Donot-DUEye: An IoT Enabled Edge Device to Monitor Blood Alcohol Concentration from Eyes

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***Abstract*—Accidents are unfortunate incidents which happen unexpectedly and unintentionally. Driving under influence (DUI) is one of the major reasons for accidents to occur. Self control is not an effective solution for reducing accidents due to DUI. In order to address this issue, the emerging auto mobile technology should have a system which allows to monitor the blood alcohol content of the user. Having this in mind, we propose a system, Donot-DUEye, which helps in automatically detecting the alcohol content and makes the decision whether the user can drive or not. Donot-DUEye uses pupil dilation, raise in blood pressure and cause of redness in people to analyze the driving capability of the person and displays the message on the vehicle's infotainment screen, with an accuracy of approximately 95%.**

***Index terms*—** Internet of Things (IoT), Smart Cars, Smart Healthcare, Alcohol Level Detection, Blood Alcohol Concentration, Driving Under Influence (DUI).

I. Introduction

Road safety is one of the primary measures in order to protect the people of any country. Even though there are many road signs and educational lessons, the number of accidents being noted is correspondingly increasing. There were 37,461 lost lives in accidents in 2016 in the United States alone. Overall, 25% of the accidents were due to the driving under influence (DUI) [1].

The growth in science and technology is adding intelligence to all components of life, making it "Smart-life". The key point of Smart-Life is the ability to communicate with all the other components, which in turn is known as the Internet of Things (IoT) [2].

A major component of Smart-Life will be Smart-Cities. Smart-Cities are comprised of Smart-Healthcare, Smart-Buildings, and Smart-Transportation, otherwise known as Smart-Cars [3]. There has been immense growth in the automobile technology where the invention of driver-less cars is also possible. The schematic representation of the idea proposed in this research to make the technology more controllable is presented in Figure 1.

The organization of the paper is as follow: Section II defines the novel contributions, Section III defines the broader perspective of the idea, Section IV summarizes state of the art-related prior research, Section V presents system level modeling and feature extraction of the system, Section VI presents the experimental implementation of the concept, the validation and results and Section VIII provides the conclusion and future scope of the project.

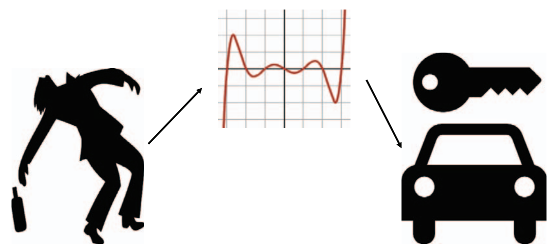

Fig. 1: Schematic Representation of Donot-DUEye

II. Novel Contributions of this Paper

Growth in technology should be balanced with lifestyle and cost of life in any society. Apart from natural calamities, the rate of death through road accidents can be controlled with improvements in today's technology. This paper proposes a system which can stop some causes of road accidents.

Many different reasons can be considered for the accidents to occur out of which driving under influence or drinking and driving is one of the major factors. Based on these facts, this research proposes a noninvasive, non-wearable, technology related smart system which can be incorporated in the new trend, smart cars. The major contributions of this research are:

- A monitoring system which is activated by human touch.
- A noninvasive method of monitoring alcohol levels.
- A system which determines the physical state of a person and decides if the person can drive.
- The automatic scan of the bio-metrics of the user is done at setup and is verified every time the user touches the steering wheel, thereby preventing the misuse of technology.
- The scanned data is sent to the cloud for future usage and the notification is displayed on the navigation screen.

A device prototype of the proposed Donot-DUEye system is presented in Fig. 2.

III. Donot-DUEye: A broad perspective of Automatic Alcohol Detecting System through IoT

The broad picture of the idea presented in this research is presented by Figure 3. To optimize the system, it activates only when it recognizes the touch of the user i.e., when there is a user touching the sensor, the blood pressure levels and the iris

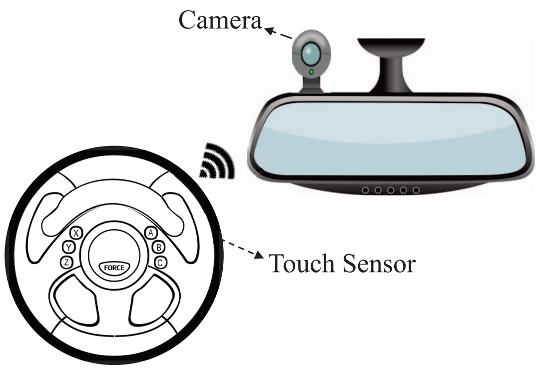

Fig. 2: Device Prototype of Donot-DUEye

scan of the user are taken and compared with results which are stored during the initial setup. If there are any changes observed the driver is considered to be drunk. The engine is locked along with a display image on the car's infotainment screen. The gathered and measured data are also stored in the cloud for future purposes.

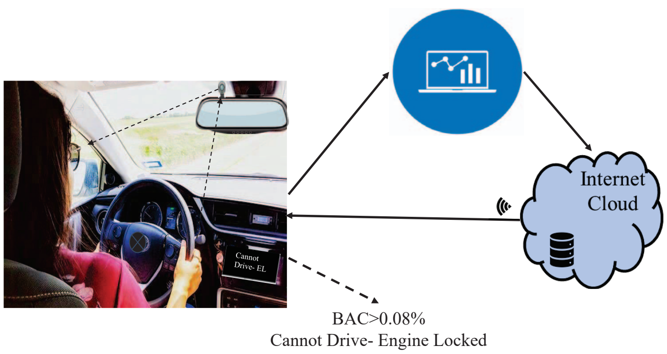

Fig. 3: Broad Picture of Donot-DUEye

IV. Related Prior Research

Alcohol detection has been a traditional research area with many varied approaches. In order to be on par with the consumer electronic technology, Driven Alcohol Detection System for Safety, Nissan and other companies like Hyundai try to incorporate the automatic alcohol level detection systems in smart cars. These systems use either breath or touch sensors at specified buttons such as the start button. However, as these systems are using breath as one of the detecting mechanisms there may be situations where one of the passengers is drunk but not the driver, leading to misjudgment of the system. Also, if the touch sensor detection is limited to only one point, there may be cases where improper usage of the system can take place. Research proposals for alcohol detection helmets using a breath analyzer or alcohol sensor are proposed in [4] and [5]. As helmets are easy to remove, there are ways to misuse the system. Alcohol detection using the breath and microprocessors is proposed in [6]–[8].

The current state of the art for detecting alcohol levels using wearable and non-wearable approaches is summarized in Table I. Wearables existing in the market allow the person to wear them and help to monitor the alcohol consumption [9]–[12]. However, they only work if the user decides to make them work. They do not help in avoiding accidents, therefore they are not intelligent enough for the current technology. There are other breath analyzing non-wearables which use smart phones for a person to know their alcohol consumption [13]–[16]. However, they do not monitor if the person is about to get on the road and drive. Thus, they do not help in avoiding accidents.

TABLE I: Alcohol Level Trackers

Name	Type	Technology used	Drawback
WrisTAS [9]	Wearable	Uses transdermal alcohol sensor	Does not avoid driving and occurrence of accidents.
BACtrack SKYN [10]	Wearable	Touch sensor	Does not avoid driving and occurrence of accidents.
Proof [11]	Wearable	Skin sensor	Does not avoid driving and occurrence of accidents.
Vive [12]	Wearable	Skin Sensor	Does not avoid driving and occurrence of accidents.
BAC track [13]	Non-wearable	Breathe analyzer	Does not avoid driving and occurrence of accidents.
Floome [14]	Non-wearable	Breathe analyzer	Does not avoid driving and occurrence of accidents.
Breeze [16]	Non-Wearable	Breathe analyzer	Does not avoid driving and occurrence of accidents.
Lapka [15]	Non-wearable	Breathe analyzer	Does not avoid driving and occurrence of accidents.

There is a significant change in the eyes, such as the pupil diameter and the expansion in the volume of the blood vessels inside the eyes leading to eye redness, when a person is drunk [17]–[19]. There is also a change in the blood pressure levels of a person when alcohol is consumed [20]. The changes in the parameters of the eyes, particularly the pupil diameter is established and discussed in [21], [22]. Mathematical approaches have been implemented in [21] and [22] in order to establish the relationship among the blood alcohol concentration and eye parameters. However, the process of automatic identification using the Internet of Things (IoT) is lacking. This research improves the existing approaches by introducing an automatic system that scans and compares the iris parameters, considers the blood pressure levels of the person and decides if the driver is in a good mental state to drive.

V. System Level Modeling of the Alcohol Tracking System - Donot-DUEye

An overview of the proposed Donot-DUEye system is shown in Figure 4. Here, whenever a person starts the car with the touch of his hand, the blood pressure data is taken along with the iris data using a camera on the rear view mirror. The system will not process the information until the iris scan has completed. Once the data are collected, they are sent to the microcontroller where the computations are performed. After the computations are performed, depending on the decision that is provided, the car may or may not be accessible to the driver, displaying this information on the car infotainment screen. The gathered data along with the computational decision are sent to the IoT cloud for future purposes. Thus, the proposed system is converted to a "thing" in an IoT network.

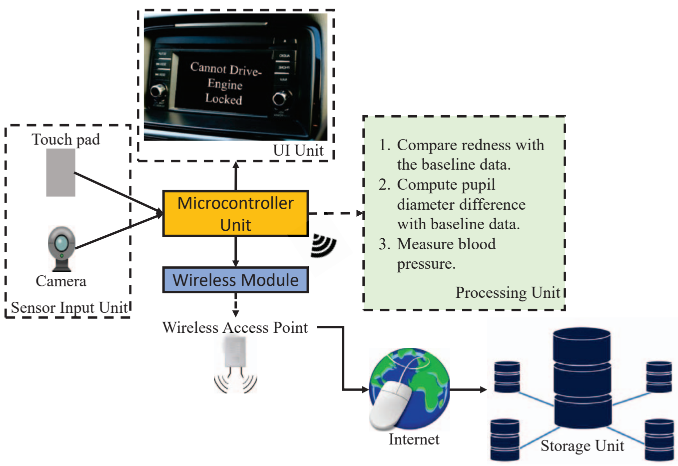

Fig. 4: Architectural View of Donot-DUEye

A. Working Principle of the Donot-DUEye System

The flow of the design that is used in this system is represented in figure 5. When a person is in the car and starting the engine, the sensor for blood pressure gets activated by his/her touch and triggers the camera sitting on the rear view mirror. Once the system gets activated as a whole, the blood pressure data along with the iris data are captured. This captured data is sent to the microcontroller wherein the mental and physical state of the person will be analyzed and a decision to allow him/her drive is then made. The decision will then be displayed on the car's infotainment screen and the engine will be locked or started, accordingly. All this data along with the predicted decisions will be sent to the database in the cloud for storage and future purposes.

B. Feature Extraction for Donot-DUEye System

For the above mentioned system, we have considered the amount of redness and the changes in the pupil diameter in the eyes and blood pressure variations of a person. The changes in the blood pressure are gathered using a sensor, while the image inputs are considered from the camera. A 0.5 mm change in pupil diameter change indicates high alcohol levels [19] and is used as a baseline in order to validate the changes automatically. Also, the system will be trained to recognize little or high change in the redness before or after consumption of alcohol. For the blood pressure, a range higher than 140 mmHg systolic, 90 mmHg diastolic will be considered negative and the person will not be allowed to drive [20], [23].

TABLE II: Features Considered in Donot-DUEye

Factor Considered	Parameter Range
Blood Pressure	120/80 to 140/90
Pupil Diameter	0.5mm change
Redness	Baseline Comparison- Feature extraction in Data Analysis Tool

C. Data Collection for Training Donot-DUEye System

In order to train the Donot-DUEye system with the required features, images from Brazilian photographer Marcos Alberti wine project have been considered [24]. In this project, Marcos has taken images of people who had consumed 3 glasses of wine. Only the images with clear face, eyes open are considered for training in this model. The rest of the images are discarded as they do not meet the purposes of this research. As the blood alcohol content (BAC) calculation considers factors like weight and hours after consumption of beverage, it is clear that this data set is very useful for the Donot-DUEye system. Example images which are used for training the Donot-DUEye model are shown in Figure 6 and Figure 7.

Generally, one drink is considered as 10 to 12 oz of beer at 4% to 5% alcohol or 8 to 12 oz of wine cooler at 4% to 6% alcohol or 4 to 5 oz of table wine at 9% to 12% alcohol or 2.5 oz of fortified wine at 20% alcohol or 1.25 oz of 80 proof distilled spirits at 40% alcohol or 1 oz of 100 proof distilled spirits at 50% alcohol. Here, we considered each wine glass as 5 oz with 12% alcohol. Three glasses of wine i.e., 15 oz of wine with a total of 36% alcohol content produces a BAC of at least 0.22% for a person weighing 170lbs according to the on-line BAC calculator [25]. Also, the BAC variation for a person with their weight and hours after consumption according to the on-line calculator is represented in Table III. The weight of a person is considered within a range from 150 lbs to 200 lbs with the hours of alcohol consumption being 1.

D. Design Metrics

The probability of the event to fall in different classifications defines the confidence of the system. A confidence interval (CI) is calculated instead of presenting a single error code as:

$$CI = z\sqrt{\frac{\alpha \cdot (1-\alpha)}{N}} \tag{1}$$

where CI denotes the interval, α is the accuracy (equation 2), N is the sample size and z is the critical value from the Gaussian distribution [26]. The skill of the learning algorithm to predict accurately is known as accuracy or testing accuracy

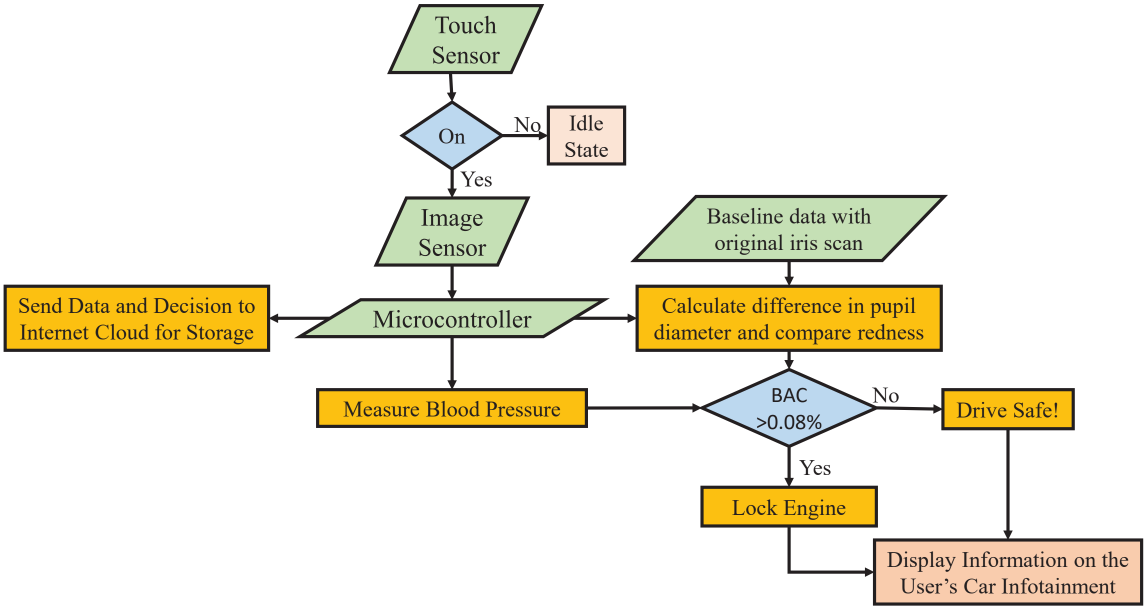

Fig. 5: Working Principle of Donot-DUEye

TABLE III: BAC Calculation Chart

Oz of drink	Total % of alcohol in drink	Wt (lbs)	Hours spent	BAC (mg) %
5	12	150	1	0.015
10	24	150	1	0.105
15	36	150	1	0.255
5	12	160	1	0.013
10	24	160	1	0.097
15	36	160	1	0.238
5	12	170	1	0.0114
10	24	170	1	0.09
15	36	170	1	0.223
5	12	180	1	0.01
10	24	180	1	0.085
15	36	180	1	0.210
5	12	190	1	0.008
10	24	190	1	0.079
15	36	190	1	0.198
5	12	200	1	0.0075
10	24	200	1	0.075
15	36	200	1	0.1875

A. Considered Image B. Discarded Image

Fig. 6: A sample of considered (left) and discarded images (right).

Fig. 7: A sample eye redness image considered for training.

(α). The percentage of correct predictions from total number of predictions can be known as accuracy in simple terms which is represented as:

$$\alpha = \left(\frac{TCP}{TPM} \cdot 100 \right), \tag{2}$$

where TCP denotes Total Correct Predictions and TPM denotes Total Predictions Made.

VI. Implementation of the Donot-DUEye System

While the system is being setup, the baseline information of the user i.e., the weight and iris scan of the person will be stored in the device. Every time the person wants to start the vehicle, the touch pad located inside the steering will be activated. The blood pressure from the pad will be measured. Once the detected blood pressure is inside the range, then the camera on the rear view will be activated. This will start the process of scanning the redness in eyes. When the redness is detected, the dilation in the pupil diameter will be measured.

A total of 212 images were used to test and train the model. Out of these 212 images, 53 images were used as baseline state images or sober state images. Some of the images were discarded as the eyes of the people were closed at 2 glasses of wine and at 3 glass wine stages. So, out of total 159 images with faces who consumed alcohol, only 108 were used for training and testing the model. Therefore, out of 212 images, 161 images were considered for the model. The cross-validation has been implemented with 10 folds and with an initial learning rate of 0.04%. 129 images were used for training the model while the remaining 32 images were used for testing.

A Raspberry Pi with its camera to scan the redness and dilation is considered as the edge platform and is represented in Figure 8.

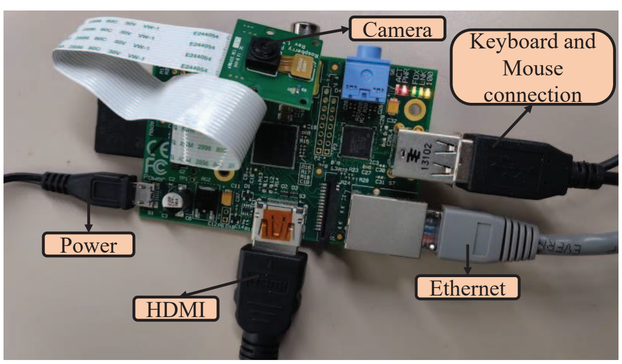

Fig. 8: Raspberry Pi Platform for Donot-DUEye System

After the process is completed, the dilation of pupil and the blood pressure are displayed on the Raspberry Pi frame. Also, the message to the user which is displayed on the infotainment of the vehicle is displayed on the frame of the Raspberry Pi as shown in Figure 9. The same can be displayed on an LCD module connected to the Raspberry Pi.

The confidence of the detection of dilation is approximately 90%.

VII. Validation of the Proposed Donot-DUEye System

For the execution of the Donot-DUEye System, the model has been trained using TensorFlow as the data analysis tool.

Fig. 9: Raspberry Pi Execution in Donot-DUEye System

The Lite version i.e., TensorFlow Lite has been installed on the Raspberry Pi along with the required packages for the implementation. TensorFlow Lite has been used for implementation as Donot-DUEye focuses on edge platform applications. The accuracy results for a few images are represented in Table IV. The comparison between the 10 fold cross-validation with 5 multiple cross-validations with learning rate of 0.04% is shown to indicate that the accuracy of the model increases with the increase in the data for training and testing the model.

TABLE IV: Accuracy results of the Donot-DUEye

Image ID	CI(%) for 10 fold cross-validation with 15 epochs	CI for 5 Repeated 5 fold cross validation with 15 epochs
Image 1	87	91
Image 2	85	92
Image 3	89	95
Image 4	86	94
Image 5	90	95

The characteristics of Donot-DUEye are represented in Table V. SSD MobileNet is used as it is compatible and fast on edge platform applications.

TABLE V: Donot-DUEye characteristics.

Characteristics	Specifics
Input System	Touch on Steering and Images from Camera
Data Acquisition	Database
Data Analysis Tool	TensorFlow Lite
Input Dataset	129 images
Classifier	SSD MobileNET
Types of stages considered	3
Accuracy	95%

A comparison of Donot-DUEye technology with other state-of-art works is presented in Table VI.

VIII. Conclusions and Future Research

Impaired driving is a growing concern for causing accidents. The need for development of applications which will increase the safety regulations of people is very important. There are

TABLE VI: Comparison of Donot-DUEye with other Research Articles.

Name of paper	Features Used	Drawbacks	Accuracy %
Willoughby, et al. [27]	Facial features - smile, lips, etc	This research requires manual input and doesnt help in smart-cars or automated technology to prevent accidents.	81
Gabriel Hermosilla, et al. [28]	Facial Features	Doesn't apply in real-time applications, not on edge platforms.	86.96
Gupta, et al. [29]	Glare detection of lights while driving	Manual input needed and it is not ideal for driving safety.	NA
Donot-DUEye	Blood Pressure, Pupil Dilation and Eye redness	Could improve the application with more dataset information.	95

many applications which monitor people for alcohol intake. However, most of the applications require breath analyzers or manual checkers to analyze the alcohol content in the human body. Donot-DUEye eliminates this issue by introducing a self monitoring, self locking system which will automatically disable the engine if the driver is not sober. This is implemented by considering the touch pad where the blood pressure is monitored along with the rear view camera to scan and compare the pupil dilation and redness to the baseline biometric information saved to the system at the initial setup stage.

By using the SSD MobileNet classifier, and TensorFlow Lite data analysis tool, the detection of pupil dilation to identify the sober to non-sober state of a person is determined with a 90% confidence interval and 95% accuracy rate on the 53 subjects participated in Marco Albertis "3 Glasses Later" data set. Donot-DUEye not only produces accurate results, it helps in a significant growth of technology in similar fields.

In future research, we would like to focus on proposing more robust, sophisticated solutions in similar research fields which will improve people's lifestyles.

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