12th International Workshop on Robot Motion and Control

RoMoCo '19

8-10 July 2019, Poznań University of Technology,

Poland

Workshop Digest

PATRONAGE – technical co-sponsorship:

Welcome from Workshop General and Program Chairman

It is our pleasure to introduce you to the Technical Program of the Twelfth International Workshop on Robot Motion and Control (RoMoCo'19), Poznań University of Technology, Poznań, Poland, July 8-10, 2019.

This Workshop is the twelfth edition of the series of the RoMoCo Workshops (the previous one were held in 1999, 2001, 2002, 2004, 2005, 2007, 2009, 2011, 2013, 2015 and 2017). It is an internationally recognized event, technically co-sponsored by the IEEE Robotics and Automation Society, Polish Chapter IEEE Robotics and Automation Society, IEEE Polish Section, IEEE Control Systems Society, and the Polish Society for Measurement, Automatic Control and Robotics (POLSPAR), Polish NMO of IFAC. The Workshop is organized under the auspices of the Institute of Automation and Robotics of the Poznań University of Technology, Poland.

Interest in robot motion and control has remarkably increased over recent years. Novel solutions of complex mechanical systems such as industrial robots, mobile robots, walking robots, multi agent systems, SLAM systems and their applications are the evidence of significant progress in the area of robotics. In this year's edition control of autonomous vehicles, control and motion planning of walking robots, control of underwater and aerial vehicles, motion planning and control of nonholonomic systems, control and identification of robot manipulators, collision avoidance of autonomous vehicles, space robotics, force control, and robotic applications seem to be the research ideas of most interest to the robotics community. We strongly believe that RoMoCo Workshop brings new ideas in control technologies and path planning algorithms that are currently used in research laboratories and in industrial applications. The main objective of RoMoCo Workshops is to present the most recent results concerning robot motion and control to the robotics community.

42 original works have been selected for oral presentation at the Twelfth International Workshop on Robot Motion and Control. Accepted contributed papers and plenary papers are from 19 countries all over the world. In average each paper has got three reviews and based on the comments all of the accepted papers were corrected and finally will appear in the IEEE Xplore. This year we are also establishing a Young Author Award that will honor an excellent paper presented at the Workshop, which is distinguished by its originality, importance of the topic and quality of presentation. Selection of the award winner is based on the reviews of the paper, comprising both the content and its delivery during Workshop.

We are very grateful to the five invited distinguished plenary speakers this year:

- Professor Eduardo Bayro-Corrochano from CINVESTAV, Campus Guadalajara, Department of Electrical Engineering and Computer Science, Intelligent Control Systems Laboratory, Jalisco, México
- Professor Konstantinos J. Kyriakopoulos from Control Systems Laboratory Mechanical Engineering Dept. National Technical University of Athens, Greece,
- Professor François Chaumette from IRISA, Inria Rennes-Bretagne Atlantique, Campus de Beaulieu, Rennes, France
- Professor Bruno Siciliano from PRISMA Lab, Dipartimento di Ingegneria Elettrica e Tecnologie dell'Informazione, Università degli Studi di Napoli, Italy

We would like to express my thanks to all reviewers who did very hard work in evaluating all papers. We strongly appreciate their help and patience in communicating with me through the ras.papercept.net system.

RoMoCo'19 is a forum where the state–of–the–art, the latest developments relating for robot motion and control are presented and discussed by Ph.D. students of robotics and automation, informatics, mechatronics and production engineering systems. It will also be of interest to well experienced scientists and researchers working in the aforementioned fields.

This year RoMoCo Workshop is financially supported by two companies Encon-Koester and WObit. They exhibit their products at the Workshop cite with short oral presentations during the Workshop. Certainly we express our thanks for their effort and support.

Finally, We would like to express my thanks to all participants and all the members of the Program Committee for their help in keeping good standards of RoMoCo'19 meeting.

We wish you a memorable stay in Poland.
Welcome to RoMoCo'19 and Poznan University of Technology, Poland.

Krzysztof Kozłowski

RoMoCo 2019
General Chairman

Wojciech Kowalczyk

RoMoCo 2019
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T. Zielińska (Poland),
C. Zieliński (Poland)

TIME-TABLE RoMoCo 2019

Monday, July 8, 2019

08.30 - 09.15 Opening ceremony
09.15 - 10.15 Plenary session I (E. Bayro)
10.15 - 10.45 Encon-Koester - Latest Trends in Robotics Education and Research
10.45 - 11.15 Coffee break
11.15 - 12.30 MoA1: Theoretical Control Aspects of Nonlinear Systems (44,9,29)
MoA2: Control of Flying and Underwater Vehicles (10,11,22)
12.30 - 13.30 Lunch
13.30 - 14.45 MoB1: Force Control (24,33,30)
14.45 - 15.15 Coffee break
15.15 - 16.05 MoC1: Control and Motion Planning of Walking Robots (5,32)
16.05 - 16.55 MoD1: Human Movement (35,36)
16.55 - 18.35 MoE1: Navigation and control of mobile robots I (14,15,16,53)
19.00 - Get together party

Tuesday, July 9, 2019

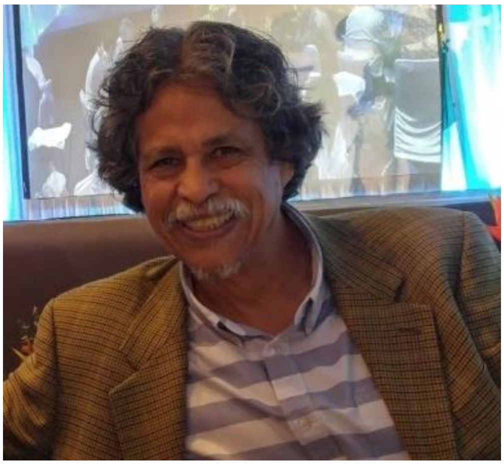
08.30 - 09.30 Plenary session II (K. Kyriakopoulos)
09.30 - 10.30 Plenary session III (F. Chaumette)
10.30 - 10.45 WObit - How to be successful in robotic products' development?
10.45 - 11.15 Coffee break
11.15 - 12.30 TuA1: Navigation and Control of Mobile Robots II (19,20,43)
TuA2: Trajectory Tracking of Mobile Robots (6,27,40)
12.30 - 13.45 TuB1: Rescue and Inspection Robotics (13,34,38)
TuB2: Space Robotics (26,31,42)
13.45 - 14.45 Lunch
15.30 - 19.00 Excursion
20.00 - Banquet

Wednesday, July 10, 2019

08.30 - 10.10 WeA1: Sensor Based Control of Mobile Robots (21,28,41,3)
10.10 - 10.40 Coffee break
10.40 - 11.55 WeB1: Selected Control Problems of Mobile Manipulators (47,54,25)
12.00 - 13.00 Lunch (Program Committee Meeting)
13.00 - 14.00 Plenary session IV (B. Siciliano)
14.00 - 14.30 Coffee break
14.30 - 15.45 WeC1: Computational Aspects of Robotics (8,17,18)
15.45 - 17.00 WeD1: Sensory Feedback in Robotics (4,23,37)
17.00 - 17.20 Closing Ceremony
17.30 - Farewell Party

Plenary Session I

Geometric Cybernetics and Social Robotics



Eduardo Bayro-Corrochano

CINVESTAV, Campus Guadalajara

Department of Electrical Engineering and Computer Science

Intelligent Control Systems Laboratory

Jalisco, México

Monday, July 8, 2019 09.15-10.15

Speaker Bio: Eduardo Bayro-Corrochano received the Ph.D. degree in cognitive computer science from the University of Wales, Cardiff, U.K., in 1993.From 1995 to 1999, he was a Researcher and Lecturer with the Institute for Computer Science, Christian Albrechts University Kiel, Germany, where he worked on applications of geometric Clifford algebra for cognitive systems. He is currently a Full Processor with the Department of Electrical Engineering and Computer Science, CINVESTAV Campus Guadalajara, Jalisco, Mexico. He is author of six Springer Verlag books and published over 220 refereed journal articles, book chapters, and conference papers

Prof. Bayro-Corrochano was an Associate Editor of the IEEE Trans. on Neural Networks and Learn Systems and Journal of Mathematical Imaging and Vision. He is a member of the editorial board of the Journal of Pattern Recognition and Journal of Robotica. He is a Fellow of the International Association of Pattern Recognition Society and IEEE senior member.

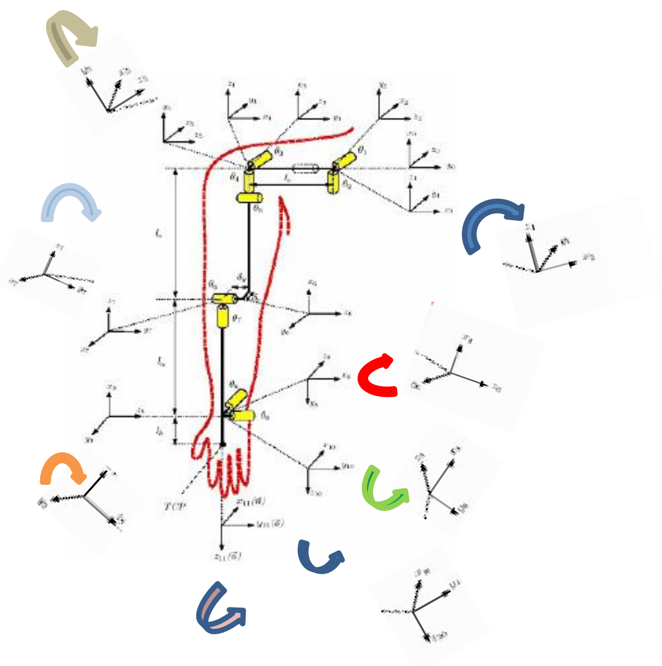
He was general chair of ICPR'2016, Dec. 4-8, Cancun, Mexico and of IEEE/RAS Humanoids 2016, Nov. 15-17, Cancun México.

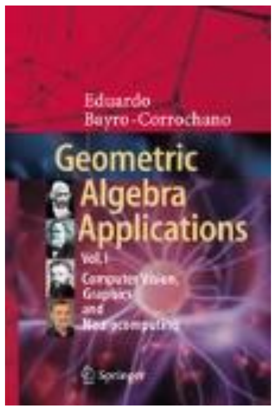
Geometric Cybernetics and Social Robotics

Eduardo Bayro-Corrochano

CINVESTAV, Electrical Engineering and Computer Science Department, Guadalajara, Jalisco México, edb@gdl.cinvestav.mx

- In this talk we introduce Geometric Cybernetics, for that we use as a mathematical framework the conformal geometric algebra for applications in computer vision, graphics engineering, learning, control and robotics.
- This framework appears promising for dealing with screw theory, Lie algebras and groups using bivector algebras (spinors), kinematics, dynamics and projective geometry problems without the need to abandon the mathematical system.
- For modeling and control problems, we reformulate the Newton-Euler dynamics and compute recursive Hamiltonians and design using screw theory localized controllers for robot manipulators.
- For control of manipulators and artificial hands, we have developed the quaternion spike neural network that is used in a localized control fashion.
- For social robotics, we present some applications in medical robotics and biomedical engineering with high social impact.





Plenary Session II

The Quest for Provable Robotic Motion Planning

Konstantinos J. Kyriakopoulos

Control Systems Laboratory

Mechanical Engineering Dept.

National Technical University of Athens,

Greece

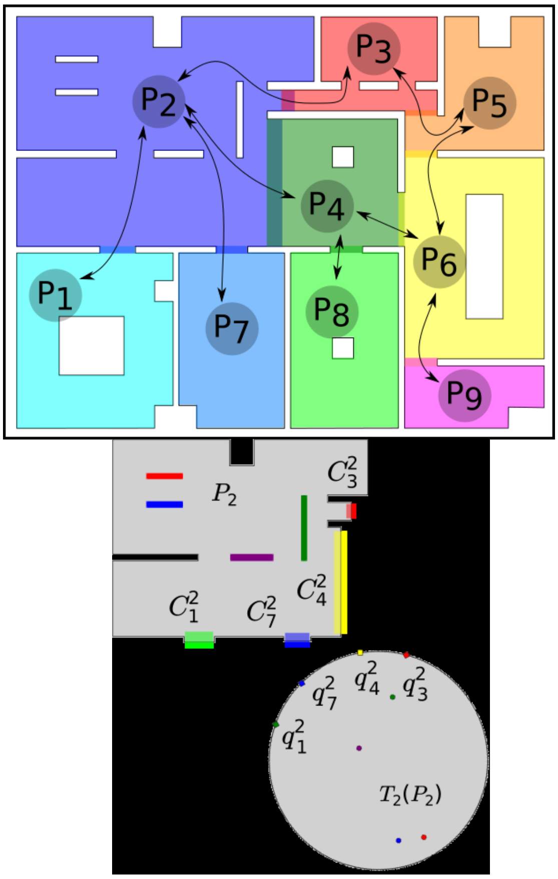
Tuesday, July 9, 2019 08:30 - 9:30

Speaker Bio: He was born in Athens, Greece in 1962. He received the Diploma in mechanical engineering with Honors from the National Technical University of Athens (NTUA), Greece, in 1985 and the MS and Ph.D. in Electrical, Computer & Systems Engineering from Rensselaer Polytechnic Institute (RPI), Troy, NY in 1987 and 1991, respectively. From 1988 to 1991 he did research at the NASA Center for Intelligent Robotic Systems for Space Exploration. Between 1991-93 he was an Assistant Professor at the Electrical, Computer and Systems Engineering Department of RPI and the New York State Center for Advanced Technology in Automation and Robotics. Since 1994 he has been with the Control Systems Laboratory of the Mechanical Engineering Department at NTUA, Greece, where he currently serves as a Professor and Director of the Post-Graduate Program on „Automation Systems". His current interests are in the area of Nonlinear Control and Embedded Systems applications in Sensor Based Motion Planning & Control of multi-Robotic Systems: Manipulators & Vehicles (Mobile, Underwater and Aerial). He was awarded the G.Samaras award of academic excellence from NTUA, the Bodosakis Foundation Fellowship (1986-1989), the Alexander Onassis Foundation Fellowship (1989-1990) and the Alexander Von Humboldt Foundation Fellowship (1993). Dr. Kyriakopoulos has published more than 320 papers to journals and refereed conferences; he is Specialty Chief Editor for „Frontiers in Robotics and AI" and he serves in the editorial committees of a number of journals and conferences, while he has served as an administrative member of a number of international conferences. He has acted as PI in 35 R & D projects, half of which funded by the European Commission. He is an IEEE Fellow.

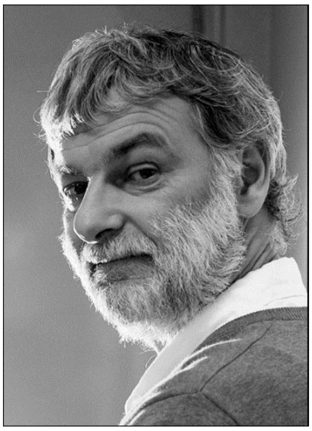
The Quest for Provable Robotic Motion Planning

Kostas J. Kyriakopoulos
National Technical University of Athens, Greece

- We consider several robotic platforms (ground, underwater, aerial) subject to various kinematic constraints, and for combinations of classes of environment, sensing and cooperation type.
- Extensions of Navigation Functions for the non-holonomic and multi-agent cases
- Combination of vector fields with viability principles
- Integration of Harmonic Maps and Potential Fields.
- Applications: single / multi-robot cooperative mobile manipulation (ground and underwater), air-traffic conflict resolution, etc.



Plenary Session III



Geometric and end-to-end robot vision-based control

François Chaumette

IRISA, Inria Rennes-Bretagne Atlantique

Campus de Beaulieu, Rennes

France

Tuesday, July 9, 2019 09:30 - 10:30

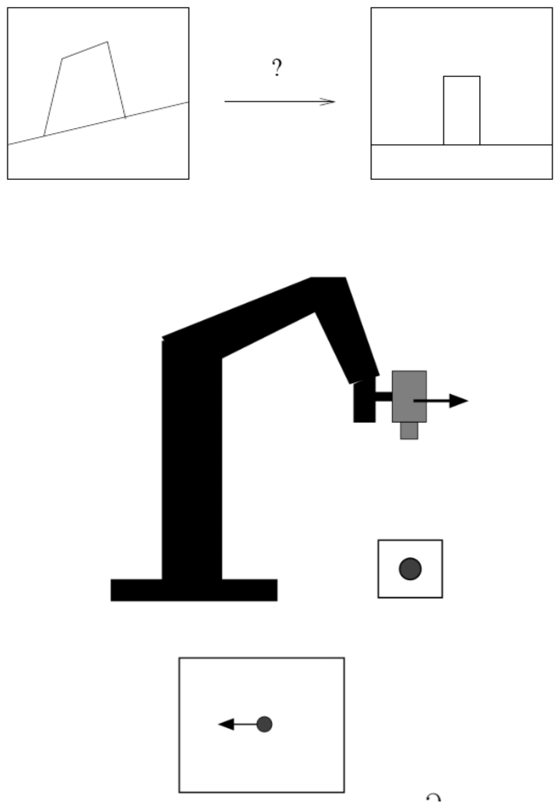
Speaker Bio: François Chaumette, IEEE Fellow, is an Inria senior research scientist at IRISA in Rennes, France, where he lead the Lagadic group since 2004. He received the M.Sc. (eng.) degree from „Ecole Nationale Supérieure de Mécanique", Nantes, in 1987 and a Ph.D. in computer science from the University of Rennes in 1990. His research interests lie in the area of robot vision, mainly visual servoing and active perception. He has published over 250 journal or conference papers, with the 2002 Best IEEE Transactions on Robotics and Automation Paper Award. He has served on the technical program committee of the main conferences in computer vision (ECCV, CVPR, ICCV) and robotics (ICRA, IROS, RSS). He has been Associate Editor of the IEEE Transactions on Robotics (2001-2005) and Funding Senior Editor of the IEEE Robotics and Automation Letters (2015-2018). He is currently in the Editorial Board of the Int. Journal of Robotics Research, and Senior Editor of the IEEE Transactions on Robotics.

Geometric and end-to-end robot vision-based control

François Chaumette

Rainbow group, Inria Rennes, France

- RObot MOtion COntrol in closed loop from visual data
- Basic concepts, modeling & control properties for two main approaches:
  - Geometric visual servoing (uses image processing to extract geometric features)
  - Photometric visual servoing (same inputs as for deep learning)



Plenary Session IV

Robotic Dynamic Manipulation: Perception, Planning and Control

Bruno Siciliano

PRISMA Lab

Dipartimento di Ingegneria Elettrica e Tecnologie dell'Informazione

Università degli Studi di Napoli, Italy

Wednesday, July 10, 2019 13:00-14:00

Speaker Bio: Professor Bruno Siciliano is Director of the Interdepartmental Center for Advances in Robotic Surgery (ICAROS), as well as Coordinator of the Laboratory of Robotics Projects for Industry, Services and Mechatronics (PRISMA Lab), at University of Naples Federico II. Fellow of the scientific societies IEEE, ASME, IFAC, he received numerous international prizes and awards, and he was President of the IEEE Robotics and Automation Society from 2008 to 2009. Since 2012 he is on the Board of Directors of the European Robotics Association. He has delivered more than 150 keynotes and has published more than 300 papers and 7 books. His book "Robotics" is among the most adopted academic texts worldwide, while his edited volume "Springer Handbook of Robotics" received the highest recognition for scientific publishing: 2008 PROSE Award for Excellence in Physical Sciences & Mathematics. His research team got 18 projects funded by the European Union for a total grant of 10 M€ in the last ten years, including an Advanced Grant from the European Research Council.

Robotic Dynamic Manipulation: Perception, Planning and Control

Bruno Siciliano
Department of Electrical Engineering and Information Technology
University of Naples Federico II

- Non-prehensile manipulation and manipulation of non-rigid objects
- Novel techniques for 3D object perception, dynamic manipulation control and reactive planning
- Innovative mobile platform with a torso, two lightweight arms with multi-fingered hands, and a sensorised head
- Pizza-making robochef as advanced demonstrator to emulate human ability to carry out challenging dynamic manipulation tasks

RoDyMan platform

Sponsor Presentation I

Monday, July 8, 2019 10.15-10.45 - **Encon-Koester**

Latest Trends in Robotics Education and Research

Maciej Antonik
Encon-Koester, Poland

- Fast pace of technology development forces changes in how we teach engineering
- Many engineering jobs that will be in demand 5-10 years from now don't exist yet
- Teachers don't have time to prepare and update professional laboratories
- Researchers need tools that allow them to focus on algorithms and quickly prototype on hardware

Sponsor Presentation II

Tuesday, July 9, 2019 10.30-10.45 - **WObit**

How to be successful in robotic products' development?

Przemysław Degórski
Director of Development, Production and Sales, WObit, Poland

- Modern world continually changes and requires everyone to be very sensitive and react fast.
- Sensitivity means that your dream and passion must be fitted to existing environment, which is critical for development.
- Are the robots so important at all or is there something else that motivates us to our activities?
- Almost everybody desires to be successful, but what should be in our focus and how to create targets to feel fulfilled.
- How your success may influence your local environment?

Technical Program Digest
Monday , 8th July, 2019

Theoretical Control Aspects of Nonlinear Systems

11.15-11.40 MoA1.1: On Stabilization of Nonlinear Systems with Drift by Time-Varying Feedback Laws – *Alexander Zuyew, Victoria Grushkowskaya (Germany)*

11.40-12.05 MoA1.2: Cooperative Control of Integrator Negative Imaginary Systems with Application to Rendezvous Multiple Mobile Robots – *Ola Skeik, Junyan Hu, Farshad Arvin, Alexander Lanzon (United Kingdom)*

12.05-12.30 MoA1.3: SDRE-Based Suboptimal Controller for Manipulator Control – *Slawomir Stępień, Paulina Superczyńska, Oskar Lindenau, Marcin Wałęsa, (Poland)*

Control of Flying and Underwater Vehicles

11.15-11.40 MoA2.1: Numerical Test of Underwater Vehicle Dynamics Using Velocity Controller – *Przemysław Herman (Poland)*

11.40-12.05 MoA2.2: Quadcopter Fractional Order Controller Accounting for Ground Effect – *Seyed Alireza Mirghasemi, Dan Necsulescu, Jerzy Sasiadek, (Canada)*

12.05-12.30 MoA2.3: Indoor Navigation Based on Model Switching in Overlapped Known Regions – *Edgar Macias-Garcia, Jesus Adan Cruz Vargas, Julio Zamora-Esquivel, Eduardo Bayro-Corrochano (Mexico)*

Force Control

13.30-13.55 MoB1.1: Extended Factitious Force Idea vs Non-Ideal Velocity Constraints Method in Control of the SSMP Platforms- *Wojciech Grzegorz Domski, Alicja Mazur(Poland)*

13.55-14.20 MoB1.2: Adjustability for Grasping Force of Patients with Autism by iWakka: A Pilot Study – *Masakazu Nomura, Natalia Agnieszka Kucharek, Igor Zubrycki, Grzegorz Granosik, Yoshifumi Morita, (Poland)*

14.20-14.45 MoB1.3: Experimental Verification of Force Interactions for RobinHand Prototype Motion Controller – *Łukasz Mucha, Krzysztof Lis, Dariusz Krawczyk (Poland)*

Control and Motion Planning of Walking Robots

15.15-15.40 MoC1.1: Comparative Study of Muscles Effort During Gait Phases for Multi-Muscle Humanoids – Teresa Zielińska, Jikun Wang, Weimin Ge, Linwei Lyu(Poland)

15.40-16.05 MoC1.2: A Novel Locomotion Controller Based on Coordination between Leg and Spine for a Quadruped Salamander-Like Robot – *Xueyou Zhang, Yongchun Fang, Wei Zhu, Xian GUO (China)*

Human Movement

16.05-16.30 MoD1.1: Predictive Control Applied to Precision Machine Tool Based on Dynamic Model – *Joao Mauricio Rosario, Liz Katherine Rincon Ardilla, Dider Dumur, Leonimer Flavio de Melo (Brazil)*

16.30-16.55 MoD1.2: Activities Prediction Using Structured Data Base – *Vibekananda Dutta, Teresa Zielińska (Poland)*

Navigation and Control of Mobile Robots I

16.55-17.20 MoE1.1: Task Harmonisation for a Single-Task Robot Controller – Wojciech Dudek, Maciej Węgierek, Jarosław Karwowski, Wojciech Szynkiewicz, Tomasz Winiarski *(Poland)*

17.20-17.45 MoE1.2: Predicting Vehicle Control Errors in Emergency Swerving Maneuvers – *Michael Schmidt, Daniel Töpfer, Stephan Schmidt (Germany)*

17.45-18.10 MoE1.3: Object Detection and Mapping During European Robotic Competitions - Lesson Learned – *Majek, Karol, Janusz Będkowski, Michał Pełka, Jakub Ratajczak, Andrzej Masłowski (Poland)*

18.10-18.35 MoE1.4: Accuracy Comparison of Navigation Local Planners on ROS-Based Mobile Robot – *Bartłomiej Cybulski, Agnieszka Węgierska, Grzegorz Granosik (Poland)*

Theoretical Control Aspects of Nonlinear Systems

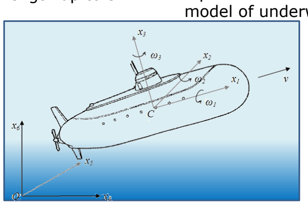
Chair *Francois Chaumette, Inria Rennes-Bretagne Atlantique*
Co-Chair

11:15–11:40	MoA1.1

On stabilization of nonlinear systems with drift by time-varying feedback laws

Alexander Zuyev
Max Planck Institute for Dynamics of Complex Technical Systems, Germany
Victoria Grushkovskaya
Institute of Mathematics, University of Würzburg, Germany

- Stabilizability results for nonlinear control-affine systems with non-zero drift
- General systems satisfying the local controllability assumption with iterated Lie brackets of length up to 3
- A novel control design scheme with time-varying trigonometric polynomials
- Explicit formulas for state-dependent control coefficients
- Examples: controlled Euler's equations and a mathematical model of underwater vehicle



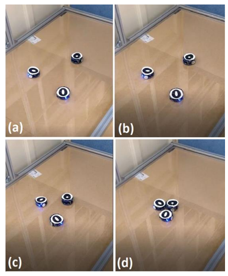
Controlled underwater vehicle

11:40–12:05	MoA1.2

Cooperative control of integrator negative imaginary systems with application to rendezvous multiple mobile robots

Ola Skeik, Junyan Hu, Farshad Arvin, and Alexander Lanzon
School of Electrical and Electronic Engineering , University of Manchester, UK

- Show that the NI property is preserved for multiple MIMO integrator systems with directional information flow that is balanced and strongly connected.
- Derive conditions that guarantee output consensus and output tracking for strongly connected, balanced and directed networks of integrators subject to energy-bounded disturbances using the NI internal stability theorems.
- Provide experimental results from both real-robot and simulation to validate the results in solving a rendezvous problem for multiple WMR.



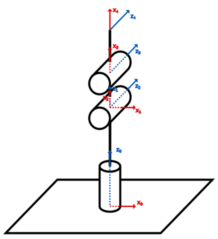
Position snapshots of 3 Mona robots at different time durations starting from initial position and ending in rendezvous.

12:05–12:30	MoA1.3

SDRE-based suboptimal controller for manipulator control

Sławomir Stępień, Paulina Superczyńska, Marcin Wałęsa, Oskar Lindenau
Institution of Automatic Control and Robotics, Poznan University of Technology, Poland

- modelling and control of a robotic arm with state-dependent Riccati equation (SDRE) method
- manipulator dynamics SDC parameterization for both stabilization and trajectory tracking problem
- numerical example with 3 DOF manipulator confirms usefulness of the proposed technique.



3DOF manipulator kinematics

Control of Flying and Underwater Vehicles

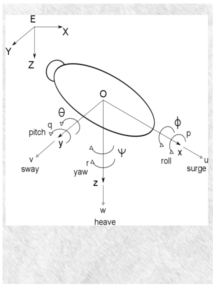
Chair *Adam Ratajczak, Wroclaw University of Technology*
Co-Chair

11:15–11:40	MoA2.1

Numerical Test of Underwater Vehicle Dynamics Using Velocity Controller

Przemyslaw Herman
Institute of Automation and Robotics, Poznan University of Technology, Poland

- The paper addresses the problem of underwater vehicle dynamic model evaluation using a velocity tracking controller
- In the approach the inertia matrix is decomposed and the equations contain new rates
- The method is suitable for fully actuated underwater vehicles moving at low speed
- Dynamics analysis is based on the proposed procedure
- Simulation results were performed on a 6 DOF underwater vehicle model



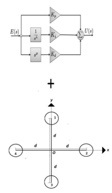
Coordinate system for 6 DOF vehicle

11:40–12:05	MoA2.2

Quadcopter Fractional Order Controller Accounting Ground Effect

Seyed Alireza Mirghasemi and Dan Necsulescu
Mechanical Eng Department, University of Ottawa, Canada
Jurek Sasiadek
Mechanical and Aerospace Eng Department, Carleton University, Canada

- Introduction of fractional calculus and its mathematical tools
- Presenting the dynamic of quadcopter and how the ground effect considered
- Discussing the fractional controller and its tuning method
- Results showing marginal improvement

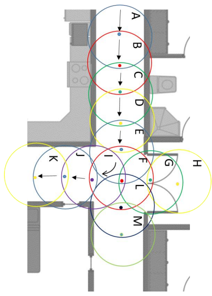

Block Diagram of Fractional Order Controller
And a Sketch of Quadcopter

12:05–12:30	MoA2.3

Indoor Navigation Based on Model Switching in OKR

Edgar Macias, Adan Cruz, Julio Zamora
Anticipatory Computer Lab, Intel Labs, México
and Eduardo Bayro
Department of Automatic Control, CINVESTAV IPN, México

- A novel drone navigation algorithm based in Overlapped Known Regions (OKR) is proposed.
- Each region has an associated neural network model, trained to localize the drone.
- Adaptive convolutional kernels are employed to reduce significantly the size of each model.
- Experimental results prove the effectiveness of adaptive kernel to preserve generalization capacity against parameter reduction.



Force Control

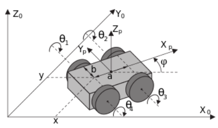
Chair Maciej, Marcin Michałek, Poznan University of Technology (PUT)
Co-Chair

13:30–13:55 MoB1.1

Extended factitious force idea vs non-ideal velocity constraints method in control of the SSMP platforms

Wojciech Domski and Alicja Mazur
Chair of Cybernetics and Robotics,
Wrocław University of Science and Technology, Poland

- Extended factitious force method for control of skid-steering mobile platforms and the approach of non-ideal velocity constraints.
- The same model for both methods is presented and compared.
- Extended factitious force introduces new virtual inputs to the system while the non-ideal velocity constraints method allows a small disturbance which bends the constraints imposed on the system.
- The methods are compared in terms of an estimation of slippage.



Skid-steering mobile platform

13:55–14:20 MoB1.2

Adjustability for Grasping Force of Patients with Autism by iWakka: A Pilot Study

Masakazu Nomura and Yoshifumi Morita
Electrical and Mechanical Engineering, Nagoya Institute of Technology, Japan
Natalia Kucharek, Igor Zubrycki, and Grzegorz Granosik
Automatic Control at Faculty of Electrical, Electronic, Computer and Control Engineering, Lodz University of Technology, Poland

- A pilot study was conducted to explore the applicability of iWakka to autistic patients.
- Eight participants with autism were involved.
- The AGF (Adjustability for Grasping Force) of the four participants was improved after training.
- We noticed a reduction in the yaw head displacement of three participants.
- It was suggested that iWakka has the potential to improve the AGF and their focus of attention of patients with autism

An autistic person training with iWakka.

14:20–14:45 MoB1.3

Experimental verification of force interactions for RobinHand prototype motion controller

Łukasz Mucha, Dariusz Krawczyk
Foundation of Cardiac Surgery Development , Poland
Krzysztof Lis
Department of Machine Technology, Silesian University of Technology, Poland

In article, the design stages, principle of operation and static tests of the force that is exerted on the operator by the RobinHand motion controller were presented. Besides that, details of such issues as, the developed laboratory stand for testing the force interactions, all concepts and ways of implementing the transfer of tactile stimuli from real devices or virtual reality to the user/surgeon, subsequent variants of the developed devices with the short description of them, the project of the operator-surgeon stand that is based on the assumption that the method of control of this device is compatible with the natural work of the surgeon as well as the project of control console that is used to manipulate the surgical robot were presented.

Control and Motion Planning of Walking Robots

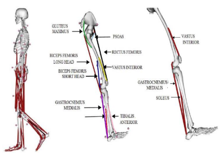
Chair *Miroslaw Galicki, University of Zielona Gora, 65-516 Zielona Gora, Szafrana 4,*
Co-Chair

15:15–15:40	MoC1.1

Comparative study of muscles effort during gait phases for multi-muscle humanoids

Teresa Zielinska, Jikun Wang
Faculty of Power and Aeron. Eng., Faculty of Mechatronics , Warsaw University of Technology, Poland
Weimin Ge, Linwey Lyu
School of Mechanical Eng., Tianjin Univ. of Technology, China

- Muscles effort during the gait
- Classificantion of the muscles effort
- EMG signals recorded in the human legs
- Classification of the muscles effort
- Comparisions, conclusions



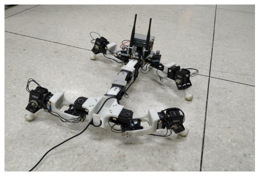
Investigated muscles

15:40–16:05	MoC1.2

A Novel Locomotion Controller Based on Coordination Between Leg and Spine for a Quadruped Salamander-like Robot

Xueyou Zhang, Yongchun Fang, Wei Zhu and Xian Guo*
The Institute of Robotics and Automatic Information Systems
Nankai University, China

- The quadruped salamander-like robot has flexible spine and legs
- The inverse kinematics is utilized to calculate the control for the legs
- Biological inspiration is employed for the control of the spine
- The coordination between the legs and the spine is ensured by the utilization of the static stability principle
- A modified trajectory is generated by force feedback to cross obstacles



Salarobot

Human Movement

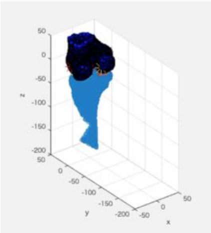
Chair *Przemyslaw Herman, Poznan University of Technology*
Co-Chair

16:05–16:30	MoD1.1

Kinematic Simulator of e-Knee Robo that Reproduces Human Knee-Joint Movement

Goro Hatano, Yoshifumi Morita
Electrical and Mechanical Engineering, Nagoya Institute of Technology, Japan
Kozlowski Krzystof, Piotr Sauer
Automation and Robotics, Poznan University of Technology, Poland

- In this study, we aimed to develop simulator of e-Knee Robo that reproduces human knee-joint movement.
- Bones are modelled by approximate polynomial equations and contact points between femur and tibia were searched by finding same gradients.
- Introducing parameters from e-Knee Robo as conditions, 5 degrees of freedom movements were calculated against each flexion angle(0-90[°])
- The results indicate that a part of movement of simulator is similar to that of e-Knee Robo.



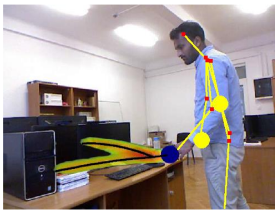
Developed simulator

16:30–16:55	MoD1.2

Activities Prediction Using Structured Data Base

Vibekananda Dutta and Teresa Zielinska
Institute of Aeronautics and Applied Mechanics
Warsaw University of Technology, Poland

- In this paper, we address a method for forecasting human activities by prognosis the sequential actions.
- The proposed method was investigated in a supervised setting, considering the human relations with the objects.
- The design of the structured database and the corresponding graph structure is summarized.
- Validation of the proposed approach using our and commonly available datasets, comparison of the results with the other state-of-the-art methods are discussed.



Experimental visualization of an activity forecasting

Navigation and Control of Mobile Robots I

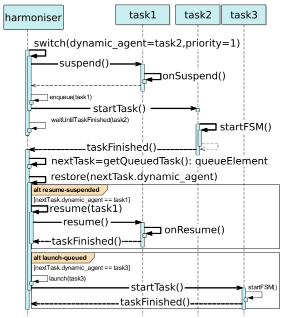
Chair *Dariusz Pazderski, Poznan University of Technology*
Co-Chair

16:55–17:20	MoE1.1

Task harmonisation for a single-task robot controller

Wojciech Dudek, Maciej Węgierek, Jarosław Karwowski, Wojciech Szynkiewicz, Tomasz Winiarski
Warsaw University of Technology, Institute of Control and Computation Engineering, Poland

- Service robots are required to handle many requests of tasks, even during realisation of another one,
- A robot can not switch the current task to another one at any time,
- We define inter-agent communication and system behaviours which enable **suspension of a current task** and **its resumption later**
- The method does not depend on a specific scheduling algorithm, which may differ between robot applications



Example scenario of task harmonisation

17:20–17:45	MoE1.2

Predicting Vehicle Control Errors in Emergency Swerving Maneuvers

Michael Schmidt, Otto-von-Guericke-University Magdeburg
Daniel Töpfer, Volkswagen AG Group Research
Stephan Schmidt, Otto-von-Guericke University Magdeburg

17:45–18:10	MoE1.3

Object Detection and Mapping During European Robotic Competitions - Lesson Learned

Karol Majek, Janusz Będkowski, Michał Pełka, Jakub Ratajczak, Andrzej Maslowski
Digital Mobile Robotics, NASK, Poland

- Annotated dataset with Objects of Potential Interest (OPIs)
- Automatic detection of OPIs using deep neural network
- Open source object detection package for ROS
- Object detection and 6DSLAM running simultaneously during realistic mission

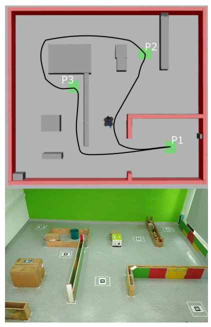
Objects detected automatically during ERL Emergency 2018

18:10–18:35	MoE1.4

Accuracy comparison of navigation local planners on ROS-based mobile robot

Bartlomiej Cybulski, Agnieszka Wegierska and Grzegorz Granosik
Institute of Automatic Control, Lodz University of Technology, Poland

- Comparison of three local planners available in navigation stack in ROS
- Tests conducted in the simulation and real environment
- The accuracy and repeatability of planners were measured using motion capture system



Technical Program Digest
Tuesday , 9th July, 2019

Navigation and Control of Mobile Robots II

11.15-11.40 TuA1.1: Point-To-Surfel-Distance (PSD-) Based 6D Localization Algorithm for Rough Terrain Exploration Using Laser Scanner in GPS-Denied Scenarios – *Adam Niewola, Leszek Podsędkowski, Jakub Niedźwiedzki (Poland)*

11.40-12.05 TuA1.2: Collision-Free Navigation of N-Trailer Vehicles with Motion Constraints – *Leonardo Guevara, Miguel Torres-Torriti, Fernando Auat Cheein, (Mexico)*

12.05-12.30 TuA1.3: Interval-Based Solutions for Reliable and Safe Navigation of Intelligent Autonomous Vehicles – *Nadhir Mansour Ben Lakhal, Lounis Adouane, Othman Nasri, Jaleleddine Ben Hadj Slama, (France)*

Trajectory Tracking of Mobile Robots

11.15-11.40 TuA2.1: IstiABot, an Open Source Mobile Robot for Education and Research – *Rémy Guyonneau, Franck Mercier (Poland)*

11.40-12.05 TuA2.2: Optimal Trajectory Tracking Control of Omni-Directional Mobile Robots – *Mirosław Galicki, Marek Banaszkiewicz, (Poland)*

12.05-12.30 TuA2.3: On Time-Delayed Feedback Trajectory Tracking Control of a Mobile Robot with Omni-Wheels – *Aleksandr Andreev, Olga Peregudova, (Russia)*

Rescue and Inspection Robotics

12.30-12.55 TuB1.1: Multi-Body Dynamics Experimental Analysis for Non-Destructive Inspection Robot in Water Main Pipe – *Jongho Bae, Jaekyu An, Goobong Chung (South Korea)*

12.55-13.20 TuB1.2: Step Climbing Method for Crawler Type Rescue Robot Using Reinforcement Learning with Proximal Policy Optimization – *Mifu Totani, Noritaka Sato, Yoshifumi Morita (Japan)*

13.20-13.45 TuB1.3: Control Method for Rollover Recovery of Rescue Robot Considering Normalized Energy Stability Margin and Manipulating Force – *Noritaka Sato, Makoto Kitani, Yoshifumi Morita (Japan)*

Space Robotics

12.30-12.55 TuB2.1: Lagrangian Jacobian Motion Planning with Application to a Free-Floating Space Manipulator – *Joanna Ratajczak, Krzysztof Tchoń (Poland)*

12.55-13.20 TuB2.2: Trajectory Reproduction Algorithm in Application to an On-Orbit Docking Maneuver with Tumbling Target – *Adam Ratajczak, Joanna Ratajczak (Poland)*

13.20-13.45 TuB2.3: Tracking of Numerically Defined Trajectory by Free-Floating 3D Satellite – *Wojciech Grzegorz Domski, Alicja Mazur (Poland)*

Navigation and Control of Mobile Robots II

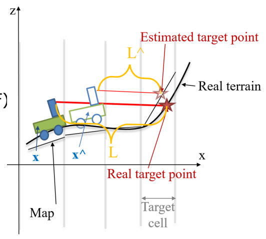
Chair *Grzegorz Granosik, Lodz University of Technology*
Co-Chair

11:15–11:40 TuA1.1

PSD-based 6D localization algorithm for rough terrain exploration using laser scanner in GPS-denied scenarios

Adam Niewola, Leszek Podsędkowski, and Jakub Niedźwiedzki
Institute of Machine Tools and Production Engineering, Lodz University of Technology, Poland

- Point-to-Surfel Distance (PSD-) based algorithm uses lidar measurements without features extraction and without full point clouds comparison
- We use one-dimensional distance measurement for correction (by EKF) of 3 translational and 3 rotational coordinates of robot pose thanks to extended description of innovation covariance matrix
- Simulations and real-time experiments confirmed the advantages of proposed method in rough terrain exploration without typical landmarks



The innovation value $i = L - L^{\wedge}$ used in correction phase of EKF

11:40–12:05 TuA1.2

Collision-free navigation of N-trailer vehicles with motion constraints

Leonardo Guevara and Fernando Auat Cheein
Department of Electronic Engineering, Universidad Técnica Federico Santa María, Valparaíso, Chile.
Miguel Torres-Torriti
Department of Electrical Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile.

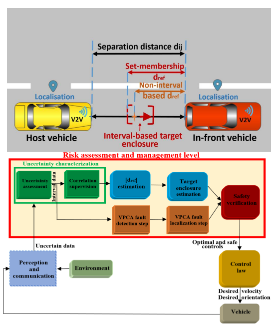
- In this work a collision-free navigation strategy for N-trailer vehicles is proposed to perform several tasks simultaneously: trajectory tracking control, off-track errors reduction, external obstacles avoidance and inter-vehicle collision avoidance.
- To validate the proposed strategy, a Generalized N-trailer (GNT) structure with a car-like tractor and 10 trailers is tested in simulation to track an U-shape trajectory in presence of unknown obstacles.
- The well-known information about external infrastructure is also considered to reduce unsafe trailers off-track errors in turning scenarios.
- The motion constraints imposed by the car-like tractor physical limitations and the interconnections between trailers are also considered by restricting the control input in order to avoid collision between trailers.

12:05–12:30 TuA1.3

Interval-based Solutions for Reliable and Safe Navigation of Intelligent Autonomous Vehicles

Nadhir Mansour Ben Lakhal[1, 2], Lounis Adouane[1], Othman Nasri[2] and Jaleleddine Ben Hadj Slama[2]
[1]Institut Pascal, Clermont Auvergne University, France
[2]LATIS Lab, University of Sousse, Tunisia

- Compare performances of several uncertainty handling techniques for intelligent navigation systems
- Introduce an interval-based approach to characterize uncertainty impacting the navigation process
- Develop a set-membership diagnosis handling interval data to ensure high sensitivity to faults
- Provide a reliable risk management approach to monitor an Adaptive Cruise Control (ACC) system



Control architecture of interval analysis-based ACC

Trajectory Tracking of Mobile Robots

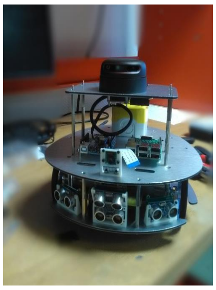
Chair *Vojtech Vonasek, Czech Technical University in Prague*
Co-Chair

11:15–11:40	TuA2.1

IstiABot, an Open Source Mobile Robot for Education and Research

Remy Guyonneau and Franck Mercier
Polytech Angers, University of Angers, France

- Conception and realization of an open source wheeled robot
- Robot based on a CANBus Network
- Education and research applications
- Education application: setting a PID controller
- Research application: implementing a SLAM algorithm under ROS middle-ware



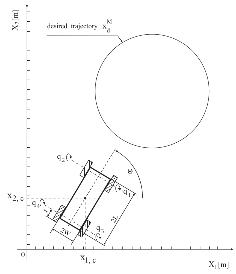
IstiABot

11:40–12:05	TuA2.2

Optimal trajectory tracking control of omni-directional mobile robots

Mirosław Galicki
Faculty of Mechanical Engineering, University of Zielona Góra, Poland
Marek Banaszkiewicz
Centrum Badań Kosmicznych, PAN, Warszawa, Poland

- The non-singular first-order terminal sliding mode manifod is introduced
- A new controller based on the transpose of the extended Jacobian matrix is proposed
- The offered control scheme is shown to be globally finite-time stable and locally optimal
- In order to eliminate the undesirable chattering effect, a technique of boundary layer is proposed



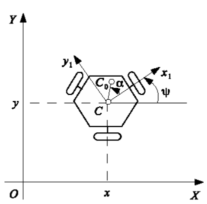
A kinematic scheme of the FMWMR and the task to be accomplished

12:05–12:30	TuA2.3

On Time-Delayed Control of a Mobile Robot with Omni-Wheels

Aleksandr Andreev and Olga Peregudova
Department of Information Security and Control Theory,
Ulyanovsk State University, Russia

- We consider a dynamical model of the mobile robot with three omni-wheels wherein the platform's center of mass is displaced from its geometrical center.
- A solution to the trajectory tracking control problem is proposed on the base of a delayed output feedback.
- A nonlinear bounded controller is constructed without measuring the velocities by using the method of Lyapunov functional.



Model of a mobile robot with three omni-wheels

Rescue and Inspection Robotics

Chair *Alexander Zuyev, Max Planck Institute for Dynamics of Complex Technical Systems*
Co-Chair

12:30–12:55 TuB1.1

Multi-body Dynamics Experimental Analysis for Non-Destructive Inspection Robot in Water Main Pipe

Jongho Bae, Jaekyu An, Goobong Chung
KIRO(KOREA INSTITUTE OF ROBOT CONVERGENCE), HANYANG UNIVERSITY

Pohang, Gyeong-buk, Republic of Korea

- This study introduces the development of mobile robot system for non-destructive inspection of water main pipe.
- Multi-body dynamics experimental analysis was conducted based on the simplified kinematic model
- In order to improve simulation, Contact and Friction force mechanics was applied to this simulation.
- Finally, we analyzed the defect by extracting the actual data of simulation defect during the test piping experiment

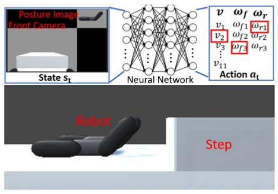
Non-Destructive Inspection Robot

12:55–13:20 TuB1.2

Step climbing method for crawler type rescue robot using reinforcement learning with Proximal Policy Optimization

Mifu Totani, Noritaka Sato, Yoshifum Morita
Department of Electrical and Mechanical Engineering,
Nagoya Institute of Technology, Japan

- We propose a step climbing method for rescue robot by using reinforcement learning with Proximal Policy Optimization.
- The input data are the image of a camera on the robot and a posture image of the robot.
- Using a dynamics simulator, we compared the remote control with the human body and the learning model.
- The result showed that the task time was reduced and the success rate was improved by using the learned model.



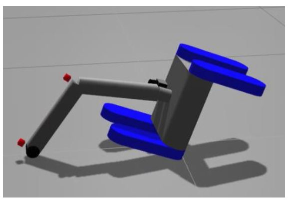
Proposed method with PPO (top)
and robot climbing step in a simulator (bottom).

13:20–13:45 TuB1.3

Control Method for Rollover Recovery of Rescue Robot Considering Normalized Energy Stability Margin and Manipulating Force

Noritaka Sato, Makoto Kitani and Yoshifumi Morita
Department of Electrical and Mechanical Engineering,
Nagoya Institute of Technology, Japan

- An autonomous control method for rollover recovery of a rescue robot is proposed.
- In the proposed method, sub-crawlers are controlled to reduce the normalized energy stability margin, initially.
- Subsequently, a manipulator is used to push the ground and rotate the robot.
- The experiment using a Gazebo similar was performed to verify effectiveness of the proposed method



The simulated robot,
which is recovering from the rollover situation
by the proposed control method

Space Robotics

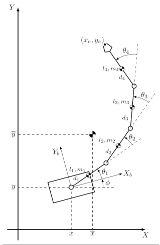
Chair *Kostas Kyriakopoulos, National Technical Univ. of Athens*
Co-Chair

12:30–12:55	TuB2.1*

Lagrangian Jacobian motion planning with application to a free-floating space manipulator

Joanna Ratajczak and Krzysztof Tchoń
Department of Cybernetics and Robotics,
Wroclaw University of Science and Technology, Poland

- The paper presents an application of the Lagrangian Jacobian motion planning algorithm to non-holonomic robotic systems.
- The new algorithm minimizes the energy of the trajectory variations.
- Application to free-floating space manipulators equipped with 3 or 4 DOF on-board manipulator.
- In comparison to the Jacobian pseudoinverse, the new algorithm results in more compact motion and control energy saving.



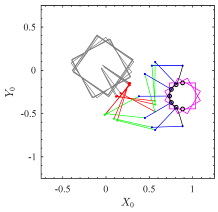
4 DOF on-board space manipulator

12:55–13:20	TuB2.2

Trajectory Reproduction Algorithm in Application to an On–Orbit Docking Maneuver with Tumbling Target

Adam Ratajczak
Department of Control Systems and Mechatronics
Joanna Ratajczak
Department of Cybernetics and Robotics
Wroclaw University of Science and Technology, Poland

- A new algorithm for a trajectory planning (reproduction) problem for nonholonomic systems.
- The instantaneous map allows to construct a system of nonlinear functional equations which solution is a demanded control function.
- The large scale root–finding algorithm is employed.
- The new algorithm is applied to a docking maneuver of a free–floating space manipulator with a tumbling target.



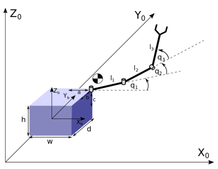
XY path in the contact phase

13:20–13:45	TuB2.3

Tracking of numerically defined trajectory by free-floating 3D satellite

Wojciech Domski and Alicja Mazur
Chair of Cybernetics and Robotics,
Wrocław University of Science and Technology, Poland

- A free-floating 3D satellite with a 3 DoF manipulator arm.
- The input-output decoupling procedure for control of a manipulator's end-effector in task space.
- Numerically defined first and second derivative of desired trajectory.
- Simulation results for different granularity of numerical derivatives.



Satellite's model with marked coordination systems

Technical Program Digest
Wednesday , 10th July, 2019

Sensor Based Control of Mobile Robots

8.30-8.55 WeA1.1: VFO Controller for Set-Point Visual Servoing of Unicycle-Like Mobile Robots Equipped with a Camera of an Uncertain Depth Scale Factor – *Maciej Marcin Michałek, Runhua Wang, Xuebo Zhang (Poland)*

8.55-9.20 WeA1.2: Control System Shell of Mobile Robot with Voice Recognition Module – *Andrzej Skrzypek, Wawrzyniec Panfil, Mateusz Andrzej Kosior, Piotr Przystałka, (Poland)*

9.20-9.45 WeA1.3: A Novel 3D Laser Scanner Design for Variable Density Scanning – *Adam Niewola, Leszek Podsędkowski (Poland)*

9.45-10.10 WeA1.4: A Nonlinear Optimal Control Approach for Four-Wheel Omnidirectional Robotic Vehicles – *Gerasimos Rigatos, Krishna Busawon, Masoud Abbaszadeh, Patrice Wira (France)*

Selected Control Problems of Mobile Manipulators

10.40-11.05 WeB1.1: Path Tracking by the Nonholonomic Mobile Manipulator – *Mateusz Cholewiński, Alicja Mazur (Poland)*

11.05-11.30 WeB1.2: Multi-Sensor Extrinsic Calibration with the Adam Optimizer – *Joanna Piasek, Rafał Staszak, Karol Piaskowski, Dominik Belter (Poland)*

11.30-11.55 WeB1.3: FABRIC: Framework for Agent-Based Robot Control Systems – *Dawid Seredyński, Tomasz Winiarski, Cezary Zieliński, (Poland)*

Computational Aspects of Robotics

14.30-14.55 WeC1.1: Planning TS Trajectory Using MLAT in O(n Log N) – *Dan Ophir, Ahiya Davidovitch (Izrael)*

14.55-15.20 WeC1.2: Computation of Approximate Solutions for Guided Sampling-Based Motion Planning of 3D Objects – *Vojtech Vonasek, Robert Pěnička,(Czech Republic)*

15.20-15.45 WeC1.3: Sensor Lattices: Structures for Comparing Information Feedback – *Steven M. LaValle, (Finland)*

Sensory Feedback in Robotics

15.45-16.10 WeD1.1Adaptive Controller with Output Feedback for Dielectric Electro-Active Polymer Actuator – *Jakub Kolota, Jakub Bernat (Poland)*

16.10-16.35 WeD1.2: Design and Evaluation of a Factorization-Based Grasp Myoelectric Control Founded on Synergies – *Roberto Meattini, Daniele De Gregorio, Gianluca Palli, Claudio Melchiorri, (Italy)*

16.35-17.00 WeD1.3: RSQ Motion - a Prototype of the Motion Analysis System in the Joints– *Piotr Sauer, Bartłomiej Lubiatowski, Szymon Chorodenski, Bartosz Breninek, Gruszczyński, Kacper* (Poland)

Sensor Based Control of Mobile Robots

Chair *Dan Ophir, Ariel University*
Co-Chair

08:30–08:55 WeA1.1

VFO controller for set-point visual servoing of unicycle-like mobile robots equipped with a camera of an uncertain depth scale factor

Maciej M. Michałek and Runhua Wang, Xuebo Zhang

Institute of Automation and Robotics
Poznań University of Technology, Poland

Institute of Robotics and Automatic Information Systems
Nankai University, China

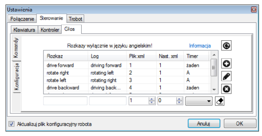
- Vector Field Orientation (VFO) control law is proposed for visual servoing of the input-constrained unicycle-like robot equipped with an on-board camera of an uncertain depth scale factor
- Simulation results illustrate robustness of the proposed VFO control system even to substantial uncertainty of the scale factor
- Robustness property of the VFO control system allows avoiding a precise calibration of the on-board camera for the scale factor

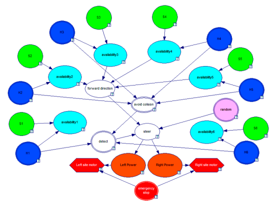
08:55–09:20 WeA1.2

Control System Shell of Mobile Robot with Voice Recognition Module

Andrzej Skrzypek, Wawrzyniec Panfil,
Mateusz Kosior, Piotr Przystałka
Institute of Fundamentals of Machinery Design,
Silesian University of Technology, Poland

- Mobile robot control system with the voice recognition software module is shown
- Proposed system includes features related to expert system shells
- One of the most important functionalities of the developed system is the ability to edit the knowledge base of the controller
- A Bayesian-based behavioural controller is used to guarantee a partial autonomy of the robot
- Verification tests were carried out in order to prove the efficiency and usability of the system



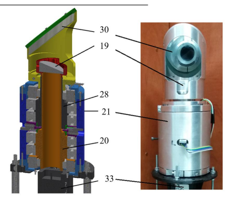


09:20–09:45 WeA1.3

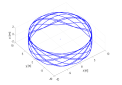
A novel 3D laser scanner design for variable density scanning

Adam Niewola and Leszek Podsędkowski
Institute of Machine Tools and Production Engineering, Lodz University of Technology, Poland

- We developed two versions of our lidar: wide field-of-view (it uses mirror and prism) and narrow field-of-view (it uses two prisms)
- Unlike the 3d lidars available on the market (Velodyne, Robosense, Ouster), our device uses a single laser range finder (LRF) instead of multiple LRFs positioned with various orientations.
- By modifying of the speed of optical elements in our device, one can obtain various paths of the laser beam
- Therefore, we can obtain higher density of the point cloud (than available scanners) dependent on the scanning time, not on the number of LRFs



Design of our 3D scanner (30 – mirror, 19 – prism, 20-21 – rotating bushings, 33 – LRF)



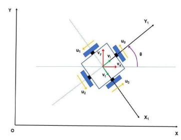
Ability of controlling of laser beam path by modifying of mirror and prism relative speed

09:45–10:10 WeA1.4

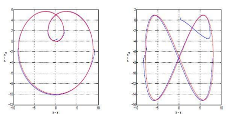
A nonlinear optimal control approach for four-wheel omnidirectional robotic vehicles

Gerasimos Rigatos, Industrial Systems Institute, Greece
Krishna Busawon, University of Northumbria, UK
Masoud Abbaszadeh, General Electric, USA
Patrice Wira, Univ. d' Haute Alsace, France

- A nonlinear optimal control approach is proposed for four-wheel omnidirectional mobile robots.
- it is shown that this control method can provide the only optimal solution to the control problem of omnidirectional robotic vehicles.
- The state-space model of the robotic vehicle undergoes approximate linearization around a temporary operating point, through first-order Taylor series expansion and through the computation of the associated Jacobian matrices.
- To select the feedback gains of the H-infinity controller a Riccati equation is solved at each time- step of the control method.
- The global stability properties of the control loop are proven through Lyapunov analysis.



The omnidirectional vehicle



Tracking of reference paths by the omnidirectional robot

Selected Control Problems of Mobile Manipulators

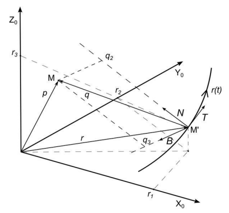
Chair *Steven M LaValle, University of Oulu*
Co-Chair

10:40–11:05	WeB1.1

Path Tracking by the Nonholonomic Mobile Manipulator

Mateusz Cholewiński and Alicja Mazur
Chair of Cybernetics and Robotics, Electronics Faculty,
Wrocław University of Technology

- Paper presents a path following problem and solution for nonholonomic mobile manipulator
- Mathematical model consists of kinematics and dynamics
- Three dimensional orthogonal parameterization using Serret-Frenet frame is used in order to describe the movement of end-effector relative to path
- Dynamic and kinematic controllers are proposed
- Proof of proper action and numerical results are presented



Path following problem using Serret-Frenet frame based orthogonal parameterization

11:05–11:30	WeB1.2

Multi-sensor extrinsic calibration with the Adam optimizer

Joanna Piasek[1] and Rafal Staszak[2]
[1]Institute of Automation and Robotics, PUT, Poland
Karol Piaskowski[2] and Dominik Belter[2]
[2]Institute of Control, Robotics and Information Engineering, PUT, Poland

- Calibration procedure for the robot equipped with three RGB-D cameras (mounted on the wrist of the arm, robot's head and the mobile base).
- The proposed method finds all the relative transformations between cameras in a single optimization procedure.
- We compare the proposed application of the Adam optimizer with black-box evolutionary algorithm, Levenberg-Marquardt optimization, and graph-based optimization.

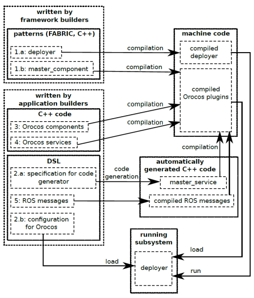
Mobile manipulation robotic platform used in this research

11:30–11:55	WeB1.3

FABRIC: Framework for Agent–Based Robot Control Systems

Dawid Seredyński and Tomasz Winiarski and Cezary Zieliński
Institute of Control and Computation Engineering,
Warsaw University of Technology, Poland

- FABRIC – framework and toolchain that facilitates semi-automatic generation of agent based control systems for robots
- It combines agent based formal specification with implementation employing component based frameworks
- The specification is divided into a number of items, produced using a DSL and C++ source code
- Verification: control system of complex service robot with two arms, grippers and moveable head and torso



Computational Aspects of Robotics

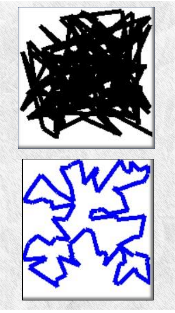
Chair *Andrzej Maslowski, Warsaw University of Technology, Warsaw, Poland*
Co-Chair

14:30–14:55	WeC1.1

Planning TS Trajectory Using MLAT in o(n log n)

Dan Ophir and Achiya Davidovich
Computer Science, Ariel University, ISRAEL

- **TS** is Traveling Salesman problem namely to find the shortest path connecting several points.
- **MLAT** is a Multi Level Adaptive Technik: the problem is divided on gradually decreasing resolution from coarse to fine and solved on each level, transferring the solution to finer level and vice versa. The process converges.
- **Simulated Annealing** - is a method of finding the best solution in a collection of one problem with several random initial conditions.
- **TS** – solution was received by mixing the MLAT and the Simulated Annealing methods.

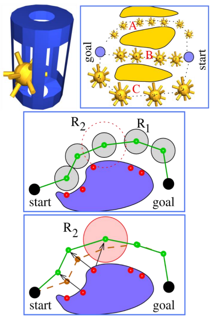

Initial and final solutions (100 points) using the method.

14:55–15:20	WeC1.2

Computation of approximate solutions for guided sampling-based motion planning of 3D objects

Vojtech Vonasek and Robert Penicka
Czech Technical University in Prague, Czech Republic

- The task is to find a path for a solid 3D object
- Sampling-based planner finds several approximate solutions by scaling-down the robot
- Approximate solutions found for a small robot guides the sampling for a larger robot
- Boundary configurations located at the surface of obstacles are detected
- The approximate solution is shifted away from the boundary configurations, to improve the sampling with a larger robot
- The proposed RRT-based planner achieves higher success rate than other planning methods



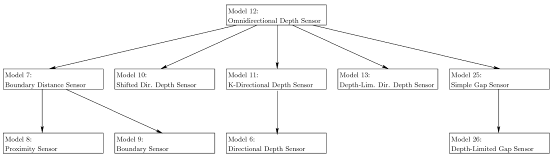
R1-small robot, R2-large robot, red-boundary configurations,brown-solution for small robot, green-solution for larger robot

15:20–15:45	WeC1.3

Sensor Lattices: Structures for Comparing Information Feedback

Steven M. LaValle
Center for Ubiquitous Computing
Faculty of Information Technology and Electrical Engineering
University of Oulu, Finland

- Sensing uncertainty arises from many-to-one mappings
- A partition lattice based on mapping preimages reveals important filtering structure
- The sensor lattice is traversed during filtering



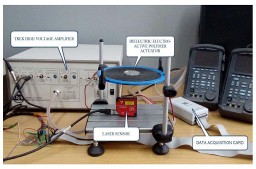
Sensory Feedback in Robotics

Chair *Eduardo Bayro-Corrochano, CINVESTAV, Unidad Guadalajara*
Co-Chair

15:45–16:10	WeD1.1

Adaptive Controller with Output Feedback for Dielectric Electro-Active Polymer Actuator

Jakub Bernat and Jakub Kołota
Institute of Automation and Robotics
Poznan University of Technology, Poland



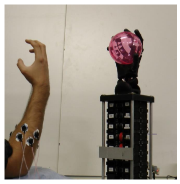
- An adaptive controller with output feedback was used in order to solve the position control of a nonlinear actuator built with a Dielectric Electro-Active Polymer
- Paper presents the modeling process of the device taking into account the nonlinear model and its linearization.
- The identification process was carried out and the results were compared with experiments with good agreement.
- The authors applied Model Reference Adaptive Controller with output feedback were voltage is an input signal and distance is an output.
- Presented approach allows to development a control method resistant to changing the parameters of DEAP device.

16:10–16:35	WeD1.2

Design and Evaluation of a Factorization-Based Grasp Myoelectric Control Founded on Synergies

Roberto Meattini, Daniele De Gregorio, Gianluca Palli and Claudio Melchiorri
DEI – Department of Eletrical, Electronic and System Engineering
University of Bologna, Italy

- The article presents a **factorization-based myoelectric proportional** control for the hand closure level of a robotic hand



- **Four different factorization algorithms** are tested (Factor Analysis, Fast Independent Component Analysis, Non-negative Matrix Factorization and Principal Component Analysis)
- The results report for **better performances of the Non-negative Matrix Factorization** algorithm, that can be used for controlling robotic hands in a real telemanipulation scenario

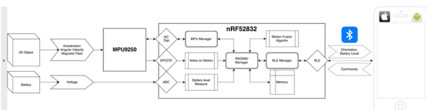
16:35–17:00	WeD1.3

RSQ Motion – a prototype of the motion analysis system in the joints

Piotr Sauer
Institute of Automation and Robotics, Poznan University of Technology, Poland
B. Lubiatowski, S. Chorodeński, B. Breninek, K. Gruszczyński
RSQ Technology Company, Polnad

- RSQ Motion is the diagnostic system which allows to analyze the movement of human body.
- This system can be used in proprioception studies.
- The RSQ system is built from 15 measuring modules.
- Each module contains MPU-9250 sensor

Avatar in the unity environment – visualisation of left hand movement



Idea of RSQ Motion operation

RoMoCo'19 Author Index

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