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Using MindWave Mobile2 sensor to Detect the Driver's Drowsiness

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Abstract:

One of the primary factors contributing to traffic accidents is sleepiness, which is brought on by exhaustion or overwork, then lowers the activity of brain neurons in the nervous system. Therefore, it is necessary to develop methods to detect drowsiness. There are several methods for detecting drowsiness, including eye closure detection and driving pattern-based detection. This research uses an Electroencephalography EEG by MindWave Mobile 2 sensor to measure brain waves in order to detect drowsiness. The sensor provides information about electrical signals to the brain, then sent to the Arduino UNO board via Bluetooth HC-05 and, when a person falls asleep, activates an alarm. The point at which a person feels drowsy can be identified after experimenting with this gadget in a number of activities, sleep, and sleepiness scenarios.

Keywords: EEG, Drowsiness, Arduino UNO, MindWave Mobile 2.

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استخدام مستشعر MindWave Mobile2 للكشف عن نعاس السائق

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الملخص

أحد العوامل الأساسية التي تساهم في وقوع حوادث المرور هو النعاس، والذي يحدث بسبب الإرهاق أو العمل الشاق، حيث يقلل النعاس نشاط الخلايا العصبية الدماغية في الجهاز العصبي. لذلك، من الضروري تطوير طرق للكشف عن النعاس. هناك عدة طرق للكشف عن النعاس، بما في ذلك اكتشاف إغلاق العين والكشف القائم على نمط القيادة. يستخدم هذا البحث تخطيط كهربية الدماغ EEG بواسطة مستشعر موجات الدماغ MindWave Mobile2 لقياس موجات الدماغ من أجل اكتشاف حالة النعاس. يوفر المستشعر معلومات حول الإشارات الكهربائية للدماغ، ثم يتم إرسالها إلى لوحة اردوينو اونو عبر بلوتوث HC-05، وعندما يبدأ الشخص في النوم، يقوم بتنشيط إشارة تنبيه. يمكن تحديد النقطة التي يشعر فيها الشخص بالنعاس بإجراء عدة اختبارات بواسطة مستشعر موجات الدماغ في عدد من الأنشطة وسيناريوهات النوم والنعاس.

الكلمات المفتاحية: النعاس، تخطيط كهربية الدماغ، لوحة اردوينو اونو، مستشعر موجات الدماغ.

Introduction

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 three stages [1]. Each year, thousands of accidents and fatalities on the highways are caused by tired or sleepy drivers. Up to 15% of major injuries and up to 30% of fatal crashes are related to it. When a motorist doesn't get enough sleep or after driving a long distance, driver tiredness happens. Fatigue and alcohol impairment both have an impact on the safety of drivers. According to a U.S. population survey, 37% of workers slept fewer than the minimum 7 hours that is advised [2]. The Malaysian Institute of traffic Safety Research MIROS reports that there were 414,421 traffic accidents in 2010 with 28,269 casualties and 6,872 deaths. These accidents cause financial damages. With the highest estimated road traffic death rate per 100,000 people, Malaysia is placed 18th [3].

Driving pattern-based detection and eye closure detection are two of the numerous methods available for identifying driver fatigue. Dependability is high for driving pattern-based detection; however, it only addresses the consequences of driving while intoxicated. If an accident doesn't happen before these effects become apparent, it might already be too late. The accuracy of the vision system used to determine eye closure is the limiting factor in this detection technique, which allows for quicker identification of driver drowsiness than driving pattern detection.

New methods based on variations in human physiology as a function of weariness are being investigated in response to the shortcomings of the driver drowsiness detection systems already in use, which include low accuracy and inadequate reaction time. such as heart rate, respiration rate, pulse pattern, electrocardiogram ECG, and common brain signals, among others [4].

Since the 1930s, EEG has been used to identify the stages of sleep. It has also been employed in clinical settings to track tiredness in pilots and drivers. However, because they need the use of pricey equipment and complex skin preparation with conductive gel for adequate monitoring, these medical-grade EEG devices are impracticable for common driver sleepiness detection [5].

The EEG is the physiological signal most commonly used to measure drowsiness. The EEG signal has various frequency bands, including the delta band (0.5–4 Hz), which corresponds to sleep activity, the theta band (4–8 Hz), which is related to drowsiness, the alpha band (8–13 Hz), which represents relaxation and creativity, and the beta band (13–25 Hz), which corresponds to alertness. A decrease in the power changes in the alpha frequency band and an increase in the theta frequency band indicates drowsiness [6]. EEG can play an important role in enhancing human life quality using the brain signal for Brain Computer Interface BCI controlled devices. Because the brain signals are different according to the activities of a human, BCI allows people to communicate with a computer using their mind [7].

There are three primary types of drowsiness detection: vehicle-based, behavioral, and physiological [8]. Measures with a physiological basis: The relationship between the physiological signal's electrocardiogram ECG and electrooculogram EOG. Heart rate, brain activity, and pulse rate can all be used to identify sleepiness. Similar research by [9] uses the first-order Hidden Markov Model to calculate the dynamics of the Bayesian network at various time slices and incorporates information like the contact physiological features such as the ECG and EEG. The results of the experimental validation demonstrate the usefulness of the suggested approach and suggest that the physiological characteristics of the contact particularly the ECG and EEG are important indicators for determining a driver's level of weariness.

Commercially accessible EEG sensors with a single channel can be used to measure driver awareness. Thus, the research utilized the MindWave Mobile2 gadget since it is lightweight, simple to use, and compatible with Bluetooth and Arduino.

Material and methods

1. MindWave Mobile 2

In this research a device MindWave mobile2 was used, as shown in figure 1. This is the MindWave Mobile2 from NeuroSky, an EEG headset that safely measures and transfers the power spectrum (alpha waves, beta waves, etc.) data via Bluetooth Low Energy or Bluetooth Classic to wirelessly communicate with the computer, iOS, or Android device. Simply slip this headset on to see the brainwaves change in real time with the MindWave Mobile 2 the user can monitor the levels of attention and relaxation.

Figure 1 NeuroSky MindWave Mobile 2.

2. HC-05 Bluetooth

The Bluetooth module, which is intended for transparent wireless serial connection setup, is an easy-to-use Bluetooth SPP Serial Port Protocol module. It can easily interface with a controller or PC with its serial communication protocol. as seen in figure 2.

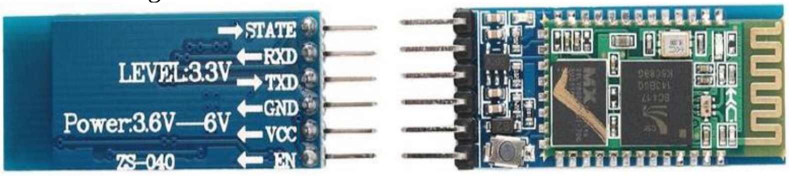

Figure 2 HC-05 Bluetooth**.**

3. Alarm unit

The alarm unit's buzzer serves as a warning indication, as seen in figure 3, when the driver begins to feel sleepy.

Figure 3 Buzzer.

4. Arduino Uno

Because there are fewer ports, the Arduino Uno was used. A microcontroller board based on the ATmega328 is called the Arduino Uno. It contains six analog inputs, a 16 MHz crystal oscillator, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything needed to support the microcontroller; the user can power it with a battery or an AC-to-DC adapter or connect it to a computer via a USB cable to get going. The FTDI USB-to-serial driver chip is not used by the Uno, in contrast to all previous boards [10]. As illustrated in figure 4.

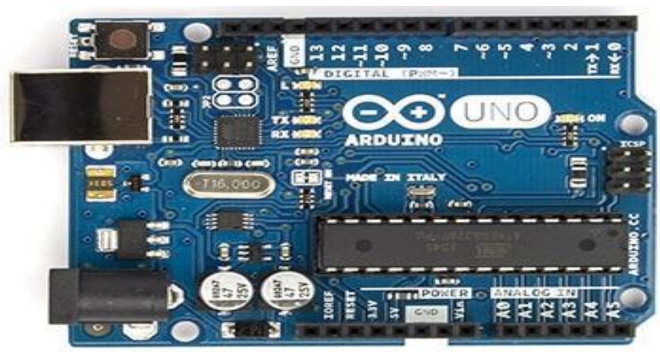

Figure 4 Arduino UNO**.**

5. Block diagram of system

Figure 5, shows the block diagram of the overall system.

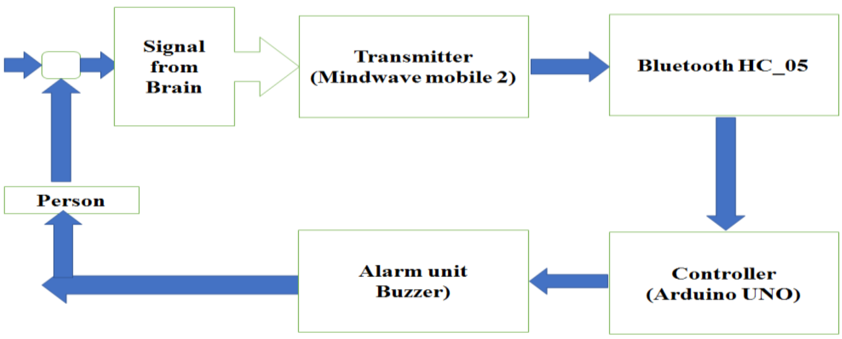

Figure 5 Block Diagram of the Overall system.

6. Flowchart of system

The figure 6, showed the flowchart of the system.

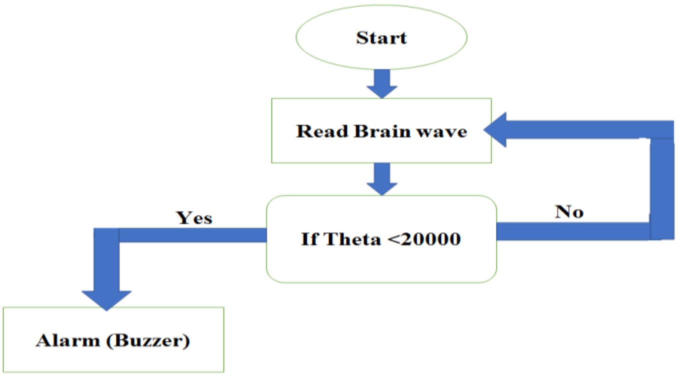

Figure 6 Flow chart of the system.

7. Connect HC-05 Bluetooth with Arduino

The following figure 7 shows the connection of Arduino with HC-05 Bluetooth.

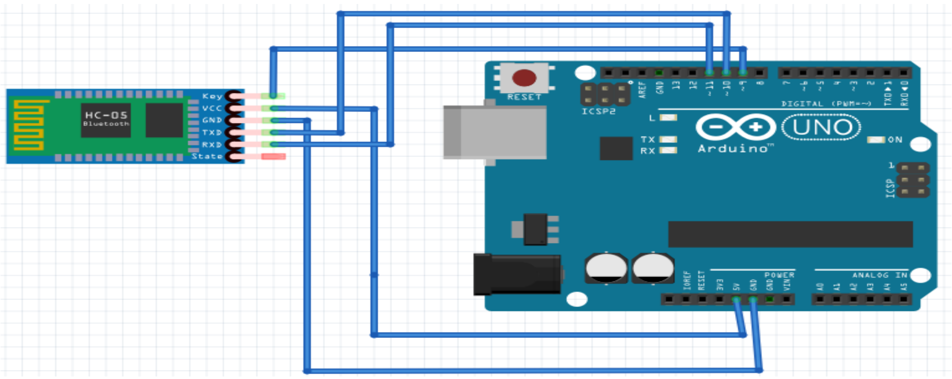

Figure 7 Connect Arduino with Bluetooth HC-05 Module.

Following the connection, use AT Command, which is a set of commands that one can use to reprogram the parameter of the HC-05 Bluetooth module, to be associated with NeuroSky MindWave mobile 2.

In the AT Command MindWave There is Unique Number which can obtained from connecting NeuroSky MindWave mobile2 with computer Bluetooth, the use can get the number from properties of MindWave Mobile 2 as in the following figure 8.

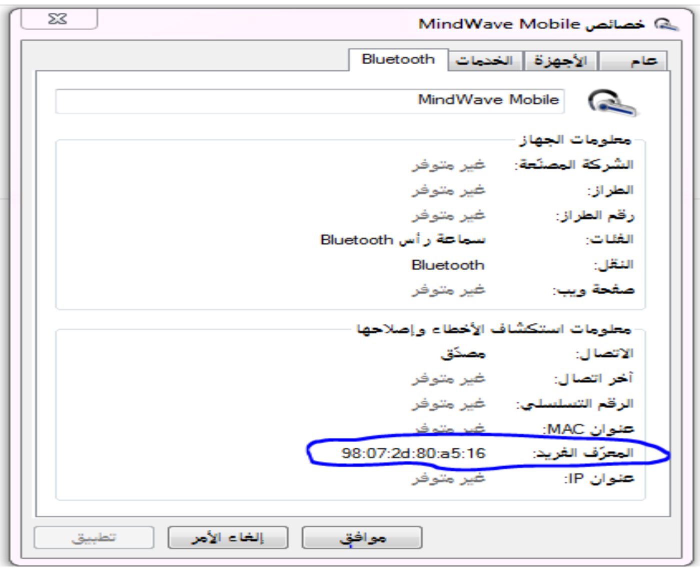

Figure MindWave Mobile 2 Unique Number.

Next, is linked the Arduino to the computer and launch the IDE software's Serial Monitor. From there, the user can configure the Bluetooth HC-05 by utilizing the AT instructions listed in table 1. (via the use of code unique to this system).

Table 1 AT Commands and Result.

Commands	Results
AT	OK
AT+UART=57600,0,0	OK
AT+ROLE=1	OK
AT+PSWD="1234"	OK
AT+CMODE=0	OK
AT+BIND="9807,2d,80a516"	OK
AT+IAC="9E8B33"	OK
AT+CLASS=0	OK
AT+INQM=1,9,48	OK

8. HC-05 Bluetooth connection settings with MindWave mobile 2

Figure 9 shows the HC-05 Bluetooth connection settings with MindWave mobile 2.

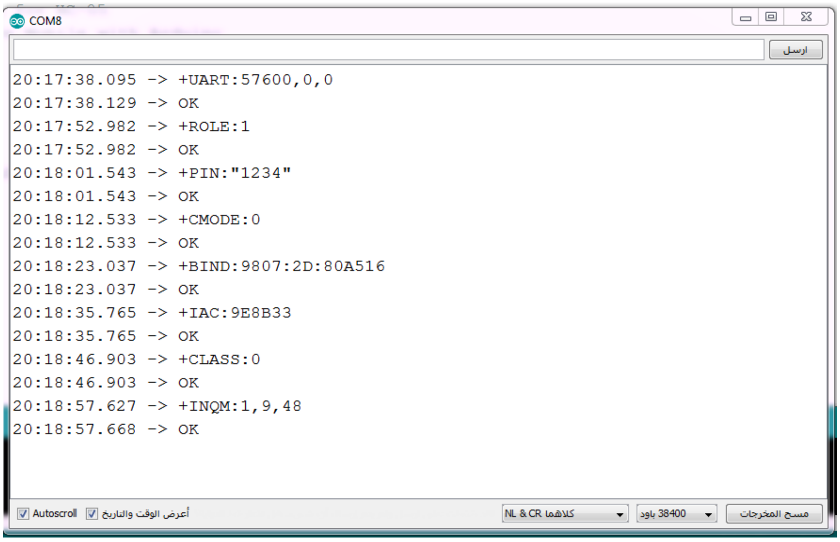

Figure 9 HC-05 Bluetooth connection settings with MindWave mobile 2.

Figure 10, shows the connection of the HC-05 Bluetooth with NeuroSky MindWave Mobile 2 and the buzzer's long leg (+) to pin 6 and short leg (-) to GND on the Arduino.

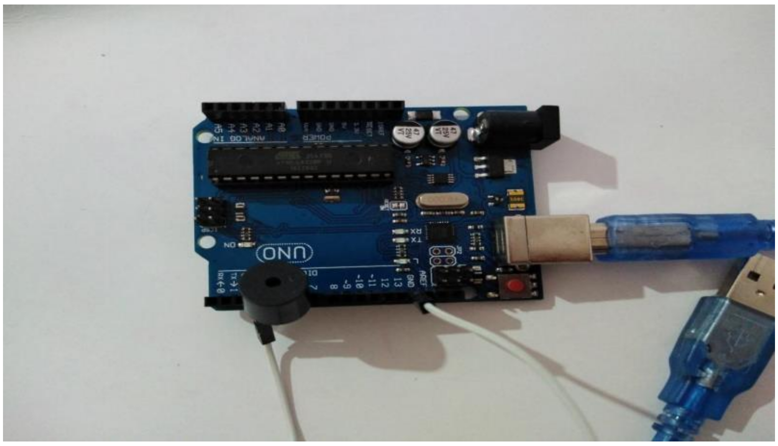

Figure 10 Connect the buzzer with Arduino**.**

All electronic parts are connected with Arduino Uno board, the following figure 11 shows the complete parts connections of the system.

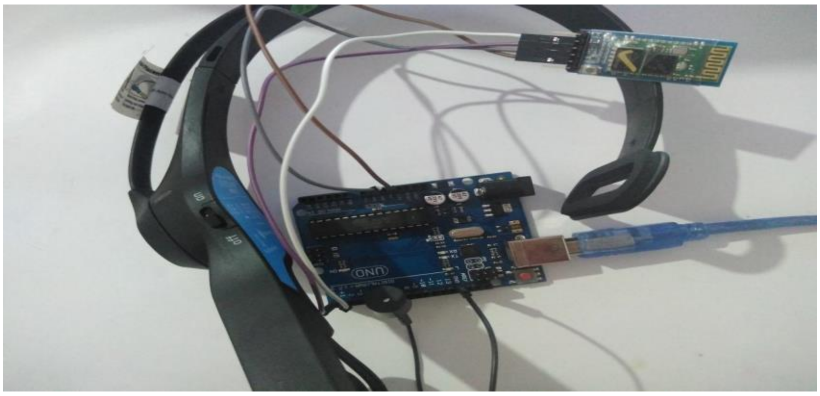

Figure 11 The complete parts connections of the system**.**

Results and discussion

Developing systems through the collaborative use of electronics and computing is made easier with the help of Arduino, an open-source and open hardware firm. Thanks to Arduino technology, computing systems may now create and implement solutions by directly integrating software and hardware. Analogously to a traditional computer, an Arduino board exhibits an input-output system that can handle various data kinds and execute many actions [11].

The development of EEG algorithms to detect exhaustion is one of the various fatigue countermeasure technologies that academics have been studying in recent years [12]**.** Additionally, EEG is one of the most accurate measures of exhaustion, according to [13]**,** and as such, it appears to be a viable fatigue countermeasure strategy [14].

For one minute, a sample of the three states' readings activity, tiredness, and sleep were obtained in each case. Each of the three cases in tables 2, 3, and 4 displays 61 readings from the sample because the total readings required more than 100 pages due to the large amount of data they included. The fact that the numbers are not constant and fluctuate suggests that brain activity varies moment to moment. However, we may determine the degree of drowsiness when we observe that the theta wave counts are fewer than 20,000.

Table 2 In the case of activity.

Time (Pm)	Theta value	Time (Pm)	Theta value	Time (Pm)	Theta value
19:52:18.434	34419	19:52:36.435	30202	19:52:54.450	1250
19:52:19.420	61967	19:52:37.421	50284	19:52:55.437	30057
19:52:20.440	22181	19:52:38.441	49821	19:52:56.409	22238
19:52:21.426	48935	19:52:39.428	34960	19:52:57.822	15448
19:52:22.446	56566	19:52:40.414	17234	19:52:58.822	40984
19:52:23.432	49897	19:52:41.468	41331	19:52:59.822	22701
19:52:24.418	3645	19:52:42.419	64468	19:53:00.440	50149
19:52:25.439	42694	19:52:43.439	45815	19:53:01.425	55803
19:52:26.436	44243	19:52:44.426	48324	19:53:02.446	63744
19:52:27.424	48978	19:52:45.445	45872	19:53:03.432	25101
19:52:28.443	20260	19:52:46.418	25847	19:53:04.452	48794
19:52:29.429	35407	19:52:47.449	59680	19:53:05.438	8568
19:52:30.449	64346	19:52:48.442	63412	19:53:06.424	37192
19:52:31.435	59348	19:52:49.427	1781	19:53:07.445	37192
19:52:32.455	15010	19:52:50.446	15886	19:53:08.431	52800
19:52:33.442	23008	19:52:51.444	22170	19:53:09.417	43522
19:52:34.428	31144	19:52:52.439	7190	19:53:10.437	26836
19:52:35.414	19649	19:52:53.428	39562	19:53:11.424	19004

Figure 12 shows the theta wave in the time. The data has taken from Table 2.

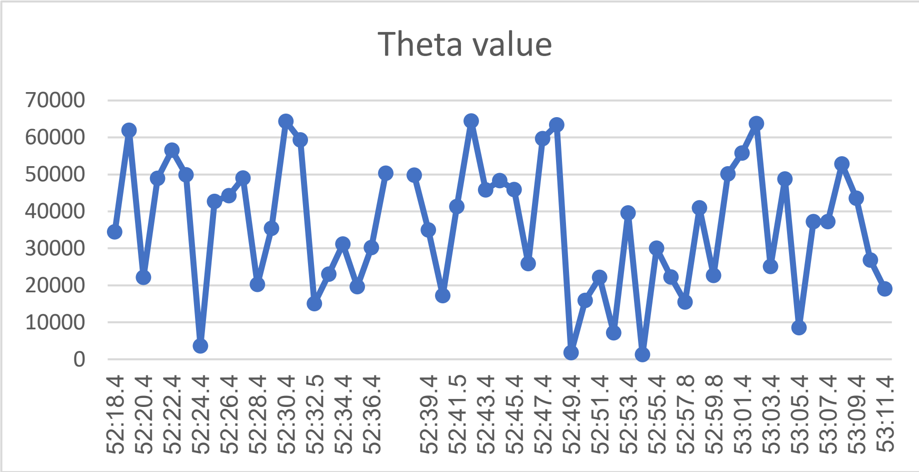

Figure 12: The theta wave from table 2.

Table 3 In case of drowsiness**.**

Time (Pm)	Theta value	Time (Pm)	Theta value	Time (Pm)	Theta value
00:42:10.910	2424	00:42:30.889	1828	00:42:50.871	12499
00:42:11.895	34155	00:42:31.915	44959	00:42:51.895	6745
00:42:12.888	12068	00:42:32.902	33760	00:42:52.888	55954
00:42:13.883	10748	00:42:33.887	732	00:42:53.873	22698
00:42:14.909	5681	00:42:34.881	28528	00:42:54.897	16682
00:42:15.895	42350	00:42:35.908	17066	00:42:55.894	52064
00:42:16.884	25681	00:42:36.893	18613	00:42:56.881	25744
00:42:17.908	7110	00:42:37.883	20600	00:42:57.911	28821
00:42:18.892	53228	00:42:38.908	8292	00:42:58.867	16102
00:42:19.911	52069	00:42:39.867	51082	00:42:59.893	39904
00:42:20.895	56521	00:42:40.886	11320	00:42:00.901	34556
00:42:21.887	1599	00:42:41.871	40970	00:43:01.884	10316
00:42:22.881	44887	00:42:42.897	31151	00:43:02.908	25041
00:42:23.871	7499	00:42:43.890	24315	00:43:03.893	38603
00:42:24.905	10071	00:42:44.874	19498	00:43:04.891	22911
00:42:25.892	1401	00:42:45.874	5682	00:43:06.891	28760
00:42:26.882	62368	00:42:46.903	41246	00:43:07.879	31677
00:42:27.907	46831	00:42:47.897	42101	00:43:08.906	38784
00:42:28.901	35903	00:42:48.886	39228	00:43:09.875	49797
00:42:29.864	63417	00:42:49.877	57515	00:43:10.910	2424

Figure 13 shows the theta wave in the time. The data has taken from Table 3.

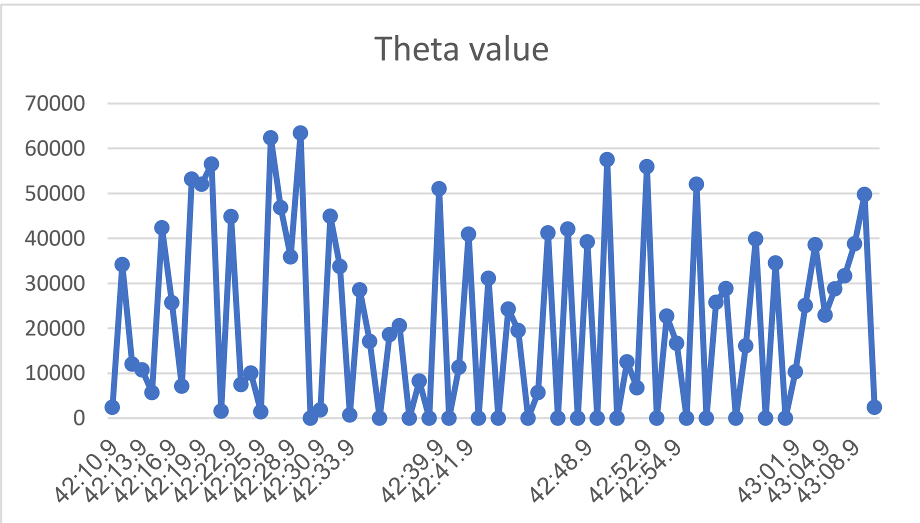

Figure 13 The theta wave from table 3.

Table 4 In case of Sleeping**.**

Time (Pm)	Theta value	Time (Pm)	Theta value	Time (Pm)	Theta value
14:57:19.857	7131	14:57:40.837	21043	14:58:01.840	58793
14:57:20.841	28364	14:57:41.836	23637	14:58:02.860	50595
14:57:21.833	15105	14:57:42.889	38721	14:58:03.861	19207
14:57:22.851	6874	14:57:43.842	34207	14:58:04.850	15180
14:57:23.841	18574	14:57:44.863	24518	14:58:05.844	21570
14:57:24.859	19620	14:57:45.860	33649	14:58:06.864	25199
14:57:25.845	36203	14:57:46.844	18635	14:58:07.851	50362
14:57:26.864	18947	14:57:47.864	10592	14:58:08.836	15163
14:57:27.849	25127	14:57:48.859	14910	14:58:09.856	31761
14:57:28.868	26629	14:57:49.845	15485	14:58:10.842	23449
14:57:29.852	18046	14:57:50.838	6946	14:58:11.851	14480
14:57:30.838	22671	14:57:51.847	10946	14:58:12.837	5036
14:57:31.864	29454	14:57:52.841	28429	14:58:13.862	25113
14:57:32.859	50367	14:57:53.861	15296	14:58:14.848	29752
14:57:33.844	21320	14:57:54.853	13190	14:58:15.834	13870
14:57:34.839	20888	14:57:55.846	59612	14:58:16.857	15775
14:57:35.859	23540	14:57:56.868	8365	14:58:17.847	28786
14:57:36.855	58690	14:57:57.854	11426	14:58:18.873	25758
14:57:37.839	46278	14:57:58.841	5976	14:58:19.858	56625
14:57:38.865	47825	14:57:59.861	14015	14:58:20.858	15757
14:57:39.851	592	14:58:00.847	47155		

Figure 14 shows the theta wave in the time. The data has taken from Table 4.

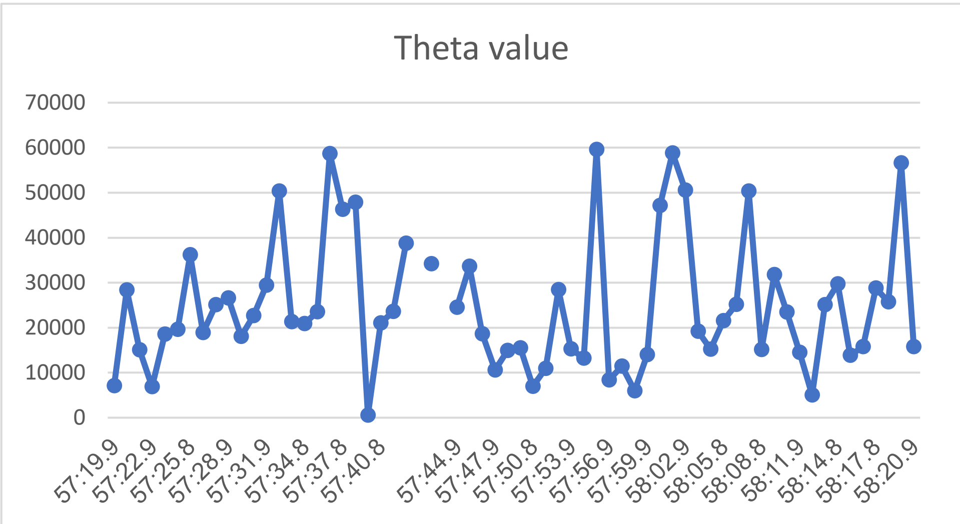

Figure 14 The theta wave from table 4**.**

According to [15]**,** The smallest and least expensive EEG headgear, the NeuroSky MindWave, can detect a user's level of sleepiness. While amusement and mental stimulation are the primary objectives, MindWave can also offer additional benefits when utilized appropriately. Low-beta and high-beta outputs from MindWave can also be used to identify sleepiness. The results of present study in table (2), showed the number of theta wave readings less than 20,000 is (13) represents the percentage (21.31%) and the average value of the theta (35922).
Moreover, in Table (3) an increase in the number of theta wave readings and its number (23) represents a ratio (37.70%) and the average value of the theta (27554), and notice an increase in the readings of the theta wave less than 20000 in the case of sleep indicated in table (4), its number is (28), a reading that represents (45.90%) and the average value of Theta (25143), which is the largest of the three readings.
In a related study, [14] measured the four EEG activities delta (δ), theta (θ), alpha (α), and beta (β) during a driving session that was monotonous for 52 participants 36 males and 16 females. The results showed that the conditions were stable for delta and theta activities over time, with a slight decrease in alpha activity and a strong decrease in beta activity. Furthermore, [9] show that contact physiological features particularly ECG and EEG are important indicators of a driver's level of weariness.

Conclusion

The conclusions reached through this research are summarized as follows:

1. Brain waves are electrical waves of certain frequencies. They work through the activity of neurons in the brain, which represent thoughts, feelings. And the Low frequency brain waves are often associated with relaxed state while higher frequency waves are associated with movements, and alertness.
2. EEG signal is a brain signal recorded from human scalp by using electrodes, and the Low-cost EEG devices such as the NeuroSky MindWave mobile 2 can be used to detect driver drowsiness.
3. NeuroSky MindWave mobile 2 device uses one dry electrode that is placed on the center of the forehead. These device's ability to integrate with open-source software's, and flexible script languages, such as MATLAB or Arduino, make them suitable candidates for further research in the detection of drowsing states.
4. The EEG raw data that is passed from the NeuroSky MindWave mobile 2 device is simply a measurement of the electrical potential that is occurring within the brain. The device samples this activity at a rate of 512 HZ.
5. Brain waves change rapidly, according to the activity that a person performs, and according to the sensations he feels.
6. Theta wave is what appears and measures drowsiness.
7. The more readings theta wave that is less than 20,000 increases the person's level of drowsiness and fatigue, and we notice that fatigue and drowsiness is inversely proportional to theta value.

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