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A Smart Phone Enabled Driver Monitoring and Alerting System

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ABSTRACT

The objective of this research work is to build a driver monitoring system. Nowadays because of the road accidents every year the death rate keep on increasing and the vehicle production rate is also increasing which leads to pollution. Drive Safe application is developed to alert the drivers for dangerous driving events with respect to driver behavior and road conditions. This system focuses on four of 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 phone'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. A messaging system is also employed to know the urgent and important calls while the driver is driving. An Emergency system is developed to tell about the driver problem to the outside people.

Keywords: Head Pose, Lane Detection, Driver Alert, Context Switching, Messaging System, Emergency System

I. INTRODUCTION

Driving while 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. 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.

Many mobile applications are available today for drive safely. But some are by default disabling the social media applications and others send default text messages to the numbers from where call come to that particular mobile which is using that app. Because of this condition, the drivers are isolated and no information was shared with the drivers while they are driving. For the emergency purposes too they are not allowed to use the mobile if they are using that app.

Therefore, for the above reasons we propose Drive safe, the first driver safety app that uses both cameras on smart phones. Drive Safe 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. A messaging system is employed to tell the person whose is calling the driver when he is in driving.

Several research projects are designing vision-based algorithms to detect drowsiness (using fixed mounted cameras in the car) of the driver. 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)[1]. 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 a single camera using Ada Boost algorithm.

Figure 1. Driver monitoring system

II. FRAMEWORK OF DRIVE SAFE APPLICATION

The overall architecture diagram of the Drive safe app includes four event engines to find the dangerous driving conditions namely dangerous driver event engine and dangerous road event engine.

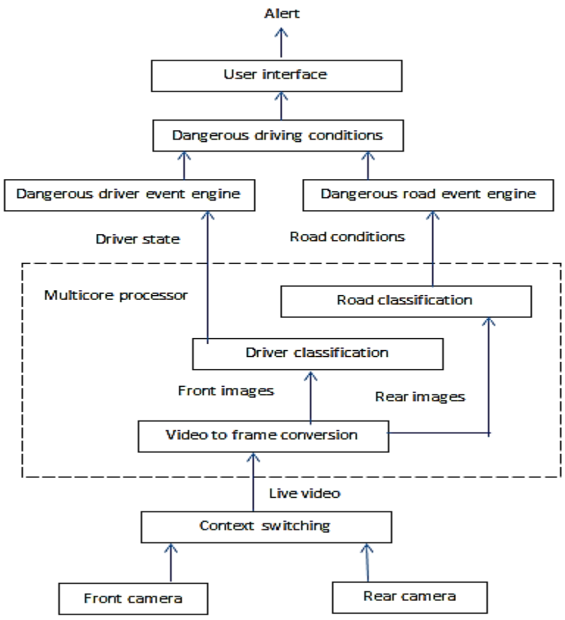

Figure 2. Overall architecture of Drive safe application

This driver monitoring system focuses on four of the most commonly occurring dangerous driving events. 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

- Object 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

It 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.

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.

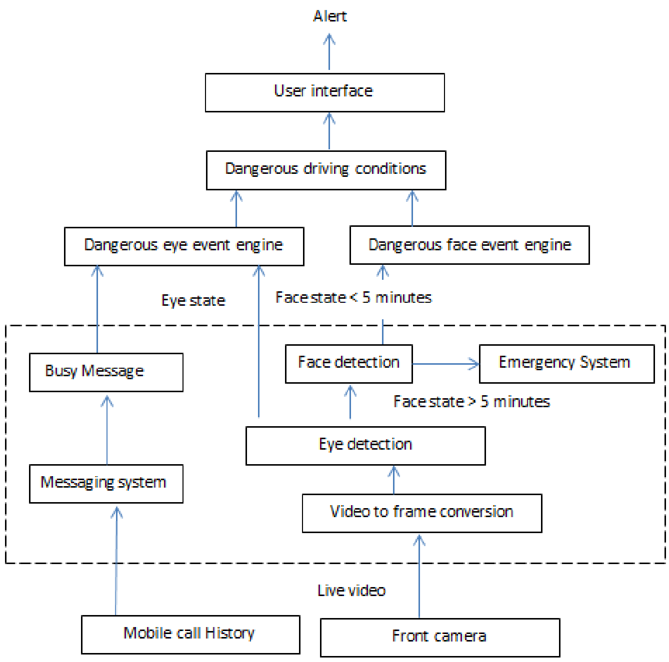

Figure 3. Dataflow diagram of driver classification in front camera

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.

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 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 ≥ 45 degree)
(iv) facing to the right (b ≥ 45 degree)

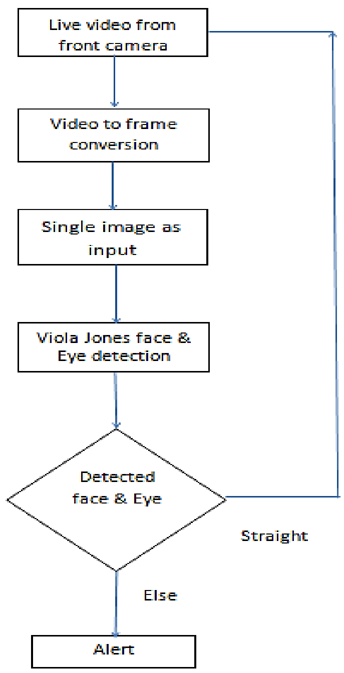

Figure 4. Design of front camera events

3) Messaging system: While driving if the driver is getting a call, first time the call will be cut and a text message saying that the driver is busy will be send back to the called person. If the call is coming again from same number means that it is urgent and important so that the driver will be alerted with the called number saying that a particular number called twice. So the driver can know about the urgency and by stopping the car he can call back to called person which makes the driver known with the urgent information's and also he can drive safely. The following algorithm Message System explains the massaging system working.

Algorithm: Message System

(From driver call history)
If(n_missed call == 1)
        Busy message to called person
Else if (n_missed call >= 2)
        Alert with called number to driver
End

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4) Emergency System: This part of the Drive safe 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 then this problem about the driver will be messages 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 text message 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.

Algorithm: Emergency System

(Frames from front camera)
If (! detected face) && (nframes > 9000)
        Make Emergency call
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 driver is going in a wrong way or in a right way.

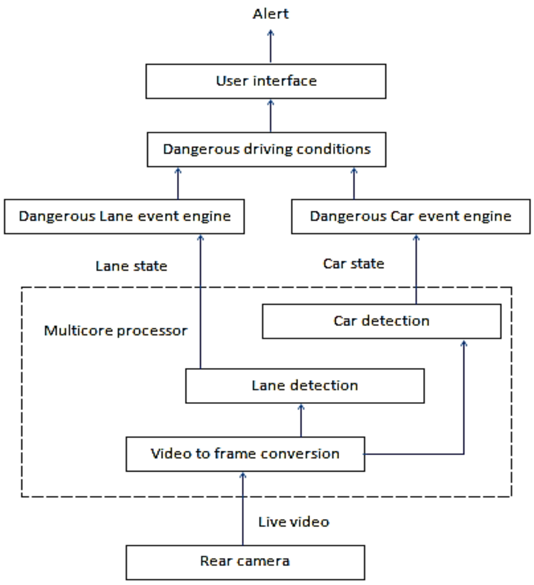

Figure 5. Dataflow diagram of road classification in rear camera

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

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. 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. The following flow chart figure 6 shows the Design of rear camera events with car and lane detection in our system.

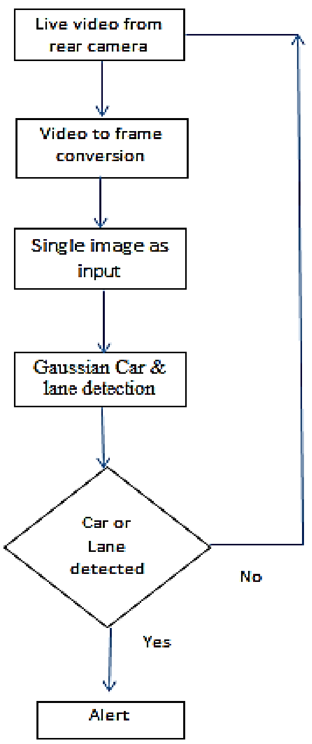

Figure 6. Design of rear camera events

C. Context Switching Algorithm

Context switching algorithm is used to switch between front and rear cameras. In drive safe app first, 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 I 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.

TABLE I. 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 DRIVE SAFE 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. 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.

IV. RESULTS AND DISCUSSIONS

Drive safe app will work well for color videos and non-color videos too. Therefore, there is no need of high quality videos. However, the lightning condition must be good enough. Face detection will work for both faces with glass and without glass. However, the eye detection will not be efficient for face with glass.

We evaluated the drive Safe using 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. The key metric in drive Safe performance is its ability to detect instances of dangerous driving under real-world conditions. For all the videos using the confusion matrix true positive, false negative, false positive and true negative values are tabulated in the below table II.

TABLE-II
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 Drive Safe is 95% which is shown via the below Figure 7 and Figure 8.

TABLE III
THE OVERALL ACCURACY FOR DETECTING DANGEROUS DRIVING CONDITIONS.

Videos	TPR	FNR	FPR	TNR	AC	Precision
1	0.99	0.91	0.83	0.91	0.98	0.99
2	1	0	0	1	1	1
3	0.7	1	0	1	0.95	1
4	0.99	0.28	0.56	0.94	0.99	0.99
5	0.74	0.25	0.83	0.94	0.81	0.94
6	0.79	0.21	0.32	0.98	0.95	0.73
Avg	-	-	-	-	95%	94%

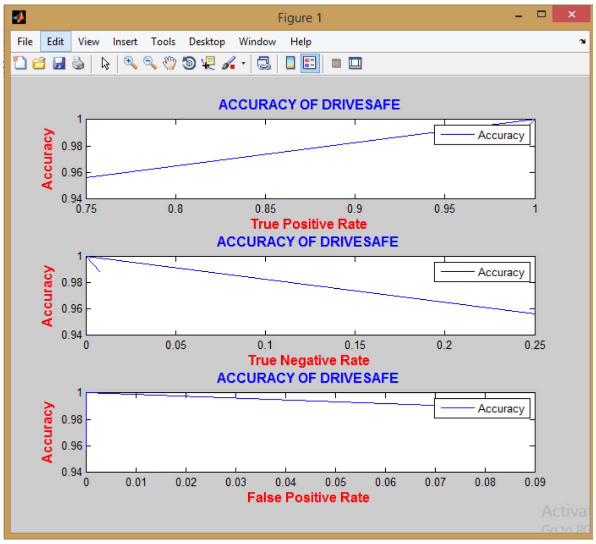

Figure 7. Accuracy of Drive Safe for the recorded scenarios #1

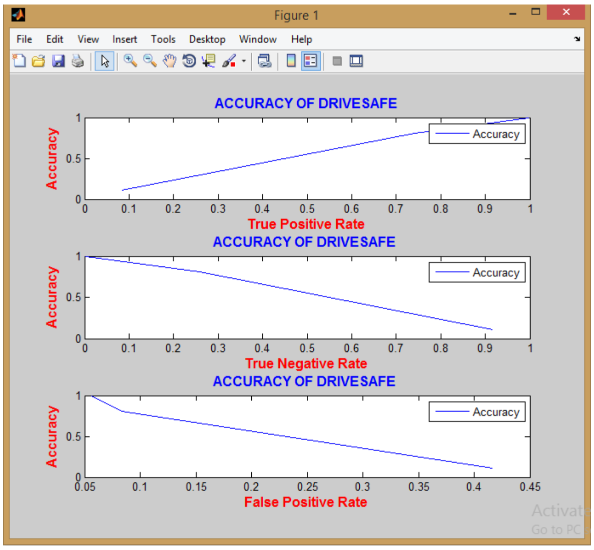

Figure 8. Accuracy of Drive Safe for the recorded scenarios #2

V. CONCLUSION

This paper describes the design, implementation and evaluation of Drive Safe 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 behavior 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 95% accurate. This performance looks very promising with the challenges of different driver contexts. Our plan is to increase the accuracy percentage.

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