ARM Processor based Vehicle Safety System for Indian roads

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Abstract: After drunken driving, mobile phone usage is the leading cause of accidents around the world. Also, at sudden stoppages on cross roads or due to sudden obstructions on road, natural or otherwise the driver cannot anticipate back bumper and side collision. Also, low height railing or pavements in blind spots while parking may damage the vehicle. Costly mobile phone jammers while effective render emergency communication impossible. As alcohol detection and vehicle tracking system are successfully implemented we are proposing an essential vehicle safety kit which is absent in majority of the vehicles on Indian roads. Furthermore this can be an addition to the developing cognitive driver assistance system. The proposed system provides vehicle with safety features like SMS alert facility, blind spot detection and tail gating detector. The vehicle is equipped with ultrasonic sensors and a GSM modem interfaced with Nuvoton ARM cortex processor. The driver has access to a user interface consisting of LCD (128 x 64 pixels), a keypad and switching ports. The driver may access two modes of distance sensing with sensors located on left, right and rear of the car. A braking system is actuated in the parking mode if the distance measured from the sensors crosses the defined threshold. In the traffic mode the driver is alerted and can take preventive action. In case of an emergency the driver can send a text or call from the stored numbers in the memory using the keypad. To save time and to maintain the driver’s focus on the road a default text can be sent to a default number by a single key pad entry. Call service from the system eliminates the need of using the phone and prevents driver’s loss of focus. Further the freedom to choose the number and the corresponding message to be sent is available when the vehicle is at rest. The system thus prevents accidental damage to the vehicle and its passengers while eliminating the use of phone by the driver.

Keywords: ARM, GSM, SMS, LCD

Introduction:
Every year nearly 1.4 million people die while driving because of their over-bearing cell phones. In India, an estimated 1.35 lakhs people died due to road accidents in 2010, which is approximately 10% of road accident fatalities worldwide and these figures are the highest in the world [1]. Statistically there has been an increase of 1.9% in accidents and 5% in deaths from 2002-2012 [2]. Talking or texting, using a cell phone while driving, is a major distraction leading to an accident. An immediate hazard for the driver is dialing a phone while a more serious issue is conversing on the phone. Such distractions are classified into two different categories namely, 1. Physical distraction: Which involves removing of one hand from the steering wheel to hold and operate the phone and visual distraction which involves taking one’s eyes off the road to pick and put down the phone as well as dial numbers. 2. Cognitive distraction: Cognitive (mental) distraction occurred when tasks are performed concurrently, i.e., when a driver is using a hand-held or hands-free mobile phone while driving, she or he must divide their attention between operating and maintaining the conversation and operating the car while manoeuvring through traffic phone and maintaining the conversation and part to operating the vehicle and responding to the constantly changing road and traffic conditions [1]. While Cell phone jammers can disable the mobile phones in the neighborhood for as long as you are within the area of the portable cell phone jammer the widespread usage of tool is becoming irritating and dangerous as their use in public places may be very irritating and dangerous for the ill people and those who have pace maker located in the heart. It will also cause serious interference with “100” call and other emergencies in the area of active disruption of human health and safety risks [3], [4].

In the past, many researchers have focused on obstacle detection in front or back of the vehicle but accidents may also take place when the driver is changing lanes or making a turn and they missed the vehicle or pedestrian in their blind spot area. The proposed model also detects obstacles in the potential hazards, i.e. pedestrians and vehicles in blind spot area and warns the driver.

Motivation:
Driver distraction is one of the leading causes of motor vehicle accidents. Driver distraction while using cell phone is the most common and challenging. An estimated 1.35 lakh people died in 2010, due to road accidents in India with an average of more than one death and four injuries every minute, accounting for nearly 10% of global accidents. The report ‘Road accidents in India’ by the Transport Research Wing of the Ministry of Road transport and Highways, Government of India shows that “driver fault” is the single most important factor which accounted for 81% of total accidents. According to World Health Organization (WHO), road accidents rank as the 9th leading cause of death and account for 2.2% of deaths globally. This number is expected to increase and ranked as the 5th leading cause by 2030 if no action is taken to address the current crisis. Road traffic...
fatalities are forecast to rise from the current level of nearly 1.3 million deaths annually to more than 1.9 million deaths per year by 2020. Having established this background it is important to develop and implement strong mechanisms for prevention of mobile phone use while driving [1]. The unique approach being adopted is that the driver can be dissuaded from using phones by providing the capability to send urgent texts by the push of a button [5]. Also blind spot parking and tail gating protection are covered by cost effective and portable arm microcontrollers [6]. Integrating the test module with other implemented features provides a reliable assistance system for cognitive vehicle control.

General Analysis:
While international foundations like AAA Foundation based in Washington DC, ATSIP based in Georgia, USA conduct research to identify traffic safety problems, foster research that seeks solutions and disseminate information and educational materials, they also further the development and sharing of traffic records system procedures, India is not a part of any organisation. Developed nations take an active interest in providing uniformity of traffic laws and regulations through the timely dissemination of information and model legislation on traffic safety issues through organisations such as The National Committee on Uniform Traffic Laws and Ordinances (USA), the Indian RTO has sadly restricted itself to the registration of vehicles and the issue of driver’s licences and doesn’t take an active interest in law enforcement.

In a survey conducted in India, the majority of the drivers 475 (82%) agreed use of mobile phone while driving. 527 drivers (91.1%) identified that using a mobile phone while driving increases the chances of accidents. 180 (31%) of drivers admitted that they have met with an accident as a result of using a cell phone. 428 drivers (74%) indicated that advanced technology should be developed to restrict the driver from using a mobile phone while providing provision to make or to receive call when the vehicle is stopped. 150 respondents (26%) opted for a total ban on the use of mobile phone while driving. Nearly 400 drivers (69%) admitted that they will drive fast if mobile communications are completely blocked inside the vehicle by using technologies like mobile jammers. From the above study it is apparent that though driver are knowledgeable with regards to the risks associated with usage of mobile phone while driving, they still are unwilling to give up the habit, unless effective technology was developed which provides the option to attend emergency calls ensuring the safety of the driver [6]. A blind spot detection device is for protection against misshapenness such as automobiles collisions, obstacles, and accident that leads to great loss of human lives and can have disastrous results. Technology used for this purpose works by detecting the other automobiles, obstacles and bystanders. Upon detecting, the device triggers a timer that delays the activation of alarm circuitry for a brief period of time. This time delay is instituted to minimize the triggers of nuisance alarm by a momentary intrusion in the hazard zone. If the obstacle’s presence is still detected after the delay time, LED’s and audible alarms are triggered to alert the system operator of the dangerous situation. The alarms remain activated for a time period, allowing the operator to clear the hazard zone [6].

There is a proposal to develop a device to find people who use mobile phones while driving and evade from stringent laws enforced by the government easily. The technique facilitates the government to take adequate actions against those who are violating these laws. To meet the requirements of an intelligent vehicle monitoring system, the architecture integrates Global Position System (GPS), Global System for Mobile communications (GSM) and a Microcontroller as a whole. This device is used to prevent texting and calling of mobile phones while driving vehicles. If the driver is using the phone while the vehicle is in motion, it triggers a signal which notifies the cops with the vehicle’s number plate and the location with the help of GPS system. It receives the mobile signal and detects the presence of mobile. This signal eventually triggers the microcontroller with a glowing LED. Due to the voltage fluctuation, the message is sent to the cops using GSM communication [5]. Also an alternate system has been proposed in which the driver needs to activate call divert to this number before entering a mode. In this mode, upon receiving an incoming call while driving, the GSM modem automatically sends an SMS to the calling number with a fixed message indicating that the person has been driving. The system has a dashboard Graphics LCD that can show the calling number. This makes the driver 100% hands free. This proposal also includes a method for detecting the early signs of fatigue/drowsiness during driving [7]. While Safety features such as anti-lock braking system, brake assist, safety airbags, central locking, power door locks are now present in every vehicle. Anti-theft alarm and engine immobi-liser’s are being put in new models to ensure safety of occupants. A few companies such as AUDI has a customized Audi parking system along with a rear view camera with rear ultrasonic parking sensors [8] and Honda Accord comes with a Forward Collision Warning (FCW) system and a tiny camera placed with Overdimension vehicle route maps that help the driver in changing lanes comfortably [9]. The only complete implementation of the above safety features is going to be in car model Mercedes Maybach S600 with PRE-SAFE break with pedestrian recognition., PRE-SAFE plus rear end collision protection., BAS PLUS with cross-traffic assist and HEAD-UP display [10]. To summarise in the absence of above mentioned vehicular safety systems in majority of the vehicles on Indian roads and to tackle the rising number of accidents while increasing the convenience of the
driver we are interfacing ultrasonic sensors and GSM modem with Nuvoton NUC140 to provide a system for increasing vehicular safety on Indian roads.

Methodology:

Blind Spot detection System follows the algorithm shown in Figure 1.

Two SR04 Ultrasound Sensors are used. Each sensor is initialised by a different timer and uart ports are used for communication. A timer is initialised with 12 MHz frequency in one shot mode and counter starts when a trigger pulse is sent by the sensor. On receiving the echo the counter is stopped and echo width is used to calculate the distance. The formula used is distance = (Echo Width * (340/2) / 10000) where echo width can range from 150 micro seconds to 25 milliseconds. The sensor connections are made as shown in Figure 2.

The sensor configurations are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1: Sensor Configurations</th>
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<td><strong>Configuration 1</strong></td>
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<tr>
<td>Sensor A threshold 30 cm</td>
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<tr>
<td>Sensor B threshold 30 cm</td>
</tr>
</tbody>
</table>

Configuration 1 is for side blind spot detection and has sensor A on left and sensor B on right. Configuration 2 is for parking mode and has sensor A on left and sensor B behind the vehicle. These are shown in Figure 3.

In both the configurations the distance is measured and if distance is less than threshold alert message is flashed on LCD, led corresponding to sensor position blink and buzzer is sounded in both cases.

SMS Alert System
SMS Alert System follows the algorithm shown in Figure 4.

GSM Modem is communicating by UART ports and displaying information on LCD and is shown in Table 2 and the connection diagram in Figure 5.

<table>
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<tr>
<th>Table 2: GSM Port connections</th>
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<tr>
<td>NUC140</td>
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<td>GPB0</td>
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<td>GPBI</td>
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Figure 3: Two sensor configurations

Figure 4: SMS alert system algorithm

Figure 5: GSM Modem connection diagram
AT commands are sent to message stored numbers with stored message text. The selection of the number and the message is made using LCD screen and the keypad entry.

Components and Tools:
GSM Module- SIMCOM SIM300 V1.1: GSM Communication is used for transmission of data between the vehicle unit and the external handset. The user uses a GSM Module with a SIM card and can connect with any phone. The GSM Module used is shown in Figure 6.

HC-SR04 ultrasonic sensor
The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats or dolphins do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package. From 2cm to 400 cm or 1” to 13 feet operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module. HC-SR04 is shown in Figure 7.

Nuvoton kit
The Nuvoton NUC140 is a microcontroller board based on ARM Cortex -M0 core with Up to 50MHz, Single-cycle 32-bit Multiplier and NVIC supports 32 interrupts with 4 level priorities. The MCU Block Diagram is shown in Figure 8 and the peripherals in the board are shown in Figure 9.

Implementation:
The complete test setup is shown in Figure 10.
The configuration 1 is activated by pressing key 1. It indicates the vehicle to check right side as the distance between the obstacle and the vehicle is 4cm. The display is seen on the screen and is shown in Figure 11.

*Figure11: Configuration 1 activated on pressing 1.*

The configuration 2 is activated by pressing key 2. It indicate the vehicle to check left side as the distance between the obstacle and the vehicle is 2cm. The display is seen on the screen and is shown in Figure 12. Meantime on pressing key 3 on the board, an emergency message is sent to a number which is already in the data base and is displayed on the screen as shown in Figure 13 and received message as shown in Figure 14.

*Figure12: Configuration 2 activated on pressing 2.*

*Figure13: on pressing 3, emergency message is sent to stored emergency*

*Figure14: Message received on emergency number.*

Different keys have been programmed and if pressed accordingly, it sends messages to the telephone numbers available in the database indicating about traffic jam or any other reasons. The snap shot of one example is shown in Figure 15.

The kit and peripherals are arranged in a portable console for ease of use as shown in Figure 16. The system can be easily implanted in the vehicle.

*Figure15: Message received on home number.*

*Figure16: The kit and peripherals are arranged in a portable console.*
Conclusion and Future scope of work:

The Vehicle Safety System is a useful tool for the personal car owner. The system provides safety features like SMS alert facility, blind spot detection and tail gating detector. It can further be equipped with vehicle tracking system and incorporate alcohol detection to have the complete vehicle safety gear. This system is a cost-effective technological solution which can tackle the growing accidents and deaths on Indian roads and ease the driver convenience. One of the improvements possible is to detect the obstacle from side and rear for BSDS (Blind Spot Detection System) with vision system. A real image acquired during car driving has a lot of information to examine the target vehicle, background image, and noises such as lighting and shading. While it is hard to extract only the target vehicle for the background image with satisfied robustness the target vehicle can be detected by repetitive image processing such as sobel and morphological operations and a Kalman filter designed to cancel the background image and prevent the misreading of the target image. This method processes an image with improved speed and robustness and is better for Blind spot detection [11].

Another improvement that can be made is to factor the weather, driving speed, and background for it to be a real driver assistance system. A hybrid scheme for pedestrian and vehicle detection, and develop a warning system dedicated for lateral blind spot area under different weather conditions and driving speeds can be adopted. Histogram of oriented gradients and support vector machines methods are used for pedestrian detection. The image subtraction, edge detection and tire detection are applied for vehicle detection. The system can be used under different weather conditions such as daytime or nighttime and different driving speeds and offer’s drivers a helpful assistance in safety of vehicle lateral blind spot area [12].

References:

[2] Introduction, Center of Science and Environment, India