UNIVERSITI TEKNOLOGI MARA

CLASSIFICATION OF BRAIN ACTIVITY USING MUSCLE ACTIVATION MARKER FOR BCI CONTROLLED HAND PROSTHESIS

KHAIRUNNISA BINTI JOHAR

Thesis submitted in fulfilment
of the requirement for the degree of
Master of Science

Faculty of Mechanical Engineering

November 2017

ABSTRACT

The use of body-powered prostheses can be tiring and lead to problems with compliance and prosthetic restoration. Apparently, brain-Computer-Interfaces (BCI) offer a means of controlling prostheses for patients that are unable to operate such devices due to physical limitations. An issue with BCIs is that they tend to either require invasive recording methods, posing a surgical risk or work by generating control signals from not task related brain activity patterns such as right versus left hand, hand versus leg or visual stimulation and therefore are not intuitive in their control. This study aims at testing the possibility of controlling the grasp and release of an upper limb prosthetic terminal device by classifying Electroencephalogram (EEG) data from isometric finger extension and flexion real movements. Data from five healthy subjects were recorded using a consumer grade non-invasive Emotiv EPOC headset. During the measurement of five subjects, they were asked to perform isometric finger extension and flexion of their right hand. To bring the EEG data into correlation with the executed movement, simultaneous electromyogram (EMG) recording was proposed as an alternative method for recording visual cued movement. Classified EMG data was used to generate markers in the EEG data and to the epoch data. The EEG data was then filtered to increase the signal to noise ratio and allow better classification while spectrally weighted common spatial patterns (spec-CSP) were used for feature extraction. Using linear discriminant analysis (LDA), a successful classification rate of up to 73.2% between isometric finger extension and flexion, 79.9% between isometric finger flexion and rest and 81.8% between isometric finger extension and rest were obtained. In this study, a novel EMG-assisted approach was developed for classifying EEG data from isometric finger extension and flexion movements. It has displayed feasibility for a more intuitive control on upper limb prosthetic terminal device using low-cost BCI without the risks associated with invasive measurement.

ACKNOWLEDGEMENT

First of all, I would like to thank to God the Almighty upon the completion of my thesis. Without His blessed, it is impossible for me to complete my research and wrote this thesis. Special thanks to my research supervisor, Dr Ayuni Che Zakaria and my research co-supervisor, Associate Professor Dr-Ing Low Cheng Yee for their ideas, guidance, advice and assistance in helping me to perform this research. Thank you to my co-supervisor, Associate Professor Dr Fazah Akhtar Hanapiah for her idea, opinion and consultation on the medical aspect throughout this research.

Moreover, I would like to dedicate my special thanks to my beloved husband Muhd Faiz Azim Mahmood, beloved daughter Khayra Kamiliya, parents, parents in law and my family members for their support in term of idea, financial and encouragement in completing my research. Thank you for your encouragement and understanding me.

Thank you to my fellow research team Gerrit Lange, Nurul Atiqah Othman, Mohamad Amlie Abdul Kasim, Farhana Idris, Nur'Amirah Busu, Haszerul Salleh and everyone that has contributed their idea, help and support directly or indirectly to me in performing this project. Without their help and assist, it would be difficult for me to complete my work and research. Thank you so much.

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Human brain is a wonderful gift comprising complicated and limitless information as it is a centre of the human body that controls all physical and mental behaviour while continuously improving according to ages. Each specific part of the brain controls a particular task of the human body. Therefore, people with severe physical disabilities such as amyotrophic lateral sclerosis, spinal cord injury, stroke and cerebral palsy can no longer do a particular physical task. To help those people to improve their daily life and communication with other people, there is a need for building a direct communication between human brain and computer, which is known as Brain-Computer-Interface (BCI).

BCI is refers to a range of techniques and technologies directly interfaced with the nervous system. It is the technology where human can control a machine or device through brain instructions. BCI systems record any signal activities from the brain and interpret them to allow control commands generation for external devices [1]. BCI is also used in prosthetics in which they can restore or replace the function of damaged or lost limbs. Due to direct connection to the brain, they can allow patients to control prosthesis even in those with damaged nervous systems, those that lost the muscles used for the desired movement or even those suffering from locked in syndrome [2].

A complex mechanical BCI system would allow users to control an external system, possibly a prosthetic device, by creating an output of specific Electroencephalography (EEG) frequency. EEG is the most studied potential non-invasive interface mainly due to its fine temporal resolution, ease of use, portability and low set-up cost. In addition, EEG has been historically dominated by BCI researchers as providing non-invasive, painless, ease of use, portable and with no implantation approaches [3]. The input was obtained from EEG mental tasks that include the movement of a limb, respiratory, speech and heart.