VOLUMETRIC ALL-OPTICAL PHYSIOLOGY FOR FUNCTIONAL CONNECTOME STUDY IN DROSOPHILA VISUAL PATHWAY

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ABSTRACT

The emergent properties of brain are governed by the complex neuron network. To investigate the functional connectivity among brain neurons, stimulation and recording of many individual neurons are necessary. Compared to traditional electrophysiology method, all-optical physiology [1], which use light to stimulate and record neuron responses, provides advantages of non-invasiveness and high spatial resolution. Recently, several all-optical physiology platforms have been published; however, most of them are limited in two-dimensional interrogation. Since neuron responses in the brain are intrinsically 3D, a platform with volumetric all-optical physiology capability is highly desirable.

In this work, a 3D all-optical physiology platform is constructed based on the combination of single-photon stimulation and two-photon full volumetric recording, where the latter is achieved by integrating a high-speed tunable acoustic gradient-index (TAG) lens [2, 3]. We apply the platform to the *in-vivo* study of *Drosophila* anterior visual pathway, i.e. MED → AOTU → BU [4]. With precise stimulation on upstream neurons in AOTU and continuous fast volumetric recording on their downstream counterparts in BU, functional connectome between AOTU and BU are unraveled. Note that BU is formed by more than sixty densely packed microglomeruli, which are 2-μm-diameter spheres. Our volumetric platform is capable to not only resolve all of them, but also reveal detailed spatiotemporal coding between the subunit of AOTU and BU microglomeruli in a single trial. In addition, the precise stimulation helps to decompose the upstream AOTU into more specific sub-groups that are difficult to identify with structural anatomy. This platform paves the road toward studying 3D functional connectome non-invasively in neuron-dense brain areas.

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