New AI camera could revolutionize autonomous vehicles

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The image recognition technology that underlies today's autonomous cars and aerial drones depends on artificial intelligence: the computers

essentially teach themselves to recognize objects like a dog, a pedestrian crossing the street or a stopped car. The problem is that the computers running the artificial intelligence algorithms are currently too large and slow for future applications like handheld medical devices.

Now, researchers at Stanford University have devised a new type of artificially intelligent camera system that can classify images faster and more energy efficiently, and that could one day be built small enough to be embedded in the devices themselves, something that is not possible today. The work was published in the August 17 *Nature Scientific Reports*.

"That autonomous car you just passed has a relatively huge, relatively slow, energy intensive computer in its trunk," said Gordon Wetzstein, an assistant professor of electrical engineering at Stanford, who led the research. Future applications will need something much faster and smaller to process the stream of images, he said.

Consumed by computation

Wetzstein and Julie Chang, a graduate student and first author on the paper, took a step toward that technology by marrying two types of computers into one, creating a hybrid optical-electrical computer designed specifically for image analysis.

The first layer of the prototype camera is a type of optical computer, which does not require the power-intensive mathematics of digital computing. The second layer is a traditional digital electronic computer.

The optical computer layer operates by physically preprocessing image data, filtering it in multiple ways that an electronic computer would otherwise have to do mathematically. Since the filtering happens naturally as light passes through the custom optics, this layer operates

with zero input power. This saves the hybrid system a lot of time and energy that would otherwise be consumed by computation.

"We've outsourced some of the math of artificial intelligence into the optics," Chang said.

The result is profoundly fewer calculations, fewer calls to memory and far less time to complete the process. Having leapfrogged these preprocessing steps, the remaining analysis proceeds to the digital computer layer with a considerable head start.

"Millions of calculations are circumvented and it all happens at the speed of light," Wetzstein said.

Rapid decision-making

In speed and accuracy, the prototype rivals existing electronic-only computing processors that are programmed to perform the same calculations, but with substantial computational cost savings.

While their current prototype, arranged on a lab bench, would hardly be classified as small, the researchers said their system can one day be miniaturized to fit in a handheld video camera or an aerial drone.

In both simulations and real-world experiments, the team used the system to successfully identify airplanes, automobiles, cats, dogs and more within natural image settings.

"Some future version of our system would be especially useful in rapid decision-making applications, like autonomous vehicles," Wetzstein said.

In addition to shrinking the prototype, Wetzstein, Chang and colleagues at the Stanford Computational Imaging Lab are now looking at ways to

make the optical component do even more of the preprocessing. Eventually, their smaller, faster technology could replace the trunk-size computers that now help cars, drones and other technologies learn to recognize the world around them.

More information: Julie Chang et al. Hybrid optical-electronic convolutional neural networks with optimized diffractive optics for image classification, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-30619-y , www.nature.com/articles/s41598-018-30619-y

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