

Chapter 7

Brain–Computer Interface for Cyberpsychology

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ABSTRACT

As a new way of implementing human-computer interface, brain-computer interfaces (BCI) dramatically changed the user experiences and have broad applications in cyber behavior research. This chapter aims to provide an overall picture of the BCI science and its role in cyberpsychology. The chapter starts with an introduction of the concept, components, and the history and development of BCI. It is then followed by an overview of neuroimaging technologies and signals commonly used in BCI. Then, different applications of BCI on both the clinical population and the general population are summarized in connection with cyberpsychology. Specifically, applications include communication, rehabilitation, entertainments, learning, marketing, and authentication. The chapter concludes with the future directions of BCI.

INTRODUCTION

A 73-year-old woman was in the locked-in state caused by amyotrophic lateral sclerosis (ALS) and was taken care by her family and full-time caregivers. She could only communicate with the outside world by moving eyes to send signals to an eye tracker until the presence of Brain Painting (Kübler, Halder, Furdea, & Hösle, 2008; Münßinger et al., 2010), a P300 brain-computer interfaces (BCI)-controlled application, which was facilitated and installed at the patient's home. Painting had been her favorite hobby and the device enabled her to paint again by reading her

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brain signals extracted by electroencephalogram (EEG). The device allowed her to select a variety of tools, shapes, colors to paint on the virtual canvas. The patient stated: “I am using Brain Painting 1 to 3 times per week, but if I could, I would use it every day.” In many similar examples, the device was found to significantly improve quality of life of patients (Botrel, Holz, & Kübler, 2015; Holz, Botrel, Kaufmann, & Kübler, 2015; Holz, Botrel, & Kübler, 2015).

What Is BCI?

The story described above was one of the thousands of the real stories, showing us the state-of-art use of BCI. This technology was applied to devices such as wheelchairs, cursors and so on to link human beings’ brains with outside world directly and to change the way we live. Notably, it brings opportunities for paralyzed people to live a more convenient life while for healthy people more joyous.

So, what is BCI? In the review by Wolpaw, Birbaumer, McFarland, Pfurtscheller, and Vaughan (2002), the authors defined BCI as “a communication system in which messages or commands that an individual sends to the external world do not pass through the brain’s normal output pathways of peripheral nerves and muscles.” A more recent definition (Guger, Allison, & Müller-Putz, 2015) of BCI was “a device that reads voluntary changes in brain activity, then translates these signals into a message or command in real-time”. BCI, which is also called a mind-machine interface (MMI), or sometimes direct neural interface, brain-machine interface (BMI), is a direct communication pathway between the brain and an external device.

What Are Major Components of BCI?

A BCI system starts with human brains and ends with an external device. It typically contains 4 parts between the two ends in the order of signal acquisition, digitized signals, signal processing components (e.g. feature extraction, translation algorithm), and device command. The inputs of BCI systems refer to brain activities or signals recorded from human brains, such as the electrophysiological activity from the user. Major physiological methods of recording brain activities and different kinds of signals recorded are listed in the part 2b. The output can be commands sent to control diverse devices such as a mouse or a robotic arm. Examples of external devices chosen to be used in a BCI system are listed in part 3.

History and Development of BCI

The history of BCI is not very long, spanning a century till now (Wolpaw et al., 2002). The history started with the discovery of the electrical activity of the human brain

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