Wireless, Handheld Diffuse Reflectance Spectroscopy to Quantify Tissue Microvascular Hemodynamics

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Diffuse Reflectance Spectroscopy (DRS) is a non-invasive optical method to characterize tissue optical properties for disease diagnosis and health monitoring. Two optical fibers are often used in a DRS system: one to deliver light to the tissue and the other to gather diffuse reflectance spectra, which provide quantitative details about the structure and composition of the tissue. The conventional DRS system, however, is expensive, bulky, and composed of fragile optical fibers and multiple electrical connections. Here we propose to build a wireless, handheld, and fiber-less diffuse optical spectroscopy system. Unfortunately, the diffusion approximation utilized for data analysis of the conventional DRS is no longer valid due to the non-contact configuration of the fiber-less DRS system. To analyze the collected diffuse reflectance spectra using the handheld spectrometer, we have built a reflectance lookup table (LUT) using Monte Carlo simulation. Also, we have conducted some tests using a blood liquid phantom that is made of water, intralipid, and bovine blood, simulating human tissues to evaluate our DRS system with our LUT to extract the phantom's oxygen saturation (SO2). The results show that portable spectrometer estimated SO2 values agree with the traditional DRS system. These results demonstrate that our handheld equipment can accurately estimate tissue oxygenation and hemoglobin levels, thus providing a mean of rapid quantitative tools assessing microvascular hemodynamics.