2018 Student Workshop on Robotics and Autonomous System

Date: Monday, 15 January, 2018 | Venue: Executive Seminar Room (S2.2-B2-53), NTU

Chaired by Prof Wang Danwei

Organized by

IEEE Singapore Section, Robotics and Automation Chapter

Workshop Schedule		
9:30 – 9:50	*Acquaintance over coffee/tea*	
9:50 – 10:00	*Opening briefing – Chair, IEEE SS, RA Chapter*	
Session 1: Multi-Robot Coordination Session Chair: YANG Chule		
10:00 – 10:30	*Finite-time coordinated control of multiple mobile agents with connectivity preservation and disturbance rejection*	*SUN Chao*
10:30 – 11:00	*Robust Coordination of Unknown Networked Robot Systems*	*FENG Zhi*
Session 2: SLAM Session Chair: SUN Chao		
11:00 – 11:30	*A Probabilistic Framework for Real-Time Multi-Robot Map Matching and Merging*	*YUE Yufeng*
11:30 – 12:00	*Heading Reference Assisted Pose Estimation for Ground Vehicles*	*JIANG Rui*
Lunch		
Session 3: Robot Perception and Understanding Session Chair: YUE Yufeng		
13:00 – 13:30	*Semantic-Spatial Reasoning for Unique Role Recognition Based on the Fusion of Attribute-Interaction and Spatio-Temporal Features*	*YANG Chule*
13:30 – 14:00	*Deep learning for object detection, recognition and environment understanding on autonomous robots*	*SUN Hao*
Session 4: Robot Control and Automation Session Chair: JIANG Rui		
14:00 – 14:30	*Impedance Control in Industrial Finishing Tasks*	*KANA Sreekanth*
14:30 – 15:00	*Optimized Transition Path of a Transformable Hovering Rotorcraft (THOR)*	*SUFIYAN Danial*
Tea Break and Networking		

Instruction for student speakers:

Speakers have to bring their own laptop. Please test the slides before session start to avoid potential format problems caused by different software versions. Each speaker has 20 minutes for presentation and 10 minutes for Q&A.

Instruction for session chairs:

Session chair must introduce speakers, monitor time and give signal of at 5 and 2 minutes remaining.

Executive Seminar Room

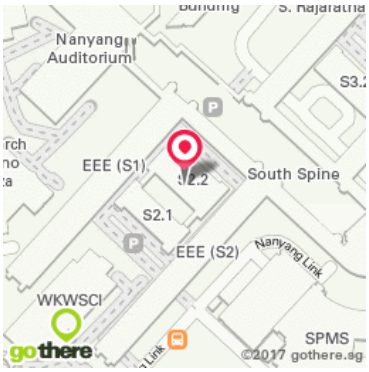
Address: S2.2-B2-53, EEE, NTU

Free Entrance

Tel: +65 85878997

E-mail: yang0438@e.ntu.edu.sg

Bus routes nearby: 179, Campus Loop Blue, Campus Loop Red



Session 1: Multi-Robot Coordination

Session Chair: YANG Chule

Time: 10:00 – 11:00

Student Speaker I

Finite-time coordinated control of multiple mobile agents with connectivity preservation and disturbance rejection

Mr. SUN Chao

School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract:

In coordinative control of multi-agent systems, the algorithms often rely critically on the connectivity of the underlying communication network. However, due to the limited sensing range of the agents, the connectivity of the network may be broken during the motion evolution. In this talk, we will present a robust finite-time connectivity preserving rendezvous algorithm for second-order multi-agent systems, based on integral sliding mode control and artificial potential field. The algorithm is further extended to address a finite-time formation tracking control problem.

Speaker Bio:

Mr. SUN Chao received his B.Eng. degree from University of Science and Technology of China in 2013. He is currently pursuing his Ph.D. degree at the School of Electrical and Electronic Engineering, Nanyang Technological

University, Singapore. His research interests include cooperative control of multi-agent systems, distributed optimization and noncooperative games.

Student Speaker II

Robust Coordination of Unknown Networked Robot Systems

Mr. FENG Zhi

School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract:

One of the most challenging problems in robots' coordination is the lack of effective distributed designs so that the robots that can work collaboratively and safely in the uncertain environment. The research community is making tremendous efforts in developing the algorithms and robust control methods that are capable of adapting to uncertainties. Their effectiveness still falls behind natural systems such as a swarm of ants or a flock of birds. This talk will focus on how a team of robots conduct tasks in a distributed and robust fashion to achieve robot coordination under both undirected and directed communication topologies. A model-free and identifier-based distributed control scheme will be developed to solve this problem.

Speaker Bio:

Mr. FENG Zhi received the M.Sc. degree from Dalian University of Technology, Dalian, China, in 2012, and the PhD degree Nanyang Technological University, Singapore, 2017. He is working as a research fellow in Nanyang Technological University. His current research interests include multi-agent systems, distributed coordination, distributed optimization, and security/resilience.

Session 2: SLAM

Session Chair: SUN Chao

Time: 11:00 – 12:00

Student Speaker I

A Probabilistic Framework for Real-Time Multi-Robot Map Matching and Merging

Mr. YUE Yufeng

School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract:

Fusing local 3D maps generated by individual robots to a globally consistent 3D map is one of the fundamental challenges in multi-robot exploration missions. In this talk, a general probabilistic framework to address the integrated map fusion problem is proposed, which is independent of sensor types and SLAM algorithms. The formulation factorizes the problem of estimating the fused map posterior into a product of relative transformation posterior and the global map posterior, providing a theoretical basis for computing the relative

transformations among map coordinate frames (map matching) and merging probabilistic map information (map merging) separately. For map matching, a multiple data association framework is proposed to address the registration of two maps generated by heterogeneous sensors. We address 3D volumetric map matching by extending the well-known iterative closest point(ICP) algorithm to include coordinate distance and structural information in a probabilistic formulation. In addition, relative transformation is evaluated based on Mahalanobis distance and map dissimilarities are integrated using relative entropy filter. The proposed approach is evaluated using mapping data collected from both indoor, outdoor and mixed indoor-outdoor environments with heterogeneous sensors, which shows its robustness and generality in 3D map fusion for multi-robot mapping missions.

Speaker Bio:

Mr. YUE Yufeng received his B.E. degree in automation from Beijing Institute of Technology, Beijing, China in 2014. He is now working towards his Ph.D. degree in Electrical and Electronic Engineering at Nanyang Technological University, Singapore. His research interests include multi-robot coordination, mapping and sensor fusion.

Student Speaker II

Heading Reference Assisted Pose Estimation for Ground Vehicles

Mr. JIANG Rui

School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract:

In this talk, heading reference assisted pose estimation is proposed to compensate inherent drift of Visual Odometry (VO) on ground vehicles, where estimation error is prone to grow while the vehicle is making turns or in environments with poor features. By introducing a particular direction as “heading reference”, a pose estimation framework has been presented to incorporate measurements from heading reference sensors into VO. A graph formulation is then proposed to represent the pose estimation problem under the commonly-used graph optimization model. Simulations and experiments on KITTI dataset and our self-collected sequences have been conducted to verify the accuracy and robustness of the proposed scheme. KITTI sequences and manually-generated heading measurement with Gaussian noises are used in simulation, where rotational drift error is observed to be bounded. Compared to pure VO, the proposed approach greatly reduces average translational localization error from 153.85 m to 24.29 m and 23.80 m in self-collected stereo visual sequences with traveling distance over 4.5 km at processing rates 19.7 Hz and 11.1 Hz, for the loosely-coupled and tightly-coupled model, respectively.

Speaker Bio:

Mr. JIANG Rui received the B.Eng. degree in Measurement, Control Technique and Instruments from Harbin Institute of Technology, Harbin, China, in 2014. He is currently a project officer with the School of Electrical and Electronics Engineering, Nanyang Technological University and pursuing his Ph.D. degree with the department

of Electrical and Computer Engineering, National University of Singapore. His research interests include data representation, intelligent sensing and navigation for autonomous vehicles.

Session 3: Robot Perception and Understanding

Session Chair: YUE Yufeng

Time: 13:00 – 14:00

Student Speaker I

Semantic-Spatial Reasoning for Unique Role Recognition Based on the Fusion of Attribute-Interaction and Spatio-Temporal Features

Mr. YANG Chule

School of Electrical and Electronic Engineering, Nanyang Technological University

Abstract:

Role recognition is a crucial problem when dealing with unspecified targets whose description is limited, or appearance is ambiguous. Moreover, the ability to discover critical entities in the scene can facilitate further contextual understanding and feedback response. In this paper, a probabilistic reasoning approach is proposed that associates semantic labels with spatial observations to recognize unique individuals in the scene. Two types of observation models have been developed to form the decision model, namely, Human Action Model (HAM) and Attribute Existence Model (AEM). HAM and AEM build probabilistic models from analyzing spatio-temporal features and attribute-interaction features, respectively. Then, both of HAM and AEM are compared with the overall distribution in the scene. Finally, the role can be comprehensively inferred through the fusion of the two observation models. Experiments are conducted in multiple environments concerning different settings and degrees of clutter. The results show that the proposed method outperforms other methods regarding accuracy and robustness, moreover, exhibits a stable performance even in complex scenes.

Speaker Bio:

Mr. YANG Chule received his B.Eng. degree in Electrical Engineering from Wuhan University, Wuhan, China, in 2014. He received his M.Sc. degree in Computer Control and Automation from Nanyang Technological University, Singapore, in 2015. He is currently pursuing his Ph.D. degree at the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. His research interests include multimodal perception and intelligent decision making for autonomous system.

Student Speaker II

Deep learning for object detection, recognition and environment understanding on autonomous robots

Mr. SUN Hao

School of Mechanical Engineering, National University of Singapore

Abstract:

Deep learning is the driving force for the next round of technology revolution. With the recent development in the past few years, deep learning has been applied to various aspects of our daily life. This talk will mainly focus on its applications in semantic perception for autonomous robots in daily indoor environment, including object detection, recognition and environment understanding. Followed by an introduction of a unified convolutional neural network for simultaneous object detection and scene classification, its applications in Robot Operating System (ROS) for mobile manipulation is introduced.

Speaker Bio:

Mr. SUN Hao is a fourth-year Ph.D. candidate at School of Mechanical Engineering, National University of Singapore. He currently works at Advanced Robotics Center (ARC) in NUS. His research focuses on semantic perception for mobile manipulation in daily indoor environment using deep learning. He is also experienced at robotics system design and integration.

Session 4: Robot Control and Automation

Session Chair: JIANG Rui

Time: 14:00 – 15:00

Student Speaker I

Impedance Control in Industrial Finishing Tasks

Mr. KANA Sreekanth

School of Mechanical and Aerospace Engineering, Nanyang Technological University

Abstract:

As we enter a new era of automation, referred to as Industry 4.0 or 4th industrial revolution, the very role of human operator is being redefined as robots become safer and, no longer ring-fenced, start to work in close proximity to humans. In this sense, the concept of Human Cyber-Physical System refers to an integrated collaborative work structure where the human, the cyber systems (virtual models and pre-process simulations), and the physical systems (robot/automation systems) join hands towards the realization of an improved and flexible factory environment.

While these definitions are very broad and encompass a variety of industrial applications, in this work we specifically target tooling tasks, e.g. polishing, carried out in collaboration with robots. Tooling tasks naturally involve force interactions (i.e. tooling) with a surface and its geometry. In this work, instead of relying on CAD models or coding, we measure geometry from experiments (geometry of contacts) and/or scanned models (triangular meshes). Path-planning will be generated on these representations.

As a second step, controlled interaction with surfaces will be generated via impedance-control frameworks, solely from pre-tuned impedance parameters and pre-planned tool paths. It will also be shown how a simple variation of this framework will allow for human-robot collaboration during tooling tasks.

Speaker Bio:

Mr. KANA Sreekanth completed his Bachelors in Electrical and Electronics Engineering from Kerala University, Kerala-India (2009-2013). He received his PG Diploma in power transmission and distribution from NPTI Bangalore, India in 2014. He is currently pursuing his Ph.D. degree under the supervision of Associate Professor Domenico Campolo in the School of Mechanical and Aerospace Engineering, under RR@NTU Corporate lab. His research focuses primarily on impedance control and collaborative path planning.

Student Speaker II

Optimized Transition Path of a Transformable Hovering Rotorcraft (THOR)

Mr. SUFIYAN Danial

Singapore University of Technology and Design

Abstract:

Hybrid aerial vehicles which combine two or more flight configurations have gained popularity over the years due to their increased flight envelope and versatility. With the inclusion of two or more flight configurations, the transition phases between them are equally as crucial. While many have worked on transition phases of more popular hybrid aerial vehicle configurations, we present our work on the Transformable HOvering Rotorcraft (THOR), a unique aerial platform that combines the manoeuvrability and hover capability of a rotor wing with the speed and endurance of a regular fixed-wing aircraft, which utilizes all flight surfaces in both modes. This presentation would briefly introduce the concept of THOR, which utilizes a structurally efficient combination of a single-axis rotor (monocopter) type with a tailless fixed wing configuration. We would also present our work and results of the hover-to-cruise transition which is explored in the form of a trajectory optimization problem, where the open-loop control inputs that minimize the cost function are determined, simulated, and flight tested experimentally.

Speaker Bio:

Mr. SUFIYAN Danial is a PhD Candidate at the Singapore University of Technology and Design (SUTD). He currently works at the Aerial Innovations Research (AIR) Laboratory at SUTD. His research primarily focuses on the design and control aspects of Unmanned Aerial Vehicles (UAVs).