Researchers build curved insect-sized artificial compound eye (w/ video)

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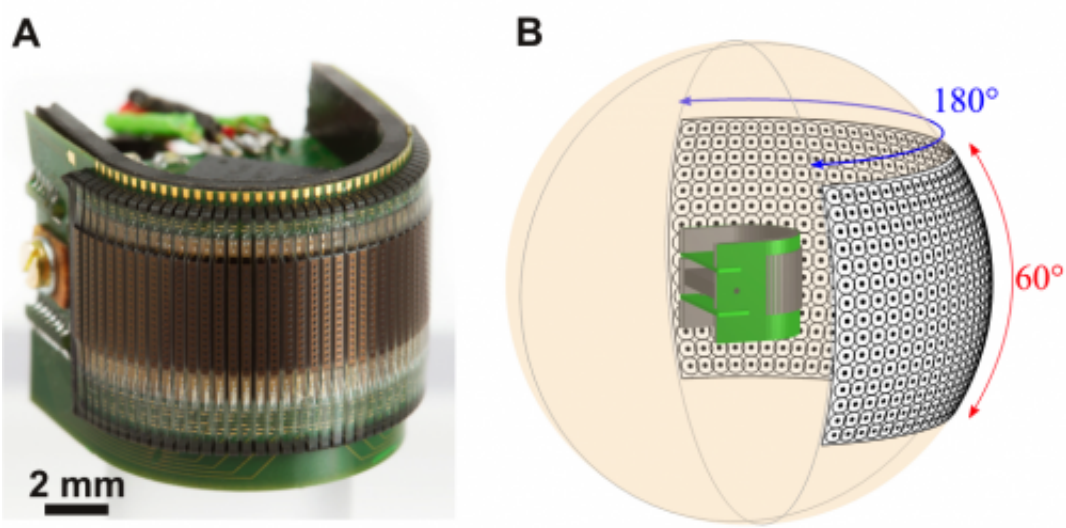

Curved Artificial Compound Eye. (A) Image of the CurvACE prototype. The entire device occupies a volume of 2.2 cm3, weighs 1.75 g, and consumes 0.9 W at maximum power. (B) Illustration of the panoramic FOV of the fabricated prototype. The dots and circles represent the angular orientation and acceptance angle of every ommatidium, respectively. Credit: Curvace

(Phys.org) —A team of European researchers working at École polytechnique fédérale de Lausanne (EPFL) in Switzerland has created an artificial compound eye that is comparable to those in insects such as the fruit fly. In their paper published in the *Proceedings of the National Academy of Sciences*, the team describes how they overcame the problem of accurately aligning photoreceptors and other optical

components on a curved surface by using stacked layers of microelectronics.

Vision in humans is achieved by two single-lens eyes and works well for fine discrimination of objects. Most other members of the animal kingdom, however, rely on compound eyes—where each eye has multiple lenses. Such eyes don't provide the degree of clarity of single-lens eyes, but they do offer a larger field of view and quick response times to movement. Scientists looking to replicate the nearly instant response times of flies and other insects as well as their ability to see most of the world around them (without having to turn their heads) have been trying to create artificial compound eyes. While there has been much progress made by many researchers in this area, there have remained two sticking points: creating the eyes of the right size and with an accurate wrapping design. In this new effort, the Swiss team appears to have made significant progress in both areas.

In insects, the eye surface is made up of a mosaic of very small optical units known collectively as the ommatidia. To create a tiny artificial compound eye, the researchers set out to duplicate the ommatidia of fruit flies and other arthropod species. Their version consists of three layers: an outer layer of lenses, a middle layer of light sensors, and an inner layer circuit board made flexible by using a stacked cut design. The result, which the team calls the CurvACE, is an artificial compound eye with a 180 degree field of view and that is small enough to sit on a nickel.

The CurvACE operates at 150 frames per second and is able to operate in either high- or low-light environments. The next step for researchers will be embedding the eye (likely as a pair) in tiny flying robots. The team notes that their new technology may have other applications as well. They suggest "smart clothes" as one example, which could change shape as a person moves to improve comfort. Another potential

application would be as security sensors or even as a means for providing texture recognition for artificial skin.

More information: Miniature curved artificial compound eyes, *PNAS*, Published online before print May 20, 2013, doi: 10.1073/pnas.1219068110

Abstract
In most animal species, vision is mediated by compound eyes, which offer lower resolution than vertebrate single-lens eyes, but significantly larger fields of view with negligible distortion and spherical aberration, as well as high temporal resolution in a tiny package. Compound eyes are ideally suited for fast panoramic motion perception. Engineering a miniature artificial compound eye is challenging because it requires accurate alignment of photoreceptive and optical components on a curved surface. Here, we describe a unique design method for biomimetic compound eyes featuring a panoramic, undistorted field of view in a very thin package. The design consists of three planar layers of separately produced arrays, namely, a microlens array, a neuromorphic photodetector array, and a flexible printed circuit board that are stacked, cut, and curved to produce a mechanically flexible imager. Following this method, we have prototyped and characterized an artificial compound eye bearing a hemispherical field of view with embedded and programmable low-power signal processing, high temporal resolution, and local adaptation to illumination. The prototyped artificial compound eye possesses several characteristics similar to the eye of the fruit fly Drosophila and other arthropod species. This design method opens up additional vistas for a broad range of applications in which wide field motion detection is at a premium, such as collision-free navigation of terrestrial and aerospace vehicles, and for the experimental testing of insect vision theories.

Project page: www.curvace.org/