DETECTING STRESS DURING REAL – WORLD DRIVING TASKS BASED ON PHYSIOLOGICAL SIGNALS USING TIME-FREQUENCY DISTRIBUTION

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2021

DECLARATION

I declare that this thesis entitled "DETECTING STRESS DURING REAL – WORLD DRIVING TASKS BASED ON PHYSIOLOGICAL SIGNALS USING TIME-FREQUENCY DISTRIBUTION is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Jeyaahthaarsine A/P Ravindar

Date : 5/07/ 2021

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APPROVAL

I hereby declare that I have checked this report entitled "DETECTING STRESS DURING REAL – WORLD DRIVING TASKS BASED ON PHYSIOLOGICAL SIGNALS USING TIME-FREQUENCY DISTRIBUTION" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature:

Supervisor Name : EZREEN FARINA BINTI SHAIR

Date: 5 / 07 / 2021

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DEDICATIONS

I want to dedicate to my parents, Ravindar A/L Ramasamy and S.Gunasegari. I also would like to dedicate to my siblings and friends for their unlimited support, motivation and understanding.

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ABSTRACT

Driving stress can be defined as any kind of change which causes physical, emotional, or psychological strain during driving. Stress is the body's response of a person to anything that needs attention or action. A driver’s excess stress can affect the driving performance and causes an increment in crash likelihood. The level of stress of a driver can be vary depending on the different conditions of driving. Physiologically, stress directly can be measured by the changes occur in the skin conductance, heart rate, respiration and muscle activities. The main goal of this study is to understand driving stress during real-world driving tasks based on the physiological signals at different driving locations using time-frequency distribution (TFD). In this project, there are 9 subjects (driver records) of at least 60 minutes duration. The physiological signals involved in this project are the electrocardiogram (ECG), electromyogram (EMG), foot galvanic skin response (Foot GSR). Three stages are implemented in this analysis of the project which are known as signal pre-processing, signal processing and signal classification. In signal pre-processing state, filtering the signals using a bandpass filter is important to decrease and also to smooth out high-frequency noise that is associated with measurements. Hence, the pre-processing step is implemented to reduce the noise impacts which can affect the interpretation of the signals. Next, in TFD, adjusting the time and frequency resolution is a must so that the important information of the physiological signals can be obtained. The average V_{rms} of the physiological signals for all the classes of driving stress was obtained by running the coding in MATLAB software. The physiological signals were combined into four different groups. The total set of average V_{rms} for all the subjects will be separated into two categories that are known as training and testing. The training data set were 80 percent while the testing data was 20 percent from the total set of average V_{rms}. To get the accuracy and performance of the classifiers the training data set and testing data set will be imported and uploaded into the classification learner toolbox in MATLAB software. The support vector machine (SVM) classifier have the highest accuracy which is 95.5% for training data set while 100% for testing data set.

ABSTRAK

Tekanan memandu boleh didefinisikan sebagai apa-apa jenis perubahan yang menyebabkan tekanan fizikal, emosi, atau psikologi semasa memandu. Tekanan adalah tindak balas badan seseorang terhadap apa sahaja yang memerlukan perhatian atau tindakan. Tekanan berlebihan pemandu boleh mempengaruhi prestasi pemanduan dan menyebabkan peningkatan kemungkinan kemalangan. Tahap tekanan pemandu boleh berbeza-beza bergantung pada keadaan pemanduan yang berbeza. Secara fisiologi, tekanan secara langsung dapat diukur dengan perubahan yang berlaku pada aktiviti kulit, degupan jantung, pernafasan dan otot. Matlamat utama kajian ini adalah untuk memahami tekanan memandu semasa tugas memandu di dunia nyata berdasarkan isyarat fisiologi di lokasi pemanduan yang berbeza menggunakan taburan frekuensi masa (TFD). Dalam projek ini, terdapat 9 subjek (rekod pemandu) dengan jangka masa sekurang-kurangnya 60 minit. Isyarat fisiologi yang terlibat dalam projek ini adalah elektrokardiogram (ECG), elektromyogram (EMG), tindak balas kulit galvanik kaki (Foot GSR). Tiga peringkat dilaksanakan dalam analisis projek ini yang dikenali sebagai pra-pemprosesan isyarat, pemprosesan isyarat dan klasifikasi isyarat. Dalam keadaan pra-pemprosesan isyarat, menyaring isyarat menggunakan penapis jalur lebar adalah penting untuk menurun dan juga untuk melancarkan bunyi frekuensi tinggi yang dikaitkan dengan pengukuran. Oleh itu, langkah pra-pemprosesan dilaksanakan untuk mengurangkan kesan kebisingan yang boleh mempengaruhi penafsiran isyarat. Seterusnya, dalam TFD, menyesuaikan masa dan resolusi frekuensi adalah suatu keharusan agar maklumat penting dari isyarat fisiologi dapat diperoleh. Rata-rata Vrms isyarat fisiologi untuk semua kelas tekanan memandu diperoleh dengan menjalankan pengekodan dalam perisian MATLAB. Isyarat fisiologi digabungkan menjadi empat kumpulan yang berbeza. Jumlah set purata V_rms untuk semua mata pelajaran akan dipisahkan menjadi dua kategori yang dikenali sebagai latihan dan ujian. Kumpulan data latihan adalah 80 peratus sementara data ujian adalah 20 peratus dari jumlah set rata-rata V_rms. Untuk mendapatkan ketepatan dan prestasi pengklasifikasi, kumpulan data latihan dan kumpulan data pengujian akan diimport dan dimuat ke dalam kotak alat pelajar klasifikasi dalam perisian MATLAB. Pengelasan mesin vektor sokongan (SVM) mempunyai ketepatan tertinggi iaitu 95.5% untuk set data latihan sementara 100% untuk menguji set data.

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LIST OF SYMBOLS AND ABBREVIATIONS

ATP - adenosine triphosphate
BBN - Bayesian Belief Networks
ECG – electrocardiogram,
EDA - Electrodermal activity
EEG - electroencephalogram
EHW - Evolvable Hardware Chip
EKG - electrocardiogram,
EMG - Electromyography
FD- Frequency distribution
Foot GSR – Foot galvanic skin response
FYP 1 - Final Year Project
FYP 2- Final Year Project 2
GSR - galvanic skin response
Hz- Hertz
KNN - K Nearest Neighbor
MATLAB – matrix laboratory
ME- Myoelectric signal
NIBIB – National Institute of Biomedical Imaging and Bioengineering
NIGMS - National Institute of General Medical Sciences
NIH - National Institutes of Health
NN - Neural Network
RMS voltage – Root mean square voltage
SCR - skin conductance response
SVM - Support Vector Machine
TD- Time distribution
TFD- Time-frequency domain/distribution
V- Voltage unit
$Vrms$ – Root mean square voltage

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In the medicine or biological field, driving stress is described as a physical, mental, or emotional factor that causes pressure bodily or mentally. Drivers experience stress on the road while driving when drivers need to exceeds their perceived coping ability [1]. Driving during peak hours and on traffic roads causes the highest level of stress among the drivers. It is because the drivers will have the feeling of being stuck and not able to do anything that may cause the drivers' stress level to increase tremendously. Next, a stressed driver can make them and other drivers around them to be in danger because a stressed driver can be a tendency to have road rage. Anxiety can rapidly change into anger when drivers are driving at a high level of driving stress. Drivers on the road can experience anxiety which means the drivers will become more anxious because of the conditions around the drivers' surroundings or the drivers are anxious before driving because of personality traits and/or disorders of mood [2]. Such anxiety can be manifest as driver stress. Driving stress can also cause severe effects on the human body. Driving stress is varied based on their driving locations such as rest, highway and city due to their respective driving conditions. Example of driving conditions that can influence and causes driving stress are light, weather, road, traffic, vehicle and drivers.

Figure 1.1 shows the graph of performance and stress level. There are two types of stress which are known as eustress and distress. Some of the researchers were able to determine the differences between these two stresses. The eustress is a stress that is positive stress, for example like happiness, or stress that brings to an eventual state which is an advantage to the living things [3]. Distress can be said as an emotion, feeling, thought, condition, or behavior that is unpleasant to experience. Hence, distress is negative stress. Distress can give an impact on the way a person think, feel, or act and can make it hard to cope with situations. This research referring to negative stress which is distress. There are plenty of researches that tells about how being very stress can affect decision-making skills [4], reduced situational awareness [5], and degraded performance [6] that can weaken the driving ability.

Figure 1.1: Graph of performance and stress level

1.2 Motivation

In this era, many people are driving to work, university and other locations based on their schedules. People prefer to drive to their destination to save time and reach on time. Since there are many cars on the road, the driving stress among drivers is increasing day by day due to some of the driving conditions. All the drivers on the road during the drive are exposed to the stressful driving situation for hours, even if those drivers are generally not suffering from stress in their everyday life. It is an undeniable truth that commutes that are long, poor weather and traffic conditions can all make it more likely that the people who drive will become stressed and experience driving stress. For many drivers, the stress of driving and angry feeling during driving on the road is trouble. A brake and direct line survey of UK drivers manage to found that 71 percent of the drivers had lost their focus at the wheel in the previous years because of being stress or annoyed on the road [7]. The well-known reason for this was the behavior of the other road users as 60 percent of the drivers stated about it [7]. 44 percent and 39 percent of the drivers stated that they are stress about their very own issue and work-related stress respectively [7].

1.3 Problem Statement

Time domain has the non-stationary property of electromyogram (EMG) signal while frequency domain has high noise environments [8] which makes them not suitable for analysing some physiological signal like electromyogram (EMG). Even time domain (TD) has fast time consumption and small dimension, the feature performance is not satisfying. Frequency domain (FD) features are not easy when detecting the physiological such as ECG and EMG due to the lower power frequency. If data is non-stationary, as rules, it is not predictable and cannot be modeled or forecasted. If the physiological signals were analysed using time domain, the results from the simulation may be false and show a relationship between two variables where one of it not exist. A high noise environment can make the result from the simulation inaccurate.

In this era, the usage of onboard electronic and in-vehicle information is increasing. As consequence, the evaluation of driver tasks demands an area of increasing importance to government and industry [9]. Other than that, understanding the driver's frustration listed as one of the key areas to make intelligent transportation systems better than the current system [10]. Driver frustration can be vary based on their driving conditions. Thus, the driving stress level also can be vary based on different driving conditions. Some people in the society determined that driving in the city can cause a high level of driving stress due to huge groups of pedestrians every day, traffic congestion and so on. Difficult driving conditions are less probably to happen when drivers are driving on the highways.

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Some classifiers such as decision trees have low performance for signal classification. There are many classifiers such as discriminant analysis, nearest neighbor classifiers, decision trees and others. Not all the classifiers can show a good performance. Good performance is essential because it affects the accuracy of the results. If the accuracy is high, it means the results are accurate. In data science, the classifiers' performances measure the predictive capabilities of the machine learning models in MATLAB software with crucial metrics such as like accuracy and precision.

Almost all metrics are based on the true and false predictions concepts which are created by the model and measured against the actual outcomes.

1.4 Objectives

The objectives of this project are:

i. To analyse the physiological signals that used to detect driving stress by using time-frequency distribution (TFD)
ii. To classify driving stress into three levels based on three driving conditions which are rest, highway and city.
iii. To compare the performance of the SVM classifier with other classifiers

1.5 Scope

This project is focusing on the simulation of the physiological signals that were used to detect the driving stress level. The physiological signals must be designed by using advanced methods and follow the procedure gradually. By using the time-frequency domain (TFD) technique, the features of physiological signals require to extract the data which can describe the three levels of stress driving based on the three driving conditions. This project is also required to determine the best classifier to use for applications of the physiological signal. MATLAB software was used for the simulation of the physiological signals.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Driving can be said as the control and operation of a vehicle while stress can be said as a type of reaction that occurs to a person from a state of calm mind to an excited state for preserving the integrity of that person. Since organisms are highly developed and natural environment independent as a socialized man, most of the things that can cause a state of strain are intellectual, emotional and perceptual [11]. Driving also can be classified as a complex activity as it needs different skills at the same time such as cognitive, physical, sensory and psychomotor [12]. Many people in the current world travelling by driving their vehicle such as a car to reach faster and safer. As we know, drivers need to have full focus and a calm mind when driving so that accidents on the road can be avoided. Hence, combating their level of stress especially on the road is crucial for the safety of many people including the drivers themselves.

There are many factors that can cause driving stress. For example, driving at peak hours and in congested areas may cause a high level of driving stress. This is because the driver will be stuck in the traffic and unable to drive even after the traffic light changes to green. The stress of daily life such as work and personal problems can frequently contribute to the pressure on the road too. According to some physiological fields, the stress of people actually can be directly measured by measuring the differences that occur in the conductance of the skin, heart rate, respiration, and the activities of muscle [13]. There are many physiological parameters and parameter combinations that can be utilized to detect stress [14]. Examples of physiological sensors that can detect stress are electrocardiogram (ECG), electromyogram (EMG), skin conductance, and respiration.

2.2 Driving stress and road rage

Road rage can cause driving stress. It is an undeniable truth that road rage can lead drivers to drive dangerously. It is because driving any vehicle under a high level of driving stress can cause decrement in the driver's control of the vehicle and capabilities of risk assessment. There are numerous research and studies show that anger emotion is among the most essential factors involved in driving that is unsafe [15]. The moment people get behind the car's wheel and begin to drive, people will involve in a series of events that take a toll on his/her levels of stress. Some forecast events example maintaining the speed of the car, braking and pulling away at the traffic lights, or not moving in traffic causes an increment in stress. Additionally, other events example like the driver being followed so closely by other vehicles on the road, being cut up while in heavy traffic, need to brake hard to avoid a collision and it soon shows clearly the reason why the driving activity is said to be one of the very stressful activity.

In research of behavior and stress of driver, some things emerge as typical reasons of tension such as cannot move in traffic or associated with congestion in start-stop drive, got stuck in the flow of traffic where all the other drivers on the road join in, perceived over-regulation that involve traffic signs, works on the road and limit of the speed on the roads that appear open and hugely free of traffic, other road drivers drive impatiently or aggressively, sudden events that result in danger increment, perceiving that the focus of other road users is getting affected by equipment in the car, no correct signal, skipping the traffic lights, getting abuse and being a victim by other users in the road, being forced to increased speed of driving by other following vehicles, forced to brake hard for many reasons, parking of vehicles that is inconsiderate and so on. Some of the listed reasons are classified as driving errors which seem to be more related to stress experienced by drivers rather than driving anger [16].

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2.3 Physiological Sensors

The physiological sensors can be related to the group that measures the blood pressure, glucose amount in blood, electrocardiograms, electroencephalograms and others in the human body. A sensor will convert the physical activity that is required to be calculated into an electrical equivalent and then process it. This is because to make the electrical signals not hard to send and to be processed more. Numerous physiological signals can detect stress, such as an electrocardiogram (ECG or EKG). It is because physiological signals can record the electrical task of the heart on the peoples' skin's surface. An electrocardiogram (ECG) sensor is a physiological sensor electrode that will be located in the human chest that will sense and send signals of the heart. Other than that, an electromyogram (EMG) sensor will measure the physical capacity of the human body muscles. Figure 2.1 shows examples of physiological sensors.

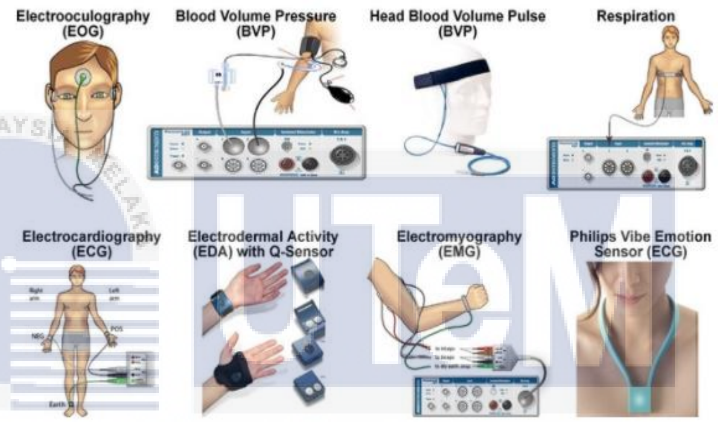

Figure 2.1: Example of physiological sensors

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2.4 Physiological Signals

Physiological signals can be defined as the readings or measurements which are produced by humans through the physiological process. An example of a physiological process is respiration. Body of humans produce various type of signals and some of it can be classified as physiological signals. Get access to the physiological signals is essential. It is because the physiological signals can be internal (pressure of blood), can generate from the human body and also might be derived from the sample of a tissue such as blood or tissue biopsy. Other than that, physiological signals can be classified into few categories such as biopotential, pressure and flow, dimensions, displacement, temperature and concentration and composition of chemicals

Data collected from the physiological signal able to detect stress. For example, the physiological sensor that produces physiological signals such as the electrocardiogram (ECG), electromyogram (EMG), skin conductance, and respiration can be used to detect the stress level of a driver at any driving condition. Not only that, the physiological signals are helpful metrics when giving feedback about the state of the driver because the physiological signals can be collected non-stop while not cause any disturbance and involve with the performance of the activity of the driver. Figure 2.2 shows important physiological signals in the body.

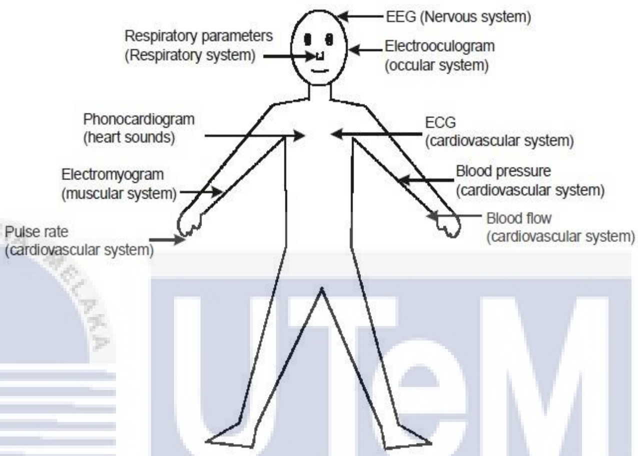

Figure 2.2: Important physiological signals in the body

2.4.1 Electrocardiogram (ECG)

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An electrocardiogram (ECG or EKG) can be said as a test that helps to check how the heart is functioning by measuring the heart's electrical activity. With each heartbeat produced by a person, an electrical impulse which is known as a wave will move through the heart. This electrical impulse can make the muscle squeeze and blood is pump from the heart. ECG measures and also record the electrical activity which passes through the heart. The process of producing an ECG is known as electrocardiography. It is a graph of voltage versus time of the human's heart's electrical task using the electrodes located on the skin [17]. An ECG signal is a type of biomedical signal that is a reflection of human heart electrical activity. Figure 2.3 shows the graph of an ECG signal.