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Advancing Swarms Systems for Mitigating Natural Disasters

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https://ucmerced.zoom.us/j/83046953084

Abstract

The miniaturization of space technology and the use of swarms holds great potential in transforming earth and space monitoring for threats, disaster management, and post-disaster reconstruction. Surrounding Earth, there are thousands of Near-Earth asteroids rich in resources such as water, organic compounds. Still, they are also in close proximity to Earth and can impact Earth and cause massive destruction. Apart from asteroid impacts, volcanic eruptions on Earth can block major air transport corridors, impact atmospheric air quality and thus stall day-to-day life activities in areas affected. Similar concerns arise from large-scale forest fires and habitat destruction. The logical next step is to develop rapid response spacecraft swarm constellations and ground robot teams that can provide persistent, round-the-clock real-time monitoring of these changing situations. Such capability can assist with predicting the evolution of the disaster event, mitigate secondary damage and deaths, and reconstruct and recover.

We address this challenge through a multi-prong approach that combines earth science, planetary science, and space systems engineering. Our early works in the sphere show the promise of creative, cooperative processes taking shape that are sometimes human-competitive and provide critical insight into little-known task domains. Our approach is especially promising when extended to a swarm of small spacecraft or robots, where holistic system-level quantitative evaluation and ranking are made possible, and teleoperation and conventional autonomous control methods cannot be scaled up. Furthermore, a swarm architecture enables dynamic reconfiguration that can facilitate improvisation and aggregation. In theory, these swarm architectures can compete and win against a monolithic single, large systems.

Using these guiding principles, we have been applying the technology to many scenarios, including developing early-warning small satellite constellations to look for incoming space threats (particularly meteors), volcanoes, and potentially forest fires. A space-based early warning network could provide a holistic view of an ongoing disaster and even help with predictions. Another role for these swarms of robots is to take on dull, dirty, and dangerous tasks on the ground. We are showing the use of infrastructure robots in performing autonomous site preparation and excavation tasks. Such systems can be easily adapted for fighting natural disasters, particularly forest fires and volcanic eruptions. Such robots could work on the frontlines to set firewalls, earth barriers, and berms to block fire or lava from advancing and in combating these scenarios without the challenges of using human teams. These robots can work continuously in environments that are too dangerous for firefighters; they can also be at the frontlines and aggressively mitigate fires or lava flow using multiple strategies. In addition, another advantage is that these systems are decentralized and can be easily scaled up, and require only high human oversight and coordination.

To date, our studies point to multiple promising pathways that produce new architectures and robust solutions to some critical challenges that await. The key is to move forward, despite individual losses and execute demonstrator, followed by pilot missions that rigorously test these technologies' potential capacity and practicality in an everchanging environment.

For additional info contact Prof. Jeanette Cobian-Iñiguez (jcobian3@ucmerced.edu)

Biography

Jekan Thanga has a background in aerospace engineering from the University of Toronto. He worked on Canadarm, Canadarm 2, and the DARPA Orbital Express missions at MDA Space Missions. Jekan obtained his Ph.D. in space robotics at the University of Toronto Institute for Aerospace Studies (UTIAS) and postdoctoral training at MIT's Field and Space Robotics Laboratory (FSRL). Jekan Thanga is an Associate Professor and heads the Space and Terrestrial Robotic Exploration (SpaceTREx) Laboratory and the NASA-funded ASTEROID (Asteroid Science, Technology and Exploration Research Organized by Inclusive eDucation) Center in Formation at the University of Arizona. Jekan and his team of students have co-authored 150 technical publications. He is the Engineering Principal Investigator on the AOSAT I CubeSat Centrifuge mission. He and his team of students were winners of the Popular Mechanics Breakthrough Award in 2016 for proposing the SunCube FemtoSat. They recently won a Best Paper Presentation Award at AMOS 2019 for the Early Warning Constellation to Detect Incoming Meteor Threats.