DARPA’s Fast Lightweight Autonomy (FLA) program is advancing autonomy to aid military operations in dense urban areas or heavily wooded forests

“The goal of Fast Lightweight Autonomy (FLA) is to develop advanced algorithms to allow unmanned air or ground vehicles to operate without the guidance of a human tele-operator, GPS, or any datalinks going to or coming from the vehicle,” said JC Ledé, the DARPA FLA program manager. Autonomous flight capabilities are being developed and demonstrated using custom payloads on a commercial quadrotor platform (DJI Flamewheel 450 airframe, E600 motors with 12″ propellers, and 3DR Pixhawk autopilot).

A traditional approach to operating small UAVs uses a human operator as the pilot. The air vehicles are typically remotely controlled with the operator watching the vehicle or teleoperated with the operator watching data from on-board sensors. These techniques work only when a highly skilled operator is coupled with a communications channel having high availability and manageable latency. However, the approach breaks down when obstacles are added to the environment, as communications degrade, and as vehicle speed increases.

Birds and flying insects maneuver easily at high speeds near obstacles. The FLA program asks the question “How can autonomous flying robotic systems achieve similar high-speed performance?”

Another traditional approach to controlling small, unmanned air vehicles uses Global Positioning System (GPS) coordinates to specify a flight path as a series of predetermined waypoints. This method for navigation has proven effective only in situations where GPS is available. It fails when GPS is lost due to interference such as jamming or poor reception indoors; as well as in settings in which GPS bounds on accuracy are not adequate for the size and speed of the platform.

Birds and flying insects are able to perform well without using predetermined waypoints or an external position reference system.

“Most people don’t realize how dependent current UAVs are on either a remote pilot, GPS, or both. Small, low-cost unmanned aircraft rely heavily on tele-operators and GPS not only for knowing the vehicle’s position precisely, but also for correcting errors in the estimated altitude and velocity of the air vehicle, without which the vehicle wouldn’t know for very long if it’s flying straight and level or in a steep turn. In FLA, the aircraft has to figure all of that out on its own with sufficient accuracy to avoid obstacles and complete its mission.”

The technology is intended to support unmanned aerial vehicle flights in GPS-denied or GPS-unavailable environments and aid military operations or search and rescue missions, among others, DARPA said. Potential applications for the technology include safely and quickly scanning for threats inside a building before military teams enter, searching for a downed pilot in a heavily forested area or jungle in hostile territory where overhead imagery can’t see through the tree canopy, or locating survivors following earthquakes or other disasters when entering a damaged structure could be unsafe.

The Defense Advanced Research Projects Agency put unmanned quadcopters through a series of tests to demonstrate autonomous flight without the aid of human operators or global positioning systems. DARPA said three research teams under the Fast Lightweight Autonomy program flew small unmanned quadcopters through various environments using onboard cameras and sensors as well as smart algorithms for autonomous navigation.

“I was impressed with the capabilities the teams achieved in Phase 1,” Ledé said. “We’re looking forward to Phase 2 to further refine and build on the valuable lessons we’ve learned. We’ve still got quite a bit of work to do to enable full autonomy for the wide-ranging scenarios we tested, but I think the algorithms we’re developing could soon be used to augment existing GPS-dependent UAVs for some applications. For example, existing UAVs could use GPS until the air vehicle enters a building, and then FLA algorithms would take over while indoors, while ensuring collision-free flight throughout. I think that kind of synergy between GPS-reliant systems and our new FLA capabilities could be very powerful in the relatively near future.”

If successful, FLA would reduce operator workload and stress and allow humans to focus on higher-level supervision of multiple formations of manned and unmanned platforms as part of a single system.

Fast Lightweight Autonomy (FLA) program

The program focuses on autonomy and not on the flight platform, where “autonomy” includes sensing, perception, planning, and control. The goal of the FLA program is to explore non-traditional perception and autonomy methods that could enable a new class of algorithms for minimalistic high-speed navigation in cluttered environments. The FLA program will demonstrate a sequence of capabilities, beginning with lower-clutter, fly-by missions and progressing to higherclutter, fly-through missions.

Through this exploration, the program aims to develop and demonstrate the capability for small (i.e., able to fit through windows) autonomous UAVs to fly at speeds up to 20 m/s with no communication to the operator and without GPS waypoints.

The FLA program is focused on developing a new class of algorithms that enables UAVs to operate in GPS-denied or GPS-unavailable environments—like indoors, underground, or intentionally jammed—without a human tele-operator.

Under the FLA program, the only human input required is the target or objective for the UAV to search for—which could be in the form of a digital photograph uploaded to the onboard computer before flight—as well as the estimated direction and distance to the target. A basic map or satellite picture of the area, if available, could also be uploaded. After the operator gives the launch command, the vehicle must navigate its way to the objective with no other knowledge of the terrain or environment, autonomously maneuvering around uncharted obstacles in its way and finding alternative pathways as needed.

Phase 1 of DARPA’s Fast Lightweight Autonomy (FLA) program concluded recently following a series of obstacle-course flight tests in central Florida. During the tests, researchers provided targets or objectives for the UAVs by uploading images or estimated direction and distance. The quadcopters had to self-navigate through various obstacle-strewn locations such as building interiors, wooded areas and a hangar before flying back to the starting point.

The recent four days of testing combined elements from three previous flight experiments that together tested the teams' algorithms' abilities and robustness to real-world conditions such as quickly adjusting from bright sunshine to the dark building interiors, sensing and avoiding trees with dangling masses of Spanish moss, navigating a simple maze, or traversing long distances over feature-deprived areas. On the final day, the aircraft had to fly through a thickly wooded area and across a bright aircraft parking apron, find the open door to a dark hangar, maneuver around walls and obstacles erected inside the hangar, locate a red chemical barrel as the target, and fly back to its starting point, completely on their own.

Each team showed strengths and weaknesses as they faced the varied courses, depending on the sensors they used and the ways their respective algorithms tackled navigation in unfamiliar environments. Some teams' UAVs were stronger in maneuvering indoors around obstacles, while others excelled at flying outdoors through trees or across open spaces.

Success was largely a matter of superior programming. "FLA is not aimed at developing new sensor technology or to solve the autonomous navigation and obstacle avoidance challenges by adding more and more computing power," Ledé said. "The key elements in this effort, which make it challenging, are the requirements to use inexpensive inertial measurement units and off-the-shelf quadcopters with limited weight capacity. This puts the program emphasis on creating novel algorithms that work at high speed in real time with relatively low-power, small single board computers similar to a smart phone."

References and Resources also include:

http://www.darpa.mil/news-events/2017-06-28

https://www.fbo.gov/index?s=opportunity&mode=form&id=38c56cd0dec12a5d3ae9b95849c102e8&tab=core&_cview=0