Autonomous Systems Interdisciplinary Research Theme

2018 Year End Report

2018 Autonomous Systems IRT
Annual Report

IRT Scope and Mission

Autonomous systems interact with human partners for extended periods of time, sometimes at remote distances and promise improved safety, reliability, efficiency, adaptability, resiliency, usability, affordability, and previously unattainable capabilities. Networked cyber-physical systems pervade modern society—from smart vehicles to medical robots, from automated infrastructure to teams of robotic explorers, from mobile devices to connected communities. The Autonomous Systems Interdisciplinary Research Theme (ASIRT) investigates how smart, safe, and secure autonomy can expand and exploit the full capabilities of these networked systems. This theme convenes faculty from across the College of Engineering and Applied Science at the University of Colorado Boulder with expertise in robotics, cyber-security, verification and validation, control theory, artificial intelligence, unmanned systems, machine learning, formal methods, and human-robot interaction.

To realize the promise of autonomous systems, the Autonomous Systems Interdisciplinary Research Theme is focused on the ability to certify their performance, showing that they are **smart** enough to perform across a wide range of conditions; they are **safe** in the face of unexpected inputs; and that they are **secure** in the face of adversarial and malicious interactions.

Most Significant IRT Accomplishments in 2018

> ASIRT faculty awarded over $20.9M for 28 autonomy-related projects since Jan 1, 2018 (the start of the IRT initiative), with funding from DARPA, DHS, DOE, NSF, DOD, NASA, and industry. Of these project

Seed Grant Summary

Autonomous Distributed Computation in Honeybee Swarms (PI: Orit Peleg)
- o Results on the dynamics of information flow in a social network of mutually shading plant was used to prepare a submission to the Human Frontier Science Program $400,000.00 Status: Pending ($1.2M collaboaration with other universities).

Autonomous Virtual Assistant for Crewed Space Missions (PIs: Torin Clark, Nisar Ahmed, Dan Szafir)
- o Based on the seed grant, the proposal "Approaches to Assess Human Performance, Trust, and Situation Awareness for Autonomous Long-Duration Exploration Missions" was submitted to the NASA Human Research Program for $1,200,000.00. The proposal was declined.

Collaboration Initiation: Formation Control in Chaotic Systems (PIs: Natasha Bosanac, Xudong Chen)
- o Natasha Bosanac, along with Jay McMahon and Nisar Ahmed, were awarded $500K from the NASA Early Stage Innovation program for the project "Autonomous Maneuvering within Chaotic Multi-Body Systems".

Collaboration Initiation: Secure Ensemble Control (PIs: Xudong Chen, Eric Wustrow, Fabio Somenzi)
- o The seed grant was used in part to prepare material for an NSF CAREER proposal by Xudong Chen titled "CAREER: Design, Control, and Estimation of Continuum Ensemble of Networked Systems."

Detection and Localization of Methane Sources Using Teams of Autonomous UAS (PIs: Sean Humbert, John Crimaldi, Michael Hannigan, Chris Heckman, Brian Argrow)

In Vivo Robot Localization (PIs: Mark Rentschler, Chris Heckman)
- o A $1M proposal based on the seed grants was submitted to NSF titled "S&AS: INT: COLLAB: An Intelligence-Driven Patient Care Approach to Reduce Medical Errors (I-CARE) by Mark Rentschler and Chris Heckman.

Natural Language Constraint-Based Learning from Demonstration (PI: Brad Hayes)

Systematic and Integrated High-Assurance Autonomous Systems (PIs: Sriram Sankaranarayanan, Chris Heckman, Nisar Ahmed, John Hauser, Ashutosh Trivedi)

Temporal-Logic Based Reinforcement Learning (PIs: Ashutosh Trivedi, Pavol Cerny, Fabio 1 474.34 299.33 Tm0 g0

- One proposal is currently being developed: "Super-Resolution for MIMO Systems (PIs; Chen and Liu)".

Algorithmic Challenges in Multi-Agent Reinforcement Learning for Autonomous Systems (PIs:

Natasha Bosanac, Eric Frew, and Jay McMahon participated in the 2018 Workshop on Autonomy for Future NASA Science Missions.

Chris Heckman was invited to be a member of the NAE Frontiers of Engineering organizing committee.

NSF AISL: Broad Implementation: Robotic Outreach Activities for Informal Science Education (RAISE) NSF; Sean Humbert (PI), Robert MacCurdy, Violet Mwaffo, and Shalom Ruben; $2,996,342.00 ; Pending.

NSF CHS: Medium: Data-Mediated Communication with Proximal Robots for Emergency Response; NSF CHS; Daniel Szafir (PI), Danielle Szafir, and Chris Heckman; $1,194,056.00; **Awarded**.

NSF CHS: Medium: Scaling Qualitative Inductive Analysis through Computational Methods; NSF CHS; Danielle Szafir (PI), Jed Brubaker, Casey Fiesler, and Michael Paul; $1,070,508.00; **Awarded**.

S&AS: INT: COLLAB: An Intelligence-Driven Patient Care Approach to Reduce Medical Errors (I-CARE) ; NSF; Mark Rentschler (PI) and Chris Heckman; $1,000,000.00 ; Pending. [Based on seed grant].

SCC: Engaging Smart and Connected Communities to Address Drone Safety and Privacy; NSF SCC; Rick Han(PI), Tam Vu, and Eric Frew; $1,873,150.00; Declined.

SCC: Interdisciplinary Approach Towards Smart and Connected Affordable Housing Communities; NSF SCC; Wangda Zuo (PI), Stefan Leyk and Brian Mueller; $2,218,933.00; Declined.

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