Smartphone and Sensor Based Drunk Driving Prevention System

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ABSTRACT

In today's world, a lot of automobile accidents take place on daily basis, majority of them due to the drivers being drunk. By statistics, at least 3 people are killed every 2 hours due to drunk driving cases, thus leading to thousands of deaths each year. Drunk driving, or Driving under Influence (DUI) of alcohol, has been and will be a major cause of automobile accidents throughout the entire world. So by this paper, we would like to propose an exceedingly competent system intended to detect and alert of condition of drivers, typically related to drunk driving. The system requires a smart mobile phone placed in vehicle, and specially designed hardware consisting of sensors which can be easily integrated in the car. A program will be installed on the hardware device as well as the smart mobile phone. Computations will be made based on sensor readings, and compared them with typical drunk driving values extracted from real driving tests. Once any it is found that the driver is under influence of alcohol, an alert will be automatically generated for the owner/relative and/or call the police before even the automobile starts, thus prevent the accident before it actually happens. We will also be implementing other additional features such as accident detection system, car proximity alarm and real time monitoring system. We are going to implement the detection system on Android smart phone and have it tested with varied kinds of driving behaviors. Studies demonstrate that the system will be able to achieve high accuracy with efficiency.

Keywords—Drunk Driving Detection, Mobile Phones, Sensors, Real time system

1. INTRODUCTION

1.1 Motivation

Automobile accidents caused by being under influence of substance in automobile drivers not only pose a serious danger to themselves but also frequently to the surrounding environment. Over 1, 37, 000 people were killed in road accidents in 2013 alone, amounting to 377 people daily, that is more than the number of people killed in all our wars put together, the main reason for these tragedies being drunk driving accidents [1]. The main concern here is not only the high crash rate related to drunk driving, but also the after effect of these types of crashes that devastate life of people entirely. Not only does drunk driving pose an immense risk to public safety and health, it also impose a heavy financial burden on the whole society, especially on the healthcare sector.

Although drunk driving is a serious problem, the detection of such cases still relies on visual observations by police officers. A marked decline of perception, recognition, and vehicle control is shown by drivers under the influence of alcohol, so they are likely to make certain types of unsafe maneuvers. Typical driving behavior for drunk drivers, namely problems

in maintaining proper lane position, speed and braking problems, vigilance problems and judgment problems were identified in various studies conducted such as by the NHTSA of U.S.it the cues of [2]. These are being used as guidelines for patrol officers to halt and test a driver for alcohol consumption.

However, this method is highly inefficient since it relies simply relies on visual surveillance of police officers to stop drunk driving drivers. In any country, there huge kilometers of roads, and not every country has enough number of patrol officers to man those roads to observe and analyze every driver's behaviors. Also, the observations are being made on certain guidelines or patterns, but it is known that often the real world situations vary a lot. Sometimes, it is not the observations of the patrol officer that fail, but the environment in which they are being perceived. As a fact, majority of the drunk driving cases go undetected. It can also be considered that a driver is pulled over after being driving under influence for a lot of distance. So it is vital to develop a system that actively monitoring drivers' driving conditions and generating alerts if any violations are found to prevent accident. Hence, it is needed that the monitoring system should actively satisfy certain requirements as follows: a quick response real-time monitoring system; an accurately performing reliable system; and specifically a low-cost and non- meddling system.

1.2. Our Contributions

Through this paper, we propose utilizing custom hardware and smart mobile phones as the platform for drunken driving detection system, as they will efficiently combine the detection and communication functions. As per our research, this is the first time such a combined system is being implemented.

As a custom hardware, it presents a customized hardware and software environment, which works in integrated way, for the development of active drunk driving monitoring system. The drunk driving system based on the hardware can function effectively on its so that it keeps on functioning even if the smart mobile phone is not responding, as all necessary components will be integrated therein. The other functions however require smart mobile phone for functioning. Minimum requirement for such a smart mobile phone is nothing but the key features of any phone, e.g., Bluetooth, GPRS connectivity, GPS connectivity. Currently, all smart mobile phones meet this requirement as they are the key features. Also, since a communication module and inbuilt speakers are naturally good enough for alerting, it is a better choice. With as many as 1.2 billion smart phones being sold in 2014 [3], and the continuous decrease in price, it is bound that each person has a smart mobile phone with the required key functionalities.

We would like to summarize the contributions of this paper by us as follows:

- We propose utilizing specialized hardware with combination of smart mobile phone as the platform for drunk driving detection and other features. As per our research, this is the first time such a combined system is being implemented.
- We design the specialized hardware with sensors for detection drunk driving and other factors in real time. This data is then relayed to smart mobile phone. We analyze the values being generated by the sensors on the mobile smart phones and then take precautionary actions as defined.
- We design and implement a drunk driving detection system with specialized hardware and smart mobile phone. The system is reliable, non-intrusive, lightweight, and power-efficient and easily integrate able in existing as well as future cars.
- We are going to conduct real tests to assess the performance of our system. In these tests, we are going to create such environment that the values generated by sensors will vary in both positive and negative conditions. The results will indicate that our detection system will achieve excellent performance in terms of result cases such as false negative and false positive.

1.3 Paper Organization:

The remaining of the paper is going to be organized as follows. Related work will be presented in Section 2. In Section 3 cues of drunk driving will be extracted. In Section 4 system design and implementation will be presented. Evaluate of our system with real driving tests will be done in Section 5 and conclude the paper in Section 6.

2. RELATED WORK

There are some existing research and proposed implementation on the detection of patterns for monitoring the

driving. Some of them are known under the name of driver vigilance monitoring, mobile phone based drunk driving detection, Driver Alcohol Detection System for Safety (DADSS) etc. They focus on monitoring and taking action after the driver begins to operate the automobile. Also, various work focus is given to real-time driving pattern recognition. In aspect, various methodologies are use by them which are described as follows.

Zhu et al[4] uses visual observation based technique to detect fatigue of driver. It uses two cameras which are mounted on the dashboard and they capture the cues related to visual display of drivers which include movements of eyelid, movements of gaze, head and facial expression, this is all based on a probabilistic model.

Another relatively simpler research was implemented by Albu et al [5]. It is claimed by them that the most critical consequence of fatigued driving is sleep onset, separate the issue of sleep onset from the global analysis of the physiological state of fatigue, and considering shuttering of eyes as cues of sleep onset. Vision-based system has been used by them to monitor the condition of eyes in order to detect drivers fatigue in driving.

In DADSS[6] The DADSS research program implemented by National Highway Traffic Safety Administration (NHTSA) implies to use sensors, as similar to our project, but with high cost. The DADSS system uses breath analyzer as well as a fingerprint sensor which then determine the level of alcohol in the driver.

3. SENSOR-BASED DRUNK DRIVING CUES

In this section, we analyze the driver for being drunk and extract the cues that are fundamental in drunk driving detection.

Our analysis is based on the values generated by the sensors integrated in the vehicles.

According to the U.S. NHTSA's report [7], different probabilities of drunk driving match up with different categories of cues. These vary into lane position maintenance problems, speed control problems, judgment and vigilance problems around.

But these situations are not always true to being a person being drunk. In a real life example, in India, one of the country with highest automobile numbers, have road conditions and traffic conditions which make the driver to sometimes drive in risky ways. He may have to swerve suddenly in case a pot hole comes along or if another automobile suddenly merges the lane. So it is not always possible to depend on the swerving or missing of lane. Also, if a person has fatigue, it may result in eyelids closing, hence it is not reliable method too.

Hence for the principle of developing actively detecting system for drunk driving, we focus on the cues of problems that are true when a person is actually drunk, i.e. the breath. Breath analyzers are actively considered as the best solution so far to check a person is drunk or not, given that they are used by police force of every country.

We will also be implementing other features such as after accident alert system and vehicle proximity system.

3.1 Sensor Based Breath Analyzing

Whenever a person drinks alcohol, its shows up in the breath as it gets absorbed from the mouth, throat, stomach and intestines directly into the bloodstream.[8]

Digestion of Alcohol does not occur upon absorption, nor does it chemically change in the bloodstream. As the blood moves through the lungs, some of the alcohol moves across the membranes of the lung's air sacs (alveoli) into the air, because alcohol will evaporate from a solution that is, it is volatile. The concentration of the alcohol in the alveolar air is related to the concentration of the alcohol in the blood. As the alcohol in the alveolar air is exhaled, it can be detected by the breath alcohol testing device. Thus when a person breaths into the breath analyzer, it is easy to check if the person is drunk. The working of breath analyzer depends on detecting of level ethanol in breath, and as per the chemical composition of alcohol, the main component of alcohol is ethanol. In general, the breath of a person consists of no level of ethanol.

3.2 Sensor Based Accident Detection And Proximity Sensor

We are also going to implement two additional features in our system, post accident alert system and while driving proximity system. The sensors being used are cheap and efficient for better functionality and ease of integration. These systems are going to help alert the respective authorities after an accident

occurs, thus leading to reducing of wastage of time after the incident. The proximity sensors are going to be implemented to alert the driver if anyone is tailgating too closely, thus taking precautionary actions before some incident occurs.

4. SYSTEM DESIGN AND IMPLEMENTATION

In this section, we introduce the design and implementation of our smart phone and sensor based drunken driving detection system. We first present the system overview followed by the design of the system. Then we elaborate on implementation details.

4.1 System Overview

The smart phone and sensor based drunk driving detection system is made up of four components, as presented in Fig. 1. They are (1) Custom designed hardware (2) Smart phone application for data processing and relaying, (3) Cloud server system and (4) Client side monitoring system. The first module is used to implement sensors which collect the data. The second module is for analyzing the values being generated by the sensors and relaying it to cloud server. The cloud server is used to store the data relayed by smart phone so as to analyze the data in future as against to history of data and to relay it forward to client side application. The client side application is being generated to monitor the sensor values at real time. Our design is general, not constrained to any particular brand of mobile phone. And our design is also power-aware, as hardware used is of low power consumption.

The work flow of our drunk driving detection system is also illustrated in Fig. 1. As soon as the driver enters the car, it is checked if the driver is drunk due to the placement of the alcohol sensor in such a manner. If the driver is found to be drunk, the hardware itself disables the ignition of the car, thus needing no intervention from smart phone or any other external entity. An alert is also sent to the respective authority that the driver is in intoxicated state as a precautionary measure. This helps in preventing accidents as the action is taken even before the driver begins to start the car, thus leading to be an efficient one so far. As for the other features, the accident alert system comes into action after an accident takes place. For this, we will be using mechanical sensors which are easily manageable and replaceable. As soon as the mechanical switches are triggered, an indication of the same is sent to the smart phone and the smart phone sends alert to the predefined contacts. The proximity sensor is initiated while driving the car. It is noted that most cause of accidents occur due to close tailgating or vehicles being too close . With the use of IR sensors, we will be implementing the proximity sense. Due to this, if another automobile comes close to the test automobile during driving, an alert is provided to driver via smart phone so that the driver will take preventive action to avoid accident.

This all information will be accessible at real time on the client side PC application too.

4.2 Design of the System

We design the hardware system in such a way that it efficiently meets requirements and integrates easily with automobiles, exiting as well as new. Required application will also be developed for respective devices with different functionalities.

To begin with, we are going to design a customized hardware. This hardware is going to consist of a PCB. The sensors for each detection system, i.e. for alcohol detection system, for accident detection system and proximity sensor system will be attached to the PCB. These sensors will be placed conveniently in and on the car so that they are easily able to generate accurate values. The PCB will also consist of three other modules, ADC, AVR and a Bluetooth module. The ADC, also commonly known as Analog to Digital Converter, will be used to convert the analog values generated by the sensors to digital so it can be relayed further. The AVR is a microcontroller. Even though the values are converted to digital by ADC, yet they exist in electrical form. They need to be converted in to data form so that they can be further relayed. Then there is the Bluetooth module. The connection between AVR and Bluetooth module is made using a serial connection. The Bluetooth module then simply transmits the values relayed by the AVR to the smart phone which is connected initially to it. A connection is also made from the PCB to ignition system of the automobile so as when the case of drunk driving is detected, the car is disabled from starting. This ensures working of core functionality by not depending on any other external modules. The values sent by the Bluetooth module are then received by a smart phone. This smart phone processes the data, and then generates alerts as per the situation. Thus, if another automobile comes to close while driving, then the proximity sensor would generate alert

on smart phone for the situation.

The smart phone is not only used to provide alerts, but also to relay the data to a cloud server. The relaying of data is done at real time, so it can be accessed easily at real time by owner/relative. This helps in ease of monitoring.

4.3 Implementation

We are going to develop the prototype of the smart phone and sensor based drunk driving detection system on a toy car. A customized PCB will be designed as well as the android application will be created such that it will work on majority of Android phones. Android phone is used since they provide Bluetooth, GPS and GPRS as key functionalities. In the following part, we describe the implementation details of the prototype.

We implement the prototype in Embedded C, Java and XML. Different IDE's will be used for different modules implementation as they provide more support to them. Such as for Android application, we will be using Eclipse, for serve Netbeans and son on. The system can be divided into five major components: user interface, data collection system, monitoring system, data processing and alert notification. After the system will be initialized it will store and load the configuration each time it is booted up. The sensors will keep running in the background as soon as the key is inserted. Also, on the android phone, the daemon keeps running in background as a Service in Android, collecting and recording the readings of sensors. These readings are processed and used to detect drunk driving. In data processing component, according to real situations, the time windows are set to 5 seconds. When drunk driving is detected, the prevention component works to disable the ignition system of the vehicle.

The hardware and android application will be designed by us. The hardware will be integrated by us temporarily in the toy car and the application will be compiled and built as a system project, signed and installed on the mobile phone using ADB tools. The approximate size of the hardware would be as of a credit card, with more in thickness. The Android application size will be around 1MB. Eventually, we may a polished version of the hardware as well as the software will be released by us for to be integrated more in other automobiles.

5. EVALUATION

We will be evaluating the smart phone and sensor based drunken driving detection prototype with real tests. In this section, we first describe how we collect the data. Then we present the system performance in different scenarios and the energy efficiency.

5.1 Data Collection

The drunk driving behavior is studied under single solution: the analyzing of breath. We will be experimenting the hardware with different types of breaths in real time to understand the difference between the normal condition and the drunk driving condition. The data will be collected using different types of alcohols so that an accurate range of values are generated which can then be applied to the system for appropriately evaluating the current condition and to avoid any false positives or negatives.

5.2 Detection Performance

A study of performance of detecting drunk driving related behaviors can be done, since drunk driving can be directly accurately detected by using the specialized sensors. The performance would be measured in terms of false negative (FN) and false positive (FP). A case of false negative occurs when drivers is drunk driving but it is not recognized by the sensors. False positive occurs when the driver is indicated be drunk by sensors but that being not true. Hence, the lower the both FN and FP are cases are, the better the performance is.

5.3 Energy Efficiency

To test power consumption of the detection system, we will be attaching the system to the automobile and fully charging the smart phone and then observe the power states under different states for a long period: 1) the smart phone runs without detecting any violation; 2) the system keeps on running, sensing, monitoring and relaying the information.

6. CONCLUSION

Thus we would like to present a highly efficient smart mobile phone sensor based drunk driving detection system via this paper. The hardware as well as the smart phone, which will be placed in the vehicle, will collect and analyze the data from specialized sensors to detect if any violations such as driving under alcohol influence are detected. We expect the system to present solution that observes very low false positive and false

negative rates, accurate evaluations. In the future might integrate more additional features to make it more efficient.

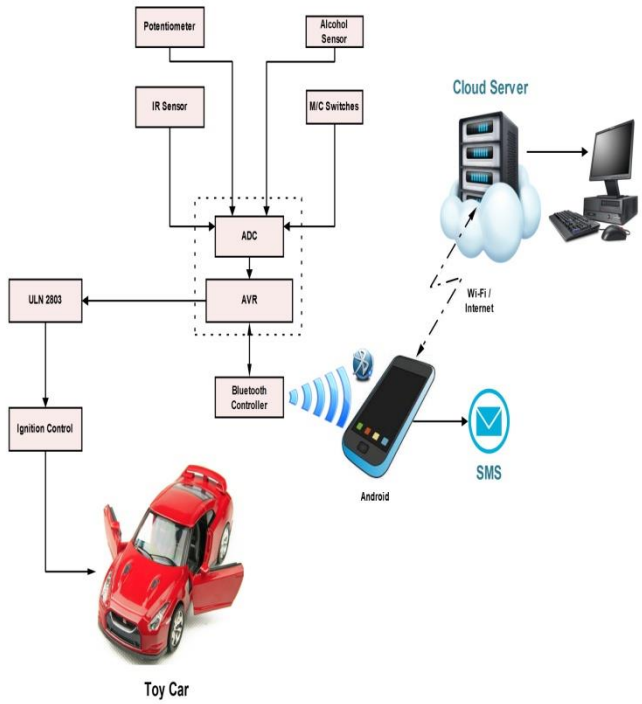

Fig. 1: Components Overview and Flow Of System

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