Chapter 19
Brain–Machine Interfaces:
Advanced Issues and Approaches

Kijpokin Kasemsap
Suan Sunandha Rajabhat University, Thailand

ABSTRACT

This chapter indicates the overview of Brain-Machine Interfaces (BMIs); the aspects of BMIs; BMIs, human-machine interfaces, and electrooculography interfaces; BMIs, Amyotrophic Lateral Sclerosis (ALS), and stroke motor recovery; speech BMIs; BMIs and neuroplasticity; and BMIs and transcranial doppler (TCD). BMIs are the computerized approaches to gaining the brain signals, investigating them, and translating them into computerized functions in order to organize the required practices. BMIs can allow people to manipulate computerized networks and various electrical devices. With the support of modern technologies, BMIs are functional and able to operate in operational settings. The chapter argues that applying BMIs has the potential to increase organizational performance and reach strategic goals in the digital age.

INTRODUCTION

The improvement of the resolution of brain signal and the ability to control external device has been the most important goal in the brain-machine interfaces (BMIs) research field (Li, Hong, Zhang, & Guo, 2014). BMIs are the advanced systems that allow individuals to interact with a computer by means of their brain signals. BMIs open new horizons for the treatment of paralyzed people, giving hope for the artificial restoration of lost physiological functions (Tankus, Fried, & Shoham, 2014). BMIs read brain signals and directly transmit them to a computer, bypassing the neuromuscular system through which individuals interact with the world. BMIs consist of a computer, an amplifier, and a skullcap, and include any form of a direct interface between brain and artificial device regarding computations (Oweiss & Badreldin, 2015). BMIs offer an alternative method of communication for individuals who are cognitively aware but unable to speak or gesture as a consequence of severe physical impairments (Lu, Mamun, & Chau, 2015).

DOI: 10.4018/978-1-5225-3004-6.ch019

BMI technology makes direct communication between the brain and a machine possible by means of electrodes (Jebari, 2013). Electrodes serve as the first critical interface to the biological organ system (Patil & Thakor, 2016). BMIs are the modern machines that can decode the physiological signals from the brain and convert them into actions in an effective manner that reflects the brain's intention (Moran, 2010). BMIs can be divided into three classes: sensory interfaces, which artificially activate the human sensory system; cognitive interfaces, which try to reestablish the communication of the neural networks; and motor interfaces, which translate the brain activity into the control commands for a device of interest (Sanchez & Principe, 2007).

BMI may take the pattern of a brain-computer interface (BCI), a direct neural interface, a brain-machine application, or a deep brain stimulating electrode (Demetriades, Demetriades, Watts, & Ashkan, 2010). Alonso-Valerdi et al. (2015) stated that motor BMI is a state-of-the-art technology that is known as BCI. BMI can translate a specific brain activity into computer command, thus establishing a direct connection between human brain and external device (Zhang, Zhou, Jin, Wang, & Cichocki, 2015). BMIs utilize the neuroelectric and metabolic brain activities to activate the peripheral devices and computers without the mediation of the motor system (Birbaumer & Chaudhary, 2015). Research using BMI technology significantly proposes the development of interfaces based on the interaction of neural networks with artificial tools to restore the motor control and full mobility of the injured area (Gongora et al., 2013).

This chapter focuses on the literature review through a thorough literature consolidation of BMIs. The extensive literature of BMIs provides a contribution to practitioners and researchers by describing the perspectives of BMIs in order to maximize the medical and technological impacts of BMIs in the robotic age.

BACKGROUND

Biomedical engineering technologies (e.g., BMIs and neuroprosthetics) are the advancements which assist human beings in various ways (Lee, 2016). Current state and availability of BMI systems urge a broader societal discourse on the pressing ethical challenges associated with the advancements in neurotechnology and BMI research (Birbaumer, Gallegos-Ayala, Wildgruber, Silvoni, & Soekadar, 2014). BMI system detects the electrical signals produced from the human brain and converts them into the control signals to operate a device by reading the user's thoughts (Choi & Kang, 2014). The electrical activities of the brain and heart have been recorded and analyzed for the diverse clinical and pathological purposes (Kim et al., 2014).

BMIs can be classified by the type of mental activity generating the BMI signals (Coffey, Brouwer, Wilschut, & van Erp, 2010). Zander et al. (2008) suggested the distinction among active BMIs, passive BMIs, and reactive BMIs. Active BMIs are those used for the direct control of devices which are based on signals intentionally generated by the user, for example a wheelchair steered by signals that correspond with motor imagery tasks performed by the user (Zander et al., 2008). Motor imagery is recognized as a dynamic state during which a subject mentally repeats a specific movement (sequence), without any overt motor output (Jeannerod, 1995). Motor imagery shares many of the same neural mechanisms with actual movement execution, with an emphasis on the prefrontal cortex, which is responsible for the creation and maintenance of an explicit representation used in thought and action (Decety, 1996).

Regarding active BMIs, the success in the motor imagery-based BMI can be attributed to the underlying neurophysiological phenomena accompanying motor imagery, termed event-related desynchro-

Related Content