AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

MECHATRONICS ENGINEERING

Hand Prosthetic Controlled System Based on Signal Pattern Recognition of Electroencephalography

A Thesis submitted in partial fulfillment of the requirements of the

M.Sc. in Mechanical Engineering

By

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B.Sc., Mechanical Engineering, Mechatronics Engineering Department
Helwan University, 2010

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Cairo – (2017)

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Date: 8//10/2017

Statement

This thesis is submitted as a partial fulfillment of M.Sc. degree in Mechanical engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis and no part of it has been submitted for a degree or qualification at any other scientific entity.

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Abstract

Electroencephalography (EEG) motor imagery (MI)-based Brain Computer Interface (BCI) systems have been recently employed to enhance the quality of life of disabled people. However, to naturally trigger particular applications (i.e. upper limb prostheses), independent BCIs appeal further paradigms to involve realistic motor imagery tasks. On the other hand, most of the EEG recording systems are clinical so that they cannot be integrated with such real time BCI mobility. In terms of machine learning, this work is intended to investigate into a realistic and intuitive motor imagery-based BCI for right hand using Consumer-graded EEG acquisition devices. The present study proposes an approach to classify imagined hand gesture tasks, including the water glass gesture and the index pointer gesture of the right hand using OPENBCI as a consumer-grade EEG acquisition device. For three subjects, the data recorded by OPENBCI were sampled with a sampling rate of 250 Hz. The Minimum Redundancy Maximum Relevance (MRMR) technique was implemented as a feature selection method along with the Support Vector Machine (SVM) algorithm for classification. By obtaining a maximum classification accuracy of 91.7%, the results shown the feasibility of such Brain Computer Interface systems to detect different motor imagery tasks for the right hand. Consequently, upper limb prostheses could be manipulated using the intended motor imagery tasks.

Key words: Brain Computer Interface (BCI), Feature Selection, OPENBCI, MRMR, ERD.

Acknowledgment

Foremost, I would like to express my sincere gratitude to my supervisors Prof. Dr. Farid Tolbah, Prof. Dr. Ann A. Kadir and Dr. Mohamed I. Awad for their continuous support of my master degree and for guiding and motivating me to produce this research work.

I would like to especially thank Dr. Mohamed Awad for suggesting the topic of the thesis to me and sharing with me all his profound knowledge of it. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my M.Sc. study.

I would like to thank in advance Eng. Mohamed Mostafa for his financial aid to purchase the experimental equipment. I will never forget all the deeds you have done for me.

I would like to thank Eng. Ahmed Abdelshakour, Eng. Ahmed El-Rakaybe, Eng. Mostafa Arafa and Eng. Mohamed Zarzoura for helping me in the admission affairs and for the motivating discussions.

I would like to thank Dr. Hussein Fouad for encouraging and supporting me.

I would not have reached this point without the infinite support of my family. I would like to thank my mother, father and my two little sisters for being there for me and for their continuous encouragement to finish my work in the best way possible.

At last but not least, I give my dearest gratitude to my wife, who gave me all the patience and passion to fulfill this work and supported me spiritually throughout my life.

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AR	**A**uto **R**egressive
BP	**B**and **P**ower
DBN	**D**ynamic **B**ayesian **N**etwork
LDA	**L**inear **D**iscriminant **A**nalysis
MD	**M**ahalanobis **D**istance
MI	Motor Imagery
MRMR	**M**inimum **R**edundancy **M**aximum **R**elevance
PCA	**P**rinciple **C**omponent **A**nalysis
PSD	**P**ower **S**pectral **D**ensity
SVM	**S**upport **V**ector **M**achines
TFR	**T**ime-**F**requency **R**epresentation

Chapter 1: Introduction

1.1. Motivation

It was estimated that there are nearly 10 million amputees all over the world. Among the world population of amputees, there are 3 million population who have upper limb amputation [1]. Thanks to the recently astonishing advances of the interaction between human and computers, multidisciplinary paradigms have been revealed to improve the quality of upper limb amputee's life. Among those paradigms, Brain Computer Interfaces are novel technologies that are devoted to assist the people with severe disabilities. Nowadays, BCIs are widely utilized in different paradigms such as rehabilitation, mental spellers, motor restoration, clinical diagnoses and mental gaming.

Among the last two decades, investigations have been diversely conducted exploiting the non-invasiveness property of Electroencephalography (EEG) signals. These studies have shown promising outcomes for helping people with different cases of disability. However, BCIs experience outstanding issues as the complexity of the disability increases.

Upper limb amputations are considered one of the most severe disabilities, due to the intervention of the arm in most of the daily life activities. Moreover, upper limbs perform in such flexible and dexterous pathways. Therefore, relative BCIs appeal further paradigms to, approximately, retrieve the functions of the amputated upper limb. In other words, diverse investigations of BCIs should be developed to trigger prosthetics by adopting the following aspects:

- BCIs should be based on recognizing realistic, voluntary and intuitive motor imagery tasks.
- Real-time BCIs should be accomplished by means of real-time computational performance.
- BCIs are not generalized yet, as the EEG waveforms are known of the non-stationarity and the low spatial resolution.