Better Than The Human Eye

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Tiny camera with adjustable zoom could aid endoscopic imaging, robotics, night vision

Researchers from Northwestern University and the University of Illinois at Urbana-Champaign are the first to develop a curvilinear camera, much like the human eye, with the significant feature of a zoom capability, unlike the human eye.

The "eyeball camera" has a 3.5x optical zoom, takes sharp images, is inexpensive to make and is only the size of a nickel. (A higher zoom is possible with the technology.)

While the camera won't be appearing at Best Buy any time soon, the tunable camera -- once optimized -- should be useful in many applications, including night-vision surveillance, robotic vision, endoscopic imaging and consumer electronics.

"We were inspired by the human eye, but we wanted to go beyond the human eye," said Yonggang Huang, Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering at Northwestern's McCormick School of Engineering and Applied Science. "Our goal was to develop something simple that can zoom and capture good images, and we've achieved that."

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The tiny camera combines the best of both the human eye and an expensive single-lens reflex (SLR) camera with a zoom lens. It has the simple lens of the human eye, allowing the device to be small, and the zoom capability of the SLR camera without the bulk and weight of a complex lens. The key is that both the simple lens and photodetectors are on flexible substrates, and a hydraulic system can change the shape of the substrates appropriately, enabling a variable zoom.

The research will be published the week of Jan. 17 by the Proceedings of the National Academy of Sciences (PNAS).

Huang, co-corresponding author of the PNAS paper, led the theory and design work at Northwestern. His colleague John Rogers, the Lee J. Flory Founder Chair in Engineering and professor of materials science and engineering at the University of Illinois, led the design, experimental and fabrication work. Rogers is a co-corresponding author of the paper.

Earlier eyeball camera designs are incompatible with variable zoom because these cameras have rigid detectors. The detector must change shape as the in-focus image changes shape with magnification. Huang and Rogers and their team use an array of interconnected and flexible silicon photodetectors on a thin, elastic membrane, which can easily change shape. This flexibility opens up the field of possible uses for such a system. (The array builds on their work in stretchable electronics.)

The camera system also has an integrated lens constructed by putting a thin, elastic membrane on a water chamber, with a clear glass window underneath.

Initially both detector and lens are flat. Beneath both the membranes of the detector and the simple lens are chambers filled with water. By extracting water from the detector's chamber, the detector surface becomes a concave hemisphere. (Injecting water back returns the detector to a flat surface.) Injecting water into the chamber of the lens makes the thin membrane become a convex hemisphere.

To achieve an in-focus and magnified image, the researchers actuate the hydraulics to change the curvatures of the lens and detector in a coordinated manner. The shape of the detector must match the varying curvature of the image surface to accommodate continuously adjustable zoom, and this is easily done with this new hemispherical eye camera.

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