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

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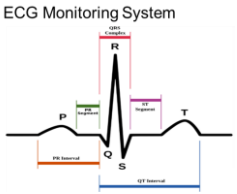
Outline of Talk

- Introduction
- Motivation
- Existing Solutions - their Issues
- Proposed Solution
- Novel Contributions
- Broad Perspective of Donot-DUEye
- Proposed Approaches of Donot-DUEye
- Implementation and Validation of Donot-DUEye
- Conclusions and Future Research

Introduction

- ✓ **Applications of IoT and IoMT**

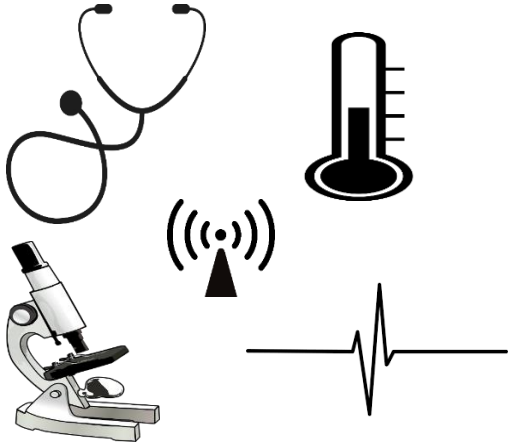


Introduction

✓ Internet of Things

- The Internet of Things is a network of devices where each device in the network is recognizable and connected.

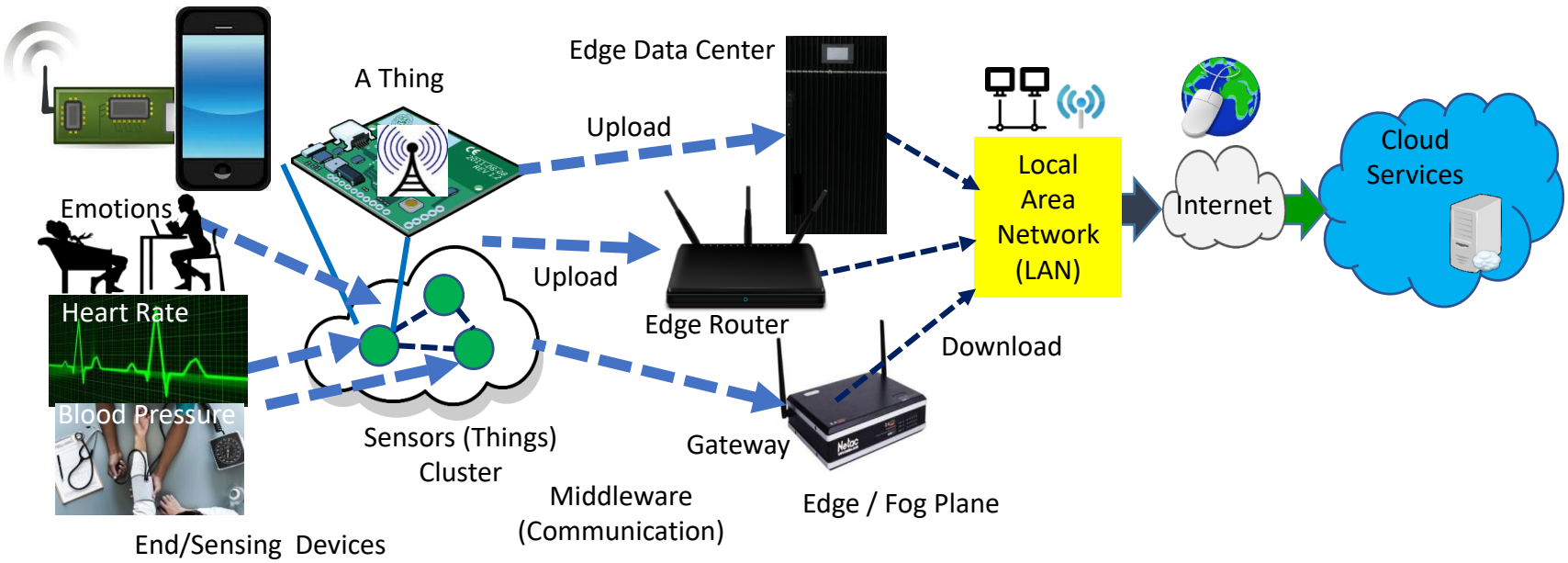
✓ Internet of Medical Things



- The Internet of Medical Things is a network of medical devices where each device in the network is recognizable and connected.

Introduction

✓**Edge Computing for Smart Healthcare?**



Introduction

- Total of 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).
- DUI or Driving While Intoxicated (DWI) is the crime or offense of driving or operating a motor vehicle while impaired by alcohol or other drugs, to a level that renders the driver incapable of operating a motor vehicle safely.

Introduction

Consequences of DUI:

- License Suspension
- Jail Time
- Fines and Fees
- Enhanced Penalties

Blood alcohol concentration (BAC), also called blood alcohol content is most used as a metric of alcohol intoxication for legal or medical purposes.

It refers to the amount of alcohol present in the bloodstream.

A BAC of 0.05% means that there is 0.05 grams of alcohol in every 100 milliliters of blood. The legal limit in most of the countries is 0.08%.

Motivation

- To prioritize the concept of care.
- To reduce the count of accidents happening.

- To prevent the incidents of accidents using technology.
- To provide a fully automated solution to avoid driving while intoxicated.

Existing Solutions

Tracker	Type	Technology used
WrisTAS 	Wearable	Uses Transdermal Alcohol Sensor
BACtrack SKYN 	Wearable	Touch sensor
Proof 	Wearable	Skin sensor
Vive 	Wearable	Skin sensor
BAC track 	Non-wearable	Breathe analyzer
Floome 	Non-wearable	Breathe analyzer
Breeze 	Non-wearable	Breathe analyzer
Lapka 	Non-wearable	Breathe analyzer

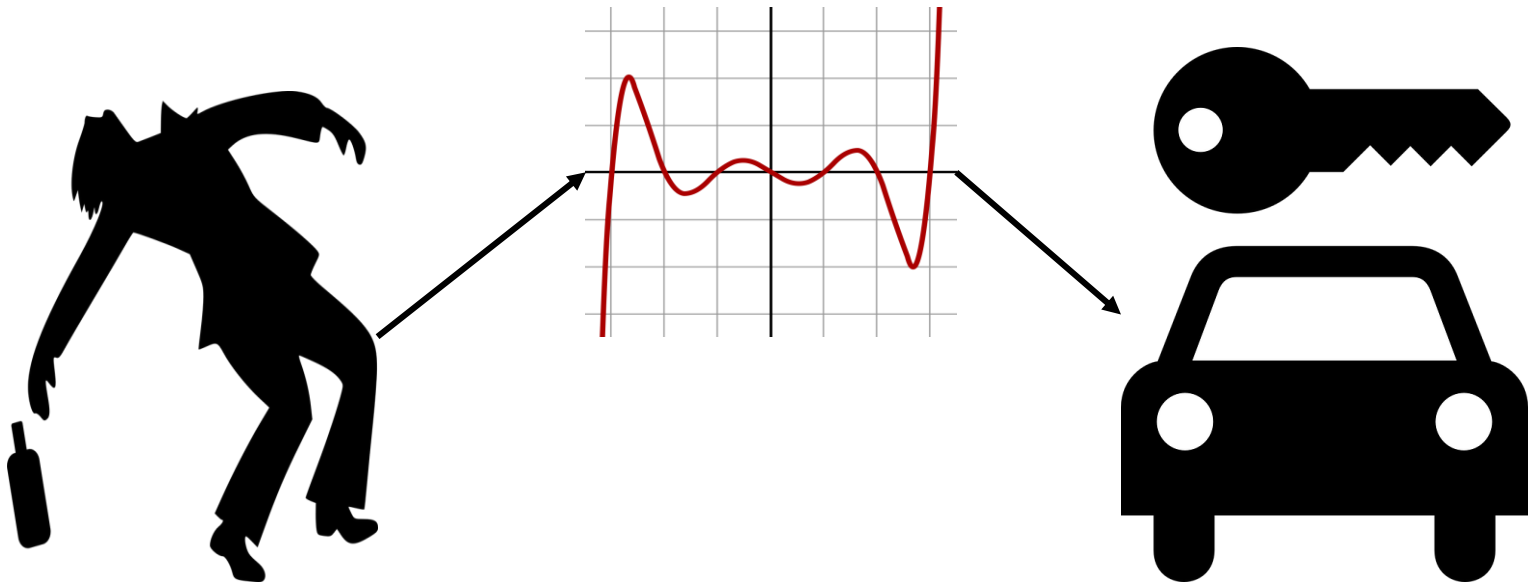
Issues of Existing Solutions

- Does not avoid driving and occurrence of accidents.
- Does not prevent accidents by taking control over the vehicles.
- Provides a way where the user can misuse the technology by switching the driver once the engine starts.
- Does not provide continuous monitoring throughout the driving period.

Addressed Research question

- How to have a non-invasive, optimized, IoT enabled system which continuously monitors the driver based on the physiological and vision signal data, analyses the data at the user end (at IoT-Edge) and stores the data at the cloud end (at IoT-Cloud)?

Proposed Solution of Donot-DUEye

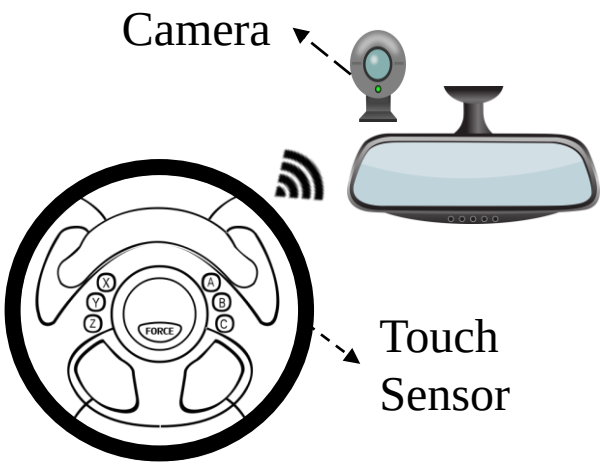


Issues Addressed in Donot-DUEye

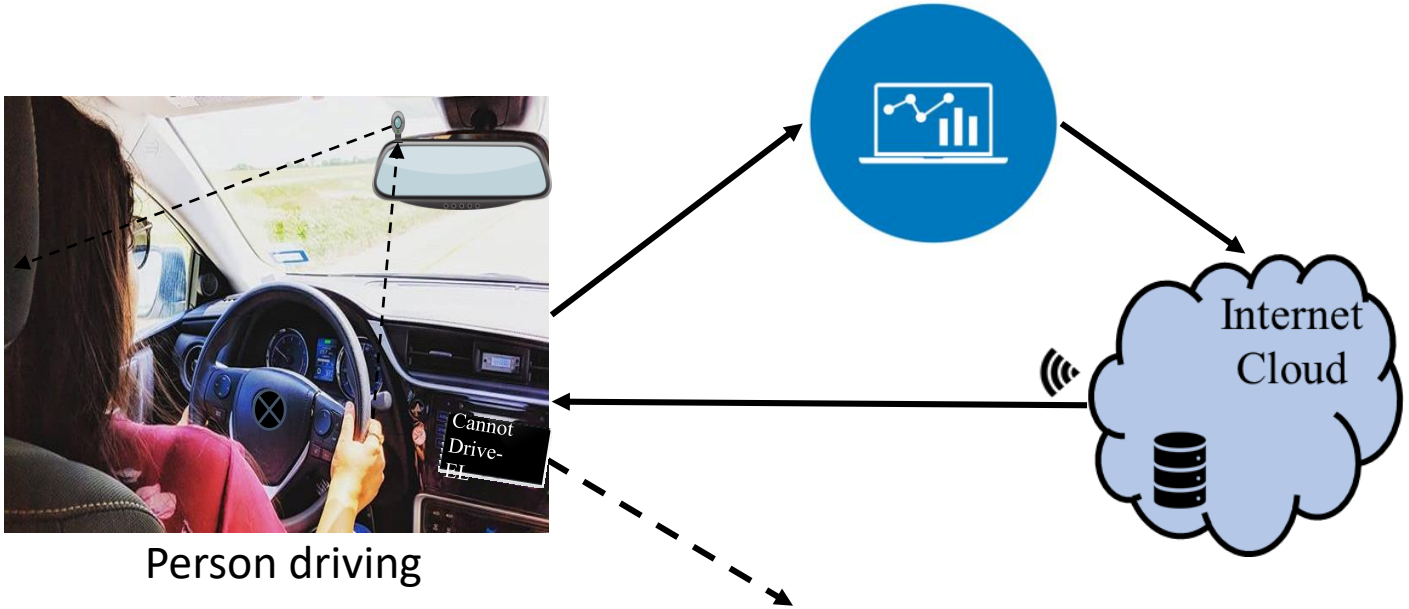
- A model that avoids driving while drunk and reduces the chances of occurrence of accidents.
- The Donot-DUEye system takes control over the vehicle as this proposes non-wearable which is incorporated to the vehicle.
- Donot-DUEye system provides continuous monitoring through out the driving period thereby minimizing the chances of misuse.
- Donot-DUEye proposes a model which analyzes the sobriety depending on both vision and physiological data.

Novel Contributions

- 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.



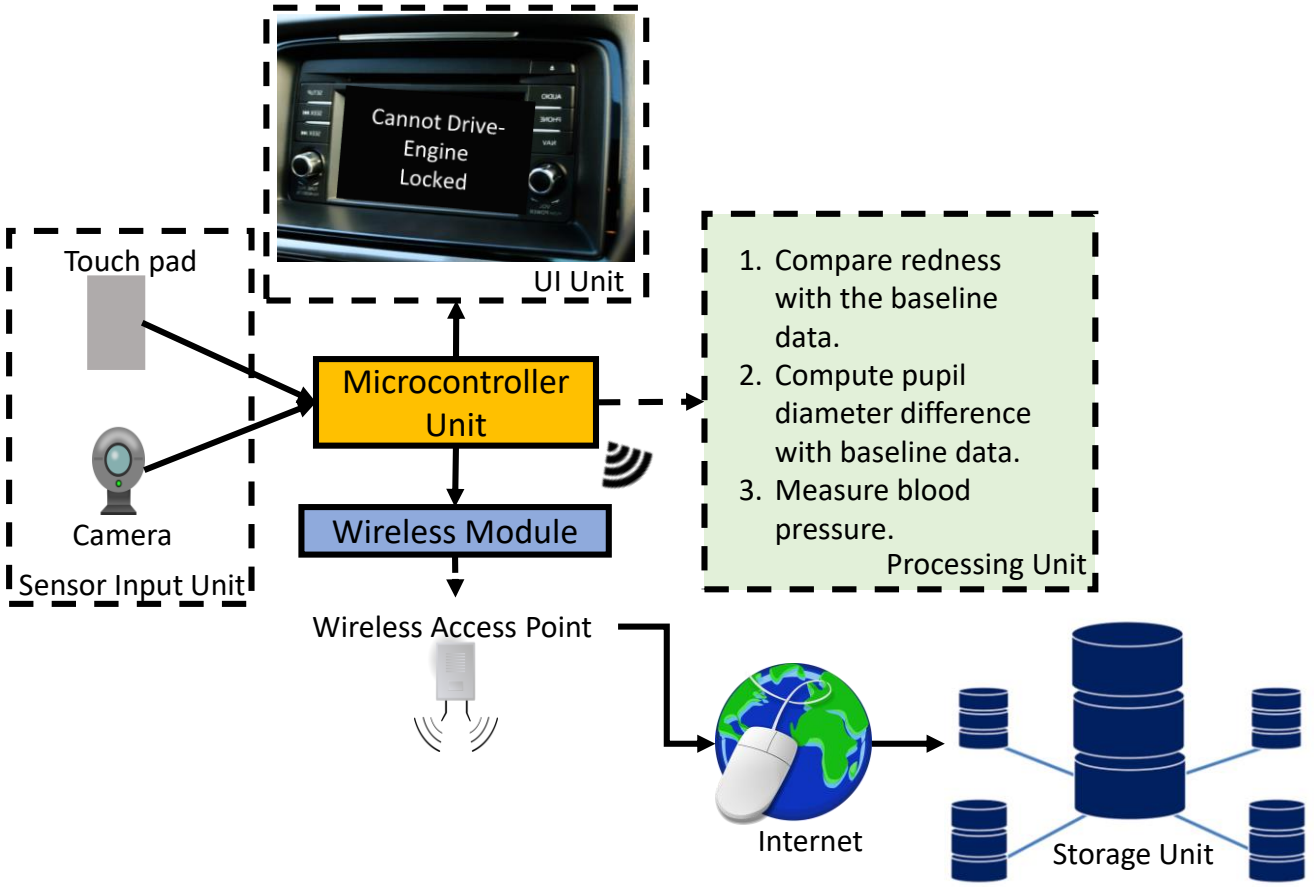
Broad picture of Donot-DUEye



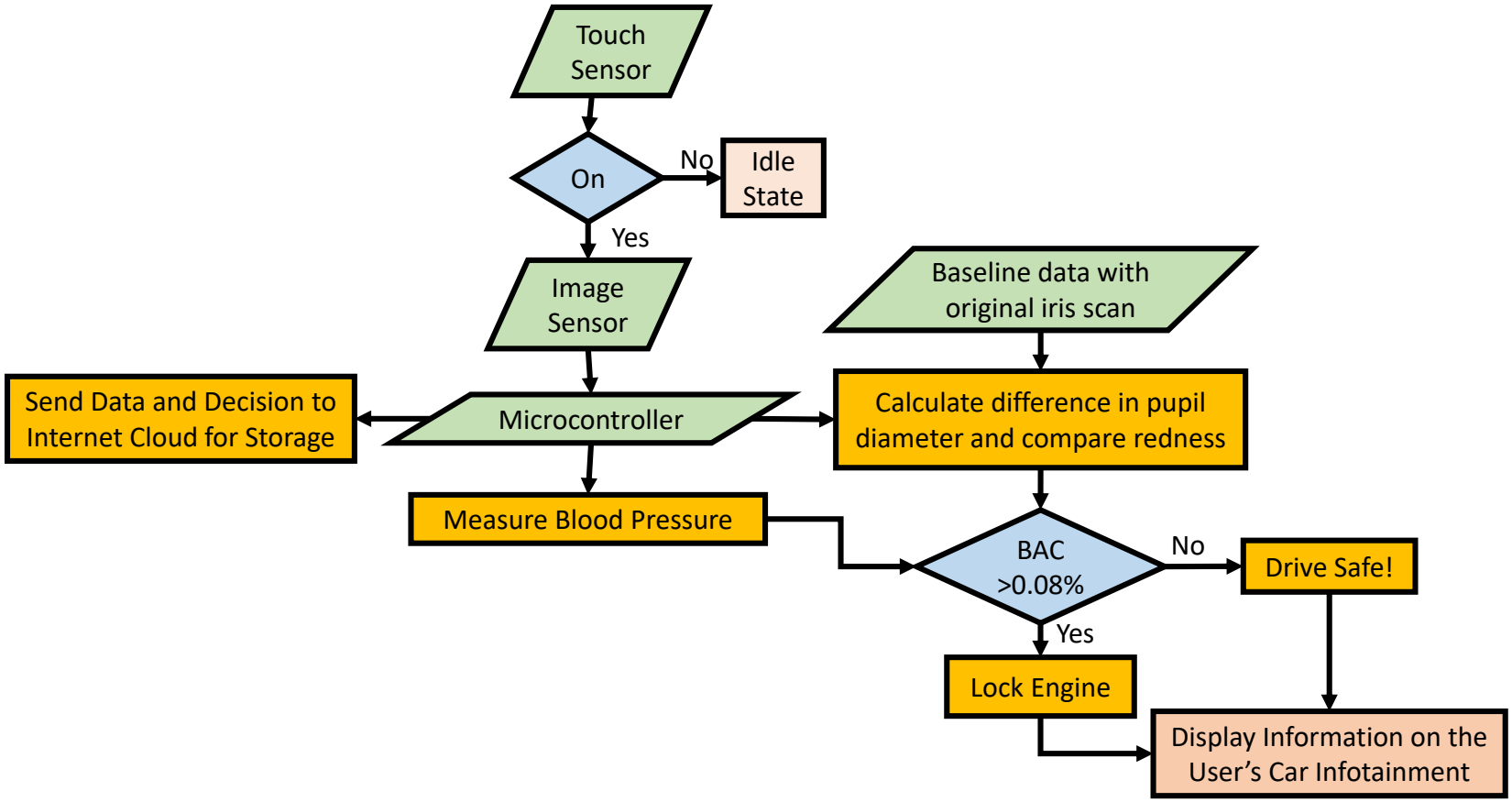
Broad picture of Donot-DUEye

- 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 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 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.

Architectural View of Donot-DUEye



Working Principle of Donot-DUEye



Working Principle of Donot-DUEye

- 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 cloudfor storage and future purposes.

Feature Extraction for Donot-DUEye

✓ Parameter Analyses

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

Data Collection for Donot-DUEye

- 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, this data set is very useful for the Donot-DUEye system.

Data Collection for Donot-DUEye

- ✓ Marcos Alberti- 3 glasses later!

A. Considered Image

B. Discarded Image

C. Sample eye redness image

BAC calculation

Oz of Drink	Total % of alcohol in drink	Weight of person (lbs)	Hours spent	BAC % (mg)
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

BAC = [Alcohol consumed in grams / (Body weight in grams x r)] x 100.
"r" is the gender constant:
r = 0.55 for females and
r = 0.68 for males.

•Ounces of beverage consumed:
1 beer = 12 oz.
Glass of wine = 5 oz.
1 shot = 1.5 oz.
•Percentage of alcohol in beverage:
1 beer = 4-7%
Glass of wine = 11-13%
1 shot = 40%

Design Metrics

- True positive (TP): Fall correctly identified as Fall
- False positive (FP): Not a fall incorrectly identified as fall
- True negative (TN): Not a fall correctly identified as not a fall
- False negative (FN): Fall incorrectly identified as not a fall

- Sensitivity or Recall or True Positive Rate (TPR) = (TP)/ (TP+FN)
- Precision = (TP)/(TP+FP)

- **Accuracy** = (TP+TN)/(TP+TN+FP+FN) and
- **Confidence Interval** = $(z^*((A * (1-A))) / n)^{1/2}$)

  where z is the critical value, A is accuracy, n is sample size

Implementation of Donot-DUEye

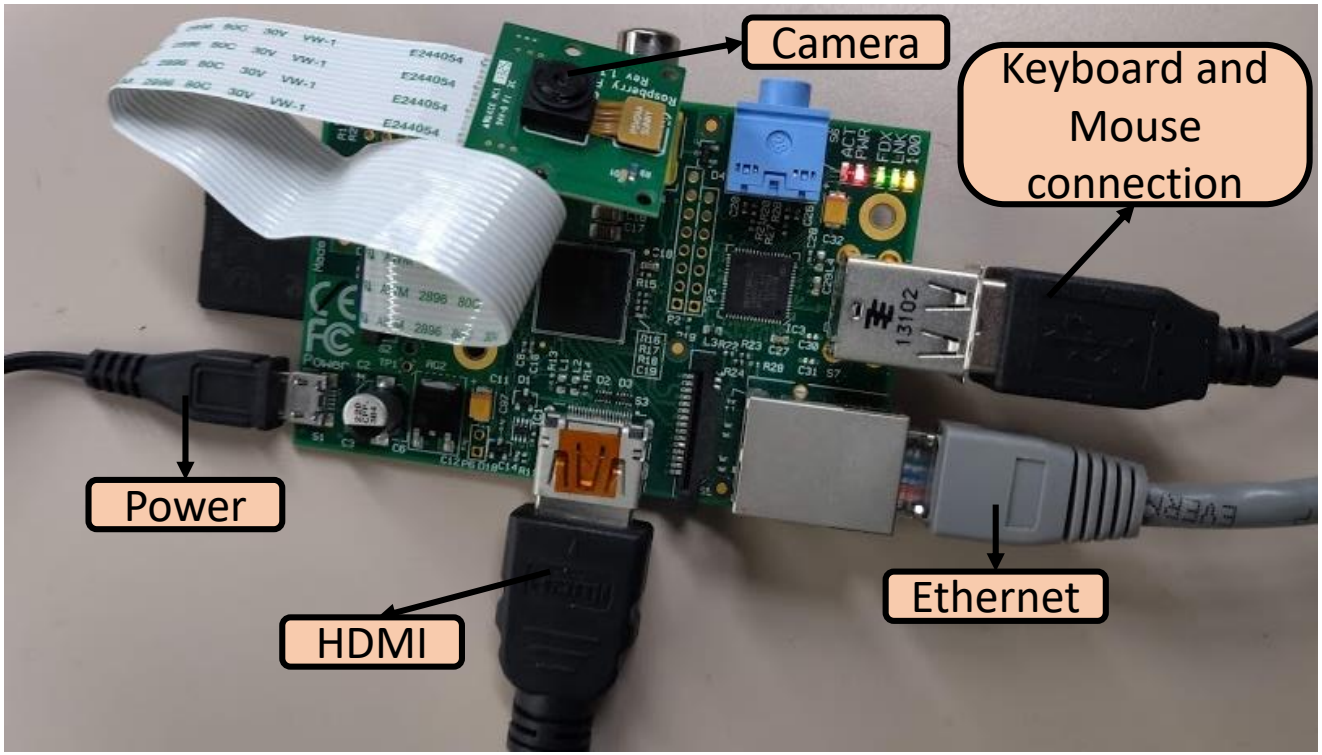
- A total of 212 images were used to test and train the model.
- Out of these 212 images, 53 images were used as baseline state images or sober state images.
- Some of the images were discarded as the eyes of the people were closed at 2 glasses of wine and at 3 glass wine stages.
- So, out of total 159 images with faces who consumed alcohol, only 108 were used for training and testing the model.

Implementation of Donot-DUEye

- 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.

Edge Computing Platform

- A Raspberry Pi with its camera to scan the redness and dilation is considered as the edge platform.

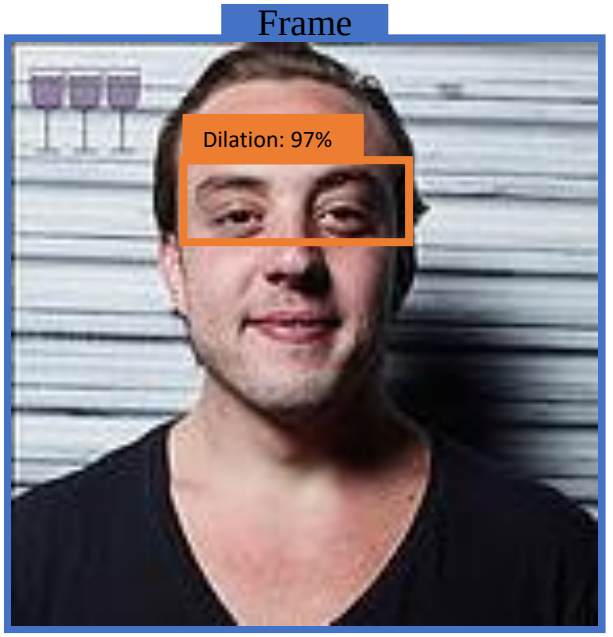


Edge Platform Result

File Edit Tabs Help

```
pi@raspberrypi ~$ python3st.py
BloodPressure: 120/80
Connecting…

BAC>=0.08%
Cannot Drive- System Locked.
```



Validation of Donot-DUEye

- TensorFlow has been used as the data analysis tool.
- The TensorFlow Object Detection API is used as the model.
- SSD MobileNet is used as a classifier as it is compatible and fast on edge platform applications.
- 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 Alberti's “3 Glasses Later” dataset.

Accuracy Results of 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

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%

Comparisons with Related Works

Name of paper	Features Used	Drawbacks	Accuracy %
Willoughby, et al.	Facial features - smile, lips, etc	This research requires manual input and doesnt help in smartcars or automated technology to prevent accidents.	81
Gabriel Hermosilla, et al.	Facial Features	Doesn't apply in real-time applications, not on edge platforms.	86.96
Gupta, et al.	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 model's accuracy with more dataset information.	95

Conclusions

- 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.
- Donot-DUEye not only produces accurate results, it helps in a significant growth of technology in similar fields by providing continuous monitoring of the driver through out the driving period.

Future Research

- To use more physiological sensors such as heart rate, temperature and respiration to make a decision of sobriety.
- To develop smart healthcare models which incorporate various activities such as type, amount and time of food consumed, the number of hours slept along with the sleep behaviors and the changes in physiological parameters during sleep to not just predict the sobriety but also to analyze the human behavior.
- To Integrate security and privacy features to our smart healthcare systems using blockchain technology for more credibility.

Questions?

Thank you!