High-throughput spatio-temporal optical coherence tomography (HT-STOC-T)

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1. Introduction

Optical coherence tomography (OCT) has become a cornerstone of ophthalmic diagnostics, yet traditional systems are limited by scanning speed and motion artifacts. Spatio-Temporal OCT (STOC-T) enables high-speed retinal imaging but suffers from reduced sensitivity. We present a high-throughput (HT) optical design that improves STOC-T sensitivity by up to 3.5× (5.4 dB).

2. Methods and results

Conventional 50/50 beam-splitters lose $\sim 75\%$ of light, and simply increasing source power is often impractical. Unlike earlier approaches relying on dark-field effects [1], our method improves throughput directly. HT STOC-T replaces the 50/50 beam-splitter with a 90/10 design and adds a pick-off mirror for illumination and detection (Fig. 1.a) [2]. This relies on the wide-angle homogeneous scattering of biological tissue. Crosstalk is reduced by introducing illumination via a deformable membrane and multimode fiber [3]. Sensitivity measurements confirmed the benefit: 81.2 dB with a 50/50 design versus 86 dB with HT, a 2.8× (4.5 dB) gain for single volumes and 3.5× (5.4 dB) with 30-volume averaging (Fig. 1.b). Synthetic phantom experiments quantified the improvement in scattering media (Fig. 1.c). *In vivo* imaging with line camera validated these results: HT axial B-scans revealed retinal plexiform layers invisible in standard STOC-T (Fig. 1.d-e).
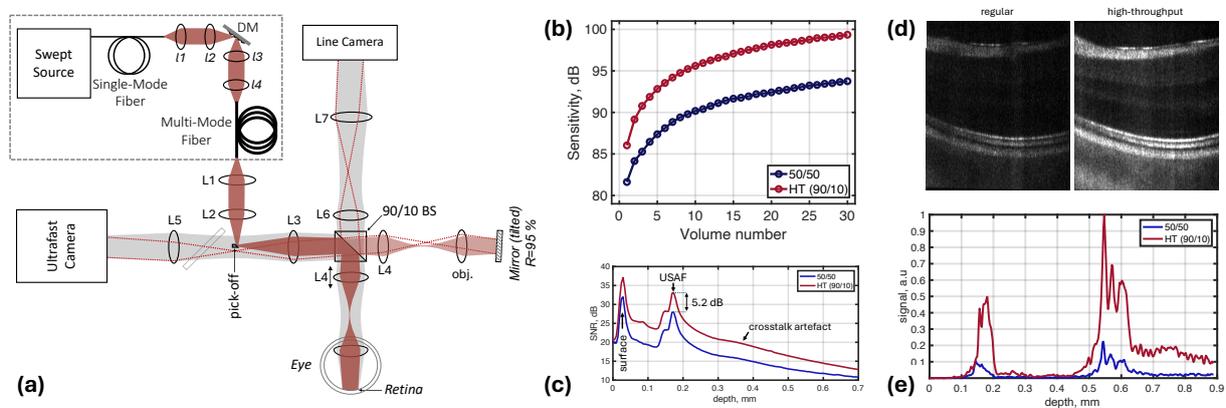

Fig. 1. a) Shows principle system structure. (b) Sensitivity as a function of averaged volumes. (c) Axial line profiles demonstrating 5,2 dB SNR gain in HT design. (d) Axial *in vivo* retinal images acquired with line camera in regular and HT modes. (e) Line profiles along the centre of images in (d).

3. References

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