Greenhouse MANAGEMENT

The drones are close

Features - Cover Story

Unmanned aerial vehicles have their coordinates set on the greenhouse industry.

April 23, 2018

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Eijiro Miyako and his research team cross-pollinated lilies using a drone with ionic gel-coated horse hair attached to its underside.
Photo courtesy of Eijiro Miyako

In Japan, one type of drone cross-pollinates lilies by remote control. In North Carolina, a second flaunts a protruding proboscis. In the Netherlands, a third avoids objects on its own.

Drones, or unmanned aerial vehicles (UAVs), are used in various applications, including military operations, aerial surveying and field agriculture. Their use in confined spaces has been limited so far, but more researchers and companies are beginning to explore how they can be used in protected crop production. Some researchers predict that in the coming years, drones will be adopted for routine use in commercial greenhouses.

Due to declines in bee populations, one use for greenhouse drones that appeals to many developers is artificial pollination. In March, Walmart requested a patent for pollinating UAVs, and both self-pollinating and cross-pollinating drones have appeared in global studies and projects. Drones can also collect and map greenhouse environmental data. UAVs that can predict yields and monitor plant health likely aren't far away from being implemented by tech-minded greenhouse owners and operators.

Drones for studying the environment

Dutch company Applied Drone Innovations (ADI) develops and prototypes drones that monitor plant growth and stress; and greenhouse environmental factors such as temperature, humidity, carbon dioxide, luminosity and volatile organic compounds, says CTO Lucien Fesselet.

ADI was founded by four friends, aeronautical engineering bachelor's students at the Inholland University of Applied Sciences, whose project, "Drones in the Greenhouse," won the 2016 Wij Inholland Award for best student project. By press time, all four company founders had already graduated university with the exception of Fesselet, who turned in his thesis days before this interview.

"It is very ambitious [work], especially when it started," Fesselet says. "We had no idea what we were getting ourselves into. And it did delay our study a lot."

In 2017, ADI obtained access to 600,000 euros in funding — 300,000 from the Inholland University of Applied Sciences and 300,000 euros in subsidies from the Netherlands Organisation for Scientific Research — for a two-year project called HiPerGreen. As part of its affiliation with the university, the company acquires help from current students in degree programs as diverse as horticulture; agriculture; mechanical and aeronautical engineering; business; and law. In turn, the students gain experience and receive university credits.

Also in 2017, ADI demonstrated its technology to Martijn van Dam, the Netherlands' former minister for agriculture affairs, at Bunnik Plants, a grower in Bleiswijk.

Bunnik Plants was the first greenhouse the company worked closely with. "We've had a very good relationship with them, and they help us a lot in terms of understanding the problem, understanding how a greenhouse works," Fesselet says. "When we started this, we were [educated in] aeronautical engineering. We called this the 'green finger feeling' when you know how plants behave. We were so far from having any of this."

Since then, the company has formed close collaborations with five greenhouses, which mostly grow potted plants, Fesselet says. In that time, the company's founders have also expanded their knowledge of biology, programming and mechanical engineering.

ADI's protoypes are currently about 65 centimeters diagonally and require a pilot, Fesselet says. But he and his colleagues hope to reduce the size and make the drones autonomous.

The company wants its drones to be able to adapt to specific requirements and conditions in different greenhouses, Fesselet says. "We try to make it as modular as possible," he says. "The way that we look at it, we try to distance ourselves from the drone itself. We want to more look at it as a platform that is capable of flying anywhere in the greenhouse."

A helping hand for self-pollination

Close by in the Netherlands, at the Delft University of Technology's Micro Aerial Vehicle Lab (MAVLab), researchers have been using self-navigating drones to pollinate flowers in greenhouses. This undertaking resulted in the development of the Autonomous Pollination and Imaging System (APIS), a "multicopter" (drone with multiple rotors) that aids self-pollinating crops such as tomatoes.

The drone detects flowers with a camera, shoots a jet of air that vibrates a branch of flowers and takes a picture of the flowers to capture the pollination and check that it was successful, according to project materials. When APIS' battery reaches 50 percent, it goes to charge at one of eight ground stations, which the researchers compare to air traffic control towers.

Researcher Christophe De Wagter was the tutor for the project, and he saw multiple reasons why his team should do this work. "The combination of indoor positioning systems and collision avoidance systems of small sizes has opened the road to flight within greenhouses," he says. "On top of that, concerns exist that in time, alternatives will be needed for pollination."

Although the first generation of APIS is limited to self-pollinating crops, De Wagter says the goal is to continue developing technology until the drones can pollinate all types of flowers. In the meantime, researchers still need to test the first generation in a greenhouse.

Artificial from stamen to pistil

While researchers have developed some drones to self-pollinate, another has retrofitted a drone to cross-pollinate. Dr. Eijiro Miyako, senior researcher at Japan's National Institute of Advanced Industrial Science and Technology (AIST), was part of a group that cross-pollinated Lilium japonicum flowers using a remote-controlled UAV that they bought on Amazon for about $100. To collect the pollen, they attached horse hair coated with an ionic gel to the bottom of the drone.

For the project, described in the 2017 study in the journal Chem titled "Materially Engineered Artificial Pollinators," Miyako learned how to fly the drone with enough accuracy to direct it to deliver pollen from the stamen of one plant to the pistil of another.

"These types of drones would somewhat contribute [to] making crops in the greenhouse," he says. "That said, we need more high-tech equipment such as GPS [global positioning system] and AI [artificial intelligence] for realizing automatic controlling of the drones. Consequently, the size of drones would be bigger against our expectations due to the incorporation of heavy computers." Miyako suspects it will take about five years before technology like his can be used in commercial greenhouses.

Since the study came out, many scientists and horticulturists have sent Miyako encouraging messages and requests to collaborate on projects. "My research has become rather popular in a short amount of time," he says.

But in addition to positive responses, Miyako also has received heated messages from beekeepers who worry pollinator drones will replace bees. "In fact, they often e-mailed me, "Do NOT take away our work by unnatural robots,'" he says. But Miyako says his intention is not to replace bees, but rather to help counter their decline.

Pollination drones for marketing

At Ernst Benary's 2017 California Spring Trials stop, visitors experienced several technological-themed developments, including a virtual reality bar, helicopter rides and a drone demonstration. For the latter, a drone pilot flew one of the devices around the breeder's Graffiti Pentas. He displayed how the technology could work, but did not actually pollinate any flowers, says Jen Calhoun, marketing specialist North America at Benary.

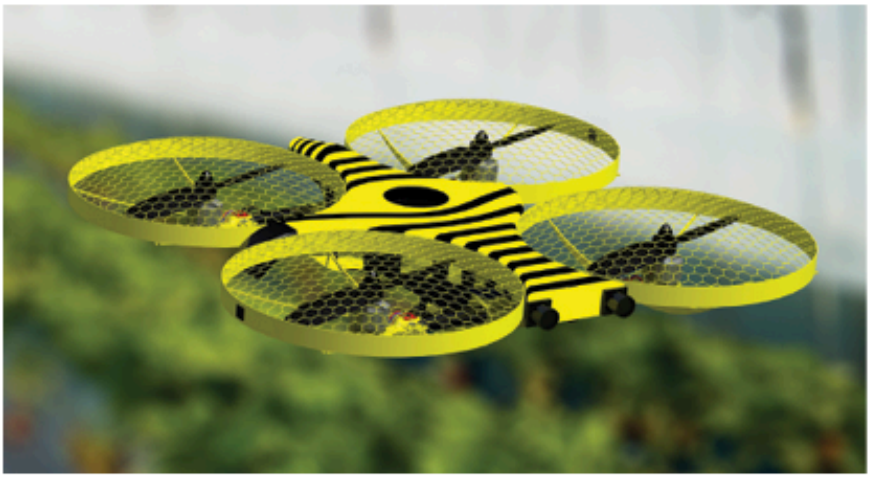
At its 2017 California Spring Trials stop, Ernst Benary brought in a drone pilot to display drone technology to visitors.
Photo courtesy of Jen Calhoun

The annual California Spring Trials has become more than a place to trial new varieties, Calhoun says. "It's all about building new relationships with people and getting new ideas for their company, so we're always trying to take it a step further, to have it not be just new varieties," she says. "That's why we decided to incorporate the technology, because that's something that our industry has been advancing quite a bit in lately."

Calhoun says she is unsure how many ornamental growers do mass pollination. "I'm not sure what that looks like, because I think most growers like to get in seed, and I don't know that they necessarily do their own pollination," she says. "But if they do, that would be a much easier way, and more controlled, where if you just have an F1 hybrid that's outside, you're just taking your chance that it might get pollinated, where this would be — you'd know exactly where it was pollinated, and when."

Natural versus artificial pollinators

Pollination drones or no pollination drones, there is reason to be worried about bee population declines, says Dr. Christina M. Grozinger, distinguished professor of entomology at Penn State University and director of the university's Center for Pollinator Research. She says half of the U.S. bumblebee species that are studied have experienced population declines.



The Autonomous Pollination and Imaging System (APIS) from TU Delft's MAVLab navigates and recharges on its own and can detect flowers in real time using imaging.

Photo courtesy of Christophe De Wagter

Reasons for decline are varied, and they can include such factors as habitat loss, pathogens and parasites, pesticides and climate change, Grozinger says. While ornamental growers don't typically release bees in their greenhouses — and likely won't use drones in the future for strictly pollination purposes, either — Grozinger says they can take steps to help bee populations such as implementing integrated pest management programs and selecting certain plants.

Grozinger is not diametrically opposed to artificial pollinators as a whole, but she doesn't think the technology seems particularly practical to use on many plants, either. "Bees and plants have co-evolved over millions of years together, so a lot of plants require fairly sophisticated handling techniques that the bees have developed in order to access the pollen, pick it up and then transmit it to the right place," she says. "For some plant species that have more open flowers, you could potentially [use drones], but it just seems like it would make more sense to have bees around that could do that for you."

Strawberries are an example of a crop that Grozinger says she cannot see drones pollinating. "Strawberries have a really interesting pollination system, where they have to be pollinated by different-sized bees to be able to pollinate each ovule and create a strawberry that's the right shape," she says. "It's like the poster child of this system where you need a lot of different kinds of pollinators to produce a high-quality product."

In response to the opponents of his project, Miyako notes that people have reacted negatively to past technological developments, such as cars, electric appliances and the iPhone. "I'd like to respectfully hear different views and perspectives, because we all have different ways of thinking," he says.

Like Miyako, De Wagter says his lab has no intention of replacing natural pollinators with artificial ones. "The goal is certainly not to reduce the amount of natural pollinators either," he says. "Instead, we do think it is wise to keep developing technology which could help in case this would be needed."

Applied Drone Innovations' Chris Ramsay, product manager; Lucien Fesselet, CTO; and Bram Sanders, software engineer and administration; test one of the company's drone prototypes.

Photo courtesy of Lucien Fesselet

Working to help the bees

Thomas Parrish decided to develop his pollination drone because of bee declines. Parrish is a professor who teaches information technology at Edgecombe Community College in Tarboro, N.C. He is also CEO of OpenRobotix Labs, which develops mobile technologies.

In addition to his roles at OpenRobotix Labs and Edgecombe Community College, Parrish is chairman of the board of the Conetoe Family Life Center, which helps builds communities through healthy eating. One of the organization's services is to teach beekeeping and sell the resulting honey. In his time on the board, Parrish says he became educated about bee population declines in North America.

Parrish says the idea for a pollinator drone was influenced by his son. "We had a conversation around the table, and my son said, 'Well, Dad, why don't you look at building drones that can pollinate, and that way, we have something to help us out until we figure out what's happening with the bees?'" he recalls.

OpenRobotix Labs is currently developing a pollination drone called the Poli-X1. The model is equipped with a proboscis in the front that touches flowers and transfers pollen. The company developed the drone to stay level as it flies back and forth. It also designed the technology to prevent "prop wash" — air current from the drone's propellers — from blowing the pollen away.

While it sells some of its technology, OpenRobotix Labs has not yet sold any pollination drones. The company is seeking funding to further develop the technology.

Parrish says the goal is for the company's pollination drones to recognize specific flower species and only pollinate species that need to be pollinated.

The Poli-X1 is about the size of Parrish's hand, but he says he would like to develop a drone that is about a third that size. Another next step, he says, would be for the drones to self-charge via solar power. "This will be ideal technology for large-scale greenhouse companies because you could just basically have these drones sit, and at a certain time of day, they can get up and take off," he says.

North Carolina company OpenRobotix Labs' Poli-X1 is equipped with a proboscis in its front that it uses to transfer pollen.

Photo courtesy of Thomas Parrish

Since he took the pollination drone idea to the drawing board in December 2016, Parrish has implemented the technology in the fields at the Conetoe Family Life Center. He and his colleagues are working on some glitches pertaining to the drone's plant identification capabilities.

Parrish thinks pollination drone technology will eventually be used in commercial ag applications. “If we don’t get the funding to do it, then somebody else ultimately will,” he says. “I think within the next 10 to 15 years, you’re going to see this as being something that agricultural companies are going to be using.”

Monitoring plant growth and health

Some drones, such as ADI’s, monitor crops themselves along with their environment. “By looking at multiple parameters, we’re trying to detect stress in the plants,” Fesselet says. “Then, based on those types of stress, we’re also trying to correlate with the kind of damage there is.”

Meanwhile, APIS, the pollination drone from TU Delft, has an onboard greenhouse map and can differentiate between multiple crop types in a single bay, De Wagter says. The drone also has imaging that allows it to detect flowers in real time. “But which post-processing can be done on the images has not been investigated in detail,” he says. “There are many image processing experts worldwide, and we believe that from this big data, many new products can be extracted. This certainly includes growth models, yield predictions and health predictions.”

Other technologies from the MAVLab could be used in monitoring commercial crops in the future. The lab develops and prototypes technology, and industry can commercialize it, De Wagter says. “We focus on technology to safely navigate in GPS-denied and confined spaces, for instance, close to plants without damaging them,” he says. “To this purpose, we have, for instance, also developed the dragonfly-like DelFly, which gently bounces off crops when it hits them and can navigate indoors. We do, however, not develop plant models nor health analysis software, but we give the drones high-end onboard cameras in order to collect the data needed for such analysis.”

Drones are developing quickly. Whether they mimic a bee or resemble a dragonfly; pollinate, monitor plant growth and stress, or take environmental readings; navigate on their own or with the help of a pilot; drones are likely to start zipping around commercial greenhouses.