Frugal Biomedical Innovations Research Internships

Summer Projects 2024

Project Title: Modeling the minimum spectral resolution required for in vivo tissue monitoring with hyperspectral near infrared spectroscopy

Supervisors:

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Location of Study:

Kresge Building, room 101

Project Description:

Insufficient blood flow to the brain is a major cause of cerebral injury and can lead to lifelong disabilities and mortality. This is because the brain requires a constant supply of oxygen, via blood flow, to generate the energy it needs to function properly. Near-infrared spectroscopy (NIRS) is a safe, portable, and non-invasive technique that has been successful in detecting cerebral injury by measuring brain tissue oxygenation (i.e., oxygen saturation). This is done by sending light of different wavelengths into the head and measuring their absorption in the brain. Since these wavelengths are absorbed differently, depending on the concentrations of oxyhemoglobin (HbO2) and deoxyhemoglobin (Hb) in the blood of the tissue, the amount of light absorption can be used to determine cerebral tissue oxygenation. The concentrations of HbO2 and Hb can be measured at relatively low cost using hyperspectral NIRS (hNIRS). In hNIRS, near-infrared light with dozens of wavelengths is sent into the tissue and the concentrations of HbO2 and Hb are obtained by differential analysis of the absorption spectra. To measure all the wavelengths simultaneously, a spectrometer is typically used, and light is collected through a narrow slit placed at the entrance of the device. For accurate measurements, efficient light collection is critical because near-infrared light is highly attenuated by tissue. Light collection can be increased by widening the entrance-slit, but this reduces the spectral resolution (i.e., the ability of the spectrometer to distinguish between the different wavelengths), resulting in lower accuracy. There is clearly a trade-off between light collection and accuracy.

We have previously acquired hNIRS data in tissue mimicking phantoms at 13 spectral resolutions. Subsequent analysis suggested that a resolution of 17nm could be used to significantly increase light collection while still providing accurate measures of HbO2 and Hb. However, the study was purely empirical. Therefore, the objectives of this project are: **1)** to use the phantom data to generate HbO2 and Hb extinction coefficients at the each of the 13 spectral resolutions, **2)** use the latter to simulate light propagation in phantoms with different concentrations of HbO2 and Hb, and **3)** analyze the simulated data to determine if the experimental results obtained in our previous study are valid for a wide range of HbO2 and Hb concentrations. If there is agreement between the simulations and the experimental findings, then we can conclusively state that a narrow slit width is not required for in vivo hNIRS. Therefore, low cost, miniature, off-the-shelf spectrometers could be fitted with wide slits to reliably monitor cerebral blood content and oxygenation, which would be extremely useful in remote and low-resource settings.

Skills and Experience Necessary:

The project requires a good understanding of light propagation in tissue and proficiency in Matlab. While this is primarily an in-person research project, there is flexibility for part of the work to be completed remotely.