demonstration.

"The study was elegantly done with a focus on short transport time and distance, which is ideal to demonstrate potential feasibility," Subbarao says. But he also says follow-up studies would need to show that it could work over longer distances and delivery times.

So how soon can hospitals receive organs by drone delivery? Subbarao and Scalea both cite the same hurdles moving forward.

Notably, a drone operated in the United States must currently remain within a pilot's line of sight throughout the entire flight. And U.S. Federal Aviation Administration regulations state that a drone may not fly higher than 122 meters (400 feet) above structures within the area in which it is flying. These limitations will affect not only vital organs but also a swath of medical supplies for which drones are being explored as a delivery method.

"Based on the national discussion about drone technology, I think that these things are going to be addressable and that we will be able to overcome each of them," Scalea says. "Not without hard work, but I do think we can do it."

After working on this project for three years, Scalea says he is thrilled that the team was able to provide a proof of principle that drones are a viable option for organ delivery. He is now working with other research groups and hospitals across the United States to identify scenarios for which drone delivery could work.

Although the group's recent experiment did not involve the kidney being transplanted into a living person, that is the obvious next step. Scalea believes that such an experiment will happen in the very near future, perhaps early in 2019. "Stay tuned," he says. —MICHELLE HAMPSON

A version of this article appears on our Human OS blog.

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NEWS

AUTOMATED EYES WATCH PLANTS GROW

Crop scientists hope to replace traditional, painstaking monitoring methods

A decade ago, a group of crop scientists set out to grow the same plants in the same way. They started with the same breeds and adhered to strict growing protocols, but harvested a motley crop of plants that varied in leaf size, skin-cell density, and metabolic ability. Small differences in light levels and plant handling had produced outsize changes to the plants' physical traits, or phenome.

The plunging price of genomic sequencing has made it easier to examine a plant's biological instructions, but researchers' understanding of how a plant follows those instructions in a given environment still lags. "There is a major bottleneck for a lot of breeders to be able to get their phenotypic evaluation in line with their genetic capabilities," says Bas van Eerdt, business development director at PhenoKey in 's-Gravenzande, Netherlands.

Breeders would like to be able to know whether a plant—or better, a whole crop—is growing on track and how it's responding to local weather conditions, by observing the way it grows. Now, with cheaper sensors and more powerful artificial intelligence algorithms, researchers are inching closer to that goal. Their hope is to make the typical 1.3 percent annual yield improvement in crop production look more like Moore's Law.

The go-to technique for this work is still optical imaging. Some researchers are now writ-

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ing software to allow growers to use smartphone cameras to quantify some parts of a crop's phenotype. But they are also adapting an array of more sophisticated imaging technologies from aerospace and biomedical physics to the field. Breeders in North Carolina and the Netherlands are using drones and greenhouses equipped with hyperspectral, fluorescent, and tomographic sensors to quantify more of their crop's phenomes.

Hyperspectral imaging can reveal hidden damage from insects. Magnetic resonance imaging (MRI) can detect droplets of water as a seed absorbs it and follow the seed through germination and other stages of development. Positron emission tomography (or PET scans) allows researchers to peer through soil into flower bulbs and visualize the layout of a plant's root system.

The European Union spent some €250 million (about US $300 million) between 2005 and 2015 on plant phenotyping research infrastructure, and American crop giants and government agencies are spending millions on this research alongside major breeding companies such as Syngenta and Bayer.

> "It's not really about the cost; it's more about the enormous amount of time that it takes."
>
> — Rick van de Zedde

In the past, evaluating a new crop variety required breeders to visit every plant in a test plot, take detailed notes, and rank all the plants for the next round of breeding. "This is actually the limiting factor in the experiments that we run," says roboticist and business developer Rick van de Zedde of Wageningen University & Research in the Netherlands. "It's not really about the cost; it's more about the enormous amount of time that it takes."

Instead, PhenoKey annotates thousands of images of test crops, adding labels to identify characteristics such as flower bud count and leaf shape. The company uses these annotations to train its artificial intelligence software on the traits of a specific type of plant. In one case he presented a few years ago, van Eerdt says, a breeding company spent no more than 50 man-hours improving an image analysis algorithm so that it could detect orchid buds with 95 percent accuracy in a greenhouse full of plants—about a twentieth of the time it took to describe the plants manually.

Van de Zedde won €22 million earlier this year to build a new Dutch national phenotyping research facility that joins a small but growing number of facilities around the world.

The ultimate goal, van Eerdt says, is to combine automated phenotyping with automated genomics screening. "If you have a deep understanding of how your genetics work…and a model that predicts phenotypic outcomes, then in theory, it's possible to predict how your crop will look," he says.

—LUCAS LAURSEN

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WHY AIS ARE CHASING CHICKENS IN MINECRAFT

The path to a generally intelligent AI might run through this virtual universe

If artificial intelligence (AI) agents are to become real players in society, using their machine abilities to complement our human strengths, they must first become players in the video game of Minecraft. And to prove themselves in Minecraft, they must work together to capture animals in a maze, build towers of blocks, and hunt for treasure while fighting off skeletons.

That, anyway, is the premise of a competition organized by Microsoft, Queen Mary University of London, and crowdAI (a platform for data-science challenges). This month, the organizers will announce the winner—the team that creates an AI that can best observe its Minecraft environment, determine which of three missions it has to accomplish, and then collaborate with another AI agent to carry out that mission.

By emphasizing adaptability and cooperation, the organizers aim to encourage research on AI agents that could one day interact with humans to accomplish tasks in the real world. And while an AI that can truly match the intellectual capacity of a human is still the stuff of science fiction, researchers could take meaningful steps toward that goal of artificial general intelligence (AGI) in the game of Minecraft.

The Multi-Agent Reinforcement Learning in MalmO (MARLO) compe-