Controlling light with sound: new liquid camera lens as simple as water and vibration

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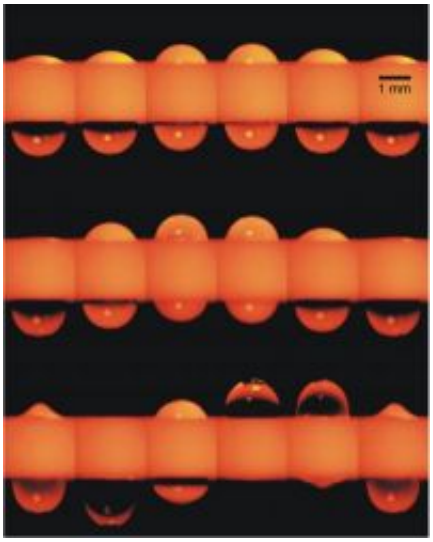

A new technique for creating liquid lenses with water and sound could enable a new generation of low cost, lightweight, energy efficient cameras. This series of time-lapse photos shows how the lens, made up of two droplets of water vibrating at a high speed, changes shape and, in turn, moves in and out of focus. The time between frames is four milliseconds. Image- Rensselaer/Carlos A. Lopez

New miniature image-capturing technology powered by water, sound, and surface tension could lead to smarter and lighter cameras in everything from cell phones and automobiles to autonomous robots and miniature spy planes.

Researchers at Rensselaer Polytechnic Institute have designed and tested an adaptive liquid lens that captures 250 pictures per second and requires considerably less energy to operate than competing technologies.

The lens is made up of a pair of water droplets, which vibrate back and forth upon exposure to a high-frequency sound, and in turn change the focus of the lens. By using imaging software to automatically capture in-focus frames and discard any out of focus frames, the researchers can create streaming images from lightweight, low-cost, high-fidelity miniature cameras.

"The lens is easy to manipulate, with very little energy, and it's almost always in focus – no matter how close or far away it is from an object," said project leader Amir H. Hirsa, professor and associate department head for graduate studies in the Department of Mechanical, Aerospace and Nuclear Engineering at Rensselaer. "There is no need for high voltages or other exotic activation mechanisms, which means this new lens may be used and integrated into any number of different applications and devices."

Results of the study were detailed in the paper "Fast focusing using a pinned-contact oscillating liquid lens," which was released online this week and will be the cover story of the October issue of the journal *Nature Photonics*. The issue also features an interview with Hirsa.

Most current methods for manipulating liquid lenses involve changing the size and shape of the area where the liquid contacts a surface, in order to bring an image into focus. This takes both time and valuable energy. Hirsa said a key feature of his new technique is that the water stays in constant, unchanging contact with the surface, thus requiring less energy to manipulate.

To do this, his new method couples two droplets of water through a

cylindrical hole. When exposed to certain frequencies of sound, the device exploits inertia and water's natural surface tension and becomes an oscillator, or something akin to a small pendulum: the water droplets resonate back and forth with great speed and a spring-like force. Researchers can control the rate of these oscillations by exposing the droplets to different sound frequencies.

By passing light through these droplets, the device is transformed into a miniature camera lens. As the water droplets move back and forth through the cylinder, the lens moves in and out of focus, depending on how close it is to the object. The images are captured electronically, and software can be used to automatically edit out any unfocused frames, leaving the user with a stream of clear, focused video.

"The great benefit of this new device is that you can create a new optical system from a liquid lens and a small speaker," Hirsa said. "No one has done this before."

The size of the droplets is the key to how fast they oscillate. Hirsa said that with small enough apertures and properly selected liquid volumes, he should be able to create a lens that oscillates as fast as 100,000 times per second – and still be able to effectively capture those images.

Hirsa says he anticipates interest in his new device from cell phone manufacturers, who are constantly seeking new ways to improve the performance of their devices and outpace their competitors in terms of lighter weight, more energy efficient phones. He also envisions small, lightweight, liquid lens cameras being integrated into a new generation of unmanned and micro air vehicles used for defense and homeland security applications.

Source: Rensselaer Polytechnic Institute