Purdue SMART Lab Highlights 2018

January 2019

Lab Overview

The Smart Machine and Assistive Robotics Technology (SMART) Lab was established in 2015 and has grown to include 1 Director, 6 PhD students, 2 MS students, 2 Undergrad students, and 1 visiting scholar. Up to date, 1 Postdoc, 2 MS students, 2 Undergrad students, 1 visiting scholar, and 1 visiting student have completed their research programs from the lab.

New Lab Space and Equipment

Lab Space

- On April 23, 2018, the SMART Lab moved from Wang Hall to A.A. Potter Engineering Center, located in Purdue University Main Campus. The lab's size is approximately 1,200 square feet and it can accommodate 15 people and 1-50 mobile robot experiments. The lab is equipped with an indoor swimming pool and a cage net where aquatic robots, mobile robots and drones can be freely and safely tested.

Equipment

- In 2018, the lab's new highlighted equipment includes 5 JACHAL mobile robots from Clearpath Robotics, 12 Hamster mobile robots, 2 Intel drones, 1 laptop, and 5 desktop PCs.

Lab Members

Current Members (12)

- **Byung-Cheol Min** (Director)
- **Jun Han Bae** (PhD Student) submitted a journal paper, titled "Sediment Sampling Methods for an Autonomous Water Quality Monitoring System" to the IEEE Journal of Oceanic Engineering and it's currently under review.
- **Sangjun Lee** (PhD Student) continued his research with the NIJ fellowship. Sangjun presented his paper, titled "Distributed Direction of Arrival Estimation-aided Cyberattack Detection in Networked Multi-Robot Systems" at the 2018 IROS in Madrid, Spain in October 2018. He also defended his doctoral proposal in December 2018.
- **Shaocheng Luo** (PhD Student) published his first journal paper as the first author, titled "Multi-robot Rendezvous Based on Bearing-aided Hierarchical Tracking of Network Topology" at the Ad Hoc Networks in November 2018. Shaocheng also defended his doctoral proposal in December 2018.
- **Manoj Penmetcha** (PhD Student) passed his preliminary exam in December 2018.
- **Tamzidul Mina** (PhD Student) presented his first peer-reviewed paper as the first author, titled "Penguin Huddling-inspired Energy Sharing and Formation Movement in Multi-robot Systems", at the SSRR 2018 in Philadelphia, USA in August 2018. He also presented his another paper at the ROBIO 2018 in Kuala Lumpur, Malaysia in December 2018.
- **Wonse Jo** (PhD Student) received a 2018-19 PRF Graduate Fellowship in April 2018. His peer-reviewed report, titled "Design of a Human Multi-Robot Interaction Medium of Cognitive Perception", has been accepted to the 2019 HRI in December 2018.
- **Shyam Kannan** (MS Student) completed his internship program in the Bell Lab in August 2018. He also defended his Masters proposal in December 2018.
- **Jee Hwan Park** (MS Student) obtained his BS degree from Mechanical Engineering at Purdue in May 2018 and started his Masters study in August 2018. He worked as TA for Dr. Min's CNIT 355 Android Programming class in fall 2018.
- **Yuta Hoashi** (Undergrad Student) worked as an undergraduate research assistant for the Robotic Water Quality Monitoring Project in the summer.

- **UC Wang** (Undergrad Student) worked on the UAV control for water quality monitoring and sediment sampling.
- **Bumjoo Lee** (Visiting Scholar)

Lab Alumni (4)

- **Ramviyas Parasuraman** (Postdoc) assumed his tenure-track faculty position at the University of Georgia in July 2018. He is an Assistant Professor it the Computer Science Department and affiliated with the Robotics Program in UGA.
- **Yeonju Oh** (MS Student) defended her MS degree with a thesis "A 360 VR and Wi-Fi Tracking Based Autonomous Telepresence Robot for Virtual Tour" and joined Samsung Electronics in South Korea in March 2018.
- **Arabinda Samantaray** (MS Student) defended her MS degree with a thesis ""Detection of Algae in Water Bodies Using Computer Vision and Deep Learning" and joined Cisco, US in May 2018.
- **Dr. Hunjung Lim** (Visiting Scholar) completed his visiting research and returned his home company, Samsung Electronics in South Korea in January 2018.

New Lab Members (4)

- **Shyam Kannan** joined the lab in January 2018. Shyam obtained his Bachelor's in Computer Science and Engineering from Anna University in India. Shyam's research interests include Multi-UAV coordination, Monocular SLAM, and Localization in GPS-denied environment.
- **Yuta Hoashi** joined the lab in April 2018. Yuta is an undergraduate student in Mechanical Engineering at Purdue and his research interests include Assistive robotics for the disabled, Rescue robots used for natural disasters, and Multi-Robot System.
- **UC Wang** joined the lab in September 2018. UC is an undergraduate student in Mechanical Engineering at Purdue and his research interests include Assistive Robotics, Search and Rescue Robots, Underactuated Robotics
- **Bumjoo Lee** joined the lab in July 2018. Prof. Lee is an Associate Professor in Myongji University in South Korea and his research interests include the areas of Humanoid Robotics, especially in motion planning and control algorithm.

Lab Meetings/Seminars

Lab Meetings

- A total of 30 lab group meetings were held in 2018. During the 2018 spring semester, the lab had a group meeting every Mondays from 1pm to 3pm in the WANG Hall facility. During the 2018 fall semester, the lab had a group meeting every Mondays from 12pm to 1:30pm in the POTR facility.

Lab Seminars

- A total of 15 paper review seminars were delivered by PhD students and Master students.

Proposal Submitted (18, $2.9M)

Awarded

- 17-18 Laboratory & University Core Facility Research Equipment Program, Role: PI, Sponsor: Purdue University, Amount: $83,500 (01/01/2018 – 12/31/2018).
- FY18-19 PRF Research Grants: Towards Autonomous Robotic Systems for Control of Harmful Algae Blooms, Role: PI, Sponsor: Purdue University, Amount: $30,144 (05/10/2018 – 09/14/2019).
- Mobile Crowd Sensing for Sustainability Challenges: A Behavioral Approach to Inducing User Participation, Role: Co-PI (David J. Yu), Sponsor: Purdue Center for the Environment, Amount: $15,000 (06/01/2018 – 06/30/2019).
- Drone-based Visual Inspection for Airplane, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (04/01/2018 – 06/30/2018).
- Distributed Multi-robot Systems for Autonomous Construction, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (11/01/2018 – 06/30/2019).

- Collaborative Interdisciplinary Machine Learning Research Infrastructure, Role: Co-PI (PI: Vetria Byrd), Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (04/01/2018 – 06/30/2018).
- Developing Crancobots to Support Automated Construction of Buildings, Role: Co-PI (PI: Jiansong Zhang), Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (11/01/2018 – 06/30/2019).
- Purdue Polytechnic Realizing The Digital Enterprise (RDE) Conference Travel Grant, Role: PI, Sponsor: Purdue University, Amount: $3,000 (05/01/2018 - 06/30/2018).
- Purdue Research Foundation (PRF) International Travel Grant, Role: PI, Sponsor: Purdue University, Amount: $2,000 (07/01/2018 – 06/30/2019).

Pending

- Socio-Technical Sensing System for Enhancing Cusco's Emergency Response Capacity, Role: Co-PI (PI: David J. Yu), Sponsor: UNSAAC, Amount: $830,549 (01/01/2019 – 12/31/2020).
- CAREER: Adaptive Human Multi-robot Systems, Role: PI, Sponsor: National Science Foundation, Amount: $500,000 (08/01/2019 – 07/31/2022).

Declined

- Center for Robots & Sensors for the Human Well-Being (ROSEHUB), Role: Co- PI (PI: Jose Garcia), Sponsor: National Science Foundation, Amount: $500,000 (08/01/2019 – 07/31/2024). *Discouraged*
- Opportunities and Challenges of Hybrid Delivery Systems in Disaster Relief Operations, Role: Co-PI (PI: Seokcheon Lee), Sponsor: National Science Foundation, Amount: $477,908 (09/01/2018 – 08/31/2021).
- The Humanitarian Flying Warehouse, Role: Co-PI (PI: Seokcheon Lee), Sponsor: Grand Challenges Canada, Amount: $236,895 (01/01/2019 – 12/31/2020).
- Design of Social Cyber-Physical Systems for Catalyzing Human Cooperation towards Community Disaster Resilience, Role: Co-PI (PI: David J. Yu), Sponsor: Purdue College of Engineering, Amount: $75,000 (07/01/2018 – 06/30/2019).
- Opportunities and Challenges of Airborne Fulfillment Center, Role: Co- PI (PI: Seokcheon Lee), Sponsor: Amazon.com, Amount: $45,050 (01/01/2019 – 12/31/2019).
- CBNU-Purdue Smart Factory Research Education Program 2019, Role: PI, Sponsor: Chungbuk National University, Amount: $40,000 (01/01/2019 – 08/31/2019).
- Design of Social Cyber-Physical Systems for Catalyzing Human Cooperation towards Community Disaster Resilience, Role: Co-PI (PI: David J. Yu), Sponsor: Purdue College of Engineering, Amount: $25,000 (8/15/2018 – 08/14/2019).

Grants Awarded (13, $1.8M)

- PFI-RP: Partnerships for Innovation in Interoperable Building Information Modeling Technology for Applications in Automated Building Code Compliance Checking and Modular Construction Automation, Role: Co-PI (Jiansong Zhang), Sponsor: National Science Foundation, Amount: $749,770 (09/15/2018 - 08/31/2021).
- CPS: Medium: Collaborative Research: Closed Loop Sustainable Precision Animal Agriculture, Role: Co-PI (PI: Richard Voyles), Sponsor: National Institute of Food and Agriculture, Amount: $541,448 (09/01/2018 - 08/31/2021).
- UNSA NEXUS: Robotic Water Quality Monitoring and Distribution Systems: A Pilot Study, Role: PI, Sponsor: Universidad Nacional de San Agustin, Amount: $365,439 (01/01/2018 - 12/31/2019).
- Cybersecurity and Safety Challenges in Autonomous Vehicles: Threats Identification and Countermeasures Development, Role: PI, Sponsor: National Institute of Justice, Amount: $100,000 (08/01/2017 - 07/31/2019).
- 17-18 Laboratory & University Core Facility Research Equipment Program, Role: PI, Sponsor: Purdue University, Amount: $83,500 (01/01/2018 – 12/31/2018).
- FY18-19 PRF Research Grants: Towards Autonomous Robotic Systems for Control of Harmful Algae Blooms, Role: PI, Sponsor: Purdue University, Amount: $30,144 (05/10/2018 - 09/14/2019).

- Mobile Crowd Sensing for Sustainability Challenges: A Behavioral Approach to Inducing User Participation, Role: Co-PI (David J. Yu), Sponsor: Purdue Center for the Environment, Amount: $15,000 (06/01/2018 - 06/30/2019).
- Drone-based Visual Inspection for Airplane, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (04/01/2018 – 06/30/2018).
- Distributed Multi-robot Systems for Autonomous Construction, Role: PI, Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (11/01/2018 - 06/30/2019).
- Collaborative Interdisciplinary Machine Learning Research Infrastructure, Role: Co-PI (PI: Vetria Byrd), Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (04/01/2018 – 06/30/2018).
- Developing Crancobots to Support Automated Construction of Buildings, Role: Co-PI (PI: Jiansong Zhang), Sponsor: Purdue Polytechnic Institute, Amount: $8,000 (11/01/2018 - 06/30/2019).
- Purdue Polytechnic Realizing The Digital Enterprise (RDE) Conference Travel Grant, Role: PI, Sponsor: Purdue University, Amount: $3,000 (05/01/2018 - 06/30/2018).
- Purdue Research Foundation (PRF) International Travel Grant, Role: PI, Sponsor: Purdue University, Amount: $2,000 (07/01/2018 - 06/30/2019).

Publications (4 journals, 7 conferences, 1 report, 2 archives)

Journals

- Shaocheng Luo, Jonghoek Kim, Ramviyas Parasuraman, Jun Han Bae, Eric T. Matson, and Byung-Cheol Min, "Multi-robot Rendezvous Based on Bearing-aided Hierarchical Tracking of Network Topology", Ad Hoc Networks, Vol. 86, pp. 131-143, April 2019.
- Ramviyas Parasuraman, Jonghoek Kim, Shaocheng Luo, and Byung-Cheol Min, "Multi-Point Rendezvous in Multi-Robot Systems", IEEE Transactions on Cybernetics, Early Access, September, 2018.
- Mythra Vsm Balakuntala, Mustafa Ayad, Richard M. Voyles, Robin White, Robert Nawrocki, Shreyas Sundaram, Shashank Priya, George Chiu, Shawn Donkin, Byung-Cheol Min, and Kristy Daniels, "Global Sustainability through Closed-Loop Precision Animal Agriculture", Mechanical Engineering Magazine Select Articles, Vol. 140, No. 06, S19-S23, June 2018.
- Byung-Cheol Min, Ramviyas Parasuraman, Sangjun Lee, Jin-Woo Jung, and Eric T. Matson, "A Directional Antenna based Leader-Follower Relay System for End-to-End Robot Communications", Robotics and Autonomous Systems, Vol. 101, pp. 57-73, March 2018.

Conferences

- Tamzidul Mina and Byung-Cheol Min, "Penguin Huddling Inspired Distributed Boundary Movement for Group Survival in Multi-robot Systems using Gaussian Processes", 2018 IEEE International Conference on Robotics and Biomimetics (IEEE ROBIO 2018), Kuala Lumpur, Malaysia, December 12-15, 2018.
- Shaocheng Luo, Jun Han Bae, and Byung-Cheol Min, "Pivot-based Collective Coverage Control with a Multi-robot Team", 2018 IEEE International Conference on Robotics and Biomimetics (IEEE ROBIO 2018), Kuala Lumpur, Malaysia, December 12-15, 2018.
- Ramviyas Parasuraman and Byung-Cheol Min, "Consensus Control of Distributed Robots Using Direction of Arrival of Wireless Signals", International Symposium on Distributed Autonomous Robotic Systems 2018 (DARS 2018), Boulder, CO, USA, Oct 15-17, 2018.
- Sangjun Lee and Byung-Cheol Min, "Distributed Direction of Arrival Estimation-aided Cyberattack Detection in Networked Multi-Robot Systems", 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2018), Madrid, Spain, October 1-5, 2018.
- Ramviyas Parasuraman, Petter Ögren, and Byung-Cheol Min, "Kalman Filter based Spatial Prediction of Wireless Connectivity for Autonomous Robots and Connected Vehicles", 2018 IEEE Connected and Automated Vehicles Symposium (CAVS), Chicago, IL, USA, August 27, 2018.
- Tamzidul Mina and Byung-Cheol Min, "Penguin Huddling-inspired Energy Sharing and Formation Movement in Multi-robot Systems", 2018 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR), Philadelphia, PA, USA, August 6-8, 2018.

- Yeonju Oh, Ramviyas Parasuraman, Tim McGraw, and Byung-Cheol Min, "360 VR Based Robot Teleoperation Interface for Virtual Tour", The 13th Annual ACM/IEEE International Conference on Human Robot Interaction (HRI), Workshop on Virtual, Augmented, and Mixed Reality for Human-Robot Interactions (VAM-HRI), Chicago, Illinois, USA, March 5, 2018.

Abstracts/Reports

- Wonse Jo, Jee Hwan Park, Sangjun Lee, Ahreum Lee, and Byung-Cheol Min, "Design of a Human Multi-Robot Interaction Medium of Cognitive Perception", 2019 ACM/IEEE International Conference on Human-Robot Interaction - Late Breaking Reports (LBR), Daegu, South Korea, March 11-14, 2019.

Archives

- Shyam Sundar Kannan, Wonse Jo, Ramviyas Parasuraman, and Byung-Cheol Min, "Mobile Robot-Assisted Mapping of Materials in Unknown Environments", arXiv preprint, 2018.
- Arabinda Samantaray, Baijian Yang, J Eric Dietz, and Byung-Cheol Min, "Algae Detection Using Computer Vision and Deep Learning", arXiv preprint, 2018.

Poster Presentations (18)

- Wonse Jo, Jee Hwan Park, Yuta Hoashi, and Byung-Cheol Min, "Development of Low-cost Prototype USVs for Water Research", 2018 Fall Purdue Polytechnic Realizing The Digital Enterprise (RDE) Poster Session, Purdue University, November 2018.
- Shaocheng Luo, Wonse Jo, Jun Han Bae, and Byung-Cheol Min, "A Systematic Solution for Autonomous Aquatic Spill Removal with a Multi-robot Team", 2018 Fall Purdue Polytechnic Realizing The Digital Enterprise (RDE) Poster Session, Purdue University, November 2018.
- Sangjun Lee and Byung-Cheol Min, "Threat Identification and Countermeasure Development for Networked Multi-Robot Systems", 2018 Fall Purdue Polytechnic Realizing The Digital Enterprise (RDE) Poster Session, Purdue University, November 2018.
- Jun Han Bae, Wonse Jo, Jee Hwan Park, Shyam Sundar Kannan, Yuta Hoashi, and Byung-Cheol Min, "Robot-based Environment Monitoring: Application to Sediment Monitoring", 2018 Fall Purdue Polytechnic Realizing The Digital Enterprise (RDE) Poster Session, Purdue University, November 2018.
- Shyam Sundar Kannan, Wonse Jo, and Byung-Cheol Min, "Mapping Materials using Multi-robot Systems in Unknown Environments", 2018 Dawn and Doom Research Symposium and Poster Competition, Purdue University, November 2018.
- Tamzidul Mina, Byung-Cheol Min, and Galen King, "Towards a Robotic Society: Bio-inspired Group Survival in Multi-robot Systems", 2018 Dawn and Doom Research Symposium and Poster Competition, Purdue University, November 2018.
- Sangjun Lee and Byung-Cheol Min, "Threat Identification and Countermeasure Development for Networked Multi-Robot Systems", 2018 Dawn and Doom Research Symposium and Poster Competition, Purdue University, November 2018.
- Shaocheng Luo and Byung-Cheol Min, "Autonomous Algae Harvesting with a Multi-robot Team", 2018 Dawn and Doom Research Symposium and Poster Competition, Purdue University, November 2018.
- Wonse Jo, Jee Hwan Park, Yuta Hoashi, and Byung-Cheol Min, "An Autonomous Multi-robot System for Harmful Algae Control", The 5th Annual C4E Environmental Community Mixer, Purdue University, October 2018.
- Shaocheng Luo, Jun Han Bae, and Byung-Cheol Min, "Oil Spill Cleanup with Multi-robot Systems", The 5th Annual C4E Environmental Community Mixer, Purdue University, October 2018.
- Jun Han Bae, Wonse Jo, Jee Hwan Park, Shyam Sundar Kannan, Yuta Hoashi, and Byung-Cheol Min, "Robot-based Environment Monitoring: an Application to Water Sediment Monitoring", The 5th Annual C4E Environmental Community Mixer, Purdue University, October 2018.
- Shaocheng Luo, Ramviyas Parasuraman, Jun Han Bae, and Byung-Cheol Min, "Environmental Operations with Multi-robot Systems", 2018 Midwest Robotics Workshop (MWRW), June 2018.
- Sangjun Lee and Byung-Cheol Min, "Direction of Arrival Estimation-aided Cyberattack Detection in Multi-Robot Systems", 2018 Midwest Robotics Workshop (MWRW), June 2018.

- Sangjun Lee and Byung-Cheol Min, "A Model-based Cyber Attack Detection and Identification for Networked Vehicle Systems", 2018 CERIAS Poster Session, Purdue University, April 2018.
- Jun Han Bae, Shaocheng Luo, Wonse Jo, Arabinda Samantaray, Jee Hwan Park, Yuta Hoashi, and Byung-Cheol Min, "Robotic Cyber-Physical Systems (CPS) for Environmental Monitoring and Operation", 2018 Purdue Polytechnic Faculty Convocation Poster Session, Purdue University, March 2018.
- Shaocheng Luo, Tamzidul Mina, Ramviyas Parasuraman, and Byung-Cheol Min, "Distributed Algorithms for Coordination of Multi-Robot Systems", 2018 Purdue Polytechnic Faculty Convocation Poster Session, Purdue University, March 2018.
- Sangjun Lee and Byung-Cheol Min, "Design of Model-based Cyber Attack Detection and Identification for Multi-Robot Systems", 2018 Purdue Polytechnic Faculty Convocation Poster Session, Purdue University, March 2018.
- Wonse Jo, Shyam Sundar Kannan, Ramviyas Parasuraman, and Byung-Cheol Min, "Development of Material Recognition Training System for Visually Impaired People", The 2018 Health and Disease Poster Session, Purdue University, March 2018.

Invited Talks (5)

- Yuta Hoashi, "A Development of Unmanned Surface Vehicles for Algae Removal", The 2018 Fall Undergraduate Research Expo, Purdue University, November 2018.
- Ramviyas Parasuraman and Byung-Cheol Min, "Herding Mobile Robots in Multiple Groups", 2018 Midwest Robotics Workshop (MWRW), June 2018.
- Byung-Cheol Min, "Multi- Robot Control using Wireless Network", Korea Internet & Security Agency (KISA), Naju, South Korea, June 2018.
- Byung-Cheol Min, "Multi- Robot Systems in Their Applications", Korea Research Institute of Ships & Ocean Engineering (KRISO), Daejeon, South Korea, June 2018.
- Byung-Cheol Min, "Field Robotics and Its Applications", Hyundai KEFICO, Gunpo, South Korea, May 2018.

Faculty Accomplishments & Awards (1)

- Dr. Min received a Seed for Success Award from Purdue University for his work with Purdue-UNSA Nexus Project. Principal investigators and co-investigators garnering an award of $1 million or more were recognized with the Seed for Success Award.

Student Accomplishments & Awards (15)

Fellowships

- Sangjun Lee received an extended NIJ Fellowship in October 2018.
- Wonse Jo received a 2018-19 PRF Graduate Fellowship in April 2018.

Scholarships

- Yuta Hoashi received the Office of Undergraduate Research Scholarship for 2018-19 from Purdue University in September 2018.
- Shaocheng Luo received a 2018 Polytechnic Institute Summer Research Grant Award in April 2018.

Poster/Paper Awards

- Jun Han Bae won the 2018 Realizing the Digital Enterprise (RDE) Graduate Student Poster Session in November 2018.
- Wonse Jo won the 2018 Realizing the Digital Enterprise (RDE) Graduate Student Poster Session in November 2018.
- Tamzidul Mina won the People's Choice Award from the 2018 Dawn and Doom Research Symposium and Poster Competition in November 2018.

Travel Grant Awards

- Tamzidul Mina won the Purdue Graduate Student Government (PGSG) Travel Grant Award in December 2018.
- Shaocheng Luo won the Purdue Graduate Student Government (PGSG) Travel Grant Award in December 2018.
- Shaocheng Luo received a Purdue Polytechnic Dean's Graduate Student Travel Grant Award in November 2018.
- Shaocheng Luo received a Purdue Computer and Information Technology Graduate Student Travel Grant Award in November 2018.
- Shaocheng Luo received a Purdue Polytechnic's Office of Globalization Graduate Student Travel Grant Award in October 2018.
- Sangjun Lee received a Purdue Polytechnic Dean's Graduate Student Travel Grant Award in August 2018.
- Sangjun Lee received a Purdue Computer and Information Technology Graduate Student Travel Grant Award in August 2018.
- Sangjun Lee received a Purdue Polytechnic's Office of Globalization Graduate Student Travel Grant Award in July 2018.

Visit us at http://www.smart-laboratory.org