Brain Neural Functional Analysis for the Evaluation of an EMG Controlled Prosthetic Hand

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In this study we use functional magnetic resonance imaging (fMRI) and functional near-infrared spectroscopy to measure the changes in the brain when using the individually adaptive myoelectrically (EMG) controlled prosthetic hand developed at our laboratory. Our purpose is to develop a prosthetic hand that provides a feeling close to a natural hand. In order to do so, we look for the differences in the brain activation between healthy and amputated people, to unfold the mechanisms that link the activated area in the brain with their corresponding function.

Brain function analysis using fMRI: fMRI is a non-invasive method that measures the haemodynamic response related to neural activity in the brain due to changes in blood flow in a particular area. In order to measure the effects of the prosthetic hand use, we used the experimental setup (fig. 1.) with the electrostatic shielding of the cables and the use of a projector to transmit the prosthetic hand states inside the fMRI room. Figure 2 shows brain activation resulting from a cylinder grasping task with the following conditions:

1. **With closed eyes/ right forearm stump for emg control signals without stimulation**
2. **Open eyes/ right forearm stump for emg control signals with stimulation in the upper left arm**

The results shows that for condition one there is activation in the motor cortex (M1) there is no activation on the somatosensory area (S1). Whether, for the second condition, there is activation on both motor (M1) and somatosensory area (S1).This activation is present even if the stimulation is made on the right arm, making us think of a illusion of “ownership” developed while using the robot hand to grab an object while receiving tactile feedback (electrical stimulation).

Brain function analysis using fNIRS: fNIRS is a non-invasive method that measure changes in the concentration of oxy- and deoxy-haemoglobin (Hb) as well as the changes in the redox state of cytochrome-c-oxidase (Cyt-Ox). Though the spatial resolutions are inferior to fMRI, the time resolution is much higher. Our purpose is to develop a dynamical evaluation with normal like operation feeling Brain Machine Interface (BMI) using these two methods.

References

1) Hiroshi Yokoi, Alejandro Hernandez Arieta, Ryu Kato, Takashi Ohnishi, Wenwei Yu and Tamio Arai: Mutual Adaptation Among Man and Machine by Using f-MRI Analysis, Intelligent Autonomous Systems 9, IOS Press, ISBN 1-58603-595-9, pp.954-962 (2005)

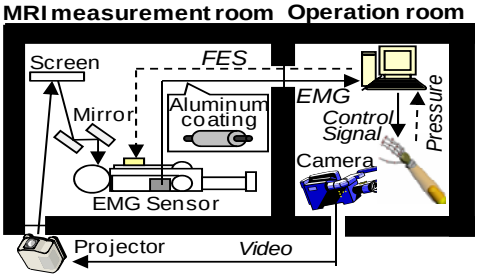
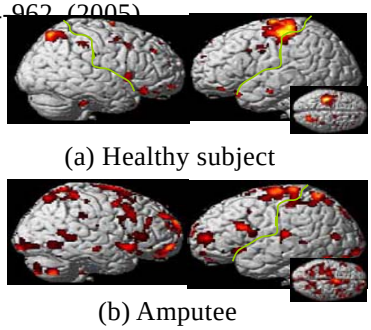


Fig.1fMRI measurement system for using EMG prosthtic hand.



(a) Healthy subject

(b) Amputee

Fig.2 fMRI image in condition II.

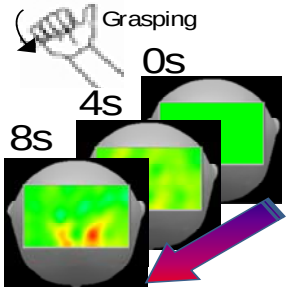


Fig.3 fNIRS image of the graspsping-motion.