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IoT Based Wearable Device Monitoring Driver's Stress, Fatigue and Drowsiness

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Abstract – Driving in the most stressful environments such as high traffic which is correlated with high degree of accidents should be avoided, so the measuring of stress, fatigue and drowsiness is done. This paper is focused to develop a wearable device to monitor the driver's abnormal conditions such as stress, fatigue and drowsiness. Physiological sensors embedded device becomes ubiquitous in the growing Internet of Things (IoT). In this study, we focus on heart beat and eye blink monitoring to develop an efficient and robust mechanism for stress and drowsiness identification. Using machine learning algorithms from the heart rate signals alone, we could achieve 90% accuracy in detecting the stress. Preprocessing is achieved to distinguish valid signals from noise. By using our system, we can provide solutions in early stage of the abnormal conditions.

Index Terms – drowsiness, fatigue, heartbeat, Internet of Things (IoT), machine learning algorithms, physiological signals, stress, wearable device.

1 Introduction

According to the National Highway Traffic Safety Administration (NHTSA), lack of attention while driving is found to be a major cause of accidents [1]. There is no predefined device to measure the physiological conditions resulting in the integration of several sensors to measure the stress index [2], which measures internal conditions such as heart rate and eye blink. The analysis of accidents shows that close monitoring of driver's internal conditions is the considerable method to improve the handling of such situations.

To predict the heart rate and eye blinking rate of the drivers, methods based on vision or physiological signals are used. In vision based methods, cameras are used to monitor the driver's distractions such as head movements, facial expressions and image processing is done on the images captured by the cameras to analyze the driver's conditions [3][4]. In physiological methods, abnormal conditions are monitored by changing in the signals according to the conditions. These methods are not sensitive to environmental conditions such as lighting and wearing of glasses [5].

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In this study, we are detecting the datasets from real time monitoring of driver's heart rate and eye blink using two analog sensors. The heart rate is detected using heart rate sensors embedded in the hand clip device and the eye blink is detected using eye blink sensors in wearable glasses. In many other studies, ECG and EEG signals are used instead of heart rate sensors but there occurs the inconvenience of using a measurement device. To solve this problem, we opt with wearable glasses and clip [6] [7].

With the using of wearable device, we apply machine learning methods and algorithms to detect the stress from heart rate signals under stressful environment [8]. We find that stress levels can be easily monitored using this sensor with high level of accuracy. Feature extraction performed using Net Beans Java platform to produce the required tabular format for analytics. For analysis, we are using K-Means clustering and Naïve Bayes classification [9].

These classifications and clustering algorithms are implemented in the R programming studio platform which provides the efficient results for the analysis of driver's conditions [10]. The clustering algorithms are used to predict the normal and abnormal data from the processed data. The classification algorithms are used to provide solution to the abnormal data based on certain conditions. The solution is provided to either the vehicle owners or nearby vehicle service centers in case of stress detections and music playing in the vehicle's music player in case of drowsiness. The music playing alert is chosen to avoid the panic of passengers.

2 RELATED WORK

Shabnam Abtahi, Aasim Khurshid, Muhammad Farhan, Behnoosh Hariri, Daniel Laroche, and Luc Martel proposed" yawning detection using embedded smart cameras" to detect the driver fatigue yawning detection is one of the main component. They design and implement this system using vision based method. They use embedded smart cameras to detect yawning. Viola jones algorithm is used for mouth and face detection. A camera is used to acquire an image of physical scene and the image is processed. The camera must be installed under the front mirror. This embedded system detects the face location by analyzing face movement.

Arun Sahayadhas, Kenneth Sundaraj and Murugappan proposed "detecting driver's drowsiness based on sensors: a review" to detect driver drowsiness which is a major factor for accidents. It is determined based on three measures such as vehicle based, physiological measures and behavioral measures. This detection is useful in the situations where the driver drives at late night or midafternoon, driver is alone high speed roadways etc. The criteria to be considered are blood alcohol level, vehicle has no mechanical defect, good weather. Drowsiness greatly depends on rate of last sleep, increasing duration of driving task. They used EOG and eye blink sensor for detecting the drowsiness.

Stephan Muhlbacher-karrer , Ahmad Haj Mosa, LisaMarie Faller, Mouhannad Ali, Kyandoghere Kyamakya proposed "a driver state detection system-combining a capacitive hand detection sensor with physiological Sensors" to detect and monitor both hand touch and position on steering wheel using capacitive hand detection sensor. The CHDS sensor is integrated in the steering wheel of the vehicle to monitor the position and touch. The electro dermal activity (EDA) sensor measures skin's ability to conduct electricity, which increases if the skin is sweaty. ECG sensor for measuring the electrical activity of heart and EEG sensor for monitoring the brain waves. Integrating both the sensors result in better accuracy. In future, the measurement of physiological signals with a sensor embedded in a driver set will be more convenient for the user.

Steven S. Beauchemin, Michael A. Bauer, Taha Kowsari, Ji Cho proposed "portable and scalable vision based vehicular instrumentation for the analysis of driver intentionality" to detect driver's visual attention which is central part of safe driving, ocular patterns accompanied by regular saccades for analysis of visual behavior and correlate with driver attention. Layer approach for vehicle instrumentation is used. Layer 1 uses instrumentation, layer 2 has device level data processing, layer 3 has data fusion and integration and layer 4 has predictive behavioral model. The advantage is that vehicle from different manufacturers is easily communicated. High level protocols can be used with network and sensor based technology.

Zheren Ma, Brandon C. Li, and Zeyu Yan proposed "wearable driver drowsiness detection using electrooculography signals "to detect driver drowsiness using three measures-vehicle based measures, behavioral measures and physiological measures.This system measures the Electrooculography (EOG-corneorential that exist in the front and back of the human eye) and transmit this signal to phone. Based on the prediction algorithm, this system alerts the user by making alarm on the phone. The main process of this system is to measure the signal, process the signal, transmit the signal and make an alarm.

3 EXISTING SYSTEM

One of the main reason for accident is stress which degrades the driving performance of the driver. In existing system, there is no device to detect / predict the driver stress and driving efficiency. In existing system, they have proposed to detect drowsiness, stress and fatigue conditions of the driver, based on vision based methods and physiological signals.

The vision based methods uses cameras and image processing to monitor the eye lid, head movement, and facial expression of the driver [3] [4]. However, sensitivity to environmental factors, such as lighting conditions and the wearing of glasses, is a major problem that must be solved. This method can detect a condition only after it begins to show on face [5] [11]. It is one of the main disadvantage in this vision based method.

To avoid this problem method based on physiological signal to detect abnormal conditions was introduced. Early detection is possible in this method. Physiological signals must overcome the inconvenience of using measurement device, and solve the problem of inter driver variance in responses.

To detect driver's fatigue, the spectral image of heart rate is used from ECG [12] which is already implemented in other system. In many other studies, EEG, EOG is used to detect drowsiness based on physiological method [5] [13] [14]. While

measuring the physiological signals, the method called preprocessing is introduced to check the quality of the signal. It's mainly used to check the reliability of the measured signal and decide whether a particular signal part is used or not. for preprocessing the existing system use PPG sensor.

The existing system, uses three part to acquire the data

1) normal 2) stress 3) drowsy state

The drowsiness can be detected by an ECG signals through conductive fabric on the steering wheel. To detect fatigue, they used capacitive sensors on seat. They used capacitive hand detection sensors to detect stress. They used SVM (support vector machine) classifier algorithm for the detection purpose. The main problem in this classifier, it contains several key parameters.

4 PROPOSED SYSTEM

In real-time environment, the goal is to predict upcoming levels of stress based on current levels of stress, driving actions and road conditions. The proposed system is to detect driver stress and driver pupil dilation. For this we used heartbeat sensor and eye blink sensor as input. Predicting the driver stress can be detected and resolved through the application of big data technique (R Programming).

In this project, we proposed heartbeat sensor and eye blink sensor to detect driver stress and driver pupil dilation. The real sensor data are transmitted into systems using COM port and these real time data are obtained using Net beans and saved in SQLYOG database which is intelligent interface to MYSQL.

The heartbeat sensor data are stored in public cloud storage namely Cloud Me. Cloud Me involves storage and sync solution which allows the users to store, access and share their content among various users outside the service. This platform is used for the storage of detected driver's heart rate and eye blink signals.

The real time data can be monitored by the travel owner / travel agency / bus service center. The real time data are processed from Net beans and imported as an excel file and transmitted to R programming studio for analytics.

Here, the real time analysis of driver's data such as heartbeat rate and eye blink is done using Machine learning algorithms such as classification and clustering.

In R programming platform, clustering and classification are processed and solution is provided. For clustering, we use k-means clustering and for classification, naive Bayes algorithm is used.

The accuracy of the solution is improved by means of using naïve Bayes which involves the probabilistic analysis with strong independent assumptions. The k-means clustering involves the partition of huge volume of data in the simple way. The website is designed to view the driver's data from anywhere and anytime to facilitate the administrators for effective analysis.

5 BLOCK DIAGRAM

5.1 EYE BLINK SENSOR

The eye is irradiated using the IR led, which accommodate +5v power supply and the reflected light is take down by an IR photo diode. This eye blink sensor is IR based; the variation across the eye will vary as per eye blink.

5.2 HEART BEAT – CLIP TYPE

Heart rate ear clip kit contain a finger clip and a receiver module. This device picks up your heart's signals from your fingertip and transfers that data into your mac or android device. The entire system has a highly sensitivity, effectively power utilized and is portable. This device picks up your heartbeat signals from your finger tip and transfers that data into your mac or android device.

5.3 DATA COLLECTION USING JAVA

Java developers provide an API to facilitate the serial communications. In order to make the API portable across platforms, the API defines an abstract Serial Port class. This class is then sub classed and platform specific functionality is implemented in the sub classed object.

5.4 CLOUD STORAGE

Cloud storage is a platform for storage where the digital data is stored in logical pools, these providers are responsible for making the data available and accessible, and the physical environment protected and running.

5.5 DATA ANALYTICS

R is an open source programming language used for statistical analysis of acquired data, graphics representation and reporting.

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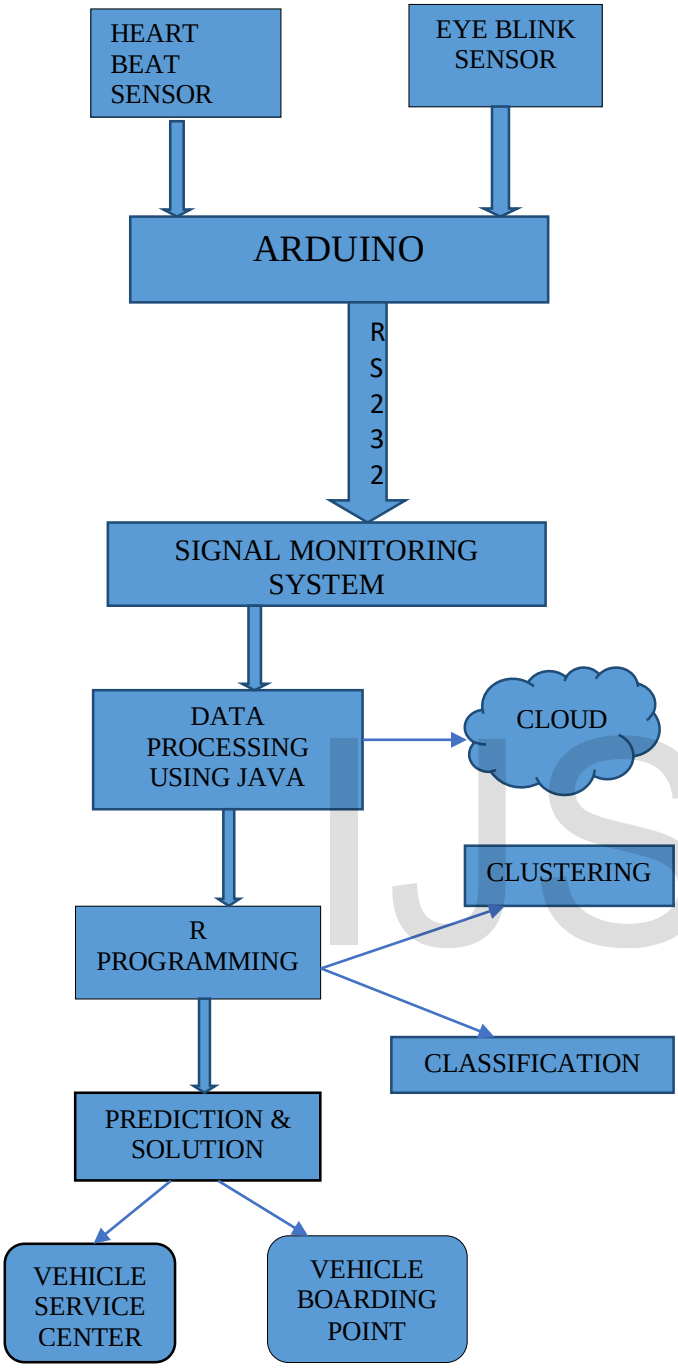

Fig 1. Architecture diagram

6 ALGORITHM

6.1 K MEANS CLUSTERING

K Means is one of the important algorithms used in machine learning analysis. The data from the cloud storage is imported into R programming studio where the clustering of heart rate data is done.

1. The driver's data is collected as n objects.

2. The collected objects (data) is partitioned into number of subsets.

3. Identify the centroid value for each subset.

4. Assign each object to a specific clusters based on the distance value calculated between the objects.

5. Each object is included in the cluster based on minimum distance. After all reallocations, new centroid is assigned for each cycle.

D= {x1, x2 …xi…xm} a data set of m records.

xi= (xi, xi2…Xin) each record is an n-dimensional vector.

$$C_j = \text{Cluster}(X_i) = \arg_j \min || X_i - \mu_j ||^2$$

$$\text{Distortion} = \sum_{i=1}^{m} (x_i - c_i)^2 = \sum_{j=1}^{k} \sum_{i \in \text{OwnedBy}(\mu_j)} (X_i - \mu_j)^2$$

(within cluster sum of squares)

6.2 NAÏVE BAYES CLASSIFICATION

Here, we have a training set of driver's heartbeat data, now we need to classify whether the driver is able to drive or not.

1. Convert the data set into frequency table.

2. Create the likelihood table by predicting the probability of driving and not driving.

3. By using Bayesian equation, posterior probability is calculated for each class. The class with highest probability is the outcome for prediction.

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7 IMPLEMENTATION

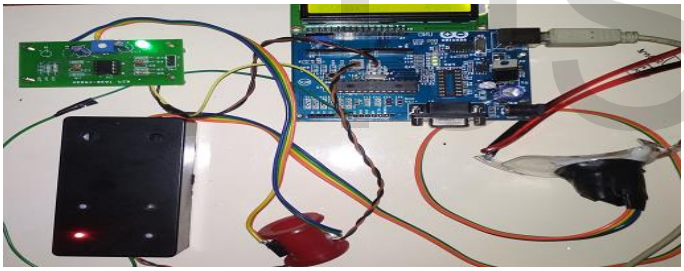
7.1 DATA

The heartbeat and the eye blink signals of driver's data were collected from various sensors (eye blink and heartbeat sensors). The datasets are segmented into two stress levels- low and high. The collected data is sent to the microcontroller through the COM port and the real time data are obtained using Net Beans saved in SQL database. The collected data is stored in the public cloud namely Cloud me. The signal classification was carried out by considering the variations in the eye blink and heartbeat signals.

7.2 FEATURE EXTRACTION

Feature Extraction was performed to extract different features from the annotated heart beat and eye blink signals using Net Beans Java Platform to produce the required Excel file format for classification in R studio environment for Knowledge Analysis. All possible signal attributes and their relations are considered for feature extraction.

7.3 EXPERIMENTAL SETUP



Heart beat sensor is a clip type device which is used to detect the heart rate of the driver. The change in heart rate can be monitored by the heart beat pulse which cause variation in the flow of blood. Eye blink sensor is a glass type wearable device based on IR. This is mainly used to detect the closing and opening position of eye.

The Arduino Uno is a microcontroller board. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog input pins out of one pin is used for heart beat input and one pin used for eye blink sensors obtained from the analog sensors. The ADC converter in Arduino Uno is used to convert analog signal into digital signals.

The purpose of cloud is to store the data and information on physical or virtual servers, which is maintained by a cloud storage provider. They are responsible for keeping the data available and accessible. Cloud me server is used in our system to store the collected information.

It is a GUI tool for the RDBMS MYSOL. It is used to directly update the values of heartbeat and eye blink in the form of a table. R studio is an open source IDE supporting R programming language for statistical computing and graphics. It includes a syntax- highlighting editor that supports direct code execution and debugging.

8 CONCLUSION

We present a smart device for monitor driver's stress, drowsiness and fatigue level in advance. By using two physiological sensors embedded in the wearable device of the drivers, we predict the solution in early stage. The classification results of this system also shows the significant improvement in accuracy by considering acute variations in the sensor outputs. By using machine learning techniques, provision of solution for any abnormal conditions is more precise and convenient. Thus the device is wearable, it is ready for easy retrofit of any vehicle. A considerable aspect for future is the measurement of signals by integrate and analyze complete parameters like blood pressure, skin response rate, fuel, mileage analysis, steering angle and speed of the vehicles. Thus the vehicle is completely monitored and controlled using Internet of Things (IoT).

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