

Development of new fNIRS-EEG system for seamless whole brain study

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1. Introduction

Functional near-infrared spectroscopy (fNIRS) is a versatile functional neuroimaging technology with non-invasive method of monitoring of brain activity. Recently, there is one of the hot topics to explore the wide area network in the brain such as functional connectivity or spontaneous brain activity functions. fNIRS has high potentials for such research topics according to the high temporal/spatial resolution compare to fMRI or EEG. On the other hand, some researches has been pointed out the importance of improvement of reliability of fNIRS signals such as to reduce the effects of skin blood flow[1] or improve the spatial resolution[2]. In order to achieve the research requirement we developed a new fNIRS-EEG system which allows seamless whole-brain measurement of the surface of the human brain, high spatial resolution measurement, multi-distance measurement, and high temporal resolution measurement. We evaluated the performances of the new system by a phantom and a healthy subject.



Figure 1 : New fNIRS system

2. System Description

2-1. Overall System Parameters:

Figure1 shows the new fNIRS system named "LABNIRS" which developed with CW system using laser diodes as light sources and photomultiplier tubes (PMT) as detectors. LABNIRS has maximum 40 sources and 40 detectors which covers a whole brain (the maximum logical channels is 142). The data analysis relies on the Modified Beer-Lambert Law (MBLL) assuming spatially homogeneous absorption changes in extra cerebral tissues. To improve accuracy, we use three-wavelength (780, 805 and 830nm) and bundled optical fibers for source. We controlled the irradiation with 1ms interval for each wavelength, and the maximum sampling rate is 166 Hz.

2-2. Optode Holder:

We implemented double density fNIRS (and EEG) holder from flexible adjustable surface holder (FLASH)[3] (Figure2). The double density[2] needs twice arrangement of the conventional method, the other arrangement is shifted at half of the optode distance from the origin. In grillage construction, electrode holders were put in the midpoint of slides of FLASH to row direction and fNIRS optodes were put in the midpoint of slides of FLASH to column direction. The holder can be also use for multi-distance measurement according to the PMT and flexible fiber settings.

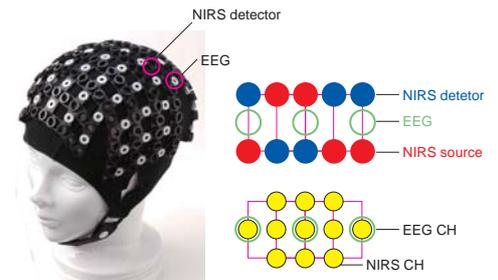


Figure 2 : Optode Holder

3. Experiment and Results

Experiment1: Finger tapping task

- Probe settings: 133 channels of fNIRS covering the whole head.
 - Subject: 1 male, 33y
 - Task: Subject performed right and left finger tappings (20s rest - 20s task - 20s rest x 5 trials).
 - Results: Figure3 shows the topographical image of the average of the oxy-Hb change at 20s after starting of the right finger tapping task.
- The results indicated the task-related activity in oxy-Hb.

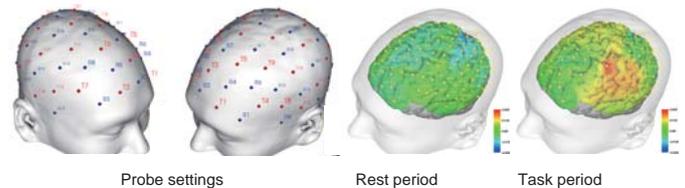


Figure 3 : Probe settings and the results of experiment 1

Experiment2: Visual task

- Probe settings: 56 channels of fNIRS covering the occipital(34ch, double density) and frontal lobe(22ch).
 - Subject: 4 male and 1 female, av29y
 - Task: Subject observed a video (30s rest - 60s task - 30s rest x3 trials).
 - Results: Figure4 shows the topographical image of the t-value of the oxy-Hb change during visual task.
- Using the double density method, spatial resolution of image was improved than conventional method to focus the activation area.

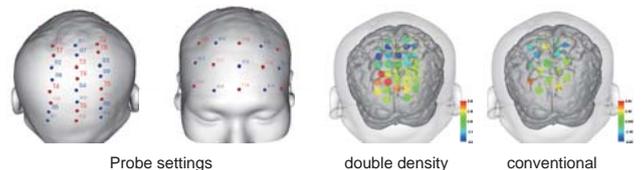


Figure 4 : Probe settings and the results of experiment 2

4. Conclusion

In this study, we developed a new fNIRS-EEG system as a non-invasive brain functional measurement system whole surface of human brain. The new fNIRS allows high performance measurement with high spatial / temporal resolution using seamless measurement techniques, double density techniques, multi-distance measurement techniques and high sampling rate system. The functional data which has high spatial resolution and wide field of view would contribute to improve the accuracy of the brain signals, and high temporal resolution could supports functional connectivity or spontaneous brain activity function research.

5. References

- [1] Takahashi et al. (2011) Influence of skin blood flow on near-infrared spectroscopy signals measured on the forehead during a verbal fluency task. *NeuroImage*, 57, 991–1002
- [2] Kawaguchi et al. (2007) Effect of probe arrangement on reproducibility of images by near-infrared topography evaluated by a virtual head phantom. *Appl. Opt.* 46, 1658-1668
- [3] Kohno et al. (2006) Functional near-infrared imaging of whole head with FLASH. *OHBM*