SUMMARY OF Ph.D. DISSERTATION

School	SURNAME, First name
Integrated Design Engineering	KAWAGUCHI, Hiroshi

Title

Image reconstruction for near-infrared topography based on light propagation analysis in the head

Abstract

Near-infrared (NIR) topography obtains images of the activated region in the brain cortex from the intensity change of light detected by the multiple fibre probes attached to the scalp. The serious problems with NIR topography are the limitation of the spatial resolution and the reproducibility of images. These problems are mainly caused by the scattering of tissues. However, the conventional imaging method ignores the influence of the scattering on NIR topography because the light propagation in the brain cannot be directly measured by experiments. In this study, the light propagation of the head models is simulated to predict the spatial sensitivity profile, which is the volume of tissue sampled by a probe pairs of NIR topography. The new image reconstruction algorithm using the predicted spatial sensitivity profile is proposed to improve the spatial resolution and the reproducibility of NIR topography.

Chapter 1 briefly reviews the background and previous studies of NIR topography.

Chapter 2 describes the principle of near-infrared spectroscopy, the inverse problem and the theory of the light propagation in biological tissues.

Chapter 3 describes the proposed imaging algorithm and the effects of the probe arrangements and the imaging algorithms on the spatial resolution and the reproducibility of the topographic image of brain activation. The multi-layered slab model, which is simplified the anatomical structure of the head, is used for the evaluation. The results reveal that the size of the activated region obtained by the conventional NIR topography is obviously greater than the actual size of the activation and depends on the position of the probe arrangement. Both the spatial resolution and the reproducibility of the topographic image of the brain activation are sufficiently improved by the proposed image reconstruction algorithm using the spatial sensitivity profile.

Chapter 4 describes the construction of the virtual head phantom. The detailed anatomical structure of the head and the optical properties are integrated in the virtual space to simulate the light propagation in the head and to predict the spatial sensitivity profile in the brain. The virtual head phantom is validated by the time-of-flight measurement of the adult forehead.

Chapter 5 describes the adequate head model to predict the spatial sensitivity profile for the image reconstruction algorithm. The image reconstruction using the spatial sensitivity profile obtained from the standard brain model, which is generated from the anatomical structure of the heads of several subjects, appropriately improves the spatial resolution and the reproducibility of the topographic image of brain activation in the virtual head phantom.

Chapter 6 summarises the results of this study and gives some suggestions for a future work.