AUTOMATIC DETECTION OF DRIVER DROWSINESS DURING SIMULATED DRIVING USING BRAINWAVES CHANGES AS INDICATOR

Cairo University

By

Ahmed Abdelhamid Mohamed Torki

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
Biomedical Engineering & Systems

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

AUTOMATIC DETECTION OF DRIVER DROWSINESS DURING SIMULATED DRIVING USING BRAINWAVES CHANGES AS INDICATOR

By

Ahmed Abdelhamid Mohamed Torki

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
Biomedical Engineering & Systems

Under the Supervision of

Prof. Dr.
Ayman M. Eldeib
Professor of Systems & Biomedical Engineering
Faculty of Engineering, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

AUTOMATIC DETECTION OF DRIVER DROWSINESS DURING SIMULATED DRIVING USING BRAINWAVES CHANGES AS INDICATOR

By

Ahmed Abdelhamid Mohamed Torki

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
In
Biomedical Engineering & Systems

Approved by the
Examining Committee

Prof. Dr. Ayman M. Eldeib	Main Thesis Advisor
Prof. Dr. Ahmed M. Albialy	Internal Examiner
Prof. Dr. Mohamed I. Aladawy Faculty of Engineering, Helwan University	External Examiner

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

Engineer's Name: Ahmed Abdelhamid Mohamed Torki
Date of Birth: 02./10/1978
Nationality: Egyptian
E-mail: Engr.ahmed.torki@gmail.com
Phone: 01061178995.
Address: 17 Ramw Building-6th of October-Giza.

Registration Date: 01./10./2009..
Awarding Date: …./…./2018
Degree: Doctor of Philosophy
Department: Biomedical Engineering & Systems

Supervisors:

Prof. Dr. Ayman M. Eldeib

Examiners:

Prof. Dr. Ayman M. Eldeib (Thesis Main Advisor)
Prof. Dr. Ahmed M. Albialy (Internal examiner)
Prof Dr. Mohamed I. Aladawy (External examiner)
Faculty of Engineering, Helwan University

Title of Thesis:

Automatic Detection of Driver Drowsiness During Simulated Driving Using Brainwaves Changes As Indicator

Key Words:
Driver drowsiness detection; Electroencephalogram; Simulated Driving

Summary:

Driver drowsiness contributes widely in vehicle accidents. Studies assessed drowsiness indicators at different driving setups. The first objective was to establish an experiment to obtain generic datasets of brainwaves epochs recorded by electroencephalogram (EEG) at forehead sites labeled with alertness and drowsiness for subjects using facial expressions recorded by videos. Subjects perform simulated driving for two hours after 6 PM. The second and third objective were to extract and select significant features that yield to highest classification accuracy between alert and drowsy using statistical and classification methods. The results showed the classification accuracy was 85.8 %.

Acknowledgments

I wish to express my deepest appreciation and sincere gratitude to Prof. Dr. Ayman M. Eldeib for his supervising and his great helpful advice and valuable guidance in this investigation.

The experiment was held in the rehabilitation laboratory in Systems and Biomedical Engineering department, Faculty of Engineering, Cairo University. The laboratory was partly funded by a grant from the Science and Technology Development Fund (STDF), Egypt.

I wish to express my deepest appreciation and sincere gratitude to Prof. Dr. Ahmed Badawy, Chairman of Systems and Biomedical Engineering Department for his support to overcome any obstacle to hold my experiment in the rehabilitation laboratory in Systems and Biomedical Engineering department, Faculty of Engineering, Cairo University.

My Deepest gratitude to Dr. Mona Foad Taher, Associate Prof. at Systems and Biomedical Engineering Department, Cairo University, for strong assistance throughout the experiment in the rehabilitation laboratory in Systems and Biomedical Engineering department, Faculty of Engineering, Cairo University.

My Deepest gratitude to Eng. Khaled Sayed, Eng. Yasen Khalifa, Eng. Mohamed Hisham and Eng.Mohamed El Bialy, teaching assistant at Systems and Biomedical Engineering Department, Cairo University, for their close guidance and strong assistance throughout the experiment.

My Deepest gratitude to Eng. Eman Magdy for support in the simulating software.

My Deepest gratitude to all subjects who accepted my invitation to perform the simulated driving task for their patience and positive attitude.

My Deepest gratitude to Eng. Ahmed Atef and Eng. Marwa Ahmed who accepted my invitation to be the two observers who assessed the video epochs for their time and efforts.

My Deepest gratitude to Prof. Dr. Sameera Ezzat who supported me a lot in statistical studies.

My Deepest gratitude to Prof. Dr. M.Hany Hussein and all my former directors for their continuous support and concern during the period of doctoral study.

Finally, I wish to thank all my family, friends, colleagues for their support and patience during all the period of the study.

Dedication

I wish to dedicate this thesis to my father and mother who raised me well and supported me all my life. Also I wish to dedicate it to all who believed in me my wife, son, sister, and my wife's parents and all my friends who supported me all over the years.

Publications

The following publications were achieved during the doctoral research

Torki, A.A. and ELDEIB, A.M., “Driver Drowsiness Detection Using Forehead Brain Signals”, Journal of Engineering And Applied Science, Vol. 63, No. 4, pp. 293 – 310, 2016.

Table of Contents

List of Tables

List of Figures

Abstract

Driver drowsiness contributes widely in the increase of possibility of vehicle accidents. Many studies assessed drowsiness indicators at different driving setups. Brainwaves recorded at different head sites resulted in better accuracies. The detection of drowsiness after normal working day with normal sleep habits was the main scope of this study.

The first objective was to establish an experiment that can obtain a dataset of recorded brainwaves recorded at forehead sites (Fp1 and Fp2 with Fpz reference) and labeled with alertness and drowsiness states by assessing video recordings of subjects' behavior especially facial expressions. Forehead sites facilitates future practical implementation of drowsiness detection system. These recordings was achieved for subjects undergoing simulated monotonous driving task for two hours after 6 PM. Brainwaves were recorded via electroencephalogram (EEG) mobile system and facial expressions were recorded simultaneously using video webcam. Recorded data for all subjects were segmented into non overlapping five seconds epochs. Each epoch of EEG signals was labelled as alert or drowsy in accordance to subject's facial symptoms in video records. The comparison of labeled brainwaves datasets was performed to test the changes in EEG signal between the alertness and drowsiness states. Features were extracted out of EEG signals recorded at forehead sites by discrete wavelet decomposition and periodogram. The second objective was to model the features using statistical regression model to predict drowsiness state according to significant features. The selected model according to data was binary logistic regression model to predict the probability of drowsiness states according to the significant features. The third objective was to build drowsiness detection algorithm using support vector machine classifier.

The recommended data set and extracted features to build the drowsiness detection algorithm were selected according to the binary logistic regression and classification of combined features results. The recommended training data set was epochs labeled Alert without any accompanied movement head or sitting posture change and epochs labeled Drowsy with slightly drowsy to extremely drowsy without any accompanied movement head or sitting posture change. The recommended combined features group consists of energy of Alpha, energy of Beta and standard deviation of Level 4 detail coefficients (Beta range) for Fp1 and Fp2. These features were extracted using discrete wavelet transformation with mother wavelet Daubechies 6 (db6). This yielded to classification accuracy was 85.8 %. This accuracy was achieved from Support vector machine classifier setup was Gaussian radial basis function kernel (scaling factor equal 0.2). The results are very promising to use Fp1 and Fp2 EEG signals. This accuracy in comparison to other researchers' studies was satisfying. Many reasons can contribute in this variance of accuracy, the driving task setup, preparation of subject for driving, vigilance states labeling, and signal preprocessing.

Chapter 1 : Introduction

1.1. Introduction

Drowsiness of drivers has been observed as one of the most contributing factors in vehicle accidents in many countries. Drowsiness detection and alerting the driver were the scope of many researches since years to minimize the number of accidents. Detecting or predicting drowsiness is not a straight forward issue. Drowsiness symptoms can be confusing. Many researchers tested and examined many indicators to build detection or prediction systems. This study worked on forehead brainwaves as indicator to build drowsiness detection algorithm. The drowsiness detection system focuses on the driving after 6 PM normal working hours.

1.2. Objective

The first objective was to establish an experiment that can obtain generic datasets of non-overlapping five seconds epochs brainwaves at forehead sites (Fp1 and Fp2 with Fpz reference) labeled with alertness and drowsiness states for subjects undergoing simulated monotonous driving task for two hours after 6 PM. The brainwaves were recorded using electroencephalogram (EEG). Forehead sites facilitates future practical implementation of drowsiness detection system. Figure 1.1 showed an illustration of the selected forehead sites for brainwaves recording in this study. The labeling was done by assessing facial expression and observing sitting posture by two observers. The facial expression and sitting posture were recorded by video simultaneously with the EEG recordings.

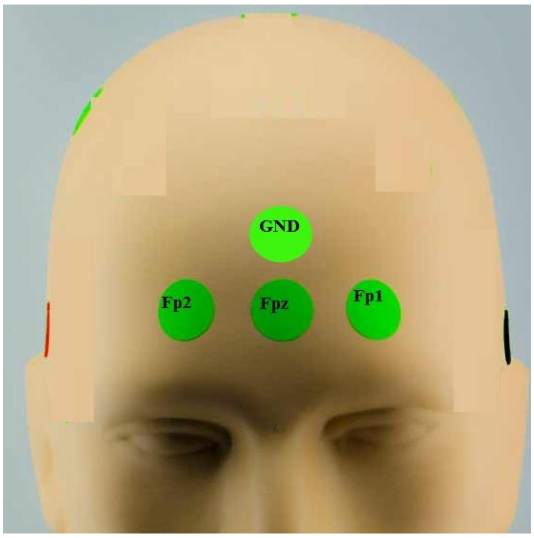

Figure 1.1. Illustration of Forehead Positions Selected In This Study