RAAD 2019 Germany Kaiserslautern

28th International Conference on Robotics in Alpe-Adria-Danube Region

June 19-21, 2019

Fraunhofer Zentrum Kaiserslautern
Technische Universität Kaiserslautern

Organized by: RRLab, TU Kaiserslautern

Book of Abstracts

Contents

Foreword

We like to welcome you to the 28th International Conference on Robotics in Alpe-Adria-Danube Region - RAAD 2019! Founded in 1992, the RAAD conference has become a solid annual event, well established in the European robotics community.

This year, RAAD 2019 is organized by the Robotics Research Lab of the department of computer science, Technische Universität Kaiserslautern. We are proud to welcome you to this year's conference in the city Kaiserslautern.

Kaiserslautern is an industrial and university city in the state Rhineland-Palatinate in the southwest of Germany. Our city is directly attached to the northwest edge of the Palatinate Forest, the biggest contiguous forest of Germany. Hence, Kaiserslautern is beautifully framed in the south and east by wooded heights like the so called Humberg or the Kahlenberg. With the foundation of the Technische Universität Kaiserslautern in 1969, its continuous growth and the settlement of several research institutes in the university's surrounding, Kaiserslautern has become a known center of research and innovation for all major technical disciplines in Germany. RAAD 2019 is therefore located within the internationally well-known research institute Fraunhofer Zentrum Kaiserslautern.

RAAD 2019 covers all major areas of robotic research, development and innovation. Among others, new applications and current trends such as Industry 4.0, Human-Robot Interaction, Medical and Rehabilitation Robotics, Robot Control and Machine Learning are covered. In relation to these topics, we are very proud that three renowned keynote speakers present the state as well as future innovations in their main research areas. These are Giovanni Muscato (Navigation of mobile robots in rough outdoor environments), Andreas Müller (Geometric Modeling of Robotic Manipulators – A Short Overview for Practitioners) and J. Marius Zöllner (From Deep Learning to Autonomous Driving).

Keeping the high quality of the conference, a thorough review process was held for paper acceptance. The review process resulted in the acceptance of 44 regular papers and 19 special session contributions out of 71 original submissions. All accepted contributions are presented throughout the conference, organized in 3 special and 10 technical sessions, bringing together leading robotic researchers from 20 countries. A special acknowledgement goes to all authors for their excellent work and to all reviewers for their professional and detailed feedback to the authors.

Beside the academic talks, several technical and social events are organized to support a friendly, cooperative and innovative spirit throughout the conference. Among others, these include technical exhibitions, excursions and guided tours.

A lot of work is required organizing this conference, we like to thank all involved persons for their spent time and effort. First of all, we would like to thank our main sponsor, the Deutsche Forschungsgemeinschaft (DFG). Further, we would like to thank the Fraunhofer Zentrum Kaiserslautern, the Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) and the Technische Universität Kaiserslautern (TUK) for providing the conference locations, technical demonstrations and administration. A special gratitude also goes to the international scientific committee, the conference's advisory board and the national and local organizing committees for their valuable support. Finally, we would like to thank all of you for participation at RAAD 2019.

We wish you a pleasant stay here in Kaiserslautern and a fruitful conference attendance.

Kaiserslautern, 19th June 2019

Karsten Berns
General Chair of RAAD 2019

Daniel Görges
Co-Chair of RAAD 2019

Organization

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Prof. Dr. K. Berns, TU Kaiserslautern

Co-Chair

Jun.-Prof. Dr.-Ing. D. Görges, TU Kaiserslautern

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Marco Ceccarelli, University of Cassino, Italy
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Roman Kamnik, University of Ljubljana, Slovenia
Gernot Kronreif, ACMIT GmbH, Austria
Andreas Mueller, Johannes Kepler University Linz, Austria
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Conference Information

All attendees must register. A personal badge will be provided to identify registered participants. All registered participants will receive a USB flash drive containing the RAAD 2019 Proceedings. A reduced registration is available for students. Full registration also includes all the social events.

Registration and Help Desks

The registration and help desks are located in the entrance area of the Fraunhofer Center and will be always active during the conference.

Registration Hours:
Tuesday June 18th: 16.00-18.00
Wednesday June 19th: 8:00-18:00
Thursday June 20th: 8:00-14:00
Friday June 21th: 8:00-10.00

Keynotes, Special and Technical Sessions

All conference rooms are located on the ground floor of the Fraunhofer Center surrounding a shared lobby area. The opening and closing ceremony, as well as all Keynotes and all special sessions will be held within the lecture hall, room Z02.02. Technical sessions are located at the two rooms Z03.08 and Z03.07. Please find the program at a glance including all sessions and rooms on page 12.

Technical Exhibition

During the conference breaks, a technical exhibition is taking place on the first floor, right above the conference lobby. Local research groups are presenting their latest achievements and offer live demonstrations of several individual robotic systems. The exhibition area can be reached by stairs directly from within the conference lobby.

Welcome Cocktail

Start: Wednesday, June 19th, 19.30-22.00
Location: Theodor-Zink-Museum Kaiserslautern

We kindly like to invite all the attendees of RAAD 2019 together with the accompanying guests to come together at our welcome cocktail. It takes place at the Theodor-Zink-Museum within the center of the city. Its exact address is Steinstraße 48 and can be reached:

a) by taxi (4 minutes from city center)
b) by bus from the bus station "Stadtmitte" -> bus no. 104 from platform D to bus station "Mainzer Tor"
c) on foot (8 minutes from city center)

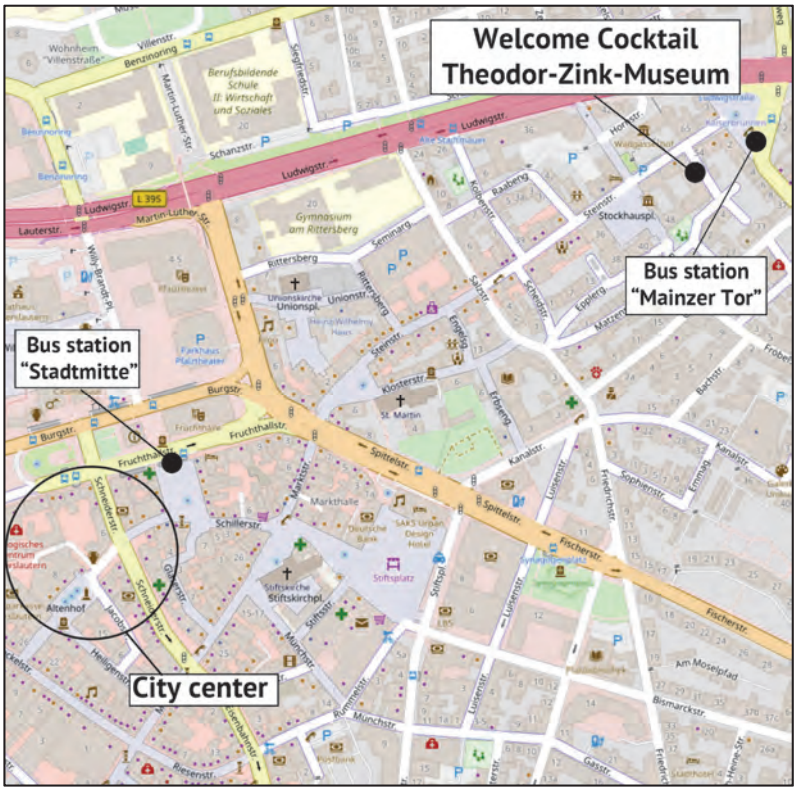

Figure 1: Welcome Cocktail "Theodor-Zink-Museum" (Map © OpenStreetMap contributors)

Social Event

Start: Thursday, June 20th, 14.15 at Fraunhofer Center
Location: World Cultural Heritage Site "Völklinger Hütte"

All RAAD 2019 conference attendees and their accompanying guests are invited to attend the guided tour to the "Völklinger Hütte". Please register your attendance to the Help desk.
The "Völklinger Hütte" is located in Völklingen in the state of Saarland. In 1994 it was the first monument of heavy industry to be classified by UNESCO as World Cultural Heritage Site. The tour of the "Völklinger Hütte", with more than 7000 meters of exciting walkways will take about two hours and will be guided in English language. After the tour you can walk around by yourself. The bus will drive back to Kaiserslautern at about 18:30 and will take you directly to the gala dinner.

Gala dinner

Start: Thursday, June 20th, 20.00
Location: At the brewery "Das Brauhaus" at "Gartenschau"

"Das Brauhaus" is located in Forellenstraße 6 near to the "Gartenschau".
It can be reached

a) by taxi (5 minutes from city center)
b) by bus from the bus station "Stadtmitte"
   bus stations near to the location: "Kammgarnstraße" -> bus no. 101 from platform B or "Kaiserslautern-West/ Westbahnhof" -> bus no. 112 from platform B
c) on foot (16 minutes from city center)
d) or you can take the train "RB 66" from the central railway station to "Kaiserslautern-West/Westbahnhof" (5 minutes).

Your personal badge serves as ticket for the gala dinner, please take care to carry it with you to the dinner location.

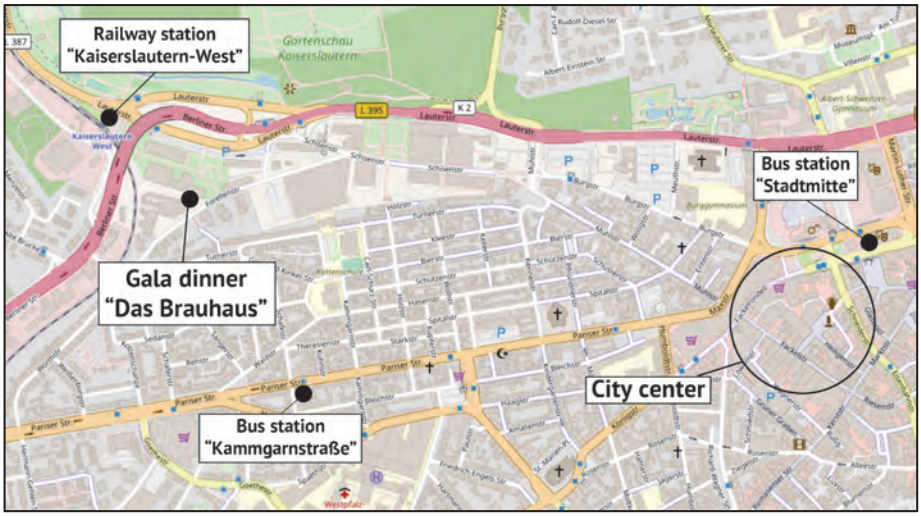

Figure 2: Gala dinner "Das Brauhaus" (Map © OpenStreetMap contributors)

Closing Ceremony

Start: Friday, June 21th 2019, 12.45-13.00
Location: Fraunhofer Center, Z02.02

We like to invite all accompanying guests to attend the closing ceremony together with the conference attendees at the Fraunhofer Center, saying goodbye to friends and colleagues

Internet

A wireless access (Eduroam included) to the Internet will be available at the Conference site.

Transportation in Kaiserslautern

There are two ways to reach the Fraunhofer Center from the city center.

a) By Taxi: It takes about 8 minutes and it costs about 10 €.

b) By Bus: The central bus station is called "Stadtmitte". From "Stadtmitte platform F" (near to the fountain) you can use the bus no. 115 to "Universität" (It takes 13 minutes) or the bus no. 106 to "Mölschbach" (It takes 8 minutes). Both buses also stop at the central railway station during the ride. Get off the bus at "Fraunhofer-Zentrum".
Important: On Thursday June 20th is a local holiday. On that day you can only use the bus no. 106. A ticket can be purchased inside the Bus in the cost of 2,10 €.
For detailed information and departure times please download the app: "myVRN"

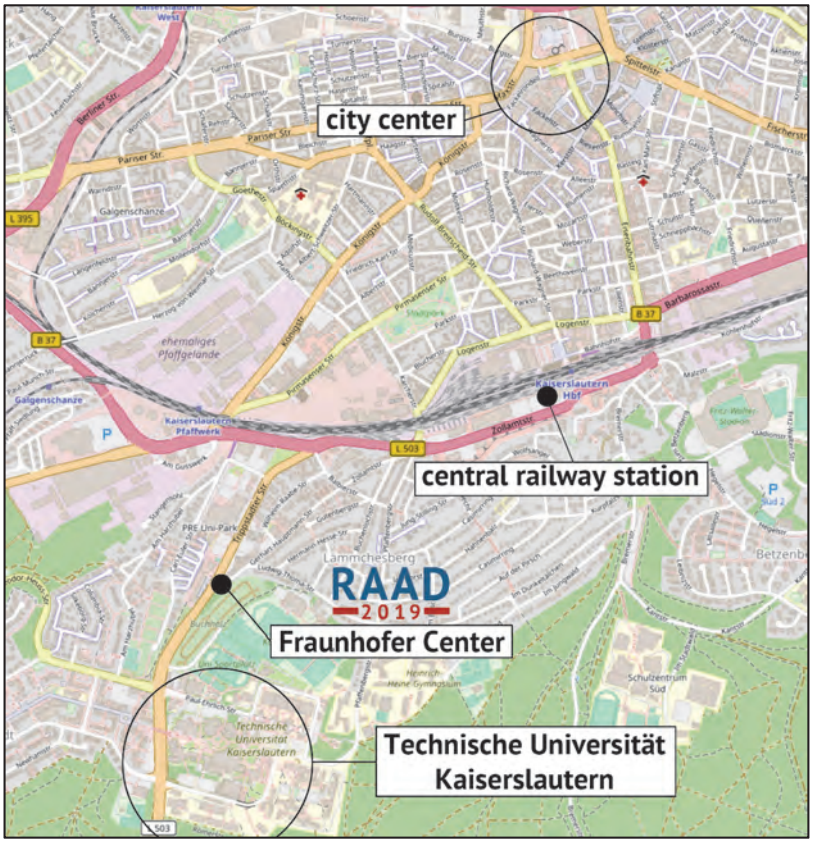

Figure 3: Transportation in Kaiserslautern (Map © OpenStreetMap contributors)

Useful Information

The currency in Germany is EURO (€). ATMs are widely available in the city center and operate all day long. Visa and MasterCard are widely accepted.

Tipping is optional and is about 10% of the bill.

Please be aware, that Thursday June 20th is a holiday. This means that apart from restaurants and bars almost all shops have closed, including supermarkets.

Program at a glance

Tuesday, June 18th	
16.00-18.00	Registration
17.00-17:30	Presentation ITWM
17.45-18.15	Presentation Smart Factory DFKI
18.15-19.30	Come Together @DFKI

Wednesday, June 19th			
Rooms	**Z02.02**	**Z03.08**	**Z03.07**
8.15-9.30	Registration		
9.00-9.30	Opening Ceremony (Z02.02)		
9.30-10.30	Keynote I (Z02.02)		
10.30-11.00	Coffee Break		
11.00-13.00	WeSS01	WeST01	WeST02
13.00-14.00	Lunch break		
14.00-16.00	WeSS02	WeST03	WeST04
16.00-16:30	Coffee Break		
16:30-17:30	WeSS03	WeST05	WeST06
19:30-22:00	Welcome Cocktail		

Thursday, June 20th			
Rooms	**Z02.02**	**Z03.08**	**Z03.07**
8.30-10.30	ThSS01	ThST01	ThST02
10.30-11.00	Coffee Break		
11.00-12.00	Keynote II (Z02.02)		
12.00-13.00	Lunch Break and ISC meeting*)		
13.00-14.00	ThST03	ThST04	ThST05
14.15	Departure to Social Event		
20.00	Gala Dinner, Award ceremony		

Friday, June 21th			
Rooms	**Z02.02**	**Z03.08**	**Z03.07**
9.00-10.00	FrSS01	FrST01	FrST02
10.00-11.00	Keynote III (Z02.02)		
11.00-11.15	Coffee Break		
11.15-12.45	FrSS02	FrST03	FrST04
12.45-13.00	Closing Ceremony		

*) ISC meeting until 14.00

Presentation time: 25 Min. + 5 Min. discussion each

Rooms

Z02.02	**Lecture hall**
Z03.08	**Seminar room**
Z03.07	**Seminar room**

Session Titles

WeSS01: Safety Related Devices and Applications I
WeST01: Medical Robotics
WeST02: Mechanical Design and Kinematics I
WeSS02: Advances in Human-Robot Interaction I
WeST03: Path Planning and Navigation I
WeST04: Industry Robotics I
WeSS03: Safety Related Devices and Applications II
WeST05: Path Planning and Navigation II
WeST06: Industry Robotics II
ThSS01: Advances in Human-Robot Interaction II
ThST01: Mechanical Design and Kinematics II
ThST02: Control I
ThST03: Communication
ThST04: Learning I
ThST05: Control II
FrSS01: Flexible Manufacturing in Industry 4.0 Environments I
FrST01: Learning II
FrST02: Multi Robot Systems
FrSS02: Flexible Manufacturing in Industry 4.0 Environments II
FrST03: Rehabilitation Robotics and Exoskeletons
FrST04: Vision
Keynote I: From Deep Learning to Autonomous Driving
Keynote II: Navigation of mobile robots in rough outdoor environments
Keynote III: Geometric Modeling of Robotic Manipulators – A Short Overview for Practitioners

Wednesday June 19th 2019		**9.30-10.30**
Room Z02.02	**Keynote I**	**From Deep Learning to Autonomous Driving** **Presenter:** *Prof. Dr. J. Marius Zöllner (KIT, Karlsruhe Institute of Technology and FZI, Karlsruhe, Germany)* **Chair:** *Karsten Berns (TU Kaiserslautern)*

Wednesday June 19th 2019		**11.00-13.00**
Room Z02.02	WeSS01	**Safety Related Devices and Applications I** **Chair: Med Amine Laribi (Université de Poitiers)** **Giuseppe Carbone (Università degli studi di Cassino e del Lazio Meridionale**)
11.00-11.30	113	Validation of an Ergonomic Contactless Master Device for a Teleoperation Platform *Sandoval Arevalo, Juan Sebastian*
11.30-12.00	126	Collaborative Robotics Safety Control Application using Dynamic Safety Zones based on the ISO/TS 15066:2016 *Giusti, Andrea*
12.00-12.30	134	Versatile Collaborative Robot Applications through Safety-rated Modification Limits *Brandstötter, Mathias*
12.30-13.00	144	Kinematic and Force Experiments on Cadavers for the Specification of a Tele-operated Craniotomy Robot *Laribi, Med Amine*

Wednesday June 19th 2019		**11.00-13.00**
Room Z03.08	WeST01	**Medical Robotics** **Chair: Roman Kamnik (University of Ljubljana)**
11.00-11.30	131	Extension of Matlab's PDE Toolbox for Developing Bionic Structural Optimization Methods: Overlapping Region Concept *Sun, Yilun*
11.30-12.00	112	Kinematic Design of a Hybrid Mechanism for Bone Reduction Surgery *Essomba, Terence*
12.00-12.30	117	Pneumo-tronic Perturbator For The Study Of Human Postural Responses *De Benedictis, Carlo*
12.30-13.00	139	Tilt-twist Method using Inertial Sensors to assess Spinal Posture during Gait *Digo, Elisa*

Wednesday June 19th 2019		**11.00-13.00**
Room Z03.07	WeST02	**Mechanical Design and Kinematics I** **Chair: Aleksandar Dragan Rodić (Institute Mihailo Pupin)**
11.00-11.30	109	An Integrated Taxonomy And Critical Review Of Module Designs For Serial Reconfigurable Manipulators *Stravopodis, Nikolaos Athanasios*
11.30-12.00	118	Geometry and Inverse Kinematics of 3- PRRS Type Parallel Manipulator *Baigunchekov, Zhumadil*
12.00-12.30	124	Linear Motion Mechanisms for Fine Position Adjustment of Heavy Weight Platforms *Hricko, Jaroslav*
12.30-13.00	125	Compliant Mechanisms for Motion/Force Amplifiers for Robotics *Hricko, Jaroslav*

Wednesday June 19th 2019		**14.00-16.00**
Room Z02.02	WeSS02	**Advances in Human-Robot Interaction I** **Chair: Kosta Jovanovic (ETF)** **Tadej Petric (Jožef Stefan Institute)**
14.00-14.30	106	Bounded Self-Motion of Functional Redundant Robots *Žlajpah, Leon*
14.30-15.00	116	On-line Adaption of Virtual Guides Through Physical Interaction *Petric, Tadej*
15.00-15.30	123	A Comparison of Policy Search in Joint Space and Cartesian Space for Refinement of Skills *Fabisch, Alexander*
15.30-16.00	127	KUKA LWR Robot Cartesian Stiffness Control Based on Kinematic Redundancy *Lukić, Branko*

Wednesday June 19th 2019		**14.00-16.00**
Room Z03.08	WeST03	**Path Planning and Navigation I** **Chair: Ivana Budinska (Slovak Academy of Sciences)**
14.00-14.30	130	Automatic Path Planning for Unmanned Ground Vehicle using UAV imagery *Zoto, Jurgen*
14.30-15.00	135	Indoor Navigation Using Existing Infrastructure for Professional Service Robots *Krastev, Evgeniy Hristov*
15.00-15.30	167	Online Trajectory Planning and Collision Avoidance for a Group of Robots using Distributed Model Predictive Control *Görges, Daniel*
15.30-16.00	166	Whole-Body Planning for Obstacle Traversal with Autonomous Mobile Ground Robots *Oehler, Martin Sven*

Wednesday June 19th 2019		**14.00-16.00**
Room Z03.07	WeST04	**Industry Robotics I** **Chair: Roman Kamnik (University of Ljubljana)**
14.00-14.30	105	Task-Dependent Energetic Analysis Of A 3 D.o.f. Industrial Manipulator *Gasparetto, Alessandro*
14.30-15.00	147	3D Printing with 6D of Freedom: Controlling Material Extrusion Speed *Kraljic, David*
15.00-15.30	164	Robotic Knitting in String Art as a Tool for Creative Design Processes *Jovanović, Marko*
15.30-16.00	156	Towards Using Natural User Interfaces for Robotic Arm Manipulation *Girbacia, Florin Stelian*

Wednesday June 19th 2019		**16.30-17.30**
Room Z02.02	WeSS03	**Safety Related Devices and Applications II** **Chair: Med Amine Laribi (Université de Poitiers)** **Giuseppe Carbone (Università degli studi di Cassino e del Lazio Meridionale)**
16.30-17.00	155	Efficient, Risk-Encoding Octrees For Path Planning With A Robot Manipulator *Werner, Tobias*
17.00-17.30	169	Structural Compliance Effects on the Accuracy and Safety of a R-CUBE Haptic Device *Carbone, Giuseppe*

Wednesday June 19th 2019		**16.30-17.30**
Room Z03.08	WeST05	**Path Planning and Navigation II** **Chair: Ivana Budinska (Slovak Academy of Sciences)**
16.30-17.00	159	Connections for Path Planning in Mobile Robotics *Nitulescu, Mircea*
17.00-17.30	171	Safe and Efficient Navigation of Autonomous Shuttle in Pedestrian Zone *Jan, Qazi Hamza*

Wednesday June 19th 2019		**16.30-17.30**
Room Z03.07	WeST06	**Industry Robotics II** **Chair: Leon Zlajpah (Jožef Stefan Institute)**
16.30-17.00	141	Grounding Of Uncertain Force Parameters In Spoken Robot Commands *Wölfel, Kim*
17.00-17.30	165	Integrated Palletizing Workstation With An Industrial Robot And a Cobot *Kováč, Juraj*

Thursday June 20th 2019		**8.30-10.30**
Room Z02.02	ThSS01	**Advances in Human-Robot Interaction II** **Chair: Kosta Jovanovic (ETF)** **Tadej Petric (Jožef Stefan Institute)**
8.30-9.00	132	Influence of Unmodelled External Forces on the Quality of Collision Detection *Gordic, Zavisa*
9.00-9.30	142	Use of Bimanual Haptic Teleoperation System for Optimized Task Performance with Adaptive Haptic Tunnel *Piškur, Jožica*
9.30-10.00	154	Feedforward Control Approaches to Bidirectional Antagonistic Actuators Based on Learning *Knežević, Nikola Milomir*
10.00-10.30	160	Knowledge Acquisition Through Human Demonstration For Industrial Robotic Assembly *Gašpar, Timotej*

Thursday June 20th 2019		**8.30-10.30**
Room Z03.08	ThST01	**Mechanical Design and Kinematics II** **Chair: Said Zeghloul (Poitiers University)**
8.30-9.00	133	Design and Control of a Flapping Wing System Test Bench *Zarate Moya, Jose Luis*
9.00-9.30	143	Approximation Of Inverse Kinematic Solution Of A Metamorphic 3R Manipulator With MLP *Moulianitis,* Vassilis C.
9.30-10.00	163	Mechanical Design, Modeling and Simulation of Human-Size Cable-Driven Over-Actuated Robotic Arm *Rodić, Aleksandar Dragan*
10.00-10.30	172	A General Approach for Automating Teleoperated Construction Machines *Lee, Hyung Joo & Brell-Cokcan, Sigrid*

Thursday June 20th 2019		**8.30-10.30**
Room Z03.07	ThST02	**Control I** **Chair: Alessandro Gasparetto (University of Udine)**
8.30-9.00	158	Torque-Based Velocity Control for Safe Human-Humanoid Interaction *Kaul, Lukas*
9.00-9.30	104	On an Analytic Generation of Null Space Spanners in Robotics *Duleba, Ignacy*
9.30-10.00	119	Velocity Motion Path Control of Redundant Robot arms *Krastev, Evgeniy Hristov*
10.00-10.30	122	Reduction of Trajectory Encoding Data using a Deep Autoencoder Network: Robotic Throwing *Loncarevic, Zvezdan*

Thursday June 20th 2019		**11.00-12.00**
Room Z02.02	**Keynote II**	**Navigation of mobile robots in rough outdoor environments** **Presenter:** *Prof. Giovanni Muscato (IEEI University of Catania, Italy)* **Chair:** *Karsten Berns (TU Kaiserslautern)*

Thursday June 20th 2019		**13.00-14.00**
Room Z02.02	ThST03	**Communication** **Chair: Kosta Jovanovic (ETF)**
13:00-13.30	103	Communication Between Robots over Intelligent Objects Realized by RFID Tags *Thormann, Christian*
13.30-14.00	107	Average Consensus with Bounded Execution under Quantization Noise *Kenyeres, Martin*

Thursday June 20th 2019		**13.00-14.00**
Room Z03.08	ThST04	**Learning I** **Chair: Giovanni Muscato (IEEI University of Catania)**
13.00-13.30	110	Task Dependent Trajectory Learning from Multiple Demonstrations using Movement Primitives *Vidaković, Josip*
13.30-14.00	153	Learning to Predict 2D Object Instances by Applying Model-Based 6D Pose Estimation *Kisner, Hannes*

Thursday June 20th 2019		**13.00-14.00**
Room Z03.07	ThST05	**Control II** **Chair: Daniel Görges (TU Kaiserslautern)**
13.00-13.30	129	Shared Impedance Control Based on Reinforcement Learning in a Human-Robot Collaboration Task *Wu, Min*
13.30-14.00	150	Gain Scheduled PID Force Control Of A Robotic Arm For Sewing Fabrics *Koustoumpardis, Panagiotis N.*

Friday June 21th 2019		**9.00-10.00**
Room Z02.02	FrSS01	**Flexible Manufacturing in Industry 4.0 Environments I** **Chair: Achim Wager (German Research Center for Artificial Intelligence (DFKI))**
9.00-9.30	115	Implementation of an autonomous Tool Trolley in a Production Line *Engemann, Heiko*
9.30-10.00	136	Developing a Production Scheduling System for Modular Factory Using Constraint Programming *Park, Hoonseok*

Friday June 21th 2019		**9.00-10.00**
Room Z03.08	FrST01	**Learning II** **Chair: Carlo Ferraresi (Polytechnic of Turin)**
9.00-9.30	157	Dataset Generation Using A Simulated World *Vierling, Axel*
9.30-10.00	161	Convolutional Encoder-Decoder Networks for Robust Image-to-Motion Prediction *Ridge, Barry Martin*

Friday June 21th 2019		**9.00-10.00**
Room Z03.07	FrST02	**Multi Robot Systems** **Chair: Nick Andrei Ivanescu (Polytechnic University of Bucharest)**
9.00-9.30	138	A Swarm Algorithm Inspired by Tree-Dwelling Bats. Experiments and Evaluations *Budinska, Ivana*
9.30-10.00	149	A Cloud Based Solution for Secure Sharing Robot and Manufacturing Resources for Research *Anton, Florin*

Friday June 21th 2019		**10.00-11.00**
Room Z02.02	**Keynote III**	**Geometric Modeling of Robotic Manipulators – A Short Overview for Practitioners** **Presenter:** *Univ.-Prof. Dr.-Ing. habil. Andreas Müller (Johannes Kepler University, Linz, Austria)* **Chair:** *Leon Zlajpah (Jožef Stefan Institute)*

Friday June 21th 2019		**11.15-12:45**
Room Z02.02	FrSS02	**Flexible Manufacturing in Industry 4.0 Environments II** **Chair: Achim Wager (German Research Center for Artificial Intelligence (DFKI))**
11.15-11.45	151	Robotic System Reliability Analysis And RUL Estimation Using An Iterative Approach *Pellegrini, Nicola*
11.45-12.15	162	Edge Computing in Smart Production *Um, Jumyung*
12:15-12:45	168	Neural Adaptive Control of a Robot Joint Using Secondary Encoders *Volkmann, Magnus*

Friday June 21th 2019		**11.15-12:45**
Room Z03.08	FrST03	**Rehabilitation Robotics and Exoskeletons** **Chair: Said Zeghloul (Poitiers University)**
11.15-11.45	101	Wrist Rehabilitation Equipment Based on the Fin-Ray® Effect *Deaconescu, Andrea*
11.45-12.15	146	A Two-degree of Freedom Mobile Ankle Rehabilitation Unit (MARU) to Improve and Track Joint Mobility *Detzel, Samuel*
12:15-12:45	140	Model Based Analysis of Trunk Exoskeleton for Human Efforts Reduction *Panero, Elisa*

Friday June 21th 2019		**11.15-12:45**
Room Z03.07	FrST04	**Vision** **Chair: Karol Dobrovodsky (Slovak Academy of Sciences)**
11.15-11.45	111	Adaptive Recognition for Tracking of Moving Objects *Dobrovodský, Karol*
11.45-12.15	114	Probabilistic Orientation Resolution for Near Symmetrical Objects using Depth Images *Hafez, Nawal Amr*
12:15-12:45	170	Generation Of Elevation Maps For Planning And Navigation Of Vehicles In Rough Natural Terrain *Keen, Hannan Ejaz*

Detailed program, Wednesday, June 19th 2019

Room Z02.02	Keynote I
Chair: Karsten Berns (TU Kaiserslautern)	

From Deep Learning to Autonomous Driving	
Prof. Dr. J. Marius Zöllner (KIT, Karlsruhe Institute of Technology and FZI)	
Keynote I	9.30-10.30
Abstract. Deep Learning and Autonomous Driving are emerging research topics that become more and more interweaved. Besides continuously upcoming new achievements in learning, we see successful approaches in the domain of autonomous vehicles reaching from learning individual components of the overall system, over several components at once, up to directly learning vehicle control commands from visual sensor input. However, when bringing these approaches to real world autonomous driving, the question on how to safely incorporate those techniques into production-grade vehicles arises. This issue can be considered manageable when learning techniques are used for highly dedicated perception tasks with a single learning step, but becomes more complex with increasing responsibilities of the learning system. If vehicles are controlled by learning-based approaches directly, rare failures will have immediate impact and thus more severe consequences. This emphasizes the importance for research towards the additional integration of expert knowledge in order to constrain vehicle behaviors in terms of safety and reliability. This presentation will outline the power and computational expressiveness of deep learning approaches in autonomous driving. Furthermore, the potential of current end-to-end learning concepts for vehicle control using supervised and unsupervised methods will be discussed. This will be followed by potential methods to combine such learning algorithms with model driven and probabilistic approaches in order to gain comprehensiveness and accountability. Experiments and results from real world scenarios with our autonomous research car CoCar will be shown.	
Biography. Prof. Dr. J. Marius Zöllner studied computer science with special focus on artificial intelligence and robotics at the University of Karlsruhe where he also received his Dr.-Ing. degree (Ph.D.) in 2005. From 1999 he worked with FZI Research Center for Information Technology where he became division manager in 2006. Since 2008 he is professor for Applied Technical Cognitive Systems at the KIT, Karlsruhe Institute of Technology and director at the FZI. Since 2012 he is also member of the executive board of the FZI. Current research activities are focusing on cognitive cars and service robotics. His main areas of research are in the perception and interpretation of the driving environment, probabilistic situation understanding, behaviour decision and machine learning.	

Room Z02.02	WeSS01	Safety Related Devices and Applications I
Chair: Med Amine Laribi (Université de Poitiers) Giuseppe Carbone (Università degli studi di Cassino e del Lazio Meridionale)		

Validation of an Ergonomic Contactless Master Device for a Teleoperation Platform	
Sandoval, Juan (University of Poitiers, PPRIME Institute) *Laribi, Med Amine (University of Poitiers, PPRIME Institute)* *Zeghloul, Said (University of Poitiers, PPRIME Institute)*	113
WeSS01-1	11.00-11.30
Abstract. In this paper we evaluate the accuracy of a contactless 6-DoF master device for a teleoperation platform. The master device is a low-cost optical tracking system, i.e. Leap Motion, capable of recognize and track the hand movements. A method to evaluate its accuracy by using a Qualisys motion capture system composed of 8 high-resolution cameras is proposed. In addition, the teleoperation control architecture is presented, where a torque-controlled robot is employed as the slave device, i.e. a 7-DoF Franka Emika robot. The results presented in this paper allow to validate the use of the Leap Motion as an accurate master device in a teleoperation chain while also to evaluate its use limits.	

Collaborative Robotics Safety Control Application using Dynamic Safety Zones based on the ISO/TS 15066:2016	
Di Cosmo, Vincenzo (Fraunhofer Italia, Free University of Bolzano) *Giusti, Andrea (Fraunhofer Italia)* *Vidoni, Renato (Free University of Bolzano)* *Riedl, Michael (Fraunhofer Italia)* *Matt, Dominik Tobias (Fraunhofer Italia, Free University of Bolzano)*	126
WeSS01-2	11.30-12.00
Abstract. In this work we propose a safety control approach for industrial applications of collaborative robotics based on the requirements of the latest safety standards. The safety requirements are verified by performing intersection tests between bounding volumes whose dimensions are computed online, based on the speed of the manipulator along its stopping trajectory. This approach aims at tackling efficiency problems that may arise enforcing excessively conservative constraints that would impair the contribution of the robot to collaborative tasks. It does so, neither undermining the robustness of the safety algorithm nor increasing excessively its complexity. To this end, implementation and computational simplicity have been preferred by 1) evaluating online only the largest contributions to the protective separation distance required by the technical specification, and 2) using a conservative approach for less predictable data. The proposed method has been tested by means of an experiment for collaborative pick-and-place operations.	

Versatile Collaborative Robot Applications through Safety-rated Modification Limits	
Brandstötter, Mathias (Joanneum Research) *Komenda, Titanilla (Fraunhofer Austria Research GmbH,* *Vienna University of Technology)* *Ranz, Fabian (Fraunhofer Austria Research GmbH, Vienna University of Technology)* *Wedenig, Philipp (Joanneum Research)* *Gattringer, Hubert (Johannes Kepler University Linz)* *Kaiser, Lukas (Joanneum Research)* *Breitenhuber, Guido (Joanneum Research)* *Schlotzhauer, Andreas (Joanneum Research)* *Müller, Andreas (Johannes Kepler University Linz)* *Hofbaur, Michael (Joanneum Research)*	134
WeSS01-3	12.00-12.30
Abstract. A robot is a flexible tool and handling device. However, by eliminating safety fences when using collaborative robots, regulations on personal safety must be followed. This has a tremendous influence on the application flexibility of such robotic systems. Any modification on the system or application will require a new risk assessment before the system can be put back into operation. This circumstance costs time and money and stands in contradiction to the nature of a robot as a versatile and adaptable device. In this paper we present a potential solution to overcome this restriction. To this end, safety-rated modification dimensions are introduced and admissible variations are determined indicating the limits up to which the system or application can be changed in compliance with safety regulations. A model-based strategy for estimating the aforementioned modification limits is presented. For simple use case modifications, this method can easily be illustrated as presented in this paper. The proposed approach gives rise to a novel safety concept for collaborative robotic applications, which ensures flexibility while respecting safety standards.	

Kinematic and Force Experiments on Cadavers for the Specification of a Tele-operated Craniotomy Robot	
Essomba, Terence (Pprime Institute) *Sandoval, Juan (Pprime Institute)* *Laribi, Med Amine (National Central University)* *Wu, Chieh-Tsai (Chang Gung Memorial Hospital)* *Breque, Cyril (Pprime Institute, University of Poitiers)* *Zeghloul, Said (Pprime Institute)* *Richer, Jean-Pierre (University of Poitiers)*	144
WeSS01-4	12.30-13.00
Abstract. This paper presents a preliminary study for the characterization of Burrhole craniotomy procedures, in order to define the specifications for the design of a teleoperated craniotomy robot. Surgeon's gestures are recorded through a motion capture system during the execution of several craniotomy tasks, allowing to characterize the drilling tool range movements. Moreover, a tele-operated platform is used to record the interaction forces produced between the drilling tool and the human skull during the procedure, obtaining an order of magnitude of the force feedback a dedicated tele-operated craniotomy system would need to provide during a craniotomy procedure.	

Room Z03.08	WeST01	Medical Robotics
Chair: Roman Kamnik (University of Ljubljana)		

Extension of Matlab's PDE Toolbox for Developing Bionic Structural Optimization Methods: Overlapping Region Concept	
Sun, Yilun (Technical University of Munich) *Lueth, Tim C. (Technical University of Munich)*	131
WeST01-1	11.00-11.30

Abstract. In this paper, we present a novel method called Overlapping Region Concept to extend Matlab's Partial Differential Equation (PDE) Toolbox to apply free-form surface loads during finite element analysis. In our institute, we are developing a toolbox called SG-Library in Matlab to combine multidisciplinary methods to achieve automatic design and manufacturing of medical robots and mechanisms. Recently, we have also integrated the PDE Toolbox into the SG-Library to develop some bionic methods like CAO and SKO to optimize the structure of our robots. During the implementation of these bionic methods, we have encountered the problem of applying free-form surface loads in FEM analysis. The typical workflow of PDE Toolbox separates the surface of a 3D geometry into one or more feature surfaces with sharp boundaries. Boundary conditions can be only applied to such feature surfaces. This is a remarkable drawback for the development of our methods since the surface profile of our model is constantly changing during the shape optimization. Therefore, we need to develop a method to apply free-form surface loads independent from the feature surfaces. In this paper, we use the concept of overlapping region to determine the free-form surface for applying boundary conditions. With this new method, we can achieve robust FEM analysis during the structural optimization process.

Kinematic Design of a Hybrid Mechanism for Bone Reduction Surgery	
Essomba, Terence (National Central University) *Nguyen Phu, Sinh (National Central University)*	112
WeST01-2	11.30-12.00

Abstract. In severe fracture cases, a bone can be completely separated into two fragments. In order to guarantee a re-ossification of the bone, it is mandatory to reposition the bone fragment together. This process requires a delicate surgery called "bone reduction surgery". The most advanced technique relies on the use of a robots to manipulate the bone fragments with higher precision and stability. The present work introduces the kinematic design of a new hybrid mechanical architecture to perform this task. It is made of one 3-PRP planar mechanism and one 3-RPS tripod mechanism. Its kinematic model is resolved while taking account the tripod parasitic motion. The workspace of this mechanism is then compared to the standard hexapod mechanism that is widely used in bone reduction surgery. It reveals that the proposed mechanism benefits from a larger workspace.

Pneumo-tronic Perturbator For The Study Of Human Postural Responses	
Maffiodo, Daniela (Politecnico di Torino) *Franco, Walter (Politecnico di Torino)* *De Benedictis, Carlo ((Politecnico di Torino)* *Paterna, Maria (Politecnico di Torino)* *Muscolo, Giovanni Gerardo (Politecnico di Torino)* *Roatta, Silvestro (University of Torino)* *Ferraresi, Carlo (Politecnico di Torino)* *Dvir, Zeevi (Tel Aviv University)*	117
WeST01-3	12.00-12.30
Abstract. This paper describes the design and operational principles of a device that imparts a well-controlled mechanical force or impulse, a so-called perturbation, to a pre-selected point on the surface of the human body. This perturbator will be integrated within a system aimed at measuring and evaluating human postural reaction in a clinically meaningful way. The ease of use and versatility of the device renders it suitable for manual operation but it can also be integrated in a robotized system. The hardware, control law and characterization of the perturbator are presented. Preliminary results indicate that the device is able to generate repeatable perturbations with characteristics appropriate to the intended application. Further improvements are discussed and proposed.	

Tilt-twist Method using Inertial Sensors to assess Spinal Posture during Gait	
Digo, Elisa (Politecnico di Torino) *Pierro, Giuseppina (Politecnico di Torino)* *Pastorelli, Stefano (Politecnico di Torino)* *Gastaldi, Laura (Politecnico di Torino)*	139
WeST01-4	12.30-13.00
Abstract. In the clinical context, the need to estimate spinal posture during gait is constantly growing. The most functional way to achieve this goal is first to model the rachis as a multibody structure with rigid segments and second to apply the tilt-twist method. Inertial Measurement Units (IMUs) are the suitable instrumentation to do this because they are portable, low cost, not invasive and free from laboratory constraints. The aim of this pilot study was the assessment of spinal angles by applying the tilt-twist method to IMU's data. A marker stereo-photogrammetric system (Optitrack) was adopted as gold standard. Three IMUs (MTx Xsens) were positioned on C7, T12 and S1 vertebral levels. A young healthy subject performed a gait trial at a self-selected speed. Data analysis focused on rotation matrices obtained simultaneously from both the instrumentations. Post-processing algorithms identified movement values of flexion-extension and lateral bending from both IMUs and stereo-photogrammetric system. Comparison graph with the obtained angular patterns showed very similar trends for the three spinal segments. Inertial sensors are suitable to be used to assess spinal posture during gait.	

Room Z03.07	WeST02	Mechanical Design and Kinematics I
Chair: Aleksandar Dragan Rodić (Institute Mihailo Pupin)		

An Integrated Taxonomy And Critical Review Of Module Designs For Serial Reconfigurable Manipulators	
Stravopodis, Nikolaos.☒.(University of the Aegean) *Valsamos, Charalampos (University of the Aegean)* *Moulianitis, Vassilis C. (University of the Aegean)*	109
WeST02-1	11.00-11.30
Abstract. Modular, reconfigurable, self-reconfigurable and metamorphic robots have already been in research since the last quarter of the previous century however and quite several different module designs have been presented in the relevant literature. As such, these modules need to be taxonomized and critically reviewed in order to form the basis for the design of new modules. The present paper introduces such a taxonomy based on the governing aspects of the modules in the literature and a weighted grading system for their critical review. Fifteen different module designs are examined and graded to identify their suitability for serving as the basis for the design of new modules for a self-metamorphic robotic manipulator system.	

Geometry and Inverse Kinematics of 3- PRRS Type Parallel Manipulator	
Baigunchekov, Zhumadil (Satbayev University) *Mustafa, Azamat (Satbayev University)* *Kaiyrov, Rustem (☒l-Farabi Kazakh National university)* *Amanov, Bekzat (☒l-Farabi Kazakh National university)* *Kassinov, Abzal (☒l-Farabi Kazakh National university)*	118
WeST02-2	11.30-12.00
Abstract. In this paper the methods of structural synthesis and invers kinematics of 3-PRRS type parallel manipulator (PM) are developed. This PM is formed by connecting of a moving platform with a fixed base by three passive closing kinematic chains of PRRS type. Constant and variable parameters characterizing the geometry of links and relative motions of elements of joints are defined. Invers kinematics of the PM is solved of the basis of solution of the loop-closure matrix equations of the legs.	

Linear Motion Mechanisms for Fine Position Adjustment of Heavy Weight Platforms	
Havlik, Stefan (Slovak Academy of Sciences) *Hricko, Jaroslav (Slovak Academy of Sciences)* *Prada, Erik (ZTS VVU Kosice)* *Jezný, Jaromír (ZTS VVU Kosice)*	124
WeST02-3	12.00-12.30
Abstract. This paper describes the design, development and experimentation of the linear motion mechanisms for very fine position adjustment of heavy weight platforms. It is proposed the concept that includes the precise electric motor / actuator, the ball-screw motion transducer and the no-backlash motion reducer based on compliant / elastic mechanism. The design, experimental equipment and results from measurements are presented. Such configuration enables to use available ball-screw mechanisms and to reduce the cost of the whole positioning system.	

Compliant Mechanisms for Motion/Force Amplifiers for Robotics	
Hricko, Jaroslav (Slovak Academy of Sciences) *Havlik, Stefan (Slovak Academy of Sciences)*	125
WeST02-4	12.30-13.00
Abstract. The force and motion amplifiers are essential mechanical elements used in building small and (micro) robotic devices. This paper brings a short overview of some mechanical structures and their performance characteristics. Three concepts of force amplifiers are analyzed and results from simulations are discussed. The specific design of the linear motion force amplifier/motion reduction for a high-accuracy positioning device with large payload capacity is discussed.	

Room Z02.02	WeSS02	Advances in Human-Robot Interaction I
Chair: Kosta Jovanovic (ETF) Tadej Petric (Jožef Stefan Institute)		

Bounded Self-Motion of Functional Redundant Robots	
Žlajpah, Leon (Jozef Stefan Institute) *Petrič, Tadej (Jozef Stefan Institute)*	106
WeSS02-1	14.00-14.30
Abstract. In this paper we consider a problem how to exploit a task space motion for lower-priority tasks when the end-effector motion allows some deviation of the motion for the primary task. Using a common redundancy resolution method, the self-motion is only possible in the null-space. Therefore, we propose a novel combination of controllers in two spaces: in the task space and in the reduced task space, where DOFs corresponding to spatial directions allowing the deviations are excluded. The motion generated by the controller in the reduced task space is mapped into the main task and by properly selecting the controller parameters the resulting motion does not violate the constraints. To demonstrate the effectiveness of the proposed control we show simulation examples where motion in a constraint region is used to avoid joint limits.	

On-line Adaption of Virtual Guides Through Physical Interaction	
Petric, Tadej (Jozef Stefan Institute) *Zlajpah, Leon (Jozef Stefan Institute)*	116
WeSS02-2	14.30-15.00
Abstract. Virtual guide framework allows efficient learning and control of complex robot behaviors in human-robot interaction scenarios. The framework can help to guide users to move in a predefined direction or prevent them to enter a forbidden-region. As such, the framework also allows efficient modulation of regions by changing of parameters. In this paper, we introduce and evaluate the means of adapting path parameters through physical interaction. The main goal was to introduce an algorithm into a virtual guide framework which can partially modify the path trajectories. The path updates are based on physical interaction and allow human intervention to improve the task performance. This enables to update the path trajectory only where needed and hence, to bypass the need to re-learn the whole trajectory from scratch. Since virtual guides are also active while learning, the required effort from the user is lower compared to the required effort when the user is teaching the robot with kinesthetic guidance. The effectiveness of the proposed algorithm has been demonstrated with simulation results and experiments on a KUKA LWR robot.	

A Comparison of Policy Search in Joint Space and Cartesian Space for Refinement of Skills	
Fabisch, Alexander (DFKI GmbH)	123
WeSS02-3	15.00-15.30
Abstract. Imitation learning is a way to teach robots skills that are demonstrated by humans. Transfering skills between these different kinematic structures seems to be straightforward in Cartesian space. Because of the correspondence problem, however, the result will most likely not be identical. This is why refinement is required, for example, by policy search. Policy search in Cartesian space is prone to reachability problems when using conventional inverse kinematic solvers. We propose a configurable approximate inverse kinematic solver and show that it can accelerate the refinement process considerably. We also compare empirically refinement in Cartesian space and refinement in joint space.	

KUKA LWR Robot Cartesian Stiffness Control Based on Kinematic Redundancy	
Lukić, Branko (University of Belgrade) *Petrič, Tadej (Jožef Stefan Institute)* *Žlajpah, Leon (Jožef Stefan Institute)* *Jovanović, Kosta (University of Belgrade)*	127
WeSS02-4	15.30-16.00
Abstract. This paper is dealing with one important topic for physical human-robot interaction, and that is achieving and/or optimizing of an arbitrary Cartesian stiffness of robot's end-effector (EE). The focus is given on redundant compliant robots with serial elastic actuators with fixed joint stiffness, but can reconfigure without changing the EE position. The work presented in this paper is an approach where the robot redundancy is exploited to achieve the desired or at least some optimal Cartesian stiffness of robots EE. Robot tasks can be divided into primary and secondary tasks. In our case, the primary task is to track the Cartesian position reference and the secondary task is to optimize EE Cartesian stiffness behavior while keeping the desired EE position. This means that the EE position is a constraint in the robot Cartesian stiffness optimization. The algorithm for the Cartesian stiffness optimization has been initially tested using the simulation, and then evaluated on the 7-DOFs KUKA light weight robot.	

Room Z03.08	WeST03	Path Planning and Navigation I
Chair: Ivana Budinska (Slovak Academy of Sciences)		

Automatic Path Planning for Unmanned Ground Vehicle using UAV imagery	
Zoto, Jurgen (Politecnico di Torino) *Musci, Maria Angela (Politecnico di Torino)* *Khaliq, Aleem (Politecnico di Torino)* *Chiaberge, Marcello (Politecnico di Torino)* *Aicardi, Irene (Politecnico di Torino)*	130
WeST03-1	14.00-14.30
Abstract. Field machines play an important role in the management of agricultural environments. Increasing use of automated machines in precision agriculture has gained significant attention of farmers and industries to minimize human work load to perform tasks such as land preparation, seeding, fertilizing, plant health monitoring and harvesting. Path planning is considered as a fundamental step for agricultural machines equipped with autonomous navigation system. For mountain vineyards, path planning is a big challenge due to terrain morphology and unstructured vineyards. This paper proposes a workflow to generate an automatic coverage path plan for unmanned ground vehicles (UGVs) using georeferenced imagery taken by an unmanned aerial vehicle (UAV). First, image acquisition is performed over a vineyard to generate an orthomosaic and a digital surface model, which are then used to identify the vine rows and inter-row terrain. This information is then used by the algorithm to generate a path plan for UGV.	

Indoor Navigation Using Existing Infrastructure for Professional Service Robots	
Chikurtev, Denis (Bulgarian Academy of Sciences) *Yovchev, Kaloyan (Sofia University)* *Chivarov, Nayden (European Polytechnical University)* *Rangelov, Ivaylo (European Polytechnical University)*	135
WeST03-2	14.30-15.00
Abstract. The share of service robots is increasing. Large number of those robots are the professional service robots such as customer service and logistics robots. One of the main requirements of these robots is the ability to navigate in an environment where a GPS system cannot be used. This article investigates existing methods for indoor localization and navigation. It proposes a new complete approach. This approach does not require the integration of a new indoor navigation system. Instead, the existing 24/7 video surveillance infrastructure, as well as the capabilities of the service robot, are considered. The proposed approach can reduce both the initial cost of integrating the robotic system as well as the maintenance costs. Subsequent maintenance can be done entirely remotely. The suggested approach is validated experimentally on a mobile robot.	

Online Trajectory Planning and Collision Avoidance for a Group of Robots using Distributed Model Predictive Control	
Costantini, Giuliano (University of Kaiserslautern) *Rostami, Ramin (University of Kaiserslautern)* *Görges, Daniel (University of Kaiserslautern)*	167
WeST03-3	15.00-15.30
Abstract. In this paper the trajectory planning problem for unicycle robots is studied. This problem is particularly difficult to solve online due to its inherently nonlinear and nonconvex structure. The first aim of the paper is to overcome these difficulties using model predictive control (MPC) when a single robot is considered. Several requirements must be fulfilled by the optimal trajectory, such as respecting physical limitations as well as track constraints. The second aim of the paper is to extend the results to a group of robots using distributed MPC providing formation control and inter-robot collision avoidance.	

Whole-Body Planning for Obstacle Traversal with Autonomous Mobile Ground Robots	
Oehler, Martin Sven (Technische Universität Darmstadt) *Kohlbrecher, Stefan (Technische Universität Darmstadt)* *von Stryk, Oskar (Technische Universität Darmstadt)*	166
WeST03-4	15.30-16.00
Abstract. A common challenge for autonomous mobile ground robots in unstructured environments is the traversal of obstacles without risking to tip over. Previous research on prevention of vehicle tip-over is mostly limited to basic mobility systems with only few degrees of freedom (DOF). In this paper, a novel whole-body motion planning approach is presented. Based on a 3D world model and a given planned path, the trajectories of all joints are optimized to maximize robot stability. The resulting motion plan allows the robot to cross obstacles without tipping over. Compared to existing approaches, the proposed approach considers environment- and self-collisions during planning. Few assumptions about the robot configuration are made which enables the adoption to different mobile platforms. This approach is evaluated for a simulated and a real robot. The platform is a tracked vehicle with adjustable flippers and a five DOF manipulator arm. In several test scenarios, it is shown that the proposed approach effectively prevents tip-over and increases robot stability.	

Room Z03.07	WeST04	Industry Robotics I
Chair: Chair: Roman Kamnik (University of Ljubljana)		

Task-Dependent Energetic Analysis Of A 3 D.o.f. Industrial Manipulator	
Boscariol, Paolo (University of Padova) *Scalera, Lorenzo (Free University of Bolzano/Bozen)* *Gasparetto, Alessandro (University of Udine)*	105
WeST04-1	14.00-14.30
Abstract. In this paper a preliminary analysis of the energetic performance of an industrial manipulator is presented. In particular, the paper investigates the effects of the trajectory planning on the overall energy consumption of the manipulator in a pick & place task, focusing also on the location of the path within the workspace. An electro-mechanical model of the actuators and the inverse dynamic model of the robot have been developed and used to estimate the robot energy consumption when executing a basic motion task. Results are then collected into energy consumption maps, showing how the location of the task within the robot workspace affects the energetic performance of the robot.	

3D Printing with 6D of Freedom: Controlling Material Extrusion Speed	
Kraljic, David (University of Ljubljana) *Stefanic, Matej (University of Ljubljana)* *Kamnik, Roman (University of Ljubljana)*	147
WeST04-2	14.30-15.00
Abstract. 3D printing is conventionally performed with manipulators with only three degrees of freedom (DOF), resulting in objects consisting of horizontal layers and inherent weakness in the vertical direction. This shortcoming is mitigated by printing along curved surfaces, which requires manipulators with more degrees of freedom, a new way of trajectory planning, and a dynamic control of material extrusion speed - the issue addressed in this paper. Our printing set-up, which we describe in the paper, includes an industrial 6 DOF manipulator. The manipulator has non-negligible inertia as well as other limiting constraints, and thus fails to achieve the programmed speed on many of the printing path segments leading to either overflow or underflow of material and poor object quality. We develop a simple empirical approach to predict the speed on problematic path segments and adjust the speed of extrusion, ensuring the correct amount of material is deposited.	

Robotic Knitting in String Art as a Tool for Creative Design Processes	
Jovanović, Marko (University of Novi Sad) *Vučić, Marko (University of Novi Sad)* *Tepavčević, Bojan (University of Novi Sad)* *Raković, Mirko (University of Novi Sad)* *Tasevski, Jovica (University of Novi Sad)*	164
WeST04-3	15.00-15.30
Abstract. The application of industrial robots in creative industries has shown great potential in the last decade. The interpretation of images as tangible and artistic works of art is depicted with various elements and techniques. The usage of a continuous piece of string allows for the design process to explore dierent methods of achieving comprehensible images in the form of string art. With dierent computational tools and design techniques it becomes possible to explore design thinking coupled with automated fabrication. In this paper, the emphasis is placed on generating a large scale string art pieces out of smaller tiles, that can be used as wall art. By using an integrated work ow it is possible to generate the program for robotic knitting of the string art piece, by adjusting the parameters that govern the entire process.	

Towards Using Natural User Interfaces for Robotic Arm Manipulation	
Girbacia, Florin Stelian (Transilvania University of Brasov) *Postelnicu, Cristian Cezar (Transilvania University of Brasov)* *Voinea, Daniel (Transilvania University of Brasov)*	156
WeST04-4	15.30-16.00
Abstract. In this paper, we propose a Natural User Interface (NUI) based on Leap Motion controller which enables intuitive manipulation of a 6-DOF Jaco robotic arm. By using this NUI interface, we aim to study the effects of hand movements and gestures for interaction with a robotic arm. We present a qualitative evaluation of the proposed NUI system by trials with subjects carrying out a standard robotic arm manipulation session using both the conventional joystick interface and the NUI based one. The results are discussed in the last part of the paper.	

Room Z02.02	WeSS03	Safety Related Devices and Applications II
Chair: Med Amine Laribi (Université de Poitiers) Giuseppe Carbone (Università degli studi di Cassino e del Lazio Meridionale)		

Efficient, Risk-Encoding Octrees For Path Planning With A Robot Manipulator	
Werner, Tobias (Universität Bayreuth) *Harrer, David (Universität Bayreuth)* *Henrich, Dominik (Universität Bayreuth)*	155
WeSS03-1	16.30-17.00
Abstract. Recent research in robotics envisions shared human-robot workspaces to combine individual advantages of humans and robots. As part of this vision, robot manipulators must avoid collisions with humans and other a priori unknown obstacles in the shared workspace. State-of-art approaches (e.g. certainty grids, bounding volume hierarchies) test robot poses for collisions under individual limitations (e.g. memory or processing overhead, assumption of global views or noiseless sensors). In contrast, we contribute a sample-based pose test alongside a hierarchical representation of risk over the shared workspace. Our contribution has low memory and processing overhead, and allows for local, outdated, or noisy sensor views. Experiments with real-world data validate this claim and show advantages and limits of our approach over competing variants. We conclude that our pose test and risk representation enhance real-time path planning for robot manipulators in current and future use cases.	

Structural Compliance Effects on the Accuracy and Safety of a R-CUBE Haptic Device	
Gorgulu, Ibrahimcan (Izmir Institute of Technology) *Carbone, Giuseppe (University of Calabria)* *Acinapura, Antonio (University of Calabria)* *Mundo, Domenico (University of Calabria)* *Can Dede, Mehmet Ismet (University of Calabria)*	169
WeSS03-2	17.00-17.30
Abstract. This paper addresses the contribution of structural compliance on stiffness and safety of a R-CUBE Haptic Device. Structural compliance is determined in several poses via FEM analysis and addressed by referring to local and global indices of performance. Results are also compared with evidences from experimental tests. Comparison of numerical and experimental data allows to identify and separate the contributions to the overall compliance that are due to the structural stiffness, or other contributions such as joint clearance, pose and loading conditions.	

Room Z03.08	WeST05	Path Planning and Navigation II
Chair: Ivana Budinska (Slovak Academy of Sciences)		

Connections for Path Planning in Mobile Robotics	
Nitulescu, Mircea (University of Craiova) *Ivanescu, Mircea (University of Craiova)*	159
WeST05-1	16.30-17.00
Abstract. This work presents the theoretical solutions that are possible for connecting the linear segments of the global trajectories developed for mobile robots in their operating scenes. Generated most often in a purely polygonal form by the global planner of trajectories, they cannot be executed directly than by mobile robots that have the pivotal capability around their axis of vertical symmetry. For all the other constructive structures of the mobile robots and whatever type of their control, e.g. with the trajectory stored in memory or with the wired trajectory mapped on the ground, these techniques are needed. This paper presents three techniques for connecting the polygonal paths using only pure circular arcs, circular arcs and splines curves, respectively arcs of clothoid. Theoretical support of each method, examples and the assessment of specific influences on the behavior of a mobile robot at changing sections on trajectory are included.	

Safe and Efficient Navigation of Autonomous Shuttle in Pedestrian Zone	
Jan, Qazi Hamza (TU Kaiserslautern) *Klein, Sascha (TU Kaiserslautern)* *Berns, Karsten (TU Kaiserslautern)*	171
WeST05-2	17.00-17.30
Abstract. This paper summarizes the navigation of autonomous shuttle in a pedestrian area using behavior-based architecture with Pedestrian Interaction System (PIS). For pedestrians to accept autonomous shuttles in their vicinity, it is important to have safe distance between the shuttle and the pedestrians. The PIS determines the scheme of interaction with pedestrians based on their behavior. It also keeps the pace of the shuttle by recognizing safe conditions in pedestrian zone. The experiments are performed in a simulated environment. It shows that the shuttle moves efficiently on a predefined track, keeping the safety of the environment when PIS is active.	

Room Z03.07	WeST06	Industry Robotics II
Chair: Leon Zlajpah (Jožef Stefan Institute)		

Grounding Of Uncertain Force Parameters In Spoken Robot Commands	
Wölfel, Kim (Universität Bayreuth) *Henrich, Dominik (Universität Bayreuth)*	141
WeST06-1	16.30-17.00
Abstract. Speech-based robot instruction is a promising field in private households and in small and medium-sized enterprises. It facilitates the use of robot systems for non-experts as well as experts, even while the user executes other tasks. Considering force-based robot motions, the common approach is to map verbs to robot motions depending on the tool and the work piece. While this method works well for a wide variety of applications, it limits the user to a fixed force for a given manipulation task and does not allow extensions like "hard" or "soft". To overcome this drawback, we contribute an approach for a defuzzification of uncertain force parameters to numerical robot motions. To proof the reliability of our approach, we apply it on a motion with varying material parameters.	

Integrated Palletizing Workstation With An Industrial Robot And a Cobot	
Hajduk, Mikuláš (Technical University of Kosice) *Kováč, Juraj (Technical University of Kosice)* *Varga, Jozef (Technical University of Kosice)* *Bezák, Martin (Technical University of Kosice)* *Pilat, Zbigniew (Warsaw University of Technology PIAP)* *Tomči, Peter (Manex spol. sr.o. Košice)* *Andrejko, Peter (Manex spol. sr.o. Košice)* *Jenčík, Robert (Manex spol. sr.o. Košice)*	165
WeST06-2	17.00-17.30
Abstract. It is anticipated that the field of industrial robot deployment will continue to grow in the coming years. However, an even higher growth rate is expected in deployment of cooperative robots. This means that the area of robotics will be one of the decisive factors in increasing competitiveness on the variable product market. It is logical that such an expansion of robotics cannot be based on solo robotic workplaces. Rather, ever increasing collaboration of different robot types is expected to take place. In co-operation with the SjF, MANEX sees the near future in implementing automation to its production, namely automation of lines and workplaces where industrial robots-cobots-men work together or in a complementary manner. The issue of this integration is relatively new and it is still difficult to find comprehensive methodologies of how to approach it. The article presents a framework proposal for deployment of different robots and the man in the area of final palletizing and packaging. It goes without saying that newer and newer approaches and methodologies and practical experience will be garnered in the future in both, the academia and in practical applications.	

Detailed program, Thursday, June 20th 2019

Room Z02.02	ThSS01	Advances in Human-Robot Interaction II
Chair: Kosta Jovanovic (ETF) Tadej Petric (Jožef Stefan Institute)		

Influence of Unmodelled External Forces on the Quality of Collision Detection	
Gordić, Zaviša (University of Belgrade) *Jovanović, Kosta (University of Belgrade)*	132
ThSS01-1	8.30-9.00
Abstract. Physical Human-Robot Interaction requires collision detection to enable a safe sharing of workspace between humans and robots, mostly using model based algorithms. Majority of robot tasks involve physical interaction with the environment, and consequently the forces occurring during the interaction. This paper presents an experimental testing of influence of unmodelled but intentional forces on the quality of collision detection algorithms. Results from testing of different manipulation and assembly tasks are shown and discussed in terms of their significance to collision detection and similarity with real collisions. Presented results and conclusions from this paper may serve as guidelines for future collision detection related work by offering a better understanding and insight on the relevance of intentional external forces.	

Use of Bimanual Haptic Teleoperation System for Optimized Task Performance with Adaptive Haptic Tunnel	
Piškur, Jožica (University in Ljubljana) *Šlajpah, Sebastjan (University in Ljubljana)* *Nemec, Bojan (Institut "Jožef Stefan")* *Mihelj, Matjaž (University in Ljubljana)* *Munih, Marko (University in Ljubljana)*	142
ThSS01-2	9.00-9.30
Abstract. This paper presents bimanual haptic teleoperation system with implemented haptic tunnel for optimized task performance. The teleoperation system includes two industrial robots as slaves and two haptic robots as masters. The bimanual control is based on impedance control with included adaptive haptic tunnel. Task is performed in relative coordinates where base of the robot is set at end effector of one slave robot while the position of second slave robot is defined relatively to the new base. Haptic tunnel is defined with a) reference trajectory obtained with initial task execution and described with Gaussian radial basis functions, b) adaptive radius of the tunnel based on error between reference and traveled trajectory and percentage of the contact with the haptic tunnel. After each task execution the performance is evaluated following by proper adaptation of haptic tunnel. Developed algorithm was tested with a simple assembly task of inserting car bulb into its base.	

Feedforward Control Approaches to Bidirectional Antagonistic Actuators Based on Learning	
Knežević, Nikola (University of Belgrade) *Lukić, Branko (University of Belgrade)* *Jovanović, Kosta (University of Belgrade)*	154
ThSS01-3	9.30-10.00
Abstract. Safe physical human-robot interaction is a decisive feature in wider adaptation of robots in homes and factories. To that end, a lot of researchers consider new actuation mechanisms and particularly Variable Stiffness Actuators (VSAs) which contribute to robot safety, but also to increase energy efficiency and outperforming rigid actuators in repetitive tasks. However, advantages of VSAs come with their price – issues in design and control of such multivariable non-linear systems. Novel approaches and methods in soft computing methods such as machine learning and neural networks are opening new horizons in VSA control. In this paper, a comparative analysis is carried out between the neural network feedforward control and locally weighted projection regression as a technique for model learning of bidirectional antagonistic VSA – qb move maker pro. Set of measurement is used to create mapping between two motor positions as inputs and measured actuator position and estimated stiffness as outputs. Comparative analysis of the two different approaches for feedforward control observing performances in open loop control, followed by closed loop testing with a simple feedback regulator for fine tuning. Learning techniques result in robust and generalized models that can predict required inputs in oreder to achieve good output tracking.	

Knowledge Acquisition Through Human Demonstration For Industrial Robotic Assembly	
Gašpar, Timotej (Jožef Stefan Institute) *Deniša, Miha (Jožef Stefan Institute)* *Ude, Aleš (Jožef Stefan Institute)*	160
ThSS01-4	10.00-10.30
Abstract. With the ambition to introduce robots into assembly lines, not suitable for classical automation, the ease of robot programming is becoming more significant then ever. This paper proposes using various approaches for gaining knowledge from human demonstrations. This knowledge is applied to perform assembly tasks in a industrial robotic cell. Real industrial use case is used for evaluation of proposed approaches. It shows their viability and presents different scenarios which call for different approaches of learning and execution of assembly tasks and its subsets.	

Room Z03.08	ThST01	Mechanical Design and Kinematics II
Chair: Said Zeghloul (Poitiers University)		

Design and Control of a Flapping Wing System Test Bench	
Zarate Moya, Jose Luis (Technische Universität Ilmenau) *Witte, Hartmut (Technische Universität Ilmenau)*	133
ThST01-1	8.30-9.00
Abstract. The design of an adaptable system to analyze the properties of flight dynamics in flapping wings systems helps to identify their characteristics and allow the use of different control techniques to improve their performance. These devices present difficult in modeling; therefore, the software to identify the system parameters divided in several stages gives the feasibility to manage these complexities. This work presents the design of a prototype test bench based on a mathematical modeling of a balancing beam with a flapping mechanism with wings. This system consists of a bar that has a rotational degree of freedom contained in the vertical and horizontal plane each, where in one end the flapping mechanism is located. This movement is produced by the thrust force due to wings flapping coupled to a gear set and two motors for each wing. The tunable speed of rotation in the direct current motor allows controlling the force of thrust, managing the bar movement towards a determined angular position measured by an Inertial Measurement Unit (IMU) and two encoders in both axes. The model was obtained experimentally.	

Approximation Of Inverse Kinematic Solution Of A Metamorphic 3R Manipulator With MLP	
Tzivaridis, Markos (University of Patras) *Moulianitis,* Vassilis C. *(University of the Aegean)* *Aspragathos, Nikos (University of Patras)*	143
ThST01-2	9.00-9.30
Abstract. In this paper, a feedforward neural network is trained towards the generalisation of the inverse kinematics of a 3R metamorhic manipulator with one pseudojoint. A two hidden-layered network is trained with data produced by several anatomies of the metamorphic manipulator and tested to an unforeseen anatomy. The data are separated to aspects per anatomy and combined to one training set. Various configurations of the network is trained using the Levenberg-Marquardt backpropagation method and the best of them is derived. As it will be shown the derived network can achieve very low generalisation errors.	

Mechanical Design, Modeling and Simulation of Human-Size Cable-Driven Over-Actuated Robotic Arm	
Rodić, Aleksandar Dragan (Institute Mihajlo Pupin) *Hioki, Shunsuke Yo (Yokohama National University)* *Radmilović, Marija Miroslav (Institute Mihajlo Pupin)* *Jovanović, Miloš Dragoljub (Institute Mihajlo Pupin)*	163
ThST01-3	9.30-10.00
Abstract. This paper presents new mechanical design of a human-sized, lightweight, redundant, over-activated and cable-driven robotic arm dedicated to development of collaborative industrial humanoid. Mechanical design of the robotic arm includes some original technical solutions which reduce total mass of the mechanism, includes passive compliance in the structure and implements redundant number of servo-motors and corresponding mechanical degrees of freedom. Robot motion is achieved by synergy of operation of numerous driving motors that move rob joints by pulling/releasing non-tensile cables. By implementing of the redundant number of driving motors, system achieves enhanced mobility and manipulative capabilities, optimize power consumption and increases robustness of the system against the failures of servo-drives. The set of technical requirements imposed in the paper corresponds to the biological model of the human-size arm. Interesting, selected references in this field of research are listed in the paper, too. At the end of paper, some characteristic simulation results are presented, analyzed and discussed with aim to validate the obtained design and theoretical results.	

A General Approach for Automating Teleoperated Construction Machines	
Lee, Hyung Joo (RWTH Aachen University) *Brell-Cokcan, Sigrid (RWTH Aachen University)* *Schmitz, Katharina (RWTH Aachen University)*	172
ThST01-4	10.00-10.30
Abstract. Despite enormous research advances in robotics, most of repetitive and dangerous tasks on construction sites are still manually performed. The challenge to robotic automation lies in the nature of construction site. Robots must be able to handle large payloads, outdoor conditions, dirty and dynamic environment. Therefore, attempting to develop a new robot for construction sites is a formidable task. In this paper, a generic method is introduced to adapt existing stable hydraulically driven construction machinery so that proven robots can be obtained at a significant reduction in e ort. Fist, the bus system of the machinery is utilized to communicate with the user's computer. Then, a control framework is developed which is based on the closed-loop inverse kinematic (CLIK). The method is experimentally validated on a demolition machine Brokk 170, that is originally designed to be controlled with a remote controller.	

Room Z03.07	ThST02	Control I
Chair: Alessandro Gasparetto (University of Udine)		

Torque-Based Velocity Control for Safe Human-Humanoid Interaction	
Shingarey, Dmitriy (Karlsruhe Institute of Technology (KIT)) *Kaul, Lukas (Karlsruhe Institute of Technology (KIT))* *Asfour, Tamim (Karlsruhe Institute of Technology (KIT))*	158
ThST02-1	8.30-9.00
Abstract. Torque-controlled robots are essential for safe human-robot interaction (HRI). To develop robots with such capabilities, sensing and control mechanisms are needed to implement sophisticated torque control, in addition to position and velocity control. In this paper we address the question of how joint level torque control can be implemented and seamlessly integrated into tasks that require precise velocity control. We present a control scheme that takes a desired velocity and torque as input to generate control output driving the joints at this velocity, and simultaneously realizing compliant behavior for safe HRI. We propose a novel method to integrate torque and velocity control into a single controller. The controller consists of an inner torque control loop embedded in an outer velocity control loop, and is hence called Torque-Based Velocity Control (TBVC). Experiments demonstrating the performance of the proposed control scheme are carried out on the humanoid ARMAR-6.	

On an Analytic Generation of Null Space Spanners in Robotics	
Duleba, Ignacy (Wroclaw University of Science and Technology) *Karcz-Duleba, Iwona (Wroclaw University of Science and Technology)*	104
ThST02-2	9.00-9.30
Abstract. In this paper three algorithms are presented to automatically generate bases of null spaces (kernels) in an analytic form, for some tasks of robotics. Orthogonal (orthonormal) bases of kernels can be derived if required. Additionally, a switching procedure is described to continuously transfer from a currently used basis, which becomes ill-conditioned, to another, well-conditioned basis. The algorithms are illustrated on computing the Jacobian matrix kernel of an exemplary 4DoF planar pendulum robot to point out their advantages and disadvantages.	

Velocity Motion Path Control of Redundant Robot arms	
Krastev, Evgeniy Hristov (Sofia University)	119
ThST02-3	9.30-10.00
Abstract. This paper proposes a novel, integrated method for kinematic motion control of a redundant robot arm subject to a prescribed velocity profile of the end effector in task space. Unlike most of the existing solutions this method assumes that the velocity profile of motion is defined in task space and not in joint space. It can be seamlessly extended to support other optimization criteria for the redundant robot arm motion. The capability to optimize the manipulability measure of the robot motion in addition to following a prescribed velocity profile in task space is another important novelty of the proposed solution. The mathematical model provides efficient software implementation. It is tested in different scenarios for kinematic path control of well-known in the literature reference kinematic models of industrial robots. The obtained numerical results allow to compare and evaluate the quality of the obtained solutions with respect to the existing ones. The obtained results can be extended to computing the joint motion of a non-redundant robot arm for a given velocity profile of the end- effector motion.	

Reduction of Trajectory Encoding Data using a Deep Autoencoder Network: Robotic Throwing	
Lončarević, Zvezdan (Jozef Stefan International Postgraduate School) *Pahič, Rok (Institute Jozef Stefan)* *Simonič, Mihael (Institute Jozef Stefan)* *Ude, Aleš (Institute Jozef Stefan)* *Gams, Andrej (Institute Jozef Stefan)*	122
ThST02-4	10.00-10.30
Abstract. Autonomous learning and adaptation of robotic trajectories by complex robots in unstructured environments, for example with the use of reinforcement learning, very quickly encounters problems where the dimensionality of the search space is beyond the range of practical use. Dierent methods of reducing the dimensionality have been studied earlier. In this paper we explore the use of deep autoencoders, where the dimensionality of autoencoder latent space is lower. However, a database of actions is required to train a deep autoencoder network. The paper presents a study on the number of required database samples in order to achieve dimensionality reduction without much loss of information.	

Room Z02.02	Keynote II
Chair: Karsten Berns (TU Kaiserslautern)	

Navigation of mobile robots in rough outdoor environments	
Prof. Giovanni Muscato (IEEI University of Catania)	
Keynote II	11.00-12.00

Abstract. Unmanned Ground Vehicles (UGV) are certainly useful in performing tasks in outdoor environments. Several applications have been proposed for agriculture, humanitarian demining, exploration of volcanoes, search and rescue, just to name a few. However autonomous navigation or even the teleoperation of a mobile robot in rough environments, can be really hard. The talk will present several approaches that have been experimented in the past years by our research group, adopting the cooperation between UGVs and Unmanned Aerial Vehicles (UAVs). In particular, we adopted UAVs to perform a survey of the region of interest and on the basis of the images acquired to build a terrain surface model. Then a terrain traversability analysis is performed, taking into account the specific navigation features of the considered ground vehicle. The approach can be also improved by using flocks of UAVs and by a suitable planning of their trajectories, in order to obtain in a faster way detailed maps of the environment. When the terrain becomes extremely hard autonomous navigation of an UGV can be risky and teleoperation by a human operator should be implemented. For these scenarios we developed a suitable interface, combining information coming from different sensors to increase situational awareness and speed-up decision making. Other experimented UAV systems that will be presented, involve autonomous following of the UGV and autonomous landing on the moving UGV. The developed strategies, the algorithms, the hardware and software architectures and several experimental results will be shown for the different approaches. In particular, the application areas have regarded volcanic exploration, landslide monitoring and humanitarian demining.

Biography. Giovanni Muscato received the Electrical Engineering degree from the University of Catania, Catania, Italy, in 1988. After completing graduation, he was with the Centro di Studi sui Sistemi, Turin, Italy. In 1990, he joined the DIEEI University of Catania, where he is currently a Full-Time Professor of robotics and automatic control and since 2018, Director of the Department. His current research interests includes service robotics and the cooperation between ground and flying robots. He was the coordinator of the EC project Robovolc and is the local coordinator of several national and European projects in robotics. He is the author of more than 300 papers in scientific journals and conference proceedings and three books in the fields of control and robotics. Prof. Muscato is with the Board of Trustees of the Climbing and Walking Robots (CLAWAR) Association and Senior member of the IEEE. Web site: www.muscato.eu .

Room Z02.02	ThST03	Communication
Chair: Chair: Kosta Jovanovic (ETF)		

Communication Between Robots over Intelligent Objects Realized by RFID Tags	
Thormann, Christian (Hochschule Mittweida) *Winkler, Alexander (Hochschule Mittweida)*	103
ThST03-1	13:00-13.30
Abstract. This article presents an approach to communication between robot controllers via RFID transponders, where the partners in communication read and write data into a joint transponder. In some scenarios, cable-based communication, e.g. using connections of digital inputs and outputs or fieldbuses, can be substitute. Using the new approach, it is not necessary to integrate the robot controller into the network of the factory. Since at all times no more than one robot can communicate with the transponder, an effective algorithm of collision avoidance has been implemented. We propose an approach that uses random waiting times for avoiding collisions. The approach is verified by a practical experiment, where two robots hand over a workpiece. Additionally, further scenarios of communication over RFID tags in intelligent workpieces are mentioned.	

Average Consensus with Bounded Execution under Quantization Noise	
Kenyeres, Martin (Slovak Academy of Sciences) *Kenyeres, Jozef (Sipwise GmbH)*	107
ThST03-2	13.30-14.00
Abstract. Quantization in the digital signal processing provides the representation of transmitted information with a finite number of the bits. Therefore, this process is crucial for the communication models with bounded bandwidth channels. This paper is focused on the average consensus algorithm with a finite-time execution and a uniform quantization update rule over high-scale wireless sensor networks modeled as random geometric graphs. The experimental part is concerned with a comparison of various initial configurations of the average consensus algorithm with a uniform quantization scheme with a modified number of bits allocated for quantization and di⊠erent parameters of the implemented stopping criterion. Our goal is to find the most appropriate configuration in terms of the estimation precision quantified by the mean square error.	

Room Z03.08	ThST04	Learning I
Chair: Giovanni Muscato (IEEI University of Catania)		

Task Dependent Trajectory Learning from Multiple Demonstrations using Movement Primitives	
Vidaković, Josip (University of Zagreb) *Jerbić, Bojan (University of Zagreb)* *Šekoranja, Bojan (University of Zagreb)* *Švaco, Marko (University of Zagreb)* *Šuligoj, Filip (University of Zagreb)*	110
ThST04-1	13.00-13.30
Abstract. We propose a model for learning robot task constrained movements from a finite number of observed human demonstrations. The model uses the variation between demonstrations to extract important parts of the movements and reproduce trajectories accordingly. Regions with low variability are reproduced in a constrained manner, while regions with higher variability are approximated more loosely to achieve shorter trajectories. The demonstrations are sampled into states and an initial state sequence is chosen by a minimum distance criterion. Then, a method for state variation analysis is proposed that weights the states according to its similarity to all the other states. A custom function is constructed based on the state-variability information. The time function is then coupled with a state driven dynamical system to reproduce the trajectories. We test the approach on typical two-dimensional task constrained trajectories with constrains on the beginning, in the middle and the end of the movement. The approach is further compared with the case of using a standard exponentially decayed time function.	

Learning to Predict 2D Object Instances by Applying Model-Based 6D Pose Estimation	
Kisner, Hannes (TU Chemnitz) *Thomas, Ulrike (TU Chemnitz)* *Schreiter, Tim (TU Chemnitz)*	153
ThST04-2	13.30-14.00
Abstract. Object detection and pose estimation still are very challenging tasks for robots. One common problem for many processing pipelines is the big amount of object data, e.g. often it is not known beforehand how many objects and which object classes can occur in the surrounding environment of a robot. Especially model-based object detection pipelines often focus on a few different object classes. However, deep learning algorithms were developed in the last years. They are able to handle a big amount of data and can easily distinguish between different object classes. The drawback is the high amount of training data needed. In general, both approaches have different advantages and disadvantages. Thus, this paper presents a new way to combine them in order to be able to estimate 6D poses for a higher amount of different object classes.	

Room Z03.07	ThST05	Control II
Chair: Daniel Görges (TU Kaiserslautern)		

Shared Impedance Control Based on Reinforcement Learning in a Human-Robot Collaboration Task	
Wu, Min (TU Kaiserslautern) *He, Yanhao (TU Kaiserslautern)* *Liu, Steven (TU Kaiserslautern)*	129
ThST05-1	13.00-13.30
Abstract. In this work a shared impedance control scheme for a hybrid human-robot team is designed for transporting a rigid workpiece to a desired position. Within the scope of proposed control structure, both human and robot are regarded as mechanical impedance and their parameters are adapted continuously in real-time. Reinforcement learning is used to find an impedance parameter set for the whole team to optimize a task-orient cost function. Then the learned parameters are further adjusted by taking human's disagreement into consideration. The proposed method is aimed to reduce human's control effort during collaboration and be flexible to variation of the task or enviroment. Experimental results are presented to illustrate the performance.	

Gain Scheduled PID Force Control Of A Robotic Arm For Sewing Fabrics	
Misios, Ioannis H. (University of Patras) *Koustoumpardis, Panagiotis N. (University of Patras)* *Aspragathos, Nikos A. (University of Patras)*	150
ThST05-2	13.30-14.00
Abstract. In this paper, a manipulator's gain scheduled PID force feedback controller is designed and implemented for the robotized sewing of fabrics, using a commercial sewing machine. The proposed manipulator controller should keep a constant tension of the fabric, to achieve high quality of cloth's seams, as the length of the fabric is shortened along the sewing process. For the controller design, a non-linear model of the fabric is considered, varying with the actual length between the grasping and sewing points. The model is based on a simplified Kelvin-Voigt model with non-linear spring and damper coefficients, which also depend on the type and the length of the fabric and are estimated experimentally. The Model-based PID tuning process from Simulink is used, for tuning and scheduling the gains of the PID controller corresponding to fabric's different actual lengths. The determined sets of gains are used for controlling on-line an Adept Cobra s800 robot to manipulate a woven piece of fabric during the sewing process, where the proposed approach is tested. The proposed manipulator's force control approach maintains a stable tensional force on the fabric and therefore the quality of the seam and hence of the cloth could be enhanced. Finally, it is compared with a PID controller with constant gains.	

Detailed program, Friday, June 21th 2019

Room Z02.02	FrSS01	Flexible Manufacturing in Industry 4.0 Environments I
Chair: Achim Wager (German Research Center for Artificial Intelligence (DFKI))		

Implementation of an autonomous Tool Trolley in a Production Line	
Engemann, Heiko (Tshwane University of Technology) *Badri, Sriram (RWTH Aachen University)* *Wenning, Marius (RWTH Aachen University)* *Kallweit, Stephan (University of Applied Sciences Aachen)*	115
FrSS01-1	9.00-9.30
Abstract. In recent years, the rising demand for customised products has changed the requirements for industrial production. Nonetheless human workers are still an important part of the production process, especially in the area of final assembly. In the production of small series as well as customer-configured products, tools for different work tasks are used on different workstations at various instances of time. This paper documents the development of an autonomous tool trolley (ATT), which makes the production equipment effortless available directly at the required location. The implemented control system is based on the Robot Operating System (ROS) and provides autonomous navigation functionalities. An experiment compares different sensor concepts used for localisation. The experiments are performed in the unstructured environment of an industrial production line. The best preforming sensor setup is used for the task of autonomous navigation. A final experiment proves that the positioning accuracy of the developed ATT is suitable for the tool delivery task.	

Developing a Production Scheduling System for Modular Factory Using Constraint Programming	
Park, Hoonseok (Kyung Hee University) *Um, Jumyung (Kyung Hee University)* *Jung, Jae-Yoon (Kyung Hee University)* *Ruskowski, Martin (German Research Center for Artificial Intelligence (DFKI GmbH))*	136
FrSS01-2	9.30-10.00
Abstract. This paper presents a production scheduling system that optimizes operations of a modular factory. The proposed system consists of a database, a scheduling optimizer and an interface connecting two other components. A scheduling model for optimal schedules plays a key role in the scheduling system. In this research, we aim to develop the scheduling model using constraint programming and design a data mart storing the related operational data. In particular, we set the modular factory environment to the hybrid flow shop and apply the constraint programming for scheduling. We provide a case study to test the performance of the proposed scheduling model with the synthesized dataset based on a modular factory environment in SmartFactoryKL	

Room Z03.08	FrST01	Learning II
Chair: Carlo Ferraresi (Polytechnic of Turin)		

Dataset Generation Using A Simulated World	
Vierling, Axel (TU Kaiserslautern) *Sutjaritvorakul, Tanittha (TU Kaiserslautern)* *Berns, Karsten (TU Kaiserslautern)*	157
FrST01-1	9.00-9.30
Abstract. In this paper we focus on a missing part of solving the detection of human workers around the load and the truck of a crane. Current solution attempts use Convolutional Neural Networks to detect these workers in images. Especially the detection around the load cannot be solved with the use of public datasets as the viewing angles differ too much. We therefore propose and evaluate an approach which uses a simulation engine to create automatically labeled images to train a network for this use case.	

Convolutional Encoder-Decoder Networks for Robust Image-to-Motion Prediction	
Ridge, Barry (ATR Computational Neuroscience Laboratories, Jožef Stefan Institute); *Pahič, Rok (Jožef Stefan Institute)* *Ude, Aleš (Jožef Stefan Institute)* *Morimoto, Jun (ATR Computational Neuroscience Laboratories)*	161
FrST01-2	9.30-10.00
Abstract. A deep encoder-decoder network was previously proposed for learning a mapping from raw images to dynamic movement primitives in order to enable a robot to draw sketches of numeric digits when shown images of same. In this paper, the network architecture, which was previously constructed entirely with fully-connected linear layers, is modified to include convolutional layers in order to improve the image encoder component and make the network more robust to noise. The convolutional layers are pre-trained as part of an MNIST digit classifier and adapted for use in the encoder-decoder network, before the network is trained using a dataset composed of digit images and corresponding writing trajectories. This architecture was tested on several challenging noisy digit datasets and the use of convolutional layers is shown to provide a robust improvement in results.	

Room Z03.07	FrST02	Multi Robot Systems
Chair: Nick Andrei Ivanescu (Polytechnic University of Bucharest)		

A Swarm Algorithm Inspired by Tree-Dwelling Bats. Experiments and Evaluations.	
Zelenka, Ján (Institute of Informatics Slovak Academy of Sciences) *Kasanický, Tomáš (Institute of Informatics Slovak Academy of Sciences)*	138
FrST02-1	9.00-9.30
Abstract. The paper describes a new swarm based algorithm inspired by the behavior of tree bats. The algorithm is designed to search through an unknown environment and look for objects of interest. Individual robotic swarm agents are equipped with memory to make the search more efficient. The proposed algorithm has been evaluated in comparison to a uniform search. Changing the parameter "shout" changes the behavior mode of the algorithm. By decreasing the parameter, parallel scan by smaller groups of agents is achieved. A higher value of the parameter leads to a sequential scanning by a large group of agents.	

A Cloud Based Solution for Secure Sharing Robot and Manufacturing Resources for Research	
Anton, Silvia (University Politehnica of Bucharest) *Ivanescu, Nick (University Politehnica of Bucharest)* *Iacob, Iulia (University Politehnica of Bucharest)* *Borangiu, Theodor (Polytechnic University of Bucharest)* *Răileanu, Silviu (University Politehnica of Bucharest)*	149
FrST02-2	9.30-10.00
Abstract. Nowadays the cloud systems are more and more present in industry, being part of Industry 4.0, and this can be seen also at the production level, in manufacturing systems and in robotics. Cloud services are used to improve and interconnect the manufacturing processes with the higher-level enterprise components (enterprise resource planning systems and other operational systems). The paper presents a solution for cloud – manufacturing system integration where the cloud system is used to remotely access and control a manufacturing system for research and training purposes. The access to the manufacturing sys-tem is configured in cloud as a service, the connection to the manufacturing system being implemented through a set of virtual machines which are deployed, and custom configured in cloud. The paper describes the architecture of the system, the deployment scenarios and presents the limitations and performances of the system obtained during the tests.	

Room Z02.02	Keynote III
Chair: Leon Zlajpah (Jožef Stefan Institute)	

Geometric Modeling of Robotic Manipulators – A Short Overview for Practitioners

Univ.-Prof. Dr.-Ing. habil. Andreas Müller

Keynote III 10.00-11.00

Abstract. Robots are controlled mechanisms. Their analysis, design, and intelligent control hence require adequately accurate and yet efficient mechanical models. Here efficacy concerns the computational complexity of the kinematic and dynamic models but also the modeling procedure itself and the model parameterization. The computational effort of a mathematical formulation is largely due to the used representation of spatial kinematic and dynamical quantities. Noting that the kinematics and dynamics of a rigid body evolves on a Lie group gives rise to coordinate invariant formulations. Moreover, recognizing that screws form the algebra of the Lie group of rigid body motions gave rise to compact and computationally efficient models for the kinematics in terms of the product of exponentials and for the dynamics, such as the composite rigid body forward dynamics algorithm. Yet these formulations are not widely used; rather traditional approaches are used relying on the Denavit-Hartenberg convention and a separate description of translational and rotational motions. This presentation gives a brief introduction to the Lie group modeling of rigid body robots with arbitrary topology. The simplicity of such formulations is discussed and it is shown how this leads to geometric modeling concepts that allow for a simple and intuitive modeling in terms of readily available data without compromising computational efficiency. The kinematics modeling is discussed for serial as well as for parallel robots. For the latter it is shown how loop closure constraints can be formulated in a coordinate invariant manner and how this allows for regularization of redundant constraints. The geometric modeling provides a direct link to geometric mechanics and allows for application of geometric numerical integration methods on Lie groups. This is briefly discussed.

Biography. Andreas Müller obtained diploma degrees in mathematics (1997), electrical engineering (1998), and mechanical engineering (2000), and a PhD in mechanics (2004). He received his habilitation in mechanics (2008) and is currently professor in robotics at the Johannes Kepler University, Linz, Austria. His current research interests include holistic modeling, model-based and optimal control of mechatronic systems, mechanism theory, redundant robotic systems, parallel kinematic machines, biomechanics, and computational dynamics.

Room Z02.02	FrSS02	Flexible Manufacturing in Industry 4.0 Environments II
Chair: Achim Wager (German Research Center for Artificial Intelligence (DFKI))		

Robotic System Reliability Analysis And RUL Estimation Using An Iterative Approach	
Aggogeri, Francesco (Università degli Studi di Brescia) *Adamini, Riccardo (Università degli Studi di Brescia)* *Merlo, Angelo (Ce.S.I. Centro Studi Industriali)* *Borboni, Alberto (Università degli Studi di Brescia)* *Eytan, Amit (We Plus S.p.A.)* *Németh, István (Budapest University of Technology and Economics)* *Taesi, Claudio (Università degli Studi di Brescia)* *Pellegrini, Nicola (Università degli Studi di Brescia)* *Aivaliotis, Panagiotis (University of Patras)*	151
FrSS02-1	11.15-11.45
Abstract. This paper presents a novel methodology to evaluate robotic system reliability and Remaining Useful Life (RUL) integrating FMECA (Failure Modes, Effects and Criticality Analysis), data-driven and model-based methods. Starting from the FMECA analysis, the methodology proposes to identify the main critical components of new parts or systems, using life data analysis. A database collects and shares data directly from the field on similar systems and applications. Data are stored and managed via a web-based interface, the user may obtain them in real time as needed, when a modification in the robot or production cells occurs. Information are captured through a set of appropriate sensors, selected and located studying historical life data. From this dataset, RUL of components may be estimated using data-driven methods and model-based approaches. Then, the RUL results are shared with ERP systems to optimize production resources and maintenance activities and with FMECA again, to improve new projects in a closed loop. A preliminary application of the methodology is proposed on an anthropomorphic robot integrated in a production cell. This research is a part of PROGRAMS: PROGnostics based Reliability Analysis for Maintenance Scheduling, H2020-FOF-09-2017-767287.	

Edge Computing in Smart Production	
Um, Jumyung (Kyung Hee University) *Gezer, Volkan (Deutsches Forschungszentrum für Künstliche Intelligenz)* *Wagner, Achim (Deutsches Forschungszentrum für Künstliche Intelligenz)* *Ruskowski, Martin (Deutsches Forschungszentrum für Künstliche Intelligenz)*	162
FrSS02-2	11.45-12.15
Abstract. Due to the personalized and fast-shifting market demands, artificial intelligence is recognized as the breakthrough to achieve mass-customized and localized micro factories. This concept is defined as Cyber-Physical Production System, enabling to provide the data lake to the Cloud platform of artificial intelligent service in order to optimize modularized and flexible manufacturing facilities. Even though there exist standardized protocols from device to IT system, there are still challenges for the synchronization between cyber-model and physical object, and the application of the decision made by cyber-model. On the side of operation platform, Cloud platform is the major stream of operation environment of machine learning services. However, at the same time, unstable connection with manufacturing resources is the another challenge in factory application. This paper uses an Edge Computing architecture which is the mediator with machine, by providing local Cloud services with fast response time and preprocessing of vast amount of data. The Edge Service proposed in this paper is the augmented reality device to communicate with cyber-model. Utilized Edge platform controls the computing resources and prioritizes all processes of Edge Services for dynamic update of production line and human-interaction with cyber model.	

Neural Adaptive Control of a Robot Joint Using Secondary Encoders	
Weigand, Jonas (TU Kaiserslautern) *Volkmann, Magnus (TU Kaiserslautern)* *Ruskowski, Martin (TU Kaiserslautern)*	168
FrSS02-3	12.15-12.45
Abstract. Using industrial robots for machining applications in flexible manufacturing processes lacks a high accuracy. The main reason for the deviation is the flexibility of the gearbox. Secondary Encoders (SE) as an additional, high precision angle sensor offer a huge potential of detecting gearbox deviations. This paper aims to use SE to reduce gearbox compliances with a feed forward, adaptive neural control. The control network is trained with a second network for system identification. The presented algorithm is capable of online application and optimizes the robot accuracy in a nonlinear simulation.	

Room Z03.08	FrST03	Rehabilitation Robotics and Exoskeletons
Chair: Said Zeghloul (Poitiers University)		

Wrist Rehabilitation Equipment Based on the Fin-Ray® Effect	
Deaconescu, Andrea (Transilvania University) *Deaconescu, Tudor (Transilvania University)*	101
FrST03-1	11.15-11.45
Abstract. A swift post-traumatic recovery of upper limbs can be achieved best by means of dedicated rehabilitation equipment. A speedy recovery process ensures the early reintegration of patients into society. The rehabilitation equipment proposed in this paper is conceived for the simultaneous passive mobilization of the radiocarpal, metacarpophalangeal and interphalangeal joints. The elements of novelty put forward by this equipment refer to the Fin-Ray® effect underlying the design of the hand support and to its operation by means of a pneumatic muscle – an actuator with inherently compliant behavior. The discussion includes the occurring of hysteresis, and concludes that it does not affect the efficiency of the rehabilitation exercises.	

A Two-degree of Freedom Mobile Ankle Rehabilitation Unit (MARU) to Improve and Track Joint Mobility	
Detzel, Samuel (Technical University of Munich) *Mercader, Alexandra (Technical University of Munich)* *Dietz, Christian (Technical University of Munich)* *Nakamura, Go (Robot Rehabilitation Center in the Hyogo Institute of Assistive Technology)* *Lueth, Tim C. (Technical University of Munich)*	146
FrST03-2	11.45-12.15
Abstract. Rehabilitation for conditions affecting the knee and ankle involve regular mobilization exercises. In order to facilitate the adherence to a rehabilitation plan, we present a mobile and simple to use device consisting of a base and an actuated foot plate. The device can be used for both mobilization and strengthening exercises. Apart from rotation around the ankle, the movement of the foot in the sagittal plane is controlled to imitate walking using a four-bar linkage, potentially expanding the benefits of the exercises to the knee. The trajectory can be fitted to the patient's individual needs by adjusting the linkage dimensions. Using torque sensors, we monitor the exerted forces and can adjust the actuation accordingly. The device can be easily controlled by the patient through a smartphone app, which also supplies additional features such as progress monitoring, with a separate interface for the treating physician.	

Model Based Analysis of Trunk Exoskeleton for Human Efforts Reduction	
Panero, Elisa (Politecnico di Torino) *Muscolo, Giovanni Gerardo (Politecnico di Torino)* *Pastorelli, Stefano (Politecnico di Torino)* *Gastaldi, Laura (Politecnico di Torino)*	140
FrST03-3	12.15-12.45
Abstract. Recent studies highlighted the importance of assisting workers for human efforts reduction in manual handling and lifting tasks by using wearable exoskeletons. In this paper, several configurations of a trunk exoskeleton in terms of hinge joint positions are investigated with the attempt to identify the best ones for human efforts reduction. Both human joints loads and interface forces are considered and compared through simulations. The proposed computational approach may be the starting point for the analysis of design and development of effective human assistance devices.	

Room Z03.07	FrST04	Vision
Chair: Karol Dobrovodsky (Slovak Academy of Sciences)		

Adaptive Recognition for Tracking of Moving Objects	
Dobrovodský, Karol (Slovak Academy of Sciences) *Andris, Pavel (Slovak Academy of Sciences)*	111
FrST04-1	11.15-11.45
Abstract. An adaptive multilocator for online recognition and tracking of moving objects is considered. The vision system is based on the fast real time sub image localization module aimed to recognize patterns in order to track the motion of the selected object. In order to reduce mistakes concerned with the identity, the system is able to recognize several similar objects simultaneously. Nevertheless, the operator can point out an object on the screen to correct the tracking process. An adaptation of the actual patterns according to the lastly localized objects in the area of interest is performed in each step of the real time process. The aim of the paper is to present an effective adaptation and correction procedure based on constant primary patterns defined by the operator and varying secondary patterns defined by the automatic adaptation.	

Probabilistic Orientation Resolution for Near Symmetrical Objects using Depth Images	
Hafez, Nawal (Technische Universität München) *Dietrich, Vincent (Siemens Corporate Technology)* *Zwick, Michael (Technische Universität München)*	114
FrST04-2	11.45-12.15
Abstract. Accurate pose estimation of objects is crucial for various applications. Industrial objects often have challenging properties, namely being texture-less and displaying near symmetry. Common pose estimation methods generally show difficulties in estimating the correct orientation because a discrete amount of orientations is similar due to their near symmetry. In this paper, we examine how localization of challenging objects can be improved with the knowledge about symmetry properties. We develop an algorithm that estimates a distribution over all possible orientations based on an initial pose, a CAD model, and a depth image. Providing a probabilistically valid distribution facilitates decision making in robotic applications in contrast to only providing the most likely pose. We test our algorithm on simulated as well as real data.	

Generation Of Elevation Maps For Planning And Navigation Of Vehicles In Rough Natural Terrain	
Keen, Hannan Ejaz (TU Kasierslautern) *Berns, Karsten (TU Kasierslautern)*	170
FrST04-3	12.15-12.45
Abstract. We propose a system, which generates a precise elevation map of natural rough terrain. It uses basic sensors such as LiDAR and Stereo camera to generate point clouds. Based on the requirements of high precision, specific techniques are integrated to receive adequate maps in real-time. The presented methodology allows an easy extension of existing maps.	

Recipients of past RAAD Awards

RAAD 2009 Workshop, Brasov, Romania, May 25-27, 2009

Best Research Paper Award RAAD 2009:

Recipients: Belfiore Nicola Pio, Verotti Matteo, Consorti Luciano, Department of Mechanics and Aeronautics, *Sapienza University of Rome*, Italy

Paper Title: Comparative Analysis of Isotropy Indices in RR and RRP Arms

Paper Abstract. In this paper isotropy and manipulability in RR dyads and RRP arms are analyzed and the solutions are obtained in algebraic symbolic forms. Such analysis is performed by means of two different methods: the classical approach based on the condition number and the Lie product. Although both the methods are known since decades, an accurate comparison of the two approaches has never been presented in literature. In particular, the geometrical interpretation of the Lie Product allows appreciating some interesting differences between the two methods.

Best Application Paper Award RAAD 2009:

Recipients: Cepon Peter, Kamnik Roman, Kuzelicki Jernej, Bajd Tadej, Munih Marko, Faculty of Electrical Engineering, *University of Ljubljana*, Slovenia

Paper Title: Experimental Mobile Robotic Platform

Paper Abstract. The paper presents an experimental mobile robotic platform aimed at user friendly development of new mobile robotics applications. The development system incorporates the mobile platform construction, the drive unit with traction and steering wheel, main controller, the drive controller and the software development environment. The embedded controller running under xPC Target real time operating system is implemented in mobile platform. The controller controls drive units via CAN communication. The system enables software development and robot control on a remote host supervisory computer. The development system is based on Mathworks Matlab tools Simulink, Stateflow and xPC Target. This configuration allows the development of control algorithm in graphical mode by building and connecting functional blocks. In this way the development system is built providing user friendly graphical software development environment, optimal tuning of parameters, acquisition and logging of signals, and easy incorporation of new devices.

Best Student Paper Award RAAD 2009:

Recipients: Dumitrache Alexandru, Centre for Research & Training in Industrial Control, Robotics and Materials Engineering, *University Politehnica of Bucharest*, Romania

Paper Title: Calibration of wrist-mounted profile laser scanning probe using a tool transformation approach

Paper Abstract. This paper describes a method for calibrating a 3D laser scanning device mounted on the wrist of a 6-DOF robot arm, by computing a tool transformation for the laser sensor reference frame. The calibration procedure involves scanning a spherical object fixed in the robot workspace, and it makes possible aligning many individual scans taken from different orientations. Another advantage of this approach is that further applications are made possible, such as using the laser sensor for accurate robot guidance and alignment.

RAAD 2010 Workshop, Budapest, Hungary, June 23–25, 2010

Best Research Paper Award RAAD 2010:

Recipients*:* Andrej Gams, Tadej Petrič, Leon Žlajpah and Aleš Ude from Slovenia

Paper Title: Optimizing parameters of trajectory representation for movement generalization: robotic throwing

Abstract*:* For effective use of learning by imitation with a robot, it is necessary that the robot can adapt to the current state of the external world. This paper describes an optimization approach that enables the generation of a new motion trajectory, which accomplishes the task in a given situation, based on a library of example movements. New movements are generated by applying statistical methods, where the current state of the world is utilized as query into the library. Dynamic movement primitives are employed as the underlying motor representation. The main contribution of this paper is the optimization of dynamic movement primitives with respect to the kernel function positions and over the entire set of demonstrated movements. We applied the algorithm to a robotic throwing task, where the location of the target is determined by a stereo vision system, which can detect infrared markers. The vision system uses two Nintendo WIIMOTEs for cameras.

Best Application Paper Award RAAD 2010:

Recipients: Andrea Manuello Bertetto, Costantino Falchi, Rinaldo Pinna and Roberto Ricciu from Italy

Paper Title: An Integrated Device for Saffron Flowers Detaching and Harvesting

Abstract: This work is concerned with a mechanical system designed to harvest Crocus Sa-tivus (saffron) flowers. The system is conceived as a shoulder portable device with two mainparts: the first one is specifically designed to detach the flower containing three stigmas, which are the costly final product; the second one is aimed to collect the detached flower through a vacuum collector. This paper describes the operating principle of the detaching and of the harvesting devices. The former device imitates one of the procedures followed by the pickers but with the peculiarity that allows harvesting the flower without separating it from its leaves, which is a significant advantage since it simplifies the mechanical detachment of the flower. The paper also deals with some experimental tests in the laboratory carried out in order to highlight the dynamic behaviour of the detaching and of the harvesting devices.

Best Student Paper Award RAAD 2010:

Recipients: Stanislav Sula, Giuseppe Carbone and Doina Pisla from Romania and Italy

Paper Title: An Experimental Evaluation of Earthquake Effects on Mechanism Operation

Abstract: The results of successful experiments for investigating the earthquake effects on mechanism operation by using Cassino Parallel Manipulator (CaPaMan) as an earthquake simulator are presented. The experimental tests have been carried on by using a slider-crank and a four bar linkage as representing machine operations. The mechanism behavior has been experienced as strongly influenced when the mechanism motion has low speed as compared to earthquake disturbances. But even at high speed mechanisms are affected by the variable earthquake frequency.

RAAD 2012 Workshop, Naples, Italy, September 10–13, 2012

Best Research Paper Award 2012:

Recipients: Silvia Anton, Irina Mocanu, Florin Anton, Theodor Borangiu and Marco Ceccarelli from Romania and Italy

Paper Title: Gesture Recognition for Robot Assistance in Ambient Assisted Living Environments

Abstract: The paper presents a model for pattern discovery of human body posture and gesture interpretation. The model will be used in an ambient intelligent system, called AmIHomCare. The AmIHomCare system is an intelligent ambient system which performs home medical assistance of elderly or disabled people. One component of the AmIHomCare system performs daily activity recognition and monitoring. Each activity is viewed as a sequence of sub-activities. Each sub-activity is composed of a pair of person context (location in the room) and person body posture. The posture of the person is then considered as a full body gesture. The body gesture is detected by using a model for pattern discovering using decision trees. The proposed model allows the detection and interpretation of human static and dynamic gestures. Next, the human gestures will be associated with response actions executed by an assistant robot which will improve the quality of life of the assisted person.

Best Application Paper Award RAAD 2012:

Recipients: M. Donnici, G. Lupinacci, P. Nudo, M. Perreli, S. Meduri, B. Sinopoli, D. Pulice, C. Pace and G. Danieli from Italy

Paper Title: Using Navi-Robot in conjunction with a CAT equipment to guide precision biopsies

Best Student Paper Award 2012:

Recipients: Luka Peternel and Jan Babič from Slovenia

Paper Title: Using Human Sensorimotor Ability to Control Robot Stability: Construction and Evaluation of Human-Robot Interface

Abstract: Abstract. Humanoid robotics has been a subject of many studies in the past years. The humanoid robots are to imitate the human body, characteristics and behaviour. Humans are extremely adaptable and are able to learn many things throughout their life. Our motivation is to exploit this ability to teach robots. If we want to teach a robot how to perform a certain task we need to adapt to the robot dynamics by controlling it with our own body. It is crucial that the robot remains stable at all times. Therefore the human needs to maintain its stability. Robot stability is related to its centre-of-mass (COM) position. In order for human to be able to keep the robot stable while performing and teaching it a certain task, he needs effective feedback information. We decided to use tactile, vestibular and proprioceptive feedback by exerting a force on a human operator at the point of his COM position. To achieve this, we developed a special haptic interface and tested if it is possible to effectively use it to maintain robot stability.

RAAD 2013 Workshop, Portorož, Slovenia, September 11 –13, 2013

Best Research Paper Award 2013:

Recipients: Emre Ugur, Yukie Nagai and Erhan Oztop from Austria, Japan and Turkey

Paper Title: Parental scaffolding as a bootstrapping mechanism for learning grasp affordances and imitation skills

Abstract: Parental scaffolding is an important mechanism utilized by infants during their development. Infants, for example, pay stronger attention to the features of objects highlighted by parents and learn the way of manipulating an object while being supported by parents. Parents are known to make modifications in infant-directed actions, i.e. use "motionese". Motionese is characterized by higher range and simplicity of motion, more pauses between motion segments, higher repetitiveness of demonstration, and more frequent social signals to an infant. In this paper, we extend our previously developed affordances framework to enable the robot to benefit from parental scaffolding and motionese. First, we present our results on how parental scaffolding can be used to guide the robot and modify robot's crude action execution to speed up learning of complex actions such as grasping. For this purpose, we realize the interactive nature of a human caregiver-infant skill transfer scenario on the robot. During reach and grasp attempts the movement of the robot hand is modified by the human caregiver's physical interaction to enable successful grasping. Next, we discuss how parental scaffolding can be used in speeding up imitation learning. The system describes how our robot, by using previously learned affordance prediction mechanisms, can go beyond simple goal-level imitation and become a better imitator using infant-directed modifications of parents.

Best Application Paper Award RAAD 2013:

Recipients: Michael Sfakiotakis, Manolis Arapis, Nektarios Spyridakis and John Fasoulas from Greece

Paper Title: Development and Experimental Evaluation of an Undulatory Fin Prototype

Abstract: Bio-inspired thruster designs encompass significant potential for developing a new generation of underwater vehicles with enhanced propulsion and manoeuvring abilities, to address the needs of a growing number of underwater applications. Undulatory fin propulsion, inspired by the locomotion of cuttlefish and of certain electric eel species, is one such approach currently under investigation. Within this framework, we present the design and experimental evaluation of an undulatory fin prototype, comprised of eight actively-controlled fin rays, which are interconnected by a flexible membrane. A control architecture, based on an artificial Central Pattern Generator (CPG), is used to produce the rays' motion pattern associated with the undulatory movement of the fin. Experimental results from a parametric study indicate that the prototype can achieve speeds up to 1.45 fin lengths per second, and highlight the effect of the various kinematic parameters on the attained velocity and wave efficiency.

Best Student Paper Award 2013:

Recipients: Igor Cvišić and Ivan Petrović from Croatia

Paper Title: Inertial aided sensor platform stabilization on multirotor aerial vehicles

Abstract: Multiple rotor Unmanned Aerial Vehicles (UAVs) are becoming ubiquitous because of their construction simplicity and ease of maintenance. Such UAVs are able to hover, take off and land vertically. In addition, it is straightforward to design an on-board attitude autopilot. In comparison with classical helicopters, multi-rotor aircrafts provide less dangerous testbed in urban and cluttered environments due to their small-size and light-weight blades. In this paper, we present our prototype of aerial vehicle with eight rotors, which carries a unique platform for exteroceptive sensors. We designed inertial aided stabilization of the movement of the platform, decoupling the motion of exteroceptive sensors from the vehicle motion. This directly contributes to improved position and attitude estimation in visual navigation and smoother perception of the

environment, and indirectly to achievement of the vehicle autonomy in urban and cluttered environments. The functionalities of the prototype aerial vehicle and the stabilizing platform are tested in simulation and experimentally.

RAAD 2014 Conference, Smolenice, Slovakia, September 3 – 5, 2014

Best Research Paper Award 2014:

Recipients: Andrej Gams and Tadej Petrič from Slovenia

Paper Title: Adapting periodic motion primitives to external feedback: modulating and changing the motion

Abstract: This paper evaluates the means of adapting periodic motions using either force or position feedback in order to permanently modify the motion, i.e. learn a new trajectory in order to comply with the conditions of the external environment. We evaluate three different approaches: a modulation approach using repetitive control, and two learning approaches of changing the motion. Simulation results have shown that all three approaches can be used with minor differences amongst them. Tests on a 7 degree-of-freedom Kuka LWR robot have shown that the approaches can be used in the real-world.

Best Application Paper Award RAAD 2014:

Recipients: Mirko Rakovic, Marko Jovanovic, Branislav Borovac, Bojan Tepavlevic, Milutin Nikolic and Mladen Papovic from Serbia

Paper Title: Design and Fabrication with Industrial Robot as Brick-laying tool and with Custom Script Utilisation

Abstract: The paper presents methodology and implementation of parametric architectural design of brick-laying walls fabricated by industrial robotic arm. As a design tool Grasshopper is used, a visual programming editor that runs within the Rhinoceros 3D CAD application. Grasshopper offers a range of objects for creating parametric models including brick-laying walls. However it lacks the ability of integration with fabrication tools. To overcome this problem, a custom C# script has been developed. As the fabrication tool, the ABB-IRB 140 robotic arm is used. Thus the C# script is written in such a way to obtain the RAPID code for controlling ABB industrial robots. The C# script enabled automated generation of RAPID code in accordance to the Grasshopper generated geometries of walls.

Best Student Paper Award 2014:

Recipients: Sromona Chatterjee, Timo Nachstedt, Florentin Wlirgotter, Minija Tamosiunaite, Poramate Manoonpong, Yoshihide Enomoto, Ryo Ariizumi and Fumitoshi Matsuno from Germany, Denmark and Japan

Paper Title: Reinforcement Learning Approach to Generate Goal-directed Locomotion of a Snake-Like Robot with Screw-Drive Units

Abstract: In this paper the authors apply a policy improvement algorithm called Policy Improvement with Path Integrals (PI) to generate goal-directed locomotion of a complex snake-like robot with screw-drive units. PI is numerically simple and has an ability to deal with high dimensional systems. Here, this approach is used as a model-free learning mechanism to find proper locomotion control parameters, like joint angles and screw drive velocities, of the robot for moving toward a given goal in a given time. Proper control parameters were also found when the robot was configured with different shapes and for different starting positions of the robot. The learning process was achieved using a simulated robot and the learned parameters were successfully transferred to the real one.

RAAD 2015 Conference, Bucharest, Romania, May 25-27, 2015

Best Research Paper Award 2015:

Recipients: Viorel Stoian, Ionel Cristian Vladu and Ileana Vladu from Romania

Paper Title: A New Hyper-Redundant Arm and its Control System

Abstract: This paper presents a new hyper-redundant robotic arm structure and its sensorial, driving and control systems. A system of cables actuated by DC motors is used for bending. The position of the robot can be obtained by bending it with the cables and by blocking the position of the needed elements using an electro pneumatic system. The major advantage of this type of actuator consists in the fact that the robot can be moved using a boundary control by cables with a single actuating unit, the position blocking system for any element being relatively simple. The main features and advantages of the sensorial system and global robot system are presented. The dynamic model of the arm is developed using Lagrange's formalism; the motion control system is based on the adaptive computed-torque method. Finally, experimental results are described.

Best Application Paper Award RAAD 2015:

Recipients: Aleksandar Rodić, Ilija Stevanović, Miloš D. Jovanović and ⊠or⊠e Urukalo from Serbia

Paper Title: On building remotely operated underwater robot-explorer with bi-manual poly-articular system

Abstract: The paper addresses the mechanical design of a river underwater robot (remotely operated vehicle - ROV) suitable for implementation in delicate and risky underwater tasks. The main factors that determine the mechanical design of the robot are hydrodynamic drags and low underwater visibility. The robot body is inspired by biological models of fishes as well as by the "golden ratio" a natural geometry proportion that commonly appears in nature. The underwater ROV presented in the paper has two redundant, poly-articular, tendon-driven robot arms, suitable for use in submarine tasks due to their flexibility and light mechanical structure. The paper explains how robot propulsion is determined and which kind of thruster motors are chosen for this purpose. The designed mechanical structure is evaluated by corresponding simulation tests and the results of which are analysed. The paper finally presents concluding remarks and objectives of future work.

Best Student Paper Award 2015:

Recipients: Pauline Chevalier, Brice Isableu, Jean-Claude Martin and Adriana Tapus from France

Paper Title: Individuals with Autism: Analysis of the First Interaction with Nao Robot based on their Proprioceptive and Kinematic Profiles

Abstract: The research aims to develop a new personalized social interaction model between a humanoid robot and an individual suffering of Autistic Spectrum Disorder (ASD), so as to enhance his/her social and communication skills. In order to define individual's profile, we posit that the individual's reliance to proprioceptive and kinematic visual cues will affect the way an individual suffering of ASD interacts with a social agent. We describe a first experiment that defines each participant's perceptive-cognitive and sensorimotor profile with respect to the integration of visual inputs, thanks to the Sensory Profile questionnaire and an experimental set-up. We succeeded to form 3 groups with significant different behavioural responses inside our subject pool formed by 7 adults and 6 children with ASD. In a second experiment, we presented the Nao robot to all of our participants. We video-analysed their behaviours and compared them to the profiles we defined. In view of our results, this first interaction confirmed our hypothesis: participants with a weak proprioceptive integration and strong visual dependency had more successful interaction than participants with an overreliance on proprioceptive input and hypo-reactivity to visual cues.

RAAD 2016 Conference, Belgrade, Serbia, June 30 – July 2, 2016

Best Research Paper Award 2016:

Recipients: Leon Žlajpah from Slovenia

Paper Title: Kinematic Control of Redundant Robots in Changing Task Space

Abstract: In the paper we propose a task-space kinematic velocity controller for tasks where the task does not require motion in all spatial directions and these directions also change over time. For that, the controller is mapped from the world space to the task space which may change during the task execution. To simplify the mapping we propose that the desired task location is the origin of the task frame. Effectiveness of the proposed control approach is illustrated by an experiment on a dual arm robot system performing a ring task.

Best Application Paper Award RAAD 2016:

Recipients: Mohammad M. Aref, Reza Ghabcheloo, Antii Kolu and Jouni Mattila

Paper Title: Vision-Guided Autonomous Forklift

Abstract: This paper tackles the problem of integrating Visual Servoing Control (VSC) into the functionalities of an Articulated-Frame-Steering (AFS) hydraulic forklift. The controller is capable of breaking down high-level messages into piecewise commands for the different software modules of the vehicle. It also preserves seamless cooperation of the modules for a successful pallet-picking mission. The proposed architecture has been verified on a real machine. Videos of the test runs are available on YouTube.

Best Student Paper Award 2016:

Recipients: M. Jovanović, J. Tasevski, B. Tepavčević, M. Raković, D. Mitov, B. Borovac from Serbia

Paper Title: Fabrication of Digital Anamorphic Sculptures with Industrial Robot

Abstract: The fabrication process of complex architectural designs in the real world requires precise and complex movements in the workspace. The robotic arms can fulfil this requirement, which makes them an excellent choice for a set of digital fabrication tasks. This paper presents a design methodology for the generation of anamorphic sculptures based on input gray scale image. To represent pixels in real world, wooden sticks are used. The colour of a gray scale image is represented by setting the appropriate orientation of the wooden sticks with respect to the initial vertical position. To achieve good results a large number of sticks is required to be placed and oriented precisely. In order to do this, the holes are drilled at a specified angle in a wooden base. Drilling is carried out with a driller mounted on ABB IRB140 robot arm. After the drilling is finished, wooden sticks are manually placed in each hole.

RAAD 2017 Conference, Turin, Italy, June 21 – July 23, 2017

Best Research Paper Award 2017:

Recipients: Carbone Giuseppe from Italy, Bogdan Gherman, Ionut Ulinici, Calin Vaida, and Doina Pisla from Romania

Paper Title: Design Issues for an Inherently Safe Robotic Rehabilitation Device

Abstract: This paper outlines the main design issues for an upper limb rehabilitation device. In particular, human motions have been measured and analysed in order to identify a safe workspace required for a rehabilitation device. A preliminary design solution is proposed based on a cable-driven parallel architecture, which can provide the required operation workspace and significantly improve the safety of the rehabilitation procedure as compared with exoskeletons or traditional robotic devices.

Best Application Paper Award RAAD 2017:

Recipients: Katiuscia Sacco, Guido Belforte, Gabriella Eula, Terenziano Raparelli, Silvia Sirolli, Elisabetta Geda, Giuliano Carlo Geminiani, Roberta Virgilio, and Marina Zettin from Italy

Paper Title: P.I.G.R.O.: An Active Exoskeleton for Robotic Neurorehabilitation Training Driven by an Electro-Pneumatic Control

Abstract: This paper presents the structure and the main innovations of P.I.G.R.O. (Pneumatic Interactive Gait Rehabilitation Orthosis). It is an active exoskeleton electro-pneumatically controlled with 6 DoF (Degree of Freedom) in the sagittal plane. Robotic neurorehabilitation trainings are its main field of application. Some preliminary tests are carrying on with brain stroke and ictus patients.

Best Student Paper Award 2017:

Recipients: Yu-Hsun Chen, Marco Ceccarelli, and Hong-Sen Yan from Taiwan and Italy

Paper Title: Performance Analysis of the Automata in a Blossoming Flower Clock in the 18th Century

Abstract: This paper presents a performance evaluation of an automaton mechanism in a Blossoming Flower Clock that is preserved in Beijing palace museum. Even though the mechanical structure inside this clock is uncertain, the feasible mechanisms for these automata are synthesized through a systematically design procedure in a previous study. In this paper, the historical background of this clock is introduced first, and then the dimension design, kinematic and dynamic analysis are proposed to provide the numeral results for a performance characterisation. The proposed procedure can also be applied to other automata for reconstructing and analysing the mechanical performance.

RAAD 2018 Conference, Patras, Greece, June 6 – July 8, 2018

Best Regular Paper Award 2018:

Recipients: Leon Žlajpah, Tadej Petric from Slovenia

Paper Title: Virtual Guides for Redundant Robots Using Admittance Control for Path Tracking Tasks

Abstract: Virtual guides are used in human-robot cooperation to support a human performing manipulation tasks. They can act as guidance constrains to assist the user to move in the preferred direction or along desired path, or as forbidden-region constraint which prevent him to move into restricted region of the robot workspace. In this paper we proposed a novel framework that unifies virtual guides using virtual robot approach, which is represented with the admittance control, where a broad class of virtual guides and constraints can be implemented. The dynamic properties and the constraints of the virtual robot can be defined using three sets of parameters and variables: desired motion variables, dynamic parameters (stiffness, damping and inertia) and dead-zones. To validate the approach we implemented it on a KUKA LWR robot for the Buzz-Wire tasks, where the goal is to move a ring along a curved wire.

Best Applicative Paper Award RAAD 2018:

Recipients: Giuseppe Quaglia, Walter Franco, Matteo Nisi from Italy

Paper Title: Stair-Climbing Wheelchair.q05: from the concept to the prototype

Abstract: In this paper, an electric stair-climbing wheelchair, named wheelchair.q05, able to move on flat ground and to climb stairs, is presented. The proposed solution has been developed through a series of studies and designs, all based on a smart hybrid triple leg-wheel locomotion unit. The stability of the device is guaranteed by a rear support of a pair of pivoting wheels during motion on flat ground, and by the support of an idle track, when climbing on or going down stairs. By means of mechanisms and actuators, it is possible to change the configuration of the wheelchair, from the flat ground motion to the stair climbing configuration.

Best Student Paper Award 2018:

Recipients: Florian Pucher, Hubert Gattringer, Christoph Stöger, Andreas Müller, Ulrich Single from Austria

Paper Title: Modeling and Analysis of a Novel Passively Steered 4WD Mobile Platform Concept

Abstract: Applications in the field of mobile robotics have high demands on flexibility and maneuverability of mobile platforms. Especially in logistics, vehicles have limited space for the movement. This paper presents the analysis and control of a mobile platform which uses a novel steering principle. The considered vehicle is able to perform a steered forward movement, lateral motion or pure rotation without the need of steering motors. The kinematics is analyzed and a kinematic model is derived. For simulation a dynamic model formulated in terms of redundant coordinates is used. A control scenario where reference values are commanded by a joystick is presented. For feedforward control design, a reduced dynamic model based on minimal velocities and the kinematic model are used. For feedback control, a cascaded structure with an inner velocity loop for the wheels and a superimposed steering control is used. The efficiency of the presented control approach is demonstrated by simulation results.

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