ISSN:3032-1085

https://doi.org/10.61796/jmgcb.v1i4.408

# HEART RATE VARIABILITY BASED DRIVER DROWSINESS DETECTION

**Naba Ali Maktouf[1], Sajid Saleh Khalaf[2]**

[1,2] College of Engineering Technology, Middle Technical University

***Received: Feb 22, 2024; Accepted: March 29, 2024; Published: Apr 30, 2024;***

**Abstract:** Driver drowsiness may cause traffic injuries and death. Various methods have been given to detect drowsiness, for instance, image-based biometric-signals-based. In this project, a new approach using heart rate and head tilt is discussed. The aim of the project is to provide a device with simple components that enables the driver to save his life by avoiding accidents caused by frequent sleepiness by giving a sound alert (alarm), which forces the driver to wake up and regain control of the car This device is not considered a treatment for the problem of sleep, but rather a preventive tool from accidents daily the project was designed with simple components, the most important of which are (ECG sensor and acceleration sensor Arduino, alarm device). ECG sensor: it used to give an ECG signal to Arduino to analysis it. ADXL335 sensor: it is placed behind the driver's head. This sensor senses the fall of the driver's head when he sleeps. It was added to sense better.



## Introduction

Recently as the number of cars has increased rapidly, car accidents caused by driver inattention from the drowsiness has become a serious social problem. According to the U.S. National Highway Traffic Safety Administration, falling asleep while driving is responsible for at least 100 000 automobile crashes annually, leading to an annual average of roughly 40 000 non-fatal injuries and 1550 fatalities .Further, the National Sleep Foundation has reported that 60% of adult drivers drive while feeling drowsy and 37% have even actually fallen asleep during driving [1]. Several researches on developing drowsiness detection systems for drivers have been reported in the literature and proposed in the way of a non-intrusive monitoring these drowsiness detection methods can be categorized into two major approaches. Video recognition techniques using camera images have been used widely in the method this approach analyses the images captured by cameras to detect physical changes in drivers, such as eyelid movement, eye gaze, yawning and head nodding [2]. This vision-based method is not very accurate because it is severely affected by environmental backgrounds, driving conditions and driver activities. A few cases have been studied to monitor the condition of car drivers using biomedical signal measurement to detect driver's drowsiness. The biomedical signal measurement method to detect driver drowsiness has. DROWSINESS DETECTION CATEGORIES 1Vehicle based (2) Behavioral based (3) Physiological based. Vehicle based measures: A number of 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.

Behavioral based measures: The behavior of the driver, including yawning, eye closure, eye blinking, head pose, etc. is monitored through a camera and the driver is alerted if any of these drowsiness symptoms are detected. Physiological based measures: The correlation between physiological signals ECG and EOG. Drowsiness is detected through pulse rate; heart beat and brain information [3].

If car technologies are going to prevent or at least warn of driver fatigue, what symptoms does the driver give off that can be detected? According to research, there are multiple categories of technologies that can detect driver fatigue. The first is the use of cameras to monitor a person's behavior. This includes monitoring their pupils, mouth for yawning, head position, and a variety of other factors. The next of these technologies is voice recognition. Often a person's voice can give off clues on how fatigued they are. The detail explanation of the underlying techniques of drowsiness detection that are mostly used for the detection purpose [4]: Many researchers have considered the following physiological signals to detect drowsiness. (ECG), (EEG). (HR) also varies significantly between the different stages of drowsiness, such as alertness and fatigue. Therefore heart rate, which can be easily determined by the ECG signal, can also be used to detect drowsiness. 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. The Electroencephalogram (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.

Local binary patterns (LBPs) have aroused increasing interest in image processing and computer vision. As a nonparametric method, LBP summarizes local structures of images efficiently by comparing each pixel with its neighboring pixels[5]. The most important properties of LBP are its tolerance regarding monotonic illumination changes and its computational simplicity. This technique is mostly used for detecting emotions on the face like, happiness, sadness, excitement etc. LBP (local binary pattern) is used in drowsiness detection for detecting face of the driver, it divides the image into four quadrants then the top and bottom part are detecte Measured using steering angle sensor and it is a widely used vehicle-based measure for detecting the level of driver drowsiness. Using an angle sensor mounted on the steering column, the driver's steering behavior is measured. When drowsy, the number of micro-corrections on the steering wheel reduces compared to normal driving. Furlough and Graham found that sleep deprived drivers made fewer steering wheel reversals than normal drivers .To eliminate the effect of lane changes, the researchers considered only small steering wheel movements (between 0.5° and 5°)[6]. Which are needed to adjust the lateral position within the lane? In general, steering behavior is influenced by characteristics of the driving task (e.g. speed, curvature, and lane width), driver traits (e.g. driving experience), and driver states (e.g. Laxness, distraction or fatigue). Drivers are constantly judging the situation ahead and applying small, smooth, steering adjustments to correct for small road bumps and crosswinds by turning the steering wheel in small increments. The most common implementation of an optical sensor system uses infrared or near-infrared LEDs to light the driver's pupils, which are then monitored by a camera system. Computer algorithms analyze blink rate and duration to determine drowsiness. The camera system may also monitor facial features and head position for signs of drowsiness, such as yawning and sudden head nods. Depicts the use of optical detection system[7,8]. In this eye blinking rate and eye closure duration is measured to detect driver's drowsiness. Because when driver felt sleepy at that time his/her eye blinking and gaze Between eyelids are different from normal situations so they easily detect drowsiness. In this system the position of irises and eye states are monitored through time to estimate eye blinking frequency and eye close duration. And in this type of system uses a remotely placed camera to acquire video and computer vision methods are then applied to sequentially localize face, eyes and eyelids positions to measure ratio of closure Using these eyes closer and blinking ration one can detect drowsiness of driver. Such a system, mounted in a discreet corner of the car, could monitor for any signs of the head tilting, the eyes drooping, or the mouth yawning simultaneously [9,10].

Vital signs are the most effective way to detect drowsiness in this project. The ECG sensor was used to detect fluctuations in the driver's heartbeat, as it is known that the ECG sensor maps the electrical heart signal with the possibility of displaying it. As for the heartbeat, it will be obtained by Detection of the R wave of the heart signal that will be extracted, where the normal pulse rate ranges from 60 to 100 and drops below 60 in other cases, including drowsiness. When this low pulse rate is detected by the sensor, a warning sound will be sounded to the driver by using another component (the buzzer) [11,12]. The use of another sensor is the tilt sensor, as it is known that the head when drowsy may tilt at a certain angle, and a certain angle has been considered as an indicator of drowsiness, and upon reaching this angle also, a warning sound will be sounded so that the driver can regain focus and regain control steering wheel.

## Methods

The electrical heart signal produced by the heart is given in picture bellow:

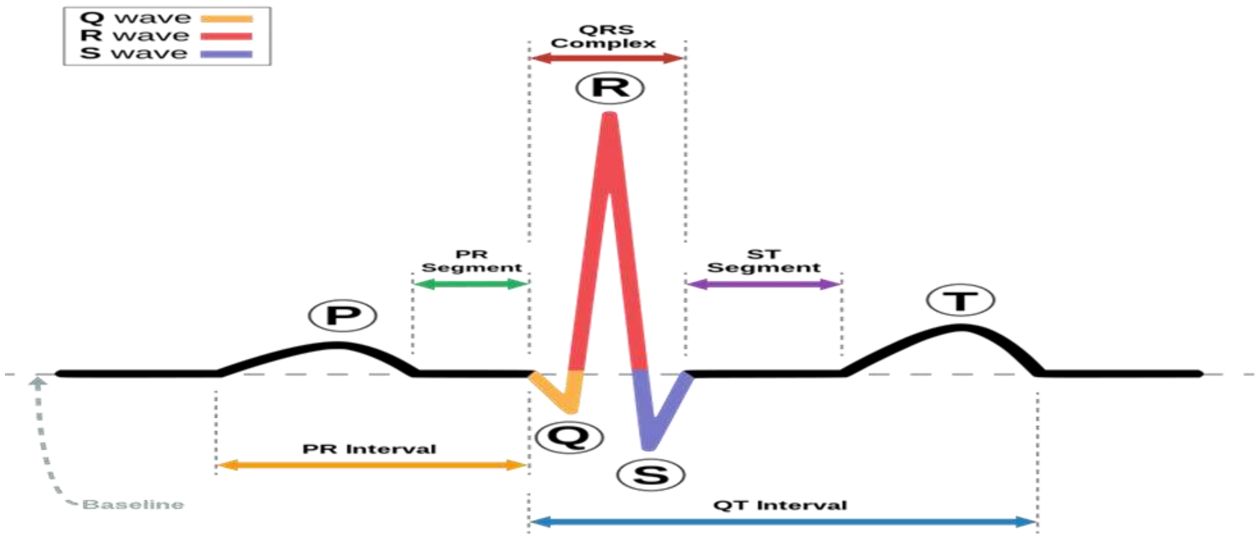



FIGURE1. The heart signals.

1-The p wave: It is the first wave that appears and indicates the depolarization resulting from the passage of an electric current in both the right and left atrium. The extent of the wave's height indicates the strength of the exerted effort, and the wave's width indicates the period it takes for that. Its range ranges from 0.08-0.12.

2-The Q wave: This wave indicates the depolarization resulting from the passage of an electric current on the inter ventricular septum. There is difficulty in determining it because it is very small. Its range is (0.3-0.4 sec).

3-The R wave: The highest wave in terms of intensity and the lowest time. It is considered one of the most important waves as it indicates the depolarization of both the right and left ventricles. Its range is about (0.05-0.08 sec).

The time period between the P wave and the R wave expresses the time taken by the current from the starting point of the p wave until the starting point of the R wave, that is, from the beginning of depolarizing the cells of the atria until the current reaches the ventricles. Its range ranges from (0.12-0.20 sec).

4-The S wave: It represents depolarization in the remaining part of the base of the left ventricle, the base of the right ventricle, and the upper part of the ventricular diaphragm. It is always negative and ranges between (0.3-0.8sec).

5-The T wave: represents ventricular repolarization and thus diastole of the ventricles to fill with blood and its average duration is 0.2sec.

The time between the S wave and the T wave represents electrical rest, during which the ventricles wait for repolarization.

## HEART RATE CONCEPT

The number of times your heart beats per minute.

The wave generated in the arteries as a result of the contraction of the heart, which is called the heartbeat.

The resting heart rate for adults ranges between 60 and 100 beats per minute. In general, a lower resting heart rate indicates more efficient heart function and better cardiovascular health. For example, a normal resting heart rate for a well-trained athlete might be around 40 beats per minute. The heart rate during sleep It was found that the heart rate naturally decreases during sleep from the normal position, as it may range between (45-55) beats per minute. If the driver's heart rate drops to this range, this indicates that he has entered the sleep stage, so our device will alert the driver to wake him up.

Calculate heart rate

Heart Rate=60/(RR Interval (in second))

Peak detection in ECG detects R-R in a specific time (it uses to calculate heart rate from ECG signal in Arduino). We use peak detection(R-R) to detect heart rate from ECG signal.

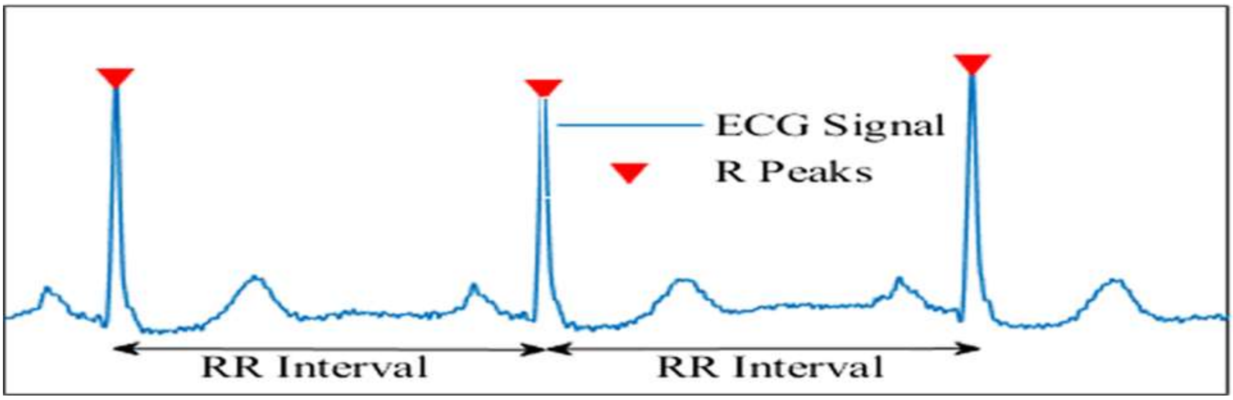



FIGURE2. R-R interval detection.

2.3 PEAK DETECTION FOR DATA VISUALIZATION

Peaks are spike-shaped patterns in time series data. Detecting them is often useful, since peaks can represent anomalies and sudden events. Peak detection can be put to good use in data visualization where it can direct attention to areas of potential value.

2.4 SYSTEM MODULE

The proposed system includes an AD8232 ECG Sensor and ADXL335sensor, buzzer and Arduino Uno R3 as shown in the figure [3]. The ECG sensor includes a set of electrodes. It is placed in its designated places in the body to calculate the pulse correctly, and the inclination sensor is placed behind the head to calculate the angle of inclination. The two sensors are connected to the Arduino through a specific code the pulse and the angle of inclination are calculated and a warning is given to the driver through the buzzer.

FIGURE3. Block diagram for proposed system

## .Results and Discussion

The purpose of the device is to find a solution to get rid of the driver's drowsiness while driving. This device is not considered a treatment, but rather a preventive tool

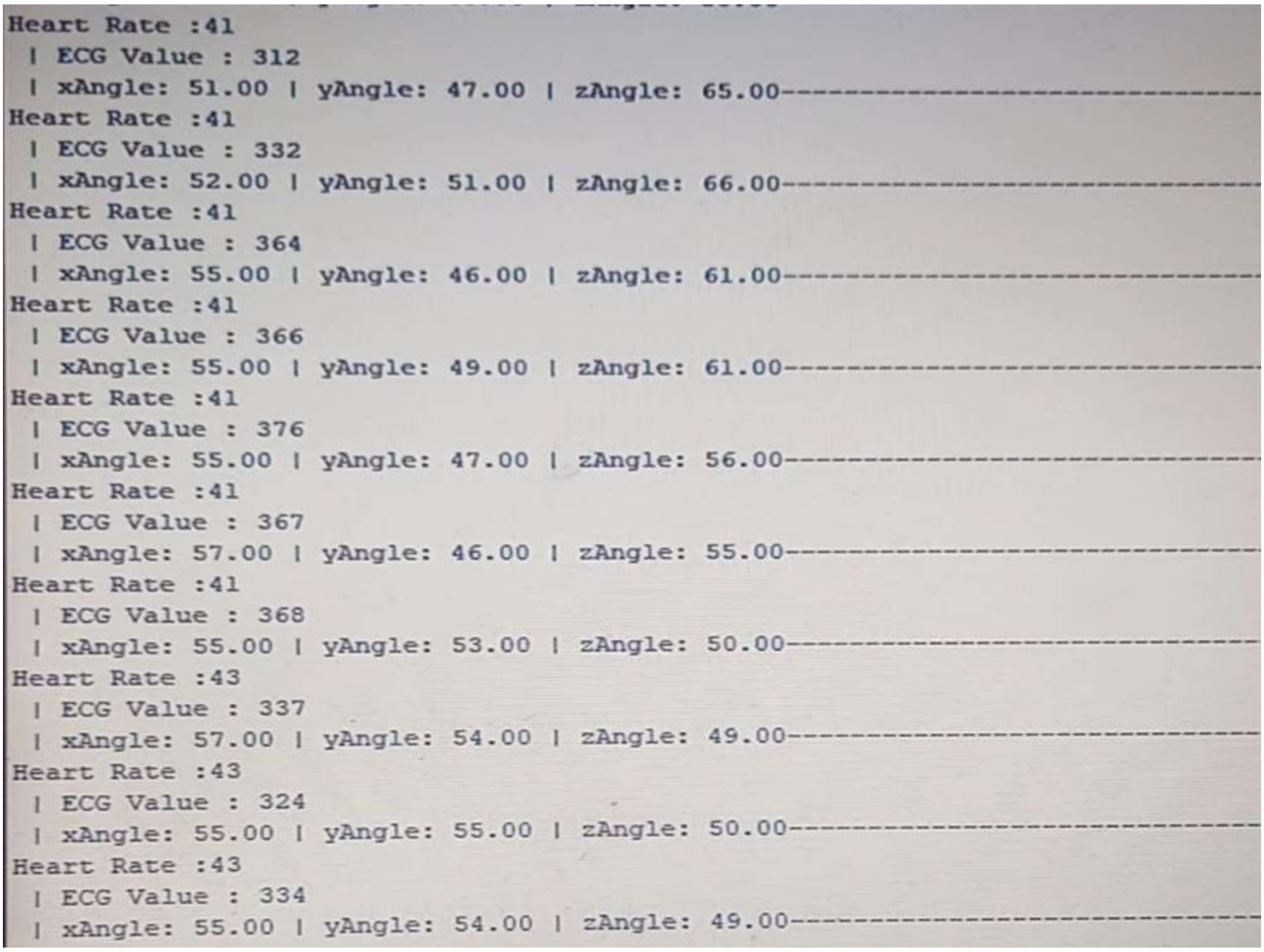
After operating the device, we will obtain a set of results regarding the heart rate and the angles of inclination in the normal state and in the case of drowsiness in the figure (a)we will obtain of the heart rate of the person and the angles of inclination of his head before drowsiness (in the normal state). The normal values of the pulse are from (60 to 100) beats per minute. in Figure (a) We note the heart rate values of the person 89 beats per minute, and this is considered a normal value for the heart rate and the alarm will be off, the heart rate can increase or decrease depending on the emotions and movement of the person or the movement of the electrodes, but the rate values must remain within the normal range from (60 to 100) beats per minute. In the case of drowsiness, it decreases heart rate values less than 60 beats per minute in the figure (b) we notice the pulse values ranging from (41 to 55) beats per minute. Also, the angles of inclination of the head in relation to the angles of the X axis should be greater than 45, the angles of the Y axis should be greater than 50, and the angles of the Z axis should be greater than 45 of these values, it is considered an indication of the driver's drowsiness. When these values are reached with a low rate of heart, an alarm will start so that the driver can get rid of drowsiness and regain control of driving. A very important note regarding the results of the inclination angles in Figure (a) and Figure (b) [13,14].

The driver's head is in a state of continuous motion while driving and may move for reasons beyond drowsiness, so the range of values read by the tilt sensor is in a state of continuous change, so we notice that there are close values between figure (a) and figure (b) [15]. Therefore, according to the condition mentioned in the code, the angle of the X-axis must be greater From and the angle of the Y axis is greater than and the angle of the Z axis is greater than at the same time that the pulse decreases until the alarm device starts working and the axes reach the inclination values, but in the case that the pulse is normal, it is not sufficient to trigger the alarm device [16,17].


FIGURE 4.The resuilts. (a) Heart rate values and head tilt angles before sleepiness (in the normal state)

-Normal heart rate values (60 to 100) beat per minute.

-The alarm is off



```
Heart Rate :41
 | ECG Value : 312
 | xAngle: 51.00 | yAngle: 47.00 | zAngle: 65.00--------------------------------
Heart Rate :41
 | ECG Value : 332
 | xAngle: 52.00 | yAngle: 51.00 | zAngle: 66.00--------------------------------
Heart Rate :41
 | ECG Value : 364
 | xAngle: 55.00 | yAngle: 46.00 | zAngle: 61.00--------------------------------
Heart Rate :41
 | ECG Value : 366
 | xAngle: 55.00 | yAngle: 49.00 | zAngle: 61.00--------------------------------
Heart Rate :41
 | ECG Value : 376
 | xAngle: 55.00 | yAngle: 47.00 | zAngle: 56.00--------------------------------
Heart Rate :41
 | ECG Value : 367
 | xAngle: 57.00 | yAngle: 46.00 | zAngle: 55.00--------------------------------
Heart Rate :41
 | ECG Value : 368
 | xAngle: 55.00 | yAngle: 53.00 | zAngle: 50.00--------------------------------
Heart Rate :43
 | ECG Value : 337
 | xAngle: 57.00 | yAngle: 54.00 | zAngle: 49.00--------------------------------
Heart Rate :43
 | ECG Value : 324
 | xAngle: 55.00 | yAngle: 55.00 | zAngle: 50.00--------------------------------
Heart Rate :43
 | ECG Value : 334
 | xAngle: 55.00 | yAngle: 54.00 | zAngle: 49.00--------------------------------
```

(b) Heart rate values and head tilt angles during sleepiness (in the abnormal state)

-Abnormal heart rate values less than 60 beats per minute.

-(X>45,Y>50,Z>45)

## Conclusion

The ECG signal capability contributing to the daily application continues to evolve day by day. With the advancement of technology, ECG points to potential as a potential mechanism towards a sleepiness detection system. Driver drowsy is a state between sleep and wakefulness due to body fatigue while driving. This condition has become a common problem leading to road accidents and death. It has been proven in previous studies that biological signals are closely related to a person's reaction. Electrocardiogram (ECG) is an electrical indicator of the heart, and it provides benchmarks because it reflects the activity of the heart that can detect changes in human response that relate to our emotions and reactions

## References

[1] Marco Javier Flores • José María Armingol • Arturo de la Escalera.: Real-Time Warning System for Driver Drowsiness Using Visual Information. In: Springer Science + Business Media B.V. 2009.

[2] Luis M. Bergasa, Jesús Nuevo, Miguel A. Sotelo, RafaelBarea, and María Elena Lopez.:Real-Time System forMonitoring Driver Vigilance. In: ieee transactions on intelligent transportation systems, vol. 7, no. 1, march 2006.

[3] Mohamad-Hoseyn Sigari, Mahmood Fathy, and Mohsen Soryani.: A Driver Face Monitoring System for Fatigue and Distraction Detection. In: Hindawi Publishing Corporation International Journal of Vehicular Technology, Volume 2013, Article ID 263983, 11 pages.
[4] Jay D. Fuletra, Bulari Bosamia: A Survey On Driver's Drowsiness Detection Techniques presented at IJRITCC in November 2013.
[5] Ming-ai Li, Cheng Zhang, Jin-Fu Yang. :An EEG-based Method for Detecting Drowsy Driving State. In: Fuzzy.
[6] J. Zulley, R. Popp, Mudigkeit im Straßenverkehr, ADAC e.V. M ¨ unchen, Artikelnummer 2831141, M ¨ unchen, 2012. ¨
[7] M. Goncalves, R. Amici, R. Lucas, T. Akerstedt, F. Cirignotta, J. Horne, D. Leger, W. T. McNicholas, M. Partinen, J. Teran-Santos, P. Peigneux, L. Grote, C. National Representatives as Study, Sleepiness at the wheel across europe: a survey of 19 countries, J Sleep Res 24 (3) (2015) 242– 53. doi:10.1111/jsr.12267.
[8] M. N. Rastgoo, B. Nakisa, A. Rakotonirainy, V. Chandran, D. Tjondronegoro, A critical review of proactive detection of driver stress levels based on multimodal measurements, ACM Computing Surveys 51 (5) (2018) 1–35. doi:10.1145/3186585.
[9] D. Riemann, E. Baum, S. Cohrs, T. Cronlein, G. Hajak, E. Hertenstein, P. Klose, J. Langhorst, G. Mayer, C. Nissen, T. Pollm ¨ acher, S. Rabstein, ¨ A. Schlarb, H. Sitter, H.-G. Weeß, T. Wetter, K. Spiegelhalder, S3-leitlinie nicht erholsamer schlaf/schlafstorungen, Somnologie 21 (1) (2017) ¨ 2–44. doi:10.1007/s11818-016-0097-x.
[10] R. McKenzie and C. Seago, ''Assessment of real losses in potable water distribution systems: Some recent developments,'' Water Sci. Technol. Water Supply, vol. 5, no. 1, pp. 33–40, 2005.
[11] D. Misiunas, ''Failure monitoring and asset condition asssessment in water ¯ supply systems,'' in Proc. 7th Int. Conf. Environ. Eng., no. 2, 2008, pp. 648–655.
[12] Suruhanjaya Perkhidmatan Air Negara. (2016). Non Revenue Water (NRW). [Online]. Available: http://www.span.gov.my/index.php/en/ statistic/water-statistic/non-revenue-water-nrw-2016.
[13] Agung M. A and Basari 2017 AIP Conf. Proc. 1817 040015.
[14] World Health Organization 2000 The World Health Report 2000: Health Systems: Improving Performance (Jenewa: World Health Organization).
[15] Meijs L P B, Galeotti L, Pueyo E P and others 2014 Americ. J. of Phys.-Heart and Circulatory Phys. 00419.
[16] Shaw L J, Xie J X, Phillipsand L M and others 2016 Heart Asia 8 1-7 .
[17] T. Hwang, M. Kim, S. Hong, and K. S. Park, "Driver drowsiness detection using the in-ear EEG," 2016 38th Annual Interna