LIGHTWEIGHT HIGH-DENSITY DIFFUSE OPTICAL TOMOGRAPHY USING sCMOS DETECTION

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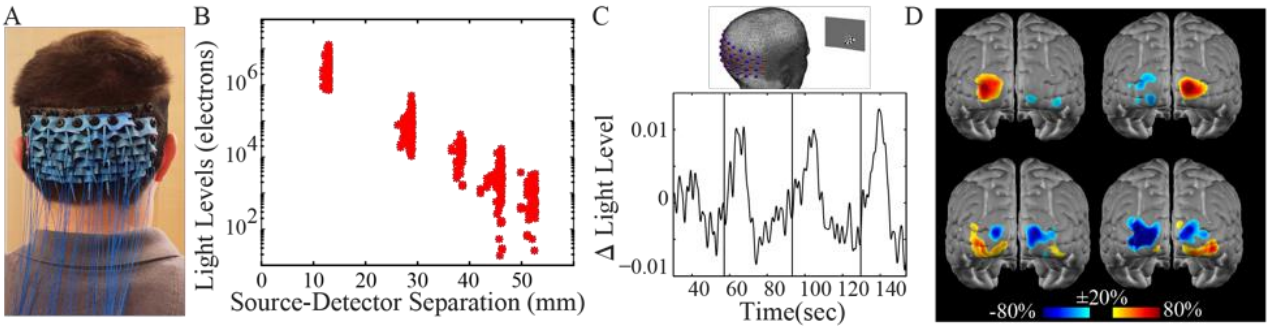
The widespread adoption of optical neuroimaging has been restricted by the tradeoff between cap wearability and brain coverage [1]. Increased coverage requires more fibers and larger imaging consoles, however these changes drastically reduce the wearability of the imaging cap and the portability of the entire system. The size of the detection fibers, which is driven by signal-to-noise considerations, is the primary obstacle to fabricating more wearable and portable optical neuroimaging arrays. Here we report on a design that leverages the low-noise of scientific CMOS cameras, along with binning and noise reduction algorithms to use fibers with approximately 30x smaller cross-sectional area than current high-density diffuse optical tomography (HD-DOT) systems [2].

We have developed a Super-Pixel sCMOS Diffuse Optical Tomography (SP-DOT) system (Fig. 1a) that uses 200um diameter source and detector fibers, with a lightweight low-profile, wearable design. A super-pixel algorithm leverages pixel binning to provide dynamic range (DNR), Noise Equivalent Power (NEP), and cross- talk (CT) specifications comparable to previous HD-DOT [2]. We have demonstrated retinotopic mapping with a SP-DOT system (Fig. 1). The system has a high DNR (>10^5), high frame rate (>6Hz) and low NEP (< 9fW/√Hz).

The sCMOS-based SP-DOT system design provides an interesting approach to improving the weight/coverage trade off and has promising signal-to-noise. While the prototype presented here is limited to the visual cortex, the weight reduction to the cap should enable full-head and effectively wearable imaging caps. This technology may open up neuroimaging to further study brain development in children, answer clinical questions right at the bedside, and extend optical imaging to study higher-order, distributed brain function.

[1] White BR, Liao SM, et al. Neuroimage, 2012. 59(3).
[2] Eggebrecht AT, Ferradal SL, et al. Nat Photonics 2014.
[3] Eggebrecht AT, White BR, et al. Neuroimage 2012; 6.



An immediate drop right after papaverine injection was also recorded, which was likely due to the acute pain caused by the drug injection. In conclusion, according to our study, the FD-NIRS instrument with a side-firing fiber optic sensor can noninvasively and continuously quantify tumor oxygenation during anti-hypoxia treatment, and thus provide an effective feedback on the effectiveness of the drug and the optimal temporal window for delivery of irradiation.