SSRR 2017

The 15th IEEE International Symposium on Safety, Security and Rescue Robotics

Oct 11-13, 2017 Shanghai, China

Conference Digest

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http://www.ssrr-conference.org/2017

Welcome Message

Dear SSRR 2017 Attendees!

A warm welcome to Shanghai! We are honored to host you at the 15th IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR) 2017, held at ShanghaiTech University, Shanghai, China. This year's edition of the annual event is held from October 11 to 13, and it is fully sponsored by the IEEE Robotics and Automation Society.

This is the first time that SSRR is held in China, but it is also the first IEEE conference held at ShanghaiTech University, which was founded in 2013. We are proud to welcome all participants on the brand-new campus (opened in Summer 2015) and hope that you will have a wonderful experience at ShanghaiTech, Shanghai and China.

Shanghai is the most populous “city proper” in the world and of global importance, also with respect to science and research. China is the biggest and fastest growing robotics market worldwide and Shanghai is aiming to become a global center for robotics development and manufacturing. Unfortunately, China also has a great demand for effective disaster relief and safety technology, such that it is timely to finally host SSRR here.

This year the conference had 55 submitted papers, with 39 being accepted after a rigorous peer-review process. Besides the technical sessions, the program also features four exciting plenary talks. On Wednesday, October 11, Sven Behnke will report on “Perception and Planning for Autonomous Mobile Robots in Complex Environments”. Thursday’s talk will be held by Tetsuya Kimura and it has the title “Standardization and Robot Innovation”. On Friday, Satoshi Tadokoro will present on “ImPACT Tough Robotics Challenge Program for Disaster Response and Prevention”. We are especially happy to also present a speaker from Industry. Shuo Yang from DJI Innovations will also talk on Friday about “The Present and Future of Search & Rescue Drones”.

Besides the plenary talks and technical sessions, we furthermore warmly invite you to our social program, consisting of a Welcome Reception, a Conference Banquet in the heart of Pudong, right next to the Oriental Pearl TV tower, an Awards Lunch and a Farewell Party.

Lastly and most importantly, I would like to thank all the committee members, session chairs, reviewers, and authors; without their participation and help, this conference could not run successfully. Furthermore, I am really thankful for the help of the SIST staff members and student volunteers. I wish for everyone a pleasant and useful experience at SSRR 2017.

Sören Schwertfeger
General Chair
SSRR 2017
ShanghaiTech University, Shanghai, China

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Local Information

SSRR 2017 is held in ShanghaiTech University, at the School of Information Science and Technology (SIST). The venue is located in the new campus in the Zhangjiang Hi-Tech park in Pudong, Shanghai. The address of the campus is:

393 Middle Huaxia Road, Pudong, Shanghai, 201210
上海市浦东新区华夏中路393号 邮编：201210

All sessions take place in the SIST Auditorium. It is on the ground floor of the SIST building number 1, right inside the lobby (you can’t miss it – there will be big SSRR 2017 advertisement).

Please print the following taxi cards to show to your taxi driver:
http://www.ssrr-conference.org/2017/SSRR2017_TaxiCard_ShanghaiTech.pdf
http://www.ssrr-conference.org/2017/SSRR2017_TaxiCard_Parkyard.pdf

The conference hotel is the Parkyard Hotel: http://www.parkyardhotelshanghai.com
Phone: +86 021 6162 1168
Address: No.699 Bibo Road, Pudong New Area, Shanghai
There will be a shuttle bus between the hotel and ShanghaiTech University.

Arriving at Pudong International Airport you have three options to reach the hotel:

- Take the Maglev Train (up to 430 km/h). Arriving at Longyang Road you will then take a taxi (maybe 10 minutes) to the hotel.
- Take a taxi from the airport. Be sure not to follow anybody offering you "taxi" service (this would be an expensive limousine service) but to go to the marked taxi waiting area just outside the arrival hall.
- Take the subway line number 2 to Zhangjiang High Technology Park station.

Social Activities

The **Welcome Reception** will be open between 18:00 and approx. 21:00 on Tuesday, Oct 11. It will be held at the Parkyard Hotel. You will be able to register for the conference. Drinks and a finger food will be served.

The **Conference Banquet** will be held in the "Old Shanghai No. 8 Restaurant" right next to the famous Shanghai TV tower, in the center of Pudong, Shanghai. Buses will bring your from ShanghaiTech University and Parkyard Hotel to the restaurant and back – details will be announced on Oct 12. You will enjoy Chinese food and culture.

Afterwards you can have the chance to do some sightseeing in Lujiazui, the heart of Pudong. Options are:

- Visit the highest observation deck in the world (561m) in the Shanghai Tower (Open 8:30 – 22:00; tickets stop selling at 21:00 and are 200RMB)
- Visit the Shanghai World Financial Center with a glass-bottom observation deck at 474m. (Open 8:00 – 23:00; tickets stop selling at 22:00 and are 180 RMB)
- Visit the Oriental Pearl Radio and TV Tower right next to the restaurant, with an observation deck at 350 m. (Open 8:00 – 22:00; tickets stop selling at 21:00 and are 220 RMB)
- Explore Lujiazui and walk along the river promenade.
- Take the tourist tunnel to the other side of the river (PuXi) to explore the Bund and Nanjing Road. (Tunnel open 8:00 – 22:30; 50RMB)

For your return you can take subway line number 2 from Lujiazui (or East Nanjing Lu if you are in PuXi) back to Zhangjiang Hi-Tech Park station (6 stations; 17 minutes; last train leaves around 23:10).

The **Awards Lunch** will be held on October 13 in the faculty restaurant of ShanghaiTech University.

The **Farewell Party** in the evening of October 13 will take place at Chantime Plaza, one subway stop from the Hotel (Jinke Road station).

Program at a Glance

The program is also available online at:
https://ras.papercept.net/conferences/conferences/SSRR17/program/

	Tue, Oct 10	Wed, Oct 11	Thu, Oct 12	Fri, Oct 13
08:00		Registration		
08:50		Opening	Registration	Registration
09:00		Keynote Sven Behnke 9:00 - 10:00	Keynote Tetsuya Kimura 9:00 - 10:00	Keynote Satoshi Tadokoro 9:00 - 10:00
09:30				
10:00		Coffee Break	Coffee Break	Coffee Break
10:30		We3T1: Robotics and Automation for Safety and Security I 10:30 - 12:10	Th8T1: Perception for Navigation, Hazard Detection, and Victim Identification 10:30 - 12:10	Fr12T1: Mechanisms, Mechatronics, and Embedded Control 10:30 - 12:10
11:00				
11:30				
12:10		Lunch (Cafeterias) 12:10 - 13:10	Lunch (Cafeterias) 12:10 - 13:10	Awards Lunch at Faculty Restaurant 12:10 - 13:30
12:30				
13:00		We4T1: SLAM in Complex And/or Extreme Environments 13:10 - 14:30	Th9T1: Unmanned Ground, Aerial, and Marine Vehicles I 13:10 - 14:30	
13:30				Keynote Shuo Yang 13:30 - 14:30
14:10				
14:30		Demo + Comp. + Coffee Break 14:30 - 15:30	Demo + Comp. + Coffee Break 14:30 - 15:30	Fr14T1: Unmanned Ground, Aerial, and Marine Vehicles II 14:30 - 15:50
15:00				
15:30		We5T1: Human-Robot Interaction and Interfaces 15:30 - 16:50	Th10T1: Robotics and Automation for Safety and Security II 15:30 - 16:50	
16:00				Coffee Break
16:30		Coffee Break		Fr15T1: Autonomous Search and Rescue 16:10 – 17:50
17:00	Registration 17:00 – 18:00	Panel Discussion 17:00 – 17:45	Dinner Banquet Shuttle Bus Service	
s17:30				
18:00	Registration & Welcome Reception Conference Hotel (Parkyard) 18:00 - 21:00			SSRR Farewell Party 18:30 - 19:30 (only finger food)
18:30				
19:00				
19:30				
20:00				
20:30				
21:00				

Plenary Talk I

Perception and Planning for Autonomous Mobile Robots in Complex Environments

Speaker: Sven Behnke
Institute for Computer Science, Universität Bonn, Germany
Date: Wednesday, October 11, 2017
Time: 9:00 – 10:00

Abstract:
Mobile robots in complex environments, like rough terrain or inside buildings need to perceive their environment in 3D in order to act. We equipped autonomous ground vehicles and micro aerial vehicles with 3D laser scanners, cameras, and other sensors. The distance measurements are registered and aggregated in an efficient way in order to create 3D representations of the robot surroundings. By categorizing surfaces, detecting objects, and estimating their pose, these maps are enriched with semantics and segmented into meaningful parts. We developed efficient methods for semantic perception, e.g. using deep learning. Based on these percepts, navigation and manipulation plans are made. Our team demonstrated 3D navigation in challenging application domains: for ground robots in search & rescue and space exploration scenarios and for flying robots in indoor and outdoor inspection tasks. Our robots also performed challenging manipulation tasks, like the use of tools and the collection of objects with micro aerial vehicles.

Speaker Bio:
Sven Behnke received his MS degree in Computer Science (Dipl.-Inform.) in 1997 from Martin-Luther-Universität Halle-Wittenberg. In 2002, he obtained a PhD in Computer Science (Dr. rer. nat.) from Freie Universität Berlin. He spent the year 2003 as postdoctoral researcher at the International Computer Science Institute, Berkeley, CA. From 2004 to 2008, Professor Behnke headed the Humanoid Robots Group at Albert-Ludwigs-Universität Freiburg. Since April 2008, he is professor for Autonomous Intelligent Systems at the University of Bonn and director of the Institute of Computer Science VI.
His research interests include cognitive robotics, computer vision, and machine learning.

Plenary Talk II

Standardization and Robot Innovation

Speaker: Tetsuya Kimura
Department of System Safety, Nagaoka University of Technology, Japan

Date: Thursday, October 12, 2017
Time: 9:00 – 10:00

Abstract:
In ISO/IEC Guide 2, standardization is defined as "activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context," or summary of "lessons learned."
From this viewpoint, the standardization can be an effective tool to accelerate the utilization of innovative technology. In this talk, the effectiveness of the standardization for robot innovation is introduced by considering DHS-NIST-ASTM standard performance test method for the response robots and ISO 13482(safety standard for personal care robots).

Speaker Bio:
Tetsuya Kimura received Dr.of Eng. from Tokyo Institute of Technology related to nonlinear robust control of a pneumatic system in 1995. He was a research associate of Kobe University and Osaka Prefecture University and since 2001, he has been an associate professor of Nagaoka University of Technology.
His research interest is the utilization of the response robots considering both technology and social system development. He is also working for several Japanese government projects, e.g., World Robot Summit and FUKUSIMA Robot Test Field, and standard development, e.g., personal care robot(ISO 13482) and consumer products(walking pole and riding gear).

Plenary Talk III

ImPACT Tough Robotics Challenge Program for Disaster Response and Prevention

Speaker: Satoshi Tadokoro
Graduate School of Information Sciences, Tohoku University, Japan

Date: Friday, October 13, 2017
Time: 9:00 – 10:00

Abstract:
ImPACT Tough Robotics Challenge Program (ImPACT-TRC) focuses on research into robust disaster robot technologies for accessibility, sensing & recognition, recovery, and environmental compatibility. Five types of robots, i.e. UAVs, construction robots, serpentine robots, legged robots and cyber rescue canine, are being developed with advanced visual, auditorial & haptic sensing, robust actuators, mechanisms & control, human interface, and robust wireless communication. A field evaluation meetings is held periodically for the milestones of R&D. It shows the applicable technologies to the users and industry to promote disruptive innovation in disaster response, recovery and preparedness as well as new field robot business. This plenary talk will present a part of its research results and products of this two years as well as application to real disaster.

Speaker Bio:
Satoshi Tadokoro graduated from the University of Tokyo in 1984. He was an associate professor in Kobe University in 1993-2005, and is a professor of Tohoku University since 2005, a vice dean in 2014, and a research professor since 2014. He is a president of International Rescue System Institute since 2002 and IEEE RAS President in 2016-2017. He served as a project manager of MEXT DDT Project on rescue robotics in 2002-2007 having contribution of more than 100 professors nationwide, and PI of NEDO projects related to disaster robotics. His team developed various rescue robots, two of which called Quince and Active Scope Camera are well-known because they were used in disasters such as in nuclear reactor buildings of the Fukushima-Daiichi Nuclear Power Plant Accident. He is a project manager of Japan Cabinet Office ImPACT Project in 2014-18. IEEE Fellow, RSJ Fellow, JSME Fellow, and SICE Fellow.

Plenary Talk IV

The Present and Future of Search & Rescue Drones

Speaker: Shuo Yang
DJI Innovations, Shenzhen, China

Date: Friday, October 13, 2017
Time: 13:30 – 14:30

Speaker Bio:

Shuo Yang is the Director of Intelligent Navigation Technologies at DJI. He obtained his B.Eng and M.Phil degrees from Hong Kong University of Science and Technology (HKUST). He is involved in developing flight control and navigation technologies for several DJI flagship products, such as the Inspire 1, Phantom 4 and Matrice 100 drones and the A3 flight controller. He has coauthored 4 academic papers and obtained near 10 US patents. Shuo is also leading an educational robotics competition project called RoboMaster at DJI.

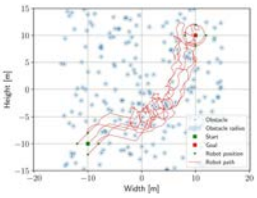
Robotics and Automation for Safety and Security I

10:30–10:50	We3T1.1

Formation Obstacle Avoidance using RRT and Constraint Based Programming

F. Båberg, P. Ögren
KTH Royal Institute of Technology

- Formation keeping in cluttered environment
- Combination of CBP and RRT
- Compared to RRT with Linear Interpolation
- Fewer nodes and shorter time in scenarios with high obstacle densities



10:50–11:10	We3T1.2

Survey in Fukushima Daiichi NPS by Combination of Human and Remotely-Controlled Robot

Tomoki Sakaue, Shin Yoshino, Koju Nishizawa, Kohei Takeda
Tokyo Electric Power Company Holdings (TEPCO)

Outline:

A small remotely-controlled robot and an overlook camera device were developed by TEPCO Research Institute for surveying water leakage in Fukushima Daiichi Nuclear Power Station.

This robot system was deployed in Fukushima Daiichi, going through several tests and a risk assessment for confirming its reliability.

The survey was executed successfully by combination of human and the robot system in November 2015, and finally traces of water leakage were found.

Appearance of the robot

11:10–11:30	We3T1.3

Robotic Bridge Statics Assessment Within Strategic Flood Evacuation Planning Using Low-Cost Sensors

Maik Benndorf[1], Thomas Haenslemann[1], Maximilian Garsch[2], Norbert Gebbeken[2], Christian A. Mueller[3] ,Tobias Fromm[3], Tomasz Luczynski[3] and Andreas Birk[3]
[1]University of Applied Sciences Mitweida, Germany [2] University of the Bundeswehr, Germany [3]Jacobs University Bremen, Germany

11:30–11:50	We3T1.4

On 3D Simulators for Multi-Robot Systems in ROS: MORSE or Gazebo?

- Literature review of different ROS-compatible simulators for multi-robot systems.
- Qualitative and quantitative analysis (such as CPU load, GPU load and real-time factor) between MORSE and Gazebo using a multi-robot patrolling case study.
- ROS used as a middleware for both simulators.
- Overall, MORSE performed better than Gazebo.

11:50–12:10	We3T1.5

Field Experiment Report for Exploration of Abandoned Lignite Mines with Teleinvestigation Robot System

Hiroyasu Miura, Aichi Institute of Technology
Ayaka Watanabe, Aichi Institute of Technology
Masayuki Okugawa, Aichi Institute of Technology
Masamitsu Kurisu, Tokyo Denki University
Susumu Kurahashi, Aichi Institute of Technology

SLAM in Complex and/or Extreme Environments

13:10–13:30	We4T1.1

3D Registration of Aerial and Ground Robots for Disaster Response: An Evaluation of Features, Descriptors, and Transformation Estimation

Abel Gawel[1], Renaud Dubé[1], Hartmut Surmann[2], Juan Nieto[1], Roland Siegwart[1], Cesar Cadena[1]
[1]Autonomous Systems Lab, ETH Zurich, Switzerland
[2]Fraunhofer IAIAS / University of Applied Sciences Gelsenkirchen, Germany

- Fusion of Heterogeneous robotic sensor data can be challenging in SaR scenarios.
- We propose to use 3D feature descriptors to globally align aerial reconstructions and ground-robot LiDAR maps.
- Several 3D registration techniques are evaluated in SaR indoor and outdoor scenarios.

13:30–13:50	We4T1.2

SLAM auto-complete: completing a robot map using an emergency

Malcolm Mielle, Martin Magnusson, Henrik Andreasson, and Achim J. Lilienthal
MRO Lab AASS, Örebro University, Sweden

- Robot exploration time can be quicken by using prior information. We focus on emergency maps (EM).
- A graph-SLAM formulation with information from both modalities is implemented.
- The graph is optimized, fusing the EM and the robot map into one map.
- The EM's inaccuracies in scale are corrected. We handle up to 70% of wrong correspondences between corners.

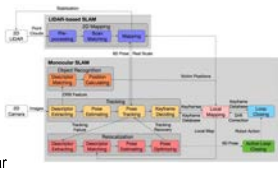
Robot map completed with an emergency map

13:50–14:10	We4T1.3

Robust SLAM system based on monocular vision and LiDAR for robotic urban search and rescue

Xieyuanli Chen, Hui Zhang, Huimin Lu, Junhao Xiao, Qihang Qiu and Yi Li
College of Mechatronics and Automation,
National University of Defense Technology, China

- It is The first trial to use a monocular SLAM in the USAR on ground mobile robots, which can complete most USAR missions, including localization, mapping and object recognition using the same local visual feature.
- A monocular and 2D LiDAR combined SLAM system is proposed to solve the problem of the scale drift and the unreadable map in monocular SLAM, as well as the problem that the robot pose cannot be tracked by the 2D LiDAR SLAM when the robot climbing stairs and ramps.

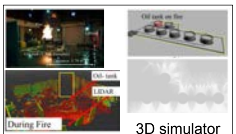

The overview of the proposed SLAM system

14:10–14:30	We4T1.4

Evaluation of LIDAR and GPS based SLAM on Fire Disaster in Petrochemical Complexes

Abu Ubaidah bin Shamsudin*, Naoki Mizuno*, Jun Fujita**, Kazunori Ohno*, Ryunosuke Hamada*, Thomas Westfechtel*, Satoshi Tadokoro* and Hisanori Amano***
*Graduate School of Information Sciences, Tohoku University, Japan
**Mitsubishi Heavy Industries LTD., Nuclear Plant Component Designing Department, Japan
***National Research Institute of Fire and Disaster, Fire and Disaster Management Agency, Japan

- We want to know if SLAM with interval heat cover protection can be used in fire disasters.
- We build simulator a fire disaster and evaluated the accuracy of the SLAM.
- The average accuracy of GPS and LIDAR based SLAM was in the range 0.25-0.36m with sensor's heat cover protection interval; 1s open for measurement and 9 s covering for cooling.



Fire effect
3D simulator with fire effects

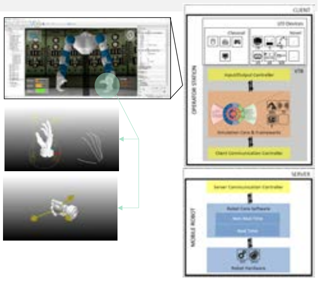
Human-Robot Interaction and Interfaces

15:30–15:50	We5T1.1

Robotic Teleoperation: Mediated and Supported by Virtual Testbeds

Torben Cichon, Jürgen Roßmann
Institute for Man-Machine Interaction (MMI), RWTH Aachen, Germany

- Using a digital twin in a Virtual Testbed for training, support, prediction, and analysis before, after or during mission
  - Abstraction for the user
  - Natural interaction and control
  - Intuitive Visualization
- Symbiosis of virtuality and realty

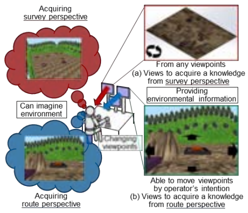


15:50–16:10	We5T1.2

A Pre-offering View System for Teleoperators of Heavy Machines to Acquire Cognitive Maps

Ryuya Sato, Mitsuhiro Kamezaki, Satoshi Niuchi, Shigeki Sugano, and Hiroyasu Iwata
Waseda University

- This study determined a view system for teleoperators before work based on knowledge in cognitive science.
- Although previous studies focus on only views during work and views were determined based on only their experiences.

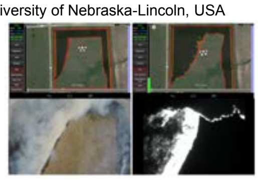


16:10–16:30	We5T1.3

UAS-Rx Interface for Mission Planning, Fire Tracking, Fire Ignition, and Real-Time Updating

Evan Beachly, Carrick Detweiler, Sebastian Elbaum, and Brittany Duncan
Department of Computer Science and Engineering, University of Nebraska-Lincoln, USA
Dirac Twidwell
Department of Agronomy and Horticulture, University of Nebraska-Lincoln, USA

- Describes the development and initial testing of an Unmanned Aerial System interface for prescribed fires
- This system allows fire experts to reach previously inaccessible terrain and better monitor current fire state
- Initial results indicate that allowing users to update a simple fire model in real time results in a better projection of fire



Example from the prescribed fire outside Western, Nebraska of the fire model spread (top left), GoPro video (bottom left), FLIR video (bottom right), and updated model with manual updates of the fire position (top right).

16:30–16:50	We5T1.4

Proposal of Simulation Platform for Robot Operations with Sound

Masaru Shimizu, Chukyo University
Tomoichi Takahashi, Meijo University

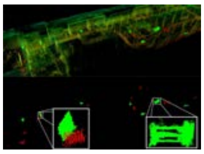
Perception for Navigation, Hazard Detection, and Victim Identification

10:30–10:50	Th8T1.1

Reliable Real-Time Change Detection and Mapping for 3D LiDARs

Lorenz Wellhausen, Renaud Dubé, Abel Roman Gawel, Roland Siegwart, Cesar Cadena Lerma
Autonomous Systems Lab, ETH Zürich, Switzerland

- Changes in 3D maps when patrolling environment are of special interest
- Compute Mahalanobis Hausdorff distance as measure for change likelihood
- Clusters of points are classified with Random Forest Classifier
- Changes are continuously mapped and reported online during a sortie



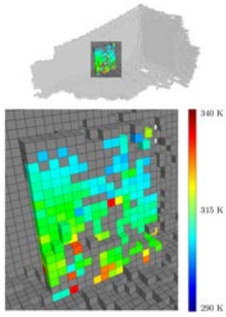
Changes detected in real decommissioned power plant data set

10:50–11:10	Th8T1.2

Tempered Point Clouds and OctoMaps: A Step Towards True 3D Temperature Measurement in Unknown Environments

Björn Zeise and Bernardo Wagner

- Remotely measuring temperatures in unknown environments can be error-prone due to unknown surface emissivities
- Combining thermal images and viewing angle information allows:
  - Classification of regarded material and
  - Estimation of improved surface temperature values
- Evaluation was done by using OctoMaps holding 40 temperature measurements per cell (each taken at a different viewing angle)
- Distinction between metal and dielectric surface areas and extensive temperature improvement were demonstrated



11:10–11:30	Th8T1.3

Fusing of Radar, LiDAR and Thermal Information for Hazard Detection in Low Visibility Environments

Paul Fritsche, Björn Zeise, Patrick Hemme and Bernardo Wagner
Real Time Systems Group, Leibniz Universität Hannover, Germany

- Building maps of environments with changing visibility for search and rescue missions
- Detecting thermal hazards through fused radar, LiDAR and thermal information
- Experiments involving real fog

11:30–11:50	Th8T1.4

Vehicle Detection and Localization on Bird's Eye View Elevation Images Using Convolutional Neural Network

Shang-Lin Yu [1], Thomas Westfechtel [2],
[1] National Cheng Kung University, Taiwan
Ryunosuke Hamada [2], Kazunori Ohno [2], Satoshi Tadokoro [2]
[2] Tohoku University, Japan

- Point cloud data of the LIDAR is transformed into a 3 channel bird's eye view (BV) elevation image which allows us to utilize common RGB-based detection networks.
- Due to the nature of the bird's eye view image, detected vehicles are directly localized with their ground coordinates.
- Our proposed method achieves an average precision of 87.9% for an intersection over union value of 0.5 and 75% of the detected cars are localized with an absolute error of below 0.2m

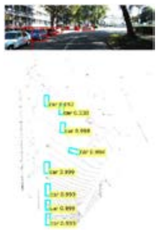


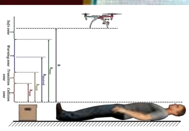
Fig: Results of the vehicle detection on BV (lower) and projected to RGB (upper)

11:50–12:10	Th8T1.5

INTELLIGENT VEHICLE FOR SEARCH, RESCUE AND TRANSPORTATION PURPOSES

Abdulla Al-Kaff, Francisco Miguel Moreno, Arturo de la Escalera and José María Armingol
Intelligent Systems Lab - Universidad Carlos III de Madrid

- The system is able to detect and classify the human bodies and the objects using **low-cost depth sensor**.
- Victims bodies are detected using **SVM** and **HOG** features.
- Moreover, a **semi-autonomous reactive control** is implemented; to control the position and the velocity of the UAV for safe approaching maneuvers to the detected objects.

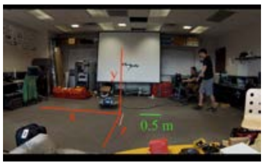


Unmanned Ground, Aerial, and Marine Vehicles I

13:10–13:30	Th9T1.1

Visual Pose Stabilization of Tethered Small Unmanned Aerial System to Assist Drowning Victim Recovery

This paper proposes a method for visual pose stabilization of Fotokite, a tethered small unmanned aerial system, using a forward facing monocular camera. Conventionally, Fotokite stabilizes itself only relative to its tether and not relative to the global frame. It is, therefore, susceptible to environmental disturbances (especially wind) or motion of its ground station. Related work proposed visual stabilization for unmanned aerial systems using a downward facing camera and homography estimation. The major disadvantage of this approach is that all the features used in the homography estimation must be in the same plane. The method proposed in this paper works for features in different planes and can be used with a forward-facing camera. This paper is the part of a bigger project on saving drowning victims using lifesaving unmanned surface vehicle visually servoed by Fotokite to reach the victims. Some of the used algorithms are motion sensitive and, therefore, it is desirable for Fotokite to keep its pose relative to the world. The method presented in this paper will enable to prevent gradual drifting of Fotokite in windy conditions typical for coastal areas or when the ground station is on a boat. The quality of pose stabilization was quantitatively analyzed in 9 trials by measuring metric displacement from the initial pose. The achieved mean metric displacement was 34 cm. The results were also compared to 3 trials with no stabilization.



13:30–13:50	Th9T1.2

A Decentralized Multi-Agent Unmanned Aerial System to Search, Pick Up, and Relocate Objects

Rik Bähnemann, Dominik Schindler, Mina Kamel, Roland Siegwart, and Juan Nieto
Autonomous Systems Lab, ETH Zürich, Switzerland

- A modular, decentralized, collision-free multi-agent aerial search, pick up and delivery system
- Image to position commands visual servoing
- Electropermanent magnet gripper design
- Evaluation and deployment of the system in different Environments.
- Second place MBZIRC 2017 in Challenge 3 and Grand Challenge

Public demonstration of our system youtu.be/sk0XZ01Paqw

ETH Zürich
Autonomous Systems Lab

13:50–14:10	Th9T1.3

Competition Task Development for Response Robot Innovation in World Robot Summit

T.Kimura[1], M. Okugawa[2], K. Oogane[3], Y. Ohtsubo[4], M. Shimizu[5], T. Takahashi[6], and S. Tadokoro[7]
[1]Nagaoka Univ. of Tech., [2]Aichi Inst. of Tech., [3]Niigata Inst. of Tech., [4]Kindai Univ., [5]Chukyo Univ., [6]Meijo Univ., [7]Tohoku Univ., Japan

- Japanese government hosts a robot competition World Robot Summit in 2020 to promote robot innovation.
- The tasks of the disaster robotics category of WRS are introduced,
- The consideration of robot innovation promotion with the WRS tasks is carried out.

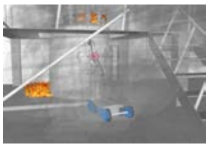


Figure. Plant Disaster Prevention Challenge Mission P4[Disaster Response]

14:10–14:30	Th9T1.4

Events for the Application of Measurement Science to Evaluate Ground, Aerial, and Aquatic Robots

Adam Jacoff, NIST
Richard Candell, National Institute of Standards and Technology
Anthony Downs, NIST
Hui-Min Huang, National Institute of Standards and Technology
Kenneth Kimble, National Institute of Standards and Technology
Kamel Saidi, National Institute of Standards and Technology
Raymond Ka-Man Sheh, Curtin University
Ann-Marie Virts, National Institute of Standards and Technology

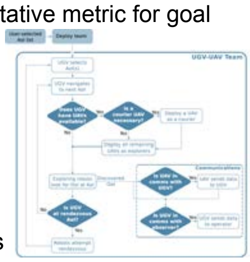
Robotics and Automation for Safety and Security II

15:30–15:50	Th10T1.1

An Investigation of Goal Assignment for a Heterogeneous Robotic Team

Jason Gregory, Iain Brookshaw, Jonathan Fink, S.K. Gupta
ARL, UMD, USC

- Present a framework and quantitative metric for goal assignment strategies
- Consider a team of 1 UGV and 3 UAVs in simulation
- Propose 3 feasible policies
- Consider real-world constraints including failure, battery life, and communications

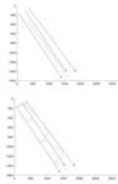


15:50–16:10	Th10T1.2

Autonomous Observation of Multiple USVs from UAV While Prioritizing Camera Tilt and Yaw Over UAV Motion

Leela Krishna C. G., Mengdie Cao, Robin R. Murphy
Department of Computer Science and Engineering,
Texas A&M University, College Station, Texas 77843

- Autonomous repositioning of the UAV at regular intervals to observe USVs during a disaster scenario will provide the operator with better situational awareness.
- Prioritizing camera movements increased the number of times each USV is visited (on an average by 6.2 times more).
- It also reduced the percentage of the duration that the UAV is not observing any USV (on an average by 19.8\%).



UAV Path (in Blue) With & Without Tilt, Yaw

16:10–16:30	Th10T1.3

Visual Servoing for Teleoperation Using a Tethered UAV

Xuesu Xiao, Jan Dufek, and Robin Murphy
Department of Computer Science and Engineering, Texas A&M University, TX

- Perception for teleoperation is usually limited by the robot's onboard camera.
- Teleoperated visual assistant is used but causes problems, such as increased teamwork demand, miscommunication, and suboptimal view points.
- An autonomous tethered UAV is used as visual assistant in this work
- Visual servoing algorithm is developed to maintain a constant 6-DOF configuration to the teleoperation Point of Interest

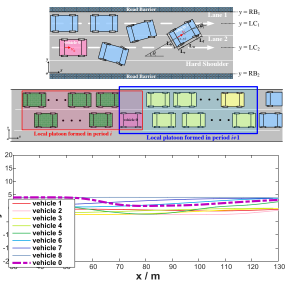
Visual Assistant Servoing the primary robot

16:30–16:50	Th10T1.4

Paving Green Passage for Emergency Vehicle: Real-Time Motion Planning under the Connected and Automated Vehicles Environment

Bai Li et al.
College of Control Science and Engineering, Zhejiang University, China

- Emergency vehicle clearance task is described as a multi-vehicle motion planning (MVMP) problem using connected and automated vehicles;
- A multi-stage decentralized MVMP method is proposed;
- Through dividing the nominal formulation into multiple stages, the online computation burdens are avoided, thereby achieving real-time computation capability.



Mechanisms, Mechatronics, and Embedded Control

10:30–10:50	Fr12T1.1

Position Estimation of Tethered Micro Unmanned Aerial Vehicle by Observing the Slack Tether

Seiga Kiribayashi, Keiji Nagatani
New Industry Creation Hatchery Center, Tohoku University, Japan
Kaede Yakushigawa
The graduate school of engineering, Tohoku University, Japan

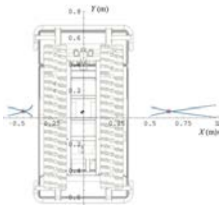
- To extend the operation time of a MUAV, the authors proposed a power-feeding tethered MUAV.
- A position estimation method for the MUAV by observing the slack is proposed.
- To evaluate the method, the authors developed a prototype of a helipad with a tether winding mechanism for the tethered MUAV, and conducted indoor experiments.

10:50–11:10	Fr12T1.2

Inertia-based ICR Kinematic Model for Tracked Skid-Steer Robots

Jorge L. Martínez, Jesús Morales, Anthony Mandow, Salvador Pedraza and Alfonso García-Cerezo
Dpto. Ingeniería de Sistemas y Automática, Universidad de Málaga, Spain

- The effect of inertial forces on the instantaneous centers of rotation (ICRs) of tracks is analyzed by means of dynamic simulations of a mobile robot moving on hard horizontal terrain
- A new kinematic model is proposed in terms of three indices for sliding, eccentricity and steering efficiency that allows to estimate actual track ICR positions as a function of inertia measurements and track speeds



Estimation of track ICR distributions

11:10–11:30	Fr12T1.3

WAREC-1 - A Four-Limbed Robot Having High Locomotion Ability with Versatility in Locomotion Styles

Kenji Hashimoto, Shunsuke Kimura, Nobuaki Sakai, Shinya Hamamoto, Ayanori Koizumi, Xiao Sun, Takashi Matsuzawa, Tomotaka Teramachi, Yuki Yoshida, Asaki Imai, Kengo Kumagai, Takanobu Matsubara, Koki Yamaguchi, Gan Ma and Atsuo Takanishi
Waseda University, Japan

- A four-limbed robot having various locomotion styles such as bipedal/quadrupedal walking, crawling and ladder climbing
- WAREC-1 has commonly structured limbs with 28-DoFs in total with 7-DoFs in each limb
- The robot is 1,690 mm tall when standing on two limbs and weighs 155 kg
- The robot realized vertical ladder climbing and moving on rubble by creeping on its stomach

11:30–11:50	Fr12T1.4

Design of Special End Effectors for First Aid Robot

Taesang Park, DGIST
Choong-Pyo Jeong, DGIST
jaeseong Lee, DGIST
Seonghun Lee, DGIST
Ikho Lee, Daegu Gyongbuk Institute of Science & Technology
HYEON JUNG KIM, DGIST
Jinung An, DGIST
Dongwon Yun, Daegu Gyeongbuk Institute of Science and Technology (DGIST)

11:50–12:10	Fr12T1.5

A Preliminary Study on a Groping Framework without External Sensors to Recognize Near-Environmental Situation for Risk-Tolerance Disaster Response Robots

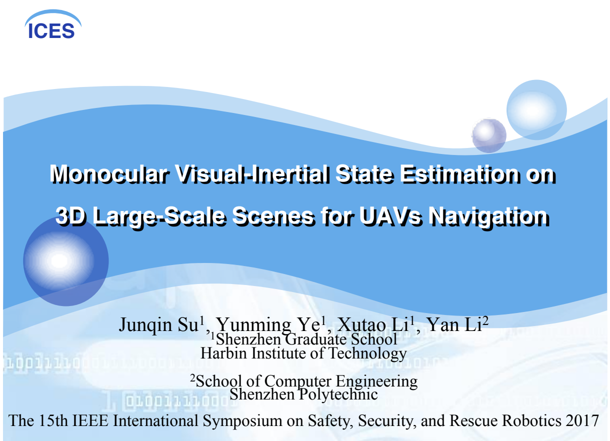
Kui Chen[1], Mitsuhiro Kamezaki[2], Takahiro Katano[1], Taisei Kaneko[1], Kohga Azuma[1], Yusuke Uehara[1], Tatsuzo Ishida[2], Masatoshi Seki[3], Ken Ichiryu[3], Shigeki Sugano[1]
1.Modern Mechanical Engineering, Waseda University 2.Research Institute for Science and Engineering (RISE), Waseda University 3. Kikuchi Seisakusho Co., Ltd.

- Arms actively touch the environment, record the contact information, then re-construct a three-dimensional local map
- This method can recognize different terrains and shapes of objects without using external sensors

Four-arm four-flipper crawler robot OCTOPUS

Unmanned Ground, Aerial, and Marine Vehicles II

14:30–14:50	Fr14T1.1



14:50–15:10	Fr14T1.2

A Review on Cybersecurity Vulnerabilities for Unmanned Aerial Vehicles

Leela Krishna C. G. and Robin R. Murphy
Department of Computer Science and Engineering,
Texas A&M University, College Station, Texas 77843

- 6 attacks on GPS, 2 attacks on the control communications stream and 2 attacks on data communications stream.
- UAV-related research to counter cybersecurity threats focuses on GPS Jamming and Spoofing, but ignores attacks on the controls and data communications stream.
- Operator can see a UAV flying off course due to a control stream attack but has no way of detecting a video replay attack (substitution of a video feed).

UAV Attack Taxonomy

15:10–15:30	Fr14T1.3

Vision-based Autonomous Quadrotor Landing on a Moving Platform

D. Falanga, A. Zanchettin, A. Simovic,
J. Delmerico, and D. Scaramuzza
Robotics and Perception Group, University of Zurich, Switzerland

Letting quadrotors autonomously land on moving platforms through:

- Onboard, vision-based state estimation and control
- Platform detection and tracking
- Real-time trajectory generation to follow the moving target

15:30–15:50	Fr14T1.4*

Case Study and Analysis of Small Unmanned Aerial Vehicle Operations for Post-Disaster Assessment

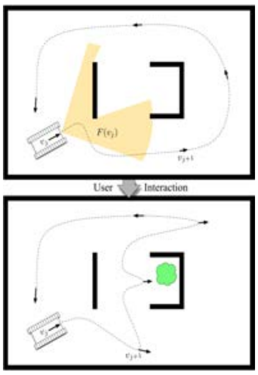
Juan Augusto Paredes, Pontificia Universidad Católica del Perú
Carlos Saito, Pontificia Universidad Catolica del Peru
Julio Ramírez, PUCP
Monica Abarca, Pontificia Universidad Catolica del Peru
Andres Flores, Pontificia Universidad Catolica del Peru

Autonomous Search and Rescue

16:10–16:30 Fr15T1.1

Optimizing Autonomous Surveillance Route Solutions from Minimal Human-Robot Interaction

- **Goal:** Maximize the probability of detecting a target while traversing an environment subject to resource constraints that make full coverage infeasible.
- **Observation:** Human teammate often possesses essential knowledge of the mission, environment, or other agents.
- **Solution:** Human-robot Autonomous Route Planning (HARP) system that explores the space of surveillance solutions to maximize task-performance using information provided through minimal interactions with humans.
- **Outcome:** Experimental results have shown that with minimal interaction we can successfully leverage human knowledge to create more successful surveillance routes under resource constraints.

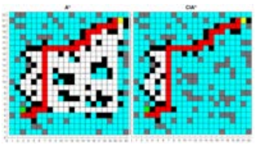


16:30–16:50 Fr15T1.2

Continuously Informed Heuristic A* - Optimal path retrieval inside an unknown environment

Athanasios Kapoutsis, Christina Malliou, Savvas Chatzichristofis and Elias Kosmatopoulos
ECE, DUTH, Greece

- Optimal path retrieval between two points inside an unknown environment, utilizing a physical robot-scouter.
- Proposed CIA* inherits the A* optimality and efficiency guarantees.
- Exploits the learnt formation of the obstacles to revise the robot's searching plan.
- Achieves an average enhancement of 40% over the typical A*, on the cells that have to be visited.



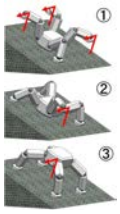
Comparison between A* and CIA*

16:50–17:10 Fr15T1.3

Crawling Gait Generation Method for Four-limbed Robot Based on Normalized Energy Stability Margin

Takashi Matsuzawa, Kenji Hashimoto, Xiao Sun, Tomotaka Teramachi, Shunsuke Kimura, Nobuaki Sakai, Yuki Yoshida, Asaki Imai, Kengo Kumagai, Takanobu Matsubara, Koki Yamaguchi, Tan Wei Xin and Atsuo Takanishi
Waseda University, Tokyo, Japan

- Crawling motion consists of limb-stance phase and torso-stance phase.
- Crawling gait generation method is based on normalized energy stability (NESM) margin of the torso support area.
- The method can reduce the possibility of collision between the feet and the ground caused by the torso rolling.
- It is confirmed that proposed method contributes to improvement of stability during crawling on rough terrain.



Overview of crawling gait generation method

17:10–17:30 Fr15T1.4

Collaborative Air-Ground Target Searching in Complex Environments

Changsheng Shen, Yuanzhao Zhang, Zimo Li, Fei Gao and Shaojie Shen
Hong Kong University of Science and Technology

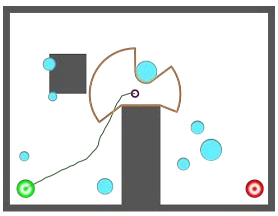
- EKF-based robot pose estimation.
- Dynamic obstacle avoidance for UGV with online trajectory generation.
- Fully autonomous navigation in previously unknown environments.
- Flexibility of being easily modified into distributed EKF.

17:30–17:50 Fr15T1.5

Safe Navigation in Dynamic, Unknown, Continuous, and Cluttered Environments

Mike D'Arcy, Pooyan Fazli, and Dan Simon
Cleveland State University

- Navigate safely around static and moving obstacles
- New samping-based local planner (ProbLP) + DRRT global planner
- Probability distribution to bias trajectory sampling
- 77% less collisions than the baseline local planner



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