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Car Anti-Collision and Intercommunication System using Communication Protocol (A Prototype Model)

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Abstract

Road safety has been an important concern in the world over the past few years since millions of people die every year because of car accidents and many more are injured. The wireless communication technologies enabled vehicles on a highway to communicate in order to share vehicle state information and information to avoid potential collision. Here, a protocol which avoids vehicle accidents is discussed. The vehicle state information is being obtained, using ultrasonic sensors, to predict potential accident and accordingly, reduces the vehicle speed. This protocol provides warning message when the distance is reduces than the safety limit. Here, the car is equipped with an ultrasonic sensor, which will continuously tracks for any obstacles from the front side. If the obstacle is detected, then the microcontroller will continuously compare the distance given by the ultrasonic sensor. If the distance goes on reducing indicating that, the front car is coming closer to the current car then the microcontroller program will start reducing the speed until the distance is within safe limit. A prototype model will be developed and tested against actual parameters on the road.

Keywords: Anti-Collision System, Braking System, Sensor, Communication Protocol.

Introduction

Safety is a necessary part of man's life. Road accidents account for a severe threat to human lives from both an injury as well as a financial perspective. Given that vehicles are designed to facilitate a smooth means of transportation, manufacturers have long been in the process of designing vehicles based on principles of reliability and safety. However, due to reasons such as human-error, circumstantial error and negligence, accidents occur.

Today, special attention is focused on the technologies that can reduce traffic accidents. Services provided by the Intelligent Transportation System (ITS) include collision warning; collision avoidance; and automatic control are eventually expected to result in a reduction of critical traffic accidents. The data is provided by sensors, information systems and analyzer devices located inside the vehicles. Low-cost vehicular enhancements are an impediment for large scale deployment.

Automated highway systems and intelligent transportation systems (ITS) were introduced to accelerate the development and use of intelligent integrated safety systems that use information and communication technologies as an intelligent solution, in order to increase road safety and reduce the number of accidents in our future roads. In contrast, as mobile wireless devices became an essential part of our lives, and the ubiquitous 'anywhere, anytime' connectivity concept is gaining attraction.

Vehicular Communication Systems are an emerging type of networks in which vehicles and roadside units are the communicating nodes; providing each other with information, such as safety warnings and traffic information. As a cooperative approach, vehicular communication systems can be more effective in avoiding accidents and traffic congestions than if each vehicle tries to solve these problems individually.

In-Vehicle communication protocols:

Embedded automotive networks are designed considering a harsh in-vehicle environment mainly caused by noise and electromagnetic interference (EMI). In-vehicle protocols are implemented to provide reliable and available communication under harsh conditions and disturbances. In general, these protocols define both physical and data link layer in the ISO/OSI reference model and they are developed based on some alternative medium access control mechanisms:

- CSMA/CD (carrier sense multiple access / collision detection), e.g. Ethernet,

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- CSMA/CR (CSMA / collision resolution), e.g. CAN,
- CSMA/CA (CSMA / collision avoidance),
- TDMA (time division multiple access), e.g. TTP/C,
- FTDMA (flexible TDMA), e.g. Byteflight and FlexRay,
- Distributed solution relying on tokens, e.g. TTP (Timed Token Protocol),
- Centralized solutions by the usage of masters, e.g. LIN and TTP/A.

Background

The earliest research into inter-vehicular communications was conducted by JSK (Association of Electronic Technology for Automobile Traffic and Driving) of Japan in the early 1980s (Tsugawa, 2005). This work treated inter-vehicular communications primarily as traffic and driver information systems incorporated in ATMS (Asynchronous Transfer Mode).
From the 1990s through 2000, American PATH (Hedrick et al., 1994) and European "Chaffeur" (Gehring et al., 1997) projects investigated and deployed automated platooning systems through the transmission of data among vehicles.

Recently, the promises of wireless communications to support vehicular safety applications have led to several national/international projects around the world:

Since 2000, many European projects (CarTALK2000, FleetNet, etc.), supported by automobile manufacturers, private companies and research institutes, have been proposed with the common goal to create a communication platform for inter-vehicle communication.

The FleetNet project in Germany (FleetNet project- Internet on the road, supported by six manufacturers and three universities from the 2000 though 2003, produced important results on several research areas, including the experimental characterization of VANETs, the proposal of novel network protocols (MAC, routing) and the exploration of different wireless technologies.
The vehicular network applications can be classified into three categories:

a) Communication between vehicles, this will enable various traffic safety and traffic information applications
b) Vehicle to fixed infrastructure communication can provide numerous applications, like remote internet access that can provide various entertainment services
c) Cars equipped with sensors can act as a remote sensing node to provide vital road side information other environmental conditions in large areas.

Till date, there have been number of protocols proposed for vehicular networks. They are classified as[6]:

1) **Unicast**- Traditional routing protocols and position based routing protocols can be used to establish unicast communications. This type of protocols requires a service discovery mechanism, which in turn increases overheads and introduces latency, thus reducing the network capacity. Hence, this method cannot be applied for safety critical applications.
2) **Flooding**- This approach has been discussed in previous section. There are protocols designed to improve the flooding approach i.e. to reduce the number of retransmissions and to increase the bandwidth usage .
3) **Diffusion**-Each node maintains a view (environmental representation) of its surroundings and periodically broadcasts that view. Each time a view is received that view is aggregated with the local one.

The protocols can also be classified on the basis of applications or the urgency of the message, for an example: protocols for alert message (safety applications) dissemination, vehicle to internet communication & vehicle to vehicle communication.
One of the main applications for vehicular network is broadcasting of safety messages, which may include dissemination of road side information, traffic and accident. These services require delivery of message to all vehicles traveling over a geographical area, with high reliability and low delay. Thus, the broadcast or multi cast approach is considered to be better for this application.

This method associates a defer time with each transmission and allows nodes to make a decision for transmitting the message after defer time runs out. That is, node drops the message from retransmission; if it receives another copy of the same message before it's defer time runs out.
Two important issues in emergency message dissemination in vehicular communications are addressed:

a) Identifying application requirements for vehicular cooperative collision warning
b) Achieving congestion control for emergency warning messages based on the application requirements. They have proposed VCWC (Vehicle Collision Warning Communication) scheme, in which, the abnormal vehicle generates a message consisting of geographical

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location, speed, acceleration and moving direction of the vehicle, to warn other surrounding vehicles. The protocol defines congestion control policies for reducing the delay.

Another vital safety application is gathering road side information via sensors networks and multicasting it to vehicles. It involves acquisition, processing and transmission. Jeppe & Lars have done a comparative study on two message dissemination protocols: a Zone flooding and a Zone diffusion protocol for this application.

Zone Flooding: It is a variant of flooding in which, a hop-count is embedded and decremented while forwarding. The packet can be forwarded till hop count is zero. To reduce retransmissions, each node maintains a sequence number and a sequence list. For further reduction in the dissemination of packets the concept of a flooding zone is introduced which requires the support of GPS device.

Zone Diffusion: Each node maintains an environment representation (ER) representing the surrounding environment via sensors. The ER is periodically broadcasted and updated every time data arrives from other nodes. In this packets are never forwarded as in the case of Zone Flooding.

Protocols for anti-collision system: With lot of limitations, different anti-collision systems had been introduced by using different communication protocols such as-

(1)A Communication Protocol for a Vehicle Collision Warning System:

This proposes a protocol to support s a vehicle collision warning system. By sharing vehicle state information, the protocol is able to predict collisions and deliver warning messages to address different emergency scenarios.

The protocol is based on the concept of Shortest Safety Distance between vehicles and the Safety Invariant. The protocol provides mechanisms to evaluate potential violations of the safety invariant and propagate warning messages to avoid them in a timely manner. It ensures that warning messages are propagated to all endangered vehicles in an emergency scenario in an efficient manner by keeping the number of messages low.

We have simulated the system using the SPIN model checker to show the correctness of the protocol and its effectiveness in eliminating redundant messages.

Communication protocols has focused on two main areas:

1) Message forwarding mechanisms 2) MAC layer protocols.

For the MAC layer, unlike traditional wireless networks where IEEE 802.11 standard is used, a VCWS requires a more adaptive MAC layer because of the differences listed above. To satisfy latency requirements, several protocols have been proposed, such as the Dedicated Short Range Communications (DSRC) protocol which provides high data transfer rates and supports both roadside to vehicle and vehicle to vehicle communications.

(2)A Collision-Avoidance Warning System Using Laser Radar:

Here system consist of laser radar sensor that detects the distance to the target vehicle, a vehicle speed sensor that detects its own speed, a signal processor that evaluates the seriousness of the warning from the above information, an indicator and switch box and output circuit for monitoring signals.

As a collision avoidance system, an automatic braking system that operates under critical conditions would be ideal. However, it such a braking system which operates only in extreme emergencies. Unnecessary braking against the driver's will must be strictly avoided. An example would involve a driver closing on a vehicle in order to pass it. Thus, a warning system for avoiding rear-end collisions has been developed.

A number of systems using microwave radar have been developed since the 1970s to avoid such collisions. One major problem for such radar systems is excessive false alarms created by guardrails, lampposts, etc. located adjacent to the road. Also, microwave radar is not yet practical due to large antenna size, high cost and difficulties in getting approval in regard to the Radio Law in Japan. The authors tried to apply a cheaper, small, practical laser radar sensor to the warning system. A comparison between the microwave and laser radar is done. There is little difference in performance, but overall the laser radar seems to be superior to microwave radar, even though its sensitivity deteriorates easily with bad weather conditions and dirty optical parts.

The system consists of a laser radar sensor that detects the distance to the target vehicle, a vehicle speed sensor that detects its own speed , a signal processor that evaluates the seriousness of the warning from the above information, an indicator and switch box and output circuit for monitoring signals.

System Structure

Generally this is described in following system

Anti-Collision System:

This block consists of designing a system to avoid a direct collision between the two cars those are used for study. For this, two Car models representing the two CARS are used. Here the car will be equipped with

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an ultrasonic sensor which will continuously track for any obstacles from the front side. If the obstacle / CAR is detected then the microcontroller will continuously compare the distance given by the ultrasonic sensor. If the next car is at a safe distance, then the CAR will keep going at the same speed. If the distance goes on reducing indicating that the front car is coming closer to the current CAR then, the microcontroller will start applying brakes until the distance is within safe parameters. This process will continue in a loop until the CAR comes to a Stop (but not switch off).

In this way we can ensure the safe distance between the two cars and thus accident can be avoided.

Braking System:

This block consists of a DC motor based car for study. The microcontroller will increase or reduce the speed of DC motor via Pulse width modulation. The microcontroller will increase or decrease the ON time and OFF time of the entire pulse time. If the ON time is decreased, then the voltage applied to the DC motor gets reduce and the speed of the DC motor reduces.

Intercommunication System:

In this block, the system is developed, in which the cars that are close by can communicate with each other using zigbee. Distance between the car is continuously monitored. If the speed decreases suddenly, the car behind comes to know about it instantly and the brakes are applied avoiding a possible accident (reduces the speed of the controlled car). The cars can also communicate about the traffic condition, Weather condition etc through GPS/GSM.

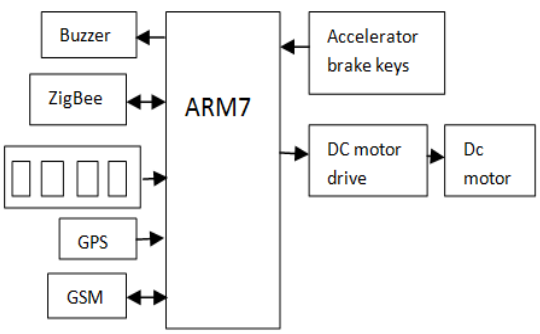

Fig 1: Block diagram for car 1

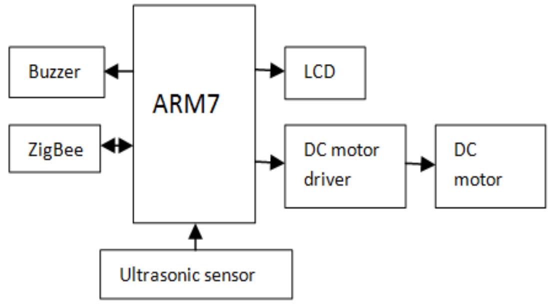

Fig 2: Block diagram for car 1

The overall system is described in fig 1 fig 2

Buzzer: Buzzer is used in a system to indicate or to grab the emergency attention occurred. Buzzer act as a panic horn which indicates the need of instant attention as in the condition goes haywire.

DC motor: DC motors are used to physically drive the application as per the requirement provided in software. The dc motor works on 12v. to drive a dc motor, a dc driver L293D is used. The dc motor driver is capable of driving two dc motors at a time. In order to protect the dc motor from a back EMF generated by the dc motor while changing the direction of rotation, the dc motor driver has an internal protection suit.

Liquid Crystal Display: LCD is used in a project to visualize the output of the application. We have used 16x2 LCD which indicates 16 columns and two rows. So, we can write 16 characters in each line. So, total 32 characters we can display on 16x2 LCD.

LCD can also used to check the output of different modules such as speed of car, location of car, display of question asked by other car, etc interfaced with the microcontroller. Thus LCD plays a vital role in a project to see the output and to debug the system module wise in case of system failure in order to rectify the problem.

ARM7 Microcontroller: The LPC2148 microcontroller is based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

The System Control Block includes several system features and control registers for a number of functions that are not related to specific peripheral devices. These include the Crystal Oscillator, External Interrupt Inputs, Miscellaneous System Controls and Status, Memory Mapping Control, PLL(Phase Locked Loop), Power Control, Reset, VPB Divider, Wakeup Timer. Each type

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of function has its own register(s) if any are required and unneeded bits are defined as reserved in order to allow future expansion. Unrelated functions never share the same register addresses.

The microcontroller will increase/decrease DC speed via Pulse width modulation. The microcontroller will increase or decrease the ON time and OFF time of the entire pulse time. If we decrease the ON time then the voltage applied to the DC motor will reduce and the speed of the DC motor will be reduced.

Ultrasonic Sensor: Ultrasonic sensors are basically used to measure the distances between the obstacle / object and the sensor. The ultrasonic sensor works on Doppler Effect.

It consists of a ultrasonic transmitter and a receiver. The transmitter transmits the signal in one direction. This transmitted signal is then reflected back by the obstacle and received by the receiver. So the total time taken by the signal to get transmitted and to received back will be used to calculate the distance between the ultrasonic sensor and the obstacle. This detailed function and diagram is described in chapter 2.

In the present model four Emergency keys are included. Actually these keys may represent ambulance service, brake fail, emergency and addresses respectively.

ZigBee: ZigBee is a specification for suit of high level communication protocols using small low power digital radios based on IEEE802 standard for personal area networks. ZigBee devices mainly used in mesh networks form to transmit data over longer distances, passing distance through intermediate devices to reach more distance ones. ZigBee is used for communicating the messages used in the emergency keys, GPS coordinates, speed and distance.

Global system for mobile communication (GSM): Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication. A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. A GSM modem exposes an interface that allows applications such as SMS to send and receive messages over the modem interface. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone.

Global Positioning System (GPS): The NAVSTAR Global Positioning System (GPS) is a satellite-based radio-positioning and time transfer system designed, financed, deployed, and operated by the U.S. Department of Defense. GPS has also demonstrated a significant benefit to the civilian community who are applying GPS to a rapidly expanding number of applications.

Operation Flow

The system operational flow is depicted as fig 3. Firstly, both car 1 and car 2 are started. The second car will be equipped with an ultrasonic sensor which continuously measures the distance given by the ultrasonic sensor. Then the sensor will check for the obstacles. If the obstacle is detected then distance is measured. The distance "D" is given to microcontroller and it compares with safe distance "actual" .If the car 1 is at a safe distance then the car will keep going at the same speed. If the distance keeps reducing indicating that front car is coming closer to current car then microcontroller will start applying brakes until the distance :D" is within safe parameters. This process will continue in a loop until car comes to a stop (but not switch off). This is the main operational flow of the system shown in fig 3.

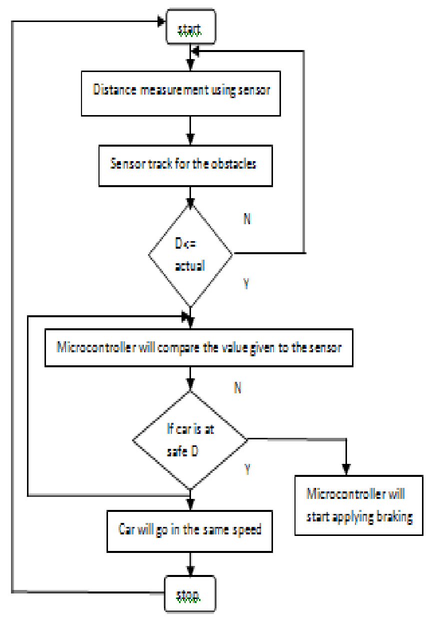

Fig 3: Operation flow

Results and Discussion

A prototype model is developed and tested with respect to actual parameters on road such as distance between the cars, location at the instant of collision, the reciprocating action of the car with respect to the distance between the two cars under considerations fig 4. Following results are obtained after design and testing.

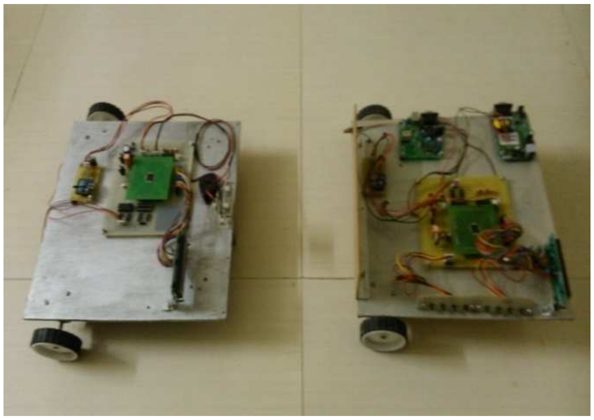

Fig 4: Prototype model

1. **Power supply:**
   (1) Input supply variation-
   The below table no 1 gives the result of 5v power supply. It shows that for various input supply output is 5v.

Table No 1

INPUT(UNREGULATED SUPPLY)	DC OUTPUT (REGULATED)
12.13v	5V
12.34v	5V
12.78v	5V
13.17v	5V

Below table no 2 gives the result of 3.3v power supply. It shows that for various input supply output is 3.3v.

TABLE NO 2

INPUT(UNREGULATED SUPPLY)	DC OUTPUT (REGULATED)
12.13v	3.3V
12.34v	3.3V
12.78v	3.3V
13.17v	3.3V

The overall power supply is shown in below fig 5.

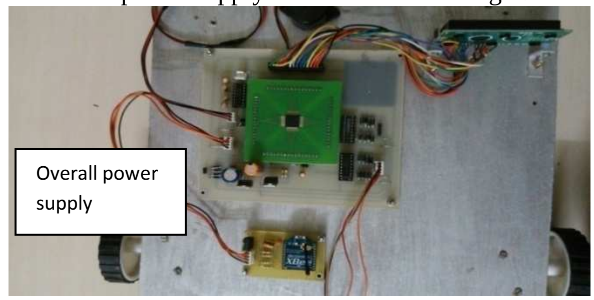

Fig 5: Overall power supply

2. **Software development for ARM7:**
   The software developed and used for ARM7 microcontroller gives the correct and expected results, which are described further in fig no.6.

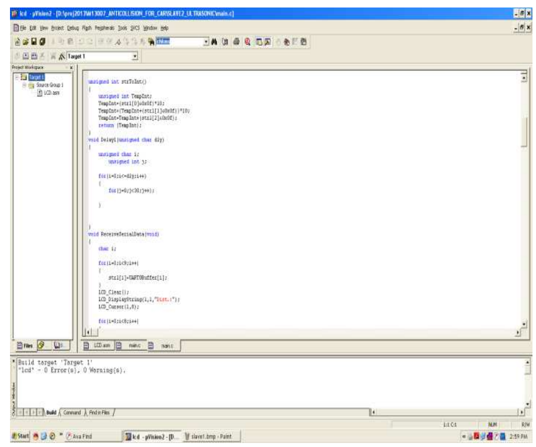

Fig 6: Software development

3. **The model** is tested for maximum distance between the cars versus angular separation between the cars and the results are given in table no 3. Moreover, the relationship between maximum distance (cm) between cars and the angular separation between the cars is shown in fig 7.

TABLE NO 3

DISTANCE(cm)	ANGLE(Degree)
206.31	90°
198.79	87°
196.02	85°
Not detected	83°
197.13	93°
195.93	95°
Not detected	97°

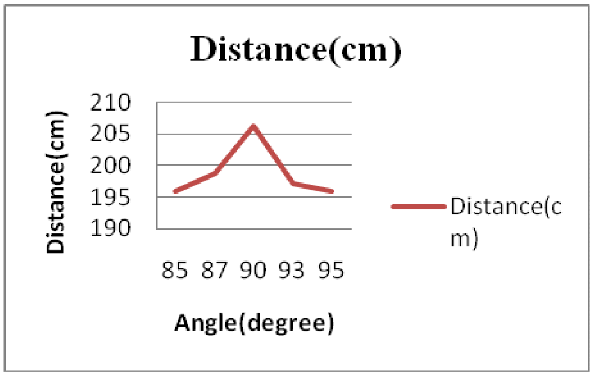

Fig 7: Distance Vs Angle

It is concluded from the nature of graph that maximum distance between the cars sense by the sensor (206.31cm) is at 90° that is when both the car in line. As the angles goes on increasing the maximum distance between the cars is sensed by the sensor goes on decreasing sharply within the range 90 to 87 and 90 to 93.

4.GPS position after collision:

The GPS location is shown in fig 8. This gives exact position of car accident.

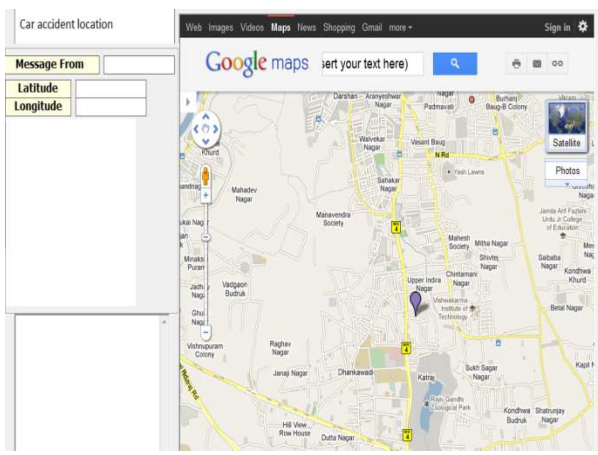

Fig 8:GPS position

5.**Buzzer indication:**

The buzzer gives alarm when the obstacle is detected by the car.

6.**The "Car** Anti-Collision and Intercommunication System using Communication Protocol (A Prototype model) works good and given the performance analysis as well.

Conclusion

1. The prototype model for present study shows the reliable performance against various parameters.
2. The hardware design for power supply and other units is correct as per the specifications.
3. Software developed for ARM7 microcontroller is correct for required performance.
4. From result 3, It is concluded from the nature of graph that maximum distance between the cars sensed by the sensor (206.31cm) is at 90° that is when both the cars in line. As the angles goes on increasing the maximum distance between the cars is sensed by the sensor goes on decreasing sharply within the range 90° to 87° and 90° to 93°.
5. From result 4, it gives exact position of car accident.
6. From result 5, buzzer gives alarm when the obstacle is detected by the car.

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