IMPROVING LIGHT DELIVERY FOR OPTOGENETICS USING WAVEFRONT SHAPING

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New developments in neuroscience are enabling us to understand the brain at unprecedented temporal and spatial resolution. One of these exciting new techniques is optogenetics, which allows select neuronal populations of the brain to be targeted to express light sensitive ion channels. These enable optical control of the electrophysiological state of the cell, enabling neurons to be activated or deactivated using light. However, due to the strongly scattering nature of biological tissue in the brain, tightly focusing light to a specific voxel is not possible with conventional optical techniques. In this poster we will present the results of our recent work to develop new optical wavefront shaping tools which enable us to focus light inside strongly scattering media and discuss the outlook for such tools for improving light delivery for techniques such as optogenetics.

The focus of our work is to use an optical wavefront shaping technology termed Time-Reversed Ultrasound- Encoded (TRUE) focusing [1,2]. This strategy uses ultrasound to form an ultrasonic focus at depths beyond the optical diffusion limit. This ultrasound focus modulates photons passing through it via the acousto-optic effect, shifting their frequency by the ultrasound frequency. Then, by detecting these ultrasound-tagged photons, we can measure the optical wavefront corresponding to the tagged photons and selectively time-reverse this optical field using a technique called Digital Optical Phase Conjugation (DOPC) [3]. This wavefront is then used to send photons back into the scattering tissue in such a way that they travel in a time-reversed fashion, constructively interfering at the location of the ultrasound focus. This allows us to focus light in highly scattering media beyond the optical diffusion limit at ultrasonic resolution (~30 micrometers at 50 MHz).

In this poster we will present results from recent work using the TRUE focusing technique to perform optogenetic stimulation. We demonstrate in 300 and 500 micrometer thick living brain slices that the TRUE focusing technique can be used to improve the spatial resolution of optogenetic stimulation compared to conventional optical methods. Furthermore, we will discuss the outlook and challenges facing the development of wavefront shaping techniques such as TRUE focusing for applications in neuroscience and other areas of biotechnology.

References:

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