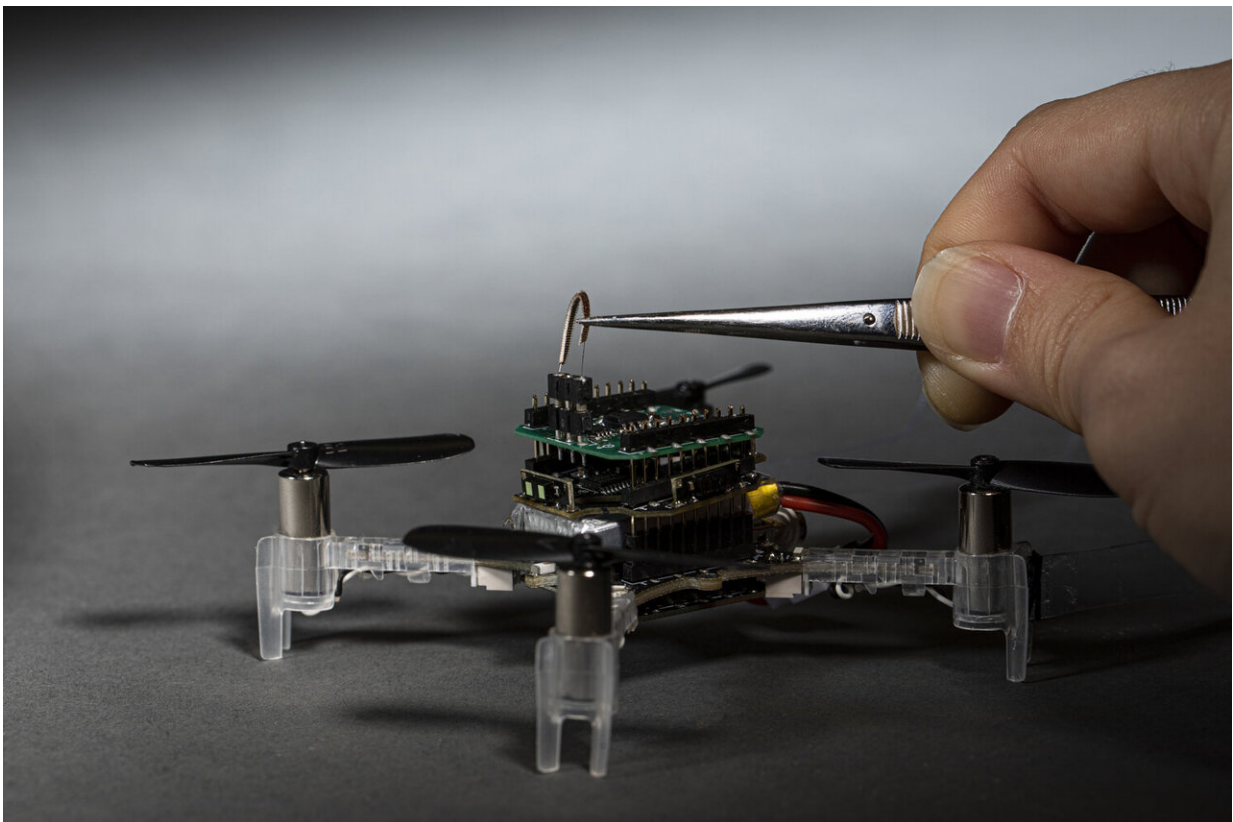


'The Smellicopter,' an obstacle-avoiding drone that uses a live moth antenna to seek out smells

December 8 2020



By adding tiny wires into either end of the antenna (the arc being attached here), the researchers were able to connect it to a circuit and record its responses.
Credit: Mark Stone/University of Washington

One huge advantage of drones is that these little robots can go places where people can't, including areas that might be too dangerous, such as unstable structures after a natural disaster or a region with unexploded devices.

Researchers are interested in developing devices that can navigate these situations by sniffing out chemicals in the air to locate disaster survivors, gas leaks, explosives and more. But most sensors created by people are not sensitive or fast enough to be able to find and process specific smells while flying through the patchy odor plumes these sources create.

Now a team led by the University of Washington has developed Smellicopter: an autonomous drone that uses a live antenna from a moth to navigate toward smells. Smellicopter can also sense and avoid obstacles as it travels through the air. The team published these results Oct. 1 in the journal *IOP Bioinspiration & Biomimetics*.

"Nature really blows our human-made odor sensors out of the water," said lead author Melanie Anderson, a UW doctoral student in mechanical engineering. "By using an actual moth antenna with Smellicopter, we're able to get the best of both worlds: the sensitivity of a biological organism on a robotic platform where we can control its motion."

The moth uses its antennae to sense chemicals in its environment and navigate toward sources of food or potential mates.

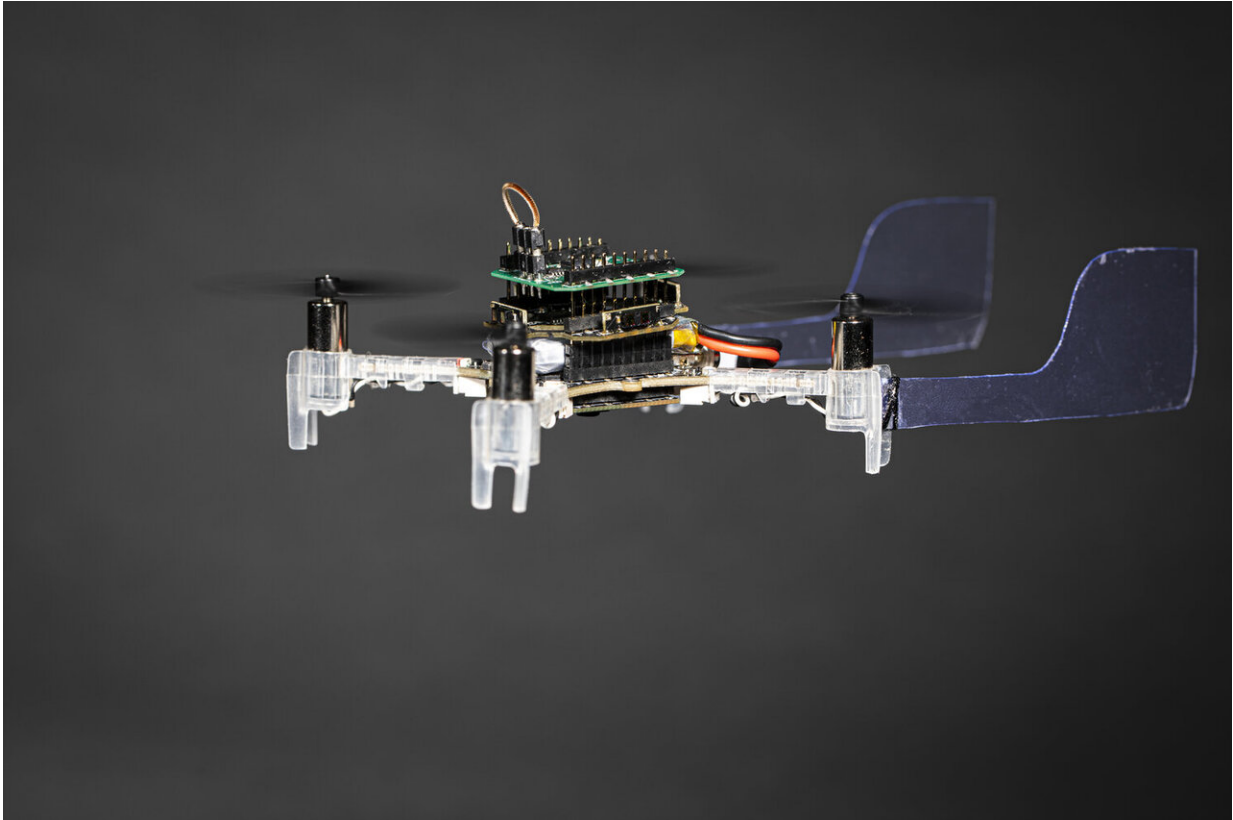
"Cells in a moth antenna amplify chemical signals," said co-author Thomas Daniel, a UW professor of biology who co-supervises Anderson's doctoral research. "The moths do it really efficiently—one scent molecule can trigger lots of cellular responses, and that's the trick. This process is super efficient, specific and fast."

The team used antennae from the *Manduca sexta* hawkmoth for Smellicopter. Researchers placed moths in the fridge to anesthetize them before removing an antenna. Once separated from the live moth, the antenna stays biologically and chemically active for up to four hours. That time span could be extended, the researchers said, by storing antennae in the fridge.

By adding tiny wires into either end of the antenna, the researchers were able to connect it to an electrical circuit and measure the average signal from all of the cells in the antenna. The team then compared it to a typical human-made sensor by placing both at one end of a wind tunnel and wafting smells that both sensors would respond to: a floral scent and ethanol, a type of alcohol. The antenna reacted more quickly and took less time to recover between puffs.

To create Smellicopter, the team added the antenna sensor to an [open-source](#) hand-held commercially available quadcopter drone platform that allows users to add special features. The researchers also added two plastic fins on the back of the drone to create drag to help it be constantly oriented upwind.

"From a robotics perspective, this is genius," said co-author and co-advisor Sawyer Fuller, a UW assistant professor of mechanical engineering. "The classic approach in robotics is to add more sensors, and maybe build a fancy algorithm or use machine learning to estimate wind direction. It turns out, all you need is to add a fin."



Smellicopter has two plastic fins (shown here in blue) on the back to create drag to help it be oriented so that it is constantly facing upwind. Credit: Mark Stone/University of Washington

Smellicopter doesn't need any help from the researchers to search for odors. The team created a "cast and surge" protocol for the drone that mimics how moths search for smells. Smellicopter begins its search by moving to the left for a specific distance. If nothing passes a specific smell threshold, Smellicopter then moves to the right for the same distance. Once it detects an odor, it changes its flying pattern to surge toward it.

Smellicopter can also avoid obstacles with the help of four infrared sensors that let it measure what's around it 10 times each second. When

something comes within about eight inches (20 centimeters) of the drone, it changes direction by going to the next stage of its cast-and-surge protocol.

"So if Smellicopter was casting left and now there's an obstacle on the left, it'll switch to casting right," Anderson said. "And if Smellicopter smells an odor but there's an obstacle in front of it, it's going to continue casting left or right until it's able to surge forward when there's not an obstacle in its path."

Another advantage to Smellicopter is that it doesn't need GPS, the team said. Instead it uses a camera to survey its surroundings, similar to how insects use their eyes. This makes Smellicopter well-suited for exploring indoor or underground spaces like mines or pipes.

During tests in the UW research lab, Smellicopter was naturally tuned to fly toward smells that moths find interesting, such as floral scents. But researchers hope that future work could have the [moth antenna](#) sense other smells, such as the exhaling of carbon dioxide from someone trapped under rubble or the chemical signature of an unexploded device.

"Finding plume sources is a perfect task for little robots like the Smellicopter and the Robofly," Fuller said. "Larger robots are capable of carrying an array of different sensors around and using them to build a map of their world. We can't really do that at the small scale. But to find the source of a plume, all a robot really needs to do is avoid obstacles and stay in the plume while it moves upwind. It doesn't need a sophisticated sensor suite for that—it just needs to be able to smell well. And that's what the Smellicopter is really good at."

More information: Melanie Joyce Anderson et al. A bio-hybrid odor-guided autonomous palm-sized air vehicle, *Bioinspiration & Biomimetics* (2020). [DOI: 10.1088/1748-3190/abbd81](https://doi.org/10.1088/1748-3190/abbd81)

Provided by University of Washington

Citation: 'The Smellicopter,' an obstacle-avoiding drone that uses a live moth antenna to seek out smells (2020, December 8) retrieved 16 April 2024 from

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