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Monte Carlo simulation of spatial resolution and penetration depth of two dimensional optical imaging methods

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Abstract:

Two dimensional optical imaging, such as intrinsic optical imaging (IOI) and voltage sensitive dye imaging (VSDI) are widely used to map brain function. Due to the light scattering and absorption in biological tissues, there is incomplete knowledge of the penetration depth and spatial resolution of the signals [1-2]. Monte Carlo method has been successfully employed to simulate light propagation in highly scattering tissues. Here, we use Monte Carlo simulations to carry out a systematic study of the spatial resolution and penetration depth of IOI and VSDI [3-4].

We modeled the tissue as a uniform medium with a refractive index of 1.4, scattering and absorption coefficients of 35/mm and 0.27/mm, and anisotropic factor of 0.9. To simulate the absorption in IOI, we assume that there is a thin column of absorbers evenly distributed from the brain surface to 1 mm deep into the cortex. For the fluorescence in VSDI, we either assume a uniform distribution of fluorophores from 0 - 1mm deep in the cortex or use a staining profile measured experimentally in [5]. The excitation light is collimated and uniformly illuminates the tissue. The backscattered light (for IOI) or fluorescence (for VSDI) is collected and imaged onto a CCD camera by two lenses arranged in a 4f configuration. The system configuration can be varied by changing the numerical aperture (NA) and/or depth of focus of the lens closer to the tissue, as would be done in a real experiment.

We find that 1) The spatial resolution worsens with the increase of NA and depth of focus. 2) The percent contribution from different depths does not change with NA and depth of focus when a large area (> 200 μm by 200 μm) is activated. In addition, the amplitudes of the contributions are similar between IOI and VSDI with a uniform distribution of fluorophores. However, VSDI

with little staining on the surface [5] has smaller contributions from layer I. 3) The percent contribution from different depths varies with NA and depth of focus when the activated areas are small (< 100 μm x 100 μm). 4) When the effect of surface vessels is considered, their contribution is reduced significantly with the increase of NA and depth of focus, thus increasing the percent contribution from the cortex itself. Therefore, it is advised to use larger NA and depth of focus to suppress the effect of surface vessels. However, when an area is devoid of large vessels, using larger NA and depth of focus does not achieve deeper penetration.

1. Polimeni et al, PNAS 102, 4158 (2005)
2. Orbach and Cohen, J. Neurosci. 3, 2251 (1983)
3. Boas at al, Optics Express 10, 159 (2002)
4. Dunn and Boas, Optics Lett. 25, 1777 (2000)
5. Ferezou et al, Neuron 50, 617 (2006)

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