Driver Sleep Detection and Alarming System

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Abstract

Drowsiness appears in situations of stress and fatigue unexpectedly and inconveniently. It may be produced by sleep disorders, certain types of medications, and even boredom because of driving for an extended period. The sleeping sensation reduces the level of vigilante, producing dangerous situations and increases the probability of an accident occurring. Those in the prime of their lives are particularly vulnerable, with road injuries the leading cause of death among those 15-29 years old. The results in terms of damage, injury, and death can be only as permanent. Drivers who are tired and sleepy have delayed reactions and make bad decisions. This study intends to develop a device or a system that will help drivers in minimizing road accidents. The review uses the concept of the Human-Computer Interaction and Usability Test as it follows the maximization of the ease, efficiency, and safety of the product and also to have well-designed software that has a sizeable impact on learning time, performance speed, error rates, and personal satisfaction.

Keywords
drowsiness, driver, detection.

1. Introduction

Road traffic injuries and deaths have a terrible impact on individuals, communities, and countries. They involve massive costs too often overburdened health care systems occupy scarce hospital beds consume resources and result in significant losses of productivity and prosperity, with deep social and economic repercussions. According to the 2016 report of WHO, 1.24 million road traffic deaths occur every year. This makes it the number one cause of death among those aged 15-29 years. This number is predicted to increase to around 1.9 million by 2030 and to become the seventh leading cause of death if no action is to be taken.

The anti-sleep driving alarm for people doing all night drives as well as security guards and others we have to sit in one place for long periods of time without any stimulating interaction. The newest high-tech way to stay awake is good whether you ever have to drive back home after an exhausting day at work or just need to get something done and sleep is not an option. This trusty sleep alarm will keep you at full alert and is always ready to help if your head dozes off. This has the potential to save lives on the road. Long-distance lorry drivers can fall asleep by driving too long hours due to the pressures put on them to get the goods to their destination at certain times. This item has the potential to keep them awake or at least to tell them when they are overtired and need to stop driving.

This study intends to develop a device or a system that will help the driver in minimizing road accidents.

1.1 Problem Statement

Driver exhaustion is a significant variable in an expansive number of vehicle accidents. Late insights assess that yearly 1,200 deaths and 76,000 injuries can be credited to weariness-related accidents. Less attention leads the driver to be distracted and the likelihood of a street accident goes high. Drowsiness-related accidents have all the earmarks of being more serious, because of the higher speeds involved distraction and the driver being not able to take any avoiding activity, or even brake, before the accident. The improvement of innovations for recognizing or preventing tiredness of the driver is a significant test in the field of an accident preventing systems. Because of the danger that that drowsiness presents on the road, strategies need to be created for checking its influences. Loss of awareness because of tiredness causes a few changes in the human body and activities. These side effects and parameters empower us to effectively measure the drowsiness level.

Every year, 1.25 million people around the world die due to road crashes – a global problem that the World Health Organization (WHO) says is both predictable and preventable. Most of the victims come from low and middle-income countries.

Those in the prime of their lives are particularly vulnerable, with road injuries the leading cause of death among those 15-29 years old. The Philippines is also seeing worrying figures, with data from the Philippine Statistics Authority (PSA) showing that the number of deaths due to road crashes has been increasing since 2006. According to the latest available data, 10,012 people died due to road crashes in 2015 – a 45.76% increase from 6,869 deaths recorded in 2006.

1.2 Objectives

The objectives of this project is to develop a system that can detect the sleepiness of the driver and make alarms accordingly. There will be an ECG Sensor Chip. The electrocardiogram (ECG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart. It will be the tool that monitors the heart rate and transfer it to the microcontroller.

1.3 Scope and Limitation of the Study

The study focuses on drivers of the Province of Bulacan, which the researchers considered the typical driver, student driver, security guard driver, and so forth, which always seen in the road of Bulacan. The researchers studied the route of the drivers with time-consuming of 8 hours and above of travel because they usually experience tiredness and drowsiness while driving for an extended period. The study is conducted within the timeframe of November 2019.

2. Literature Review

According to available statistical data, over 1.3 million people die each year on the road and 20 to 50 million people suffer non-fatal injuries due to road accidents. the US National Highway Traffic Safety Administration (NHTSA) conservatively estimated that a total of 100,000 vehicle crashes each year are the direct result of driver drowsiness. These crashes resulted in approximately 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses. The German Road Safety Council (DVR) claims that one in four highway traffic fatalities are a result of momentary driver drowsiness.

A driver who falls asleep at the wheel loses control of the vehicle, an action that often results in a crash with either another vehicle or stationary objects. To prevent these devastating accidents, the state of drowsiness of the driver should be monitored. The following measures have been used widely for monitoring drowsiness:

1. Vehicle-based measures—Several metrics, including deviations from lane position, movement of the steering wheel, pressure on the acceleration pedal, etc., are constantly monitored and any change in these that crosses a specified threshold indicates a significantly increased probability that the driver is drowsy.
2. Behavioral measures—The behavior of the driver, including yawning, eye closure, eye blinking, head pose, etc., are monitored through a camera, and the driver is alerted if any of these drowsiness symptoms are detected.
3. Physiological measures—The correlation between physiological signals (electrocardiogram (ECG), electromyogram (EMG), electrooculogram (EoG) and electroencephalogram (EEG)) and driver drowsiness has been studied by many researchers

The term “drowsy” is synonymous with sleepy, which simply means an inclination to fall asleep. The stages of sleep can be categorized as awake, non-rapid eye movement sleep (NREM), and rapid eye movement sleep (REM). The second stage, NREM, can be subdivided into the following three stages:

- Stage I: transition from awake to asleep (drowsy)
- Stage II: light sleep
- Stages III: deep sleep

3. Methods

3.1 System Design

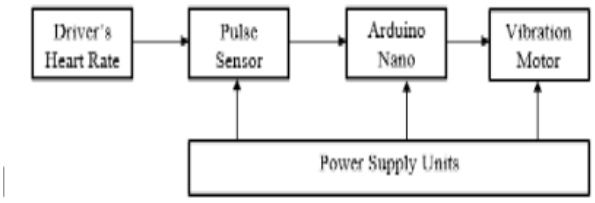

Figure 1. The systematic level block diagram

Figure 1 shows the system design wherein a power supply unit is connected to the pulse sensor, Arduino nano, and

vibration motor. The mentioned detectors are then connected like a watch to monitor the heart rate of the driver.

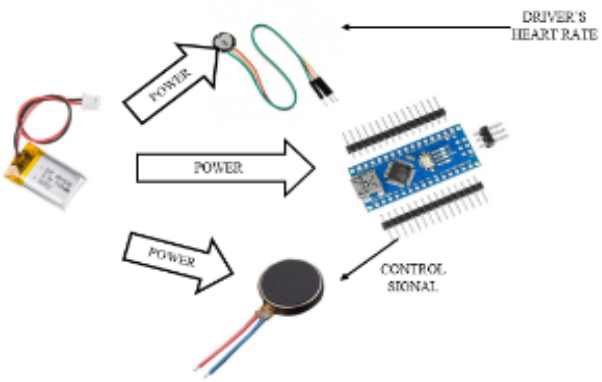

Figure 2. Systematic block diagram of real components prevision

Figure 2 shows the systematic block diagram of real components prevision which includes all the power and control signal.

Block Description

- The Arduino Nano

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P (Arduino Nano 3.x). It has more or less the same functionality as the Arduino Duemilanove but in a different package. It lacks only a DC power jack and works with a Mini-B USB cable instead of a standard one.

- Pulse Sensor

Pulse Sensor Amped is a plug-and-play heart-rate sensor for Arduino and Arduino compatibles. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data.

- Lithium Polymer Battery

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, lithium-poly, and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte.

- Vibration Motor

An eccentric rotating mass vibration motor (ERM) uses a small unbalanced mass on a DC motor when it rotates it creates a force that translates to vibrations.

3.2 Design of Working Prototype

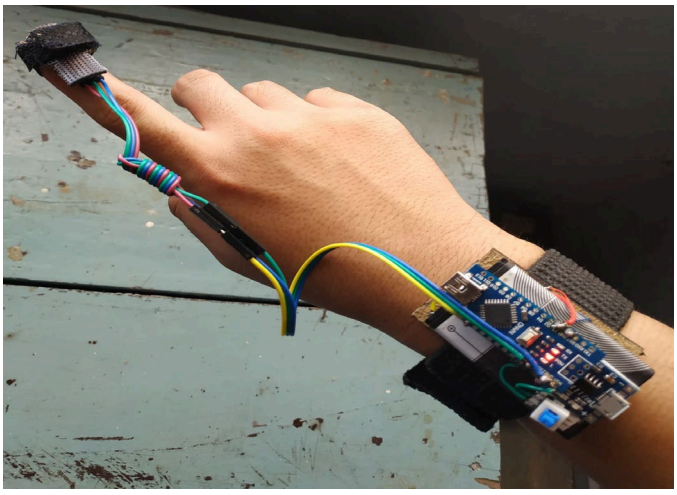

Figure 3. Working Prototype

Figure 3 is the picture of the working prototype of the device. It shows how the device can be worn to monitor the heart

rate and send signal to alert the driver in case of sleepiness. It is like a watch wherein the pulse rate will be monitored with the use of ECG. It is also connected to a finger where the vibration signal will be sent to alarm the driver and thus avoid accident brought about when the driver fell asleep while driving.

4. Result and Discussion

Table 1. Arduino results

USER	TASK	AGE	GENDER	TIME OF OBSERVATION	HEART RATE		
					INITIAL	DURING	FINAL
1	DRIVER 1	38	M	4:30 am	81bpm	79bpm	84bpm
2	DRIVER 2	49	M	9:00pm	68bpm	59bpm	63bpm
3	STUDENT 1	21	M	7:00 am	62bpm	49bpm	60bpm
4	STUDENT 2	18	F	2:00pm	64bpm	47bpm	52bpm
5	SECURITY GUARD	41	M	4:00am	85bpm	74bpm	75bpm

The researchers used the proportionality test since they used random sampling. Through this test, they can prove that the numbers of the sample are significant enough to prove the information came from the survey as shown in Table 1. Most of the respondents say that the factors affecting the alertness level of the drivers are tiredness, lack of sleep, and long-distance travel.

Heart rate, which can be easily determined by the Electrocardiographic (ECG) signal, can be used to detect drowsiness. A heart rate is affected by many variables. Each individual's heart rate is different from one person to another. For all people, the heart rate varies depending upon how physically active the person is. The normal heart rate is 60-75 beats per minute (bpm) but it varies significantly, this will include the limitation of the product. Others have measured drowsiness using Heart Rate Variability (HRV), in which the low (LF) and high (HF) frequencies fall in the range of 0.04–0.15 Hz and 0.14–0.4 Hz, respectively which is equivalent to 2.4-24 bpm (Sahayadhas, Sundaraj, & Murugappan, 2012). This statement proved by Tina M. St. John M.D. that the average heart rate during sleep decreases by roughly 24 beats per minute in young adults and 14 beats per minute in the older than age 80. The concept of sounds and vibration will help the drowsy person to recover from the state of drowsiness, however, the applicable research literature generally indicates that rumble strips that generate a 3 to 15 dBA increase above the ambient in-vehicle sound level can be detected to awaken drivers (Campbell, 2012). Also, some evidence suggests that a sudden change in a sound level above 15 dBA could startle a driver. The vibration is also applicable to bring back the alertness level of the driver. According to Dorothy Bruck and Ian Thomas (Bruck & Thomas, 2007), the intensity that is needed to awake a person is 100 Hz to 150 Hz. With this concept, the researchers will develop a device that will alert drivers from being drowsy.

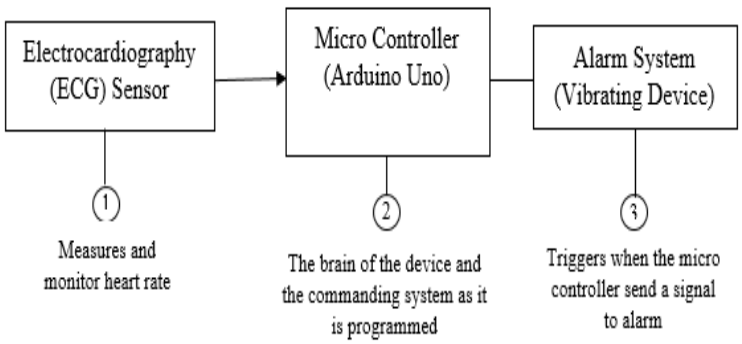

Figure 4. Concept of the function of the device

Figure 4 is the concept of the function of the device. The ECG sensor measures and monitors heart rate, the Arduino Uno acts as the brain of the device and the command system, and the vibrating device which triggers the micro controller send a signal to alarm the driver.

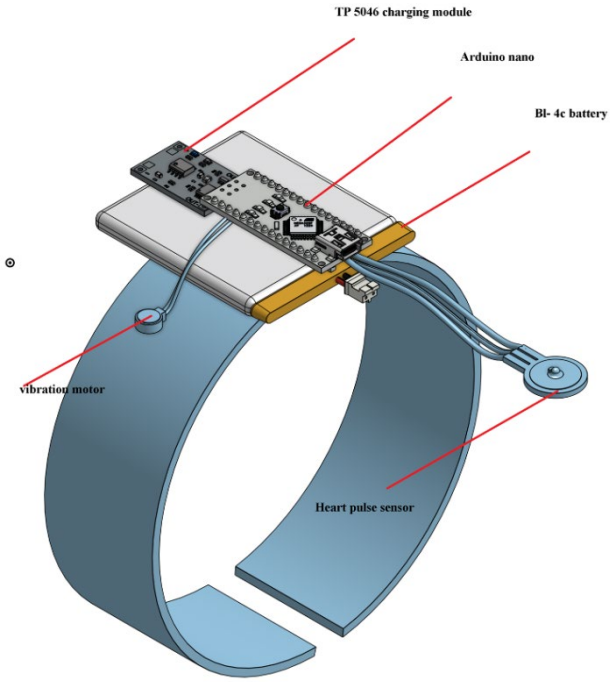

Figure 5. Working prototype design

Figure 5 is the design of the working prototype wherein a heart pulse sensor is connected to the pulse of the driver. The sensor is then connected to a power source which is BI-4c battery, an Arduino nano, a TP 5046 charging module which is also connected to a vibration motor that will send signal to the driver.

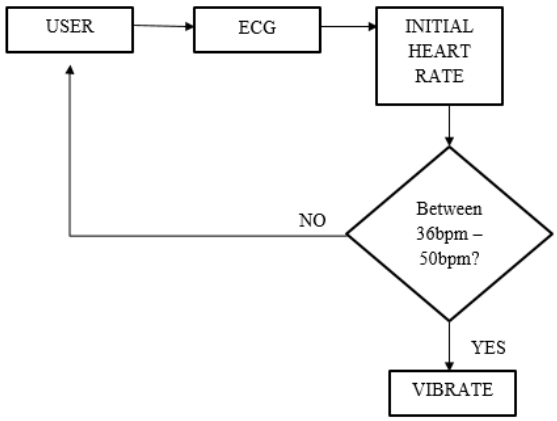

Figure 6. Block diagram of the developed system

Figure 6 shows the block diagram of the developed system. The heart rate of the user or the driver who is wearing the device will be monitored through the ECG. The initial heart rate of the driver will be monitored and if it goes below 36bpm or above 50bpm the device will vibrate that will awaken the driver. Table 2 shows the list of the detailed specification of the parts of the device as well as its cost per unit.

Table 2. Product specification

Equipment	Function	Cost
TP 5046 Charging Module	The TP4056 is a complete constant-current/constant-voltage linear charger for single-cell lithium-ion batteries. Its SOP package and low external component count make the TP4056 ideally suited for portable applications. Furthermore, the TP4056 can work within USB and wall adapter	₱180.00
Arduino nano	The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P (Arduino Nano 3.x). It has more or less the same functionality as the Arduino Duemilanove but in a different package. It lacks only a DC power jack and works with a Mini-B USB cable instead of a standard one.	₱260.00
BI-4c battery	Onboard systems usually consist of two or more batteries that function independently when powering the 12 or 24 V consumers. These batteries require independent charging with reliable battery isolators or battery combiners	₱299.00

Vibration Motor	An eccentric rotating mass vibration motor (ERM) uses a small unbalanced mass on a DC motor when it rotates it creates a force that translates to vibrations. A linear resonant actuator (LRA) contains a small internal mass attached to a spring, which creates a force when driven.	₱200.00
Heart Pulse Sensor	The heart rate sensor measures your heart rate in Beats per Minute using an optical LED light source and an LED light sensor. The light shines through your skin, and the sensor measures the amount of light that reflects. The light reflections will vary as blood pulses under your skin past the light.	₱450.00
Push buttons for Watch	Push-button (Wake-up Switch Button and Power button) is used for the interactions for the smartwatch as a normal watch does.	₱40.00

5. Recommendations and Conclusion

The analysis and design of driver drowsiness detection and alert system are presented. The proposed system is used to avoid various road accidents caused by drowsy driving.

At the end of the study, the researchers have attained the main objective which is the prevention of road accidents caused by drowsy driving. It is attained by supporting the specific objective, the researchers were able to develop a device that will help the drivers to stay awake and alert while driving through the use vibrating device.

Considered the facts mentioned in Discussion in V Section it is concluded that the hybrid method that the researchers proposed for drowsiness detection is more suitable than the detection techniques which consider only one category of measurements such as physiological, behavioral, or vehicle-based methods

As a recommendation for this device, the researchers recommend improving the system by:

- Providing LED to display the heart rate of the driver because when we are falling asleep or feeling drowsy our heart rate changes, it will go down and the sound alert will enter.
- Sound alert that is attached to the device to notify the drivers when their heart rate is dramatically changing due to drowsiness or sleepiness.
- Changing the materials in manufacturing this device materials that can handle any situation for example using rubber as the case of the device so that when the drivers accidentally hit it with another object and create the impact it will not break.

- Providing a long-lasting battery that can power the device for a long time.

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