Drones collaboratively explore scenarios with limited communications

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Communication is key for any team trying to collaboratively complete a task, whether it is comprised of people or autonomous robots. But while people can use intuition and experience to manage unforeseen circumstances, a robot cannot operate outside of its programming.

For many squadrons of drones operating in the field—perhaps scouting for a radiation leak in a nuclear facility with thick concrete walls or mapping miles of ocean floor—remaining in constant contact is impossible. Their programming, then, must be able to adapt to challenges such as a changing operational area or sudden loss of communications.

Michael Zavlanos, the Mary Milus Yoh and Harold L. Yoh, Jr. Associate Professor at Duke University, is working on intermittent communication protocols that allow robots to temporarily disconnect from each other to autonomously operate in such difficult terrains.

"By disconnecting from the network, the robots can cover different areas free of communication constraints," said Zavlanos. "The goal is to ensure that they will always eventually reconnect at properly negotiated meeting locations to transfer information between one another."

But what happens when a robot doesn't arrive at a communication point at the scheduled time? Do the other robots wait forever? If just a few things go wrong at once, the entire system can deadlock with robots waiting for each other at different locations.

To get around this issue, Zavlanos programs his squadron of robots in a way that they can tolerate uncertainty in the arrival times at the communication locations. In this way, communication events are guaranteed to take place and information can eventually propagate from any robot to any other robot in the team in an intermittent way. While this problem may seem simple for small teams of just a few robots, it quickly becomes daunting when scaling up to dozens of drones or more.

"The question we're really trying to answer is which robots should communicate where and when so that information can be propagated indefinitely," said Zavlanos. "We also want these robots to design these sequences of communication events in a distributed way using only local information, even though they are essentially disconnected from each other most of the time."

Zavlanos's current work involves four autonomous ground robots searching for four different colored stars, which represent important pieces of information. The simulation also includes various marked locations for potential communication. As they work through their search pattern and communicate with one another, eventually one robot gathers all four stars and returns them to the user.

"In this specific experiment, the robots already know in advance what tasks they need to accomplish," said Zavlanos. "But we're also working on an adaptive version where the tasks are announced in real-time, and the robots must plan new search paths while simultaneously ensuring that their communication protocols remain intact."

More information: Yiannis Kantaros et al. Sampling-Based Optimal Control Synthesis for Multi-Robot Systems under Global Temporal Tasks, *IEEE Transactions on Automatic Control* (2018). DOI: 10.1109/TAC.2018.2853558

Multi-Robot Data Gathering Under Buffer Constraints and Intermittent Communication arxiv.org/abs/1706.02092

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