Deep drone acrobatics

June 23 2020

A quadrotor performs a matty flip. Credit: Elia Kaufmann

A navigation algorithm developed at the University of Zurich enables drones to learn challenging acrobatic maneuvers. Autonomous quadcopters can be trained using simulations to increase their speed, agility and efficiency, which benefits conventional search and rescue operations.

Since the dawn of flight, pilots have used acrobatic maneuvers to test the

limits of their airplanes. The same goes for flying drones: Professional pilots often gage the limits of their drones and measure their level of mastery by flying such maneuvers in competitions

Greater efficiency, full speed

Working together with microprocessor company Intel, a team of researchers at the University of Zurich has now developed a quadrotor helicopter, or quadcopter, that can learn to fly acrobatic maneuvers. While a power loop or a barrel role might not be needed in conventional drone operations, a drone capable of performing such maneuvers is likely to be much more efficient. It can be pushed to its physical limits, make full use of its agility and speed, and cover more distance within its battery life.

The researchers have developed a navigation algorithm that enables drones to autonomously perform various maneuvers—using nothing more than onboard sensor measurements. To demonstrate the efficiency of their algorithm, the researchers flew maneuvers such as a power loop, a barrel roll or a matty flip, during which the drone is subject to very high thrust and extreme angular acceleration. "This navigation is another step towards integrating autonomous drones in our daily lives," says Davide Scaramuzza, robotics professor and head of the robotics and perception group at the University of Zurich.

Trained in simulation

At the core of the novel algorithm lies an artificial neural network that combines input from the onboard camera and sensors and translates this information directly into control commands. The neural network is trained exclusively through simulated acrobatic maneuvers. This has several advantages: Maneuvers can easily be simulated through reference

trajectories and do not require expensive demonstrations by a [human pilot](#). Training can scale to a large number of diverse maneuvers and does not pose any physical risk to the quadcopter.

Only a few hours of simulation training are enough and the quadcopter is ready for use, without requiring additional fine-tuning using real data. The algorithm uses abstraction of the sensory input from the simulations and transfers it to the physical world. "Our [algorithm](#) learns how to perform acrobatic maneuvers that are challenging even for the best human pilots," says Scaramuzza.

Fast drones for fast missions

However, the researchers acknowledge that human pilots are still better than autonomous drones. "Human pilots can quickly process unexpected situations and changes in the surroundings, and are faster to adjust," says Scaramuzza. Nevertheless, the robotics professor is convinced that drones used for search and rescue missions or for delivery services will benefit from being able to cover long distances quickly and efficiently.

  More information: E. Kaufmann et al. Deep Drone Acrobatics. *Robotics: Science and Systems (RSS)*. 11 June 2020. arxiv.org/pdf/2006.05768.pd

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