9th International Conference on
Interactive Collaborative Robotics

ICR 2024

Conference Programme and Abstracts

October 14-18, 2024
Mexico City, Mexico

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- School of Engineering of the National Autonomous University of Mexico, UNAM, Mexico
- St. Petersburg Federal Research Center of the Russian Academy of Sciences, SPC RAS, Russia

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- Jesus Savage, National Autonomous University of Mexico (UNAM), Mexico
- Andrey Ronzhin, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), Russia
- Leonid Fridman, National Autonomous University of Mexico (UNAM), Mexico

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- Humberto Sossa, National Polytechnic Institute (IPN), Mexico
- Lev Stankevich, Peter the Great St. Petersburg Polytechnic University (SPbPU), Russia
- Enrique Sucar, National Institute of Astrophysics, Optics and Electronics (INAOE), Mexico
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- Alexandr Smerchansky, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), Russia

Conference at a glance

Monday, October 14, 2024	
09:00-10:00	**Registration (for on-site participants)**
10:00-11:00	**Tutorial 1:** Robotics and artificial intelligence technologies in science and society Invited Speaker: Andrey Ronzhin https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
11:00-12:00	**Tutorial 2:** Evolutionary Machine Learning for Control System Synthesis in Robotics Invited Speaker: Elizaveta Shmalko https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
12:00-13:00	**Coffee Break and Exibition**
13:00-14:00	**Tutorial 3:** Sliding Mode Control in 21st Century Invited Speaker: Leonid Fridman https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
14:00-15:00	**Tutorial 4:** FESTO Robotics: Purpose and Workforce Development towards Industry 4.0. Invited Speaker: Eduardo García https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
Tuesday, October 15, 2024	
09:00-10:00	**Registration (for on-site participants)**
10:00-11:00	**Tutorial 5:** Human-Robots Biointerface Invited Speaker: Roman Meshcheryakov https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
11:00-12:00	**Tutorial 6:** Autonomous Control Systems for Ground and Aerial Unmanned Vehicles Using Ergonomic Graphical Interfaces Invited Speaker: Anton Saveliev https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
12:00-13:00	**Coffee Break and Exibition**
13:00-14:00	**Tutorial 7:** Using Hidden Markov Models in Robotics Invited Speaker: Jesus Savage https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
14:00-15:00	**Tutorial 8:** Image analysis: Artificial Neural Networks: Basics and why they are so powerfull Invited Speaker: Humberto Sossa https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09
Wednesday, October 16, 2024	
08:00-10:00	**Online Oral Session 1:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Dmitry Dobrynin, Rinat Galin
09:00-10:00	**Registration (for on-site participants)**
10:00-10:30	**Opening Ceremony:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Jesus Savage

10:30-12:00	**Plenary Session 1:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Andrey Ronzhin
12:00-12:15	**On-line Joint Photography of Conference Participants**
12:15-13:00	**Coffee Break and Exibition**
13:00-15:00	**Oral Session 2:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Marco Negrete, Alejandro Velazquez
Thursday, October 17, 2024	
08:00-10:00	**Online Oral Session 3:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chairs: Anton Saveliev, Evgeni Magid
10:00-11:30	**Plenary Session 2:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Roman Meshcheryakov
11:30-12:15	**Oral Session 4:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Konstantin Yakovlev, Oleg Darintsev
12:15-12:30	**Closing Ceremony**
12:30-13:00	**Coffee Break and Exibition**
13:00-15:00	**Round Table: The Future of Robotics.** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Roman Meshcheryakov
15:00-16:00	**Exibition**
Friday, October 18, 2024	
10:00-18:00	**Social event**

The time of the video conference is specified in the time zone of Mexico City, Mexico (UTC - 6): https://www.worldtimebuddy.com/utc-to-mexico-mexico-city.

Conference Programme

Wednesday, October 16, 2024	
08:00-10:00	**Online Oral Session 1:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Dmitry Dobrynin, Rinat Galin
	Denis Bordyugov, Evgeniy Briskin, and Nikolay Sharonov. Mathematical Model and Design of the Mobile Robot with Propellers which Working on the Periodic Jamming Effect
	Zalimhan Nagoev, Kantemir Bzhikhatlov, Inna Pshenokova, and Alim Unagasov. Algorithms and Software for Simulation of Intelligent Systems of Autonomous Robots Based on Multi-Agent Neurocognitive Architectures
	Anna Klimenko and Arseniy Barinov. A Technique of Distributed Missions Assignment Problem Solving in Heterogeneous Groups of Aerial Rescue Robots
	Dmitry Dobrynin. About one Way to Scan a Surface for a Home Walking Robot
	Dmitry Dobrynin and Yulia Zhiteneva. Overcoming Obstacles with a Home Walking Robot
	Ildar Nasibullayev and Oleg Darintsev. Algorithms for Planning Trajectory of a Modular Wheeled In-pipe Robot
	Rinat Galin, Roman Meshcheryakov, Yaroslav Turovsky, and Saniya Galina. Mutual Adaptation Model of Operator and Controlled Object in Ergatic Robotic System
	Elizaveta Shmalko and Vladimir Serebrenny. Optimal Control Problems in Collaborative Multi-Agent Robotic Systems
09:00-10:00	**Registration (for on-site participants)**
10:00-10:30	**Opening Ceremony:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Jesus Savage
10:30-12:00	**Plenary Session 1:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Andrey Ronzhin
	Simon Boes, Maria-Elena Algorri, and Hartmut Köhn. Camera-based Navigation: Convolutional Neural Networks vs Rule-based Approaches
	Erik Francisco-Agutín, Gustavo Rodriguez-Gomez, and José Martinez-Carranza. Tracking of Mobile Objects with an UAV and a DNN Controller
	Elena Rubleva, Konstantin Mironov, and Aleksandr Panov. Stabilizing Manipulator Trajectory via Collision-Aware Optimization
12:00-12:15	**Joint Photography of Conference Participants**
12:15-13:00	**Coffee Break and Exibition**

13:00-15:00	**Oral Session 2:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Marco Negrete, Alejandro Velazquez
	Maksim Mustafin, Tatyana Tsoy, Yang Bai, Mikhail Svinin, and Elvira Chebotareva. Augmented Reality Interface for UR5e Robot that Transfers Parts to a Human in Collaborative Assembly
	Lisandro Vazquez-Aguilar and Veronica E. Arriola-Rios. Prediction of Deformations on Elastic Objects Using an LSTM Model
	Aidar Zagirov, Elvira Chebotareva, Sergey Osokin, Hongbing Li, and Evgeni Magid. User Perception and Evaluation of a Portrait Drawn by KUKA KR3 AGILUS Manipulator
	Olga Kozachek, Nikolay Nikolaev, Olga Slita, and Alexey Bobtsov. Parameter Identification Algorithm for a LTV System with Partially Unknown State Matrix
	Le Duc Tiep, Pham Tuan Thanh, Luong Thi Thanh Ha, and Nguyen Van Trong. Improve Working Performance and Adjust Asynchronous Motor Speed in Robot Actuators with an H-bridge Inverter
	Tran Van Tuyên, Tran Xuan Tinh, and Konstantin Krestovnikov. Adaptive Fast Terminal Sliding Mode (FTSM) Control and High Gain Observer (HGO) for Multi-Motor Web Transport Systems
	Oleg Sumenkov, Taisia Medvedeva, Sergei Gusev, and Leonid Fridman. Super-Twisting Algorithm Gain Adjustment Strategy for Manipulator Position Control
	Verónica E. Arriola-Ríos, Ricardo César Arzate Trujillo, Jesús Alejandro Franco Piña, Alejandro Maldonado Vázquez, Francisco Emanuel del Moral Morales, Rodrigo Liprandi Cortes, and Karina Vianey Prado Oropeza. Robo-surveillance of a Solar Park for a Workshop in Interdisciplinary Education
15:00-16:00	**Exibition**
Thursday, October 17, 2024	
08:00-10:00	**Online Oral Session 3:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chairs: Anton Saveliev, Evgeni Magid
	Vladimir Filaretov, Aleksandr Zuev, and Aleksandr Timoshenko. Development of a Dynamic Model of an Underwater Manipulator in Identification Form
	Otari Didmanidze, Maria Karelina, Vladimir Filatov, Dmitriy Rybakov, Nikita Andriyanov, Sergey Korchagin, Yuliya Kafiyatullina, and Denis Serdechnyy. Development of a Computer Vision System for an Optical Sorting Robot
	Kirill Kasmynin and Konstantin Mironov. Vectorized Visibility Graph Planning with Neural Polygon Extraction
	Artem Egorov, Marina Astapova, and Mikhail Uzdiaev. Method for Maximizing the Number of Detected Keypoints on Homogeneous Under-lying Surfaces
	Niyaz Imamov, Bulat Abbyasov, Tatyana Tsoy, Edgar A. Martínez-García, and Evgeni Magid. Evaluation of a Weather Plugin in Gazebo: A Case-Study of a Wind Influence on PX4-based UAV Performance
	Anton Saveliev, Dmitry Anikin, Andrey Ronzhin, Gennady Erokhin, and Vadim Agafonov. System for Placing Seismic Sensors Based on Actions of UAVs Group with Optimized Flight Plan
	Konstantin Krestovnikov. Aerial Manipulation System for Automated Installation Seismic Activity Sensors

	Azad Bayramov, Samir Suleymanov, and Fatali Abdullaev. The Robotic Control System of UAV Based on Artificial Intelligence Technologies
10:00-11:30	**Plenary Session 2:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Roman Meshcheryakov
	Oleg Stepanov, Yulia Litvinenko, and Alexey Isaev. Recursive Estimation Algorithms for AUV Collaborative Navigation in Case of Ab-normal Outliers in Measurements
	Stepan Dergachev and Konstantin Yakovlev. Decentralized Unlabeled Multi-Agent Navigation in Continuous Space
	José Martinez-Carranza. Robotics Drones
11:30-12:15	**Oral Session 4:** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Konstantin Yakovlev, Oleg Darintsev
	Kirill Muravyev and Konstantin Yakovlev. NavTopo: Leveraging Topological Maps for Autonomous Navigation of a Mobile Robot
	Oleg Darintsev and Airat Migranov. Integration of Ant Colony Algorithm and Neural Networks for Task Management and Allocation in Groups of Mobile Robots
	Le Van Nghia, Tran Van Tuyen, and Andrey Ronzhin. Fish Image Classification Based on MobileNetV2 with Transfer Learning Technique for Robotic Application in Aquaculture
12:15-12:30	**Closing Ceremony**
12:30-13:00	**Coffee Break and Exibition**
13:00-15:00	**Round Table: The Future of Robotics.** https://us06web.zoom.us/j/83782678933?pwd=SE9EUlhxdnpsbWVENEJ2aEhrWXJDdz09 Chair: Andrey Ronzhin, Jesus Savage, Roman Meshcheryakov, Tofig Babaev
15:00-16:00	**Exibition**
Friday, October 18, 2024	
10:00-18:00	**Social event**

Abstracts

Tutorials

Tutorial 1: Robotics and Artificial Intelligence Technologies in Science and Society.
Invited Speaker: Prof. Andrey Ronzhin, Director of St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS).
Abstract: A distinctive feature of an intelligent robotic system is the ability to move and function in a non-deterministic environment. To implement this characteristic, it is necessary to develop all on-board systems of the robot: sensory, computing, executive, energy, based on artificial intelligence technologies. Also, when designing a robot, the operating environment and intended purpose should be taken into account. The tutorial discusses the problems of positioning and navigation of water, land and air robots, and considers ways to overcome them. Integrating information from several sensors of various types or robots increases the accuracy and reliability of their positioning, allowing you to avoid collisions and collisions on routes. The functioning of a group of robots and their interaction with each other makes it possible to solve larger-scale problems based on the synergistic effect and combination of their sensory, computing, and energy resources. With the development of unmanned vehicles and the intellectualization of robotic devices, the issue of human-machine interaction remains relevant. Here two main tasks should be considered: remote control of the robot by the operator and interaction of the robot with an untrained user based on natural methods of communication. During the tutorial, key research of the St. Petersburg Federal Research Center of the Russian Academy of Sciences in the field of robotics, human-machine interaction, digital transformation of agriculture and environmental management are presented.

Tutorial 2: Evolutionary Machine Learning for Control System Synthesis in Robotics.
Invited Speaker: Dr. Elizaveta Shmalko, Senior Researcher in the Federal Research Center Computer Science and Control of the Russian Academy of Sciences
Abstract: Machine learning today makes it possible to automate many processes, from programming to writing songs or paintings. In these areas neural-network-based methods are most popular, trained on very large amounts of sample data. However, there are areas of research where there is little or no training data. Such areas include control engineering.
The optimal control synthesis is the most general problem in control system engineering and at the same time the most difficult one. It is solved for various purposes, like to ensure stability of the control object at a certain point in the state space, or to track a given

	trajectory by the object to achieve a control goal with a given quality criterion and so on. The development of control laws using machine learning methods has formed a distinct field of research of machine learning control (MLC). Most works use the so-called parametric approach, when the structure of the control system is specified, for example, in the form of a PID controller, or even a neural network controller, and then, using machine learning methods, the quasi-optimal parameters of the given controller are adjusted. However, with such parametric approach, the class of functions describing the feedback control system is limited. Today, modern numerical methods of evolutionary machine learning based on symbolic regression make it possible to automatically search for both the optimal structure of a multidimensional function that describes the desired control system and its parameters in accordance with a given quality criterion. The tutorial starts with the formal statement of the control synthesis problem as MLC, considers several genetic programming (GP)-based methods of symbolic regression, their encoding procedures and optimization algorithms, and several applied control engineering problems in mobile robotics are shown and the directions for future research are discussed.
	Tutorial 3: Sliding Mode Control in 21st Century. **Invited Speaker:** Prof. Leonid Fridman, Professor of Department of Control Engineering and Robotics, Division of Electrical Engineering of Engineering Faculty, UNAM. **Abstract:** Sliding mode controllers (SMC) are one of most popular classes of robust controllers used in robotics. The history and evolution of sliding control will be revisited. The precision of the SMC will be discussed. The methods for adjustment of chattering and energy consumption for different classes of SMC will be observed. The simple proportional-integral (PI) and proportional-integral-derivative (PID) controllers like tuning rules for SMC design. Videos with the experimental illustration of the properties of the main sliding mode algorithms are presented.
	**Tutorial 4:** FESTO Robotics: Purpose and Workforce Development towards Industry 4.0. **Invited Speaker:** Dr. Eduardo García, Didactic Coordinator Center Zone & NKAM Festo-LabVolt **Abstract:** With Industry 4.0, humans and technology are getting even closer together. Since the beginning of the 21st century, as Asimov has imagined, humans and robots are increasingly closer, sharing tasks, and jobs: robotics are now interacting with humans in safer spaces using intelligent sensor technology. Due to this increasing sensorics and intelligent algorithms, these machines represent an ever-decreasing risk when dealing with humans and furthermore help them with their daily work by relieving them of heavy tasks, for example in the assembly process. Of course, the purpose of robots must be justified to add value beyond a “playful experiment".

	Technology is becoming more intelligent and more adaptive and is increasingly able to adjust itself to changing conditions and to human intervention at any time. We will not have fully automated processes everywhere. Instead, there will be variable processes, and this is where the ability of humans to communicate directly with technology is called on. That means technology must understand humans, whilst humans must understand the technology and do so intuitively: develop the industry workforce to face the challenges to integrate and share processes with robotics must be a main strategy for the organizations. Industry Workforce has to learn to use effectively simulation software, to apply programming skills, integrate mobile devices to access customized information and in this way, they will be sensitized to the production facilities' important key variables for predictive maintenance or monitor energy consumption. Learning robotics is a path to foster the Industry 4.0.
	**Tutorial 5:** Human-Robots Biointerface. **Invited Speaker:** Prof. Roman Meshcheryakov, Head of Laboratory of Cyber-Physical Systems, V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences. **Abstract:** Human-robot interaction has a long history with various types and methods of communication. The development of communication methods goes from the simplest signals to advanced technologies of mutual group communication. The tutorial will present a retrospective and the current state of human-robotic interfaces. Biointerfaces using ocolus, EEG, ECG, respiration and other sensors are shown. The use of tactile, temperature and proprioceptive feedback robot-human allows to improve interaction. Of interest is the creation of robots that imitate the user's activity and are combined into a hybrid artificial intelligence.
	**Tutorial 6:** Autonomous Control Systems for Ground and Aerial Unmanned Vehicles Using Ergonomic Graphical Interfaces. **Invited Speaker:** Dr. Anton Saveliev, Head of Laboratory of autonomous robotic systems, SPC RAS. **Abstract:** To date, human-machine interaction and autonomous control systems for robotic devices continue to develop actively. However, there are still many problems related to how a robotic device should function under various external influences. Such processes are complicated by the target tasks themselves, which the robotic tool is focused on at a given time. Each target task, be it agriculture, terrain monitoring, cargo delivery, etc., is achieved through a set of sensors and actuating mechanisms available to the robotic tool. Sensory and executive mechanisms are connected by both energy resources and information systems, which together serve to achieve the set goal. To ensure operational control, the user of a robotic device should receive only the information in the graphical interface that allows him to draw a conclusion about critical external influences or internal changes that have occurred in the robot. Such ergonomic interfaces make it possible to reduce data

	flows between the user and the robot, as well as focus on tasks that cannot be solved by the robot independently in offline mode. During the tutorial, key results of research of Laboratory of autonomous robotic systems of SPC RAS and several demostrations of control for ground and aerial unmanned vehicles are presented.
	**Tutorial 7:** Using Hidden Markov Models in Robotics. **Invited Speaker:** Prof. Jesus Savage, Head of BioRobotics Laboratory, Division of Electrical Engineering of Engineering Faculty, UNAM. **Abstract:** In this tutorial the use of discrete Hidden Markov Models (HMMs) for the image classification task is presented. By fragmenting an image into sections, it's feasible to obtain vectors which represent visual features locally, but globally they can represent an image conditioning a spatial sequence. Using clustering techniques, it is possible to obtain an alphabet from vectors and then symbol sequences are constructed to obtain a statistical model that represents a class of images. Using HMMs for image classification uses less computational resources than Convolutional Neural Networks (CNNs), obtaining competitive results with respect to fine tuned CNNs, but using significantly less computing resources. This is of interest in the development of mobile robots with computers with limited battery life, but requiring the ability to detect and add new objects to their classification systems.
	**Tutorial 8:** Image analysis: Artificial Neural Networks: Basics and why they are so powerfull. **Invited Speaker:** Dr. Humberto Sossa, Head of Robotics and Mechatronics Laboratory of the Computing, Research Center of the National Polytechnic Institute. **Abstract:** Artificial neural networks (ANN) are nowadays tools used for providing very efficient solutions to many problems in areas as diverse as health, water, environment, security, education, and so on. In this tutorial, we first provide an introduction, where we talk about the biological brain from which ANNs emerge. We then present a set of related concepts to the field of artificial neural networks. These concepts are necessary to follow the presentation of this tutorial. Hereafter, we expose the main theme of this tutorial, why artificial neural networks are a powerful tool for solving different problems. In short, at the end of the tutorial, we present our conclusions and our work in progress in this field of artificial intelligence (AI).

Plenary Session 1

Simon Boes, Maria-Elena Algorri, and Hartmut Köhn, TH-Köln – University of Applied Sciences, Gummersbach, Germany.

Lecture Title: Camera-based Navigation: Convolutional Neural Networks vs Rule-based Approaches

Abstract: We compare the performance of rule-based image processing algorithms for autonomous navigation with that of a Convolutional Neural Network approach based on an Nvidia CNN architecture. We detail our implementation of Hough-Transform-based and pixel-based navigation algorithms and discuss their advantages and disadvantages, including a quantitative comparison of their navigation performance in terms of speed, stability and reliability. We describe how rule-based algorithms can be used to train Convolutional Neural Networks that result in enhanced navigation with high speed, stability and reliability. We discuss the advantages of training Convolutional Neural Networks with binary images instead of colour images and the resulting enhanced performance. We present our experiments on autonomous navigation with model cars racing on unknown tracks using the different algorithms and conclude with some recommendations for the use of each algorithm.

Erik Francisco-Agutín, Gustavo Rodriguez-Gomez, and José Martinez-Carranza, Instituto Nacional de Astrofísica, Óptica y Electrónica, Puebla, Mexico

Lecture Title: Tracking of Mobile Objects with an UAV and a DNN Controller

Abstract: The success of the Ingenuity helicopter mission on Mars underscores the growing need for autonomous navigation technologies in Unmanned Aerial Vehicles (UAVs). However, detecting and tracking moving objects with unknown dynamics remains a challenge in planetary exploration. Current optimal control algorithms outperform classical controllers but struggle to generate control signals within the required operating time, leading to high computational costs. We propose a Deep Neural Network (DNN) architecture pre-trained with Model Predictive Control (MPC) for horizontal motion control, coupled with a Proportional-Integral-Derivative (PID) controller for the altitude and orientation of a UAV for mobile target tracking. This hybrid approach reduces computational costs, significantly improves the speed of control signal generation, and maintains performance similar to MPC even in scenarios where it was not trained on. In these cases, when the target vehicle increased its speed, the neural controller was able to follow it without the vehicle escaping the field of view. Control commands are computed from the estimated trajectory using visual information from RGB images and UAV states. Testing is conducted in Gazebo with the Parrot Bebop 2.0 and Husky Robot.

Elena Rubleva, Moscow Institute of Physics and Technology, Dolgoprudny, Moscow, Russia.
Konstantin Mironov, Moscow Institute of Physics and Technology, Dolgoprudny; AIRI Artificial Intelligence Research Institute, Moscow, Russia.
Aleksandr Panov, Moscow Institute of Physics and Technology, Dolgoprudny; AIRI Artificial Intelligence Research Institute; Federal Research Center "Computer Sciences and Control", Moscow, Russia.
Lecture Title: Stabilizing Manipulator Trajectory via Collision-Aware Optimization
Abstract: In this work, we develop an optimization-based solution for a manipulation planning among obstacles. This task is particularly challenging for collaborative manipulators when the operations include movements through the singular configurations. Trajectory optimization for this case requires a collision model, which allows converging to a valid solution from an invalid initial guess. By improving the initial trajectory approximation and optimizing collisions with advanced obstacle representation, it significantly enhances trajectory planning accuracy and efficiency. In our work, we propose a method based on the combining of obstacles. We use Octomap as the baseline (obstacles are represented as a set of cubes). This creates the need to calculate each cube when calculating the trajectory. Enlarging cubes to parallelepipeds allows one to obtain a collision-free trajectory faster. We have conducted a set of experiments with Octomap and with the representation of obstacles in the form of enlarged cubes. Experiments have shown that enlarging cubes to parallelepipeds reduces planning time and increases the success rate.

Plenary Session 2

Oleg Stepanov, Yulia Litvinenko, and Alexey Isaev, ITMO University; Concern CSRI Elektropribor, JSC, St. Petersburg, Russia.
Lecture Title: Recursive Estimation Algorithms for AUV Collaborative Navigation in Case of Abnormal Outliers in Measurements
Abstract: The problem of navigation for multiple autonomous unmanned underwater vehicles is considered, when information about the distances between the vehicles within the group is used as measurements. Two cases are discussed: in the first case, distance measurement errors have a normal distribution, while in the second case they contain abnormal outliers. Three algorithms within the stochastic Bayesian approach have been design to solve the problem: the well-known extended Kalman filter and the recently developed correntropy extended Kalman filter. The third algorithm is a modification of the extended Kalman filter. To construct it, a special procedure described in this paper was used, which aims to reject abnormal outliers in the errors of measuring the distance between underwater vehicles. This procedure is based on comparing the filter residual with the calculated value of the corresponding

	diagonal elements of the covariance matrix of measurement prediction errors. Their interrelations and differences for all three algorithms are analyzed. By conducting predictive simulation using the method of statistical tests, their accuracy, consistency, and computational complexity were compared. For this purpose, the methodology published earlier by the authors of the paper was used. The results of a comparative analysis of the algorithms were obtained both in the absence and presence of outliers in distance measurement errors.
	**Stepan Dergachev and Konstantin Yakovlev**, HSE University; Federal Research Center for Computer Science and Control of Russian Academy of Sciences, Moscow, Russia. **Lecture Title:** Decentralized Unlabeled Multi-Agent Navigation in Continuous Space **Abstract:** In this work, we study the problem where a group of mobile agents needs to reach a set of goal locations, but it does not matter which agent reaches a specific goal. Unlike most of the existing works on this topic that typically assume the existence of the centralized planner (or controller) and limit the agents' moves to a predefined graph of locations and transitions between them, in this work we focus on the decentralized scenarios, when each agent acts individually relying only on local observations/communications and is free to move in arbitrary direction at any time. Our iterative approach involves agents individually selecting goals, exchanging them, planning paths, and at each time step choose actions that balance between progressing along the paths and avoiding collisions. The proposed method is shown to be complete under specific assumptions on how agents progress towards their current goals, and our empirical evaluation demonstrates its superiority over a baseline decentralized navigation approach in success rate (i.e. is able to solve more problem instances under a given time limit) and a comparison with the centralized TSWAP algorithm reveals its efficiency in minimizing trajectory lengths for mission accomplishment.
	**José Martinez-Carranza**, Instituto Nacional de Astrofisica Optica y Electronica, Puebla City, Mexico **Lecture Title:** Robotics Drones **Abstract:** Drones have become indispensable in a range of civilian applications, including surveillance, monitoring, and critical infrastructure inspection. However, many of these tasks still rely on human pilots and expertise to interpret sensor data. This dependence highlights the potential for AI to enhance drone autonomy, transforming them into intelligent aerial robots. This keynote will explore various examples of projects developed in my research group on AI-enhanced autonomous drones. These include utilising visual Simultaneous Localisation and Mapping (SLAM) for autonomous flight, and generative AI for recognising previously unvisited locations, the latter particularly relevant for applications such as parcel delivery by drones.

Online Oral Session 1

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

Lecture Title: Mathematical Model and Design of the Mobile Robot with Propellers which Working on the Periodic Jamming Effect

Abstract: We consider a robot moving along a horizontally or inclined located rod. The potential use of the robot is possible for moving along extended rod structures (pipes, ropes, power lines). The design includes two bushings, one of which, due to frictional forces as a result of jamming, wraps around the rod and is held on it, while the other one moves freely. When mobile robot moving along a horizontally located rod occurs design adds two servo drives and additional weights which servo drives turns, under the action of the weight and the friction force between the supporting element and the guide the bushing jams, while the other is able to move freely along it. When moving along an inclined guide there is no need for additional weights, the engagement with the supporting surface is due to friction forces and the force acting from the linear actuator. The principle of operation of the propeller is based on the effect of periodic jamming. A mathematical model has been developed. Obtained dependencies which are necessary to determine the robot design features. A 3d model of a mobile robot with propulsion devices operating on the effect of periodic jamming has been developed, on it basis has been assembled the test stand.

Zalimhan Nagoev, Kantemir Bzhikhatlov, Inna Pshenokova, and Alim Unagasov, The Federal State Institution of Science Federal Scientific Center Kabardino-Balkarian Scientific Center of Russian Academy of Sciences, Nalchik, Russia.

Lecture Title: Algorithms and Software for Simulation of Intelligent Systems of Autonomous Robots Based on Multi-Agent Neurocognitive Architectures

Abstract: The work presents an approach to the design of intellectual decision-making systems of autonomous robots, which consists in the synthesis of cognitive architectures and multi-agent systems. As a cognitive architecture, architecture is used, the nodes of which are multi-agent systems. This approach is based on the computing abstraction of the processes of multi-agent exchange of information between the neurons of the brain, in which individual neurons of the brain are considered as rational software agents that perform cooperative interaction with each other in order to maximize their local target functions. A simulation model of a decision-making system has been developed. The software implementation of the process of interaction between agents is presented within the framework of a multi-agent neurocognitive decision-making model. The algorithm and a program for modelling multi-agent neurocognitive architectures have been developed. Such architectures, through the collaboration of agents, can provide the search for suboptimal solutions under conditions of partial uncertainty. The developed software can be used to simulate the

	decision-making process for performing tasks in a real environment. In particular, the presented formalism of multi-agent neurocognitive artificial intelligence systems is experimentally used to ensure goal-directed behavior of autonomous mobile robots.
	**Anna Klimenko**, Institute of IT and Security technologies of Russian State University for Humanities, Moscow, Russia. **Arseniy Barinov**, V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia. **Lecture Title:** A Technique of Distributed Missions Assignment Problem Solving in Heterogeneous Groups of Aerial Rescue Robots **Abstract:** This research considers a problem of distributed missions assignment in the heterogeneous group of aerial rescue robots, which function without obstacles on plain landscape. A new technique of distributed missions assignment problem solving is proposed, based on the metaheuristic optimization algorithms independent runs, which are launched on robots in a distributed manner. The novelty of the technique is that metaheuristics instances with varying computational complexities are formed and distributed through the heterogeneous robotic group with the usage of efficient algorithms for the block size forming and assignment. Computational complexities of metaheuristics instances are formed with two contradictory criteria: the first one is the minimization of the makespan of the missions assignment problem solving via independent runs, the second one is the metaheuristic instance maximization because of the solution quality degrading in case of small number of algorithm iterations. This improves the makespan of distributed missions assignment problem solving significantly without considerable degrading of the overall missions assignment result. Selected simulation results demonstrate the improvement of overall mission assignment time up to 2 times with the mission assignment solution degrading less than 26% in the worst case and without degrading in the best case.
	**Dmitry Dobrynin**, Federal Research Center for Computer Science and Control RAS, Moscow, Russia. **Lecture Title:** About one Way to Scan a Surface for a Home Walking Robot **Abstract:** The paper discusses the principles of building a home quadruped robot's vision system for stepping over obstacles and walking up stairs. The vision system measures the distance to the support surface at the places where the robot's legs may be positioned. The proposed system is based on the use of several TOF sensors to measure the distance to possible reference zones. A surface scanning model is presented to determine the reference areas. The issues of the influence of surface properties on the measurement results are considered. The influence of the instability of the sensor tilt angles and its width of the radiation pattern on the measurement accuracy is analyzed. It is shown that the use of sensors with a small angle of inclination makes it possible to measure the parameters of horizontal surfaces with sufficient accuracy. Conclusions are drawn and recommendations are given

	to improve the accuracy of measurements. The test on the simulator showed a good match of the measured profile of the stage with the theoretical results. The proposed scanning method allows to reduce the cost of the control system, reduce the requirements for computing power and increase the battery life of the home robot.
	**Dmitry Dobrynin**, Federal Research Center for Computer Science and Control RAS, Moscow, Russia. **Yulia Zhiteneva**, State University of Humanities and Technology, Orekhovo-Zuyevo, Russia **Lecture Title:** Overcoming Obstacles with a Home Walking Robot **Abstract:** The paper considers the principles of building a home walking robot capable of walking on complex surfaces – stairs and ladders. A home walking robot must walk confidently on various flat surfaces and be able to step over small obstacles. To detect obstacles and scan the surface, the robot has a simplified scanning system based on inexpensive TOF sensors for measuring distances. A mathematical model of the robot's legs, which is used to control the drives, is presented. A model of the robot's sensor system is presented, which is used to detect obstacle parameters and build a height map. Two ways of over-coming obstacles are considered – stepping over small obstacles and walking on wide stairs. An estimate of the maximum size of obstacles is given, which are determined by the geometric dimensions of the robot's legs and the parameters of the sensor system. The principles of walking on narrow stairs are formulated. Modeling of the proposed ways to overcome obstacles is performed. The simulation showed acceptable stability of the robot when walking. It is shown that the proposed methods of overcoming obstacles have low computational complexity. This reduces the computing power requirements of the home walking robot control system and increases battery life.
	**Ildar Nasibullayev and Oleg Darintsev**, Mavlyutov Institute of Mechanics UFRC RAS, Ufa, Russia. **Lecture Title:** Algorithms for Planning Trajectory of a Modular Wheeled In-pipe Robot **Abstract:** The 2D and 3D mathematical and computer models of the kinematics of a modular wheeled robot when it moves inside the pipe for inspection of the inner surface are presented in this paper. In the 2D model the transition of the leading module from a linear trajectory to an arc with a constant radius and sub-sequent exit to a straight trajectory is considered. A numerical algorithm for the driven modules motion based on the position of the leading module and the constraint equation is constructed. As the analysis results of the simulation data, the dependence of the deviation between leading and driven modules trajectories versus the radius of the curved section is revealed. The optimal trajectory of the robot movement inside the curved pipe is synthesized in which all modules remain within the safety zone, considering the deviations of the modules from the trajectory of the first one. An analytical 3D model is obtained which allows calculating the following movements: along the helical line trajectory (working mode of pipe

	inspection); dynamic change in the pitch of the helix; transition to movement along the circumference or along the pipe. The deviations of the trajectory of the driven modules from the trajectory of the leading module are analyzed and structural methods of reducing the magnitude of these deviations are proposed. Computer models were coded with the C++ and Python programming languages. The visualization of the modular robot movement was carried out by the 3D modeling software Blender.
	**Rinat Galin, Roman Meshcheryakov, Yaroslav Turovsky, and Saniya Galina**, V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia. **Lecture Title:** Mutual Adaptation Model of Operator and Controlled Object in Ergatic Robotic System **Abstract:** The presented paper deals with the problem of developing a model of mutual adaptation of the operator and the controlled object in an ergative robotic system. The simplest collaborative robotic system is taken as a robotic system, the participants of which are a manipulator type robot and an operator. Mutual adaptation in the control process is considered on the example of a system with service discipline and application of an alternative approach. An example of solving the problem of adapting the service discipline of a mass service system under conditions of unpredictability of the external environment, which inevitably change the optimal setting of the service discipline, is given. The main components of the developed model of the system with adaptive control on the basis of neural network are given. The basic structure of this system is proposed. In this way it will be possible to move to a suboptimal solution in the current situation, extremizing the given criterion of efficiency of system functioning. The paper provides an overview of work in the field of robot control and applications for robotic systems using neural networks.
	**Elizaveta Shmalko**, Federal Research Center "Computer Science and Control" of Russian Academy of Sciences, Moscow, Russia. **Vladimir Serebrenny**, Bauman Moscow State Technical University, Moscow, Russia. **Lecture Title:** Optimal Control Problems in Collaborative Multi-Agent Robotic Systems **Abstract:** The paper considers human-robot collaboration from the control point of view as the joint activity of robots and people in a single multi-agent system to achieve the desired objective with the optimal value of a quality criterion. The paper proposes a mathematical statement of the control problems for such complex plant. In the proposed formulation, the role of a person is described in the form of an additional control vector, with the help of which the influence of phase constraints is reduced in terms of functional minimization. So, the problem statements of the optimal control and the control general synthesis problems for collaborative systems include additional control vector in phase constraints. The problems are formulated for a single collaborative cell and for multi-agent collaborative system. The problem statements for multi-agent

	systems include also dynamic phase constraints to avoid collisions between robots. The problems of collaborative control in the proposed formulations can be solved by modern numerical methods of machine learning control. An example of optimal control problem for two mobile robots with two controlled phase constraints as operational zone for human-operators is presented. The problem is solved using machine synthesized optimal control method.
Oral Session 2	
	**Maksim Mustafin, Tatyana Tsoy, and Elvira Chebotareva**, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russia. **Yang Bai**, Graduated School of Information Science and Technology, Osaka University, Osaka, Japan. **Mikhail Svinin**, College of Information Science and Engineering, Ritsumeikan University, Shiga, Japan. **Lecture Title:** Augmented Reality Interface for UR5e Robot that Transfers Parts to a Human in Collaborative Assembly **Abstract:** Collaborative assembly is one of the most common tasks in collaborative robotics, which requires an efficient, simple and user-friendly way of communication with a collaborative robot. This paper presents an augmented reality (AR) interface for controlling a UR5e robot in order to get assembly parts from a robot's desktop in a collaborative assembly process. This AR interface is based on the concept of a smart mirror that recognizes user's hand gestures as control signals. A goal of the study is to investigate user perception of a contactless interaction method with a collaborative robot UR5e using the proposed AR interface. The conducted experiments involved 15 participants who are not professional operators of robots and industrial manipulators. During the experiments, the participants demonstrated a quick adaptation and an evident interest to working side by side with the UR5e robot using the AR interface. Our results suggest that the developed AR interface is flexible, intuitive for an operator, scalable in terms of development for different cases of production goals and can be recommended for equipping a workcell for collaborative assembly of various products.
	**Lisandro Vazquez-Aguilar and Veronica E. Arriola-Rios**, Department of Mathematics, Faculty of Science, Universidad Nacional Autonoma de Mexico UNAM, Mexico City, Mexico. **Lecture Title:** Prediction of Deformations on Elastic Objects Using an LSTM Model **Abstract:** A volumetric deformable object does not have a fixed representation. Its contour changes as forces are applied on it. The number of distinctive traits like corners or points of high curvature are modified and the level of detail required for its description varies as its shape becomes simple or more intricate. Furthermore, the type of deformation it will undergo varies drastically depending on its material and original shape. For these reasons mobile robots face a challenging problem when on the need of manipulating everyday

	objects like toys, cushions or dishwashing sponges. In this paper we propose a Long short-term memory (LSTM) neural network that learns to predict the deformation of the contour of an elastic object, taking as input the original contour and the sequence of position and force measurements of the robotic finger that interacts with it. Even though the representation of the contour we use is still of fixed length, our model makes reasonable predictions of deformation for interactions it has not seen before for the entire interaction and not only for the next frame as other models in the literature do. Also, since it uses only local information of pieces of the object, we envision that this work can be extended to cover the case of representations of varying length.
	**Aidar Zagirov, Elvira Chebotareva, and Sergey Osokin**, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russia. **Hongbing Li**, Department of Instrument Science and Engineering, Shanghai Jiao Tong University, Shanghai, Minhang, China. **Evgeni Magid**, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russia; Tikhonov Moscow Institute of Electronics and Mathematics, HSE University, Moscow, Russia. **Lecture Title:** User Perception and Evaluation of a Portrait Drawn by KUKA KR3 AGILUS Manipulator **Abstract:** Creating an artistic portrait is considered one of the most complex areas of a generative art. Currently, generative artificial intelligence (AI) has made significant advancements in generating portraits of people based on photographic images. This has opened up new opportunities for utilizing AI achievements in robotic artistry. However, questions related to evaluation and human perception of such works, including their artistic value, remain open. In our work, we present experimental results of integrating the processing of human photographs using the generative model InstantID with a drawing robot and studying users' reactions to the obtained images. In our experiments, we generated graphic portraits of people and constructed their images using KUKA KR3 AGILUS robot. We then asked participants to rate the resulting portraits based on three parameters: similarity/recognition, beauty/aesthetics, and evoked emotions. The results of the experiments can be used in social robotics, including art therapy that involves social robots and human-robot interaction.

	**Olga Kozachek, Nikolay Nikolaev, Olga Slita, and Alexey Bobtsov**, ITMO University, Saint-Petersburg, Russia. **Lecture Title:** Parameter Identification Algorithm for a LTV System with Partially Unknown State Matrix **Abstract:** This work is devoted to the problem of unknown parameters identification for the case when the state of the system is not measured directly and only the input and output signals of the system are known. In this paper an adaptive state observer and parameter identification algorithm for a linear time-varying (LTV) system is developed. The state matrix of the system under consideration contains unknown time-varying parameters of a known form. Every unknown parameter can be described by a second-order dynamical system, generating sinusoidal signal with unknown frequency and initial conditions. The developed algorithm allows to observe the state vector without identification of the unknown parameters using only measured output signal and known input signal. As soon as the state vector estimate is obtained, the parameter identification algorithm is applied to find unknown parameters of the system. The identification algorithm that was proposed in previous papers of the authors is used for this purpose. The system that is considered in the paper is written as general linear time-varying model. Since many nonlinear systems after linearization can be transformed into linear time-varying systems, the proposed algorithm can be applied for different technical objects, such as mobile robots, manipulators, electro-mechanical systems, etc.
	**Le Duc Tiep, Pham Tuan Thanh, Luong Thi Thanh Ha, and Nguyen Van Trong**, Le Quy Don University of Technology, Hanoi, Vietnam. **Lecture Title:** Improve Working Performance and Adjust Asynchronous Motor Speed in Robot Actuators with an H-bridge Inverter **Abstract:** This article proposes a calculation plan to control H-bridge inverter switching based on changing the law of distribution of non-zero voltage states according to the power law ratio, 0 voltage states according to the division law in speed control of the asynchronous motor in H-bridge inverter switching pulse width modulation. The results of this plan are surveyed, analyzed, compared and evaluated using simulation models on the software Matlab-Simulink. The focus is on the speed response ability when controlling a asynchronous motor in different pulse width modulation modes, speed indicators stability and stiffness of the mechanical characteristic curve, time to reach a steady speed state of the engine, and the maximum load torque that the motor can work. These parameters are used to compare, analyze and evaluate the effectiveness of the proposed plan in different switching modes. This has important implications for using asynchronous motors in robot structures. It makes motor control more effective and increases the motor's loadcarrying capacity and mechanical power.

	Additionally, it provides the basis for simplifying the structure in the design of inverter systems and the control configuration for asynchronous motor drive systems.
	**Tran Van Tuyên**, Military Technical Academy of Vietnam, Hanoi, Vietnam. **Tran Xuan Tinh**, Air Defence – Air Force Academy of Vietnam, Hanoi, Vietnam. **Konstantin Krestovnikov**, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia. **Lecture Title:** Adaptive Fast Terminal Sliding Mode (FTSM) Control and High Gain Observer (HGO) for Multi-Motor Web Transport Systems **Abstract:** The research object of the article is the web winding system, which has a complex MIMO structure, has variable parameters and is affected by noise. In reality today, the controllers of this system mainly use linear control methods. However, linear control methods do not always provide the desired quality. Therefore, research, development and application of nonlinear algorithms to improve system quality is essential. A substantial amount of developments in the field of regulators for complex systems with variable parameters has been realized in the field of robotics and manipulation systems. This paper presents the results of synthesizing the adaptive fast terminal sliding controller based on the neural network for the web winding system for elastic material. The survey and evaluation results by simulation on Matlab-Simulink software show that this controller ensures the quality requirements even when the system is affected by random input noise and model parameters change. The application of the developed solutions in robotics will improve the quality of control and increase the efficiency of mechanical systems.
	**Oleg Sumenkov, Taisia Medvedeva, and Sergei Gusev**, Mathematical Robotics Science Division, Sirius University of Science and Technology, Sirius, Russia. **Leonid Fridman**, Mathematical Robotics Science Division, Sirius University of Science and Technology, Sirius, Russia; Facultad de Ingenieria, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico. **Lecture Title:** Super-Twisting Algorithm Gain Adjustment Strategy for Manipulator Position Control **Abstract:** Buildin controllers of industrial manipulators ensure high repeatability of actions even under unknown changes of external payload. Most manipulator manufacturers do not provide access to joint torque control, and only position/velocity control is available in presence of disturbances and system imperfections. Thus, an external control loop design for compensation of system perturbations may enhance the position accuracy of manipulators using encoder feedback. Then, the Super-twisting algorithm (STA) appears as a reasonable choice since it generates continuous control

	signal and provides the theoretically exact compensation for Lipschitz perturbations. However, unmodeled dynamics and signal processing delays existing in the system exhibit chattering that cannot be eliminated. The paper provides the strategy for designing and adjusting external control loop with STA controller to enhance position accuracy. Namely, two-steps Super-twisting algorithm (STA) gains adjustment strategy is proposed. Firstly, it is found that for ABB IRB 1600 the sine mixture signal provides the system response allowing to identify the plant structure as first-order system with time delay. At the second step, Harmonic Balance (HB) method is used to estimate system output oscillation amplitude. Since HB method considers the first harmonic of the periodic motion, Pade approximation of time delay was chosen leading to the HB close-from solution. The proposed STA gain adjustment strategy was tested on simulation and verified through an experiment. Experiments with industrial manipulator ABB IRB 1600 demonstrated the increased position accuracy of the proposed methodology compare to LQR-predictor model and build-in control system.
	**Verónica E. Arriola-Ríos, Ricardo César Arzate Trujillo, Alejandro Maldonado Vázquez, Francisco Emanuel del Moral Morales, Rodrigo Liprandi Cortes, and Karina Vianey Prado Oropeza**, Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico. **Jesús Alejandro Franco Piña**, Escuela Nacional de Estudios Superiores, Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico. **Lecture Title:** Robo-surveillance of a Solar Park for a Workshop in Interdisciplinary Education **Abstract:** The field of intelligent mobile robotics is highly interdisciplinary by nature, spanning interest from mechanical, electric, and electronic engineering to computer science, physics, cognition and neuroscience. Yet, there are few opportunities during undergraduate education to experience work and communication between students from these disciplines. For this reason, we devised a scenario where knowledge from these diverse disciplines could be demonstrated and used for experiments by students during a one-week workshop. This scenario consists of trials with two different robots. The first phase of the trials makes use of a simple differential robot where the basics of electronics, communications over WiFi and Bluetooth networks are taught. The second phase makes use of an omnidirectional robot whose task is to survey a solar park to detect dusty solar panels. Its job is only to navigate through the park detecting the panels and sending one photo of the panel to a nearby workstation. This workstation processes the images captured by the small robots to detect whether the panels in them are clean or dusty, using a U-net neural network. Here we report our experience on the first two editions of this interdisciplinary work-shop.

Online Oral Session 3

Vladimir Filaretov, Institute of Automation and Control Processes FEB RAS, Vladivostok, Russia.
Aleksandr Zuev, Institute of Automation and Control Processes FEB RAS; M.D. Ageev Institute of Marine Technology Problems FEB RAS, Vladivostok, Russia.
Aleksandr Timoshenko, M.D. Ageev Institute of Marine Technology Problems FEB RAS; Far Eastern Federal University, Vladivostok, Russia.
Lecture Title: Development of a Dynamic Model of an Underwater Manipulator in Identification Form
Abstract: The paper proposes a new method for constructing dynamic models of underwater manipulators installed on board autonomous underwater vehicles. These models are designed to identify unknown parameters of the interaction of an underwater manipulator with a viscous medium during its movement. A feature of these models is that unknown parameters, including coefficients of added masses and damping coefficients, are included in the equations of dynamics of the manipulator linearly relative to known kinematic parameters. These coefficients can be determined using classical identification methods such as the least squares method or methods based on the application of the linear Kalman filter. The identified parameters can then be used in adaptive underwater manipulator control systems to implement automatic execution of underwater technological operations. To do this, the identification procedure must be carried out in close proximity to the intended working area of the underwater vehicle with a manipulator, where the desired coefficients can be considered constant. The correctness of the proposed models and the possibility of identifying these coefficients were verified during mathematical simulation of the movement of an underwater vehicle with a manipulator mounted on it at various initial parameters of a viscous medium.

Otari Didmanidze, Maria Karelina, Vladimir Filatov, Dmitriy Rybakov, Nikita Andriyanov, Sergey Korchagin, Yuliya Kafiyatullina, and Denis Serdechnyy, State University of Management, Moscow, Russia.
Lecture Title: Development of a Computer Vision System for an Optical Sorting Robot
Abstract: The use of sorting robots at some stages of agricultural production seems quite promising. In addition to the high-tech design, the most important element of such robots may be a pattern recognition system, which in turn, in addition to optical devices, includes an intelligent decision support system. This paper presents the development of a computer vision system for recognizing suitable samples of grain crops for an optical sorting robot. The aim of the work is to create a reliable and efficient algorithm that can accurately determine the presence and characteristics of damage in images of wheat, oats and peas. Modern machine learning methods, such as convolutional neural networks, were implemented to train the recognition model. The development process included

	collecting and preparing training data, selecting and setting up the neural network architecture, as well as testing and optimizing the algorithm. A comparison of computer vision libraries YOLO, FASTER R-CNN, VISSL, OpenCV was carried out. The resulting system demonstrated high accuracy in recognizing defects and morphological features of seeds in test images, with an accuracy of up to 87%. The developed system can be used in optical sorting robots and various mechatronic applications related to automation of agricultural processes, product quality analysis, robotic phenotyping devices, as well as in seed quality control systems and in intelligent control systems for agricultural production processes in crop production.
	**Kirill Kasmynin**, Moscow Institute of Physics and Technology, Dolgoprudny, Moscow, Russia. **Konstantin Mironov**, AIRI Artificial Intelligence Research Institute, Moscow, Russia; Ufa University of Science and Technology, Ufa, Russia. **Lecture Title:** Vectorized Visibility Graph Planning with Neural Polygon Extraction **Abstract:** This article proposes an approach for path planning in environments with obstacles. The methodology integrates recent neural obstacle polygon extraction with visibility graph path planning, complemented by the integration of vectorization techniques. That significantly enhances path planning efficiency. The modular design of the neural network method, encompassing contour detection, vertex identification, and polygon approximation modules, facilitates improved performance compared to traditional methods. Furthermore, the investigation into vectorization's impact on the intersection operation accelerates algorithm speed, contributing to faster path planning processes. Experimental results validate the efficacy of the integrated approach, showcasing notable improvements in path planning efficiency, especially with the utilization of vectorization techniques. The study systematically addresses challenges such as slow graph construction and inaccurate obstacle detection, providing a robust solution for optimizing path planning processes. Moreover, the implementation of multiple modules in the methodology enables its versatility for testing with various environments. This versatility allows researchers to assess the method's performance across diverse scenarios and visualize the results effectively. Overall, the integrated approach offers a comprehensive solution for optimizing path planning in complex environments, demonstrating its potential to stream-line path planning processes and improve mobile robot navigation.

	**Artem Egorov, Marina Astapova, and Mikhail Uzdiaev**, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences, St. Petersburg, Russia. **Lecture Title:** Method for Maximizing the Number of Detected Keypoints on Homogeneous Underlying Surfaces **Abstract:** The developing area of unmanned aerial vehicle (UAV) applications states an urgent problem of positioning in the case of Global Satellite Positioning System (GNSS) or Gyro-Peak Navigation System (GNS) absence. The widespread visual SLAM positioning algorithms are based on the based on keypoints detetection algoriths that process in most cases RGB images. However, in the case of processing images of homogeneous uderlying surfaces (e.g., forrests, forests, deserts, water spaces, etc.), RGB data could be insufficient in terms of the small number of possible detecting keypoints. In this case, multi-spectral data that contain more electromagnetic radiation wavelengths bands, as well as spectral indices coputed using combinations of spectral bands could be essential for effective processing of homogenous areas of the underlying surfaces in terms of keypoints detection. This paper is devoted to developing a novel method of search for a combination of spectral channels that provides the maximum number of detecting keypoints using pretrained DARKFEAT deep neural network on the image og homogeneous underlying surface. The results of the experiments have shown that the number of detected keypoints on average increased 1.44 times in the calculated index images compared to RGB images and, in turn, resulted in an average 1.592-fold increase in the number of keypoint matches in the current and previous images.
	**Niyaz Imamov and Tatyana Tsoy**, Laboratory of Intelligent Robotic Systems, Intelligent Robotics Department, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russia. **Bulat Abbyasov**, Tikhonov Moscow Institute of Electronics and Mathematics, HSE University, Moscow, Russia. **Edgar A. Martínez-García**, Institute of Engineering and Technology, Department of Industrial Engineering and Manufac-turing, Autonomous University of Ciudad Juarez, Chihuahua, Cd Juárez, Mexico. **Evgeni Magid**, Laboratory of Intelligent Robotic Systems, Intelligent Robotics Department, Institute of Information Technology and Intelligent Systems, Kazan Federal University, Kazan, Russia; Institute of Engineering and Technology, Department of Industrial Engineering and Manufac-turing, Autonomous University of Ciudad Juarez, Chihuahua, Cd Juárez, Mexico. **Lecture Title:** Evaluation of a Weather Plugin in Gazebo: A Case-Study of a Wind Influence on PX4-based UAV Performance

	Abstract: Unmanned aerial vehicles (UAVs) are utilized in a wide range of real-world applications including search and rescue missions, 3D mapping, building inspection and reconstruction. In a real-world environment, severe weather conditions significantly impact UAV operations. Wind is one of the most dangerous weather factors that can destabilize and even destroy a UAV. Preparing UAV flight algorithms for real-world conditions in order to minimize risks of damage and malfunctioning is a crucial part of a UAV system development. This paper analyses a wind influence on UAV virtual model performance with-in the Gazebo simulator. The paper focuses on gazebo_wind_plugin package used for creating a windy virtual environment. PX4-LIRS package is used for simulating a UAV within the Gazebo. Three types of experiments were run to evaluate capabilities of the plugin to simulate typical issues that arise in real-world scenarios: a UAV wind resistance, a wind effect on a UAV tilt angle and on a flight velocity. Virtual experiments demonstrated that gazebo_wind_plugin could serve for PX4 UAV flight scenarios modeling in Gazebo simulation with a satisfactory level of realism.
	**Anton Saveliev, Dmitry Anikin, and Andrey Ronzhin**, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia. **Gennady Erokhin**, Immanuel Kant Baltic Federal University, Kaliningrad, Russia. **Vadim Agafonov**, LLC R-Sensors, Dolgoprudny, Russia. **Lecture Title:** System for Placing Seismic Sensors Based on Actions of UAVs Group with Optimized Flight Plan **Abstract:** A trajectory planning system for a group of unmanned aerial vehicles (UAVs) designed for seismic exploration tasks is proposed. The developed system is capable of efficiently allocating tasks and planning trajectories even considering large state spaces. The system has low computation cost, considers possible failures of UAVs in the group and provides online trajectory replanning in case of possible collisions. Series of experiments were conducted on real UAVs and in the Gazebo simulation environment, which demonstrated the computational efficiency of the system: the time for distributing tasks among UAVs was 0.007 s, and the maximum time for calculating one trajectory was 0.103 s. A comparison of the proposed solution with other methods for 7 UAVs showed that in terms of the total task completion time, the system outperformed the ECBS-TA method by 1% and the PC-TAFF method by 0.05%. In terms of individual mission execution time, the system surpassed the ECBS-TA method in 6 out of 7 UAVs and PC-TAFF in 2 out of 7 UAVs. The conducted tests demonstrated the effectiveness of the developed solution and the feasibility of its use.

	**Konstantin Krestovnikov**, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia. **Lecture Title:** Aerial Manipulation System for Automated Installation Seismic Activity Sensors **Abstract:** The development of unmanned aerial vehicles (UAVs), the improvement of their production technologies and control methods are constantly expanding the range of tasks in which the use of UAVs is relevant and economically feasible. One area in which the use of UAVs can provide significant benefits is the transportation of seismic activity sensors in hard-to-reach or dangerous areas. The work proposes an approach to the automated transportation, installation and collection of seismic activity sensors, which requires precise landing of the UAV. Positioning of the UAV during landing is carried out using technical vision and a fractal ArUco marker. The work describes the development of an original design for a gripper device and a transport fastening for the sensor. The principles of constructing the hardware of the gripper control system and its integration with the design and equipment of the UAV are considered, and the algorithms for the functioning of the gripper control module are described. Experiments were carried out that confirmed the effectiveness and performance of the proposed solutions. The collection of seismic activity sensors from the surface was successful in 80% of cases with deviations from the target landing point of up to 115 mm in the horizontal plane. The advantage of the developed gripper device is its relatively low weight – 1020 g, with the mass of the transported cargo being equal to 2760 g. The proposed kinematic scheme and its implementation using a screw-nut transmission eliminates the energy costs for fixing the transported cargo in flight. The low mass of the gripper and low requirements for the accuracy of positioning of the UAV at the landing point distinguishes the developed solutions from other existing ones and proves their promise in performing the tasks of manipulating and transporting ground objects using unmanned aerial systems.
	**Azad Bayramov**, Institute of Control Systems, Baku, Azerbaijan. **Samir Suleymanov**, Institute of Geology and Geophysics, Baku, Azerbaijan. **Fatali Abdullaev**, Republican Seismic Survey Center, Baku, Azerbaijan. **Lecture Title:** The Robotic Control System of UAV Based on Artificial Intelligence Technologies **Abstract:** The results of developing an algorithm for controlling and navigating an unmanned vehicle using the artificial intelligence method are presented in paper. The remote control in difficult conditions limits the capabilities of the unmanned aerial vehicle and reduces the efficiency of the entire system. In this case, the aircraft can perform tasks depending on the variability of external factors. An algorithm of the control has been developed for using a visual or inertial navigation system to determine the coordinate and time

	characteristics of an unmanned aerial vehicle in the event of non-functioning of the global satellite navigation system. The developed algorithm of the on-board computer itself determines the coordinate-time characteristics of the unmanned aerial vehicle in autonomous flight mode. The proposed algorithm and control architecture are applied to an unmanned aerial vehicle intended to perform a reconnaissance flight. Then, in the paper there have been presented the architecture of control and navigation system based on artificial intelligence for winged UAV, the electrical diagram of the UAV control system, the electrical diagram of the magnetometer, the electrical diagram of the barometer and electrical diagram the driver in UAV.
Oral Session 4	
	**Kirill Muravyev and Konstantin Yakovlev**, Federal Research Center "Computer Science and Control" of Russian Academy of Sciences, Moscow, Russia. **Lecture Title:** NavTopo: Leveraging Topological Maps for Autonomous Navigation of a Mobile Robot **Abstract:** Autonomous navigation of a mobile robot is a challenging task which requires ability of mapping, localization, path planning and path following. Conventional mapping methods build a dense metric map like an occupancy grid, which is affected by odometry error accumulation and consumes a lot of memory and computations in large environments. Another approach to mapping is the usage of topological properties, e.g. adjacency of locations in the environment. Topological maps are less prone to odometry error accumulation and high resources consumption, and also enable fast path planning because of the graph sparsity. Based on this idea, we proposed NavTopo – a full navigation pipeline based on topological map and two-level path planning. The pipeline localizes in the graph by matching neural network descriptors and 2D projections of the input point clouds, which significantly reduces memory consumption compared to metric and topological point cloud-based approaches. We test our approach in three large indoor photo-relaistic simulated environments and compare it to a metric map-based approach based on popular metric mapping method RTAB-MAP. The experimental results show that our topological approach significantly outperforms the metric one in terms of performance with 8 times less memory usage and two orders less path planning time, keeping proper navigational efficiency.
	**Oleg Darintsev**, Mavlyutov Institute of Mechanics URFS RAS, Ufa, Russia. **Airat Migranov**, Ufa University of Science and Technology, Ufa, Russia. **Lecture Title:** Integration of Ant Colony Algorithm and Neural Networks for Task Management and Allocation in Groups of Mobile Robots **Abstract:** This paper addresses the use of intelligent algorithms for task allocation and trajectory planning in groups of mobile robots. Structural schemes and methodologies for management and

	planning have been developed, where the ant colony algorithm is used for generating initial solutions for task distribution and route searching, while a neural network is applied for subsequent optimization and adjustment of robot trajectories in real-time. The overall structural scheme of the management and planning system includes elements such as a task distribution unit among robots, an initial solution generator, a trajectory optimizer, a robot control subsystem, and a monitoring and adjustment unit. Special attention is given to the implementation of the task distribution subsystem (initial solution generator) based on the ant colony algorithm and the movement trajectory optimization block based on a neural network. The initial solution generator is used to find the initial set of routes and task distribution strategies among a group of mobile robots using the ant colony algorithm, which simulates the foraging behavior of ants. The neural network analyzes the formed set of routes for efficiency and safety, adjusting them according to current conditions and new information about obstacles or changes in tasks. Simulation results are presented using a group of mobile robots working in a field with various obstacle configurations. The simulation results conclude the feasibility of using the developed approach in real-world task allocation scenarios in a group of robots.
	**Le Van Nghia and Andrey Ronzhin**, St. Petersburg Federal Research Center of the Russian Academy of Sciences (SPC RAS), St. Petersburg, Russia. **Tran Van Tuyen**, Military Technical Academy of Vietnam, Hanoi, Vietnam. **Lecture Title:** Fish Image Classification Based on MobileNetV2 with Transfer Learning Technique for Robotic Application in Aquaculture **Abstract:** Intelligent aquaculture helps solve the problems of traditional aquaculture by applying smart production methods. The combination of technology and the art of farming has opened the door to the smart seafood industry, where artificial intelligence, IoT and automation systems are effectively applied and are completely changing management. From water quality management to monitoring the health of farm animals, harvesting, and feeding are all done automatically and quickly with high efficiency. Among them, fish classification is an essential task in smart aquaculture. In the field of image classification DCNN has achieved remarkable successes. However, applying DCNN models also requires a large amount of data to train the model and a long training time. Therefore, applying a model based on MobileNetv2 has solved these problems. In this article, the fish image classification method based on MobileNetv2 with Transfer learning is applied. We used the MobileNetV2 network pre-trained by the ImageNet dataset as the base network and added the following layers to the base model and Softmax classifier, this new model is Adam optimized. This method finally achieved a classification accuracy of 98.18% in the test dataset of 330 images of 5 fish types.

Venue and Format of the Conference

9th International Conference on Interactive Collaborative Robotics (ICR 2024) will be held in a hybrid format: face-to-face participation taking place on Auditorio Raúl Marsall, edificio de U de Posgrado e Investigación de la Facultad de Ingeniería, CU, UNAM, Mexico City, Mexico (Av. Universidad 3000, Ciudad Universitaria, Coyoacán, Cd. Mx., CP 04510) and an online video conference. The conference programme with link on video conference is available on the website too: https://icr.nw.ru/2024/.

The official language of the conference is English.

One link for video conference for Tutorials, 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 videoconference is indicated in the time zone of **Mexico / Mexico City time zone (UTC - 6)**.

Contacts

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Web sites: https://icr.nw.ru/2024,
https://biorobotics.fi-p.unam.mx/icr-2024/