Driver Behavior Detection System with Inter-Vehicle Communication

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***Abstract*-Inter-vehicle communication assisted vehicular system plays a major role in preventing the road traffic fatalities. In this paper, we integrated inter-vehicle communication system with driver behavior detection system to form a robust and self-reliance road accident prevention system .The driver behavior detection system detects the driving phases (normal, alcohol intoxicated, exhaust and careless) of the driver and if the driver behavior is not normal, message regarding the behavior of the driver is carried to the vehicles in vicinity of the abnormal driver's vehicle so that they may be cautious enough to prevent road accidents. And if the abnormal behavior of the driver persists still, the vehicle is halted.**

***Keywords*–Dedicated short-range communication, driver behavior detection system, intelligent transport system, inter-vehicle communications, vehicular ad hoc networks.**

I. INTRODUCTION

Road traffic collisions has become an alarming issue in the current century, taking away thelives of millions of people around the world every year. According to the reports of WHO (the World Health Organization), injuries in road accidents registered a high death toll of 1.24 million worldwide in the year 2010 [1].

And also, middle-income countries have the highest annual road accident fatality rates, at 20.1 per 100 000, while this rate in high-income countries is lowest, at 8.7 per 100 000 [1].Especially in countries like India, at about 243475 accidents had occurred in 2011-12, which is only next to China with 275983 road fatalities per annum [1].

Wireless technologies form a suitable platform to support communication between vehicles. So, these technologies find wide role in advanced vehicle safety applications. In particular, the dedicated short range communications (DSRC) at 2.45 GHz is a convenient zoneto effectively support wireless data communications between different vehicles on road and between vehicles and infrastructure.

The adaption of wireless communications from vehicle-to-vehicle or to infrastructurepaves a way for many vehicle safety applications. Wireless technologies are advancing at a rapid phase, and this growth provides chances to utilize these technologies in support of advanced vehicle safety applications.

Cellular technologies reports accidents only after they occur, whereas, dedicated short range wireless data communication technologies report the abnormalities of the driver in advance, therebyforming crash avoidance countermeasures. Dedicated short range communications (DSRC) at 2.45 GHz offers the potential to support low latency wireless data communications between vehicles, and between vehicles and infrastructure. This type of data communications along with vehicle allows many vehicle safety applications.

Wireless communications augmented the progress in the intelligent transportation systems (ITS), which played a crucial role in road safety applications [2], [3]. Vehicular ad hoc networks (VANETs) uses dedicated short-range communication (DSRC) to allow nearby vehicles to communicate either with each other or with roadside equipment. This type of communication offer a wide range of safety applications to improve road safety and traffic efficiency. VANET safety applications improve traffic efficiency by preventing accidents from occurring, e.g., intersection collision avoidance, warning about violating traffic signal, approaching emergency vehicle warning, etc. [4].

Over the past few decades researchers have been working in the domain of vehicle automation using many techniques. Many models have been proposed to monitor and detect the status of drivers. Some models monitored the behavior of the vehicle or the driver in isolation, whereas others have focused on monitoring a combination of the driver, the vehicle, and the environment, to detect the status of the driver.

It is evident from studies in[5] that more than 50% of road traffic fatalities can be prevented if the information is given at least half second in advance of the happening of the accident. Most of the driver behavior detection techniques have involvement in the automated measures after the happening of the accidents. These measures doesn't guarantee the saving of life and property.

The system in this paper, monitors the combined behavior of the driver, the vehicle and the environment and impose anecessary control action if the driver behavior is not normal. Except our system, no monitoring technique that implements the above functions on a single system exists till date.

In [6], driver abnormality detection techniques are broadly classified as i. physiological parameters measurement ii. driver's biological and physical parameter detection and iii. vehicle's parameters measurement.

In this paper, we used the combination of ii and iii. techniques to detect driver behavior and integrated these techniques with inter-vehicle communication network (IVC) to report this data to other vehicles and stopthe vehicle of abnormal driver if the abnormality persists still.

The remaining portion of this paper covers the following: Section II describes about inter-vehicle communication, Section III covers study of driver behavior. In Section IV, system architecture is presented. Section V depicts system layout and its operation. Finally, concluding remarks are drawn in Section VI.

II. Inter-vehicle Communication

Inter-vehicle comminication (IVC), forms core component of the intellgent transportation system (ITS) architecture.A driver or his vehicle can easily communicate with other drivers (or their vehicles) in this communication system. In this way, data collected through IVC helps to achieve road traffic saftey and efficiency [7].

Moving vehicles with short/long range communiation devices forming vehiclular ad hoc networks/mobile ad hoc networks are modes of IVC.The main applications of IVC can be summarized into three classes [7].

A. Information and Warning Functions

It helps in the dispatch of data regarding the roads to vehicles far away from the sites of interest.

B. Communication Based on Logitudinal Control

It helps avioding accidents and to arrange platooning.

C. Co-operative Assistance System

These systems coordinates vehicles at critical points like blind crossings and highway entries.

There are many challenges that arise due to the implementation of IVC in real time scenario. These challenges are

i. Reducing the Delay Time of the Information Transfer During the Communication

There will be many instances where the information should be sent with fast delivery rates. Lag in these communications may cost the loss of property and even lives in many cases. So, delay time between the inter-vehicle nodes should not be entertained in any case.

ii. Supporting Multi-Vehicle Communication at a Time

An IVC node must have a capability to receive the message packets from more than one vehicle at a time. Because an action which is followed by the interpretation of the message received only from a single vehicle may put the other vehicles in danger.

iii. Giving Appropriate Delivery Priority to Warning Messages among the Vehices

The priority to the delivery of the messages must be purely based on the amount of risk the neighbouring vehicles are involved but not on the distance the other vehicles are located from the accident prone vehicle.

For example, there will be some cases where the threat faced by the neighbouring vehicels is less when compared to the far behind vehicles which may be prone to higher risks if the message is not delivered at the correct time. In such cases the message delivery priority must be proportional to the amount of risk a vehicle is subjected.But it should not be purely proportional to the distance from the vehicle.

In this paper,we used the 'Information and warning functions' as a main application of IVC in the form of alert messages to other drivers.

III. Study of Driver Behavior

Driver's behavior is termed as complicated and dynamic interactions between three entities- the driver, the vehicle and the environment [8].

In [8], driver behavior is termed as periodic shift among sequences of phases (e.g., normal, alcohol consumption, exhaust and careless). The driver performs some alterations among some of the above mentioned phases during his driving time span. The behavior of the driver can be represented as follows

$$B = \{P_{t=1}, P_{t=2}, \ldots, P_{t=n}\} \quad (1)$$

where$B$ is the behavior of the driver, P is the phase, and t is the time. The phases of the driver were classified into four classes: normal phaseP_n, alcohol consumed phase P_a, exhaustedphase P_e and careless phaseP_c

1) Normal Phase: This phase involves scenario where driver concentrates on the driving task. In this phase, he maintains normal vehicular speed with no sudden acceleration. There will not be any alcohol consumption. A fixed and proper distance between lane markings is maintained and the driver will have his eyes completely open while driving. The above specifications are the criteria for a driver to be normal driving phase.

2) Alcohol Consumption Phase: In this phase, alcohol intoxication is done in driver's body. The effect of this causes him to perform driving actions like abrupt change in speed of the vehicle, not following proper lane positions. He also will not have his eyes opened for more than 80% for a given time.

3) Exhaust Phase: Here the driver losses concentration on driving due to driving for lengthy spans. The work in [9]-[11] defines this phase in which a driver driving after a period of 17 h without sleep behaves exactly as a driver who has 0.05% intoxication of alcohol. At the same time, a driver driving after a period of 24 h with no sleep behaves in the same way as one who has 0.1% intoxication of alcohol. Based on this, fatigue driving was defined as driving that exhibits the same characteristics as drunk driving but without alcohol intoxication in the driver's blood.

4) CarelessPhase: The driver will be classified into thisphase only if he doesn't possess any alcohol intoxication and not having his eyes closed but performing the functions like untimely lane changes and uncontrolled acceleration and speed variations.

IV. SYSTEMARCHITECTURE

The system in this paper incorporates the following four main layer as mentioned in [8].

A. Data Sensing Layer

The information regarding the driver,the vehicle and the environment is collected contextually. This layer has various sensors embedded in it.

B. Data Retrieval Layer

The data from the sensors is gathered in this layer and controls these sensors.

C. Data Interpreting Layer

In this layer, data received from the data acquisition unit is transferred into a machine- executable which is later interpreted by the processor.

D. Reasoning and Control Action Layer

In this layer, the present state of the driver is depicted and a proper control action is initiated based on the driver's phase (e.g., normal, exhaust, alcohol consumed or careless). This layer has the following components – The on board processor, user interface, CU-1 having alarm, CU-2 performing control action and sendingmessage tothe neighboring vehicles. The processor performs following two functions:

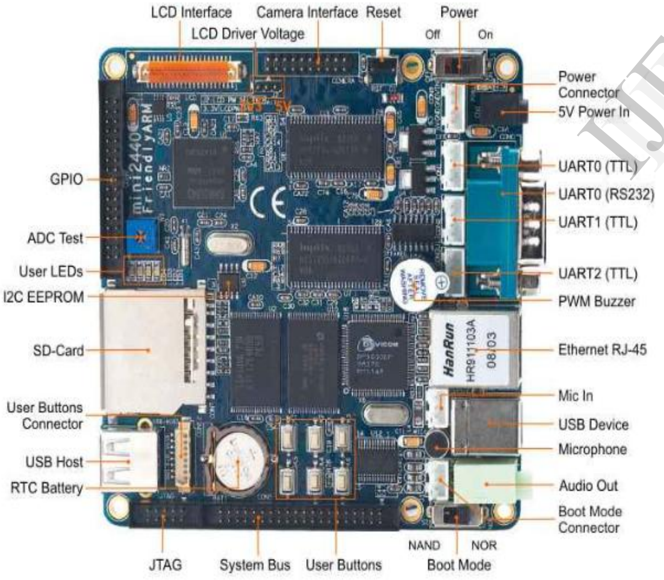

Fig. 1. Friendly ARM Mini2440 board

- *Behavior detection:* Actual driver behavior is detected based on the data from data sensing layer. No action is taken if the driver's behavior is normal. If there is acase of abnormal driving behavior (e.g., alcohol consumed, exhaust or careless), a control action is followed.
- *Control Action:* In this case, an alarm is triggered which halts the vehicle. CU-1 controls to keep the driver alert. The signal is received in the case of abnormal behavior from the processor.After CU-2 receives the signal from the processor indicating abnormal driving behavior,the processor also sends messages to other vehicles regarding the abnormal data of the driver and in the severe abnormality case the vehicle of the abnormal driver is stopped.The above two actions are performed by the processor as shown in the Fig.1

V. SYSTEM LAYOUT AND OPERATION

The Fig. 2 shows the layout of the system.

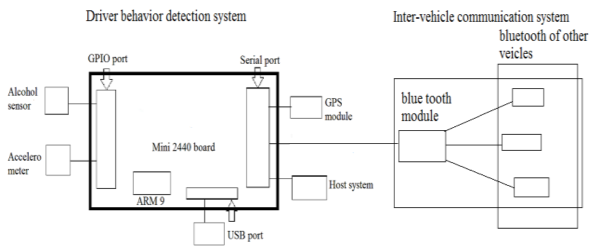

Fig.2. Layout of system

Fig. 2 shows the layout of the working system which consists of two modules i. driver behavior detection module and ii. inter-vehicle communication module. Driver behavior detection module consists ARM9 processor as the core components and various sensors like alcohol sensor and accelerometer sensor are interfaced to the board through General purpose input output port (GPIO) port, universal serial bus (USB) video class (UVC) eye camera is interfaced through universal serial bus (USB) port and global system for mobile (GSM) and global positioning system (GPS) modules are interfaced through serial port to complete the behavior detection system.

The system operation can be divided into three stages, first two stages being controlled by driver behavior detection module and third stage is controlled by inter-vehicle communication module.

In the first stage, the data of the driver, the vehicle and the surrounding environment is collected by the sensors.

In the second stage the data gathered by the sensors is given to the processor and by using behavior detection algorithm, the processor calculates the drivers behavior i.e., the phase (normal, exhaust, alcohol consumed and careless) in which the driver is there. The processor also performs corrective action if the driver is not in normal mode.

In the third stage, the corrective action like sending the data corresponding to the abnormal behavior of the driver to the neighboring vehicles is done by the Bluetooth modules in inter-vehicle communication modules.

Thus the drivers of the neighboring vehicles may predict the action of the vehicle of the abnormal driver in advance and be alert in dealing with the vehicle.

VI. CONCLUSION

In this paper, we are able to distinguish the four behavioural modes (normal, alcohol consumption, exhaust and careless) of the driver by using ARM9 processor and various sensors very efficiently and integrated this driver behaviour system with inter-vehicle communication system which will be able to take control action in prior to happening of the road accidents to form an automated vehicular control system. The method used in this paper has a great potential in preventing road traffic fatalities to a large extent.

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