Advanced Drowsiness Detection Systems Based on Human Activities and Videos

Garv Modwel, Anu Mehra, Nitin Rakesh, K K Mishra

Abstract*: Drowsiness and lack of attention in driving are main two reasons for any road accident. So far several approaches like face recognition, measurement of human body using wrist band, measuring heart beat and others are defined to detect these kinds of situations to avoid such accidents. All these approaches need some forceful/peripheral attachment with/on driver to do so other than these approaches other solutions are having various limitations in functionalities. In case of solutions using face detection, it is difficult to get the face impression during night or in dark/dull light when maximum chances of accidents are suggestive. On the other hand, with solutions using wristband, drivers have to wear wristband while driving, similarly there are several methods where drivers need to wear some headband or external device. In this manuscript, we have proposed a comprehensive and experimented solution for drowsiness problem. Our approach is sovereign of any device/external gadget dependency. Proposed approach introduces the algorithmic solution to detect the sleeping behavior of a driver with existing parameters and will generate alert for the driver and vehicles near the vehicle driver suffering from drowsiness or lack of attention. The proposed approach is tested over more than 180 test cases with efficacious results.

***Index Terms*: Automotive safety in automotive, Drowsiness, Car-to-car communication, driver behavior dissemination, driver fatigue detection, driver inattention monitoring, wearable devices.**

I. INTRODUCTION

This research is focused on detecting drowsiness or sleeps of a car driver and alerts driver at any point of time. Apart from simply alerting the driver, the research further talks about activating the automotive safety [1, 9-14] outlets of the vehicle by alerting the nearby vehicles and hence preventing fatal accidents. The various mediums used for alerting the driver are beep, flashlights, speaker, and devices like smart phone, which can easily be connected [6] to the car or remote automotive management [24-25]. Devices like seat belt, airbags and accelerator are mediums, which would be crucial for preventing any casualties. Warning [7] lamps, front headlamp and horn are other mediums for alerting any associated external factors. Features like SOS, autonomous driving [15-20] or some remote automotive management [24-25] could further be enabled however, it may require approvals from government authorities, which would be susceptible to change from one country to another, and hence may not be standardized. All features can be customized as per the requirement of the car manufactures. In modern world human being want to execute everything quickly and their ambitions of growing faster is creating lot of problems. Due to work and life, imbalance people are getting lot of diseases like stress, weight gain, Blood pressure and lot of similar problems. Heavy workload and stress is one of the reasons for people to have less sleep and that is causing lot fatigue in human body. Such kind of issue in day-to-day life has many direct and indirect impacts on social and personal life. In current techno upgraded world, it is common to have car and its daily usage for long hours. It is very general to use car after long working hours and with lot of mental and physical fatigue and this may cause severe accident sometime. This research work proposes unique technical solution to alert driver and vehicle surrounding such vehicle to avoid any accident. This section proves the correctness and effectiveness of the approach for existing problem. In section sixth the manuscript is concluded and discussed for the future aspects.

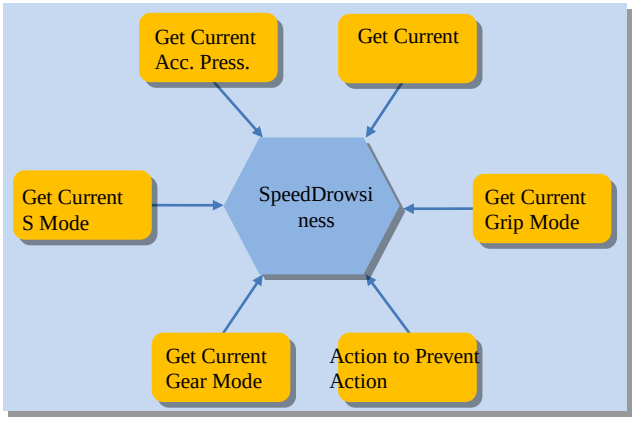

Fig. 1. Block Diagram-Advanced Drowsiness Detection System

II. DROWSINESS DETECTION AND PROBLEM FORMULATION

A. Drowsiness detection based on face recognition [2]

There are various ways of detecting drowsiness and sleep based on different parameters, one of the important parameters is face detection and respective manipulation. Since we know that, there are lot of changes in human face because of drowsiness like frequent yawning, making different type of faces, and

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change in eyes in the terms of eye open area, change in lips expression. So using certain algorithms of image processing we can easily detect above mentioned face gestures. After detecting these conditions, we can easily say that driver is under drowsiness or not.

Considering all the above facts it has a major disadvantage, it is very difficult to detect drowsiness in night time of time where visibility light inside car is very less, this case image capturing device like camera cannot detect the clear pictures of drivers, so it is very difficult to process the image and get the conclusion. Even we are deploying night vision camera in car it is difficult to conclude about the drowsiness and fatigue of driver, so such approach is having certain limitations.

B. Drowsiness detection with wearable devices [3]

Drowsiness can be detected with another approach like using some wearable devices [3]. For example, wearing wrist band like Samsung Gear or other brand and get all the details. Apart from that, there is some other way like wearing a headband and getting details related sensation in mind and decide about drowsiness. Another interesting way is to use some sensors in seat belt, get ECG value for driver, and conclude about the drowsiness. If we consider all these approaches we are forcing driver to wear some band or other things to detect drowsiness, though this is good approach to detect the issue but with some external restriction on driver and in this case all driver may follow it or not so it cannot be a best approach to detect the drowsiness.

However, there are various ways to detect drowsiness like "temperature detection", "eye blink detection", but they have respective drawbacks as mentioned above. We need to get a solution what should work in all the aspects and should be optional to activate and it should force driver to use some external devices like band or some other wearable [3]. It is important to analyze the driver's activity inside the car along with usage of automotive apparatus like steering, clutch and accelerator. On top of that, we can use some cabin conditions like cabin temperature to detect the drowsiness of driver.

Figure 1 shows some basic factors, using that we can detect drowsiness and then respective action can be taken automatically. In this solution driver has privilege to use it or not that gives a great flexibility to use as per the wish. Main factors considered for this solution are automotive safety [9-14] mode, gear mode, speed of vehicle, pressure on accelerator and grip on the steering wheel [4]. More than 280 combinations of above factors are used to decide the condition of driver.

One of the other important ways to detect drowsiness is monitoring the pressure of hands [4] and legs while driving. This technique is independent of light or temperature and requires one or both the hands on the steering wheel whereas one of the legs on clutch and the other on accelerator or breaks. The value of pressure measured on the steering wheel [4], accelerator and clutches while driving will help detect drowsiness or sleep mode. When the driver is driving on proper speed and loosing grip multiple times, it can be concluded that the driver is in the drowsy state. To detect this, we may have to use smart pressure sensors in various parts of steering [4] wheels. If all the sensors are detecting very low pressure or no pressure for a significant time, this indicates that the driver is getting drowsy or has fallen asleep.

Fig. 2. Driver's Steering Operations in normal Drive and Steering Wheel Pressure Measurement.

Above figure shows a typical steering [4] wheel with a pressure sensor. The quantity of sensors can be increased to achieve better accuracy, in general 4-8 sensors can be placed in steering [4] wheel based on which pressure can be measured and hence overall drowsiness can be detected. Pressure can be measured with a pressure sensor that is converted to a standard voltage and hence can be read on any hardware or pin of any port. For e.g., consider there are four pressure sensors applied in four directions of the steering [4] wheel, now when user starts the vehicle in drowsiness mode, and puts his/her hands on the steering wheel, there will be certain pressure on the pressure sensors. If the pressure is high on two of the four sensors it means user is keeping both the hands on the steering and driving with full alert, hence voltage of two sensors can be ORed together. In between if, one hand of the driver is occupied in activities like changing the gear, holding phone or cigarette user is still on alert and pressure continues to be applied on one of the sensor, but since we were ORing the pressure of the two sensors that means there is no change as such. Now if in a case, there is frequent change in pressure or there is no pressure that means the user is drowsy. All these conditions are met when the vehicle has some speed say at least more than 5 KMPH. These conditions of monitoring the pressure will not be applicable if car is in stable state, car should always be moving.

III. PROPOSED SYSTEM ARCHITECHURE

A. Combining various factors to judge Drowsiness

Figure 3 shows the sequence diagram of detecting the drowsiness by means of various factors like safety Mode, Gear Mode, Speed Mode, Pressure on accelerator and grip and pressure on steering [4] wheel. In this research, total 182 conditions were tested and based on that alerts were given. This is completely passive automotive safety [1, 9-14] for driver and surrounding objects like other cars or buses nearby. If safety mode is off or car is in neutral gear then the system does not need to proceed further, if not system can proceed further with the check of many parameters. Alerts are also dependent on various conditions and it is all about the measurement of parameters and deciding values.

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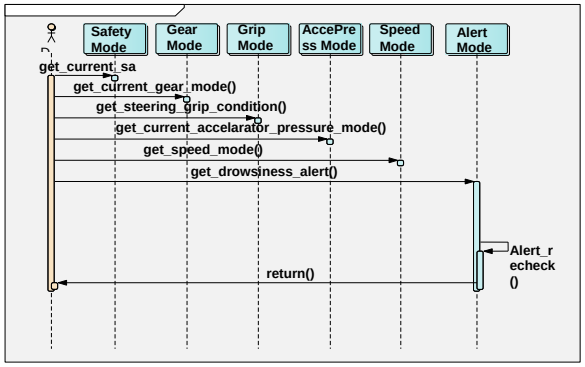

Fig. 3. Sequence Diagram Drowsiness Detection

B. Selective Alert System for Drowsiness Detection [2]

Since system is for alert, it can be used selectively for any user, if user is really looking for this kind of alert, it may not be a permanently inbuilt system. It can be implemented with the help of some switch or button to maintain the state. This alert system has many parameters holding many state machines and there are transitions in state based on the value of the parameters. There are various state machines for Safety Mode, Gear Mode, Speed Mode, Grip on Steering Mode and on behalf of that system is designed and tested.

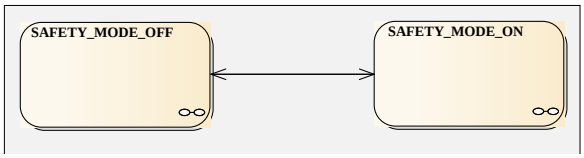

Fig. 4. State Machine Automotive safety Mode

One of the key features of this system is safety mode, which can be enabled and disabled as per the requirement. Some drivers are confident enough for not falling asleep while driving, for them safe mode can be disabled and for others it can be enabled. Another big advantage of this system is that it can be installed in existing cars also with very minimum changes. Since this system is a combination of various parameters and all the parameters keep switching the mode or status so all the important parameters hold proper state machine, for example, gear is a very important parameter and gear can be in three modes for a manual transmission car, those are neutral, gear and speed as shown below.

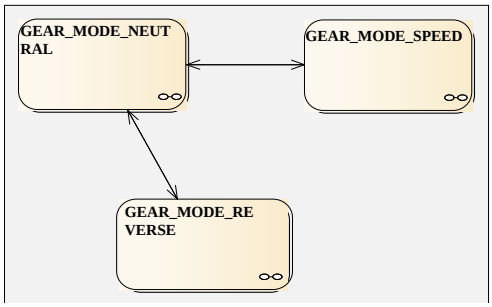

Fig. 5. State Machine Gear Mode

C. Various factors to detect Drowsiness

Figure 5 is showing all about the gear mode. Considering the requirement of the research topic we need to consider the clear-cut picture of practical scenario, for example sleep detection is useless when car is in neutral or reverse/parking mode. In order to avoid load on the system reverse and neutral gear conditions can be avoided. Another important parameter considered to detect the drowsiness is drivers grip on the steering [4] wheel, considering the way people drive, it is very difficult to detect drowsiness on behalf of this parameter alone as there is no standard for putting hand on the steering wheel. This parameter is very important as grip can be single handed or double handed, again this is not enough to detect the drowsiness as driver may hold the steering with tight grip or medium grip or with very low grip, so this is one of the most difficult parameter to rely on, however without this parameter drowsiness cannot be detected.

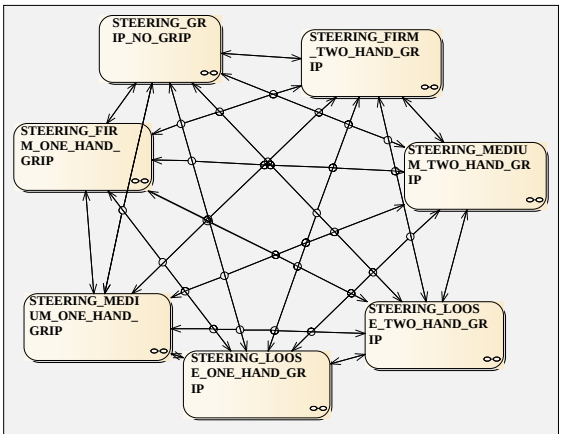

Fig. 6. State Machine-Steering wheel Grip Mode

Above diagram shows various grip mode and the deciding criteria for the grip are pressure on steering wheel and the number of hands on the steering mode. The steering [4] pressure mode may be low, medium or none based on the driver's driving practice. Important point to notice about the steering grip state machine is that it can move from one state to another without any criteria since it is dependent on human driving and there is no rule for movement or grip on the steering. Out of seven modes, few modes will be responsible for low alert, few for medium alert, few for high alert and few for no alert. In case we do not have value of other parameters, system cannot decide on behalf of this parameter alone. Another important parameter is the driver's pressure on the accelerator. If the accelerator pressure fluctuates too much then the system can have designed accordingly.

Above diagram shows the state machine of the user having value of pressure, pushed by the driver's leg, it is categorized in low, medium, high and no pressure mode. Again, this with the combination of other parameters can make a big difference in drowsiness detection [2]. Since there are number of parameters in the system based on which alerts can be generated. One alert can generate other alerts as well. Since, this system will also act as passive automotive safety system, so the level of alertness can be decided based on the risk of driver's life.

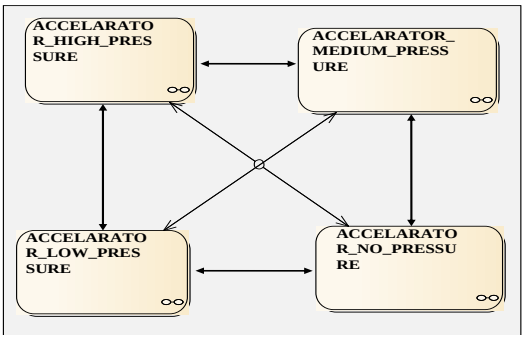

Fig. 7. State Machine–Accelerator Pressure Mode

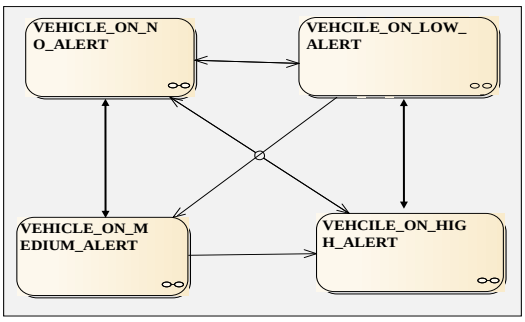

Fig. 8. State Machine Steering wheel Grip Mode

Figure 8 shows different levels of alert and their transitions. If an alert persists for long, intensity of the alert can be raised as per the requirement of design. If one alert is present more than three times in the system and human interaction is not there to neutralize the alert, then alert intensity will be raised automatically. For example, if low alert stays in the system for long and keeps repeating more than three times, low alert will be converted to high alert and same would be applicable for medium alert. Based on the type of alert, subsequent actions will be taken to alert the driver to avoid any kind of accidents. Below mentioned table 2, table 3 and table 4 shows the action and alert relationship of the system. When there is no alert, system will behave normally without any action, when there is low alert it will produce safety alerts for driver in the form of beep and warning LED [7]. Once the driver receives these alerts like accelerator pressure or steering grip, based on this, alert will set or move to another alert. If the driver is on medium alert due to state transition from low to medium alert or direct generation of medium level alert, car will continue to be on low level alert and will also force the fan or body control [23] of the car on highest speed with reverse AC mode (Hot to Cool and vice versa). It will also fluctuate the internal lightning or body control [23] of the car so that driver can get some better alert to break the sleep. So as per design there will be multiple categories of alerts like no alert, low alert, medium alert and High alert. All the alerts should have respective actors and actions to prevent accident.

Action and alert should be in such way that it should be considering the driver, car and surrounding conditions to avoid any accident. Below mentioned table shows the action on No alert, ideally there should not be any action in case of low alerts as shown in table 2.

Table 3 shows action on Low Alerts, Alert is low that means less risk for driver and surrounding vehicles. For preventing accident, we need to alert driver so that driver can come out of Table 2. Action on No alerts.

drowsiness mode, this can be done using beep sound with repetitive and increasing volume or some flashing somewhat light what can irritate driver, this sound or light should stop after the intervention from driver to make sure that driver came out of drowsiness mode. Various possible cases for low alerts are mentioned in table 3. Likewise, we will have certain action and actor for medium alert as well as shown in table 4. Last and important alert is high alert and it is useful for both driver's safety and automotive safety [1, 9-14] of the surroundings. The system will keep following the action of medium alert along with wireless communication like [5] Bluetooth ring to cell phone if it is connected [6] and the system will also activate the warning lights [7] so that surrounding vehicles can get alerted that the user is sleeping, see table 5.

Table 1. Parameters- Responsible for Sleep Detector.

```
enum gear_mode_enum
{
    GEAR_MODE_NEUTRAL=0,
    GEAR_MODE_SPEED,          // to be monitor in GEAR mode Only
    GEAR_MODE_REVERSE

};

enum steering_grip_enum
{
    STEERING_GRIP_NO_GRIP=0,
    STEERING_FIRM_TWO_HAND_GRIP,
    STEERING_FIRM_ONE_HAND_GRIP,
    STEERING_MEDIUM_TWO_HAND_GRIP,//MEDIUM ALERT
    STEERING_MEDIUM_ONE_HAND_GRIP,//MEDIUM ALERT
    STEERING_LOOSE_TWO_HAND_GRIP,  //HIGH ALERT
    STEERING_LOOSE_ONE_HAND_GRIP //HIGH ALERT

};

enum accelator_pressure_enum
{

    ACCELARATOR_HIGH_PRESSURE=0,
    ACCELARATOR_MEDIUM_PRESSURE,
    ACCELARATOR_LOW_PRESSURE,
    ACCELARATOR_NO_PRESSURE

};
enum vehicle_alert
{
    VEHICLE_ON_NO_ALERT=0,
    VEHCILE_ON_LOW_ALERT,
    VEHICLE_ON_MEDIUM_ALERT,
    VEHCILE_ON_HIGH_ALERT

};

enum vehicle_speed_mode
{

    VEHICLE_AT_NO_SPEED=0,
    VEHCILE_AT_LOW_SPEED,
    VEHICLE_AT_MEDIUM_SPEED,
    VEHICLE_AT_HIGH_SPEED

};
```

Code shown in table 1 represents the parameters responsible for sleep or drowsiness detection [2]. All

Mode	Gear Mode	Accelarartor Prssure	Steering Grip	Speed	Alert	Actor	Action
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_HIGH_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_FIRM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_NO_SPEED	VEHICLE_ON_NO_ALERT	None	None

Table 3. Action on Low Alerts.

Mode	Gear Mode	Accelarartor Prssure	Steering Grip	Speed	Alert	Action For	Actions
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHCILE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Light warning
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHICLE_ON_LOW_ALERT	Car	Beep Sound &Flash Ligh warning

Table 4. Action on Medium Alerts

Mode	Gear Mode	Accelarartor Prssure	Steering Grip	Speed	Alert	Action For	Action
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHICLE_ON_MEDIUM_ALERT	Driver	LowAlert Action+Ac Reverse+Fan Full and Internal Light Fluctuation

Table 5. Action on High Alerts.

Mode	Gear Mode	Accelarartor Prssure	Steering Grip	Speed	Alert	Action For	Action
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHICLE_ON_HIGH_ALERT	Car and Surrondings	Previous Alerts Actions+Call to Companion+Warning Light On +SOS

the parameters together are responsible for detecting different types of alerts and respective actions. For further enhancement, procedures like eyes detection may also be included but that may not be fail full proof solution.

A. Driver's Alert for Drowsiness

So far, we are done with the detection of sleep and drowsiness. Now further detection is to alert the driver that he or she is about to sleep or sleeping which may be a cause of accident. In order to alert the driver, we could follow a number of actions and all these actions are executed to make sure that the driver comes out of drowsiness state and starts to focus on driving. To achieve such functionalities, driver's safety should be of prime focus, any act of hard impact might cause adverse effects. Driver should be alerted by the ways that are usual to him or her. All the options should be enabled based on conditions like speed of the car, previous tried options and number of times drowsiness was detected. For example, if, driver is on very high speed, alert should be immediate and with strong gestures whereas if the driver is in periodic drowsiness there should be periodic alert. Considering all the kind of alerts, we can very well say that driver's alert is sum of all the alerts.

$$Al = Low\ alert\ Parameters$$
$$C = Combination\ of\ Alert\ Parameters$$

$$Al = \sum_{k=0}^{n} \binom{n}{k} \cdots (1)$$

Low Alert at any given point of Time L1=$\sum_0^n (Al)$

$$Ml = Medium\ alert\ Parameters$$

$$Ml = \sum_{k=0}^{n} \binom{n}{k} \cdots (2)$$

Medium Alert at any given point of Time M1=$\sum_0^n (Ml)$

$$Hl = High\ alert\ Parameters$$

$$Hl = \sum_{k=0}^{n} \binom{n}{k} \cdots (3)$$

High Alert at any given point of Time H1=$\sum_0^n (Hl)$. Alert at any point of time

$$A_1 = sum\ (Low\ Alerts\ + Medium\ Alerts\ + High\ Alerts)$$

$$A_1 = \sum_{0}^{n} (Al + Ml + Hl) \cdots (4)$$

Results, in figure 9-13, shows all types of alerts with respect to different parameters. Ideally multiple alerts cannot occur at same time but even if any of the alert occurs vehicle should be in alerted mode.

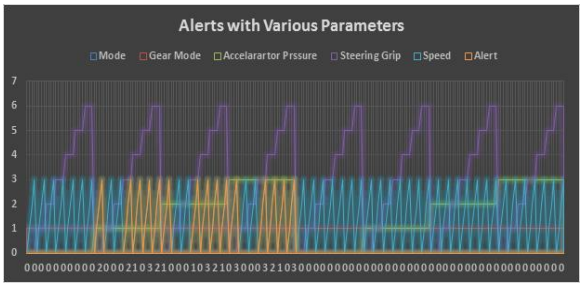

Fig. 9. Various Type of Alerts with various parameters.

Fig. 10. Condition of No Alert

Fig. 11. Condition of Low Alert

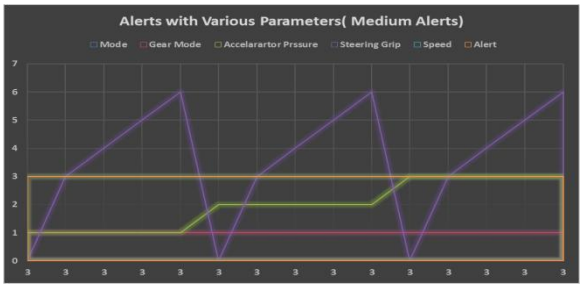

Fig. 12. Condition of Medium Alert

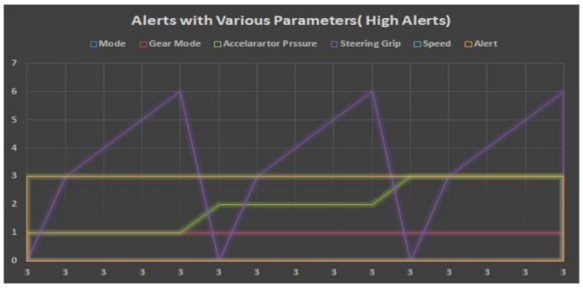

Fig. 13. Condition of High Alert

IV. EXPERIMENT DESIGN AND MATERIAL

To simulate the environment, many pressure sensors were used and to simulate speed variable resistance was used. Pressure was used for accelerator for steering wheels' points as mentioned above apart from that speed was simulated using variable resistor, in general this is a typical setup for car and same was used here, results were simulated and display using com port or hyper terminal as shown below. All the conditions of speed, steering grip and accelerator pressure were simulated using this hardware. As per the need of the condition, respective HW was given input and output was checked at screen. Based on different scenarios, alerts can be divided into 3 major categories, highly effective alert to have immediate attention of the driver, low effective alerts to inform driver about drowsiness and periodic alerts to avoid periodic drowsiness of the driver.

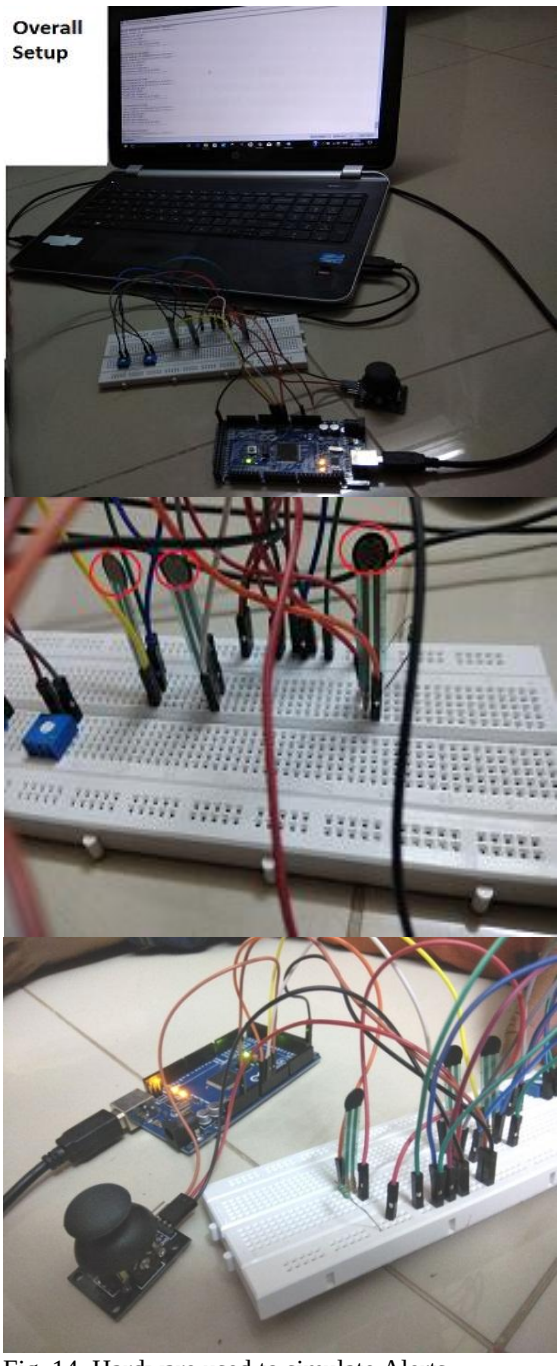

Fig. 14. Hardware used to simulate Alerts

A. Algorithm-Alert Activation

Table 6. Overall Implementation

```
PUBLIC void get_drowsiness_alert (void)
{
    printf("Checking for drowsiness\n");
    printf("\n\n\n----------Get All the
parameters----------\n\n\n");
    printf("Current Speed =%d\n", vehicle_speed);
    get_speed_mode(vehicle_speed);
    safety_mode=get_current_ safety_mode();
    gear_mode=get_current_gear_mode();
    steering_grip_condition=get_steering_grip_condition();
    accelator_pressure_condition=get_current_accelarator_pressure_mode(
);
    printf("\n\n\n----------\n\n\n");
    if(safety_mode!=
SAFETY_MODE_ON || gear_mode!=GEAR_MODE_SPEED ||
steering_grip_condition==STEERING_FIRM_TWO_HAND_GRIP ||
accelator_pressure_condition==ACCELARATOR_HIGH_PRESSURE ||
speed_mode==VEHICLE_AT_NO_SPEED )
    {
    activate_sleep_alert(VEHICLE_ON_NO_ALERT);
    printf("**************************************\n\n");
    printf("Current Alert =VEHICLE_ON_NO_ALERT\n");
    printf("**************************************\n\n");
    return ;//1
    }
    if (safety_mode==SAFETY_MODE_ON &&
gear_mode==GEAR_MODE_SPEED)
    {
    printf("vehicle is riding on SAFETY_MODE_ON with
GEAR_MODE_SPEED\n");
    if((steering_grip_condition==STEERING_LOOSE_TWO_HAND_GR
IP ) && (accelator_pressure_condition==
ACCELARATOR_MEDIUM_PRESSURE)  && (
speed_mode==VEHCILE_AT_LOW_SPEED))
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_LOW_ALERT);
    return ;//2
    }
    if(
steering_grip_condition==STEERING_MEDIUM_TWO_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_LOW_PRESSURE &&
speed_mode==VEHICLE_AT_MEDIUM_SPEED )
    {
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    printf("**************************************\n\n");
    return ;//3 medium 1
    }
    if(
steering_grip_condition==STEERING_LOOSE_ONE_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_MEDIUM_PRESSURE  &&
speed_mode==VEHCILE_AT_LOW_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    return ;//4 medium 2
    }
    if(
steering_grip_condition==STEERING_MEDIUM_ONE_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_MEDIUM_PRESSURE  &&
speed_mode==VEHCILE_AT_LOW_SPEED)
    {
```

```
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    return ; //5 medium 3
    }
    if(
steering_grip_condition==STEERING_MEDIUM_ONE_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_LOW_PRESSURE  &&
speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    return ;//6 medium 4
    }
    if( steering_grip_condition==STEERING_GRIP_NO_GRIP  &&
accelator_pressure_condition==
ACCELARATOR_MEDIUM_PRESSURE  &&
speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    return ;//7 medium 5
    }
    if(
steering_grip_condition==STEERING_MEDIUM_TWO_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_MEDIUM_PRESSURE  &&
speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_MEDIUM_ALERT);
    return ;//8 medium 6
    }
    if( steering_grip_condition==STEERING_GRIP_NO_GRIP  &&
accelator_pressure_condition== ACCELARATOR_NO_PRESSURE  &&
speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//9 high 1
    }
    if(
steering_grip_condition==STEERING_LOOSE_TWO_HAND_GRIP
&& accelator_pressure_condition== ACCELARATOR_NO_PRESSURE
&&  speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//10 high 2
    }
        if(
steering_grip_condition==STEERING_MEDIUM_TWO_HAND_GRIP
&& accelator_pressure_condition== ACCELARATOR_NO_PRESSURE
&&  speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 3
    }
    if(
steering_grip_condition==STEERING_LOOSE_ONE_HAND_GRIP  &&
accelator_pressure_condition== ACCELARATOR_LOW_PRESSURE
&&  speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 4
    }
    if(
steering_grip_condition==STEERING_LOOSE_ONE_HAND_GRIP &&
accelator_pressure_condition== ACCELARATOR_NO_PRESSURE  &&
speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 5
    }
    if(
steering_grip_condition==STEERING_MEDIUM_ONE_HAND_GRIP
&& accelator_pressure_condition== ACCELARATOR_NO_PRESSURE
&&  speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
       return ;//11 high 6
    }
    if( steering_grip_condition==STEERING_GRIP_NO_GRIP  &&
accelator_pressure_condition== ACCELARATOR_LOW_PRESSURE
&&  speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 7
    }
    if(
steering_grip_condition==STEERING_LOOSE_TWO_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_LOW_PRESSURE  &&
speed_mode==VEHICLE_AT_MEDIUM_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 8
    }
    if(
steering_grip_condition==STEERING_LOOSE_TWO_HAND_GRIP
&& accelator_pressure_condition==
ACCELARATOR_LOW_PRESSURE  &&
speed_mode==VEHICLE_AT_HIGH_SPEED)
    {
    printf("**************************************\n\n");
    printf("**************************************\n\n");
    activate_sleep_alert(VEHCILE_ON_HIGH_ALERT);
    return ;//11 high 8
    }
    }
    else
    {
    printf("**************************************\n\n");
    printf(" Current Alert =VEHICLE_ON_NO_ALERT Line =%d
File=%s\n",__LINE__,__FILE__);
    printf("**************************************\n\n");
    activate_sleep_alert(VEHICLE_ON_NO_ALERT);
    return ;
}
}
```

Code as in table 6 snippet shows the alert activation of various alerts based on different scenarios. When the driver is driving in high speed and the system detects drowsiness, driver should immediately be alerted with a strong indication, with the help of alerts like vibration in steering wheel, activating internal [7] lights, playing some warning tone if any smart device [15] is connected with car [6], and moreover by slightly fluctuating the power window. Vibration in steering wheel can be easily setup by using thin vibrators in steering wheel. In order to achieve this functionality

system needs to use Car's network effectively with the help of protocols used in cars like CAN (Controller Area Network). All the priority based devices should be given alerts and they should handle it accordingly. Car's infotainment system can play important role if it is ON when drowsiness condition is detected, this can be achieved by playing the high volume music. In alert system, there is a condition called "low priority alert" which alerts drowsiness based on the speed of the car. As a result of this alert, there could be beeps sound like seat belt alert or hand brake alert. Alertness tone can be same or different and all is dependent on the way we implement, separate tone will give user clear indication of drowsiness and hence better results.

B. Initial condition Simulation

Figure 14 shows, the simulation of the system, where all parameters are considered. This is the interface developed for simulating all scenarios based on different parameters. Here similar alerts can be invoked and can be simulated with the help of windows alert system. In this executable file all the parameters can be "get" and "set". Many options are provided to the user to manipulate all possible options and same can be tested as per the requirement. Below mentioned figure 15 shows the default options of the system in an ideal scenario containing the following values of different parameters. Considering types of alerts, alerts are categorized in four parts and each of them has some physical significance as per the situation of the vehicle, we can simulate all the conditions based on the need. We have state of No Alert, Low alert, Medium Alert and high Alert and that is component of a typical state machine.

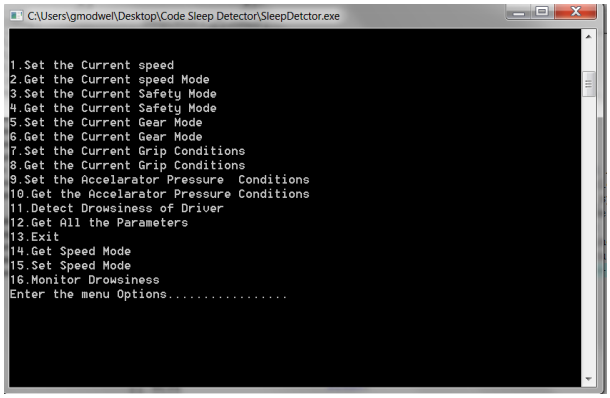

Fig. 15. Simulation Drowsiness Alert System- Main Menu

C. Alert State Machine

No alert is default state and ideal for situation and that means vehicle is in a situation where there is no chance of accident. Next state is Low Alert where vehicle have very les chance of accident due to drowsiness, say driver start yawning and that may lead driver in to sleep. Next state is medium alert where driver may start taking frequent naps and that may lead to accident. Final state is high alert where there are high chances of accident and that may cause damage to other vehicles as well. So, as per the state machine system need to work and accordingly need to alert driver and outside word.

For example, in a case of high alert (High Speed, safety Mode is On, Accelerator having no pressure and grip is loose in single hand) this may cause big accident not only dangerous for driver but also dangerous for other people on road, hence as a result we need to alert not only drivers but others as well who are nearby the vehicle. Below mentioned figure 17 shows the simulation for the same.

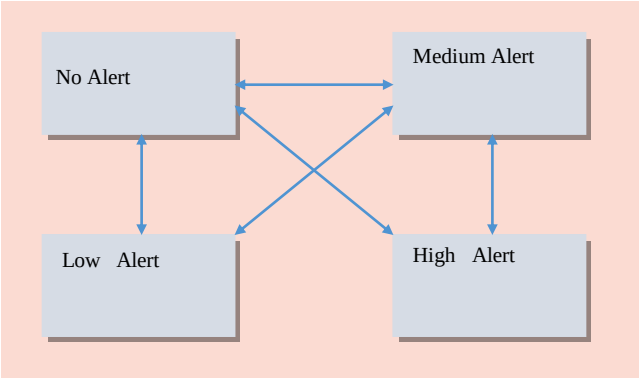

Fig. 16. Alert State Machine

D. Various Simulations

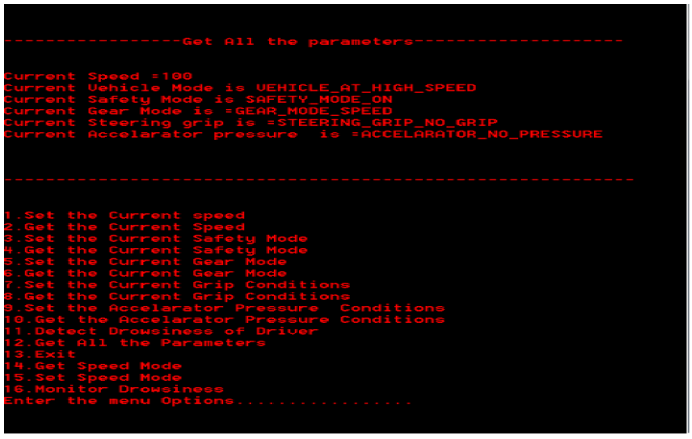

Fig. 17. High Alert Simulation

Figure 16 shows the simulation for high alert, left hand side of screen shows the input parameters and input Menu and right hand side shows the output warnings having all

the indicators buzzing periodically [7]. Logically when there is High alert directly, it will call all the lower active alerts. Here high Alert will call Medium alert and that will internally call low alert. Since action on the alerts are based on the criticality of situation so for high alert all the other active alerts should be up and running.

Considering Low alert, it is a situation when chance of accident is very less, that means a small warning [7] should be enough for the prevention similar to seat belt beep warning as shown below in Input and output figure 18.
Similar way medium level alert can be detected and according actions can be taken by the control module. Important part of

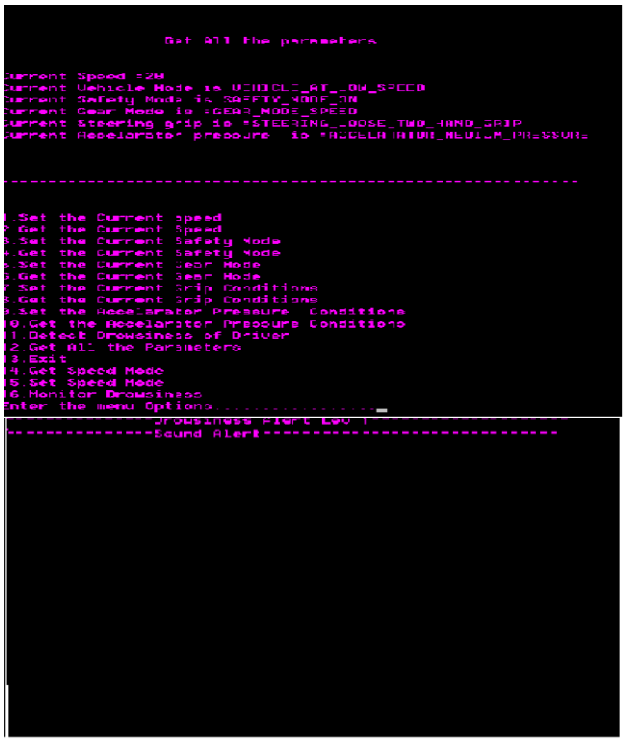

Fig. 18. Low Alert Simulation

Medium alert is that, it will use the action alert of low alert as well as shown in state machine. In this way, there are 182 possible combinations to decide the type of alert.

E. Alerts communication

This alert is an important one for this system, since this will prevent any kind of collision. There are multiple ways and resources available to achieve this. As soon as the system detects an alert, system can turn on warning lights [7], which will not only be helpful for the driver but also other cars passing nearby. This itself will avoid any accidents and will reduce chances of being hit by the back. The chances of a sleeping driver hitting others is very high, however this can also be controlled up to some extent by periodic fluctuation of headlamps (dipper). This will alert the drivers driving in the opposite direction and hence will prevent any collision because as per the standards [4], drivers should always be alert and away from a car, having warning lights [7] on whereas dipper gives an indication to pass through or it may activate some feature related to cars [15-20].

V. RESULT AND DISCUSSION

Table 7 shows the results of various conditions and respective alerts; in current system, we simulated all the alerts Low, Medium and High with various inputs, since it is optional to choose drowsiness detection [2], so user can easily avoid these alerts if user is not interested. If we analyze the overall condition of all the alerts, there are approximately eighty alerts and all the alerts are not useful, above-mentioned table 7 shows the important alerts and their category with different values of parameters. So, based on human activity in vehicle it is possible to detect drowsiness conditions of drivers and the severity, based on the time driver remain in the severity level, current level can be changed and car can take respective actions to alert driver and other vehicles nearby.

Fig.19.Medium Alert Simulation

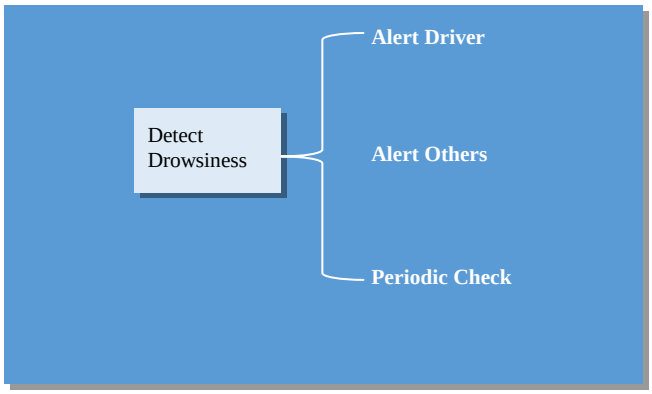

Fig. 20. Overall Functionalities-Drowsiness/Sleep Detection System

VI. CONCLUSION

The above experiment is conducted with 180 different types of test case with the developed prototype. The experiment tried to predict different drowsiness characteristics of the driver in different driving scenario. The prototype along with the algorithm developed is always giving the desirable result in all the 180 test cases and validated.

Table 7. Results of Various Conditions and Respective Alerts

Mode	Gear Mode	Accelararter Prssure	Steering Grip	Speed	Alert
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHCILE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHCILE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHCILE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_MEDIUM_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_LOW_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_GRIP_NO_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_MEDIUM_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_TWO_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_LOW_SPEED	VEHCILE_ON_LOW_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_MEDIUM_SPEED	VEHCILE_ON_MEDIUM_ALERT
SAFETY_MODE_ON	GEAR_MODE_SPEED	ACCELARATOR_NO_PRESSURE	STEERING_LOOSE_ONE_HAND_GRIP	VEHICLE_AT_HIGH_SPEED	VEHCILE_ON_HIGH_ALERT

Considering that human life is precious, it is necessary to have enough automotive safety [1, 9-14] and security irrespective of any conditions. Drowsiness has become an alarming concern now days since people are not getting enough sleep because of hectic work conditions. This can be a major cause of casualties of not only oneself but also others while driving. Considering the car's network now days all the devices are well-connected [6] with the help of CAN protocol and hence communication is done based on the priorities. Since we have priority-based communication to activate the device, it is easier for the system to alert the driver with the help of CAN messages. Based on different situations, from too severe to less severe or repetitive, alerts can be activated for the user and precious human life can be saved. Moreover in ISO 26262 [21-22] there are standards [4] to prevent car from any kind of malfunction but this doesn't provide security to user from his or her own mistakes, whereas this system is about alerting the user from their own mistakes and providing the driver with the necessary passive automotive safety[1, 9-14] System can be connected to cloud [6][8] with the help of connectivity and can notify friends and family of the driver about the drowsiness state, so that they can take necessary action.

Figure 19 shows the overall functionalities of the system, this can be adopted as a standard for the human automotive safety and can be categorized based on vehicle to vehicle. For example, this can be very beneficial for truck drivers, taxi drivers and other commercial drivers. This system can also be very helpful for hard working crowd and specifically for people who work late hours. Moreover, this system is like a gift for senior citizens to avoid any kind of accidents due to drowsiness and sleep.

Figure 21 shows the use case diagram for advanced drowsiness/sleep detection system. In general all the four wheelers are covered, which means such a system can secure a very big crowd and can change the level of driving and automotive safety [1,9-14] drastically.

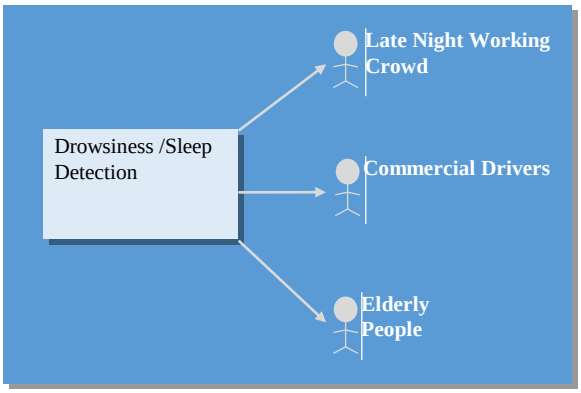

Fig. 21. Use case for Advanced Drowsiness and sleep detection

There is a lot of discussion and efforts are made on the

automotive safety [1] and security for four wheeler drivers and lot of standards [4] are defined like ISO26262[21-22] to make sure that car is not malfunctioning. In addition, there has been a lot of callback of cars due to malfunction in the components but there is very less focus on the human error. Human beings are made for making errors and they will keep doing the same. Now days there are very less standards and technologies available in world what can prevent human life from the damage done my human errors. This system addresses this concern and hence prevents human errors. It provides precaution, prevention and automotive safety [1] of not only oneself but also for others who may get affected by the errors done by you. This system provides active and passive security both and always keeps you on alert whenever you are or about to fall asleep.

Table 8. Comparison of various approaches results.

	Approaches		
	Camera Based	Wristband Based	Current
Human Intervention	NO	YES	NO
Night Time Function	LOW	HIGH	HIGH
Day Time Function	HIGH	HIGH	HIGH
Inputs for Car	YES	NO	YES
Inputs for Surroundings	NO	NO	YES

Not all the earlier approaches, may work all the time, above table shows the comparison of different approaches. Consider if wristband will give indication only if person is wearing that, in case person is not wearing that, approach may not give proper results, and driver may end up with accident. Similarly camera may not give drowsiness detection during night time as it may not detect the changes in face of driver and driver may end up with accident, so all the earlier approaches were having some issues, this approach, is about detecting drowsiness based on driver's interface with car and it can be detected easily, hence this approach covers demerits of all the earlier approaches and can be used widely in current scenario.

Table 9. Appendix a Nomenclature

Sf	Safety mode for vehicle
lSf	Last Safety Mode activated for vehicle
$V(x)$	Overall Speed
$V(0)$	Initial Speed
$V(i)$	Instant Speed
Vh	High Speed Limit
Vl	Low Speed Limit
$AP(x)$	Overall Accelerator Pressure
$AP(0)$	Initial Accelerator Pressure
$AP(i)$	Instant Accelerator Pressure
$AP(h)$	High Accelerator Pressure Limit
$AP(l)$	Low Accelerator Pressure Limit
$P(x)$	Pressure on Steering wheel
$P1$	Pressure on first sensor of steering wheel
$P2$	Pressure on second sensor of steering wheel
$P3$	Pressure on third sensor of steering wheel
$P4$	Pressure on fourth sensor of steering wheel
Al	Alert Level

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