AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Computer and Systems Engineering

A Brain-Computer Interface Speller for Smart Devices

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

Computer and Systems Engineering

by

Mahmoud Ali Reda Mohammed Ahmed Helal

Bachelor of Science in Electrical Engineering
(Computer and Systems Engineering)
Faculty of Engineering, Ain shams University, 2010

Supervised By

Dr. Mohamed Taher
Associate Professor
Computer and Systems Engineering Department
Faculty of Engineering, Ain Shams University

Dr. Seif Eldawlatly
Assistant Professor
Computer and Systems Engineering Department
Faculty of Engineering, Ain Shams University

Cairo - (2017)

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Computer and Systems Engineering

A Brain-Computer Interface Speller for Smart Devices

by

Mahmoud Ali Reda Mohammed Ahmed Helal

Bachelor of Science in Electrical Engineering
(Computer and Systems Engineering)
Faculty of Engineering, Ain Shams University, 2010

Examiners' Committee

Name and Affiliation	**Signature**
Prof. Manal Abdel Wahed Abdel Fattah Biomedical Engineering and Systems Department Faculty of Engineering, Cairo University	…….
Prof. Mohamed Hassan Elshafie Computer and Systems Engineering Department Faculty of Engineering, Ain Shams University	…….
Dr. Mohamed Mahmoud Ahmed Taher Computer and Systems Engineering Department Faculty of Engineering, Ain Shams University	…….

Date:26 September 2017

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical 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 a qualification at any other scientific entity.

Mahmoud Ali Helal

Signature

……...…….

Date:26 September 2017

Researcher Data

Name	: Mahmoud Ali Reda Helal
Date of birth	: 11/11/1988
Place of birth	: Cairo
Last academic degree	: Bachelor
Field of specialization	: Computer and Systems Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: 2010
Current job	: Senior Software Developer

Thesis Summary

Brain–computer interfaces (BCIs) have attracted much attention recently, triggered by new scientific progress in understanding brain function and by its impressive applications. BCIs have the potential to enable severely disabled individuals to communicate with other people and to control their environment.

Motor imagery is currently one of the main applications of Brain-Computer Interface (BCI) which aims at providing the disabled with means to execute motor commands. One of the major stages of motor imagery systems is reducing the dimensions of the input data and enhancing the features prior to applying a classification stage to recognize the intended movement. We utilize autoencoders as a powerful tool to enhance the input features of the band power filtered electroencephalography (EEG) data. We compare the performance of the autoencoder-based approach to using Principal Component Analysis (PCA). Our results demonstrate that using autoencoders with non-linear activation function achieves better performance compared to using PCA. We demonstrate the effects of varying the number of hidden nodes of the autoencoder as well as the activation function on the performance. We finally examine the characteristics of the trained autoencoders to identify the features that are most relevant for the motor imagery classification task.

One of the main applications of BCIs is virtual keyboards (spellers). Hex-O-Spell is considered one of well known spellers based on motor imagery. Developing Hex-O-Spell for smart devices (smart phones, tablets, …) can improve the quality of life of disabled individuals allowing them to be more independent. As part of this thesis, a Hex-O-Spell application was developed and examined on three different subjects.

Keywords: Brain-Computer Interface, BCI, Hex-O-Spell, Spellers, Autoencoder, Motor Imagery, EEG, Mobile Application

Acknowledgment

In the name of Allah, the Most Gracious and the Most Merciful

Thanks to Allah for giving me this patience and strength to complete this thesis, and to understand that every good and bad happened was the best to me

First and foremost, I would like to express my gratitude to my advisors Dr. Seif Eldawlatly and Dr. Mohamed Taher for the continuous support, patience, and immense knowledge. Their guidance helped me in all the time of research and writing of this thesis.

Second, I would like to thank my parents who taught me the value of hardwork and an education, my beloved wife for just exist in my life and my brother for the support he has provided me over the years

Finally, I need to thank Mohammed Shaaban for techincal guidance, Abd-Allah Ibrahim, Ahmed Hosni, Bassem Fargaly and Wessam for volunteering in earlier experiments. This accomplishment would not have been possible without them. Thank you.

Table of Contents

List of Figures