New technology focuses diffuse light inside living tissue

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Lihong Wang, PhD, continues to build on his groundbreaking technology that allows light deep inside living tissue during imaging and therapy.

In the Jan. 5 issue of *Nature Communications*, Wang, the Gene K. Beare Professor of Biomedical Engineering at Washington University in St. Louis, reveals for the first time a new technique that focuses diffuse light inside a dynamic scattering medium containing living tissue. In addition, they have improved the speed of optical focusing deep inside tissue by two orders of magnitude. This improvement in speed is an important step toward noninvasive optical imaging in deep tissue and photodynamic therapy.

In the new research, Wang and his team have built on a technique they developed in 2010 to improve the focusing speed of time-reversed ultrasonically encoded (TRUE) optical focusing for applications in living tissue. To focus light, the engineers use a virtual internal guide star at the targeted location. By detecting the wavefront of light emitted from the guide star, they can determine an optimum phase pattern that allows scattered light moving along different paths to focus at the targeted location.

When light is shined into living biological tissue, breathing and blood flow changes the optical interference, or speckle pattern, which can cause previous methods to focus diffuse light inside scattering media to fail. Scientists have to act quickly to get a clear image.

The new TRUE technology combines two techniques: focused ultrasonic modulation and optical phase conjugation. Researchers use a type of mirror to record then time-reverse the ultrasound-modulated light emitted from the ultrasonic focus to achieve the best focus. Previously, technology limited the speed of TRUE focusing to no more than 1 Hz. To overcome this obstacle, the team used a fast-responding photorefractive crystal that is sensitive to light at the 790-nanometer wavelength, making it suitable to focus light deep into biological tissue. The new TRUE technology is able to focus light inside a dynamic medium with a speckle correlation time as short as 5.6 milliseconds. The improved speed allowed Wang to achieve the first optical focusing of diffuse light inside a scattering medium containing living biological tissue.

Going forward, the team plans to implement the system in a reflection configuration, where light is shined and detected on the same side of the tissue.

More information: Liu Y, Lai P, Ma C, Xu X, Grabar A, Wang LV. Optical focusing deep inside dynamic scattering media with near-infrared time-reversed ultrasonically encoded (TRUE) light. *Nature Communications*, online Jan. 5, 2015. DOI: 10.1038/ncomms6904

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