Super vision
: Bring physics into convergence science

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Abstract

Optical imaging is a critical tool for life science and bio medicine because of its ability to visualize the structure of cells with molecular contrasts and probe subcellular features at high spatial resolution. However, light-based diagnostic and therapeutic systems in medicine largely remain auxiliary compared to other modalities (such as CT, MRI, etc.), mainly because light cannot reach deep into tissues. Light waves get scattered multiple times when they propagate through biological tissues. This multiple light scattering perturbs focusing of waves and poses a strong limitation to the imaging depth of high-resolution optical imaging. Multiple light scattering also attenuates the amount of light energy delivered to a target region in tissue, which sets a fundamental limitation on the efficiency of *in vivo* biosensing and light-activated therapies.

The interaction of a scattering medium with a light wave is highly complicated, and thus makes it extremely difficult to interrogate target objects within the medium. It can be, however, deterministically analyzed by 3D phase microscopy by exploiting the input-output relation, so called the transmission matrix. From the transmission matrix the eigenchannel, which is a special wave pattern resulting in constructive interference in light transmission, can be extracted. By implementing the transmission eigenchannel with a wavefront shaping technique, the maximal light penetration through a scattering medium is achieved. Furthermore, this method is applied to reflection measurements for more feasible practical applications. The light penetration is controlled without the prior recording of transmission matrix while keeping up the sample perturbation by an iterative feedback control. The cutting-edge wavefront shaping technique allows the ultra-deep, and selective focusing of light into biological tissues, thereby enables tremendous biomedical applications. As a prospective application, 3D biomechanical imaging by Brillouin microscopy is demonstrated, which is highly promising for non-contact, label-free, and 3D interrogation of the intracellular and extracellular mechanical properties. Finally, future visions of biomedical optics bringing broad impacts to medicine, life science, and natural science, are discussed.