AUTONOMOUS SYSTEMS INITIATIVE

ASI Newsletter Volume 1 Issue 3 October 2020

Welcome to the October edition of the ASI Newsletter. Workshops engaging a range of stakeholders have been taking place over the Autumn term, with three more still to come. And, as the academic year progresses, new and exciting research work by the ASI teams is underway. We look forward to sharing this with you!

ASI NEWS IN BRIEF

- ASI workshops for Themes 3 and 5 are currently being planned. Check our website regularly for details

Research Highlight

The recent devastating wildfires in western United States have foregrounded the difficulties faced by fire and rescue crews in saving lives and managing the fires' spread. Unmanned Aerial Vehicles (UAV) are a key piece of technology that help provide safer and more accurate information to guide rescue crews but are limited to observation. Research underway by Dr. Alan Lynch and his team, as part of ASI Theme 3 Sustainable Communities, explain how they are working to take UAV capabilities to the next level.

Credit: DarrenRD, https://commons.wikimedia.org/wiki/File:Landscape_view_of_wildfire_near_Highway_63_in_south_Fort_McMurray.jpg

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Unmanned Aerial Vehicles play a crucial role in natural disaster management and search and rescues, but they are also employed in several other key applications that involve human risk, including industrial infrastructure inspection and remote sensing. In all of these cases, the use of UAVs is limited to passive roles of observation and monitoring; they "see". A traditional UAV is not able to intervene and perform corrective action; they cannot "touch and feel".

The research of Dr. Lynch, Professor in the Department of Electrical and Computer Engineering and Director of the Applied Nonlinear Controls Lab at the University of Alberta, seeks to extend the capability of UAVs by equipping them with a robotic arm. This would allow it to perform actions typically required for disaster response and maintenance, such as the placement of a component, tightening of a screw, or grasping and turning a valve handle.

Prototype of the Unmanned Aerial Manipulator (UAM)

Giving UAVs the ability to touch and manipulate represents a game-changing transformation in the technology, as it opens up fundamentally new capabilities. The exciting challenge for this research group is to build on traditional UAV technology in an innovative way in order to enable the vehicle's ability to interact with the environment in an intelligent way.

> Expanding the uses of UAVs will lead to greater capabilities for many different end users including disaster relief teams and industrial maintenance crews

Under the supervision of Dr. Lynch, PhD Candidate Muhammad Awais Rafique leads the work on this exciting development. Building on his own award-winning research on the inspection of linear structures using a camera-equipped UAV, published in the prestigious IEEE journal, Trans Aerospace and Electronic Systems, Muhammad is currently focusing on developing an analytical model of the combined UAV and arm system and designing a controller to achieve the desired tracking performance of the manipulator system when performing typical maintenance tasks.

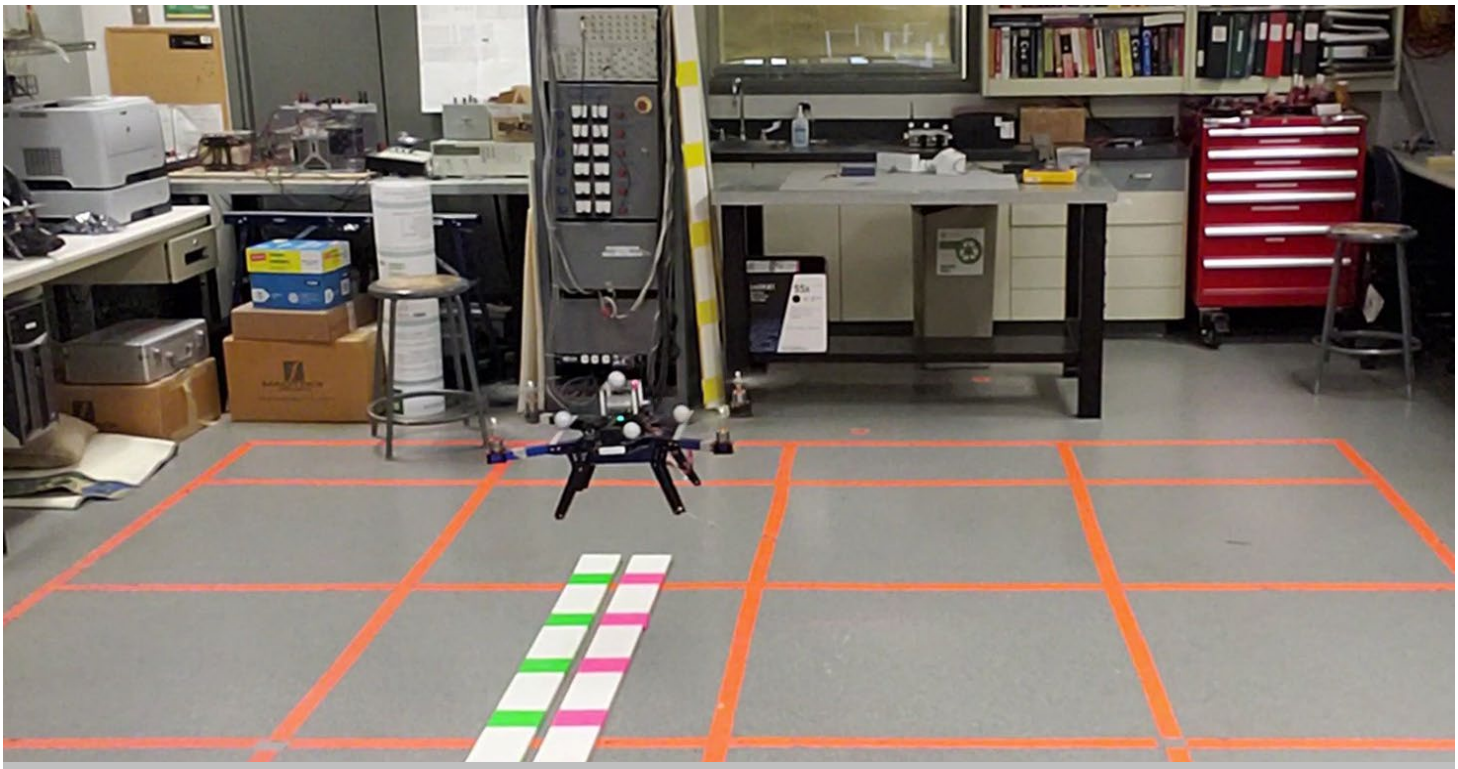
Extending UAV capabilities so fundamentally is a challenge, and Muhammad recognizes that the complexity involved in the modelling and control of a UAV plus arm combined system "requires innovative solutions." He goes on to explain, "The goal is to devise a nonlinear control for the combined system that accounts for the changes in system parameters and dynamics, and provides a robust tracking performance for the vehicle as well as arm motion."

The proposed approach will be implemented first on a simulated and lab test stand in order to prove capabilities to industrial end users. And, in order to help get this technology industry-ready, the research team has partnered with the Alberta-based advanced technology development group ACAMP who will provide expertise in prototype development and aid in the industrial testing of the devised platform. Adding manipulation capability will expand the uses of UAVs and lead to improved capability for maintenance and disaster relief tasks which will benefit disaster relief teams, along with companies who conduct industrial inspections, environmental monitoring, cleaning, and painting.

The team have been working hard to meet key research and development deadlines. "At present," says Muhammad, "the modelling of the system is near completion. At the same time, we are evaluating results from existing literature." Researchers on the team will produce a simulated design and theory by December 2020. Future goals involve incorporating visual servoing to the

manipulator to allow for alignment with the target. They have worked with QinetiQ Target Systems (Medicine Hat, AB) on vision-based control in the past and are discussing possible collaborations on this topic.

The research team for UAVs is led by Dr. Alan Lynch, Professor of Computer Engineering, and currently includes Ph.D. students Muhammad Awais Rafique, Arash Hasani, Mohamed Al Lawati, Zifei Zhang, Amir Moeini, and Ning Cao, M.Sc. student.



The team test the new UAV model's line following capability in the Lab

Spotlight on HQP

For our October newsletter HQP Spotlight, we are excited to introduce one of our University of Calgary researchers, Dylan Peterson from ASI Theme 1.

Studying under ASI Principal Investigator Dr. Henry Leung, Dylan is an M.Sc. student in the Department of Electrical and Computer Engineering and was the recipient of the Schulich School of Engineering Teaching Assistance Excellence Award in 2019.

Situated within the ASI's Theme 1, Methodologies and Tools for Autonomous Systems, his current research forms part of Dr. Leung's project 'Intelligent Technology Stack' and focuses on developing biologically inspired machine learning methods to classify sounds. Some applications for this work could be distributed sound monitoring systems where the classifier runs at the edge on a power constrained device. His approach to reducing power consumption is to train spiking neural networks for sound classification. Spiking neural networks are made up of neurons that are modelled after biological neurons; they have been shown to significantly reduce power consumption compared to traditional neural networks. Training a spiking neural network is one of the biggest hurdles, and he is currently working on developing a general training algorithm.

Dylan's aim is to show the potential of spiking neural networks for practical problems where the power savings would be beneficial. Spiking neural networks currently lag behind traditional neural networks in terms of performance, but they have been theoretically been shown to be more computationally powerful. If they are developed further to reach their theoretical potential in practice, they could potentially replace most traditional neural networks.

As he sees it, autonomous systems are greatly accelerating almost every aspect of manufacturing and repair. And with advances in neural networks, we have the ability to transform our working world. But he is also quick to point out that "the best results will come from a balance between these systems and human input and oversight."

After graduation in 2021, he hopes to stay in Alberta and enter the industry working directly on machine learning and artificial intelligence. He says "I'd love to be part of a research team and expand on my interests that include biologically-inspired computing, reinforcement learning, and control systems." Not only would Alberta benefit from his engineering skills if he fulfils this ambition, but the West Winds Music Society will hang on to an enthusiastic clarinet player!

ASI Workshop Highlights

Gathering and travel restrictions did not hinder Theme 2 Mobile Communities' recent Real-World Automated Transport Workshop, which took place virtually on October 2nd. With over 100 participants registered, ASI Researcher Dr. Randy Goebel, Professor of Computing Science at the University of Alberta and Fellow and co-founder of the Alberta Machine Intelligence Institute (Amii) opened the day's events with a thoughtful look at 'Autonomous Systems Challenges for Artificial Intelligence'. Talks that crossed between computing science and transportation engineering offered participants a rich insight into current work in automated transportation.

Key invited speakers from across Canada and the US generated interesting questions and discussions, including talks from Dr. Steven Waslander from the University of Toronto, discussing his work on uncertainty estimation on deep object detectors and Blaine Leonard from the Utah Department of Transportation, outlining the recent advances made by the DOT in applying automated transport in the state. Industry was represented by session chairs including Lead Engineers Yeatland Wong and Cheryl Szuch from Stantec. The day also included two breakout sessions where participants could 'hop' in and out of rooms to discuss the different strands of research being done by the Theme group's HQPs.

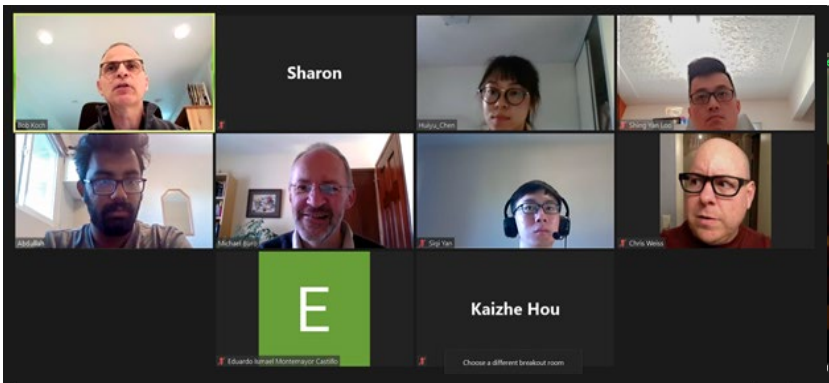
ASI Principal Investigator Dr. Bob Koch ended the day with some thoughtful closing remarks, saying "Transportation is a very competitive area. But we have some advantages here in Alberta: the cold weather, a lot of space for testing

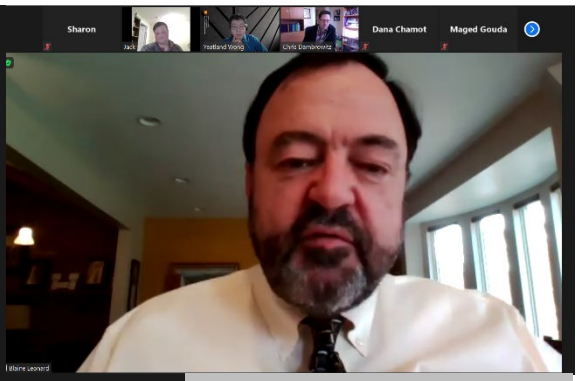
Amii co-founder and ASI researcher Dr. Randy Goebel opening the day's events

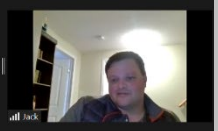
potential, and our expertise in Machine Learning and AI, which doesn't just have the potential to lure people to come here – it's already doing it."

If you missed the workshop but would like further information, you can still download the full program or contact us directly via email. Some presentations are available upon request.

Workshop plans for Theme 3 Sustainable Communities and Theme 5 Industry Communities are currently underway. Please see our website for more details as they become available!







Top left: One of several breakout room discussions with student HQPs about their current research

Top right: Invited speaker Blaine Leonard, Transportation Technology Engineer at the Utah DOT in discussion

Bottom left: Invited speaker Jack Collier, Robotics researcher for DRDC Suffield, Alberta, presenting to attendees

About ASI

The Autonomous Systems Initiative (ASI) is a forward-thinking, multi-million-dollar research program that teams up research and industry experts across Alberta to develop automated technologies spanning key areas of health, transportation, sustainability, and industry. Understanding and developing these systems will help us to remain economically competitive in a global context while effectively addressing the challenges of climate change, efficient energy production and use, transportation needs, advanced manufacturing, and medical advancement. This program develops new Information, Communications and Technology (ICT)-enabled Autonomous Systems to support healthy and sustainable communities with a focus on sensing, communication, control, and computation technologies, all linked together by artificial intelligence.

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