leading section. Basic motion trajectories of this robot are presented, the combination of which enables motion in various directions and allows different operating modes of the two-section robot to be realized.



Olga Zarina, Alexey Bobtsov, ITMO University, Saint-Petersburg, Russia.

Lecture Title: An Adaptive State Observer for a Class of Time-variant Bilinear Systems Under Condition of Partial Parametric Uncertainty.

Abstract: An adaptive observer for a bilinear time-variant dynamic system under condition of partial parametric uncertainty is proposed. The problem is solved under the assumption that unknown parameters are contained in the control matrix/vector. The key idea of the proposed algorithm is a new parameterization of the object based on two functions, one of which can be found analytically using known and measured system signals. The application of linear filters transforms the initial system to a linear static regression model containing unknown constant parameters. The unknown parameters are estimated using a gradient algorithm, and estimates of unknown state vector components are calculated based on the obtained estimates. The proposed method is applicable to a wide class of bilinear systems, including Euler-Lagrange systems describing many real technical objects and robotic systems.



Sofya Devyataya, Olga Zarina, Alexey Bobtsov, ITMO University, Saint-Petersburg, Russia.

Lecture Title: Velocity observer design via reducing to linear regression for the Euler-Lagrange systems class.

Abstract: In this paper, we consider the problem of velocity estimation for Euler-Lagrange systems. For these systems, classical observers are quite limited because, in the general case, the equations have quadratic (bilinear) dependence on generalized velocities. The proposed approach is based on the existing state observer designed for bilinear systems. This observer requires that the unknown multiplier of the state is integrable. Of course, not every arbitrary system satisfies this condition. However, Euler-Lagrange equations naturally contain partial derivatives and, what is more important, full derivatives of the mass matrix elements, as well as more complicated expressions that come from them. An advantage of this bilinear systems observer is that it reduces the velocity estimation problem to a simple linear regression form. Thanks to this, we can use different adaptive, robust, and even finite-time estimation algorithms. In the paper, we formulate some requirements that guarantee the presence of the full derivative of the natural logarithm of the mass matrix determinant in the equations of motion. This makes explicit integration possible. For the sake of completeness, we partly reproduce the existing procedure for observer synthesis with minor modifications. Also, simulation results for the cart-pendulum system implemented in MATLAB/Simulink are shown. These results demonstrate that the proposed observer converges well and has better robustness to measurement noise compared to the dirty derivative approach.



Oleg Stepanov, Alexey Isaev, ITMO University, Saint Petersburg, Russia; Concern CSRI Elektropribor, JSC, Saint Petersburg, Russia.

Lecture Title: Recursive Batch Gaussian Sum Filter for Single-Beacon Navigation Problem.

Abstract: A problem of determining the position of a slave autonomous unmanned under-water vehicle (AUV) using range measurements to the leader AUV is considered within the framework of the Bayesian stochastic approach. This problem can be interpreted as a single-beacon navigation problem. Its key feature is that the form of the posterior probability density function (PDF) varies from multi-extremal to single-extremal one. Previously, this problem was solved with the use of the Recurrent Iterative Batch Linearized Smoothing Filter with Multiple Linearization (RI-BMLS) proposed by the authors. The essence of that approach lies in identifying the point in time at which the posterior PDF becomes single-extremal, and then the recursive iterative Kalman filter is used to solve the problem. However, the RI-BMLS has some significant drawbacks: first, it is ineffective until the onset of aforesaid point in time; and second, the RI-BMLS can be computationally intensive when the posterior PDF remains multi-extremal over a long-time interval. This paper proposes the Recursive Iterative Batch Gaussian Sum Filter (RI-

	<p>BGSF), which is a modification of the RI-BMLS. Unlike the RI-BMLS, the proposed algorithm allows for the effective solution of the single-beacon navigation problem throughout the entire problem solution, which is made possible due to the representation of the posterior PDF at its multi-extremum points as a weighted set of Gaussian densities. The RI-BGSF is significantly much simpler computationally owing to the combined use of recursive and nonrecursive schemes in its design. The advantages of the proposed algorithm are demonstrated through simulations.</p>
	<p>LiBin Du, College of Ocean Science and Engineering, Shandong University of Science and Technology, Qingdao, China; Shandong Key Laboratory of Polar and Deep-Sea Environmental Sensing and Intelligent Exploration, Qingdao, China.</p> <p>Zhen Zhu, College of Electrical Engineering and Automation, Shandong University of Science and Technology, Qingdao, China.</p> <p>Vladimir Filaretov, College of Ocean Science and Engineering, Shandong University of Science and Technology, Qingdao, China; Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia.</p>
	<p>Dmitry Yukhimets, Robotic Laboratory Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia.</p> <p>ChengGang Wang, Di Tian, YunLi Nie, College of Ocean Science and Engineering, Shandong University of Science and Technology, Qingdao, China.</p> <p>Lecture Title: Hydrodynamic Performance Analysis of Rim-Driven Propeller Based on CFD.</p>
	<p>Abstract: The Shaftless Rim-Driven Thruster (RDT) is an integrated propulsion system that highly combines the duct, motor, and propeller. As the most critical component in RDT design, the rim-driven propeller addresses the shortcomings of traditional shaft-driven propellers, such as large spatial requirements, complex structures, and low efficiency. In this paper, a hydrodynamic performance simulation of a self-developed rim-driven propeller is conducted under open-water conditions to analyze the flow field characteristics, and the open-water hydrodynamic performance curves are successfully plotted to evaluate the thrust and torque coefficients. Furthermore, the propeller is investigated under oblique flow conditions to evaluate its hydrodynamic performance variations in complex underwater environments. The simulation results indicate that the oblique flow causes the propeller to bear significant alternating loads, which leads to a highly disordered flow field on the suction side of the blades. This phenomenon ultimately results in a noticeable decline in the overall hydrodynamic performance of the thruster. These findings provide important theoretical guidance for the further structural optimization and practical application of rim-driven propulsion technology.</p>



Ilya Mitin, Victor Kazantsev, Lobachevsky State University, Nizhny Novgorod, Russian Federation; Skolkovo Institute of Science and Technology, Moscow, Russian Federation.

Sergey Lobov, Susanna Gordileva, Lobachevsky State University, Nizhny Novgorod, Russian Federation.

Lecture Title: Study of Energy Efficiency of Thunniform Locomotion Using a Robotic Fish Example.

Abstract: The development of biomorphic underwater robots that utilize locomotion principles of aquatic organisms is one of the actively advancing areas of modern robotics. Of particular interest is the design of robots implementing thunniform locomotion, characteristic of highly efficient swimmers. This paper presents a fish-like robot whose design is based on the morphology of the yellowfin tuna and optimized for experimental studies of swimming kinematics under laboratory conditions. The robot is equipped with a caudal propulsion system that generates forward motion through periodic oscillations of the tail fin, mimicking the natural swimming kinematics of fish. The article describes the structural features of the robot, its internal layout, sensors, and principles of maneuvering in three-dimensional space. Experimental studies of swimming kinematics were conducted in a pool using video recording followed by computer vision data processing. Based on marker coordinates on the robot's body, swimming speed was determined under different operating modes of the tail actuator. The dependence of swimming speed and energy efficiency on tail beat frequency at constant amplitude was investigated. It was shown that swimming speed increases approximately linearly with increasing frequency. The minimum Cost of Transport (COT) value was $6.22 \text{ J}\cdot\text{kg}^{-1}\cdot\text{m}^{-1}$, which is comparable to biological prototypes and the most efficient biomorphic robots. The obtained results can be used in the further design of energy-efficient fish-like underwater vehicles.



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Victor Kazantsev, Laboratory of Neurobiomorphic Technology, Moscow Institute of Physics and Technology (MIPT), Dolgoprudny, Moscow Region, Russia; Lobachevsky State University of Nizhny Novgorod (UNN), Department of Neurotechnology, Nizhny Novgorod, Russia.

Lecture Title: Numerical Simulation of Dynamics Deformation of Bio-Inspired Robotic Wing.

Abstract: Interest in bio-inspired robotics has grown considerably in recent years, driven largely by the potential of these systems to achieve lightweight construction and high-energy efficiency. In line with this growing field, the present study employs numerical simulations to investigate dynamic deformation in a bio-inspired robotic structure. While the process of dynamic deformation can be described, using a range of constitutive mathematical models such as elastic, elastoplastic, and elastoviscoplastic frameworks this work specifically applies a linear elastic model to examine the deformation behavior. The computational results obtained from this simplified approach demonstrate a strong correlation with experimental data reported in the literature. This high degree of agreement not only validates the numerical model employed but also suggests that, under specific conditions, a linear elastic

approximation may be sufficient to capture the essential dynamic characteristics of certain bio-inspired systems. The findings provide a foundational step toward understanding more complex deformation mechanisms.

Oral Session 4: Service Robots



Igor Petukhov, Liudmila Steshina, Volga State University of Technology, Russia, Yoshkar-Ola.

Dimiter Velev, Plamena Zlateva, University of National and World Economy, Bulgaria, Sofia.

Lecture Title: Effects of Simulator Training Duration on Early-Stage Control Performance of Mobile Vehicle Platforms.

Abstract: This paper examines the impact of simulator training duration on the performance of mobile transport platform (MTP) operators in the early stages of skill development. The primary hypothesis is that the learning effect is uneven, structurally localized, and manifests itself at specific stages of task performance. An experimental study was conducted involving operators with no practical experience who underwent simulator training for 15 and 30 minutes under identical conditions. An unmanned aerial vehicle (UAV) was used as an aerial case study of mobile transport platform (MTP) control, ensuring accurate recording of trajectory parameters. The experimental task involved driving a standardized route with checkpoints, divided into time segments. To analyze structural effects, a relative segment effect metric was introduced, allowing for quantitative assessment of differences between training conditions at the level of individual trajectory segments. In addition to the overall task completion time, segmental characteristics, the number of incidents, and missed checkpoints were analyzed using nonparametric statistical methods. The results showed that longer simulator training was associated with a statistically significant reduction in overall task completion time. However, the effect is heterogeneous: significant differences are localized in specific trajectory segments characterized by increased control complexity. High variability in performance was also revealed in the early stages of training, along with a lack of a strong relationship between execution speed and control accuracy. These results demonstrate that assessing the effectiveness of operator training should consider not only integral indicators but also the task structure. Although the experiment was conducted using a UAV-based aerial case study, the proposed approach is applicable to a wide range of mobile transport platforms.



Anatoly Kalyaev, Dina Orda-Zhigulina, Scientific Research Institute of Multiprocessor Computer and Control Systems, Taganrog, Russian Federation.

Lecture Title: Design of Heterogeneous Robotic Warehouse Systems Based on an Intelligent Zone-Based Multiagent Dispatching Method.

Abstract: This paper proposes a new approach to designing robotic warehouse complexes (RWC) that include multiple heterogeneous material-handling robots and support the storage and movement of loads of different classes. The proposed approach enables automated control of such a heterogeneous robot fleet during the allocation of incoming requests by organizing this process as self-organizing multi-agent dispatching. In this framework, each material-handling robot is treated not as an externally controlled transport vehicle, but as an autonomous agent



with its own onboard computing resources and the ability to participate in decision-making.

Unlike conventional multi-agent dispatching based on a bulletin board, the developed method uses a localized swarm-based collective-intelligence mechanism: not all agents simultaneously analyze the entire pool of published requests. A request first becomes available to compatible robots located closest to the pickup point; then, as the time for which the request remains on the bulletin board increases, the search area for an assigned robot is expanded. This reduces the number of unnecessary calculations, decreases the load on robot computing units and the communication infrastructure, and reduces redundant polling of bulletin boards. The principle of local participation is based on the fact that each participant makes decisions using locally available relevant information, which improves system fault tolerance and allows the most up-to-date information to be used.



Alexey Yakushev, ITMO University, St. Petersburg, Russia.

Alexey Kashevnik, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia.

Lecture Title: Lightweight Multi-Task Emotion Recognition for Human-Robot Interaction.

Abstract: Effective and safe interaction in collaborative robotics hinges on the robot's ability to adapt its behavior to the human's cognitive and emotional state. This paper introduces EffiAtt-Emotion, a lightweight deep learning model for facial emotion recognition designed specifically for resource-constrained onboard robotic systems. With only 13.3 million parameters, the model demonstrates a high and balanced performance, achieving an accuracy of 80.6% and a macro F1-score of 0.806 for eight distinct emotion classes. We present a framework for integrating EffiAtt-Emotion into a collaborative robot's (cobot's) control loop, enabling real-time adaptive behavior. A use case on a collaborative assembly line is detailed, where the cobot adjusts its speed, provides assistance, or enters a safe stop mode in response to the human operator's recognized emotions, such as confusion, frustration, or fear. This approach directly addresses documented challenges in HRI, where human factors like stress and fatigue contribute to decreased performance and safety risks. By making the robot aware of the operator's state, our system aims to enhance task efficiency, ergonomics, and critically, to improve safety in line with the human-centric principles of Industry 5.0.



Hao Chen, Weihua Chen, Li Zhang, Zhejiang Airport Digital Technology Co., Ltd. Hangzhou, China.

Fan Ye, Minglei Fu, College of Information Engineering, Zhejiang University of Technology, Hangzhou, China.

Lecture Title: A Cloud-Edge Collaborative Framework for Personnel Identification via Wearable Smart Glasses.

Abstract: This paper presents a cloud-edge collaborative framework for personnel identification and crowd sensing based on wearable AI smart glasses in complex environments. To address the computational and power constraints of edge devices, the system adopts a cloud-edge architecture in which the smart glasses perform lightweight face detection, adaptive region-of-interest cropping, and quality-aware compression, while the cloud server executes high-dimensional feature extraction and identity matching. For identity verification, a temporal multi-frame weighted smoothing strategy integrates cosine similarity scores across

	<p>consecutive frames, achieving an overall accuracy of 96.1% in experiments. For database-free scenarios, an identity-agnostic crowd sensing pipeline combines human keypoint-based frontal orientation filtering, appearance-based role filtering for staff exclusion, and a cross-frame tracking mechanism that fuses person re-identification features with spatial association, attaining a pedestrian recognition accuracy of 97.8% and complete staff filtering in the tested controlled scenarios. Experimental results on real-world hardware demonstrate that the proposed framework balances response efficiency, recognition accuracy, and transmission cost, providing a practical solution for personnel management and crowd sensing in dynamic environments.</p>
	<p>Anton Gubankov, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia.</p> <p>Aleksander Zuev, Vladislav Gorin, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia; Admiral G.I. Nevelskoy Maritime State University, Vladivostok, Russia; Institute of Marine Technology Problems named after Academician M.D. Ageyev, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia.</p> <p>Anastasia Serdyukova, Institute of Automation and Control Processes, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia; Institute of Marine Technology Problems named after Academician M.D. Ageyev, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, Russia.</p> <p>Lecture Title: Development of a method for synthesizing adaptive control systems for unmanned aerial vehicles.</p> <p>Abstract: The paper proposes a method for the synthesis of an adaptive control system (CS) for the spatial motion of a quadrotor unmanned aerial vehicle (UAV), ensuring desired dynamic performance under conditions of parametric uncertainty and external disturbances. The proposed CS is designed to maintain stability and tracking accuracy in the presence of model inaccuracies and unknown environmental effects, including time-varying disturbances. The CS has a cascaded structure with an outer position control loop and an inner attitude control loop, implemented using nonlinear position controllers (NPC) and nonlinear attitude controllers (NAC), respectively. Parametric uncertainties and external disturbances are estimated using variable structure observers (VSOs), whose estimates are incorporated into the control laws to provide real-time compensation of uncertainties. The synthesis of the CS and VSOs is based on a mathematical model of the UAV that accounts for the center-of-mass (CM) offset and key dynamic effects. The combined influence of external disturbances and parametric uncertainties is represented in the dynamic equations as an additive disturbance term. The effectiveness of the proposed approach is demonstrated through numerical simulations in stabilization and trajectory tracking tasks.</p>



Dmitry Yukhimets, Anton Gubankov, Institute of Automation and Control Processes, Vladivostok, Russia; Admiral Nevelskoy Maritime State University, Vladivostok, Russia.

Lecture Title: Development of Control System Synthesis Method for Unmanned Aerial Vehicles Moving in a Group.

Abstract: The paper deals with a control system synthesis method for a group of unmanned aerial vehicles (UAV) which can implement search or monitoring applications (missing people, fish exploration, aerial photography and so on). Very often this requires efficiency and occurs in adverse weather conditions of the sea, highlands, deep forest, high latitudes, etc. In such conditions, navigation and communication with the ground control station may be difficult. Group control strategy «leader-followers» reduces the risks to the equipment and simplifies the creation of the flight task. To do this, a UWB beacon is placed on the leader, which allows the followers to determine the distance to him and receive data on his movement parameters. As a result, all the followers can provide navigation and maintain a set formation relative to the leader, without communication with the ground control station. The simulation results confirmed the operability and effectiveness of the proposed method UAV group control method.



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Lecture Title: Design of Intelligent Weighing System Based on Multi-Sensor Information Fusion.

Abstract: Precision weighing is a critical foundation for ensuring industrial material transportation safety, improving operational efficiency, and realizing intelligent management, whose accuracy directly affects the stability and economy of modern industrial production. Traditional weighing methods suffer from low accuracy, limited automation capabilities, and weak anti-interference performance, which are unable to meet the large-scale and intelligent demands of modern industry. Aiming at these defects, this study proposes an industrial intelligent weighing system based on multi-sensor information fusion, with its performance verified via practical tests in typical mining rail transportation scenarios. The research develops a high-precision, efficient, user-friendly system: it



systematically analyzes global existing weighing technologies to provide theoretical support for system design, optimizes component selection and installation schemes to ensure the accuracy and stability of weighing data, develops dedicated data acquisition and processing circuits to enhance the system's anti-interference ability and data processing speed, integrates upper-computer software for data display and storage, and verifies all performance indicators through practical testing. Experimental results show the system has high accuracy, fast response, and good stability, effectively meeting the actual production needs of mining rail transportation, reducing manual labor intensity, and improving operational efficiency.



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Alexey Martynov, Nikita Zatsepin, Georgy Piskunov, S.M. Kirov Military Medical Academy of the Ministry of Defense of the Russian Federation, St. Petersburg, Russia.

Lecture Title: Robotics in Environmental Monitoring of Surface Water Bodies.



Abstract: Current real-world events are exposing a critical weakness in our standard operational frameworks. Against the backdrop of escalating hybrid conflicts, the biological protection of water resources demands a radical overhaul of our fundamental containment strategies. The traditional, stationary model of sanitary surveillance has proven to be systemically rigid and immobile. The destruction of the Kakhovka Hydroelectric Dam and the large-scale flooding in the Orenburg region provided harsh empirical evidence of the total paralysis of fixed laboratory networks in disaster zones. In such scenarios, the time factor becomes fatal. The resulting diagnostic vacuum – where no testing can occur- transforms water into an ideal vector for the mass transmission of pathogens, thereby necessitating a decisive paradigm shift from the traditional method of bringing the sample to the instrument to the urgent delivery of the instrument directly to the contamination site. Development, validation, and field testing of the «VirBac-1» robotic universal mobile complex was the main goal of research group. A primary technical hurdle was overcoming the physical barrier known as the «size paradox», which refers to the difficulty of detecting extremely small viral particles in large water volumes using traditional filters that either clog instantly or fail to trap the target. To solve this, the authors deliberately abandoned the classic sieve effect in favor of electrostatic adsorption on modified nitrocellulose membranes; in simpler terms, the system uses a specialized filter with an electric charge that acts like a magnet for viral particles, trapping them regardless of their physical size. The architecture of the complex integrates this colloid-chemical principle into an automated membrane concentration cycle operating under strictly controlled pH levels and ionic strength of the solution to ensure maximum capture efficiency. The empirical data exceeded initial projections. The

resulting cyber-physical prototype completely eliminates human error during the pre-analytical stage while ensuring full operational autonomy powered by lithium-ion batteries. Crucially, the total analytical cycle time has been radically compressed: whereas standard regulatory frameworks require forty-eight to seventy-two hours. The «VirBac-1» complex reduces this time to an operationally actionable window of one point two to one point five hours. In the context of a flood or a bio-terror event, a delay of two or three days renders laboratory data useless for emergency response, whereas a result delivered in ninety minutes allows for immediate public health intervention. Consequently, the «VirBac-1» robotic complex establishes a fundamentally new technological architecture for continuous environmental monitoring of water bodies. Modeling of hydrological disaster scenarios has convincingly demonstrated that the complex is ready for large-scale, in situ screening of surface waters, effectively bypassing the logistical constraints that cripple traditional laboratory systems.

Online Session 3: Water Robotics Vehicles



Pham Van Gioi, Hoang Duc Long, Le Quy Don Technical University, Ha Noi, Viet Nam.

Le Van Tung, Thanh Dong University, Hai Phong. Viet Nam.

Lecture Title: Adaptive Energy-Shaping Error-Dynamics Control for Omni-Mecanum Mobile Robots.

Abstract: This paper presents an adaptive energy-shaping error-dynamics (AESED) control framework for trajectory tracking of omni-Mecanum-wheeled mobile robots under parametric uncertainties and external disturbances. By reformulating the tracking error dynamics as a strictly dissipative mechanical system, the approach enables systematic gain design and provides a clear physical interpretation of the closed-loop behavior. The controller operates directly in Cartesian space and incorporates an adaptive law to compensate for unknown inertial, frictional, and load-related parameters without prior knowledge of the robot model. Lyapunov-based analysis guarantees global asymptotic convergence of the tracking errors in the nominal case and ensures uniform ultimate boundedness of all closed-loop signals under bounded disturbances. Comparative simulations using the full nonlinear model of a four-Mecanum-wheeled robot demonstrate faster convergence, smaller transient overshoot, lower tracking errors, and smoother bounded control torques compared with adaptive backstepping and sliding-mode controllers. The results confirm that AESED improves trajectory-tracking performance while preserving robustness and practical implementability, making it suitable for high-precision omnidirectional robot motion in uncertain operating conditions. Future work will focus on hardware implementation, nonlinear friction modeling, and exploiting advanced holonomic trajectories to fully utilize the mobility of Mecanum-wheel robots.



Aws Ahmad, Moscow Bauman State Technical University N.E. Moscow, Russia; Financial University under the Government of the R.F., Moscow, Russia.

Arkady Yuschenko, Moscow Bauman State Technical University N.E. Moscow, Russia.

Lecture Title: Fuzzy Logic Application for Underwater Robot with Undulating Fin Control.

Abstract: This paper is devoted to the development and analysis of control algorithms for an autonomous underwater vehicle (AUV) with an undulating fin propulsor. A short review is given of studies addressing the dynamic and kinematic models of underwater robots with flexible fins. A mathematical model of the vehicle interacting with the environment is implemented in the Simscape-MATLAB library. To solve the problem of motion control of the robot in course and depth, the Active Disturbance Rejection Control (ADRC) method is proposed. This approach extends the system model by introducing an additional state variable that accounts for factors not included in the mathematical description. The virtual state is estimated online by an observer and is used in generating the control signal, thereby compensating the external disturbances. Fuzzy logic methods based on physical and hydrodynamic laws and on human experience are also applied. The advantage of the method is that it does not require an exact analytical model of AUV dynamics, particularly the relation between fin motion parameters and vehicle dynamics. Simulation results of AUV motion under rapidly varying external disturbances confirm the effectiveness of the proposed model and control strategy.



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Tran Van Tuyen, Nguyen Huy Liem, Le Quy Don Technical University (LQDTU), Ha Noi, Viet Nam.

Lecture Title: Analysis of Deep Learning Methods in Video Analytics, Robotic Monitoring, and Aquaculture Management with an Empirical Comparison of Lightweight YOLO Models for Fish Detection.

Abstract: This paper presents a review of state-of-the-art deep learning methods for video analytics in aquaculture over the period 2025–2026, complemented by an empirical evaluation of two lightweight YOLO-family neural network models for the fish detection task. Four key research directions are analyzed: fish disease detection, segmentation and phenotyping, tracking and biomass estimation, and the development of lightweight models. Based on contradictions identified between existing studies, an experimental comparison of two architectural configurations – the original YOLOv26 and YOLOv11 integrated with the Reparameterized Multi-Head attention module (RepMHD) – was conducted on the public DeepFish dataset, which contains images of fish in natural tropical marine habitats. The results show that the YOLOv11 + RepMHD configuration achieves higher Precision (0.978 vs. 0.960) and a comparable mAP@0.5 value (0.991 vs. 0.990) with 2.28 million parameters and 5.6 GFLOPs, whereas the original YOLOv26 demonstrates a higher mAP@0.5:0.95 value (0.816 vs. 0.812) with 2.38 million parameters and 5.2 GFLOPs. These findings indicate that the choice between these two strategies should be guided by the specifics of the application – particularly the priority assigned to minimizing false positive versus false negative detections.





Firas Houssein, Mikhail Medvedev, Southern Federal University, Taganrog, Russia.

Lecture Title: A Communication-Efficient Modified Consensus-Based Auction Algorithm for Distributed AUV Task Allocation.


Abstract: The problem of target positions allocation in a formation of autonomous unmanned underwater vehicles (AUVs) under conditions of limited underwater communication is considered. A consensus-based auction algorithm (CBAA) is used to solve this problem, combining decentralized task selection and an assignment approval process between agents. A drawback of classical CBAA is the significant time required to execute multiple consensus phases, especially in an underwater environment where acoustic communication channels are characterized by low bandwidth and significant data transmission delays. A modification of the CBAA is proposed, making it need only a single consensus phase followed by local calculation of the final allocation by each agent based on the full set of bids from all participants. This approach eliminates the need for repeated consensus phases and shifts some of the workload from the communication system to the AUV's onboard computing system. A comparative analysis of the communication complexity of the original and modified algorithms was conducted. The results confirm the potential of the proposed approach for rapid target positions allocation in large groups of AUVs.



Iuliia Zaitceva, St. Petersburg State University, St. Petersburg, Russia; Institute of Problems in Mechanical Engineering of RAS, St. Petersburg, Russia.

Lecture Title: Synthesis of Robust Controller based on Stability Criterion of Forced Oscillations.

Abstract: The article is devoted to the development of a classical H^∞ -synthesis method for a class of nonlinear dynamic systems where nonlinearity is described by harmonic linearization, and the parameters of the harmonic input signal – amplitude and frequency – are specified within certain ranges. The key distinction of the proposed approach from the classical one lies in explicitly accounting for the range of amplitudes and frequencies of the input signal as a synthesis parameter set by an engineer based on operational requirements, rather than implicitly estimating it according to the worst-case scenario. The method relies on the stability criterion of forced oscillations in the first harmonic approximation and transforms the synthesis problem into an amplitude-frequency-explicit design scheme with guaranteed stability bounds. The results are illustrated using an example of servo drive control with saturation nonlinearity and combined dynamic nonlinearity. It is shown that for static nonlinearities, the method provides explicit stability boundaries. For nonlinearities with growing uncertainty, the proposed approach reduces conservatism in estimation: the synthesized controller ensures formal stability guarantees within the operating range of amplitudes, whereas the classical H^∞ synthesis with conservative weighting produces values exceeding the stability threshold, indicating inability to certify stability under the same uncertainty description. Thus, the method enables formal stability guarantees within engineer-specified operational ranges by explicitly incorporating amplitude and frequency constraints, thereby reducing conservatism compared to classical worst-case approaches while maintaining compatibility with standard robust control frameworks.

	<p>Andrey Maevskiy, Vladimir Ryzhov, Alexander Zinoviev, Igor Kozhemyakin, Saint-Petersburg State Marine Technical University, Saint-Petersburg, Russia.</p> <p>Lecture Title: PathFormer: A CNN–Transformer Architecture for Autoregressive Path Planning of Unmanned Surface Vehicles in Current-Affected Waterways.</p> <p>Abstract: This paper proposes the Pathformer architecture – a hybrid neural network model for global route planning of marine robotic systems (MRCS) under dynamically changing hydrometeorological conditions. The model combines a convolutional encoder and an autoregressive Transformer decoder, generating a sequence of waypoints in a continuous coordinate space. It uses offset prediction, a causal mask with global target visibility, and a DAgger-like perturbation of the inputs. Reference trajectories are generated by A* on synthetic maps of water areas with currents. On 9000 test trajectories, the obtained goal attainment rate was 99.7%, the collision rate was 0.01% after postprocessing, and the median cost ratio was 1.004 relative to A*.</p>
	<p>Tatiana Fedorova, Vladimir Ryzhov, Igor Kozhemyakin, Ekaterina Strelets, Saint Petersburg State Marine Technical University, Saint Petersburg, Russia.</p> <p>Lecture Title: An analytical approach to evaluating the lifetime and energy efficiency of a hybrid underwater wireless sensor network with a mobile gateway.</p> <p>Abstract: This paper considers the problem of optimizing data transmission in a hybrid underwater wireless sensor network (UWSN) with a mobile gateway. The topology of conventional and reference nodes, the trajectory of the mobile gateway, and the stochastic nature of acoustic signal propagation in the underwater environment are taken into account in the proposed analytical model. The model allows for a quantitative assessment of data transmission reliability and the energy efficiency of the network's operation. Simulation results show that the energy efficiency of the UWSN is determined by the combined influence of the technical characteristics of the modems, the probability of successful data delivery, and the trajectory of the mobile gateway. It has been established that for long work cycles duration, the network lifetime is primarily determined by the initial energy reserve of the nodes and the power of the modems, whereas for short work cycles duration, the network topology has a significant impact, in particular the proportion of reference nodes along the gateway's trajectory. The optimal distance between sensors, at which total energy consumption is minimized, has been determined. It is shown that increasing the number of reference nodes allows for a significant increase in the network's lifetime without a significant increase in energy consumption. The results obtained can be used in the design of robust and energy-efficient underwater sensor networks operating in real-world aquatic environments.</p>
	<p>Vagif Abdullayev, Institute of Mathematics of the Ministry of Science and Education of Republic of Azerbaijan, Baku, Azerbaijan.</p> <p>Kamil Aida-zade, Institute of Mathematics of the Ministry of Science and Education of Republic of Azerbaijan, Baku, Azerbaijan; Azerbaijan State Oil and Industry University, Baku, Azerbaijan; Azerbaijan University of Architecture and Construction, Baku, Azerbaijan.</p> <p>Vugar Hashimov, Institute of Mathematics of the Ministry of Science and Education of Republic of Azerbaijan, Baku, Azerbaijan; National Aviation Academy of Azerbaijan, Baku, Azerbaijan.</p>



Lecture Title: Synthesis of Control of the Movement of Measurement Points of the State and Power of Heat Sources at the Ends of the Rod.

Abstract: Using the example of controlling the dynamics of the movement of sensors for measuring the temperature state on a rod, the problem of synthesizing control actions in systems with distributed parameters is investigated. Feedback is achieved by measuring the state of the process using moving remote measuring devices (sensors). Linear dependencies of the current values of control actions on the boundary conditions and on the movement of measuring devices from the measured temperature values both at the current and at past moments of the process state are proposed. In the problems, the constant feedback parameters, that is, the coefficients involved in these dependencies, are synthesized. As a result, the feedback control problem is formulated as a problem of parametric optimal control of an object with distributed parameters. To determine the optimal values of the feedback parameters, formulas for the gradient of the objective functional were obtained, which make it possible to use effective numerical methods of first-order optimization. The results of numerical experiments are presented.



Kamil Aida-zade, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan; Azerbaijan State Oil and Industry University, Baku, Azerbaijan.

Samir Guliyev, Azerbaijan State Oil and Industry University, Baku, Azerbaijan.

Seymur Mirzabayov, French-Azerbaijani University (UFAZ), Baku, Azerbaijan.

Lecture Title: Feedback Control of a Discrete System with Memory within the Class of Zonal Control Actions.

Abstract: The problem of optimal control for a discrete-time dynamical system over a finite horizon is considered under uncertainty in the initial state values and in the external parameters acting on the system. The control is generated according to a feedback law that depends only on the observable part of the state vector and its history. A functional form of the feedback law is introduced on the basis of a family of zonal controllers: the space of the observable part of the state is partitioned into a finite number of zones, and within each zone the control is defined by fixed affine coefficients, including a memory term, that is, a dependence on the previous measurement. Such a parametrization reduces the original optimal control synthesis problem to a finite-dimensional optimization problem with respect to the coefficients of the zonal law. For the cost functional averaged over the set of admissible initial states and external parameter values, analytical formulas for the gradient with respect to the feedback parameters have been derived. First-order optimality conditions are formulated, and a projected gradient algorithm is proposed for computing the optimal zonal coefficients in the presence of constraints. Results of numerical experiments on test problems are presented; they illustrate the effectiveness of the proposed approach and make it possible to compare different variants of zonal controllers.

Online Session 4: Robot Navigation

Doan Van Dung, Do Duy Khanh, Lan Anh Nguyen, Xuan-Tung Truong, Le Quy Don Technical University, Hanoi, Vietnam.

Lecture Title: An Efficient Navigation System for Autonomous Mobile Robots on Rough Terrain Environments.

	<p>Abstract: This paper presents an efficient navigation framework for autonomous mobile robots operating in rough terrain environments. The proposed approach integrates terrain perception, traversability analysis, and motion planning to enable safe and reliable navigation in complex off-road conditions. An Extended Kalman Filter (EKF) is employed to enhance robot localization, providing robust pose estimation in noisy and unstructured environments. A 2.5D elevation grid map is constructed to represent the local terrain geometry, from which a traversability cost function is formulated to evaluate terrain feasibility. To address global path planning, a Traversability-A* algorithm is proposed by extending the classical A* method with terrain-aware cost integration, allowing the planner to avoid hazardous regions. For local trajectory optimization, a Timed Elastic Band (TEB) planner is adopted to ensure kinematic feasibility and dynamic consistency. The proposed framework is implemented on a skid-steering mobile robot and validated in Gazebo-based simulation environments with uneven terrain. The results demonstrate improved navigation safety and path quality compared to conventional methods.</p>
	<p>Phuc Nguyen Xuan, Institute of System Integration, Le Quy Don Technical University, Hanoi, Vietnam.</p> <p>Thanh Nguyen Canh, School of Information Science, Japan Advanced Institute of Science and Technology, Nomi, Ishikawa, Japan.</p> <p>Huu-Hung Nguyen, Artificial Intelligence and Data science Research Center, Le Quy Don Technical University, Hanoi, Vietnam.</p> <p>Xiem Hoang Van, University of Engineering and Technology, Vietnam National University, Hanoi, Vietnam.</p> <p>Le Quy Don Technical University, Hanoi, Vietnam.</p> <p>Lecture Title: Mitigating Tracking Failures in Sparse-View Gaussian SLAM via Feature-Guided Initialization.</p> <p>Abstract: This paper presents an efficient navigation framework for autonomous mobile robots operating in rough terrain environments. The proposed approach integrates terrain perception, traversability analysis, and motion planning to enable safe and reliable navigation in complex off-road conditions. An Extended Kalman Filter (EKF) is employed to enhance robot localization, providing robust pose estimation in noisy and unstructured environments. A 2.5D elevation grid map is constructed to represent the local terrain geometry, from which a traversability cost function is formulated to evaluate terrain feasibility. To address global path planning, a Traversability-A* algorithm is proposed by extending the classical A* method with terrain-aware cost integration, allowing the planner to avoid hazardous regions. For local trajectory optimization, a Timed Elastic Band (TEB) planner is adopted to ensure kinematic feasibility and dynamic consistency. The proposed framework is implemented on a skid-steering mobile robot and validated in Gazebo-based simulation environments with uneven terrain. The results demonstrate improved navigation safety and path quality compared to conventional methods.</p>



Cong Binh Nguyen, Xuan Chiem Nguyen, Department of Automation and Computing Techniques, Le Quy Don Technical University, Vietnam.

Pavel Obukhov, Don State Technical University, Rostov-On-Don, Russia.

Pham Duy Thái, Department of Biomedical Engineering, Le Quy Don Technical University, Vietnam.

Lecture Title: Adaptive Nonlinear Hierarchical Control Based on RBF Neural Networks for Line-Following and Obstacle-Avoiding Mobile Robots under Dynamic Model Uncertainties.

Abstract: This paper proposes an adaptive nonlinear neural-network-based control law for a line-following and obstacle-avoidance robot under dynamic model uncertainties. First, the mathematical model of the line-following and obstacle-avoidance robot (LF&OAR) is unified with the conventional line-following model by employing LiDAR and camera sensors to construct a virtual line along the obstacle boundary and reconnect it with the main line, while the robot dynamics are represented in a general form. The proposed controller is developed based on a hierarchical control structure. At the kinematic level, the desired linear and angular velocities are generated using the Lyapunov approach to ensure smooth line-tracking performance, even when the reference path has large curvature. At the dynamic level, a controller is designed based on the general dynamic model of a differential-drive mobile robot using the super-twisting sliding mode control (STSMC) technique. The unknown nonlinear functions in the general dynamic model are approximated by radial basis function neural networks (RBFNNs), and an adaptive law is derived to update the network weights online. The results indicate improved tracking performance under the tested simulation and experimental conditions.



Thong Pham Duc, Academy of Military Science and Technology, Hanoi, Vietnam.

Dmitry Tarlakovskii, Lomonosov Moscow State University, Moscow, Russia.

Lecture Title: Onboard Vehicle Detection for Autonomous UAV Reconnaissance under Degraded Visual Conditions.

Abstract: Onboard object detection is a key requirement for UAV reconnaissance in communication-denied environments. Yet achieving reliable performance on a lightweight aerial platform is still challenging. From operational altitudes, targets often occupy only a few pixels, and the captured imagery is easily degraded by haze, vibration, weak illumination, and sensor noise. At the same time, the detector must run within the tight power and computing limits of embedded hardware. Existing studies have made progress on small-object detection or model efficiency, but only a limited number have examined these issues together under realistic deployment conditions. To address this gap, this work develops an improved YOLOv8-based detector for onboard aerial reconnaissance. A high-resolution P2 branch is introduced to better preserve fine-scale target cues, while Coordinate Attention is used to strengthen spatially relevant feature encoding. Model robustness is further improved through a curriculum-style training strategy that incorporates several common image degradations, namely fog blur, motion blur, sensor noise, low-light conditions, and atmospheric haze. The detector is then deployed on an NVIDIA Jetson Orin Nano for edge evaluation, where latency, power consumption, and post-quantization accuracy are measured. Results

	<p>indicate that the proposed model achieves stable detection performance in degraded visual environments and remains capable of real-time inference on embedded UAV hardware. This demonstrates its practical potential for autonomous reconnaissance applications.</p>
	<p>Satenik Akopyan, Gleb Kiselev, RUDN University, Moscow, Russian Federation.</p> <p>Lecture Title: Informed Reinforcement Learning for Mobile Robot Planning and Control Tasks based on the D*-Lite Algorithm.</p> <p>Abstract: Autonomous navigation of mobile robots in partially unknown and dynamic environments requires control strategies that are both optimal and robust to disturbances. This paper proposes a hybrid navigation framework that integrates global path planning, Pontryagin-based optimal control, and informed reinforcement learning. The system is implemented as a hierarchical ROS2-based architecture, where D*-Lite generates a global path, an optimal control module computes nominal control actions, and a TD3-based RL agent learns corrective policies to compensate for disturbances. Unlike conventional RL approaches, the proposed method leverages optimal control solutions as informative priors, allowing the agent to learn residual control policies instead of learning from scratch. This significantly reduces the exploration space and improves training efficiency. Experimental results in a Gazebo simulation with dynamic obstacles and physical perturbations demonstrate improved stability, faster convergence, and better trajectory tracking compared to standalone methods. The proposed approach provides a scalable and robust framework for integrating model-based control and data-driven learning in mobile robot navigation.</p>
 	<p>Bushra Ali, Federal Scientific Agroengineering Center VIM, Moscow, Russia; Financial University under the Government of the Russian Federation, Moscow, Russia.</p> <p>Hani Khalil, Federal Scientific Agroengineering Center VIM, Moscow, Russia; Bauman Moscow State Technical University, Moscow, Russia.</p> <p>Riham Saad, Federal Scientific Agroengineering Center VIM, Moscow, Russia; Moscow State University of Technology STANKIN, Moscow, Russia.</p> <p>Igor Smirnov, Federal Scientific Agroengineering Center VIM, Moscow, Russia.</p> <p>Lecture Title: Real-Time Stereo-Vision Semantic Navigation for Apple Orchards Using YOLOv5.</p> <p>Abstract: Autonomous navigation in orchards is highly challenging due to dense tree canopies, variable lighting, grass, uneven terrain and frequent GNSS signal blockage. This paper presents a complete, purely stereo-vision navigation system that relies exclusively on data from a single forward-facing Intel RealSense RGB-D camera. The proposed learning-based semantic algorithm uses a YOLOv5 segmentation model to perform real-time pixel-level segmentation of the ground (road) between rows. The segmentation output is processed through a distance transform and triangle fitting to extract both heading angle and lateral offset. A hybrid steering controller with mode switching generates smooth and robust control commands while end-of-row detection is performed directly from the segmentation mask which enables fully closed-loop operation without any external positioning sensors. The system was evaluated in an apple orchard under realistic natural lighting conditions. Experimental results show a mean absolute lateral error of</p>



0.1651 m and a root mean square error of 0.2056 m relative to the row centerline. The results indicate that accurate and stable row following can be achieved using only low-cost RGB-D data, making the proposed system a feasible navigation solution for orchard robotics.

Gleb Dudyrev, Gleb Kiselev, RUDN University, Moscow, Russian Federation.

Lecture Title: Differentiable LQR as a Structured Policy Output Layer for Mapless Goal-Reaching Navigation of a Mobile Robot.

Abstract: This paper addresses the problem of moving a mobile robot to a given goal in an unknown environment using local sensory data. A standard MLP policy trained with the PPO algorithm and directly generating linear and angular velocity commands is considered as the baseline approach. The proposed method is a policy architecture whose actor output is augmented with a differentiable linear–quadratic regulator layer. This architecture implements a two-level control generation scheme: the neural component of the policy produces a local control intention, while the embedded LQR layer transforms it into the final control action. The paper describes how this layer can be integrated into a continuous actor–critic policy without changing the environment action space and without moving the regulator outside the policy itself. Experimental evaluation is performed in ROS2/Gazebo using a TurtleBot3 robot in goal-reaching tasks in a free environment and in an environment with static obstacles. The comparison is conducted under a unified setup with identical observations, reward function, training and evaluation protocol, and metrics. The obtained results show that the proposed architecture does not degrade the robot's basic ability to reach the goal and, in a more complex environment, produces a meaningful difference in behavior and trajectory quality compared with a standard MLP policy, which makes the embedded differentiable LQR layer a promising direction for further research.



Mikhail Stepanyan, Anton Saveliev, Ekaterina Cherskikh, Konstantin Krestovnikov, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia.

Lecture Title: Autonomous Flight System for UAVs to Selected Objects.

Abstract: Manual control of an agricultural unmanned aerial vehicle (UAV) with simultaneous video stream analysis imposes excessive cognitive load on the operator, leading to control and observation errors. Additionally, disturbances such as forested areas, urban infrastructure, and complex terrain hinder reliable object surveillance. This paper proposes a system in which the operator provides an initial indication of the object of interest, after which the visual tracking system autonomously maintains target tracking and generates control commands without further human intervention. All computations are performed on an onboard computer additionally installed on the UAV, which does not require communication with a ground station. To ensure compatibility with the output of the PID controller, an algorithm has been developed that allows the use of a standard flight controller without modifying its internal control loops. Experimental validation of the proposed solution was conducted in a custom-developed simulation environment based on Unity. PID controller coefficients were tuned empirically, and the configuration of the CSRT tracker was selected for operation with a low-contrast object with poorly defined boundaries. For the final system evaluation, a satellite antenna mounted on a communication tower was used as the object of interest. The tracking accuracy achieved was 0.05% of the screen diagonal over the entire tracking sequence and 0.007% of the screen diagonal during the steady-state phase, when the center of the bounding box coincides with the screen center, at a display resolution of 720×480 and a processing rate of 45.5 FPS on an Intel Core i7-11700F computing platform.



Boris Lebedev, Southern Federal University, Rostov-on-Don, Russia.

Oleg Lebedev, V.A. Trapeznikov Institute of Control Sciences of RAS, Moscow, Russia.

Andrey Sukhanov, JSC «NIAS», Moscow, Russia.

Lecture Title: Methods of collecting information using unmanned aerial vehicles for monitoring difficult and remote areas.

Abstract: This study presents a new approach to modeling the study area, which involves discretizing its space into rectangular segments. A method for optimizing the coverage of the study area by unmanned aerial vehicle sensors by forming a minimal set of such rectangular segments is described. The geometric parameters (size, orientation, location) of the segments are taken into account to reduce the overall survey time. A



typical unmanned aerial vehicle route is considered as a sequence of straight segments defined by control points. An algorithm for constructing an optimal unmanned aerial vehicle route, based on the ant colony principle, has been developed, along with controls for its movement along a given path. An unmanned aerial vehicle route consists of segments that can be classified as «active» (for scanning the area) and «idle» (for moving over areas not subject to survey). In most cases, such a route consists of alternating active and idle segments. A methodology and algorithm for unmanned aerial vehicle movement between control points corresponding to specified route segments are proposed. The process of finding the optimal solution is implemented using two interconnected algorithms: an ant colony behavior model and a control agent behavior algorithm. The applied control method involves continuous replanning of the unmanned aerial vehicle trajectory in real time, taking into account its parallel movement relative to the vector that specifies the direction.



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Anton Saveliev, Ekaterina Cherskikh, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia.

Lecture Title: UAV Stabilization System Based on Machine Vision and Inertial Sensors.

Abstract: The objective of this study is to develop a stabilization system for unmanned aerial vehicles (UAVs) in agricultural industry using machine vision and inertial sensors. The proposed software solution is designed to collect and process visual and inertial data, estimate the UAV's position in space, and support flight stabilization in conditions with limited or unavailable satellite navigation.



The analysis conducted revealed that many existing UAV navigation and stabilization systems are based on GNSS. However, GNSS performance is limited in densely populated urban areas, forests, and other environments with unstable radio signals. Furthermore, GNSS signals are vulnerable to interference, jamming, and spoofing. Therefore, visual-inertial methods are a relevant approach for increasing UAV autonomy. A simulator based on ArduPilot SITL and the MAVLink interface was used as the modeling environment. UAV state estimation was performed using the OpenVINS visual-inertial platform, which combines inertial measurements with sparse visual trajectories using the MSCKF approach. The developed system demonstrates that inertial and visual data can be effectively used to estimate the UAV's position and perform corrective control. The results demonstrate stabilization accuracy of up to 0.5 m, confirming the potential of the proposed approach.



Mohammad Issa, Bauman Moscow State Technical University, Moscow, Russia.

Lecture Title: Toward Cognitive and Energy-Aware Multi-Agent UAV–UGV Collaboration under Limited Communication.

Abstract: Heterogeneous teams of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) offer complementary strengths that make them highly effective for missions in hazardous, remote, and communication-constrained environments. UAVs provide rapid deployment, wide-area sensing, and global situational awareness, whereas UGVs contribute endurance, payload capacity, physical interaction, and mobile support functions such as computation or recharging. Despite this

	<p>synergy, practical deployment remains limited by tightly coupled challenges, including intermittent communication, constrained onboard energy, delayed map sharing, dynamic task allocation, and the need for safe human supervision. This paper reviews recent advances in UAV–UGV collaboration and identifies six core design requirements: communication tolerance, energy awareness, cooperative mapping consistency, task and role adaptability, scalability, and safety with human oversight. To address these requirements jointly, a four-layer cognitive architecture is proposed, supported by a communication-energy-aware coordination model that explicitly links task utility, link quality, and energy dynamics. In addition, a hybrid auction-based task-allocation mechanism and energy-aware routing strategy are introduced to improve coordination under limited bandwidth and battery constraints. The proposed framework provides an integrated foundation for more robust, adaptive, and operationally realistic multi-agent UAV–UGV systems.</p>
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Venue and Format of the Conference

XI International Conference on Interactive Collaborative Robotics (ICR 2026) will be held in a hybrid format: on the basis of the Far Eastern Branch of the Russian Academy of Sciences (FEB RAS, 50, Svetlanskaya St., Vladivostok 690950, Primorsky Krai, Russia) and in videoconference format. The conference programme with link on video conference is available on the website too: <https://icr.nw.ru/>.

The official language of the conference is English.

One link for video conference for Opening ceremony, Sessions, Closing ceremony is: <https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09>.

NB: Please, be so kind to write all your questions to speakers in chat.

The time of the video conference is specified in the time zone of Vladivostok, Russia (UTC + 10): <https://www.worldtimebuddy.com/utc-to-russia-vladivostok>.

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