Time Resolved Whole-Head Diffuse Optical Tomography: How Fast Can We Go?

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The primary application of time-resolved optical tomographic imaging has been the production of three-dimensional, depth-resolved images of absolute values of optical absorption, optical scattering and therefore blood volume and saturation in the newborn infant brain[1,2] and the adult breast[3]. As time-resolved diffuse optical tomography (TR-DOT) requires the measurement of the flight time of photons across a volume of tissue, only a single source position can be illuminated at any one time. Furthermore, each illumination must last several seconds in order for enough photons to reach the detectors, which can be as much as 10 cm from the source when imaging the newborn infant brain. For these reasons, TR-DOT image acquisition is typically very slow. One full image sequence can take between 5 and 30 minutes[4].

By combining improvements in software design and source sequence optimization within UCL's second generation optical tomography system, MONSTIR II[5], we are able to demonstrate TR-DOT image acquisition times of less than 30 seconds for a volume comparable in size to the newborn infant head. Figure 1 shows a source illumination sequence where 12 source positions are illuminated within 30 seconds. Figure 2 shows the proposed fibre arrangement. By applying dynamic spatio-temporal filtering, TR-DOT images can be updated after each source illumination, i.e. every 2 seconds or faster. At this sample rate it will be possible to obtain 3D, depth-resolved images of transient events in the neonatal brain, including desaturation events and seizures. Furthermore, it will be possible to study low-frequency functionally induced changes in haemoglobin concentrations, such as those which form the basis of resting-state functional connectivity[6]. Development of these techniques may one day make it possible to image functional activations in deep regions of the brain using diffuse optical approaches, instead of being limited to the superficial cortex.

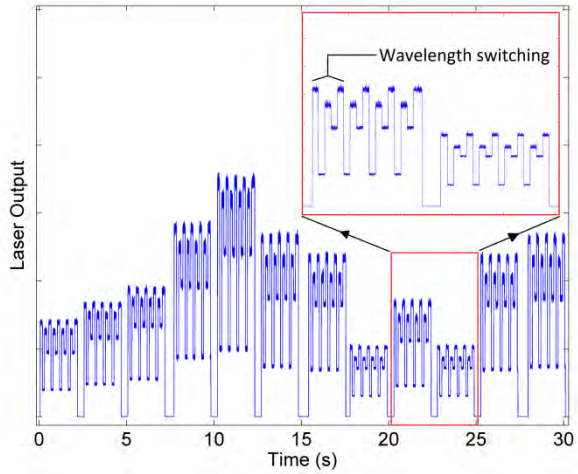

Figure 1. The intensity of output light for a given source sequence. Note the wavelength switching within each 2 second illumination period.

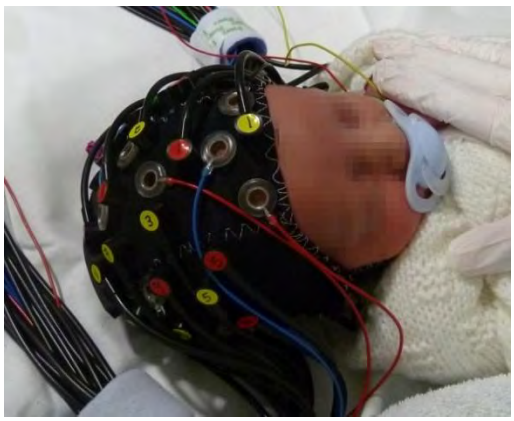

Figure 2. An infant in a soft DOT imaging cap. Prism-coupled fibres will be used to perform fast TR-DOT using this arrangement.

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