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In Cabin Driver Monitoring and Alerting System For Passenger cars using Machine Learning.

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Abstract. The primary causes of road accidents are driver errors. Such as excessive speeding, driver distraction, and driver sleepiness. Diver sleepiness and distraction can be controlled by implementing advanced technology such as an in-cabin driver monitoring system. This is a technological solution that uses a machine learning algorithm to improve road safety. This paper describes a new real-time driver monitoring and alerting system that solely monitors driver Sleepiness, diver distraction, and seatbelt wearing status in order to prevent road accidents. It employs the YOLOv5 deep learning algorithm to detect various types of distraction and For seatbelt wearing status and computer vision's cvzone framework is used to detect sleepiness using 3D facial landmarking. In this system, The camera is mounted in the centre of the vehicle's dashboard for data collection and real-time implementation. The Raspberry Pi 3b module is used for the Realtime implementation. According to the findings of this study, the system is capable of real-time implementation, and the machine learning model used in the study achieves an accuracy of more than 90%.

hahaha.. ?

1. Introduction

The Ministry of Road Transports and Highways (MORTH) has released an accident report detailing the number of road accidents in India in 2021. According to this report, 19748 accidents were reported in India. Over speeding, reckless driving, driver fatigue, and driver distraction due to cell phone use were the primary causes of the accident. As India's road infrastructure is developing long express highways are being built, but these long straight highways are making drivers drowsy and bored. As a result, many drivers attempt to operate mobile devices and some may fall asleep. As a result, there is a need for a system that can detect the driver's distraction and sleepiness status and recommends or warns them accordingly.

To overcome this severe problem this paper proposes a combined driver monitoring system that can detect both the sleepiness and distraction of driver and seat belt wearing status using machine learning and computer vision techniques. This system uses Yolo V5 algorithm for detecting types of distraction. types of distraction are finalised based on survey of 40 drivers. In This survey Drivers said that most of them feels sleepy just after lunch and dinner and some drivers also told that they feel sleepy either at late night or during early morning journeys. For detection of sleepiness computer vision's cvzone framework is used which uses 3D facial landmarks. The eye close status and mouth opening status for sleepiness and yawning detection is done by comparing eye opening ratio (EOR) and mouth opening ratio (MOR). Because this system uses the camera to detect the above-mentioned functions, it also uses the same camera to detect seat belts. By implementing this system, sensors used for seatbelt detection and occupant sensing can be eliminated. This paper discusses the proposed system in detail and highlights its potential to make a significant impact on road safety in India.

2. Literature Review

The survey contains current technologies and research on the issue of our project. It is an attempt to better comprehend the work that has gone into this field of research, as well as where our efforts should be directed when building this project.

Et al. Alexey Kashevnik [1] proposed A model for detecting the driver's seat belt fastness using a camera within the driver cabin was suggested in this study. The model is built on the neural network, which recognises the belt's main component as the first item and the belt corner as the second object. The model categorises belt fastening into three categories: not fastened, appropriately secured, and fastened behind the back. The algorithm improves edge definition to make the belt more apparent even in low-light circumstances, and it works well with infrared cameras. The methodology consists of two steps: the primary element of the belt detection and corner detection, which allows the system to recognise when the seat belt is fastened behind the human body.

Et al. DS Bhupal Naik in this paper [2] The methodology of the paper involves using Convolutional Neural Networks (ConvNets) to detect whether a driver is wearing a seat belt or not. The researchers built and trained a ConvNet using a dataset of seat belt images, both standard and non-standard. The ConvNet automatically learns features from the images and classifies them with an accuracy of 91.4%, which is better than the performance of Support Vector Machines (SVM). The methodology involves several steps, including pooling, flattening, and using the ReLU activation function.

Et al. Rupal A. Kapadi in this [3] In the recommended approach for recognising seat belts, image processing and deep learning techniques are applied. MobileNetV2 is the core safety belt identification model employed by the system. The dataset used to train the system contains images of both individuals with and without seat belts. As compared to existing state-of-the-art CNNs, the proposed system performed better on the seat belt detection task. The technology is adaptable enough to be used by any organisation, and it can identify whether or not drivers entering the facility are wearing seat belts.

Et al. Aneesa Al Redhaei [4]The objective of this article is to develop a system that employs visual signals to identify driver fatigue in real time. By analysing the aspect ratio of the eye, the system expects to detect indicators of tiredness. The approach consists of three basic phases: pre-processing, feature extraction, and model selection. At the first step of processing, the face region of each video frame is isolated. Using a facial landmarks detector, the eye region is recognised and extracted during feature extraction, and the eye aspect ratio value is obtained for each frame. In order to improve the accuracy of the detection, three distinct classifiers are employed to examine the received data and determine whether the driver's eyes are open or closed.

Et al. Mahek Jain [5] proposed methodology of the proposed system involves using facial landmark detection to detect the face in the image. Then, shape prediction methods are used to detect important features on the face. OpenCV built-in HAAR cascades are used for face detection, and a pre-trained facial landmark detector included in the dlib library is used to estimate the location of 68 (x, y)-coordinates that map to facial structures. The detector is trained on the iBUG 300-W dataset. These steps are used to detect drowsiness and yawning in drivers and give appropriate voice alerts to prevent accidents.

Et al. Narayan Darapanemi [6] given an approach that involves building a machine learning model to classify different driver distractions in real-time using computer vision. The researchers used a dataset of images of drivers engaged in various distractions such as mobile usage, drinking, operating instruments, facial makeup, and social interaction. They trained and evaluated the model using classification accuracy, with a benchmark of 90% accuracy for each class. They used convolutional neural networks (CNNs) such as VGG-16 and ResNet50, as well as an ensemble of CNNs, to predict the classes. The researchers also optimized the parameters of the model to improve its performance.

Et al. Kunlun Zhang [7] In this study, researcher provide a technique for identifying distracted driving actions using deep learning algorithms. Deep learning is a group of approaches that employ a multi-layered neural network to solve problems using images and words. Feature learning is at its core. The proposed technique employs the PCN and DSST algorithms to identify and monitor faces in real time, followed by the YOLOV3 object identification algorithm to identify potentially distracting actions, such as smoking and phone usage, that occur near to a person's face. Our approach reliably detects distracted driving activity in real time.

Et al. Md. Manowarul Islam[8] provided the approach that involves detecting distracted driving behavior using deep learning techniques. The process involves pre-processing the images of drivers in different postures such as eating, texting, and talking. Then, pre-trained convolutional models such as ResNet50, MobileNetV2 are used to recognize the distracted behaviour of the driver. Finally, the model is evaluated using testing data images and the results are analysed. The proposed method aims to mitigate the number of road accidents caused by distracted driving.

Et al. Serajeddin Ebrahimian[9] The author suggests in this work the development of an ECG/breathing signal fusion system for snooze detection. Based on the simultaneous examination of heart rate variability, power spectrum density of HRV, and breathing rate, this technique would classify sleepiness (RR). In the suggested classification technique for sleepiness levels, two models are used: a convolutional neural network model and a hybrid convolutional neural network-long short-term memory model. Trial results from a simulated driving scenario including thirty individuals validated the effectiveness of the strategy.

Et.al Elena Magan[10] this research paper involves developing an ADAS (advanced driver assistance system) that focuses on detecting driver sleepiness to prevent road accidents. The system assesses drivers' drowsiness using non-intrusive 60-second-long videos of their faces. The videos are analysed frame by frame, and the system's accuracy is assessed using the UTA-RLDD dataset, which includes videos of 60 people in two states: awake and drowsy. The training data for the system consists of 97 videos, while the test data consists of 25 videos. The system evaluates each frame of video and uses the ADAS alarm activation module to determine whether the driver should be alerted.

By this survey it is observed that there is no exclusive driver monitoring system which solely perform the task of distraction detection, Sleepiness detection and vision based seatbelt detection . Also , all other authors have used the online available dataset but in this proposed system is trained on custom dataset which is compatible with our objective. And camera based systems are best suited for this application.

3. Proposed system

The proposed system has following three function Driver Sleepiness Monitoring, Driver Distraction Monitoring and camera-based seatbelt Detection. Figure 1 indicates flow of proposed system.

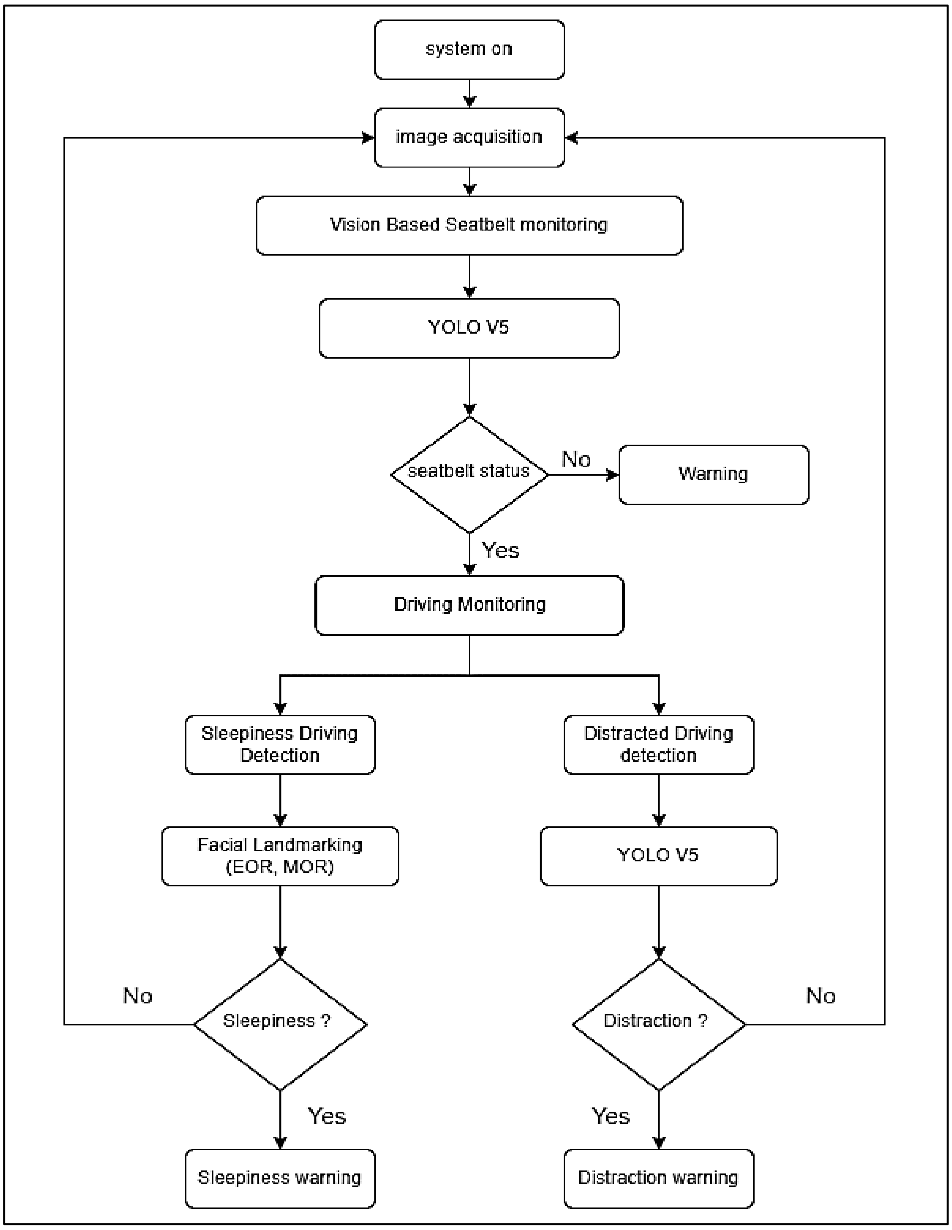
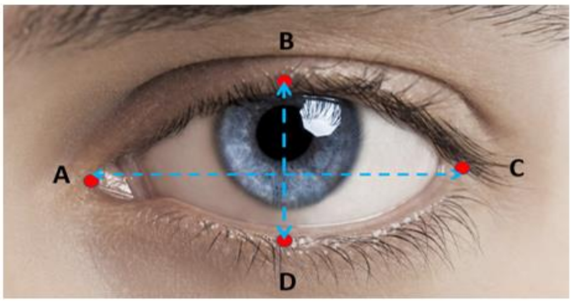


Figure 1. Flowchart of proposed system

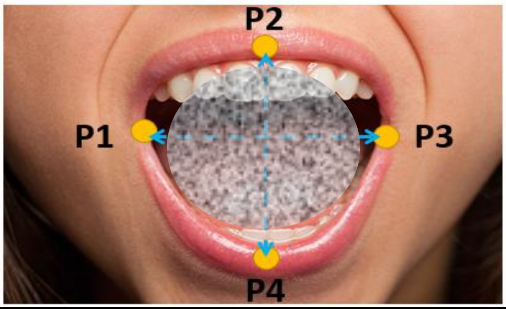
System starts with detecting seatbelt. For seatbelt detection object detection algorithm YOLO V5 is used. In this the model is trained on two classes of data 1) Driver with seatbelt 2) Driver without Seatbelt. When system detect driver without seatbelt then system triggers signal and audio-visual warning is provided to driver. If system detect detects driver with seat belt then algorithm loop proceeds forwards and checks for sleepiness status and distraction status of driver.

For Sleepiness detection, system uses cvzone python package. This is a computer vision package that makes image processing and AI functions simple to use. It is built around the OpenCV and Mediapipe libraries. This system uses inbuilt 3D Face mesh function for 468-point facial landmarking. The sleepiness is detected if (EOR) Eye opening ratio values is less than threshold value (0.25). and, for yawning detection if (MOR) Mouth opening ratio value is more than threshold value (0.5). if the driver detected with sleepiness then an irritating loud audio warning sound plays until the driver eyes open up. And when driver is detected yawning then an audio-visual recommendation warning provided to driver which says “it seems you are tired – please take a break”.



$$EOR = \frac{\text{Distance between BD}}{\text{Distance between AC}}$$

Figure 2.Indicating Eye open ratio Formula



$$MOR = \frac{\text{Distance between p2,p4}}{\text{Distance between p1,p3}}$$

Figure 3.Indicating Mouth open ratio Formula

For Distraction Detection single stage object detection algorithm YOLO V5 is used. In this the model is trained for 4 classes of distraction and 1 class of safe driving. For selection of classes of distraction survey of 40 drivers are done. Form literature review it has been found that there are 7-8 different types of distraction .the final 4 classes are chosen based on votes and remarks of drivers. The final selected classes were 1) operating mobile 2) talking on mobile 3) operating multimedia 4) talking with passenger 5) normal driving.

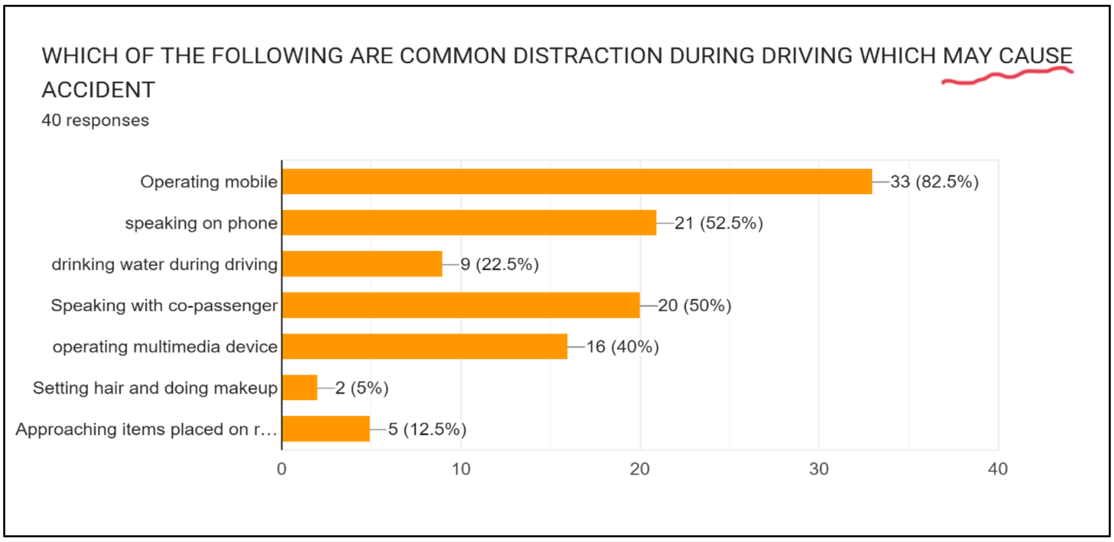


Figure 4 .Indicating survey of drivers for types of distraction

When drivers are detected with any of the distraction then it gives an audio-visual warning. If driver ignores the warning and continues with distraction then the loud audio warning plays. The sleepiness monitoring and distraction monitoring system works simultaneously and ensures safety of driver as well as occupants.

4. Methodology
The methodology for the proposed system is have 4 main building blocks.

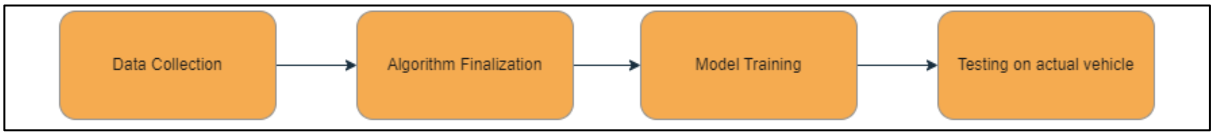


Figure 5. Flowchart of Methodology

4.1 Data collection
Data collection for this project 5 volunteers are participated. the data is also collected at different timespans and different lighting conditions.

For seatbelt monitoring dataset of 2000 images are taken out of which 1000 are of class driver with seatbelt and 1000 are of driver without seatbelt. Figure 6 two classes for seatbelt detection.

Figure 6.Classes for seatbelt Detection

For Distraction Detection dataset of 5000 images are taken and each class are provided with 1000 images each. And out of 1000 images collected for each class , 200 images are captured for each of 5 individuals. Figure 7 Showing different classes of distraction.

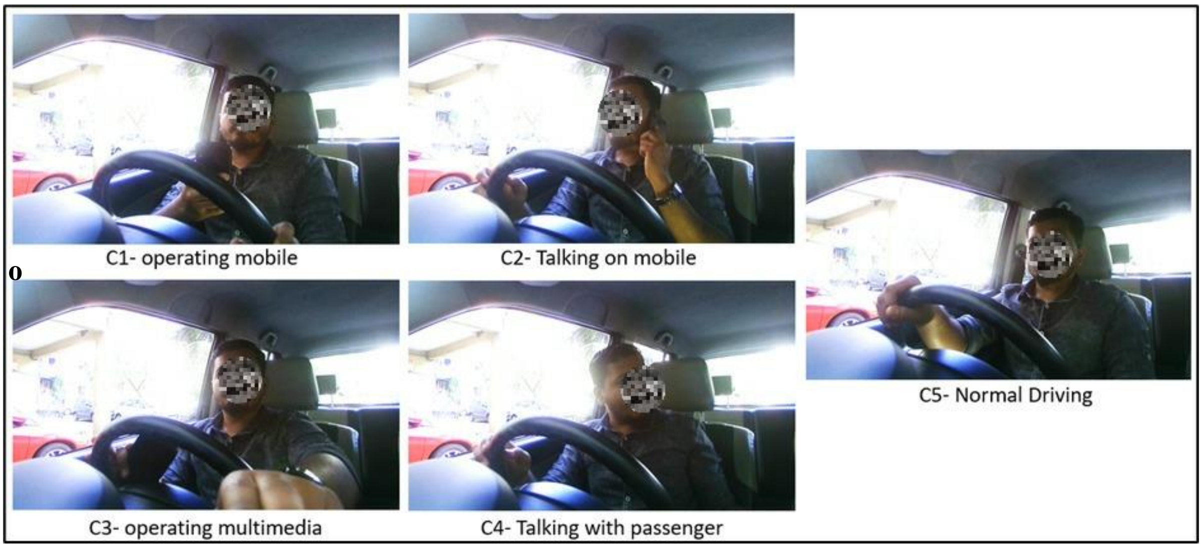


Figure 7.Different classes of Distraction

4.2 Algorithm Finalization

In the field of Automotive engineering, rapid response is crucial due to the continuous movement of vehicles at moderate to high speeds, where every second is significant. Therefore, for the detection of seatbelt usage and driver distraction, a single stage object detection model, YOLO v5, is being employed. It detects items from the input image without the use of a separate region proposal network. It employs CSPDarknet, a customised backbone network with residual connections and spatial pyramid pooling. The model processes the image using a succession of convolutional layers to build a set of feature maps that are used to predict the position, class, and confidence score of each object in the image. As SSD is also belongs to same single stage detection categories but YOLO is faster than SSD hence it is implemented in this project. Although SSD belongs to the same single stage detection category as YOLO, but YOLO faster than SSD and hence used in this project.In case of Driver sleepiness monitoring 3D facial landmarking technique is used in this project because it is simple to implement, Fast and requires less computation power.

4.3 Model training

the seatbelt detection and distraction detection system are trained solely on the YOLO v5s model. Because, YOLOv5s is the smallest and fastest model in the YOLOv5 family. It has fewer parameters and a smaller number of layers compared to YOLOv5m. YOLOv5s is designed for real-time applications.

4.3.1 System specification used for model training. The training of the model is carried out on NVIDIA GTX 1650TI GPU with 8 GB RAM and the frame work is developed using PyTorch.

4.4 Testing on actual vehicle

The prototype of this driver monitoring was implemented on raspberry pi microcontroller along with other peripherals like laptop for displaying visual warning and playing audio warning and webcam with mounting stand. The camera position used for data collection and testing is near centre of dashboard and facing towards driver. Figure 8 Indicating Experimental setup.

Figure 8.Experimental setup for testing and data collection

5. Result

The proposed system works correctly and able to detect sleepiness, distraction and seatbelt status Realtime. Figure 9 indicates warnings when driver identified with sleepiness.

Figure 9.Sleepiness detection System Results

The confusion matrix for distraction detection system indicating accuracy for each class. Our results indicate that the classification model achieved 100% accuracy for the classes of operating mobile, operating multimedia, talking with passenger, and normal driving. However, the accuracy for the class of talking on mobile was slightly lower at 92%. Figure 10 indicates confusion matrix for driver distraction.

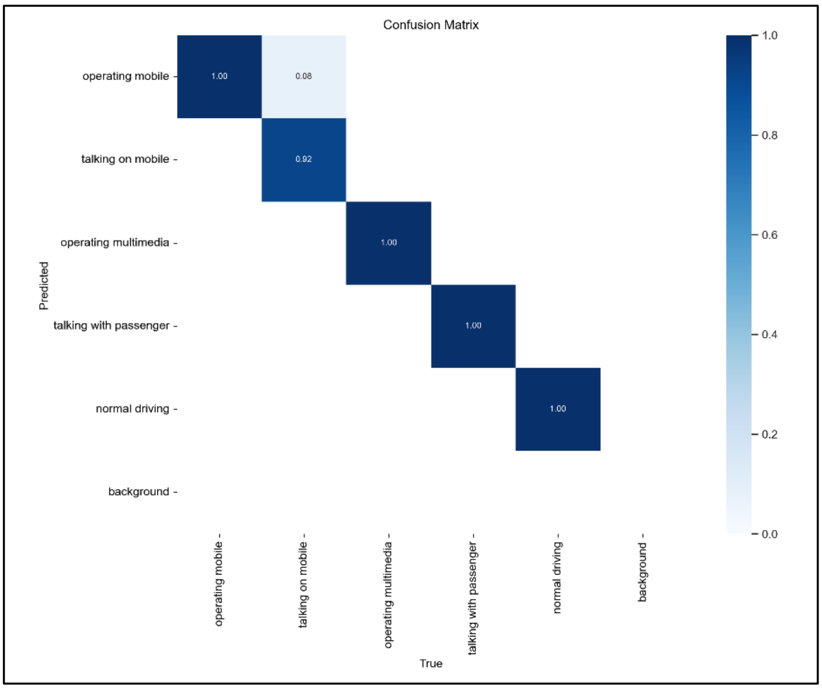


Figure 10. Indicating confusion matrix for distraction detection system

The confusion matrix for seatbelt detection indicating accuracy for classes driver with seatbelt, driver without seatbelt. The proposed system has been able to attain a 100% accuracy for each class. Figure 11 indicates confusion matrix for Vision Based Seatbelt Detection system.

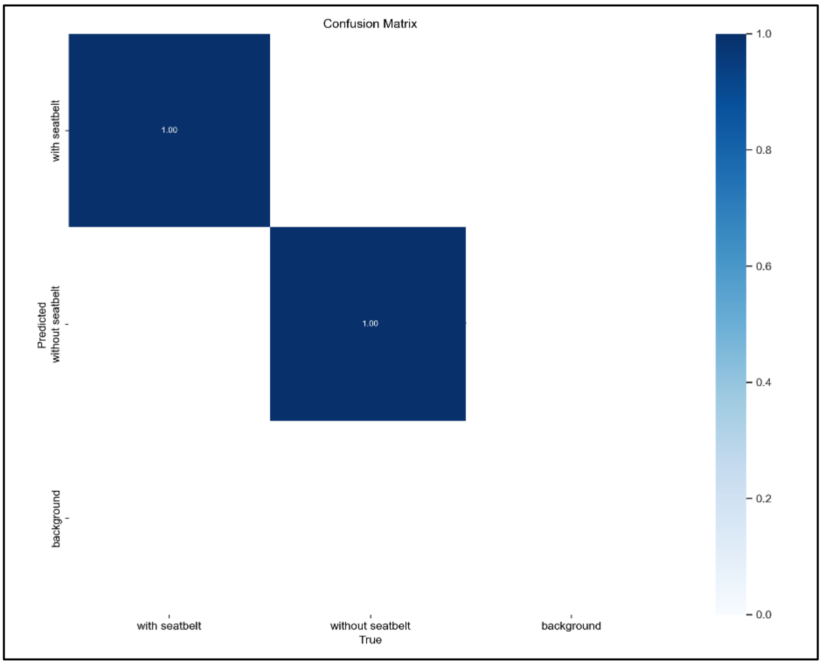


Figure 11. indicating confusion matrix for seatbelt detection system

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Figure 12 indicates results for Driver distraction detection and Figure 13 Indicates results for Vision based seatbelt detection during Realtime testing.

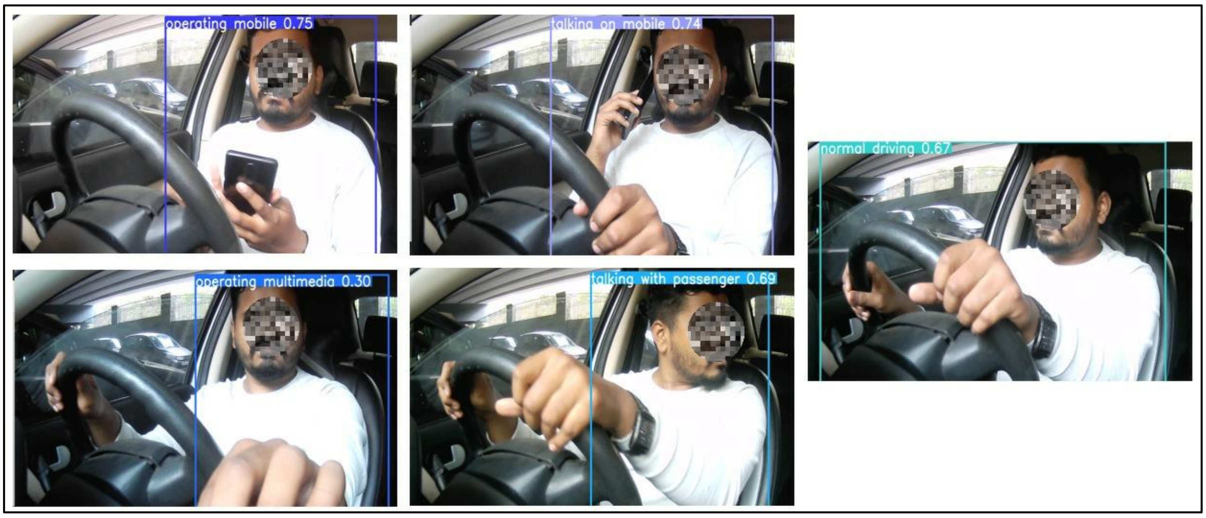

Figure 12.Distraction Detection system Realtime detection

Figure 13.Seatbelt detection system Realtime detection

6. Conclusion
Proposed system meets the objective.in which driver sleepiness system able to detect facial landmarks and provided alert when driver detected with sleepiness or yawning. In case of driver distraction and seat belt detection system both model able to achieve overall efficiency of 98.4% and 100% for seatbelt detection. for Realtime detection model is capable of detecting 9 out of 10 images. For real car deployment, the optimal camera location is in the centre of the dashboard, where the multimedia system is placed, with the camera facing the driver. As a result, the presence of other occupants will not confuse the system.

7. Future work
Currently there is no provision for sleepiness detection when driver is wearing sunglasses because it does not capture eye opening status both by facial landmarking and object detection-based approach.
To resolve this multiple system must be integrated to detect sleepiness status of driver. This technology may be modified to be used for trucks and buses, as these two types of vehicles typically commute at night and have a significant risk of the driver falling asleep. To make retro-fitment kit for existing vehicle.

8. Limitations
This system only works when camera position is fixed for both data collection and actual implementation is same slight change in camera position can cause improper detection. In some instances, such as while travelling through a tunnel or when the car is facing sunlight at a specific angle, the system may misbehave and facial landmarks cannot be identified.

9.References

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