IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-6, Issue-2 E-ISSN: 2347-2693

# Driver Behavior Monitoring and Alerting System using Samrt Phone

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**Available online at: www.ijcseonline.org**

Received: 31/Jan//2018, Revised: 08/Feb2018, Accepted: 23/Feb/2018, Published: 28/Feb/2018

***Abstract*—** Objective of this research work is to build a driver monitoring system. Nowadays because of the road accidents death rate is keep on increasing and the vehicle production rate is also increasing which leads to pollution. Driver Alert application is developed to alert the drivers for dangerous driving events with respect to driver behavior and road conditions. This system focuses on the most commonly occurring dangerous driving events: drowsy driving, inattentive driving, lane weaving and drifting, and vehicle detection. Driver behavior is monitored with his head pose and eye state using front camera of the mobile. Similarly, in the rear camera the dangerous driving conditions at the road are detected with respect to lane conditions and vehicles (living being, non-living being) on the road. If the system detects any dangerous events on any of the camera, then it alerts the driver by displaying an alert icon on the mobile's touch screen along with an audible alert message. To process the video frames from both front and rear camera a context-switching algorithm is used. So that the driver will be notices in both the way and alerted for them. An Emergency system is developed to tell about the driver problem to the outside people for dangerous events like accident, heart attack or any health issue which makes him distracted while driving.

***Keywords*—** Head pose, lane detection, context switching, emergency system, driver alert.

## I. INTRODUCTION

While driving being tired or distracted is dangerous. A total of 4, 80,652 road accidents took place in India last year resulting in the loss of 1, 50,785 lives and inflicting serious injuries on 4, 94,624 persons which because of directly attributed to distracted drivers. Surprisingly, many people drive while being tired or drowsy and according to experts, many drivers fail to recognize they are in a fatigued state [1]. Tracking dangerous driving behaviour can help raise drivers' awareness of their driving habits and associated risks, thus, helping reduce careless driving and promoting safe driving practices. Today's top-end cars come with a wealth of new safety features built-in. These include collision-avoidance, drowsy driver feedback (e.g., vibrating steering wheel), pedestrian detection. By fitting advanced sensors into the vehicle (e.g., night cameras, radars, ultrasonic sensors), the car can infer dangerous driving behaviours, such as drowsiness or distracted driving. However, only a tiny percentage of cars on the road today have these driver alert systems; it will take a decade for this new technology to be commonplace in most cars across the globe.

Therefore we propose Driver alert, the first driver safety app that uses both cameras on smart phones. Driver alert uses computer vision and machine learning algorithms on the phone to detect whether the driver is tired or distracted using the front-facing camera and road conditions in rear camera [2]. An emergency system is employed to tell the dangerous events happen to the drivers during driving to outside persons.

Several research projects are designing vision-based algorithms to detect drowsiness (using fixed mounted cameras in the car) of the driver [3]. These solutions usually detect driver states. Optalert Alertness Monitoring System (OAMS) find the drowsiness of the driver by using Johns Drowsiness Scale (JDS), Karolinska Sleepiness Scale (KSS) Algorithms that result the effects of OAMS feedback reduces drowsiness (JDS peak scores), self-reported alertness (KSS), and improves driving performance appraisal (safe distance ratings). Visual Analysis of Eye State and Head Pose for Driver Alertness Monitoring system uses eye index (EI) and head pose (HP) to find the eye state and head position with single camera using Ada Boost algorithm [4]. Driver monitoring system is shown in the figure 1. Like in figure 1 the mobile has to be mounted in front of the driver face.

Figure 1. Driver monitoring system

 

Rest of the paper is organized as follows, Section II contains the framework of driver alert application, Section III contain requirements and analysis of driver alert application, Section IV gives the result and discussions of the application in real world and Section V concludes research work with future directions.

## II. FRAMEWORK OF DRIVER ALERT APPLICATION

The overall architecture of the Driver alert application is shown in figure 2 which includes four event engines to find the dangerous driving conditions namely dangerous driver event engine and dangerous road event engine.

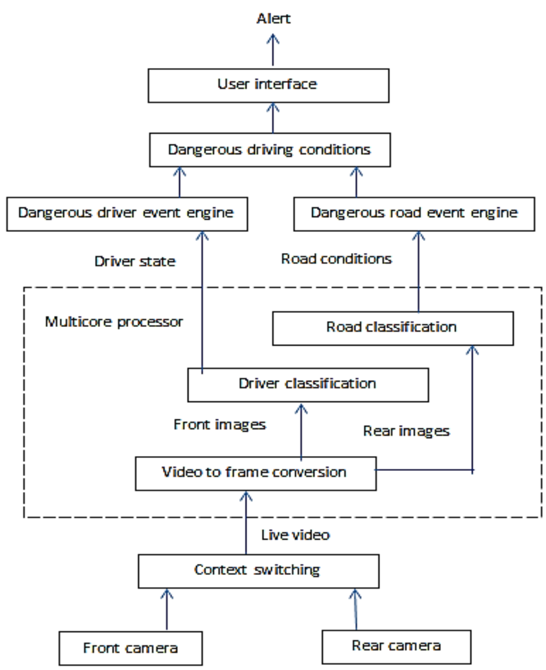


Figure 2. Overall architecture of Driver Alert application

This driver monitoring system focuses on four of the most commonly occurring dangerous driving events [2]. In Driver classification, there are two module events and at Road classification, there are two module events.

Driver classification in Front camera
- Eye event engine
- Face event engine

Road classification in Rear camera
- Vehicle detection engine
- Lane weaving and drifting engine

When the driver face and eye state meets the dangerous conditions then the process will enter into Driver classification engines namely eye event engine and face event engine. When the road condition meets the dangerous driving condition then the process will continue with Road classification engines namely Object detection engine, Lane weaving, and drifting engine. After the detection the dangerous events alert will be given to driver on the touch screen with an audible alert. The event descriptions are follows:

### A. *Driver classification in Front camera*

To avoid accidents because of driver fatigue mentioned in [5] [6] Driver alert has two event engines namely dangerous eye event engine and Dangerous face event engine. Eye event engine will do the eye detection and angle detection of the eye in addition to that driver head pose is also checked to determine whether the driver is drowsy or not. Automated Detection of Driver Fatigue Based on Entropy and Complexity Measures is used in [7]. In the proposed work eye detetion is done using Viola jones Object detection.

Similarly Face event engine will do the face detection and angle detection of the face in addition to that driver head pose is also checked to determine whether the driver is inattentive or not. The figure 3 dataflow diagram of driver classification in front camera shows the process of driver classification with eye and face detection.

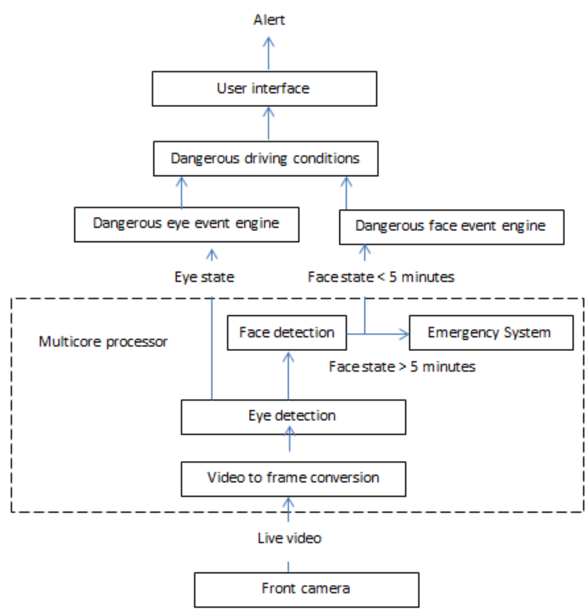


Figure 3. Dataflow diagram of driver classification in front camera

The dangerous eye event engines are explained below in detail.

1) *Dangerous Eye event engine:* Using the driver head pose drowsiness of the driver is measured.

When the driver head pose moves up or down above 45 degree then it is declared that driver is drowsy. So the alert will be given to the driver with audible alert with message on the mobile display. In literature drowsiness is detected using eye blinking rate as in [8] [9].

*2) Dangerous Face event engine*: Firstly the output of the face direction classifier is tracked. If the driver's face is not facing forward for longer than three seconds are then a dangerous driving event is inferred. Then, we monitor the turn detector. Each time when a turn is detected, the output of the face direction classifier is checked. If there is no head turn corresponding to road turning event then the driver did not check that the road is clear – as a result, a dangerous event is inferred. Inattentive driving recognizes four face related categories:

(i) no face is present; or the driver's face is either
(ii) facing forwards
(iii) facing to the left ($a \geq 45$ degree )
(iv) facing to the right ($b \geq 45$ degree)

For the above cases the system will give alert. Design of front camera events are shown in figure 4 and driver attention is maintained [10].

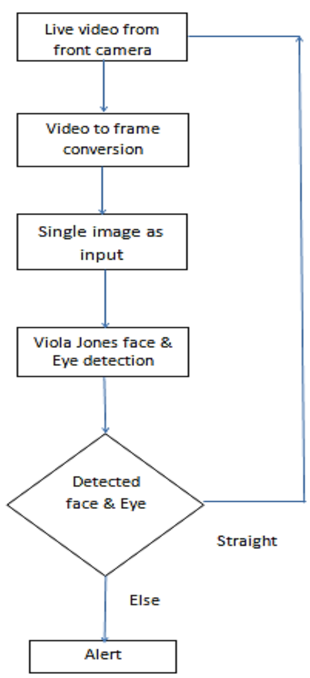


Figure 4. Design of front camera events

*3) Emergency System*: This part of the Driver alert application give alert to outside people if the driver is in dangerous conditions. For example if the driver is met with an accident or any health issue which makes him distracted from normal driving then the problem about the driver will be messaged to a number which is given by the driver at the time of app installation. In both the conditions, the driver face will not get detected for a long time which indicates that the driver is in problem and a call will be made saying that the driver is in serious problem will be sent to that particular number. Therefore, the outside person can help him and can save him. The following Algorithm Emergency System explains the working process. Video frames from front camera are used to do the process of emergency system. If face is not detected for 1 to 4 minutes then the driver classification engine will give alert. If time exceeds to 5 minutes (9000 frames) then emergency system will do its process by making a call to that particular number. The following Algorithm Emergency System explains the working of it.

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**Algorithm: Emergency System**

---

```
(Frames from front camera)
If ( ! detected face ) && (nFrames  < 9000)
        Do driver classification engine
Else if ( ! detected face ) && (nFrames  > 9000)
        Make Emergency call
Else
        No alert (Driver going correctly)
end
```

---

*B. Road Classification in Rear camera*

In Road classification, there are two event engines as similar to the Driver classification in front camera. They are Dangerous Lane event engine and Dangerous Car event engine.

Lane event engine will do the lane detection to determine whether the driver is going in a wrong way or in a right way. Similarly, car event engine will do the vehicle detection to determine the whether driver is going in a wrong way or in a right way. Letter from the Editors: A mathematical model for predicting lane changes using the steering wheel angle [11] gives the mathematical model of finding the lane on the road. Lane detection in a smart city is implemented in [12]. Lane detection is processed in the Region of Interest (ROI) area to avoid unwanted alert for the vehicles coming with a long distance [13]. In the proposed system ROI region is selected to process the lane and vehicle detection on the road.

 

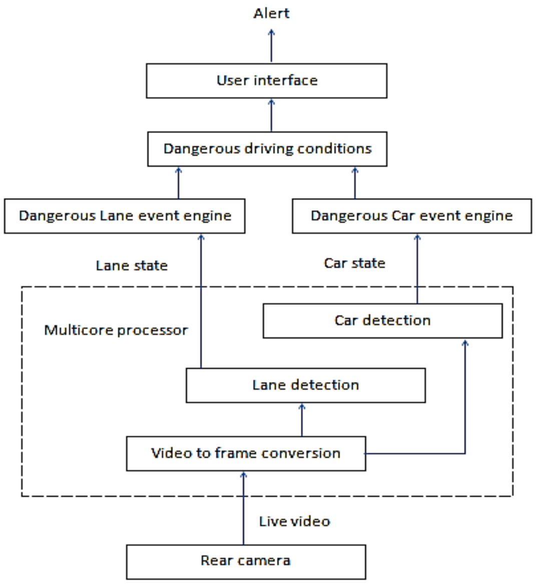


Figure 5. Dataflow diagram of road classification in rear camera

Figure 5 shows the Dataflow of road classification in rear camera. Two of the most commonly occurring dangerous driving events with respect to road conditions are: Lane weaving and drifting and vehicle detection [14] [15].

1) *Lane weaving and drifting:* Using the lanes on the road it is estimated that the driver is going in a right way or in a wrong way. If the driver is going near to the lane or exactly on the lane then it is determined that the driver is going in a wrong way. So the driver is given with an alert. Else, mean that he is going in a right way, so no alert will be given.

2) *Vehicle detection:* In vehicle detection, the car going ahead to the car, which uses this app, will be detected [2]. When the driver is going exactly straight to the car and near to the car then it is estimated that the driver is going in a wrong way. So alert will be given to driver. Else, mean that he is going in a right way. Therefore, no alert will be given [16]. The following flow chart figure 6 shows the Design of rear camera events with car and lane detection in our system.

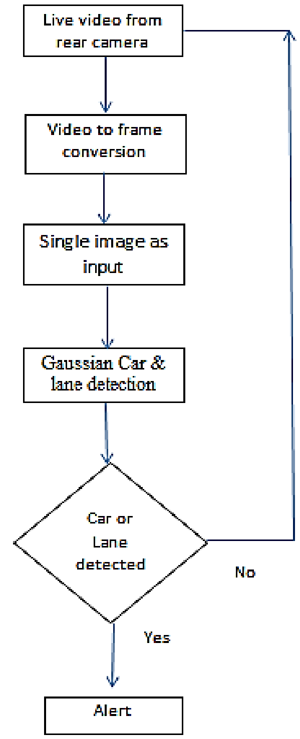


Figure 6. Design of rear camera events

### *C. Context Switching Algorithm*

Driver behavior is monitored using front camera and road condition is monitored using rear camera. To process frames from both the camera without getting instructions from the user Context switching algorithm is used [2]. It is used to switch between front and rear cameras. In driver alert app initially, the app will be set at the front camera and the driver classification process will be continued until 30 frames (1 minute). After one minute, the camera will be switched to the rear camera and do the road classification. Again after 30 frames the context switch will continue. The below algorithm context switch explains the working of it.

-----------------------------------------------------------------

**Algorithm: Context switch**

-----------------------------------------------------------------

```
if (camera at front )
        if ( nFrames > 30 )
                move to rear camera
                do the read classification
        else
                do the driver classification
else if (camera at rear)
        if ( nFrames > 30 )
                move to front camera
                do the driver classification
        else
```

 

```
                    do the road classification
end
----------------------------------------------------------------
```

The table 1 shows some of the dual camera mobile phones with its switching delay. If the delay is less then the switching delay time can be negligible. Less delay time works best [2].

Table 1. Mobiles and Its Switching Delay

| Model | Switching delay (ms) | | Face Detection(ms) |
|---|---|---|---|
| | *F-R* | *R-F* | |
| Nokia Lumina 900 | 804 | 2856.3 | 2032.5 |
| Samsung Galaxy S3 | 519 | 774 | 301.2 |

## III. REQUIREMENTS AND ANALYSIS OF DRIVER ALERT APPLICATION

### *A. Software Requirements*

MATLAB is the efficient way to work with the images. MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language [14]. And Android environment is needed to run the application. Any android version from 5.0 is sufficient to run.

### *B. Assumptions / constraints considered in the experiment*

Lighting conditions (eg overexposure, shadows), Smart phones with both the cameras and multicore processor with minimum switching delay and mobile stand [14].

## IV. RESULTS AND DISCUSSIONS

Short Papers Safe Driving Using Mobile Phones [17] gives the way to develop the application Driver alert and Driver alert application is implemented and tested with different driver face and conditions on the road. Driver Alert Application is developed in MATLAB and it is working well for colour videos and non-colour videos too. Therefore, there is no need of high quality videos. However, the lightning condition must be good enough [13]. So far in existing the algorithms used to do the eye and face detection were working well with good coloured faces not for black like faces. Driver alert is the first application working with both coloured videos and non coloured videos too.

Face detection will work for both faces with glass and without glass. However, the eye detection will not be efficient for face with glass. The screen shots of face detection, eye detection, vehicle detection, lane detection and alert given by the system are shown below in the figure 7(a) to 7(e) respectively.

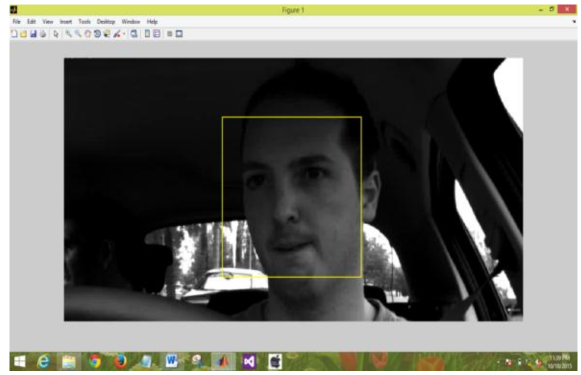

Figure 7 (a). Face detection

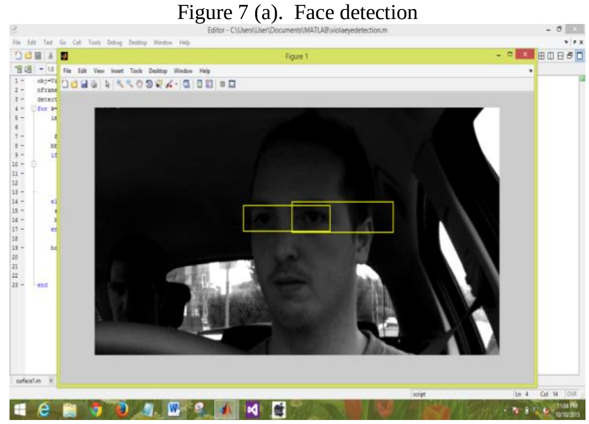

Figure 7(b). Eye detection

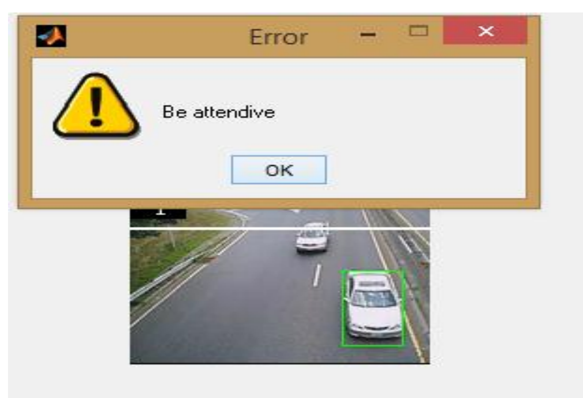


Figure 7(c). Vehicle detection

 

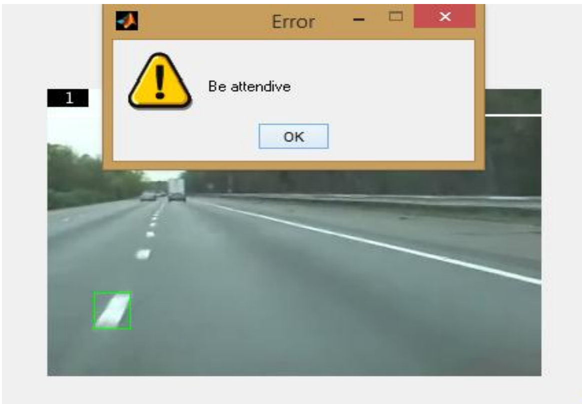


Figure 7 (d). Lane detection

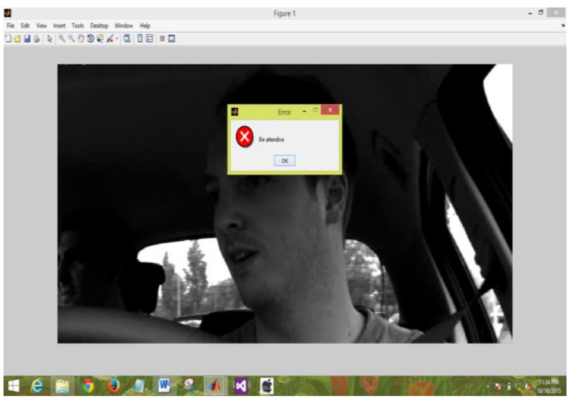


Figure 7(e). Alert for face detection

Data sets from online and real time data sets are taken with different timing and driver face. We evaluated the driver alert using the above collected different dataset collections, where we check the dangerous driving events with scenarios #1 of three videos and #2 of three videos with six study participants. In the Dataset videos, we converted the 1-second video into sequence of frames in the rate of 30 frames per second which is advised for better results. The key metric in driver alert performance is its ability to detect instances of dangerous driving under real-world conditions.

Confusion matrix is used to evaluate the performance of the system. For all the videos using the confusion matrix true positive, false negative, false positive and true negative values are tabulated in the below table 2 which represents the face detected and no alert (Face and Eye detection), face not detected and not giving alert misfortunately, face detected and giving alert wrongly, and alert when no face is detected [2].

Table 2. Confusion Matrix for the Eye State Classifying

| **# of frames** | | **Detected** | |
|---|---|---|---|
| Actual | Open | 250 | 2 |
| | Closed | 1 | 11 |

From the above table true positive rate (TPR) or recall, false positive rate (FPR), false negative rate (FNR), false positive rate (FPR), accuracy (AC) and precision are calculated across all tested dangerous driving scenarios – including both controlled and normal daily driving groups. We found the mean precision and accuracy for all scenarios and the accuracy of the Driver alert is 97% which is shown via the below Figure 8 and Figure 9. Many drowsy detection systems, vehicle detection are developed in [18] [19] [20] [21]. Driver monitoring systems and monitoring systems are developed in [22] [23] [24] [25] and the results are analysed and compared with the proposed driver alert system, which gives more promising performance with better accuracy as shown in the table 3. Sensors are also used to monitor the driver behaviour and the used of wireless sensor is given in [26].

Table 3. The Overall Accuracy for Detecting Dangerous Driving Conditions.

| **Videos** | **TPR** | **FNR** | **FPR** | **TNR** | **AC** | **Precision** |
|---|---|---|---|---|---|---|
| 1 | 0.98 | 0.93 | 0.83 | 0.93 | 0.98 | 0.99 |
| 2 | 1 | 0 | 0 | 1 | 1 | 1 |
| 3 | 0.7 | 1 | 0 | 1 | 0.98 | 1 |
| 4 | 0.99 | 0.28 | 0.57 | 0.94 | 0.99 | 0.99 |
| 5 | 0.75 | 0.24 | 0.85 | 0.94 | 0.81 | 0.94 |
| 6 | 0.79 | 0.26 | 0.32 | 0.98 | 0.95 | 0.73 |
| Avg | - | - | - | - | 97% | 96% |

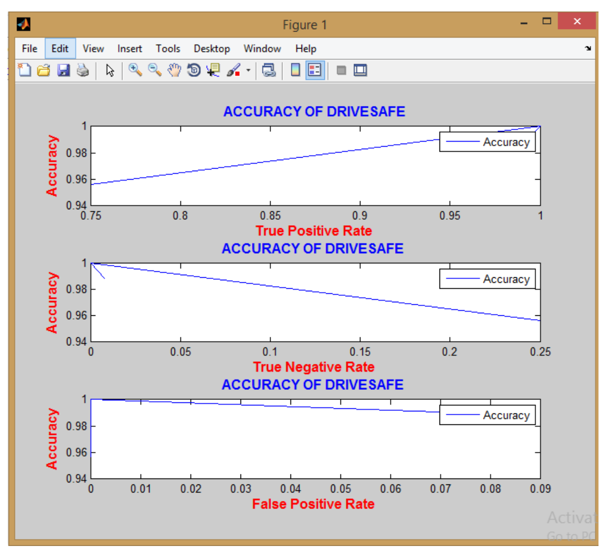


Figure 8. Accuracy of Driver alert for the recorded scenarios #1

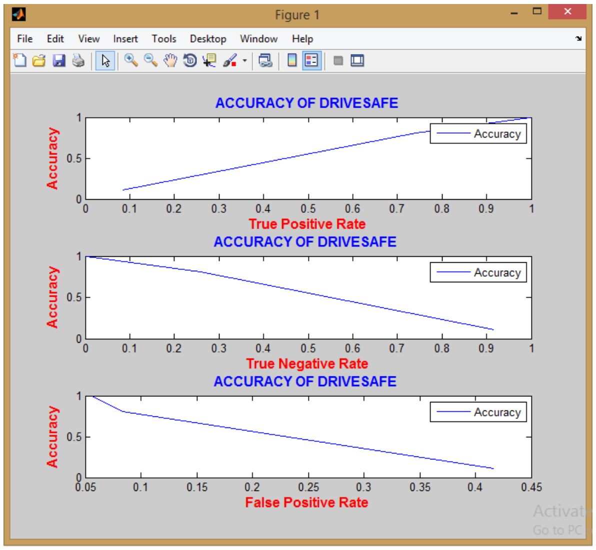


Figure 9. Accuracy of Driver alert for the recorded scenarios #2

## V. Conclusion

This paper describes the design, implementation and evaluation of Driver alert and presents results from a small-scale deployment of the app in the wild. A new algorithm called context switching is implemented to context switch between the fronts and rear camera to process the frames from both front and rear cameras. So the drivers are given alert based on both driver behaviour and road conditions and it will give protection to the drives from both the sides. Messaging system allows the driver to know about the urgent and important information's through text messages and alert. The performance of the overall system is 97% accurate. This performance looks very promising with the challenges of different driver contexts.

However the performance of the application is limited with the lightning condition. Our future work is to work with the lightning condition to increase the accuracy percentage of the driver alert application.

## Acknowledgment

The authors would like to thank Pondicherry University, Puducherry, India for the project support.

## References

[1] E. Aidman, C. Chadunow, K. Johnson, & J. Reece, "*Real-time driver drowsiness feedback improves driver alertness and self-reported driving performance*", Accident Analysis and Prevention, 81, 8–13, 2015.

[2] M. Montes-de-oca, T. J. Bao, N. D. Lane, G. Cardone, L. Torresani, A. T. Campbell, "*CarSafe : A Driver Safety App that Detects Dangerous Driving Behavior using Dual-Cameras on Smartphones*", MobiSys'13, 5–6, 2013.

[3] I. Road, E Union & D.A. Systems, "*Hybrid computer vision system for drivers eye recognition and fatigue monitoring*" ,Accident Analysis and Prevention , 126, 78–94, 2014.

[4] R.O. Mbouna, S.G. Kong, M. Chun, "*Visual Analysis of Eye State and Head Pose for Driver Alertness Monitoring",* IEEE transactions on intelligent transportation systems, 14(3), 1462–1469, 2013.

[5] A. Bener, E. Yildirim & T. Lajunen, "*Driver sleepiness , fatigue , careless behavior and risk of motor vehicle crash and injury : Population based case and control study*", journal of traffic and transport engineering, 4 (5) : 4 9 6 - 5 0 2, 2017.

[6] G. Boboc, A.I. Dumitru, T. Girbacia, C. Postelnicu, & G. Mogan, "*Effects of smartphone based advanced driver assistance system on distracted driving behavior : A simulator study*" Computers in Human Behavior, 83, 1–7, 2018.

[7] C. Zhang, H. Wang, R. Fu, " *Automated Detection of Driver Fatigue Based on Entropy and Complexity Measures*", IEEE transactions on intelligent transportation systems, vol. 15, no. 1, 2014.

[8] W. Cheng, H. Liao, M. Pan, & C. Chen, "*A Fatigue Detection System with Eyeglasses Removal*", ICACT, 331–335, 2013.

[9] K. Dwivedi, K. Biswaranjan, A. Sethi, "*Drowsy Driver Detection using Representation Learning*", IEEE Conference, 995–999, 2014.

[10] G. Divekar, A.K. Pradhan, K.M. Masserang, I. Reagan, A. Pollatsek, D. Fisher, "*A simulator evaluation of the effects of attention maintenance training on glance distributions of younger novice drivers inside and outside the vehicle*", Transportation Research Part F: Psychology and Behaviour, 20, 154–169, 2013.

[11] T.W. Planek, J. Thomas, K. Schmidt, M. Beggiato, K. Heinz, J. F. Krems, " *Letter from the Editors A mathematical model for predicting lane changes using the steering wheel angle"*, Journal of Safety Research, 85.e1-90, 2014.

[12] C. Wang, B. David, R. Chalon, C. Yin, "*Dynamic road lane management study q A Smart City application*", Transportation Research Part E, 2015.

[13] J. Son, H. Yoo, S. Kim, K. Sohn," Real-time illumination invariant lane detection for lane departure warning system", Expert Systems With Applications, 42(4), 1816–1824, 2015.

[14] S. Yi, Y. Chen, C. Chang, " *A lane detection approach based on intelligent vision*", Computers and Electrical Engineering, 42(2), 23–29, 2015.

[15] R. K. Satzoda, P. Gunaratne, M. Trivedi, "*Drive Analysis using Lane Semantics for Data Reduction in Naturalistic Driving Studies"*, IEEE Intelligent Vehicles Symposium (IV) , 1–6, 2014.

[16] Z. Sun, G. Bebis, R. Miller, "*On-Road Vehicle Detection : A Review",* IEEE transactions on pattern analysis and machine intelligence, vol. 28, no. 5, 2006.

[17] M. Fazeen, B. Gozick, R. Dantu, M. Bhukhiya, M.C. González, "*Short Papers Safe Driving Using Mobile Phones*", IEEE transactions on intelligent transportation systems, VOL. 13, NO. 3, 2012.

[18] A. Galletta, L. Carnevale, M. Fazio, A. Lay-ekuakille, M. Villari, "*An IoT Cloud System for Traffic Monitoring and Vehicular",* Accidents Prevention Based on Mobile Sensor Data Processing, 1748(c), 2017.

 

[19] F. Mohammad, K. Mahadas, G. H. Hung, " *Drowsy driver mobile application : Development of a novel scleral-area detection method*" Computers in Biology and Medicine, 76–83, 2017.

[20] V. R. Tannahill, K. M. Muttaqi, D. Sutanto, "*Driver alerting system using range estimation of electric vehicles in real time under dynamically varying environmental conditions*", IET Electrical Systems in Transportation, 107–116, 2015.

[21] M. Tesic, Z. Andric, "*Mobile phone use while driving-literary review*", Transportation Research Part F, 47, 132–142, 2017.

[22] B. Fernandes, M. Alam, V. Gomes, J. Ferreira, A. Oliveira, "*Automatic accident detection with multi-modal alert system implementation for ITS*", Vehicular Communications, 3, 1–11, 2016.

[23] W. Hsu, Y. Wang, *" Real-Time Driving Monitor System : Combined Cloud Database with GPS",* Hawaii International Conference on System Sciences, 1740–1748, 2016.

[24] M. Papadakaki, G. Tzamalouka, C. Gnardellis, T. Juhani, J. Chliaoutakis, "*Driving performance while using a mobile phone : A simulation study of Greek professional drivers"*, Transportation Research Part F: Psychology and Behaviour, 38, 164–170, 2016.

[25] N. Salameh, G. Challita, S. Mousset, A. Bensrhair, S. Ramaswamy, "*Collaborative positioning and embedded multi-sensors fusion cooperation in advanced driver assistance system*", Transportation Research Part C, 29, 197–213, 2013.

[26] B. Giri, Ravi Singh Pippal, *"Agricultural Environmental Sensing Application Using Wireless Sensor Network for Automated Drip Irrigation",* International Journal of Computer Sciences and Engineering, Volume-4, Issue-7, 2016.

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