SMALLER, SMARTER, FASTER

BLINK AND YOU'LL MISS THE FUTURE OF AUTONOMOUS ROBOTS

Nitin Sanket, assistant professor at Worcester Polytechnic Institute's Robotics Engineering Department, hopes that one day you'll barely notice a drone flitting by.

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Sanket and his team are advancing the creation of small, autonomous robots. He envisions a future in which we're surrounded by miniature drones performing tasks including pollination, searching for survivors in disaster zones, providing entertainment, delivering payloads and even serving as pets.

Taking his cues from creatures such as insects and hummingbirds, Sanket hopes to program drones that can navigate cluttered environments, dynamically evade moving obstacles and safely navigate through small gaps. To keep the robots secure and able to operate in environments where control loops might be difficult, all of the above needs to be achieved using only onboard perception and computing. That means no assistance from GPS, cloud-based computation or, eventually, motion capture.

"At some point, we want to be able to do search and rescue in the wild, flying fast enough through a forest fire to save somebody, or perhaps to look for poachers, and every second matters in these scenarios. That's one of the major reasons why we are pushing the boundary of speed, and we want these robots to be small enough that it's safe for them to move that fast. You have narrow spaces in a forest, and one option is to make your perception better, make your controls better. But the bigger the robot, the higher the probability of it running into something. So we're asking, can we make the robot small, as well as making it smarter?"

To get to a point where his robots won't need a system such as motion capture to navigate, Sanket first needs to use motion capture as his source of ground truth.

"We want to eventually fly at 30 or 40 meters per second," he explains. "Similar work is being done in drone racing, but we want to do it in a completely unstructured environment. Our focus is on the vision side—how do you actually process the data that fast?

"So how can we test that? You can't take it into a forest and actually fly at freeway speeds. You'd immediately run into a tree. So we want to do it virtually first. So, you have an empty space where all the trees are computer-generated and you have a perfect state estimator, which is motion capture. We want to start the journey there and that's how our lab got set up."

The lab in question is 36 ft long, 15 ft wide and about 12.5 ft high, and is equipped with 14 Vicon Vero cameras running on Tracker 4. "We were the first people in the country to get trained on Tracker 4," says Sanket. "It's awesome. Such an improvement."

THE FIRST STEP IS MOTION CAPTURE

"The first step towards working on onboard computing and testing for autonomous drones is testing it in the motion capture space," says Sanket. "You want to prototype something quickly, and you can inject any amount of noise into it and see how it behaves without actually subjecting the real robot to those conditions and potentially crashing a half-million-dollar drone.

"I call the process 'sim-to-real-to-sim', because you go from sim to real, then you see what issues crop up and you go back to sim and you fix your simulation model. You do this loop a couple of times and you get a very good model at the end."

Sanket and his team began by simply flying their drone as fast as they could using manual controls, and Tracker's turnkey offering worked perfectly.

The next step required a deeper exploration of the software. "Then we said, let's see if we can do this autonomously," he explains. "And that's where we started moving more towards things like the ROS API."

Sanket also emphasizes the importance of the control stack. "The other side of the story is also true," he says. "If you actually want to fly that fast, you have to do the controls. You cannot cheat. You have to do whatever nonlinear work you need to do. And for that you need a motion capture system right at the start of your project."

Sanket says that his Vicon system offers another benefit, too. "The other thing which is beautiful is it gives us free data that you need if you want to do vision work. This gives us real IMU data and real noise performance data that you cannot get otherwise. That's what makes our life a lot easier to actually do the simulation-to-real transfer."

Having used motion capture systems from multiple providers, Sanket says he insists on working with Vicon technology because "it's just easy. It works every single time. It removes painful procedures that you don't want to think about because you're focusing on the research. You don't care how the motion capture technology works—you just want to get the data you need.

"Vicon just gives you that peace of mind which you want as a researcher so that you don't have to worry about the nitty gritty details. You focus on your research and a Vicon setup just enables you to do that. And I think that's the hallmark of a good product.

He also praises Vicon's support offering throughout the procurement process. Sanket's long-term professional relationship with his Vicon rep meant that his work and needs were quickly understood, making the process extremely straightforward. "I probably interacted with the company over four emails that took me 10 minutes to write. That's it. I appreciate that a lot because when you're dealing with 300 different things, anything that makes life simple is a bonus. I value that relationship a lot," he says.

GETTING FASTER

The research that Sanket and his team are doing has already yielded dramatic results. "When we started out, we could process our motion estimation at about 30 Hertz, which was state-of-the-art at that time," he says. "Now we can do that at 100 Hertz. We have improved it by 3.3 times in the last year.

"The goal would be to push that boundary even further. Right now our perception stack is there, but our control stack is nowhere close."

Sanket has big plans to meet those goals with an improved motion capture volume. "I eventually want to expand the space," he says. "Right now we can hit about 11 or 12 meters per second, which is already very, very, fast. It's probably state-of-the-art at this stage, but it's just not fast enough for us. We want to hit 30 or 35 meters per second. Eventually, we are planning to rent out an aircraft hangar and buy another set of Vicon cameras to put there so that we can actually fly at those speeds."

For more on the work of Nitin Sanket's and his team, visit:
www.wpi.edu/academics/departments/robotics-engineering