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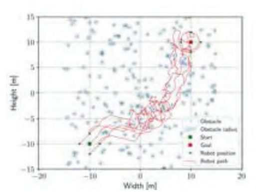
Robotics and Automation for Safety and Security I

10:30–10:50	pg. 1	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	pg. 7	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	pg. 13	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	pg. 19	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	pg. 25	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	pg. 27	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	pg. 35	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.

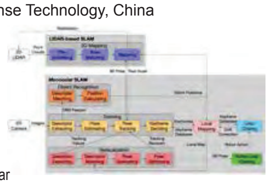
Robot map completed with an emergency map

13:50–14:10	pg. 41	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	pg. 48	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	pg. 55	We5T1.1

Robotic Teleoperation: Mediated and Supported by Virtual Testbeds

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

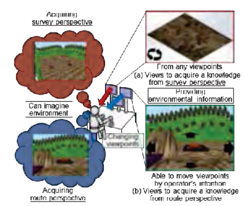
- Using a digital twin in a Virtual Testbed for training, support, prediction, and analysis before, after or during mission
  - Abstraction for the user
  - Natural interaction and control
  - Intuitive Visualization
- Symbiosis of virtuality and realty

15:50–16:10	pg. 61	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.

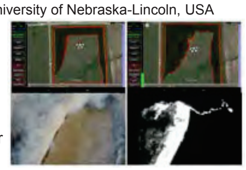


16:10–16:30	pg. 67	We5T1.3

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	pg. 75	We5T1.4

Proposal of Simulation Platform for Robot Operations with Sound

Masaru Shimizu, Chukyo University
Tomoichi Takahashi, Meijo University

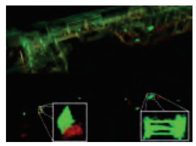
Perception for Navigation, Hazard Detection, and Victim Identification

10:30–10:50	pg. 81	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



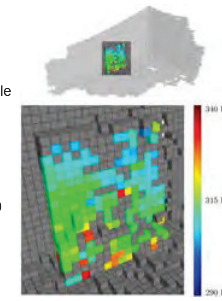
Changes detected in real decommissioned power plant data set

10:50–11:10	pg. 88	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	pg. 96	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	pg. 102	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

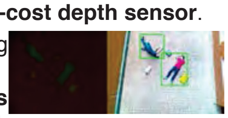
Fig: Results of the vehicle detection on BV (lower) and projected to RGB (upper)

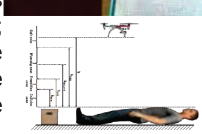
11:50–12:10	pg. 110	Th8T1.5

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.



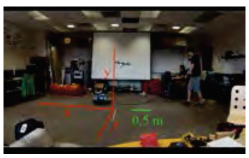


Unmanned Ground, Aerial, and Marine Vehicles I

13:10–13:30 pg. 116 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.

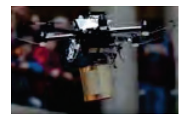


13:30–13:50 pg. 123 Th9T1.2

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 pg. 129 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 pg. 131 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

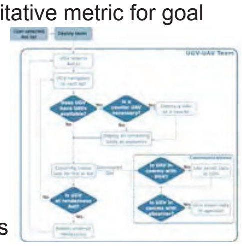
Robotics and Automation for Safety and Security II

15:30–15:50	pg. 133	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

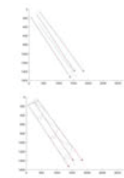


15:50–16:10	pg. 141	Th10T1.2

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\%).



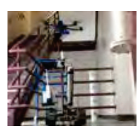
UAV Path (in Blue) With & Without Tilt, Yaw

16:10–16:30	pg. 147	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



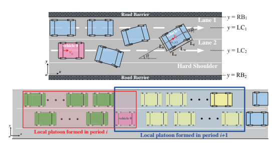
Visual Assistant Servoing the primary robot

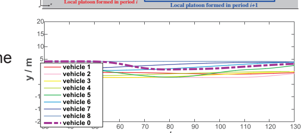
16:30–16:50	pg. 153	Th10T1.4

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	pg. 159	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

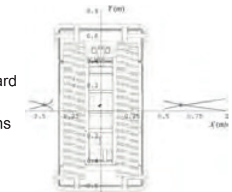
- To extend the operation time of a MUAV, the authors proposed a power-feeding tethered MUAV.
- A position estimation method for the MUAV by observing the slack is proposed.
- To evaluate the method, the authors developed a prototype of a helipad with a tether winding mechanism for the tethered MUAV,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

10:50–11:10	pg. 166	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	pg. 172	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	pg. 179	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	pg. 181	Fr12T1.5

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

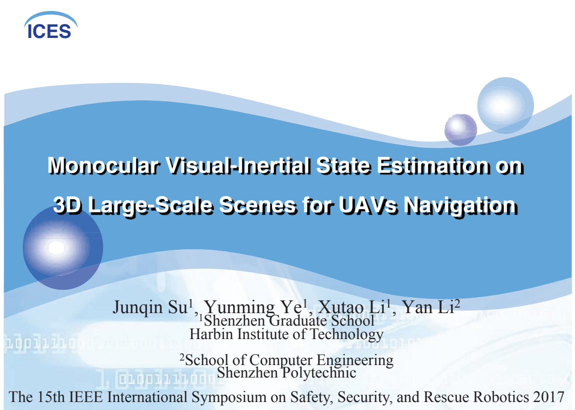
Kui Chen[1], Mitsuhiro Kamezaki[2], Takahiro Katano[1], Taisei Kaneko[1], Kohga Azuma[1], Yusuke Uehara[1], Tatsuzo Ishida[2], Masatoshi Seki[3], Ken Ichiryu[3], Shigeki Sugano[1]
1.Modern Mechanical Engineering, Waseda University 2.Research Institute for Science and Engineering (RISE), Waseda University 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	pg. 187	Fr14T1.1



14:50–15:10	pg. 194	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	pg. 200	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	N/A	Fr14T1.4*

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

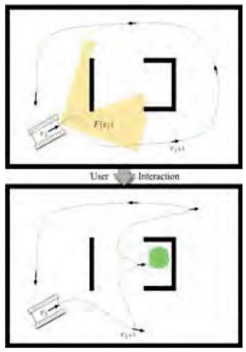
Juan Augusto Paredes, Pontificia Universidad Católica del Perú
Carlos Saito, Pontificia Universidad Catolica del Peru
Julio Ramírez, PUCP
Monica Abarca, Pontificia Universidad Catolica del Peru
Andres Flores, Pontificia Universidad Catolica del Peru

Autonomous Search and Rescue

16:10–16:30	pg. 208	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.

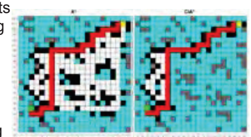


16:30–16:50	pg. 216	Fr15T1.2

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	pg. 223	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	pg. 230	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	pg. 238	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