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Toward brain-actuated car applications: Self-paced control with a motor imagery-based brain-computer interface

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Abstract

This study presented a paradigm for controlling a car using an asynchronous electroencephalogram (EEG)-based brain-computer interface (BCI) and presented the experimental results of a simulation performed in an experimental environment outside the laboratory. This paradigm uses two distinct MI tasks, imaginary left- and right-hand movements, to generate a multi-task car control strategy consisting of starting the engine, moving forward, turning left, turning right, moving backward, and stopping the engine. Five healthy subjects participated in the online car control experiment, and all successfully controlled the car by following a previously outlined route. Subject S1 exhibited the most satisfactory BCI-based performance, which was comparable to the manual control-based performance. We hypothesize that the proposed self-paced car control paradigm based on EEG signals could potentially be used in car control applications, and we provide a complementary or alternative way for individuals with locked-in disorders to achieve more mobility in the future, as well as providing a supplementary car-driving strategy to assist healthy people in driving a car.

Keywords: Brain-computer interface, Electroencephalogram (EEG), Motor imagery, Asynchronous control protocol, Brain-actuated car

Introduction

Brain-computer interface (BCI) techniques have developed rapidly over the past two decades. A BCI is a communication system in which an individual can send commands to the external world by generating specific patterns of brain signals without depending on the brain's output channels, i.e., the peripheral nerves and muscles [1]. The primary purpose of BCIs is to facilitate communication for people with severe disabilities and neurological conditions [2]. However, because BCIs can provide direct access to brain states, they can also improve interactions between machines and healthy people [3-5]. Various studies have explored potential applications of BCIs in many fields, including communication [6-8], neuro-prosthetics [9, 10], virtual reality [11], robots [1, 12, 13], robotic arms [14], and mobility control [9, 10, 15, 16]. These previous studies have demonstrated the