Analysis of the Hand-arm Motion Using a Surface Electromyography with High-density Electrodes

By measuring the surface muscle potential caused by human muscle activity using electrodes with high-density compared to a conventional surface electromyogram, spatially rich information about muscle activity can be obtained. On the other hand, movement of the hand is caused by the complicated cooperation of muscles, the surface muscle potential generated by these activities is very cumbersome and difficult to handle. Therefore, in this research, by analyzing information obtained from surface electromyography with high-density electrodes, we are conducting several studies to capture the phenomena occurring in the muscles during hand movement.

One of them is to estimate where the surface muscle potential originates from the forearm using a surface electromyography with high-density electrodes. In this study, we extended a method for determining signal sources of brain waves to identify the muscle activities of forearms and verified this by experiments. First, muscle potential on the forearm during the isometric motor task of fingers and wrists were using a high-density surface electromyogram (Fig. 1). For the identification of the signal sources, firstly the measured muscle potential is separated into independent signals by the independent component analysis, and a physics-based forward model of the forearm, which is the relation between the signal sources and the sensor points, is constructed from the MRI image for each subject. The relationship between the independent signals and the signal sources is obtained by analyzing this relationship. The estimated signal sources were evaluated on the proximity to the position of the muscle that caused the corresponding motor task, and the effectiveness of the proposed method was confirmed.

We are also working on the research to estimate the phenomena occurring in hand, especially the forces generated in the fingers, directly from the surface muscle potential measured with high-density surface electromyography. First, we measured the muscle potential with high-density surface electromyography and measured the force generated at the fingertip. We constructed an artificial neural network expressing the relationship between the potential and the force by the machine learning and then evaluated the accuracy of the model based on the determination coefficient between the estimated and the measured value. We clarified the possibility of estimation of force in each anatomical direction of each finger from the information of the high-density surface electromyography.

Keywords: Surface electromyography, Forearm, Muscle activity, Signal analysis

Reference

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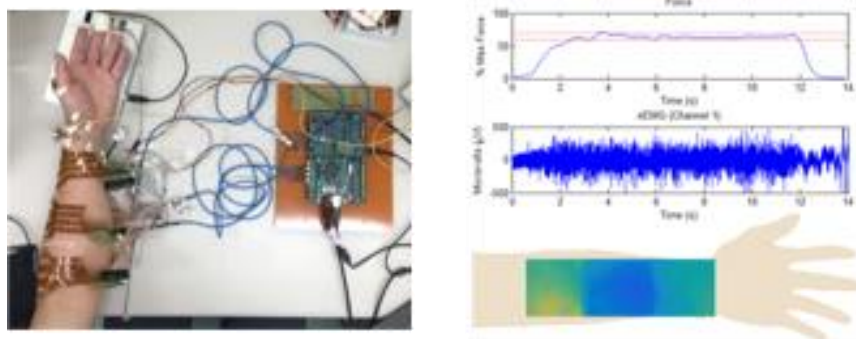
Fig 1. Experimental setup (left), an example of the measured force (upper right), an example of measured muscle potential (center right), and an example of colormap of measured muscle potential.