EXPERIMENTAL STUDY OF PHOTON PATH LENGTH IN BRAIN TISSUE USING TIME-OF-FLIGHT MEASUREMENTS

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Accurate knowledge of photon propagation in brain tissue is needed for the development of optical diagnostic techniques and for validating computational models such as Monte Carlo simulations. While photon path length in white matter is often estimated through modeling, experimental validation in the visible to near-infrared spectral range remains limited.

In this study, we present experimental results using the time-of-flight (TOF) measurement method to characterize photon path length in ex vivo cow brain tissue. Picosecond laser pulses at six wavelengths (600 nm, 640 nm, 660 nm, 720 nm, 760 nm, and 800 nm) were directed into the tissue through an optical fiber. Measurements were taken in both back-scattered (lateral) and transmission geometries. Lateral measurements were performed at distances of 4 mm, 8 mm, and 12 mm from the input fiber, while transmission measurements were conducted through tissue samples of 3 mm and 5 mm thickness, and at three distances (0 mm (in front of light sours), 4, and 8 mm).

The results of photon path length demonstrated (i) a non-monotonic dependence on wavelength, with decrease near 760 nm, likely attributable to lipid absorption; (ii) nonlinear growth was observed when the detection fiber was shifted from the ballistic path in transmission geometry, influenced by the anisotropic properties of the tissue; and (iii) substantially longer mean path lengths in white matter compared to gray matter under equivalent measurement conditions.

These findings provide valuable experimental data of light propagation in brain tissue and may aid in refining theoretical models and improving the design of optical neuroimaging systems.

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