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Brain-Computer Interface for Virtual Reality control

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Abstract

A brain-computer interface (BCI) is a new communication channel between the human brain and a computer. Applications of BCI systems comprise the restoration of movements, communication and environmental control. Within this study experiments were made, which used the BCI system to control or to navigate in Virtual Environments (VE) just by thoughts. BCI experiments for navigation in VR were conducted so far with (i) synchronous BCI and (ii) asynchronous BCI systems. The synchronous BCI analyzes the EEG patterns in a predefined time window and has 2-3 degrees of freedom. This means if the subject imagines e.g. foot movement it can move forward, if it imagines right hand movement it can turn right and with left hand movement it can turn left. The asynchronous BCI analyzes the EEG signal continuously and if a specific event is detected then the control signal is generated. If the subject images e.g. foot movement it is moving forward as long as the foot imagination is detected. Both systems are currently limited to 1-3 degrees of freedom and therefore a fast control mechanism can not be realized.

Here we show that BCI systems can also be realized for Virtual Reality (VR) control with a high degree of freedom and high information transfer rate. Therefore we implemented a so called P300 based BCI system. Such a P300 system analyzes the P300 EEG response that can be detected if an unlikely event occurs. The systems shows between 20 and 45 commands on a computer screen and the commands are highlighted in a random order. Whenever the target command is flashing up, the P300 response can be detected and a control command is initiated. In order to control a VR implementation of a house, commands for TV control, playing music, making telephone calls, navigation in the house, controlling windows and doors,… were implemented. In total 3 subjects participated in the experiments on one day. First from each subject the EEG data were acquired in order to train the system. In the next step the subjects had the task to control the VE. Therefore the experiment was divided into 3 parts with 15, 11 and 16 decisions respectively. One task was e.g. to go to the living room, to switch on the TV and to select a specific channel,… Each subject needed about 10 minutes to finish each part. The accuracy was between 83 % and 100 %.

The first experiments showed that the new P300 based BCI system allows a very reliable control of the VR system. Of special importance is the possibility to select very rapidly the specific command out of many different choices. This eliminates the usage of decision trees as previously done with BCI systems. More generally the work showed that BCI systems can also be used for goal oriented systems. This means instead of controlling a robot with move up, move up, turn left, turn left,… commands the BCI system allows to send a command like grasp the glass of water and put it onto the table. This is a more natural and faster way of controlling something.

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