ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SMART CONTROLLER TO MAINTAIN SAFE DISTANCE BETWEEN VEHICLES

Sharvil Shah
Computer Science and Engineering, VIT, Vellore, India

ABSTRACT

Due to the increasing number of road accidents there has been a growing demand for better road safety features. This paper aims to explain a system which can provide a better and secure driving experience which can be achieved with the help of evolving Computer Industry. The proposed system shall use a set of sensors to detect the objects in the periphery of the subject vehicle with the help of Virtual Ellipsoid Periphery. If the obstacle comes in that periphery, then the necessary actions are taken by the system.

KEYWORDS: Road Safety, Sensors, Virtual Ellipsoid Periphery

INTRODUCTION

The proposed hardware system emulates a scaled down version of *Autonomous Cruise Control System* keeping budget constraints in mind so that the resulting product can be used for lower segment vehicles also. Most of the car manufacturers are not able to provide road safety features in lower segment vehicles because of limited quota of resources. Advanced cruise control systems are already available which provide varied functionality to the users. These systems are mostly limited to high end users but, in the market, low segment tyrannize the market and so this proves to be highly ineffective and useless. Therefore, the dearth of an equivalent and advanced system which can be used in budget vehicles motivated the need for this system. Some attributes of the proposed system are – Low Power Requirement, Reliability, Lower Cost and Automation. Various collision avoidance systems are available in the market which help driver by providing information about the environment, some of them even control the actual motion of the car to some extent without the driver being informed. But such systems are out of reach of common people as they are mostly available in expensive cars, the proposed system has a lower cost which fulfils the basic requirement i.e. to prevent accidents to a possible extent. But, the system has to ensure that normal driving experience of the driver isn't altered as far as possible.

PROPOSED SYSTEM AND FEATURES

The proposed system is a Smart Controller that detects any obstacle in the vehicle's vicinity and acts accordingly. To achieve this, the vehicle uses Ultrasonic Sensors and Rain Sensors connected to 8051 Microcontroller. Following is the list of general features that can be achieved with the help of this proposed system.

Following Nomenclature shall be used:

Safe Range – When an object is at a safe distance from the vehicle and not detected by the sensors.

Slowing Range – When an object is detected by the sensors but the obstacle is far enough to stop the vehicle.

Stopping Range – When an object is so close that if the vehicle is not stopped immediately, collision is bound to happen.

Vehicle Type

The controller takes the vehicle type as an input from the user, hence the slowing and stopping distances vary according to the type of the vehicle selected. This also increases the scope of the system.

Timely Action And Side Ways Obstacles

The system detects any object directly in line of sight of the vehicle. If the obstacle is in the slowing range then a warning is displayed to the user. If the obstacle is in the stopping range the vehicle is stopped immediately. The controller also detects sideways obstacles and acts accordingly.

Rain Factor

The environmental factor like rain can become cause of major accidents. The proposed system detects if it is raining and factors Slowing and Stopping Distances appropriately to accommodate loss of friction.

Obstacles Outside Line of Sight

The system detects any obstacle on the blind curve i.e. obstacles which are not directly in line with the direction of motion of the subject vehicle. Also, the controller is only activated in case the driver is driving above a certain threshold speed so as to avoid problems in a high traffic situation. Figure-1 below shows demonstration of blind curve issue.

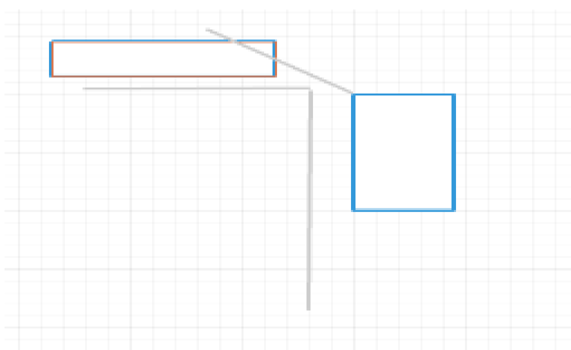

Fig. 1. Blind Curve Demonstration

TECHNICAL SPECIFICATIONS OF PROPOSED SYSTEM

The system creates an ellipsoid buffer region around the vehicle and hence the ranges will be different for all the sensors depending upon their position on the vehicle. The system take the subject vehicle type as an input and set the safety ranges accordingly, as a result it will be able to slow the speed of the vehicle based on the vehicle type. The system increases safety ranges when it detects rain. Since the system detects all the obstacles in the virtual ellipsoid zone, it detects incoming obstacles when the vehicle makes left or right turn and shall slow the vehicle down depending upon the range.

Taking usual speed of 60 kmph for car and 40 kmph for truck, the system has following values for safe range, slowing range and stopping range, which can be seen in table-1 and table-2.

The system shall be able to work in multitude of environments with a low failure rate and within real time constraints. It should be easy to use leaving only the selection of vehicle type to the user, thus handling the safety maneuvers itself without hindering the normal driving experience.

Table-1 Safety Ranges for a Car

Sensor Position	Safe Range	Slowing Range	Stopping Range
Front and Back	>37	18-37	0-18
During Rain	>51	26-51	0-26
Sides	>9	4-9	0-4
Blind Curve Sensors	>30	15-30	0-15
During Rain	>35	20-35	0-20

Table-2 Safety Ranges for a Truck

Sensor Position	Safe Range	Slowing Range	Stopping Range
Front and Back	>50	26-50	0-26
During Rain	>70	51-70	0-51
Sides	>11	6-11	0-6
Blind Curve Sensors	>40	20-40	0-20
During Rain	>45	25-45	0-25

SYSTEM ARCHITECTURE

The system can use any number of ultrasonic sensors according to the type of the vehicle. These sensors, along with the rain sensor is connected to the Microcontroller. The signal for input of the type of the vehicle is also sent to Microcontroller which in turn sets the ranges of the sensors. A relay driver is connected to the Engine and Microcontroller so that the signal of slowing and stopping can be amplified and sent to the Engine to control the wheels of the vehicle.

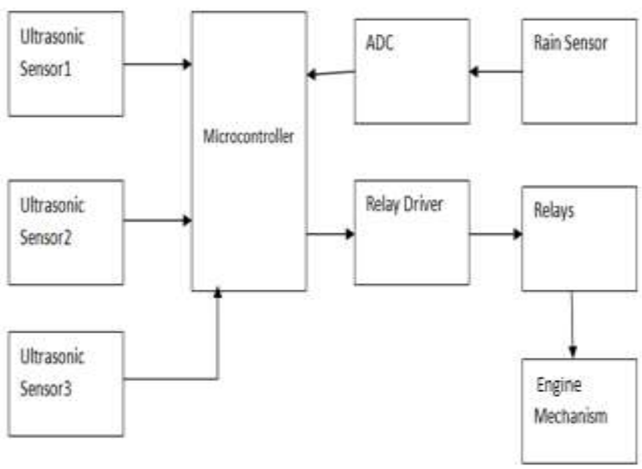

Fig. 2. System Architecture

Design Approach

Figure-3 represents a group of ultrasonic sensors which are used to provide a frontal viewport to emulate a radar type of view. The native ultrasonic sensors are line of sight therefore to get an area viewport idea, the system uses a combination of sensors in the front. If all sensors give different output, the system takes the lowest value (lowest value referring to nearest obstacle).

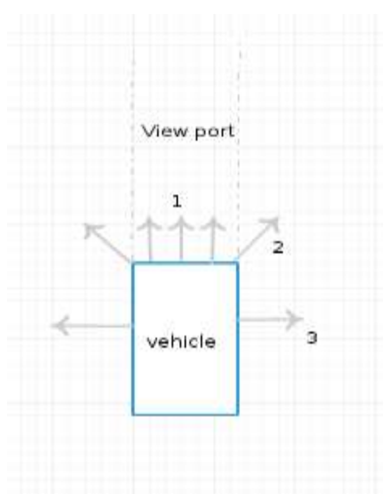

Fig. 3. Design Approach

The sensors can also help in avoiding blind turn collision and sideways collision as shown in the view port.

Ellipsoid Buffer Zone

Since higher intensity collisions usually occur in the direction of the motion of the subject vehicle, therefore the Smart Controller allows for greater safety ranges in the front and the back of the vehicle, as compared to those on the sides. In addition to these, the system has two sensors placed at 45 degree angle, on the left and right front ends of the vehicle. This arrangement of sensors creates a virtual ellipsoid safety buffer around the vehicle.

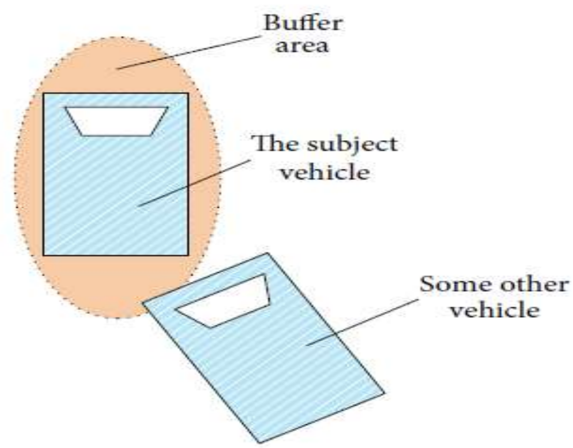

Fig. 4. Ellipsoid Buffer Region

During rainfall, the smart controller increases the safety ranges hence creating a larger ellipsoid buffer zone which is concentric to the one used in dry conditions. This allows for the variations in stopping distances due to reduced traction on wet roads.

Figure-5 depicts conceptual view of ellipsoid buffer zone in wet and dry conditions. The figure on the left shows the extended safety ranges while the one on the right shows the safety ranges during the dry conditions.

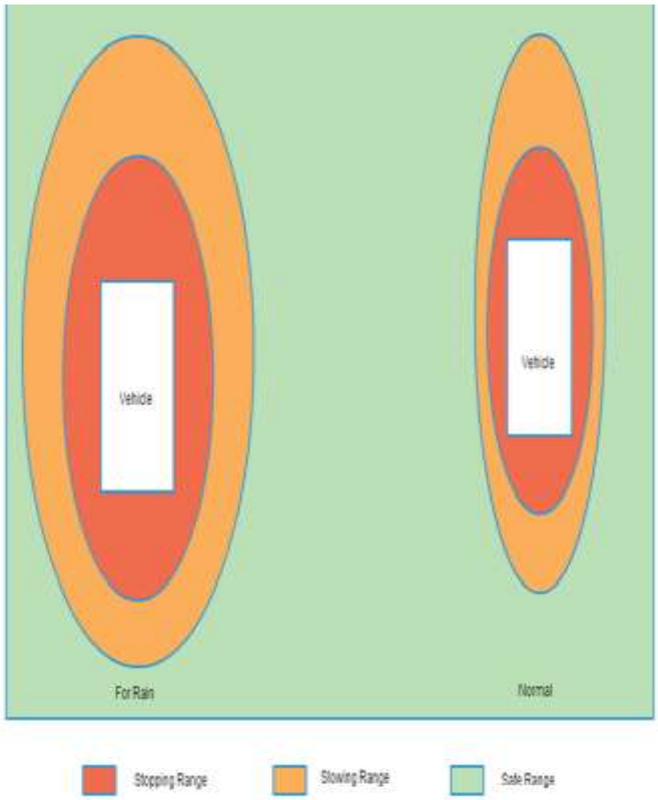

Fig. 5. Ellipsoid Buffer Region in Rainy and Dry Conditions

Control Algorithm of System

In the system, the user enters the type of the vehicle he is driving. According to that input, the stopping and slowing distances are initialized as shown in table-1. If it is raining, then the water sensor is active and accordingly stopping and slowing distance is calculated for the respective vehicle. The obstacles are detected by the sensors, if it is in the slowing range, a warning is displayed else the vehicle is stopped. The detailed system flow can be easily understood with the following flowchart. (Refer figure-6)

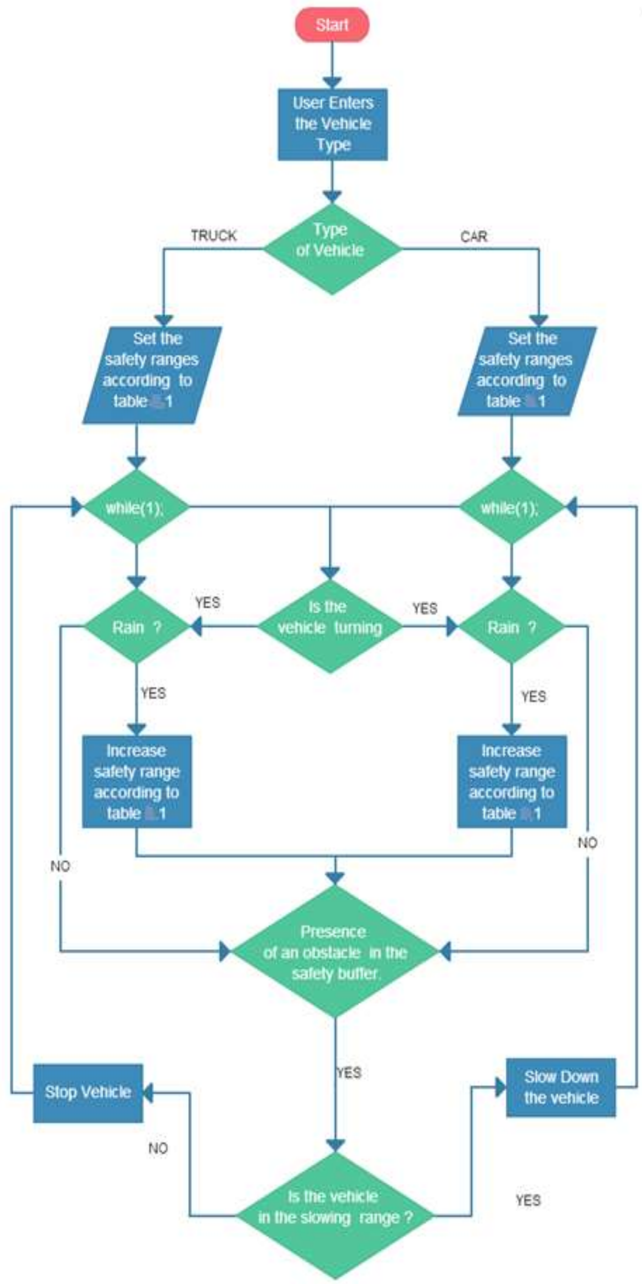

Fig. 6. Control Algorithm of System

TRADEOFFS

Radar v/s Ultrasonic Sensor (Front Detection): Radar sensors could be used instead of ultrasonic sensors. They have a wide angle view, can detect more obstacles & have a better range. Radar technology is expensive, so there is a cost-accuracy trade-off, i.e. cheaper ultrasonic sensors would be less reliable and less accurate and precise than higher end systems, but since we want a cost effective system with similar functionality the system has ultrasonic sensors.

Proximity v/s Ultrasonic Sensor (Sideways detection): There is not much difference between Proximity Sensors and Ultrasonic Sensors. Ultrasonic sensors are kind of proximity sensors used in this smart controller for sideways collision detection. A normal proximity sensor is not a very high range. But, ultrasonic sensor has a bit high range than the proximity sensor also they are as cheap as normal proximity sensors, hence the system is equipped with ultrasonic sensors for sideways detection.

Supply (Car Batteries v/s 230V supply): The system currently uses a 230V supply which is then changed to 5V DC. Instead of this the system could directly use a 5V supply provided by the car batteries.

Some constraints of this system are that any lapse in hardware could result in the system failure. Also, Accurate modeling of road geometry is an issue since the system may not be accurate enough to work on any topology of the road. Vehicle to vehicle kinematic conditions are difficult to determine because angular information of the other vehicle cannot be determined accurately in case of vehicle out of Ellipsoid Buffer Region.

CONCLUSION AND FUTURE WORK

The system explained in this paper is a minor version for direct application on road vehicles, however, it's a starting step, and the model can be further exploited to expand and consider most of the challenges that are mentioned under trade-offs. Road safety is a crucial topic of research, more studies & statistical analysis need to be made on factors like rain, distance from obstacle, speed of vehicle, friction coefficient, type of obstacle, and various other factors, before an actual working model can be incorporated into production. Moreover, since a matter of milliseconds might prove hazardous on the roads at higher speed, hence it must be ensured that the system logic & hardware are capable enough to act under real-time constraints with minimal budget so that it can be actually implemented in low segment cars.

For future work, Algorithms which take into account – Time to Collision (TTC) can be implemented using Micro-Controllers having a larger memory and faster operating frequency. Rear end collision avoidance while the vehicle is moving forward can be implemented by speeding up the vehicle depending upon other parameters. Statistical Data which is currently unavailable in most of countries can be used to make better systems which take into account the driver reaction times and the stopping times of different vehicles.

ACKNOWLEDGEMENTS

I take this opportunity to thank all the professors of VIT University who have directly or indirectly helped in this project. I would also like to thank my program chair Prof. Hari Seetha and Dr. Venkateswaran, Dean of Computing Science department for permitting to make use of facilities available in the department to carry out project successfully. Finally, I would like to thank my parents and my friends for their support.

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(I2OR), Publication Impact Factor: 3.785

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AUTHOR BIBLIOGRAPHY

Mr. Sharvil Shah
He is a 21 year old Computer Engineer passed out in May 2015 from VIT University, Vellore. Along with that, he is SAP certified ABAP consultant also having 8 months experience working in different companies as an intern.