Developing smart collision avoidance computing system implementing Bluetooth technology

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ABSTRACT

In the current scenario the world is plagued by accidents which are primarily due to human errors in judgment and hence thousands of lives are lost. These accidents can be avoided by controlling the traffic with the help of some monitoring systems. The existing monitoring systems use the technology of GPS (Global Positioning System) which generate alert messages to either mobile phones or the display held in the vehicles which require readability. This may cause the diversion on mind for drivers and meet with accidents or drivers may not find the time to read the generated messages on the display. Hence, these accidents can be avoided if only there was a mechanism to alert the driver of approaching danger. This can be done by monitoring the distance between nearby cars and alerting the driver whenever the distance becomes too short. This is precisely the aim of this paper. In this paper we propose the use of Bluetooth Technology by which we can check the speed of the car whenever it comes dangerously close to any other vehicle up front, thereby saving very many lives.

Keywords: Bluetooth, RSSI controller, Braking system, Car speed control, Accidents, Automatic, Smart Computing, and Distance

1. INTRODUCTION

Bluetooth is a wireless technology standard for exchanging data over short distances in the ISM band with a frequency between 2.4 to 2.465GHz from fixed and mobile devices, and building personal area networks (PANs). It can connect several devices, overcoming problems of synchronization.

Bluetooth was standardized as IEEE 802.15.1, but the standard is no longer maintained. So, in the range of Bluetooth device, an every single device enabled with Bluetooth acts a master node connected to Eight (8) slave nodes forming a piconet. Similarly the slave node in one piconet may be the master node for another piconet. This leads to the formation of scatternet. Scatternet can be assumed as the group of piconets.

Since Bluetooth devices are capable of communicating with eight other devices simultaneously we can monitor and check the speeds of up to eight vehicles simultaneously, thus preventing accidents. Thus if we have two Bluetooth enabled devices in two vehicles the devices automatically communicate with each other when they come in the range of up to 100 meters of each other. The range is dependent on
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the power class of the product. Power transmission rates vary in many Bluetooth devices depending upon the power saving features available in a particular unit, bandwidth requirements, transmission distance.

Personal vehicles are the most common way of transport in the recent days than preferring for local trains, metro or buses. Hence, people drive on their own and sometimes which may mislead to severe road accidents. The major cause for this may be for many reasons. Some of them may be like; it is because of no control over the speed or due to wrong interpretation of distance and speed. Interpreting speed, time and distance is the very basic and important need for effective and safe driving. As human err is most common thing in this World, there arises the technology implementations for automation systems.

So here in this paper is the proposed idea about how the existing technology can be implemented leading to the SMART COMPUTING SYSTEM which utilizes existing AUTOMATIC BRAKING SYSTEM technology and implements BLUETOOTH COMMUNICATION as a new layer over the system. This system can not only lower the accident rate but also monitors the speed which in turn reduces the traffic at any place. The importance for this system can be acquired from the past statistics of the road accidents that occurred. The statistics of road accidents is tremendous and highlights the need for such a system. The following is a graph that shows the number of person killed across the years passed. From the graph it’s clear that the persons killed due to accidents are enormous and is almost increasing still which may reduce the life expectancy more and more in the near future.

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<th>Total No. of Persons Killed (in numbers)</th>
<th>Total number of Registered Motor Vehicles (in thousands)</th>
<th>No. of Accidents per ten thousand Vehicles</th>
<th>No. of Persons Killed per ten thousand Vehicles</th>
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2. LITERATURE REVIEW

2.1 Project Overview

Traditionally, Smart Detection systems have been large, expensive, and used only in aviation or military applications. However, the presence of the GPS and other small low-cost motion sensors has made possible Smart Detection systems that are small and inexpensive enough to be used in consumer products. Commercial consumer-grade detection systems are in fact, readily found today in Japan, Europe and United States with one application being automobile navigation systems. But, even then there are many cases where the data is not spatial and complete which causing a failure in detecting the motion.

So, the system that this project proposes can be implemented with small-cost and efficient detection with user-friendly data signals transmissions too.

In this literature, the project builds a mini smart computing system which detects the relative motion of the vehicle and dynamically calculates the distance between the vehicle and other surrounding vehicles. Depending on the distance, a Bluetooth is activated and then speed control signals are transmitted to the near-by vehicles which make the vehicle to control its speed manually by the driver. When the distance is even closer, there is a chance for vehicle collision then smart computing system hands over the control from Bluetooth to commercial automatic braking system, which controls the speed depending on the situation.

2.2 Meta Architecture

2.2.1 Overview
The system consists of three layers: System Control Layer, User Layer, and Device Layer. The System Control Layer manages handling control between Bluetooth and automatic braking system. On the other hand, User Layer creates the User interface which shows the status of the vehicle relative to the other vehicles and accordingly alerting the driver with the alarm signal which can either be heard or can be seen in the display. Device layer manages the devices that are currently in the range of Bluetooth and automatically deleting the devices when they are out of range. The figure next after this paragraph shows the architecture of the system.

2.2.2 User Interface Layer

The User Interface Layer shall be designed to translate interactions between a user and the system. It shall contain two major interface categories: software (logical) – GUI (web interface) and hardware (physical) – manual device interactions. Example: It makes the driver come to know what is the current speed and what is the required speed to be from out of danger and also the relative distances between vehicle and surrounding vehicles which makes the user to analyze what must be done to avoid collisions.
2.2.3 System Control Layer

The system control layer is the core of the mini smart computing system. It is responsible for the making decisions according to the position of the vehicle and should manage both Bluetooth connectivity and the flexibility of the automatic braking system. It makes sure that the signal is sent to the particular device listed in the device layer. The system layer must be capable of sending the signal to the in-vehicle Bluetooth device which in turn sends the signal to the surrounding vehicles. The figure shown in the next page gives the outline architecture of the system control layer.
2.2.4 Device Layer

The Device Layer contains the Control Unit (CU), Bluetooth Socket. The control unit specifies the current status of the system and who is handling the control on the vehicle at every instant of time. Bluetooth Socket is used to connect to different devices when comes in the range of Bluetooth but only to a maximum of eight devices can be connected using the Bluetooth address for socket communication.

![Diagram of Device Layer]

2.3 Inter-System Data Flow

The inter-subsystem data flow tells us about the data elements related with the subsystems in each layer. This is the means of showing how each subsystem is inter-connected and inter-related with each other. It also signifies the nature and direction of the data that flows within the subsystem.

In the architecture of the smart computing system, we have system control layer on the top which mainly is the root for initiating, maintaining and terminating the connection.

Whenever a user starts his vehicle’s engine and about to drive, the system will get activated. Bluetooth is internally installed with the driver in the system which also gets activated automatically. Now, when the system finds some vehicle in the range of Bluetooth, it sends the connection request through the
Bluetooth address to the destination vehicle’s system. This automatically accepts the request without the intervention of driver and displays in the connected devices list in the device layer.

The system control layer is connected internally to Bluetooth device as it is installed in the same system and connected externally to automated braking system. When the system hands over control for Bluetooth to send an alarm signal and display it on the other vehicle’s GUI, it interacts with the device layer and also to the user interface layer.

Depending on the distance between vehicles, Bluetooth sends different types of signals. There are basically two cases in which Bluetooth sends signals and accordingly there are three different signals. Assuming the distance between the vehicles to be a variable ‘d’. The cases are:

- If the distance d is non-decreasing variable, then the Bluetooth sends the signal as “ALERT with a red spot on the GUI.
- If the distance d is constant between the vehicles but within the range of Bluetooth, then the Bluetooth just shows the constant distance with an orange spot on the GUI.

When the user for the first time installs the system in the vehicle, then the vehicle details are being saved in the saved in the system and made default. So that whenever a vehicle approaches another, the details of the vehicle can be seen in the system.

The details of the vehicle are stored in a string format and then as there is already an existing socket for Bluetooth with Bluetooth address, the string gets transferred between the vehicles using the buffered input stream and buffered output stream of the socket which is established earlier.

The Bluetooth socket which is connected entity to the device layer in the architecture manages the stream for data transfer and then sends the signals accordingly in the same socket.

Hence, when in case of a piconet and scatternet when there are multiple vehicles in the network. Every vehicle details including the current distance are being displayed on the GUI.

Whenever a vehicle among all other in a network is much closer in distance, then the system retrieves the vehicle details from the database residing in the system control layer. If there is need for displaying multiple vehicles data to be retrieved from the database, the retrieving function uses the control structure and gets the data from the data structure that best suits for fast retrieval and sorting the data according to the severity of causing accidents.

When the vehicle leaves the range of Bluetooth, then that vehicular Bluetooth connection data gets
deleted from the data structure automatically.

When the distance between the vehicles will be in such a small range, the driver probably might not be in a position to monitor the connections of the devices and hence it is made automatic for connecting without the intervention of user. Also when the user is driving the vehicle, the GUI is made visible with the approximate positions of the vehicles surrounding with sum vehicle on the GUI. Accordingly, user can estimate the speed and drive safely.

3. WORKING

This section provides the working of the smart computing system and explains how the decisions are taken by the smart system with the detection capabilities.

As the system has to serve for both the Bluetooth and braking system, an operating system is required which creates an interface between hardware and software links and also manages the synchronizations that occur in the process of signaling controls. Also the OS can be from any provider and the processor of the system can be chosen from any of the commercial processors. The system must be installed with the drivers of traditional Bluetooth and then should be configured with the application that is designed for signaling and controlling. When the Bluetooth gets configured, it is calibrated by assigning a unique Bluetooth address which is used to communicate through socket.

The automatic braking system, available in the market commercially is then made to be configured with
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the system so that it can communicate with the Bluetooth socket for handling the control.

The system when started initially shows the own vehicle details on the GUI and the time of start from initial place. When the system is started, automatically the Bluetooth is initialized, which is ready to get paired with any of the devices near-by.

The system Control Layer of the system, which has the database and has external connection to the braking system, is also configured.

The vehicle which is in motion, system control layer checks for the surrounding vehicles and their relative speed and distance. If the system find any vehicle in the range of Bluetooth, then the device layer check for the Bluetooth address through the Bluetooth socket and gets connected to the vehicle. Soon as the vehicles are connected, the connected vehicles show their details on each other’s GUI. Simultaneously, the vehicle is added in the database and stored in a data structure that which can store and retrieve data efficiently and sort the data according to the intensity of danger.

When any of the connected vehicles are approaching or the vehicle is getting closer to any of the connected ones, then the system control layer checks the appropriate vehicle which is in danger and then retrieves the details from the device layer and displays them on the GUI using the User interface layer.

The designed smart system is made intelligent, so that it can take decisions on its own on posing control to either Bluetooth or braking system depending on the time and the distance variation between the vehicles.
3.1 RSSI

Received Signal Strength Indicator is the power present in the received radio signal. As the Bluetooth socket uses RF communication, hence it needs calculation of power strength between the devices. RSSI is a generic radio receiver technology metric, which is usually invisible to the user of the device containing the receiver, but is directly known to users of wireless networking of IEEE 802.11 protocol family.

RSSI can be used internally in a wireless networking card to determine when the amount of radio energy in the channel is below a certain threshold at which point the network card is clear to send (CTS). Once the card is clear to send, a packet of information can be sent.

Once the power transmission is calculated, using the distance power relation distance between the devices is calculated. Now, to calculate the distance between vehicles dynamically, the relation is being calibrated whenever the Bluetooth socket implements new thread in the communication, the relation gets implemented and gets the distance.

As this is being implemented in the system control layer of layered architecture and then is sent to both user interface layer to display on GUI and the device layer to sort the database according to the sorted list if the vehicles data.

\[
d = 10\left[\left(P_0 - F_m - P_r - 10 \times n \times \log_{10}(f) + 30 \times n - 32.44\right) / 10 \times n\right]
\]

Where, 
- \( F_m \) = Fade Margin  
- \( N \) = Path-Loss Exponent, (ranges from 2.7 to 4.3)  
- \( P_0 \) = Signal power (dBm) at zero distance - Get this value by testing  
- \( P_r \) = Signal power (dBm) at distance - Get this value by testing  
- \( f \) = signal frequency in MHz - 2412~2483.5 MHz
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The Bluetooth radio is a short distance, low power radio operating in the unlicensed spectrum of 2.4 GHz and using a nominal antenna power of 20 dBm. At the 20 dB the range is 100 meters, meaning equipment must be within 100 meters to each other (about 328 feet) to communicate using the Bluetooth standard. With the help of this technology data can be sent to the eight devices.

Radio communication is subjected to noise and interference, as the 2.4 GHz frequencies are shared between all devices in a piconet. So the Bluetooth specification has solved this problem by employing what is called as spectrum spreading, in which the Bluetooth radio hops among different frequencies very quickly. There are 79 hops starting at 2.402 GHz and stopping at 2.480 GHz, each of which is displaced by 1 MHz. Bluetooth avoids interference by hopping around these 79 frequencies 1600 times per second. So in order to avoid it we use Bluetooth equipped car, in which each car have Bluetooth transmitter and receiver. And the every car should have minicomputer to monitor the relative position of the car with the other car.

4. SCHEMATIC DIAGRAM OF CAR

The diagram shows the schematic working of brakes in a most popular vehicle on roads that is CAR. As the diagram says, each car has the parts mentioned in the diagram. In that BOOSTER, DISC and DRUM Brakes are important and are the central structures. Booster help the vehicle to overtake the other vehicle when needed and the brakes are applied when the vehicle to control the speed with the other vehicles.

The automatic braking system is the separate entity that is commercially included in the system which would help and take the control of the vehicle from Bluetooth. It majorly has 4 components. They are:

- Speed sensors
- Pump
- Valves
- Controller
SPEED SENSORS, which are located at each wheel, is the component to that observes the speed of the vehicle and gets it the smart system.

VALVE in the brake line of each brake is controlled by the Braking System. On some systems, the valve is at three positions:

- In position one, the valve is open; Pressure from the master cylinder is passed right through to the brake.
- In position two, the valve blocks the line; Isolating the brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder.
- In position three, the valve releases some of the pressure from the brake.

PUMP is another component in the braking system.

Since the valve is able to release pressure from the brakes, there has to be some way to put that pressure back. That is what the pump does; when a valve reduces the pressure in a line, the pump is there to get the pressure back up.

CONTROLLER is the communication link between smart system and the braking system in the car. It watches the speed sensors and controls the valves.

The controller monitors the speed sensors at all times. It is looking for decelerations in the wheel that are out of the ordinary. Right before wheel locks up, it will experience a rapid deceleration. If left unchecked, the wheel would stop much more quickly than any car could. It might take a car five seconds to stop from 60 mph (96.6 kmph) under ideal conditions, but a wheel that locks up could stop spinning in less than a second.
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The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power. When the ABS system is in operation you will feel a pulsing in the brake pedal, this comes from the rapid opening and closing of the valves. Some ABS systems can cycle up to 15 times per second.

5. ADVANTAGES OF USING SMART SYSTEM

5.1 Prevents Road Accidents

The main aim of the system is to successfully reach the goal of avoiding accidents. The accidents rate can be decreased in a large number. This makes the roadways the best secured for any kind of people in any part of the world.

5.2 Better driving control

The driver of the vehicle would have a safe driving as faults in driving would be automatically corrected by the Bluetooth system. So, the driver need not pay attention all the time during driving.

5.3 Better traffic control

Smart computing system would control traffic on roads. At times when traffic is high, there is a chance of minor accidents when vehicles rush through the small gaps. This system would avoid such incidents.

6. TYPICAL DIFFICULTIES IN USING SMART SYSTEM

6.1 Lack Of knowledge

Every user who drives a vehicle must and should be given a demo on this system. Although, the system implementation and usage is simple, the user must be in a position to recognize the signals and the controls that the system produces and should react accordingly as the distance and the time are both very less in number.

6.2 Unclear and confusing language

Even though the system produces user friendly signals, the GUI interface must also capable of displaying in at least some major native languages. This increases to a wide range of usage of this system.
6.3 Limited Range of Detection

With the growing population as the evolutionary global problem, the number of vehicles on road might increase. With spatial roads which made this possible problem. So, in that case the Bluetooth cannot detect more than 8 devices.

7. FUTURE WORK

- Future work of this project is to achieve internationalization and try for a wide range communication protocol implementing a chain protocol of the Bluetooth layer itself to increase the system capacity and simultaneously solve the synchronization issues which arise upon development.

- To increase the usage and connectivity of the system with the Bluetooth from the mobile system. This can be achieved through a node to node data communication for a successful data transfer. But, there are some synchronization issues which are causing data loss. This issue can be resolved later through revising the protocol and evaluating the socket communication.

- In future, the system can be replaced with a software application, that can be installed in a smart phone. This can be made possible only if the above mentioned synchronization issue gets resolved. Then, the connectivity can be made from end users mobile to braking system and the user interface can be arranges in the smart phone itself.

8. CONCLUSION

The Bluetooth technology is being widely adopted by the Industry leaders. The possibility for new applications is very exciting with this versatile technology. It provides a simple, logical answer to all the Problems-which is built a single common radio into every mobile computer, then neither do companies have to worry about WAN, nor do communication companies need to worry about building external cables. The Bluetooth communication device will thus be a small, low powered radio in a chip that will talk to other Bluetooth enabled products. Bluetooth has been designed to solve a number of connectivity problems experienced by the mobile workers & consumers. Thus, this technology helps make the electronic devices more users friendly and helps address various other problems like accidents. All the necessary work is further done to get the technology close to each individual in all areas and also citizens reducing their panic for travelling in a high travelling and will be strived for the best to make the technology productive in the native languages.

People have to change according to the needs. In times of such drastic changes and improvement to technologies, people should have the courage to embrace these changes for a better and brighter future. People must be following proper traffic regulations and avoid all the don’ts and feeling responsible for
other’s life is the most important social thing that should arise in every individual who gets on to the road.

REFERENCES

1. “Design and Development of Automatic Vehicle accident detection & Localization of Automobile Using Bluetooth Technology.” Nitin Thakre1, Prof. Nitin Raut2, Prof. Abdulla Shaik3
2. “Providing Accident Detection in Vehicular Networks through OBD-II Devices and Android-based Smart Phones” Narsing Rao, M1; Suresh Kumar, V2
4. “Bluetooth and WAP push based location-aware mobile advertising system” Lauri Aalto, Oulu, Nicklas GöthlinJani KorhonenMediaTeam Oulu, Timo Ojala
5. “Using Inquiry-based Bluetooth RSSI Probability Distributions for Indoor Positioning” Ling Pei, Ruizhi Chen, Jingbin Liu, Heidi Kuusniemi, Tomi Tenhunen, Yuwei Chen
7. “BluEyes – Bluetooth Localization and Tracking” Ei Darli Aung, Jonathan Yang, Dae-Ki Cho, Mario Gerla
8. “Bluetooth Tracking without Discoverability” Simon Hay and Robert Harle
10. “Fingerprinting Based Indoor Positioning System using RSSI Bluetooth” Disha Adalja, Girish Khilari
11. “Bluetooth Triangulator” Varun Almula, David Cheng
13. “ELECTRO-HYDRAULIC BRAKING SYSTEM FOR AUTONOMOUS VEHICLES” V. MILANÉS1, C. GONZALEZ1, J.E. NARANJO2 and T. DE PEDRO1
17. http://en.wikipedia.org/wiki/Received_signal_strength_indication

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