MIT's intelligent aircraft fly, cooperate autonomously

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The U.S. military depends on small, unmanned aerial vehicles (UAVs) to perform such tasks as serving as "eyes in the sky" for battalion commanders planning maneuvers. While some of these UAVs can be easily carried in a backpack and launched by hand, they typically require a team of trained operators on the ground, and they perform only short-term tasks individually rather than sustained missions in coordinated groups.

MIT researchers, in collaboration with Boeing's advanced research and development arm, Phantom Works, are working to change that.

They have developed a multiple-UAV test platform that could lay the groundwork for an intelligent airborne fleet that requires little human supervision, covers a wide area, and automatically maintains the "health" of its vehicles (for example, vehicles anticipate when they need refueling, and new vehicles launch to replace lost, damaged, or grounded ones).

Aeronautics and Astronautics Professor Jonathan How, who heads the research team, believes it is the first platform to publicly demonstrate sustained, coordinated, autonomous flight with multiple UAVs.

At the Boeing Tech Expo at Hanscom Air Force Base in May, students on the team conducted more than 60 flights on demand with two UAVs. In the MIT Aerospace Controls Laboratory, the research team regularly conducts flights using three to five UAVs, which have achieved complex tasks such as persistent surveillance of a defined area.

According to John Vian, a technical fellow at Phantom Works who collaborates with the MIT team, "They have demonstrated quite successfully that UAV swarms can achieve high functional reliability by incorporating advanced health monitoring and adaptive control technology." Simply put, adaptive control addresses the fact that the parameters of the system being controlled are uncertain or vary slowly over time.

A fleet of UAVs could one day help the U.S. military and security agencies in difficult, often dangerous, missions such as round-the-clock surveillance, search-and-rescue operations, sniper detection, convoy protection and border patrol. The UAVs could also function as a mobile communication or sensor network, with each vehicle acting as a node in the network.

Such missions depend on "keeping vehicles in the air. The focus of this project is on persistence," said How. Persistence requires self-sufficiency. "You don't want 40 people on the ground operating 10 vehicles. The ultimate goal is to avoid a flight operator altogether."

The test platform consists of five miniature "quadrotor" aircraft - helicopters with four whirling blades instead of one - each a little smaller than a seagull. It also includes an indoor positioning system, as well as several miniature autonomous ground vehicles that the UAVs can track from the air.

Each UAV is networked with a PC. The setup allows a single operator to command the entire system, flying multiple UAVs simultaneously. Moreover, it requires no piloting skills; software flies the vehicles from takeoff to landing.

The vehicles in MIT's test platform are inexpensive, off-the-shelf gadgets; they can be easily repaired or replaced with a new vehicle, just as might happen in a real-world scenario involving numerous small UAVs on a long-term mission. The researchers can thus experiment constantly without concern for mishaps with expensive equipment.

"In this project, the larger system is what does the useful thing; the vehicle becomes just a cog in the wheel," said Mario Valenti, a Ph.D. candidate in electrical engineering and computer science (EECS) who works on the project with Brett Bethke, a Ph.D. candidate in aeronautics and astronautics, and Daniel Dale, a M.Eng. candidate in EECS.

Valenti, Bethke, Dale and colleagues operate the platform as often as possible, trying out different tasks, testing the system's response to sudden changes in mission (such as the appearance of new targets or the loss of a UAV) and coordinating with the autonomous ground vehicles. The laboratory provides a dynamic, real-time environment - a room with walls, furniture, equipment and other obstacles. The researchers analyze the performance of the test platform over time, using the resulting information to maximize the control system's ability to anticipate and recover from system failures.

The team has also designed an automatic docking station that allows the UAVs to recharge their batteries when they are running low. When the aircraft finish "refueling," they can then return to assist in ongoing flight operations.

In addition, the team recently achieved a milestone in autonomous flight: landing on a moving surface. Using "monocular vision," one of the quadrotors successfully landed on a moving vehicle - a remote-controlled lab cart. A video camera fastened to the UAV uses a visual "target" to determine in real time the vehicle's distance relative to the landing platform. The ground station then uses this information to compute commands that allow the UAV to land on the moving platform. This technology could enable UAVs to land on ships at sea or on Humvees moving across terrain.

Source: MIT

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