Real-time imaging for use in medicine

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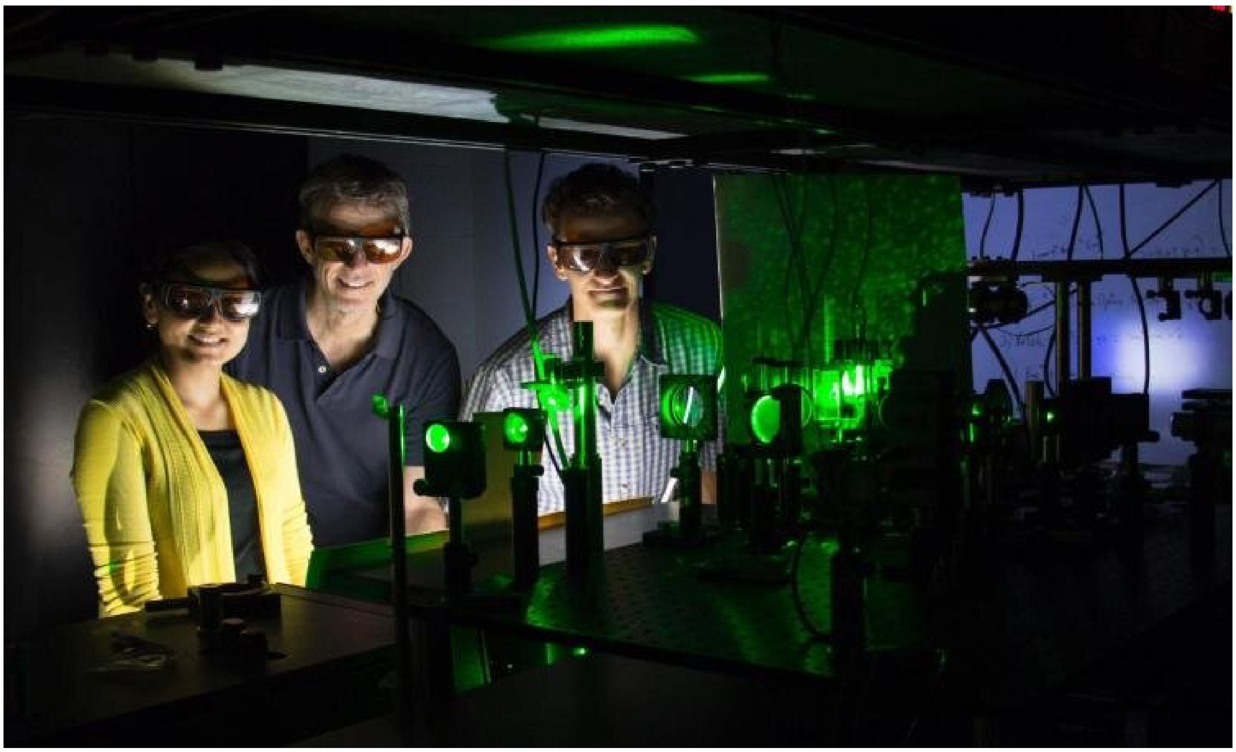

Wavefront shaping experiment at work at CU Boulder. From left to right Sakshi Singh, Rafael Piestun, and Omer Tzang. Credit: University of Colorado at Boulder

A new paper in *Nature Photonics* from researchers at CU Boulder details impressive improvements in the ability to control the propagation and interaction of light in complex media such as tissue—an area with many potential applications in the medical field.

Published Monday, the paper is titled "Wavefront shaping in complex media with a 350 kHz modulator via a 1D-to-2-D transform." The work was carried out in Professor Rafael Piestun's lab in the Electrical, Energy and Computing Engineering Department. The team included CU Boulder post-doctoral researchers Omer Tzang and Simon Labouesse, researcher Eyal Niv and CU Boulder graduate student Sakshi Singh. Greg Myatt from Silicon Light Machines, a collaborating company in this project, also worked with the group.

Controlling the process by which light waves travel into and through complex media, such as blood and skin, is a growing area of research. Unfortunately, spatial light modulation devices, which allow this by varying the properties of a beam of light in useful ways, are limited in speed. This prevents real-time applications such as imaging of live tissue or through turbulent flow, which are constantly changing by the millisecond.

To address this, Piestun's team has introduced a light wave control technique that is faster than any other available technology by more than one order of magnitude, demonstrating a record high-speed wave shaping.

Piestun said reaching this milestone required fundamental photonics and optical design, as well as hardware and software development to tailor a high speed, 1D micro-electro-mechanical device to the task at hand.

The applications of this technique are varied, including using multimode fibers as miniature endoscopes—medical optical devices used to look inside the body. By enabling imaging through multimode fibers, which are thinner and more efficient than existing endoscopes, this technique could open a window into previously inaccessible regions of the human body. Another intriguing application is in focusing light deeper into skin tissues for medical evaluation, said Piestun.

"If you try focusing a laser under the skin, you can currently only go under a millimeter deep. The idea is to go much deeper and this work could lead to that," he said.

More information: Omer Tzang et al. Wavefront shaping in complex media with a 350 kHz modulator via a 1-D-to-2-D transform, *Nature Photonics* (2019). DOI: 10.1038/s41566-019-0503-6

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