GapFlyt gives flying quadrotors a lesson in bees

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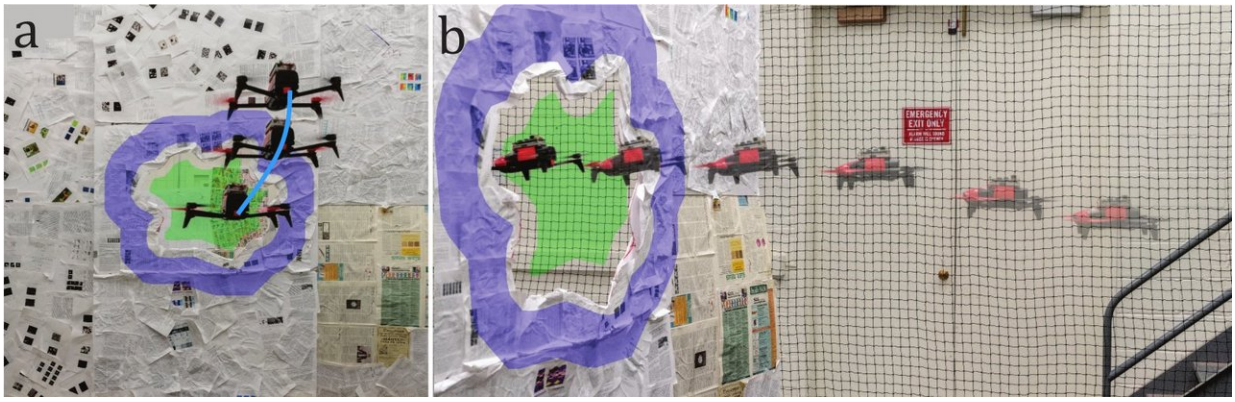

Different parts of the pipeline: (a) Detection of the unknown gap using active vision and TS2P algorithm (cyan highlight shows the path followed for obtaining multiple images for detection), (b) Sequence of quadrotor passing through the unknown gap using visual servoing based control. The blue and green highlights represent the tracked foreground and background regions respectively. Credit: arXiv:1802.05330 [cs.RO]

Researchers have come up with a system that is bio-inspired to help drones pass through small gaps. The researchers tested their system and wrote an analysis in a paper which is published in *IEEE Robotics & Automation Letters*.

"GapFlyt: Active Vision Based Minimalist Structure-less Gap Detection For Quadrotor Flight" is by Nitin J. Sanket, Chahat Deep Singh,

Kanishka Ganguly, Cornelia Fermüller and Yiannis Aloimonos. The authors are from the Perception and Robotics group at the University of Maryland in College Park.

They worked on a bio-inspired design for quadrotors. This is a framework intended for quadrotors to fly through "unknown gaps without a 3D reconstruction of the scene," they stated, "using only a monocular camera and onboard sensing."

Their attempt to note that this is all without a 3D reconstruction bears a closer look. Elsewhere, they explained that "Researchers and practitioners today use traditional computer vision algorithms with the aim of building a representation of general applicability: a 3D reconstruction of the scene. Using this representation, planning tasks are constructed and accomplished to allow the quadrotor to demonstrate autonomous behavior. These methods are inefficient as they are not task driven."

Just look at flying insects and birds—solving the problem of navigation and complex control for ages on their own, without the need to build a 3D map, they said, and are highly task-driven.

Evan Ackerman in *IEEE Spectrum* nicely offered a lesson in bees.

"Bees make this work through a sort of minimalist brute-force approach to the problem: They fly up to a small hole or gap, hover, wander back and forth a little bit to collect visual information about where the edges of the gap, and then steer themselves through. It's not fast, and it's not particularly elegant, but it's reliable and doesn't take much to execute."

The title of their paper mirrors the very question they posed as a team: "Can a quadrotor manage to go through an arbitrarily shaped gap without building an explicit 3D model of a scene, using only a monocular

camera?"

They put it to the test in experiments with different settings and window shapes. The proposed framework was tested on a modified hobby quadrotor, Parrot Bebop 2.

IEEE Spectrum carried a photo caption that further described what they used for experiments. The modified drone, said the caption, included a NVIDIA TX2 module mounted at the top. For sensing, the drone used its front-facing camera and a downward-facing optical-flow sensor, which combines a camera plus sonar.

Results? They said they achieved "a success rate of 85% at 2.5m/s, even with a minimum tolerance of just 5cm."

IEEE Spectrum noted they got that success rate over 150 trials "for different arbitrary shaped windows under a wide range of conditions which includes a window with a minimum tolerance of just 5 cm."

As for the maximum speed that the drone was able to achieve while passing through the gap, 2.5 m/s, Ackerman said it was "primarily constrained by the rolling shutter camera (which could mess up the optical flow at higher speeds), but again, this method isn't really intended for high performance drones."

Why their work matters: this paper addresses the problem of gap detection of an unknown shape and location with a monocular camera and onboard sensing. That is not to say, the question over going through gaps is new. The authors pointed out that "the problem of going through gaps has fascinated researchers from many years." Researchers elsewhere have presented algorithms for planning and control and the authors said that some works paved the way to the bio-inspired approach that they used in the paper.

More information: GapFlyt: Active Vision Based Minimalist Structure-less Gap Detection For Quadrotor Flight, arXiv:1802.05330 [cs.RO] arxiv.org/abs/1802.05330

Nitin J. Sanket et al. GapFlyt: Active Vision Based Minimalist Structure-Less Gap Detection For Quadrotor Flight, *IEEE Robotics and Automation Letters* (2018). DOI: 10.1109/LRA.2018.2843445