Ultrasonic-Tagged Remote Interferometric Spectroscopy (URIS): Advancing Optical Imaging for Deep Tissue Analysis

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Despite significant advancements in optical techniques for biological research, deep tissue studies remain limited by light scattering. Existing methods often struggle to achieve the necessary balance between spatial resolution and depth penetration. To address this challenge we introduce Ultrasonic-Tagged Remote Interferometric Spectroscopy (URIS), a novel approach that overcomes these limitations. URIS utilizes acousto-optical imaging and off-axis holography, merging the strengths of ultrasound's high spatial resolution with the rich contrast information accumulated from optical methods. By selectively detecting light interacting within a chosen region deep within scattering tissue, URIS quantifies local absorption (function), scattering (structure), and dynamics (decorrelation) of biological processes. This facilitates the exploration of fundamental biology and has the potential to enhance disease diagnosis and monitoring. In this preliminary study we demonstrate a URIS measurement of the flow speed inside a tube situated in the middle of a highly scattering medium with significantly improved sensitivity and selectivity, offering a substantial advantage over other optical methods for flow measurement. URIS not only bridges critical gaps in deep-tissue optical interrogation but also offers a powerful tool to understand biological processes and disease pathology at clinically relevant depths. Looking forward, the integration of fiber optics into URIS holds promise for further enhanced sensitivity, miniaturization, and broader clinical usage.