論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Investigation on brain activity related to human intention of performing a reaching movement
著者(和文)	KIMHyeonseok
Author(English)	Hyeonseok Kim
出典(和文)	学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第11540号, 授与年月日:2020年3月26日, 学位の種別:課程博士, 審査員:小池 康晴,金子 寛彦,中村 健太郎,八木 透,吉村 奈津江
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第11540号, Conferred date:2020/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	情報通信 ライフエンジニアリング	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（学術） (Philosophy)
学生氏名： Student's Name	Kim, Hyeonseok		指導教員（主）： Academic Supervisor(main)	小池　康晴	
			指導教員（副）： Academic Supervisor(sub)		

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Many people have been paralyzed by many causes. The quality of their life may not be as high as a healthy person. One of the reasons is that they cannot perform a voluntary movement. In order to assist people with motor impairment, some devices such as crutches and wheelchairs have been developed and used. However, those traditional devices have a limited ability to help them. In addition, for severe patients, such low-level devices may not be helpful and high-level technology is required to help them. Up to quite recently, brain-machine interfaces (BMI) have been developed, which can cover many kinds of motor disabilities to assist people with motor disabilities. BMI system communicates with devices such as a prosthetic arm and a wheelchair to control them. It also helps people with motor disabilities to interact with the external world by providing more advanced functions to enable complex motions for example, compared to conventional assistant devices.

From a functional point of view, many kinds of motor disability can be coarsely categorized into upper-limb impairment and lower-limb impairment. Lower-limb impairment leads to walking impairment and this restricts patient's mobility. Fortunately, there are devices that can compensate it as means of transportation, and we can see them easily in our daily life. However, assistant devices for upper-limb impairment have not come into use as widely as devices for lower-limb impairment even though a prosthetic arm or exoskeletons has been developed. Upper-limb is essential for reaching and grasping that are common, natural, and fundamental tasks in daily life.

Reaching is a fundamental and essential task in daily life. Understanding how reaching movements are represented in the brain and decoding these movements are important issues in BMI research. Several studies have attempted to decode reaching movements. Compared to the number of studies on brain activity during movement execution, only a few have attempted to classify the information before movement execution. Current many BMI systems have used brain activity during motor execution or motor imagery in which sensory input and motor command are included. The purpose of the study is to investigate brain activity during movement planning for reaching, which represents a period between target recognition and movement onset. We investigated brain activity during a planning phase for reaching movement using electroencephalography (EEG) signals. Although few previous studies have shown premovement EEG signals may be used for decoding, previous studies used only part of premovement EEG signals to show the feasibility of them.

First, we investigated whether EEG signals occurring before movement execution could be used to classify movement intention. Six subjects performed reaching tasks that required them to move a cursor to one of four targets distributed horizontally and vertically from the center. Using independent components of EEG acquired during a premovement phase, two-class classifications were performed for left vs. right trials and top vs. bottom trials using a support vector machine. Instructions were presented visually (test) and aurally (condition). In the test condition, accuracy for a single window was about 75%, and it increased to 85% in classification using two windows. In the control condition, accuracy for a single window was about 73%, and it increased to 80% in classification using two windows. Classification results showed that a combination of two windows from different time intervals during the premovement phase improved classification performance in the both conditions compared to a single window classification.

Since we confirmed the availability of premovement phase through the first experiment, we tried to find what information regarding the intended target during movement preparation is advantageous for decoding. In the second experiment, we investigated which movement parameters (i.e., direction, distance, and positions for reaching) can be decoded in premovement EEG decoding. Eight participants performed 30 types of reaching movements that consisted of 1 of 24 movement directions, 7 movement distances, 5 horizontal target positions, and 5 vertical target positions. Event-related spectral perturbations were extracted using independent components, some of which were selected via an analysis of variance for further binary classification analysis using a support vector machine. When each parameter was used for class labeling,

all possible binary classifications were performed. Classification accuracies for direction and distance were significantly higher than chance level, although no significant differences were observed for position. For the classification in which each movement was considered as a different class, the parameters comprising two vectors representing each movement were analyzed. In this case, classification accuracies were high when differences in distance were high, the sum of distances was high, angular differences were large, and differences in the target positions were high. Thus, all parameters for this study may have information related to the movement, but the direction and the distance are more useful for predicting intended reaching movement than the position showing significant higher accuracy for some individuals.