Small quadrotors make their moves around poles and narrow window gaps

15 September 2016, by Nancy Owano

(Tech Xplore)—Quadrotors with a difference—here is your chance to see an impressive display of what the team at the Penn Engineering GRASP Lab have been up to. The title of the video is "Estimation control and planning for aggressive flight with a small quadrotor with a single camera and IMU." The video credits list the Penn Engineering GRASP Lab and Qualcomm Technologies.

GRASP stands for general robotics, automation, sensing and perception. On September 11 that video of an autonomous 250 g quadrotor was presented, where we see it performing "aggressive" maneuvers.

The researchers show "aggressive trajectories around poles and narrow window gaps at different inclinations."

Fancy maneuvers at a level of impressive stunts are entertaining but the real big deal about all this is something else. Anyway, back to the impressive stunts, before we get to what is so important. They reported that their vehicle can traverse "narrow gaps requiring accelerations up to 1.5 g and roll and pitch angles up to 90 degrees with velocities of 5 m/s."

"This is the first time that aggressive maneuvers are solved with such a small footprint vehicle, using only on-board sensors and without relying on external motion capture systems."

That is the big deal, that they can do all this relying only on what is on board, not external motion capture systems. The computation and sensor capabilities are on-board.

Tasks for control planning and estimation are solved based on the information provided by a single camera and an IMU (inertial measurement unit). The current approach does not require any switching control strategy. It is fully based on the information of only the single camera and IMU.

Evan Ackerman in *IEEE Spectrum* in further translation said that what you are seeing in the video is a quadrotor "smart enough to use its own sensors and onboard computation for localization, state estimation, and path planning, allowing it to perform stunts without any help."

He also had this to say:

"Quadrotors are capable of doing some incredible stunts, like flying through narrow windows and thrown hoops. Usually, when we talk about quadrotors doing stuff like this, we have to point out that there are lots of very complicated and expensive sensors and computers positioned around the room doing all of the hard work, and the quadrotor itself is just following orders."

As for future work, Ackerman reported that the researchers are working on real-time mapping strategies for obstacle detection and dynamic planning. They demonstrated on a larger platform as part of DARPA's FLA program.

FLA stands for Fast Lightweight Autonomy. The FLA program explores methods that could enable a new class of algorithms "for minimalistic high-speed navigation in cluttered environments."

Vijay Kumar, Giuseppe Loianno and others said, "We are creating autonomous flying robots that are able to navigate in complex, three-dimensional environments with or without GPS with applications to search and rescue, first response and precision farming. The robots are quadrotors with onboard sensors and processors customized for state estimation, control and planning. They rely on a range of sensors that can include an IMU, cameras, a laser range scanner, an altimeter and a GPS sensor."

IEEE Spectrum said that their work, "Estimation, Control, and Planning for Aggressive Flight With a Small Quadrotor With a Single Camera and IMU," by Giuseppe Loianno, Chris Brunner, Gary McGrath, and Vijay Kumar from the University of Pennsylvania and Qualcomm, was submitted to *Robotics and Automation Letters* and ICRA 2017.

More information: www.kumarrobotics.org/

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