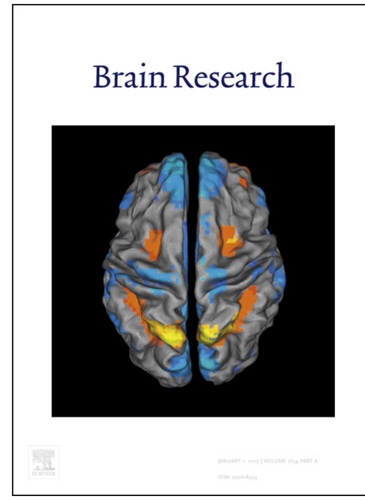

Research report

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An Approach for Brain-Controlled Prostheses Based on Scene Graph Steady-State Visual Evoked Potentials

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Abstract

Brain control technology can restore communication between the brain and a prosthesis, and choosing a Brain-Computer Interface (BCI) paradigm to evoke electroencephalogram (EEG) signals is an essential step for developing this technology. In this paper, the Scene Graph paradigm used for controlling prostheses was proposed; this paradigm is based on Steady-State Visual Evoked Potentials (SSVEPs) regarding the Scene Graph of a subject's intention. A mathematic model was built to predict SSVEPs evoked by the proposed paradigm and a sinusoidal stimulation method was used to present the Scene Graph stimulus to elicit SSVEPs from subjects. Then, a 2-degree of freedom (2-DOF) brain-controlled prosthesis system was constructed to validate the performance of the Scene Graph-SSVEP (SG-SSVEP)-based BCI. The classification of SG-SSVEPs was detected via the Canonical Correlation Analysis (CCA) approach.

To assess the efficiency of proposed BCI system, the performances of traditional SSVEP-BCI system were compared. Experimental results from six subjects suggested that the proposed system effectively enhanced the SSVEP responses, decreased the degradation of SSVEP strength and reduced the visual fatigue in comparison with the traditional SSVEP-BCI system. The average signal to noise ratio (SNR) of SG-SSVEP was 6.31±2.64 dB, versus 3.38±0.78 dB of traditional-SSVEP. In addition, the proposed system achieved good performances in prosthesis control. The average accuracy was 94.58%±7.05%, and the corresponding high information transfer rate (IRT) was 19.55±3.07 bit/min. The experimental results revealed that the SG-SSVEP based BCI system achieves the good performance and improved the stability relative to the conventional approach.

Key words: Brain-Controlled Prostheses; Brain-Computer Interface (BCI); Modeling; Scene Graph Steady-State Visual Evoked Potentials (SG-SSVEP)

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1. Introduction

The main consequence of paralysis, traumatic spinal cord injuries or neurological diseases is the loss of the motor function of the hands (Ziegler-Graham et al., 2008). Developing prostheses provides a means of restoring the function of motion, which can improve the quality of life and increase the independence of disabled individuals.

The most commonly used prosthetics are body-powered prosthetics, which include the operation of only one joint by a cable attached to a shoulder harness via a mechanical approach (Lee et al., 2014). Due to the limitations of controlling the joint and the unnatural actions, body-powered prosthetics have not been studied for a long time.

Another prosthesis type commonly used for individuals with amputations is the electromyogram (EMG)-controlled prosthesis. GL Li et al. applied EMG signals to induce prosthesis movements with real-time