Advances in Robotics (AIR 2017)

3rd International Conference of Robotics Society of India
Indian Institute of Technology Delhi, New Delhi, India

CONFERENCE SOUVENIR
GENERAL INFO AND ABSTRACTS
JUNE 28 – JULY 2, 2017

Organized by

IIT Delhi

Defence Research & Development Organisation
Ministry of Defence, Government of India

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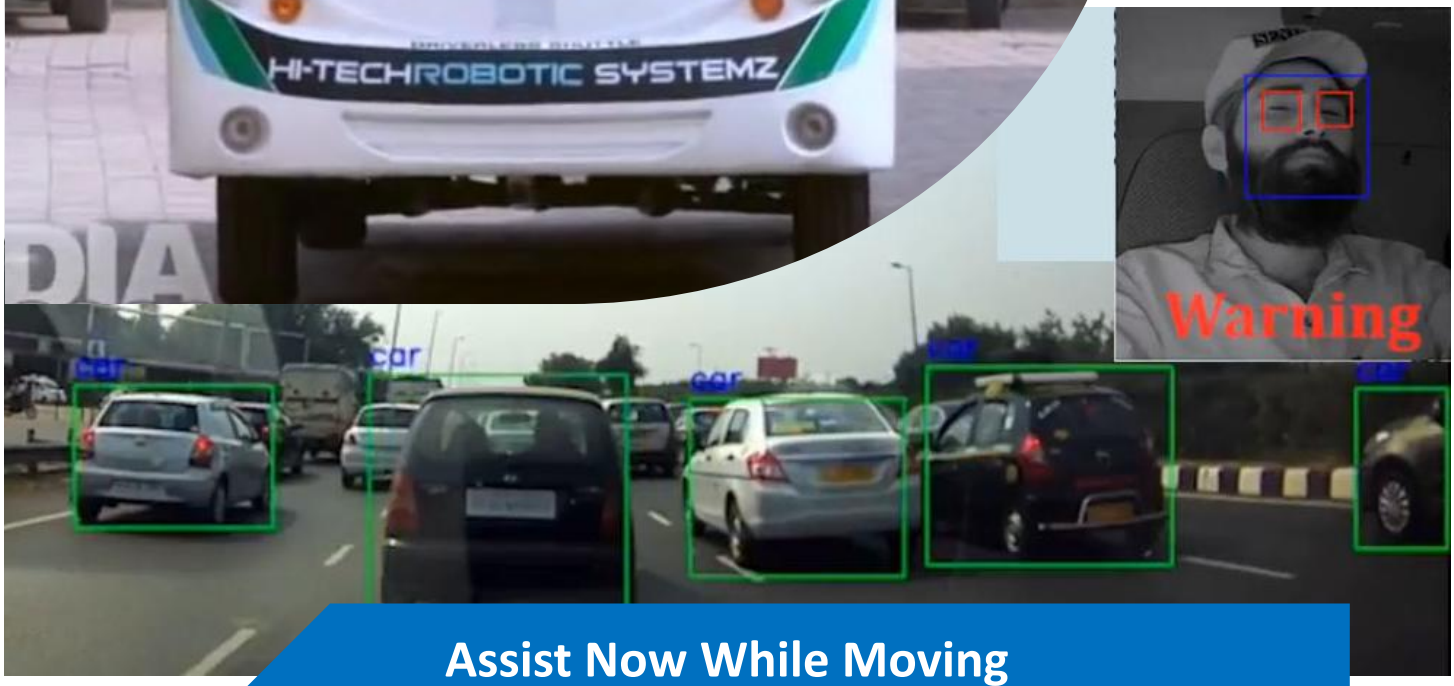

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EVOLUTION THROUGH INNOVATION

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Indian Institute of Technology Delhi

Message from Patron

Prof. V. Ramgopal Rao
Director
Indian Institute of Technology Delhi

I am happy to note that the Robotics Group at IIT Delhi is organizing the 3rd International Conference on Advances in Robotics (AIR-2017) on behalf of the Robotics Society in India during June 28-July 02, 2017. The Robotics Group at IIT Delhi with its more than 10 faculty members drawn mainly from the departments of Computer Science and Engineering, Electrical Engineering, and Mechanical Engineering is one of the very active groups not only in our campus but also in the country.

I take this opportunity to welcome all the speakers and participants from abroad and the country. I have been told that a total of 55 papers will be presented in a single-track session, and more than 200 participants will take part. I am sure the participants will have a unique opportunity to interact closely in a specialized area like Robotics in order to provide a boost to the different technology dimensions in this area. Besides, I want to thank the sponsors and the exhibitors for their contributions to make this conference successful and, possibly, a memorable one.

At the end, please do not forget to enjoy our beautiful campus and visit some of our state of the art facilities not only in the area of Robotics but also in other areas of engineering and science.

My heartfelt congratulations to the organizers and the volunteers who have put in tireless effort to organize such an international-level conference!

RSI President's Message

Mr. Manjit Singh
Distinguished Scientist (Prior to retirement from BARC)
President
Robotics Society of India

It is heartening to note that the Robotics Society of India (RSI) is organizing its 3rd International Conference – Advances in Robotics (AIR-2017) - at IIT Delhi during June 28th to July 2nd, 2017. The previous two conferences were held with great success at R&DE(E), Pune, and BITS Pilani, Goa in 2013 and 2015 respectively. As it steps into its 3rd event, the Advances in Robotics Conference has moved from strength to strength. As in previous years, we have keynote speeches from highly reputed Robotics researchers across continents. This year 143 papers were submitted, and only 34 papers were selected for oral presentation and a few others for poster and short presentation. If the Programme Committee has been too selective about acceptance, it is only to maintain a single thread of presentations and encourage dialogue among delegates of diverse specializations. It has also made a publication in the AIR-Conferences a coveted one. The conference is devoting special sessions for R&D Institutions and Industries to discuss ongoing and future development programmes in these sectors. There are tutorials and workshops on the inaugural day on specialized topics. There is also a Doctoral symposium on the ultimate day, in which PhD students make presentations on their ongoing work. The entire conference has been thoughtfully planned to include all sections of R&D in Robotics. I wish this Conference a great success and hope it generates lot of enthusiasm and activities in Robotics in the country.

From the Desk of General Chairs

Professor Santanu Chaudhury
Director, CEERI Pilani, CSIR-CEERI
Dept. of Elect. Eng., IIT Delhi

Professor Seth Hutchinson
Electrical and Computer Engineering
University of Illinois at Urbana-Champaign

Welcome to Advances in Robotics (AIR 2017) – 3rd International Conference of Robotics Society of India. Advances in Robotics (AIR) is a series of biennial international conferences on Robotics and allied disciplines held in India. The conference provides a forum for presentation and exchange of new ideas to researchers and developers from India and abroad working in the fields of robotics and its applications. The conference will have plenary talks, oral and poster presentations, workshops and special industry focussed sessions. In addition, as part of AIR 2017, we shall have Doctoral Symposium for young Ph.D candidates.

This conference is happening at a time when rapid changes in the field of robotics as well as associated areas such as machine learning and artificial intelligence are ensuring an increasingly important role of robots in business and life in general. Technological developments in computer vision, navigation, MEMS sensors, and semiconductor technologies are driving enhancements in capability, performance, autonomy, ease of use, and cost-effectiveness of industrial and service robots. Effectively, robotics is changing the industrial landscape.

The future of manufacturing is inevitably entwined with robotics and automation. Connectivity, mobility, personalization, and automated production are playing major roles in the future of manufacturing. Robotic process automation (RPA) is the new paradigm that is being adopted by companies to configure computer software using a "robot" to capture and interpret existing applications for processing transactions, manipulating data, triggering responses and communicating with other digital systems. Intelligence embedded in software agents can potentially change the contours of data analysis.

We hope AIR-2017 will provide input to think in these new directions, to define new avenues for robotics research and usher in a new era of disruptive innovation in robotics in India.

Enjoy AIR 2017 and wish you a pleasant stay at IIT Delhi.

From the desk of Programme Co-chairs

Prof. Subir Kumar Saha
Naren Gupta Chair
Dept. of Mech. Eng., IIT Delhi

Prof. Sudipto Mukherjee
Volvo Chair
Dept. Mech. Eng., IIT Delhi

Prof. Tomohiro Shibata
Professor of Kyushu
Institute of Technology

We are extremely pleased to host the third edition of the International Conferences on Advances in Robotics (AIR) at IIT Delhi during June 28-July 02,2017. It is a series of biennial international conferences initiated by the robotics researchers of India with its first one held in 2013 at R&DE(E) Pune (a DRDO laboratory). The objectives are to let our research community including the young Ph.D researchers to interact with the international keynote speakers, typically, from three different continents, and other researchers of international repute from India and abroad. The second one was held in 2015 at Goa campus of BITS Pilani. In that conference, the General Co-chair of AIR 2017, Prof. Santanu Chaudhury, who happened to be the Vice-President (Academic) of the Robotics Society of India (RSI), conceived a Doctoral Symposium where few shortlisted Ph.D students were asked to make presentations in front of several experts. This was targeting to improve the quality of the Ph.D research activities. The event was extremely successful. Hence, we continued with the same event this year also. Twenty Ph.D research scholars will make their presentations on July 02, 2017. In order to expose our participants to in-depth understanding of the contemporary topics of Robotics we have introduced this year two tutorial sessions by two eminent professors from the USA and Japan. We are hopeful about the benefits of those two sessions.

We have accepted 57 papers (for both Oral and Short Paper) out of 143 submitted (acceptance rate of about 40%). Due to some unavoidable reasons, two papers were withdrawn leaving 55 papers to be presented. All the presented papers in the conference will be recommended to the Association of Computing Machinery (ACM) for publications in their online proceedings. IEEE Robotics and Automation Society (RAS) has extended their technical co-sponsorship this year to AIR 2017. We are sure that such support has elevated the prestige of AIR 2017.

Besides thanking the authors for their contributions, we would like to express our heartfelt thanks to the administration of IIT Delhi for extending their support, Government agencies who financially supported our conference, sponsors who generously extended their financial supports, exhibitors, and the organizing committee members (faculty, staff, and students) who put enormous efforts during last several months to make the event successful. At the end, we wish all the participants to have an enjoyable stay and fruitful 5-days at IIT Delhi!

Patron

Prof. V. Ramgopal Rao
Director, IIT Delhi

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IIT Delhi/CSIR CEERI
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Advances in Robotics (AIR 2017): 3rd Int. Conf. of Robotics Society of India

June 28-July 02, 2017

Venue: Lecture Hall Complex (LHC) 111, IIT Delhi

Final Programme

June 28, 2017 (Wednesday)		
Inauguration	9:30~10:30	Inauguration
	10:30~11:00	Group Photograph and Tea/Coffee Break
Tutorial I	11:00~12:50	1. Prof. Sunil Agarwal, Columbia University, USA
	Title	**Robotics for Training of Human Gait, Posture, and Balance**
	12:50~13:50	Lunch
Tutorial II	13:50~15:20	2. Prof. Shibata Tomohiro, Kyushu Institute of Technology Japan
	Title	**Reinforcement Learning and Robotics**
	15:20~15:40	Tea/Coffee Break
Workshop	15:40~17:30	3. TCS Workshop on Robotics for Waste Management

June 29, 2017 (Thursday)									
Time	09:30~10:30	10:30~11:30	11:30~11:50	11:50~12:50	12:50~13:50	13:50~15:20	15:20~15:40	15:40~17:30	17:30~19:00
Keynote Title and Speaker	**Robots for Society: Why we need robots?** Prof. Peter Corke, Queensland University of Technology, Australia								
Sessions	**Keynote 1**	TS 1: Dynamics and Simulation	Tea/ Coffee	TS 2: Systems, and Control	Lunch	R&D/ Industry Session 1	Tea/ Coffee	R&D/ Industry Session 2	RSI-GBM

June 30, 2017 (Friday)							
Time	09:30~11:30	11:30~11:50	11:50~12:50	12:50~13:50	13:50~15:20	15:20~15:40	15:40~17:30
Keynote Title and Speaker	**Recent Robotic Research Activities at IGM, RWTH Aachen University** Prof. Burkhard Corves, RWTH Aachen University, Germany						
Sessions	TS 3: Autonomous Robotics Systems	Tea/Coffee & Poster	**Keynote 2**	Lunch & Poster	TS 4: Control, and Kinematics	Tea/Coffee & Poster	TS 5: Haptics, and Medical Robotics
Banquet	**19:00-22:00 India International Centre, 40, Lodhi Gardens, Lodhi Estate, New Delhi** (Transportation from IIT Delhi will be available after the sessions)						

July 01, 2017 (Saturday)								
Time	9:30~11:30	11:30~11:50	11:50~12:50	12:50~13:50	13:50~15:20	15:20~15:40	15:40~16:40	16:40~17:30
Keynote Title and Speaker	**Sampling-Based Motion Planning: From Intelligent CAD to Crowd Simulation to Protein Folding** Prof. Nancy Amato, Texas A&M University, USA							
Sessions	TS 6: Haptics, and Design	Tea/ Coffee & Poster	**Keynote 3**	Lunch & Poster	TS 7: Systems, and Modeling	Tea/ Coffee Break	TS 8: Control Implementation	Closing Session

July 02, 2017 (Sunday) Doctoral Symposium							
Time	09:30~11:30	11:40~12:30	12:30~13:20	13:30~15:30	15:40~16:30	16:35~17:15	17:15~17:30
Sessions	Session I Presentations	Session II Posters and Tea	Lunch	Session III Presentations	Session IV Posters and Tea	Invited Talk	Valedictory and Awards

Keynote Lectures

Prof. Peter Corke

Queensland University of Technology, Australia

Robots for society: why we need robots

Abstract: Robotics and artificial intelligence (AI) are the next transformative technologies that will impact virtually every industry, from automotive to medical devices, consumer electronics to industrial manufacturing. This talk explores the current state of robotics, and discusses the various segments of industry and society where robotics technologies are expected to have the largest impact, both in the short term and not-too-distant future.

About Speaker

Peter Corke is a professor of robotic vision at Queensland University of Technology, and director of the ARC Centre of Excellence for Robotic Vision. His research is concerned with enabling robots to see, and the application of robots to mining, agriculture and environmental monitoring. He created the Robotics Toolbox for MATLAB, which has been used globally for over 20 years, wrote the best selling textbook "Robotics, Vision, and Control," created several MOOCs, and has won national and international recognition for teaching. He is a fellow of the IEEE, former editor-in-chief of the IEEE Robotics & Automation magazine, founding and associate editor of the Journal of Field Robotics, founding multi-media editor and editorial board member of the International Journal of Robotics Research, member of the editorial advisory board of the Springer Tracts on Advanced Robotics series, recipient of the Qantas/Rolls-Royce and Australian Engineering Excellence awards, and has held visiting positions at Oxford, University of Illinois, Carnegie-Mellon University and University of Pennsylvania. He received his undergraduate and masters degrees in electrical engineering and PhD from the University of Melbourne.

Keynote Lectures

Prof. Nancy Amato

Department of Computer Science and Engineering, Texas A&M University, USA

Sampling-Based Motion Planning: From Intelligent CAD to Crowd Simulation to Protein Folding

Abstract: Motion planning has application in robotics, animation, virtual prototyping and training, and even protein folding and drug design. Surprisingly, sampling-based planning methods have proven effective on problems from all these domains. In this talk, we provide an overview of sampling-based planning and describe some variants developed in our group. We describe applications related to virtual prototyping, crowd simulation, and protein folding. For virtual prototyping, we show that in some cases a hybrid system incorporating both an automatic planner and haptic user input leads to superior results. For crowd simulation, we describe techniques for evacuation planning and for evaluating architectural designs. Finally, we describe our application of sampling-based motion planners to simulate molecular motions, such as protein and RNA folding.

About speaker

Nancy M. Amato is Regents Professor and Unocal Professor of Computer Science and Engineering at Texas A&M University where she co-directs the Parasol Lab. Her main areas of research focus are robotics and motion planning, computational biology and geometry, and parallel and distributed computing. Amato received undergraduate degrees in Mathematical Sciences and Economics from Stanford University, and M.S. and Ph.D. degrees in Computer Science from UC Berkeley and the University of Illinois, respectively. She was program chair for the 2015 IEEE Intern. Conference on Robotics and Automation (ICRA) and for Robotics: Science and Systems (RSS) in 2016. She is an elected member of the CRA Board of Directors (2014-2017), is co-Chair of CRA-W (2014-2017), and was co-chair of the NCWIT Academic Alliance (2009-2011). She received the 2014 CRA Haberman Award, the inaugural NCWIT Harrold/Notkin Research and Graduate Mentoring Award in 2014, the 2013 IEEE HP/Harriet Rigas Award, and a Texas A&M AFS university-level teaching award in 2011. She received an NSF CAREER Award and is a AAAS Fellow, an ACM Fellow and an IEEE Fellow.

Keynote Lectures

Prof. Burkhard Corves

RWTH Aachen University, Germany

Recent Robotic Research Activities at IGM, RWTH Aachen University

Abstract: In recent years there have been divers activities in the area of robotics IGM, RWTH Aachen University:

Active Shaping and assembly of flexible objects: Object integrative handling systems allow designing more lightweight and less complex robotic arms compared to standard industrial robots. This advantage in weight and costs becomes particular important, for the handling and assembly of large scale or low rigidity components. To compensate tolerances and deformations in the assembly process, the component can be shaped, using cooperating robotic arms. An exemplary assembly process was investigated and implemented as a proof of concept.

Bots2ReC Project: The Bots2Rec Project aims at the development and implementation of a semi-autonomous robotic system for the removal of asbestos contamination from rehabilitation sites, e.g. private flats build in the last 70th and 80th. Despite the high degree of industrial automation, robotic solutions are not yet used in the construction and demolition industry. The project partners will develop and adapt state of the art technology in to introduce a robotic system for the mentioned use case.

PARAGRIP: Flexible handling of elements based on reconfigurable parallel kinematic structures. In the last year, the environment of manufacturing companies has changed radically. Individualized products, varying quantities, the cost-pressure of low-wage countries and shortening product life-cycles produce a high momentum on the markets and lead to significant changes in requirements. The rapidly adaptable manufacturing which dominates the market will replace the 'rigid' full automation. Adaptability and flexibility are more important than ever. That is where the IGM developed one solution for a handling system of individualized production.

About speaker

After completing his mechanical engineering studies at RWTH Aachen University in 1984, Burkhard Corves worked as a research assistant at the Department of Mechanism Theory and Machine Dynamics (IGM) where he graduated as PhD in robotics in 1989 and took the post of a Chief Engineer of IGM. After working in special machine construction in Germany and Switzerland from 1991 to 2000, he was appointed a university professor and director of the Department of Mechanism Science and Machine Dynamics (IGM) at RWTH Aachen University in 2000. Among other duties he is the chairman of the Association of German Engineers (VDI) Advisory Board "Mechanism and Machine Science" and member of the Executive Council of the International Federation for the Promotion of Mechanism and Machine Science (IFToMM). To date, he is author and co-author of almost 300 publications in the fields of handling technology and robotics, glass machine technology, mechanism science and machine dynamics.

Local Organizing Team

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Abdullah Aamir Hayat*
Airin Dutta
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Sunil Jha
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*The organizing committee sincerely acknowledges the support of these people for the compilation of this Conference Souvenir

About Robotics Society of India (www.rs-india.org)

In the last several years robotics activities in India has moved well beyond the traditional areas of industrial applications, atomic energy, etc. and entered newer domains of education, rehabilitation, entertainment, and even into our homes. Indian robotics researchers have similarly grown from a handful to over a hundred engaged in research labs, education, industry, atomic energy, etc. Many of us felt that we should have an academic society to further augment our robotics activities and for better interaction among ourselves. With this objective the Robotics Society of India (RSI) was formed on 10th July 2011. Our memberships are open to individuals, corporate, and students.

Objectives

- Encourage interaction between robotics researches in India (academic/R&D Labs/industry).
- Hold joint workshops and conferences at the national level.
- Associate with other organizations involved in Robotics like IEEE, ASME, ACM, etc.
- Publish a newsletter, proceeding, Journals, etc.

Our Activities

RSI organizes a main event every year around the month of July. The events are Advances in Robotics (AIR) and Workshop on Robotics, held alternatively. We also bring our newsletters once in six months. Besides, the student clubs are supported with speakers. We do sponsor/support other robotics-related conferences, workshops, and special lectures.

Advances in Robotics (AIR) is an international conference of Robotics Society of India, held every two years. The details are below:

- AIR-2013 was held at R&DE, DRDO, Pune during July 4-6, 2013
- AIR-2015 was held at BITS Pilani Goa Campus, Goa during July 2-4, 2015
- AIR-2017 is getting held at IIT Delhi during June 28 – July 02, 2017.

Workshops on Robotics and its Applications are held every alternate years, focusing on a specific thrust area of robotics. The details are below:

- Workshop on Haptics and Virtual Reality in Robotics Applications was held at IIT Delhi, New Delhi
  during July 9-10, 2011 [RSI was inaugurated during this workshop]
- Workshop on Advances in Robotics was held at IIT Delhi, New Delhi during July 5-7, 2012
- International Workshop on Autonomous Vehicles and Mobile Robotics was held at IIT Delhi, New Delhi during July 6-8, 2014
- National Workshop on Advances in Robotics (NWAR) was held at IIT Madras, Chennai during July 18-19, 2016

Technical Sessions (TS)

Instructions: All presentations MUST be pre-loaded to the computer available in the room before the start of the corresponding session.

Oral Presentations (15 min each): 12 min presentation + 3 min Q&A;

Short Presentations (5 min each): 4 min presentation only + 1 min for change over.

Authors of Short Papers SHOULD put up of their paper posters on the day of their presentations in the designated area. They will explain to the participants during the Tea/Coffee and Lunch breaks. Poster should be removed at the end of the day.

June 29, 2017 (Thursday)

TS 1: Dynamics and Simulation 10:30~11:30 (60 min)

[Paper ID (4 Oral): 6, 12, 59, 62]

Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

6	Dynamic modelling and simulation of a three-Wheeled Omnidirectional Mobile Robot: Bond graph approach	Ranjan, Saumya
12	Balancing of 15-DOF Biped System	Patel, Vinay
59	RoboAnalyzer: Robot Visualization Software for Robot Technicians	Chittawadigi, Rajeevlochana
62	Integrating Mimic Joints into Dynamics Algorithms - Exemplified by the Hybrid Recupera Exoskeleton	Kumar, Shivesh

TS 2: Systems, and Control 11:50~12:50 (60 min)

[Paper ID (2 Oral): 22, 43]

Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

22	Butterfly Inspired Multi-robotic Swarm for Signal Source Localization	Jada, Chakravarthi
43	Robotic cloth manipulation for clothing assistance task using Dynamic Movement Primitives	Joshi, Ravi

June 29, 2017 (Thursday)

R&D and Industry Sessions (Presenter and time are subjected to change)

R&D/Industry Session 1 [13:50~15:20 (90 min)]

13:50~14:05: Dr. T A Dwarakanath, Div. Remote Handling & Robotics, BARC Mumbai
Title: Parallel mechanism in robots: An approaching scenario

14:05~14:20 Dr. Bani Hazra, R&DE(E), Pune
Title: Robotics Activities at R&DE(E)

14:20~14:35: Dr. S. Nandy, CSIR-CMERI, Durgapur
Title: Robotics at CSIR-CMERI

14:35~14:50 Dr. Prabhu Rajagopal, CNDE-IIT Madras
Title: Submersible robots for structural integrity assessments - CNDE-IITM perspectives

14:50~15:05: Prof. Krishnan Balasubramanian, CNDE-IIT Madras
Title: Robotic based Inspection System Developments in CNDE: On the Ground and Above

R&D/Industry Session 2 [15:40~17:30 (110 min)]

15:40~15:55: Tata Consultancy Services

15:55~16:10: Hi-Tech Robotics Systemz Limited

16:10~16:25: IEEE Standards Association

16:25~16:40: MathWorks

16:40~16:55: Yaskawa

16:55~17:10: Beckhoff

To be decided

June 30, 2017 (Friday)

TS 3: Autonomous Robotics Systems 09:30~11:30 (120 min)
[Paper ID (6 Oral + 5 Short): 5, 30, 31, 33, 38, 107 + 24, 51, 55, 110, 140]
Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

5	Robust tube-MPC based lane keeping system for autonomous driving vehicles	Murali Madhavan Rathai, Karthik
30	Development of a Planar 3PRP Parallel Manipulator using Shape Memory Alloy Spring based Actuators	Singh, Yogesh
31	Bio-inspired Underwater Robot with Reconfigurable and Detachable Swimming Modules	Ravichandran, Santhosh
33	A Hyper-Redundant Robot Development for Tokamak Inspection	Dutta, Pramit
38	Design and Development of Robots for ABU Robocon 2016	Gupta, Varan
107	Development of Low-Cost Education Platform: RoboMuse 4.0	Singh, Rishabjit

Short Paper ID | Paper Title | Primary Author (4 min, No Q&A)

24	A Review of Underwater Robotics, Navigation, Sensing Techniques and Applications	C, Swagat
51	A Floor Cleaning Robot for Domestic Environments	Kakoty, Nayan M
55	DEVELOPMENT OF 4PRR-2P HYBRID ROBOTIC SYSTEM FOR SOFT MATERIAL CUTTING	Thomas, Mervin
110	Motion Planning for an Automated Pick and Place Robot in a Retail Warehouse	Jotawar, Sharath
140	Earthworm like modular robot using active surface gripping mechanism for peristaltic locomotion	Chowdhury, Anirban

TS 4: Control, and Kinematics 13:50~15:20 (90 min)
[Paper ID (4 Oral + 6 Short): 47, 53, 56, 80 + 28, 46, 50, 57, 63, 121]
Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

47	Robust Control of Uncertain Euler-Lagrange Systems with Time-Varying Input Delay	Roy, Spandan
53	Robust Trajectory Tracking Control for an Omnidirectional Mobile Robot	Alakshendra, Veer
56	Controller Design for a Skid Steered Robot and Mapping for Surveillance Applications	George, Anand
80	Design and Implementation of GA Tuned PID Controller for Desired Interaction and Trajectory Tracking of Wheeled Mobile Robot	Damodaran, Suraj

Short Paper ID | Paper Title | Primary Author (4 min, No Q&A)

28	Motion Planning For A Four-Fingered Robotic Hand	Neha, Eram
46	Imitation Learning in Industrial Robots: A Kinematics based Trajectory Generation Framework	Jha, Abhishek
50	Kinematic and Velocity Analysis of 3 DOF Parallel Kinematic Machine for Drilling Operation	Selvakumar , Dr. Arockia
57	An Optimization Based Inverse Kinematics of Redundant Robots Avoiding Obstacles and Singularities	Chembuly, V. V. M. J. Satish
63	Design and Analysis of a Bio-inspired Flapping Wing Robot	Moitra, Sourabh
121	Workspace Analysis of a Cable Driven Leg Exoskeleton for Gait Rehabilitation	Vashista, Vineet

TS 5: Haptics, and Medical Robotics 15:40~17:30 (110 min)
[Paper ID (6 Oral): 106, 109, 115; 9, 10, 117]
Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

106	Virtual Rebar bending training environment with haptics feedback	Menon, Balu
109	Design of a novel Three-Finger haptic grasping system: Extending a Single point to Tripod grasp	Ravindran, Rahul
115	Android based augmented reality as a social interface for low cost social robots	E.K, Subin
9	Stability and Transparency in Bilateral Teleoperation of a Surgical Robot: A case study	Annamraju, Srikar
10	Designing spatio-temporal filter using adaptive sliding window for single trial EEG based BCI	Talukdar, Upasana
117	EEG-EMG based Hybrid Brain Computer Interface for Triggering Hand Exoskeleton for Neuro-Rehabilitation	Chowdhury, Anirban

July 01, 2017 (Saturday)

TS 6: Haptics, and Design 09:30~11:30 (120 min)

[Paper ID (4 Oral + 8 Short): 113, 124, 129, 130 + 49, 54, 63, 65, 67, 90; 112, 126]

Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

113	Dynamics and Control of a Vehicle-Manipulator System	Abhishek, Vishal
124	Development of Portable Gait Characterisation System	Vashista, Vineet
129	Autonomous Leader-Follower Architecture of A.R. Drones in GPS Constrained Environments	Das, Kaushik
130	A hybrid image based visual servoing for 6-D manipulator using Kinect	Raja, Rekha

Short Paper ID | Paper Title | Primary Author (4 min, No Q&A)

49	Workspace Optimization of 3PRR Parallel manipulator for drilling operation using Genetic Algorithm	Kumar, Prabhat
54	Design and Simulation of a Robot Balancing on a Sphere with Reduced Height	Johnson, Joe
65	Development of Actively Steerable In-pipe Inspection Robot for Various Sizes	Gargade, Atul
67	Design of a Compact ROV for River Exploration.	Sahoo, Avilash
90	Development of a NAO Humanoid based Medical Assistant	Kumar, Aditya
112	Visualization of Grasping Operations based on Hand Kinematics measured through Data Glove	Kakoty, Nayan M
126	Towards an Open Source Haptic Kit to teach basic STEM concepts	Koul, Majid

TS 7: Systems, and Modeling 13:50~15:20 (90 min)

[Paper ID (5 Oral + 2 Short): 58, 116, 118; 68, 69 + 72, 112]

Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

58	Small obstacle detection using stereo vision for autonomous ground vehicle	Gupta, Krishnam
116	Advanced KSOM based Redundancy Resolution of a Mobile Manipulator System for Motion on an Uneven Terrain	Hailu, Beteley
118	Terrain Adaptive Posture Correction in Quadruped for Locomotion On Unstructured Terrain	Pareekutty, Nahas
68	Identification of robot dynamic parameters using equimomental systems	Hayat, Abdullah Aamir
69	Impact Modeling and Estimation for Multi-Arm Space Robot while Capturing a Tumbling Orbiting Objects	Raina, Deepak

Short Paper ID | Paper Title | Primary Author (4 min, No Q&A)

72	Force/Position Control of 3 DOF Delta Manipulator with Voice Coil Actuator	Udai, Arun Dayal
122	Graph Based Visual Servoing for Object Category	Pandya, Harit

TS 8: Control Implementation 15:40~16:40 (60 min)

[Paper ID (4 Oral): 18, 93, 100, 138]

Oral Paper ID | Paper Title | Primary Author (12 min + 3 min Q&A)

18	Robust Non-singular Fast Terminal Sliding Mode Task-Space Position Tracking Control of an Underwater Vehicle-Manipulator System	Patre, Balasaheb
93	Implementation of an OROCOS based Real-Time Equipment Controller for Remote Maintenance of Tokamaks	Rastogi, Naveen
100	Distortion correction algorithm for remote navigation of Unmanned Ground Vehicle	Agrawal, Annapurna
138	Chance constraint based multi agent navigation under uncertainty	Gopalakrishnan, Bharath

Advances in Robotics (AIR2017)
Doctoral (PhD) Symposium
Programme Schedule: July 2, 2017

Venue: Lecture Hall Complex (LHC) 111, IIT Delhi

Time	Details
09:30 to 11:30	Session I: Oral Presentations of Researchers 1.1 to 1.10
11:40 to 12:30	Session II: Poster Session of Researchers 1.1 to 1.10 for detailed discussions with expert panel and audience over a cup of tea
12:30 to 13:30	Lunch
13:30 to 15:30	Session III: Oral Presentations of Researchers 2.1 to 2.10
15:40 to 16:30	Session IV: Poster Session of Researchers 2.1 to 2.10 for detailed discussions with expert panel and audience over a cup of tea
16:35 to 17:15	Invited Talk
17:15 to 17:30	Valedictory Session, Awards and Feedback

Sl. No.	Topic	PhD Scholar	Supervisor(s)
1.1	Multiple Mobile Robot Navigation and Coordination	Buddhadeb Pradhan	Nirmal Baran Hui Department of Mechanical Engineering, National Institute of Technology Durgapur Diptendu Sinha Roy Department of Computer Science and Engineering National Institute of Technology Meghalaya, Shilong
1.2	Modelling and Analysis of Multi-Link Flexible Manipulator	Prasenjit Sarkhel	Nilotpal Banerjee and Nirmal Baran Hui Department of Mechanical Engineering National Institute of Technology Durgapur
1.3	Mechanics of robotic grasping	Dharbaneshwer S J	Sankara J. Subramanian Department of Engineering Design Indian Institute of Technology, Madras
1.4	Locomotion Control of Biped Humanoid Robot	Manish Raj	G.C.Nandi Indian Institute of Information Technology, Allahabad
1.5	M-HULL: An Automated Underwater Inspection Robot With Split Hull	Vishakh S Kumar	Prabhu Rajagopal Department of Mechanical Engineering Indian Institute of Technology, Madras
1.6	Design and development of a novel six degrees-of-freedom parallel manipulator for medical rehabilitation	Anirban Nag	Sandipan Bandyopadhyay Department of Engineering Design Indian Institute of Technology Madras
1.7	Dynamics of Underwater Vehicle-Manipulator Systems	Anil Kumar Sharma	Subir K. Saha Department of Mechanical Engineering Indian Institute of Technology Delhi, New Delhi
1.8	Kinematic Studies of A Four-Fingered Tendon Actuated Robotic Hand	Eram Neha	Mohd. Suhaib Mechanical engineering Department Jamia Millia Islamia, New Delhi Sudipto Mukherjee Department of Mechanical Engineering Indian Institute of Technology Delhi, New Delhi
1.9	Design and Analysis of Robotic Exoskeleton for Human Upper Limb Rehabilitation	Akash Gupta	Mukul Kumar Gupta Electronics Instrumentation and Control Department University of Petroleum and Energy Studies, Dehradun
1.10	Dynamics and Control of Unmanned Underwater Vehicle Manipulator Systems	Aparna Pandharkar	Subir K. Saha Department of Mechanical Engineering Indian Institute of Technology Delhi, New Delhi

Advances in Robotics (AIR2017)
Doctoral (PhD) Symposium
Programme Schedule: July 2, 2017

2.1	Visual Feedback based Object Detection and Manipulation	Shraddha Chaudhary	Sumantra Dutta Roy Department of Electrical Engineering Indian Institute of Technology Delhi, New Delhi
2.2	Collision Avoidance Under Uncertainty	Bharath Gopalakrishnan	K. Madhava Krishna and Arun Kumar Singh International Institute of Information Technology Hyderabad
2.3	Visual Servoing Across Object Instances	Harit Pandya	K. Madhava Krishna International Institute of Information Technology Hyderabad
2.4	Towards Ontology and Semantic Mapping for Multi Agent Autonomous Robots	Abhijit Boruah	Tazid Ali Dibrugarh University, Dibrugarh Nayan M Kakoty Tezpur University, Tezpur
2.5	Investigations on adaptive multiple suction chamber control system for wall climbing applications	G. Muthukumaran	Uppu Ramachandraiah Hindustan Institute of Technology and Science, Chennai
2.6	Agile Aerial Manipulation - Modelling and Control	Ranjan Dasgupta	Shubhendu Bhasin Department of Electrical Engineering Indian Institute of Technology Delhi, New Delhi
2.7	A Robotic Algae Harvesting System for Efficient Algae Collection	Swagat C	Dhanapati Deka and Dr. Nayan M Kakoty Tezpur University Tezpur, Assam, India
2.8	Smart Technique For Minimally Invasive Automatic Suturing Robot	Varnita Verma	Mukul Kumar Gupta Electronics Instrumentation and Control Department University of Petroleum and Energy Studies, Dehradun
2.9	Novel Approach towards safety in backhoe with haptics	Meera C S	Mukul Kumar Gupta Electronics Instrumentation and Control Department University of Petroleum and Energy Studies, Dehradun
2.10	Navigation Techniques for Autonomous Mobile Service Robot	Nippun Kumaar A.A.	Sudarshan T.S.B. Department of Computer Science and Engineering Amrita Vishwa Vidyapeetham University, Bangalore

Abstracts

Paper ID: 5

Robust tube-MPC based lane keeping system for autonomous driving vehicles

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This paper proposes a novel framework for lane keeping system for autonomous driving vehicles. The method presented in this paper guarantees stability of the vehicle in presence of bounded disturbances which includes the road curves, banking angle and changes in the longitudinal velocity of the vehicle along the banked road curves. A linear parameter varying (LPV) mathematical model is utilized to define the dynamics of the ego vehicle with the longitudinal velocity of the vehicle as the time varying parameter. For a bounded velocity range, a robust stabilizing feedback gain is pre-computed using linear matrix inequalities (LMI) and semidefinite programming (SDP) techniques. A robust tube based model predictive controller (RTMPC) is implemented utilizing the disturbance invariant set and the computed robust stabilizing gain to guarantee feasibility and stability of the controller. Simulation & results displays better performance and stability of the system for the proposed controller compared to clipped LQR (CLQR) controller.

KEYWORDS: Vehicle dynamics & control, LMI, Robust model predictive control, Lane keeping system, LPV systems, Autonomous vehicles.

Paper ID: 6

Dynamic modelling and simulation of a three-Wheeled Omnidirectional Mobile Robot: Bond graph approach

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This paper presents the dynamic analysis of a three-wheeled omnidirectional mobile robot (TWOMR) using bond graph approach. The robot contain subsystem from different physical domain; the global model is obtained by integrating the model of each sub domain. Simulation is carried out using BG_V20 toolbox in MATLAB Simulink to show the effectiveness of the proposed dynamic model. The simulated results are verified with the Newton-Euler method to illustrate the efficacy of the dynamic modelling technique. The developed bond graph model can be used for various control aspects of the robot.

KEYWORDS: Mobile robot; dynamic modelling; bond graph; trajectory tracking

Paper ID: 9

Stability and Transparency in Bilateral Teleoperation of a surgical Robot: A case study

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Teleoperation plays a major role in many robotic applications such as minimally invasive surgeries, deep underwater/ space operations, hazardous manipulations etc. This necessitates the development of better controllers and architectures that are efficient for practical implementation. The systematic analysis of the developments in the field of teleoperation and the current direction of research are presented herein. This paper elaborates on the practical issues in the development of a teleoperation system, the means by which researchers have attempted to solve these, the level of success, and the future directions. The teleoperation of a surgical robot with a master-slave configuration is considered as a case study to emphasise the issues in bilateral teleoperation. Modelling of the system, the teleoperation control architecture and the stability-transparency issues are presented along with the corresponding simulation results. Finally, an architecture is suggested, which serves as a suitable platform for researchers to carryout teleoperation system analysis.

KEYWORDS: Bilateral teleoperation; Control law; Architectures; Stability; Transparency

Paper ID: 10

Designing spatio-temporal filter using adaptive sliding window for single trial EEG based BCI

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The paper presents a method that automatically segment EEG data and design an optimal spatio-temporal filter to improve the performance of EEG based BCIs. An adaptive sliding window method is proposed for automatic trial segmentation. Common Spatial Pattern is used for extracting features while Davies Bouldin Index is used as a cost function to select the optimal temporal segment. Experiment with this approach has been conducted on BCI Competition II Dataset IV. Naive Bayes Classifier has been employed for classification. Experimental results confirm that the proposed method yields minimum classification error when compared to the two traditional methods: a. EEG trial with no segmentation and b. segmenting EEG trial with classic sliding window. Minimum classification error is achieved with the proposed framework when compared to the best submission for the BCI Competition.

KEYWORDS: Common Spatial Pattern, Spatio-temporal filter, Adaptive sliding window, Davies Bouldin Index

Paper ID: 12

Balancing of 15-DOF Biped System

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This paper proposes architecture for a biped robot with six DOFs per leg and three DOFs Pelvis with each foot having capability to measure the reaction force. System is controlled by 32-bit microcontroller, sensors, strain gauges, and feedback devices for the balancing while it is on single or double foot posture. It has been observed that balance of 15-DOF biped system is achieved successfully with the help of measuring Zero Moment Point (ZMP) with strain gauge and accelerometer.

KEYWORDS: Strain gauge, High torque DC motor, Zero Moment Point (ZMP)

Paper ID: 18

Robust Non-singular Fast Terminal Sliding Mode Task-Space Position Tracking Control of an Underwater Vehicle-Manipulator System

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This paper addresses a task-space trajectory control of an underwater vehicle-manipulator system (UVMS) employed for interactive underwater tasks. The robust task-space tracking control is achieved by designing a non-singular fast terminal sliding mode controller (NFTSMC) with disturbance estimator and demonstrated on a planar underwater vehicle with serial two link manipulator arm attached to it. The proposed NFTSMC integrates a non-singular fast terminal sliding mode controller (NFTSMC) with a non-linear disturbance observer. This combination not only assures finite and faster convergence of the systems states to the equilibrium from anywhere in the phase-plane but also overcomes the problem of singularity associated with conventional terminal sliding mode controller (TSMC). In addition to this, because of the disturbance observer augmented in the proposed control law, the overall stability of the closed-loop system is enhanced to a great extent. The feasibility of the proposed NFTSMC is confirmed by performing extensive numerical simulation on the UVMS for tracking a given pre-defined task space trajectory under the influence of parameter uncertainties, ocean current and measurement sensor noises.

KEYWORDS: Underwater Vehicle-Manipulator System, Terminal Sliding Mode Control, Disturbance Observer, Task-Space Control

Paper ID: 22

Butterfly Inspired Multi-robotic Swarm for Signal Source Localization

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In biological species, cooperative social life and swarm intelligence have helped them to their survival sustainable growths. This paper considers one such recent inspiration model from butterflies so called Butterfly Mating Optimization (BMO), a meta-butterfly model preferred to capture all local-optima of multimodal functions simultaneously. This paper presents the design and architecture of Bflybots, a multi-mobile robot platform to the requirements of Bflies in the BMO algorithm. The multi-Bflybot swarm is designed to acts like butterflies in nature and follow the rules of algorithm. The practical experiments are conducted and the various results are presented. Finally, challenges that are faced and future aspects are initiated for further validation of the algorithm for other signal source localization.

KEYWORDS: Butterfly, Bfly, I-mate, Patrolling, Bflybot, localization

Paper ID: 24

A Review of Underwater Robotics, Navigation, Sensing Techniques and Applications

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The focus of this paper is to review the history of underwater robotics, advances in underwater robot navigation and sensing techniques, and an emphasis towards its applications. Following an introduction, the paper reviews development of the underwater robots since the mid 19th century to recent times. Advancements in navigation and sensing techniques for underwater robotics, and their applications in seafloor mapping and seismic monitoring of underwater oil fields were reviewed. Recent navigation and sensing techniques in underwater robotics has enabled their applications in visual imaging of sea beds, detection of geological samples, seismic monitoring of underwater oil fields and the like. This paper provides a recent review of underwater robotics in terms of history, navigation and sensing techniques, and their applications in seafloor mapping and seismic monitoring of underwater oil fields.

KEYWORDS: Underwater robotics; navigation; sensing techniques

Paper ID: 28

Motion Planning For A Four-Fingered Robotic Hand

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This paper, the concept of trajectory planning is discussed for a four-fingered tendon actuated robotic hand. The finger of the robotic hand is desired to follow a given trajectory using the best solutions out of the number of inverse kinematics solutions. The priority of the finger is to track the given trajectory. The pseudo-inverse of the jacobian matrix is utilized for the accomplishment of this task where the general solution of joint velocity was interpreted by means of the generalized inverse of the Jacobian matrix. Numerical simulation is performed for straight line, circular and elliptical trajectory to show the efficacy of the control scheme.

KEYWORDS: MATLAB Programming, Modeling and Simulations

Paper ID: 30

Development of a Planar 3PRP Parallel Manipulator using Shape Memory Alloy Spring based Actuators

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This paper presents the development of a SMA (shape memory alloy) spring actuation based 3-dof (three degree of freedom) 3PRP (prismatic-rotary-prismatic) planar parallel manipulator where each limb (3 stands for three limbs) of the manipulator having PRP joint arrangement. The active prismatic actuators are made of SMA springs. This 3PRP planar parallel manipulator has a parallel structure including a fixed base and a moving platform (endeffector) and placed in xy plane. Base and the end-effector of the manipulator are linked together by three limbs consisting of prismatic-revolute-prismatic (PRP) joint arrangement in which each limb has one active prismatic joint made of SMA springs. Forward and inverse kinematic analysis of the 3PRP planar parallel manipulator has been studied. Suitability and usage of SMA spring based actuators replacing highly bulky prismatic actuators has been investigated. In addition, the detailed study of the actuation or deflection of the SMA springs in the application of driving the manipulator has been presented experimentally. From the experimental results, it is observed that the 3PRP manipulator associated with SMA spring based actuators has larger workspace to total area required ratio as all the three active prismatic actuators actuates properly and in same time. In overall, this paper shows the 3PRP planar parallel manipulator associated with SMA spring actuators is superior alternatives to conventional motion stages for high precise micro-positioning and tracking applications.

KEYWORDS: Planar parallel manipulator; shape memory alloy springs; micropositioning

Paper ID: 31

Bio-inspired Underwater Robot with Reconfigurable and Detachable Swimming Modules

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Maneuverability and propulsive efficiency are of much interest in autonomous underwater robots. In this paper, we present a novel underwater robot design with two reconfigurable and detachable swimming modules that would be capable of offering both maneuverability and propulsive efficiency. They are also capable of reconfiguring automatically to take two different orientations favoring reduced drag in the swimming direction. A key feature of this design is that the reconfigurability is achieved without additional actuators - helpful in the development of autonomous swarm robots with good maneuverability and efficiency.

KEYWORDS: Bio-inspired underwater robots; swarm robots; re-configurable robots.

Paper ID: 33

A Hyper-Redundant Robot Development for Tokamak Inspection

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Hyper-redundant manipulators are an alternative to serial manipulators that can be used for inspection and maintenance in constrained location. They are highly suitable for inspections in tokamak environment, where the robotic systems need to have multiple degrees of freedom, light weight, fast deployment and retrieval mechanism and high dexterity. In this paper, the design concept and control mechanism of a 3 link tendon driven hyper-redundant inspection system is presented. The paper details the structural design, kinematic modelling, control algorithm development and practical implementation of the hyper-redundant robot with experiments. The prototype developed is used for evaluating the control mechanism and provide a proof of concept.

KEYWORDS: Hyper-redundant manipulator; Kinematic modelling; Tokamak

Paper ID: 38

Design and Development of Robots for ABU Robocon 2016

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This paper presents the results of the efforts made by the IIT Delhi team for ABU Robocon 2016. The design and development of two robots, namely Hybrid robot and Eco robot are discussed in detail using a subsystem approach. Finally, the implications of such robotic projects on the learning experiences of students are addressed. Detailed steps are highlighted in order to assist a participating team to successfully develop effective robots for similar competitions.

KEYWORDS: Robocon, pole climbing, non-contact force, autonomous robot, computer vision

Paper ID: 43

Robotic cloth manipulation for clothing assistance task using Dynamic Movement Primitives

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Theneed of robotic clothing assistance in the field of assistive robotics is growing, as it is one of the most basic and essential assistance activities in daily life of elderly and disabled people. In this study, we are investigating the applicability of using Dynamic Movement Primitives (DMP) as a task parameterization model for performing clothing assistance task. Robotic cloth manipulation task deals with putting a clothing article on both the arms. Robot trajectory varies significantly for various postures and also there can be various failure scenarios while doing cooperative manipulation with non-rigid and highly deformable clothing article. We have performed experiments on so%mannequin instead of human. Result shows that DMPs are able to generalize movement trajectory for modified posture.

KEYWORDS: Robotic Clothing Assistance, Dynamic Movement Primitives (DMP), Human-Robot Interaction, Learning and Adaptive Systems, Learning from Demonstration

Paper ID: 46

Imitation Learning in Industrial Robots: A Kinematics based Trajectory Generation Framework

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This paper presents a simplified approach of imitation learning for an industrial robot. The approach utilizes a teleoperation based trajectory planner to generate an end-effector trajectory through direct imitation of the human motion. The adapted planner exploits the features of the human arm kinematic model and the motion tracking system to achieve real time imitation for trajectory generation. In addition, a trajectory generalization framework, based on clustering and the closest point search is also proposed. This generic framework retrieves an optimal trajectory by utilizing all the demonstrations of the task. The approach is verified experimentally on five degrees of freedom industrial robot for a manufacturing application, where a precise trajectory is desired for execution. The experimental results reflect that the proposed approach provides an effective way to teach robots from human task demonstrations

KEYWORDS: Imitation, Kinematics, Trajectory planner, Generalization

Paper ID: 47

Robust Control of Uncertain Euler-Lagrange Systems with Time-Varying Input Delay

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In this paper, a robust control law is proposed for the tracking control problem of a class of uncertain Euler-Lagrange (EL) systems subjected to randomly varying input delay. EL systems represent a large class of real-world systems such as robotic manipulator, unmanned mobile robots etc. In comparison to the existing predictor based approaches, the proposed Robust Time-Delay Controller (ROTDC) can negotiate input delay within a specified range having an arbitrary variation. Razumikhin-type stability analysis is employed to derive the controller gain to maintain system stability for a given range of delay. Further, the closed loop uncertain system is shown to be Uniformly Ultimately Bounded (UUB) employing the proposed ROTDC. As a validation of the concept, comparative experimental results with predictor based methodology are also provided using a nonholonomic wheeled mobile robot with different time varying input delays, which demonstrate the efficacy of the proposed controller. the proposed controller.

KEYWORDS: Euler-Lagrange systems, input delay, robust control

Paper ID: 49

Workspace Optimization of 3PRR Parallel manipulator for drilling operation using Genetic Algorithm

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Manufacturing field is always focused on high productivity and higher flexibility machines. This can be achieved by the use of parallel manipulators. There are lots of advantages of Parallel robotic manipulators such as high load/weight ratio, velocity, stiffness, precision, and inertia. This work proposes a 3-DoF parallel manipulator for performing drilling operation whose workspace is optimized using Genetic Algorithm method. The workspace of the manipulator is analyzed and plotted in MATLAB software. The complete CAD model of the machine is designed in SOLIDWORKS software and the Motion analysis is also performed in order to trace the path of the tool. The proposed machine is fabricated and the drilling operation is performed in real time.

KEYWORDS: Parallel manipulator, Workspace, Genetic Algorithm

Paper ID: 50

Kinematic and Velocity Analysis of 3 DOF Parallel Kinematic Machine for Drilling Operation

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The cantilever structure of serial manipulator leads to bending under high load and vibration at high speed which affects precision and creates other problems. Parallel manipulator offers alternative to serial manipulator with higher precision and high payload capacity. Parallel manipulator with less degrees of freedom are used for drilling, contour milling, welding and tapping application with better accuracy and faster repeatability. In this paper a 3DOF parallel kinematic machine is proposed for drilling applications. The configuration of proposed PKM (Parallel Kinematic Machine) is 2PUS+PRR. The moving platform is connected with fixed platform using two links with Prismatic-Universal-Spherical (PUS) joints and one link with Prismatic-Rotational -Rotational joints (PRR). Rotational, Universal and Spherical joints are passive joints whereas prismatic joints are actuated by screw pairs with stepper motor. This paper derives Kinematic analysis, velocity equations mathematically.

KEYWORDS: Parallel manipulator; 3DOF; PKM; Kinematic analysis; Velocity analysis

Paper ID: 51

A Floor Cleaning Robot For Domestic Environments

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Although a number of cleaning machines have made its way into the market, cleaning robot in the context of domestic floor environments with different types of dust and dynamic obstacles is still a challenge. This paper presents a mobile robot with sweeping, vacuum suction and wiping capacity for effective cleaning of a domestic floor. The robot can avoid collisions with dynamic obstacles through the fusion of information from two sensors: a sharp infra red sensor and an ultrasonic sonar sensor. It can be used in both autonomous and manual mode of operations. In the autonomous mode, the robot moves in a zig-zag pattern following an edge detection algorithm. It can be controlled using an Android application in the manual mode of operation. In the experimental set-up, cleaning efficiency of 85% and 92% have been obtained in the autonomous and manual modes respectively. It can clean the floor closer to the wall upto an average distance of 16 cm at a cleaning rate of 180 sq. cm /sec.

KEYWORDS: Cleaning robot, Domestic environment, Dynamic obstacles

Paper ID: 53

Robust Trajectory Tracking Control For An Omnidirectional Mobile Robot

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Lately, utilization of portable robots has come up as an insurgency in different applications, scholarly rivalries and so on. Out of numerous versatile robots, omnidirectional portable robots has picked up prominence because of its high mobility. This paper, presents the tracking capability of a mobile robot with four Mecanum wheels in presence of the uncertainties. For the task, first equation of motion has been derived. Then, a robust controller is proposed to track the reference trajectory. Simulation results for a nonlinear trajectory proves the efficacy of the proposed controller.

KEYWORDS: Trajectory tracking; robust controller; Mecanum wheels; sliding mode control

Paper ID: 54

Design and Simulation of a Robot Balancing on a Sphere with Reduced Height

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Most of the present robot balancing over a sphere is equipped with three omnidirectional wheels connected directly to stepping motors that drives the sphere. In this paper, special attention was given to reduce the height of the robot chassis for given sphere size, by proposing a chassis which holds most of the electronics and gear mechanism in which stepping motor shaft is connected to axis of the omnidirectional wheel in perpendicular to each other, without sacrificing the omnidirectional traverse and pivot around its vertical axis capabilities. A bevel gear mechanism is used to drive the wheels from the stepper motors. Due to reduced chassis height, the overall height of robot is reduced to 320mm for sphere size of 240mm diameter, and has increased stability of robot due to lower center of mass. The designed robot has been simulated using SimMechanics, physical modeling method and tested in sphere over robot experimental setup which has been fabricated. The feasibility of developing the mechanism, kinematics and highlights of fabricated robot are described in this paper.

KEYWORDS: Design, Experimentation

Paper ID: 55

Development Of 4prr-2p Hybrid Robotic System For Soft Material Cutting

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This paper deals with the development of a hybrid robotic system with lesser cost and minimum floor space area for cutting soft materials focusing on small scale industries. A waterjet cutting system was developed as the end effector for this hybrid manipulator. The main objective is to develop a multi-purpose manipulator for cutting softer materials such as soap, sponge, leather, rubber, pastry items etc. Many of the food manufacturing industries are producing unhygienic product that can be efficiently and correctly performed with computer controlled systems that operate automatically at faster speed. The design and fabrication of the 4PRR-2P robotic system with waterjet as the end effector is explained in this paper. The soft material chosen in this work is cake.

KEYWORDS: Parallel Kinematic Machines (PKM's); Workspace analysis; waterjet cutting; Kinematic Modelling (analytical approach)

Paper ID: 56

Controller Design For A Skid-steered Robot And Mapping For Surveillance Applications

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Skid-steered robots, with their robust structure and maneuverability, are generally used as outdoor mobile robots. Both kinematic and dynamic modelling of these robots is difficult due to sliding and rolling inherent in general curvilinear motion. In order to improve motion and pose estimation, this paper proposes a kinematic and dynamic model for skid-steered mobile robots. A PID controller, tuned using Genetic Algorithm, based on the dynamic model is then proposed for accurate control of the skid-steered robot. The dynamic model developed enables motion planning for general planar motion. The coefficient of rolling resistance, the coefficient of friction, and the shear deformation modulus, all of which have terrain-dependent values are accommodated in this model. Surveillance bots are of great importance in protecting and saving human life. In this context, mobile and multi-functional robots which map their surroundings are adopted as a means to reduce environmental restructuring and the number of devices used to cover a given area. Skid-steered robots are robust and, therefore, are ideal for surveillance applications.

KEYWORDS: Skid-steered mobile robots, mapping, kinematic model, dynamic model, motion planning, PID control, Genetic Algorithm

Paper ID: 57

An Optimization Based Inverse Kinematics Of Redundant Robots Avoiding Obstacles And Singularities

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Redundant manipulators are characterized by a high number of degrees of freedom (DOF) than the required number to perform a given task. This additional DOF of the robot enhances it to work in the cluttered environment by avoiding obstacles and provides improved dexterity while performing a given task. Inverse Kinematics (IK) of redundant manipulators has infinite solutions. Among these infinite solutions, only those solutions are preferred which fulfill the criteria such as joint distance minimization, singularity avoidance, and joint torque minimization. This paper focuses on the IK of redundant manipulators for a given path with secondary objectives as performance criteria. The IK problem is formulated as an optimization problem by choosing the joint distance and singularity avoidance as objectives and obstacles in the workspace as constraints. Simulations have been performed on serial redundant manipulators by varying different types of obstacles and their positions in the workspace. Results are also reported on redundancy resolution of serial manipulators based on singularity avoidance criterion.

KEYWORDS: Redundant robots, Inverse kinematics

Paper ID: 58

Small Obstacle Detection Using Stereo Vision For Autonomous Ground Vehicle

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Small and medium sized obstacles such as rocks, small boulders, bricks left unattended on the road can pose hazards for autonomous as well as human driving situations. Many times these objects are too small on the road and go unnoticed on depth and point cloud maps obtained from state of the art range sensors such as 3D LIDAR. We propose a novel algorithm that fuses both appearance and 3D cues such as image gradients, curvature potentials and depth variance into a Markov Random Field (MRF) formulation that segments the scene into obstacle and non obstacle regions. Appearance and depth data obtained from a ZED stereo pair mounted on a Husky robot is used for this purpose. While identifying true positive obstacles such as rocks, large stones accurately our algorithm is simultaneously robust to false positive sources such as appearance changes on the road, papers and road markings. High accuracy detection in challenging scenes such as when the foreground obstacle blends with the background road scene vindicates the efficacy of the proposed formulation.

KEYWORDS: Scene understanding; Object detection

Paper ID: 59

Roboanalyzer: Robot Visualization Software For Robot Technicians

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Robots have become an irreplaceable part of various industries which has led to an increasing demand for well-trained robot operators or technicians to operate and maintain these robots. The concepts of robotics are difficult to understand from pure mathematical standpoint which has led to the development of various robot visualization software for better understanding of the robot motion. RoboAnalyzer is one such software. In this paper, the features of RoboAnalyzer and how they can be used to teach robotics concepts to robot technicians are discussed.

KEYWORDS: DH Parameters; Forward Dynamics; Forward Kinematics; Inverse Kinematics; Robot Visualization Software

Paper ID: 62

Integrating Mimic Joints Into Dynamics Algorithms - Exemplified By The Hybrid Recupera Exoskeleton

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The design of various robots in industrial and academic contexts integrates closed loops to improve the mechanical stiffness in comparison with purely serial or tree-type topologies. In particular, planar kinematic loops as parallelograms or double parallelograms are employed in such hybrid robots. Since these systems are geometrically over-constrained in the group of spatial Euclidean motions, the computational performance and numerical accuracy of any model-based dynamics software is negatively affected. This paper introduces a novel method to avoid these numerical issues for any hybrid system with loops that can be characterized by the concept of linear mimic joints: these are passive joints which depend on an active joint in a closed loop in a linear manner. With the proposed approach, the loop closure functions are automatically composed from the robot description file and integrated into the analytical equations for solving the forward and the inverse dynamics problems. The paper illustrates the application of this method for a novel shoulder mechanism containing a planar six bar mechanism that has been designed for the Recupera whole-body exoskeleton.

KEYWORDS: Hybrid robots, dynamic modeling, mimic joints, exoskeletons

Paper ID: 63

Design And Analysis Of A Bio-inspired Flapping Wing Robot

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The design of various robots in industrial and academic contexts integrates closed loops to improve the mechanical stiffness in comparison with purely serial or tree-type topologies. In particular, planar kinematic loops as parallelograms or double parallelograms are employed in such hybrid robots. Since these systems are geometrically over-constrained in the group of spatial Euclidean motions, the computational performance and numerical accuracy of any model-based dynamics software is negatively affected. This paper introduces a novel method to avoid these numerical issues for any hybrid system with loops that can be characterized by the concept of linear mimic joints: these are passive joints which depend on an active joint in a closed loop in a linear manner. With the proposed approach, the loop closure functions are automatically composed from the robot description file and integrated into the analytical equations for solving the forward and the inverse dynamics problems. The paper illustrates the application of this method for a novel shoulder mechanism containing a planar six bar mechanism that has been designed for the Recupera whole-body exoskeleton.

KEYWORDS: Bird robot, bio-inspired robot, flapping wings, aerofoil, kinematic analysis, dynamic analysis

Paper ID: 65

Development of Actively Steerable In-pipe Inspection Robot for Various Sizes

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In-pipe inspection robots are designed to remove the manpower and to work in inaccessible situation. This paper describes an in-pipe inspection robot (IPIR) which consist of a fore leg system, rear leg system and a body. The fore and rear leg systems are symmetric and are constructed by using three legs. Three legs of each leg system are arranged at an angle of 120 degree with respect to each other to operate inside a pipe. The springs are put into lower section of legs to operate inside pipes of 230mm to 300mm diameter range. In this paper, mechanical design of all major components of robot is done. Solid modeling of all robot components and its assembly is done in Solidworks 14. Several experiments are conducted in pipes of different diameters and effectiveness of steering mechanism is confirmed. This robot can be used for offline visual inspection of varies pipe elements such as straight pipe, elbows and reducers. Also it can be used to find the defects and place of defects in the pipe. This robot also has wide applications in gas pipelines, water pipelines and drain pipes etc. Also it has wide scope in chemical industries as well as in gulf countries for inspection of oil and gas pipelines.

KEYWORDS: In-pipe inspection robot (IPIR); steering mechanism; elbow; reducer; defects

Paper ID: 67

Design of a Compact ROV For River Exploration

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Remotely operated underwater vehicles (ROVs) are being extensively used in marine industry for exploration, pollution control, and military applications. With time ROVs have become smaller, less expensive, reliable and practical for small scale use. This paper presents the design of a compact low-cost ROV for river exploration with a modular structure. The ROV is neutrally buoyant which increases its efficiency. The ROV uses three thrusters for its movement inside water and has 3 degrees of freedom (DOF). A detailed 3D model is developed using SOLIDWORKS and stress analysis has been carried out to ensure it will not fail under hydrodynamic pressure. Hydrodynamic characteristics are studied using ANSYS FLUENT, which helps in determining the maximum thrust required for the vehicle propulsion and the maximum achievable velocity. The prototype is manufactured with glass fiber composite and fitted with different electronics components, sensors, and battery. The field test of the ROV is carried out in a controlled underwater environment.

KEYWORDS: Underwater vehicle; ROV; Finite element analysis; Fluid-structure interaction; Glass fiber composite.

Paper ID: 68

Identification of Robot Dynamic Parameters Based on Equimomental Systems

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Dynamic parameter identification is essential due to the model based controller, accurate off-line programming and validation of simulation results. An identification method for the dynamic parameters is proposed using the concept of equimomental systems for modeling which is dynamically equivalent system of point-masses for the first time. It is experimentally validated by torque reconstruction for a general trajectory using the estimated dynamic parameters and using it on the KUKAiiwa manipulator. Results for the estimated torque using identified model and the torque obtained from robot controller are in close match which reflects the correctness of the identified model.

KEYWORDS: Dynamic Identificaion; Equimomnetal system; Robotics

Paper ID: 69

Impact Modeling and Estimation for Multi-arm Space Robot While Capturing a Tumbling Orbiting Objects

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This paper presents impact modeling of a multi-arm robotic system mounted on a service satellite while capture of tumbling orbiting objects. A robotic system with multiple arms would be capable of capturing multiple objects simultaneously. Further when satellite is in broken state or does not have provision for grapple and tumbling, the interception is very difficult. In such cases, interception using multi-arm robotic system can be appealing as this will increase the probability of grasp in comparison to single-arm robot. In this paper, three phases of the capturing operation, namely, approach, impact and post impact have been modeled. In the approach phase, the end-effectors' velocities are designed same as that of the grasping point on the target in order to avoid high impact forces. But in practice, there will be a nonzero relative velocity between the end effector and the grapple point, leading to an impact. In the impact phase, a framework is developed to estimate the changes in the generalized velocities caused by the impact. In post impact phase, these velocities are used as an initial condition for the post impact dynamics simulations of the combined robotic system and target object. Efficacy of the framework is shown using a dual-arm robot mounted on a service satellite performing capturing operation for two tumbling objects.

KEYWORDS: Space Robot, Impact Modeling, Dynamic Simulation

Paper ID: 72

Force/position Control Of 3 Dof Delta Manipulator With Voice Coil Actuator

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Parallel manipulators are widely used in the industries for several applications. Due to its precision in motion as well as its robustness, parallel manipulators have proved its advantage over serial manipulators. In this paper, a 3DOF parallel manipulator is presented and force control of the manipulator is demonstrated. The proposed manipulator uses a direct drive voice coil arc actuators to achieve compliance required for human-robot interaction or soft mechanical manipulations. Its implementation in the proposed delta manipulator is discussed in the paper. The paper has discussed a unique method of controlling position as well as the force at the end-effector of the delta manipulator. The method used in making the manipulator compliant does not need an explicit force sensor and is convenient to implement. The method is inexpensive and works satisfactorily in a human interactive environment which is demonstrated through experiments discussed in the paper. The proposed design finds its application in robot-assisted assembly, surface finishing, cooperative manipulation, haptics etc.

KEYWORDS: Delta manipulator, voice coil actuator (VCA), force control, passive compliance

Paper ID: 80

Design and Implementation of GA Tuned PID Controller for Desired Interaction and Trajectory Tracking of Wheeled Mobile Robot

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The paper presents the design and implementation of a PID control based trajectory tracking of a nonholonomic wheeled mobile robot (WMR) with the objective of matching desired time domain specification and specified interaction. The desired time domain specification of output Y(s) is represented as a step response of a second order system with designer specific desired damping ratio (ζ) and natural frequency ($\bar{}$n). The problem of finding the unknown parameters of PID controllers is formulated in a genetic algorithm (GA) based optimization frame in which the objective is to minimize the difference between the response of the designed closed-loop system and that of the desired closed-loop system. This procedure has been illustrated for achieving the desired time domain specification for WMR, taking different settling time of output response. The interaction analyses are carried out using the concept of Relative Gain Array (RGA). The RGA for both the desired and designed closed-loop systems are found to be matching. It has shown that interaction parameter λ controls both the steady-state and transient response of the desired closed-loop system. The interaction parameter also acts as a parameter which controls the coupling and is chosen by the designer as a specification to be met by designed closed-loop system with PID controller

KEYWORDS: Wheeled mobile robot; PID controller; Trajectory tracking; Interaction, RGA, Time domain specification

Paper ID: 90

Development Of A Nao Humanoid Based Medical Assistant

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In this paper, socially assistive human-robot interaction has been explored on a NAO Humanoid Robot in order to automate the pharmacy and biomedical sector, with a broader aim of addressing all similar tasks. The problem has been divided into three sub-segments viz. pick and place operation with smooth gripping mechanism, reading printed and handwritten text from prescriptions, and use of smart detection technology, with a focus on barcode detection to locate target objects (medicine flaps) in real time. Iterative Jacobian Pseudo inverse kinematics algorithm is implemented to calculate the joint angles. To account for the poor performance of Google Tesseract for handwritten text, the image contrast is enhanced for histogram equalization and fed to maximally stable extremal regions (MSER) algorithm in a combination with Stroke Width Transform (SWT) to make text detection more robust even in presence of blur, before feeding it to Tesseract.Lastly, two techniques are developed to incorporate barcode integration with NAO, first using ALBarcodeReader API, the limitations of which are solved using vertical descent sobel scharr operator to attain real time barcode scanning for all types of barcodes.

KEYWORDS: NAO Humanoid Robot, MSER, Barcode, text detection

Paper ID: 93

Implementation of an OROCOS based Real-Time Equipment Controller for Remote Maintenance of Tokamaks

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A tokamak is a torus shaped device used to confine high temperature plasmas with the help of powerful superimposed magnetic fields. With high temperature, vacuum and radiation levels, the environment inside the tokamak is hostile to human beings. All the repair and maintenance tasks are handled by specialized Remote Handling (RH) equipment consisting of robotic manipulators, special tooling and deployment systems which are controlled by skilled RH operators. These RH equipment are integrated using a supervisory control architecture in which the control system is distributed into operator level and machine level control systems. The OROCOS real-time toolkit, available open source, is used to implement the equipment controller that encompasses the machine-level control system software and hardware for operating multi-joint programmable RH equipment devices. It provides a standard interface and insulates the operator level control system from details of low-level hardware. The communication between operator and machine level systems is achieved at 100Hz through a standard middleware.

This paper presents the detailed implementation of the equipment controller with the operator level & machine level interfaces and its successful implementation for controlling the articulated RH equipment having 25 Kg payload with a toroidal reach of ~2m and a 6 DOF industrial robot. The master control is achieved using a commercial haptic device. A novel concept of virtual move is also implemented for carrying out offline simulations. The performance tests show low latency and smooth control over the RH equipment.

KEYWORDS: Remote Handling; Tokamak, Repair and Maintenance; OROCOS; Haptic feedback; Virtual Reality

Paper ID: 100

Distortion correction algorithm for remote navigation of Unmanned Ground Vehicle

Unmanned Ground Vehicles (UGVs) are remotely operated/autonomous platform used for Dangerous, Dull and Dirty operations: famous 3 D's to avoid/minimize difficulties faced by human. These UGV's are operated from distant control station through Human Machine Interface (HMI). In case of remotely operated platform vision is an essential part which provides a real time scenario of the surroundings. Multiple cameras on-board the UGV serve the purpose of transmitting real time video feed during specific tasks like surveillance or object handling. The choice of camera as a primary source of information is very crucial which governs the success and failure of the intended operation. Field of View (FOV) is one of the most important parameter while selecting cameras for a specific task. For example, a wide angle camera is very effective for navigation of a remotely operated vehicle as it mimics the human vision to a great extent. But this type of camera has issues such as lens distortion which needs to be corrected. This paper presents a generic and real-time distortion correction algorithm for wide angle camera used as a navigation camera onboard Remotely Operated Vehicle (ROV) 'Daksh'. The unique feature of this algorithm is that it can work with any wide angle camera and frame size unlike existing model based algorithms which is camera parameter dependent, computationally intensive, and not suitable for real time operations.

KEYWORDS: Wide angle camera, Distortion model, UGV, FOV, Navigation

Paper ID: 106

Virtual Rebar Bending Training Environment With Haptics Feedback

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All building constructions in India use construction rebars (steel concrete reinforcing bars) to provide structural reinforcement for concrete work. This necessitates experts in bending and cutting rebar to correctly size and bend the long steel rods before they can be installed. This paper presents the design and working of a novel haptic based barbending simulator for providing training to novices in the construction rebar bending skill. The haptic training device is combined with a virtual environment and is capable of providing manual skill training and evaluation of prior knowledge of the trainees. The proposed system provides a multi modal simulation environment with visual, audio and haptic feedback. A preliminary evaluation of the barbending simulator prototype is also presented which demonstrates that this simulator could be used by the trainers and novices to learn the basic principles of bending a rebar.

KEYWORDS: Virtual worlds training simulations

Paper ID: 107

Development Of A Low-cost Education Platform: Robomuse 4.0

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Ever since the inception of Robotics, it has served as a great collaborative platform for researchers from the fields of mechanical engineering, electrical engineering, and computer science. Robot Operating System (ROS), one of the biggest middleware framework for robotics has lead to high paced research and development around the globe. In this paper, we present our work on developing a low-cost ROS enabled education platform for Indian research institutes. This paper begins with our learning of ROS using KUKA youBot and later goes on to discuss in detail the development of the indigenous platform: RoboMuse 4.0 and its integration with ROS.

KEYWORDS: Mobile robotics, ROS, research platform

Paper ID: 109

Design Of A Novel Three-finger Haptic Grasping System: Extending A Single Point To Tripod Grasp

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Present day haptic devices have yet to achieve multi-finger kinesthetic plus tactile feedback. This paper discusses the design of a Three-Finger gripper module that can attach to a commercial haptic device like the Novint Falcon. It will mimic grasping and lifting action and provide kinesthetic feedback via the Falcon and tactile feedback via the gripper. We first present a study on the forces exerted and typical angle and orientation of fingers while lifting or grasping an object. Based on the results obtained, we present a custom designed Three-Finger gripper module that fits on to the Novint Falcon. We show that when the user places his fingers in the finger holders and when the motors are actuated, the finger holders pull on the users' fingers and provide the required sensation.

KEYWORDS: Haptic devices; Gripper module; Object grasping; Multi-Finger haptics; Tactile and Kinesthetic effects.

Paper ID: 110

Motion Planning for an Automated Pick and Place Robot in a Retail Warehouse

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This paper describes the use of Moveit motion planning software for implementing an articulated robot based automatic pick and place system for a retail warehouse. The proposed system is expected to automatically pick things from a rack and place them in a tote and vice-versa, based on an order le. Currently, these tasks are carried out by humans leading to higher cost of operation. The motion planning methods are demonstrated through both simulation and real world experiments. We believe that the details provided in the paper will act as a tutorial for beginners and reference manual for experienced researchers and practising engineers

KEYWORDS: robot manipulator, pick and place, motion planning, inverse kinematics, TRAC-IK, Moveit

Paper ID: 112

Visualization of Grasping Operations based on Hand Kinematics measured through Data Glove

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Although a number of prosthetic hands have been reported, anthropomorphic control is still a challenge. Precise determination of human hand kinematics will certainly enhance the control for prosthetic hands. One of the ways to push the research forward is to measure and visualize the human hand kinematics in real-time during grasping operations. This paper reports the development of a data glove that can measure human hand finger joint kinematics. The measured hand kinematics is visualized for 16 grasp types, adopted from Cutkosky's grasps taxonomy, in SynGrasp MATLAB toolbox. The glove can measure the finger joint angles with an accuracy±standard deviation for metacarpophalangeal (MCP)±4 degree , proximal inter phalangeal (PIP)±2 degree and distal inter phalangeal (DIP)±2 degree during flexion/ extension and abduction/ adduction.

KEYWORDS: Hand kinematics, Data glove, Grasp Types

Paper ID: 113

Dynamics And Control Of A Vehicle Manipulator System

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In this paper, dynamics of a vehicle-manipulator system has been formulated using the NOC-based approach. The formulated dynamics was further used in computed torque control and adaptive control. Task priority redundancy resolution based method was used for kinematic control of multiple tasks. The formulation was applied for simulation of a planar vehicle-manipulator system whose results are provided in this paper.

KEYWORDS: Vehicle-manipulator system; kinematics; dynamics; control.

Paper ID: 115

Android based augmented reality as a social interface for low cost social robots

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Social robots are gradually populating the human space. The utility of such robots is enormous. They can have socially important functions like training for kids with autism and molding the character and behavior of kids. The human-like features of social robots tend to elicit and maintain and enhance positive emotions in a child. The conclusive aim of social robotics is to develop robots that can seamlessly interact with humans. Making them more anthropomorphic is one of the main tasks in designing them. A humanoid robot requires an enormous amount of compactness of all actuators and sensors for expressing anthropomorphic characters. The cost and laboring required to meet these are huge. Also, some of their facial expressions and body movements do not need any physical interaction with the real world. Here comes the need of virtual robots which have the capability of showing a higher level of anthropomorphism. This paper presents a novel method for designing a low-cost android based social robot by replacing the actuators in humanoid robots and implementing virtual avatars instead. The paper contributes a novel integration methodology which combines a mobile robotic base and a virtual character using augmented reality.

KEYWORDS: Augmented Reality(AR), Social Robot, Humanoid Robot, Human-robot interaction

Paper ID: 116

Advanced Ksom Based Redundancy Resolution Of A Mobile Manipulator System For Motion On An Uneven Terrain

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In this paper, we propose an advanced strategy for path following by a redundant mobile manipulator system (Rover) using Kohonen self- Organizing Map(KSOM) based learning architecture. The rover consists of 10 DOF mobile platform with a 4 DOF manipulator mounted on top of it. The 14 DOF system is redundant and does not have a closed form inverse kinematics solution. In addition to the redundancy resolution, as the rover moves on uneven terrain the wheel and ground contact has to be ensured. The KSOM network is first trained using forward kinematics model of the rover manipulator system, with manipulability measure and joint angles of the manipulator serving as constraints. As compared to earlier KSOM methods an adaptive multistep correction is used in the learning loop. Simulation results of the end effector tracking different trajectories on various 3D terrain profiles is presented. The method shows superior performance than previous strategies in terms of accuracy achieved and reduced program execution time.

KEYWORDS: Motion Planning; Unsupervised learning; KSOM, Redundancy, Resolution; Inverse Kinematics; 3D Terrain

Paper ID: 117

Eeg-emg Based Hybrid Brain Computer Interface For Triggering Hand Exoskeleton For Neuro-rehabilitation

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Traditionally a Brain-Computer Interface (BCI) system uses Electroencephalogram (EEG) signals for communication and control applications. In recent years different biological signals are also combined with EEG signals to produce hybrid BCI devices to overcome the limitation of lower accuracy rates in BCI. This paper presents a new approach of combining EEG and Electromyogram (EMG) signals using the spectral power correlation (SPC) to create a hybrid BCI device for controlling a hand exoskeleton. The proposed method was tested on 10 healthy individuals for measuring its performance level in terms of accuracy. The EEG-EMG SPC based hybrid BCI was trained to classify the grasp attempt and resting states of the user. Upon successful detection of a grasp attempt, the hybrid BCI triggers the hand exoskeleton to perform a finger flexion-extension motion. The proposed EEG-EMG SPC method is also compared with the conventional only EEG based method which uses common spatial pattern (CSP) based spatial filtering. The results have shown that the proposed EEG-EMG SPC method yielded an average accuracy of 90±4.86% while the conventional EEG-CSP method yielded 79.75±5.71%. This significantly ($p<0.02$) improved performance in terms of classification accuracy indicates that EEG-EMG SPC based hybrid BCI is a better alternative than the conventional EEG-CSP based BCI to generate hand exoskeleton based neurofeedback.

KEYWORDS: EEG; EMG; SPC; Hybrid BCI; Hand Exoskeleton.

Paper ID: 118

Terrain Adaptive Posture Correction In Quadruped For Locomotion On Unstructured Terrain

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In this paper, we present a method that focuses on posture correction for stable quadruped locomotion over uneven terrain. Stability is ensured by switching to stable postures during gait transitions, where the posture is selected based on the terrain, foothold reachability and gait sequence. For fast and efficient posture evaluation, we use value functions that approximate stability and kinematic parameters. Learning using regression methods is used to create the value functions, which eliminates the need for additional sensors and computation for posture evaluation. This approach has been verified both numerically and experimentally.

KEYWORDS: Robotic planning; Supervised learning by classfication

Paper ID: 121

Workspace Analysis of a Cable Driven Leg Exoskeleton

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with neurological disorders. These are externally powered devices that can apply external forces on human limbs to assist the limb motion. Human walking pattern involves repetitive and well coordinated lower limb movements. A cable driven leg exoskeleton (CDLE) uses actuated cables to apply external torques at anatomical hip and knee joints. However, a cable can apply only pulling force on a body which limits a cable driven system functionality compared to a conventional robotic manipulator. Noting that a CDLE is proposed to assist in complex lower limb motion during walking We present workspace analysis of CDLE considering planar and spatial leg model. Human walking data were used for the analysis and to study the feasibility of CDLE architecture for human gait rehabilitation.1

KEYWORDS: Leg Exoskeleton, Gait Rehabilitation, Workspace analysis

Paper ID: 122

Graph Based Visual Servoing For Object Category

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In this paper we consider the problem of servoing across different instances of an object category, in which given any exemplar from an object category the robot is required to attain a desired pose. The problem becomes relevant in practical scenarios where robots are entailed to handle a wide range of objects. The challenge here is to address the large intra-category variation in the shape of object instances. We propose a two-phase graph based visual servoing (GBVS) framework for instance invariant visual servoing. The first offline phase consists of constructing a dense graph from a large dataset of images of numerous object instances viewed under various camera poses. The vertices in the graph are images themselves and the edges represent visual servoing trajectory length predicted by our metric learning framework. The second online step requires computation of the shortest path and navigation over it through a succession of image based visual servoing (IBVS) manoeuvres. By considering 'cup' as running example to represent an object category, we validate the our approach qualitatively on images downloaded from Internet and quantitatively in terms of camera pose error on synthetic images. We report translation and rotation errors under 11% and 13% respectively.

KEYWORDS: visual servoing; instance invariance

Paper ID: 124

Development of an Adaptive Gait Characterizer

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The study of human gait remains one of the finest areas of biomechanics. Commonly available gait characterization systems provide information regarding speed, cadence and calories burnt during an exercise session. However, the gait of an individual changes continuously with every step. Thus, this work is inspired by the need to develop a system which enables real time analysis of critical spatiotemporal gait parameters while adapting to the walking pattern of the subject. The study of these parameters for a given subject enables us to perform an analysis of individualized gait pattern thereby allowing us to develop corrective measures for gait deficits. In this work we present a real-time analysis of intra-limb temporal parameters using the proposed system that adapts to the changing walking speed.

KEYWORDS: Gait Characterization, Adaptation,Rehabilitation

Paper ID: 126

Towards An Open Source Haptic Kit To Teach Basic Stem Concepts

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Haptic paddles have proven to be effective tools to teach basic concepts in STEM (Science Technology Engineering and Mathematics) education at K-12 (Kindergarten to Grade 12) level. However such devices are yet to undergo commercialization to facilitate their large scale usage by young and enthusiastic K-12 pupils. Most of the haptic paddles are available in research labs only besides being expensive, complex in nature and difficult to replicate, etc. In this work, we demonstrate the design and development of an affordable open source haptic kit with a remarkable plug and play feature. The developed kit consists of a 3D printed 1-DOF (Degrees of Freedom) haptic paddle, popular Arduino UNO as the controller, a customized driver board as shield, and a simple GUI as virtual environment. In particular, the paper discusses various issues, and the solutions proposed thereby, in using Arduino UNO as the controller for the kit. The kit features an open source, compact and portable nature, making it ideal to reproduce, modify, interface with software like MATLAB and commercialize with intended use at the K-12 level.

KEYWORDS: Haptic paddle; 3D printing; Pedagogy; Open Source

Paper ID: 129

Autonomous Leader-Follower Architecture of A.R. Drones in GPS Constrained Environments

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In this paper, we present a low cost leader-follower formation control architecture of UAVs. The low cost architecture comprises of two A.R. drones and two Raspberry Pi. The computation of each drones has been done in cost effective Raspberry Pi. The relative localization among the drones has been done using Aruco Marker. A gradient descent based self-tuning PID controller is used by the follower drone to preserve the formation with respect to the leader drone. Experimental results as well as simulation results have shown in this paper.

KEYWORDS: Formation Control, Leader-follower, UAV, Auto-tuning PID, AR. Drone

Paper ID: 130

A Hybrid Image Based Visual Servoing For 6-d Manipulator Using Kinect

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In this paper, we propose a hybrid image based visual servoing for 6-DOF robot manipulators. It avoids the drawbacks of classical position-based visual servoing. Contrary to the position-based visual servoing, this method does not require any knowledge of the geometric 3-DOF model of the object. On the other hand, the depth information of the object is required. In the proposed approach, a Kinect sensor is used as a camera, which provides depth information of the object from the point cloud. This method not only tracks the position, it also tracks the orientation of the target object. A Harris key-point detector is used to detect the image features of the object. The method is simulated in Gazebo platform with Kinect sensor mounted on 6-DOF UR5 robot manipulator, where all the physical parameters of the robot and Kinect sensor is considered. The solution is developed in C++ integrated with ROS, OpenCV. The method illustrated with a variety of simulation results with an eye-in-hand robotic system which shows the convergence of the system and potential of our method.

KEYWORDS: Eye-in-hand system; Image based visual servoing; UR5 robot manipulator; Kinect sensor; Gazebo

Paper ID: 138

Chance Constraint Based Multi Agent Navigation Under Uncertainty

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In this paper, we present an algorithm for navigating multiple robots under perception and ego-motion uncertainty. Our approach is based on the concept of the Reciprocal Velocity Obstacle which defines a set of constraints for characterizing the space of collision avoidance velocities available to each robot at a given instant in a multi-robot setting. We present a probabilistic variant of RVO obtained by defining chance constraints over the deterministic RVO constraints. Since chance constraints are in general computationally intractable, we present a family of surrogate constraints that can be used as a substitution for the original chance constraints. We show that satisfaction of surrogate constraints ensures satisfaction of original chance constraints with a specific low bound probability. We validate our formulations through numerical simulations in which we highlight the advantages of the proposed formulation over the existing methods, which handle the effect of uncertainty by using conservative bounding volumes.

KEYWORDS: Path planning;Multiagent systems

Paper ID: 140

Earthworm Like Modular Robot Using Active Surface Gripping Mechanism For Peristaltic Locomotion

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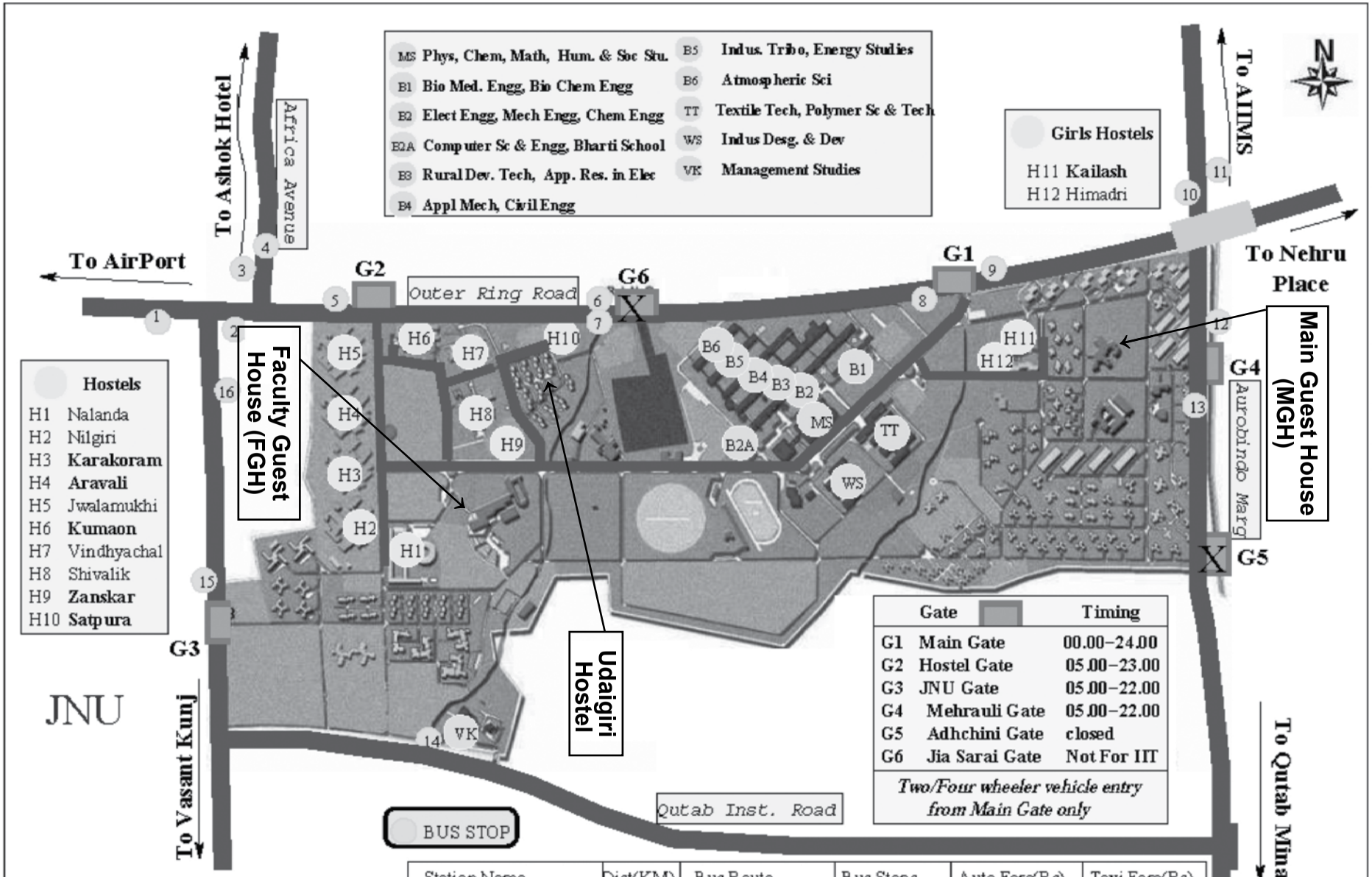
The paper discusses the complete development of a biologically inspired robot which incorporates the continuous wave peristaltic motion of an earthworm, for its locomotion. The robot has two body segments which can expand and contract with a phase difference two create a longitudinal wave from the front to the rear end of the body and uses variable surface friction generation mechanism to convert its body movements into locomotion. The expansion and contraction of the body segments are achieved using lead-screw mechanism and the variable surface friction generation is done by a double crank mechanism mounted active gripping technique. The robot has also a steering mechanism through an active revolute joint between the two segments. The locomotion of the robot is tested on different flat surfaces such as soft floor-mat, concrete, and wood for straight-line motion. The locomotion is also tested in inclined surface by varying the inclination. The ability of following different curved trajectories is also tested on PVC flex surface for circular and sinusoidal trajectories. The motion planning strategy suitable for the developed robot for following curved trajectories is also discussed. Overall, the present work gives a new design approach of building earthworm like peristaltic mobile robots which can navigate through flat as well as inclined even surfaces.

KEYWORDS: Earthworm robots; biomimicking; analysis; peristaltic locomotion; modular robot; trajectory tracking



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Old Delhi RS	19	502	10,13	70–90	150–220
ISBT, Kasmere Gate	21	501,503, 533,631	10,13	80–100	150–230
IG Airport	10	764	2,8	50–70	140–200

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