ADAPTIVE SPEED CONTROL AND COLLISION MANAGEMENT IN AUTOMOBILES USING ABS

Gokul G[1], Anirudh S R[2], Deepan Kumar M[3], Senthilkumar K K[4]

[1] Department of ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamil Nadu, India
[2] Department of ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamil Nadu, India
[3] Department of ECE, Prince Shri Venkateshwara Padmavathy Engineering College, Tamil Nadu, India
[4] Head of Department of ECE, Prince Shri Venkateshwara Padmavathy Engg. College, Tamil Nadu, India

ABSTRACT

Rear end crash is the most common type of road accident. The existence of several technologies to prevent rear end collisions in automobiles work only in low speed. Accidents that occur at low speed doesn't cause much damage. The proposed technique can prevent accidents at all speed and can be applicable to all kinds of automobiles. The design vehicle is to be equipped with RADAR to sense the distance of preceding vehicle and the speed at which it moves. It is also to be equipped with Anti-Lock Braking System that engages brake to slow down a vehicle, prone to collision until the relative speed between those vehicle and preceding vehicle becomes zero. The Time-to Collision is evaluated and is ensured to be lesser than the braking time to make relative speed to zero. Once the relative speed is made to zero before collision occurs, then the succeeding vehicle will move at a speed equal to speed of preceding vehicle maintaining a constant distance which is equal to stopping distance of vehicle at that speed. The ABS which is now available in all vehicles not only performs effective braking but also maintains stability during the braking process thus preventing collisions at any speed and ensures safety commutation.

Keyword: *Rear-end crash, RADAR, ABS and Time-to-Collision.*

1. INTRODUCTION

Roads play a major role in transportation. Due to the rapid development of automobile industry, the number of vehicles all over the world crossed 1 billion. Nowadays, road traffic has become congested and unmanageable. All the important roads are abounding with vehicles. The people in developed and developing nations tend to have their own vehicles, especially cars. Most individuals these days do not drive with diligence. Increase in the number of cars and other utility vehicles not only increase the traffic density but also increase the accidents and cause loss to life and property.

This paper describes the design of accident avoidance mechanism for vehicles by speed limiting concept to prevent rear-end crash [1]. The vehicle will be equipped with RADAR along with Anti-Lock Braking System. The vehicle can be a four-wheeler or a bus or a multi-axle truck. The vehicle can be operated in conventional roadways.

Vehicle collisions continue to happen because human cannot accurately determine distance or human sometimes make careless mistakes. And sometimes human reflex and reaction time delay to respond so quickly causes some accidents to be unpreventable. Therefore, the method of monitoring by the driver cannot effectively avoid danger.

Thus, our vehicle aims at overcoming this human inability. In this context, it is intended to develop a mechanism that prevents the accident by having a universally applicable algorithm to all kinds of automobiles and to all category of automobiles such as electric car, 2WD petrol car, 4WD diesel van as well as trailer truck.

2. SYSTEM MODEL

The complete system model of our proposed system is divided as two main modules as:

1. Vehicle detection and Collision Evaluation
2. Collision Avoidance and Braking

In this proposed system we calculate the Time-to-Collision period and compare it with the braking time required for vehicle to bring to zero relative speed. The distance covered during the braking is known as stopping distance. Our vehicle is supposed to maintain that distance or the time gap to ensure the collision cannot occur at any speed. [2]

2.1 Radio Detection and Ranging

RADAR is used to detect the preceding vehicles while ABS is used for braking. The entire process is controlled by embedded microcontroller which commands the activation and release of brakes.

Using the conventional cruise control, the driver can set the maximum speed of his car. However, adaptive cruise control utilizes a radar mounted on the bumper or behind the radiator grille. The radar keeps monitoring the traffic ahead and then adjusts with the car in front, commanding the system to set speed accordingly. The adaptive cruise control is often paired with the pre-crash system and starts braking automatically when the distance between the cars reduces drastically. This paper provides enhancement to Adaptive Cruise Control with entirely different algorithm.

The Millimeter Wave Radar operates by emitting a 76 GHz radio signal in a predefined direction through a transmitter. The waves reflected by objects located within the radar's detection range are then received back by a receiver module and processed to determine the distance and relative speed of those objects. This information can then be used to maintain safe distance or stop if necessary to avoid collision. The Indian government already delicensed frequency bands in the range of 36-38 MHz, 433-434.79 MHz, 302-351 kHz and 76-77 GHz. The radar sensor constantly scans for vehicles ahead of our vehicle.

Specifications of vehicular RADAR includes:

- Frequency: 76 GHz
- Detection Range: 150 m
- Dimensions: 99.3 x 90.4 x 39.1 (mm)
- Horizontal Viewing Angle: 16/40 Degrees (Far Range/Near Range)

The distance between the two vehicles is known with the use of RADAR. The time duration between the transmitted pulse and received pulse can be used to find the exact distance at that instant. The velocity of the preceding vehicle is known from Doppler effect. The Doppler effect is the apparent change in the frequency of a wave caused by the relative motion between the source of the wave and the observer. By comparing the pulses, the Doppler shift is found and the corresponding variation of distance is known from which the speed of preceding vehicle is calculated as shown in Figure 1.

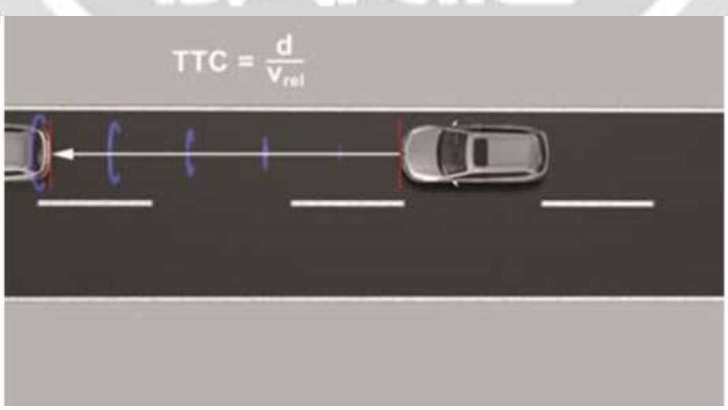

Fig -1: Calculating Time-to-Collision

2.2 Anti-Lock Braking System

Anti-Lock Braking System(ABS) is a closed circuit; hence it used the feedback control system that modulates the brake pressure in response to the wheel deceleration and wheel angular velocity to prevent the controlled wheel from locking.

The anti-lock braking system modulates the air pressure in the brake chambers to prevent wheel lockup and provide precise braking control during over-braking. This enhances:

- Vehicle stability
- Steerability under emergency braking
- Stable stopping on icy or rain-slicked road surfaces and in curves
- Stopping distance

The ECU processes the wheel-speed sensor signals to determine if a wheel is about to lock. In this case, the ECU will control ABS valve operation to modulate brake pressure and prevent the wheel from locking up. The ABS modulator valve is a solenoid-controlled air valve that can control air pressure flowing to, or exhausting from, the brake chambers. Airflow through the valve is controlled by solenoids which are controlled by the ECU.

The brain of antilock braking system consists Electronic Control Unit (ECU), wheel speed sensor and hydraulic modulator. The reason for the use of ABS is not only its effective braking, but also due to its sophisticated ECU which performs complex calculations to update speed 18 times a second. Since ABS already incorporates an ECU collision control can be easily done by activating ABS when needed. In addition to ECU, the ABS System has four other components:

1. Speed sensors
2. Valves
3. Pump
4. Controller

3. PROPOSED METHODOLOGY

The PIC microcontroller is used to implement Fuzzy Logic. The various parameters such as distance of the preceding vehicle and its relative speed, are measured using an IR sensor and are given as the inputs to the microcontroller through an analog to digital converter. Based on the inputs, the microcontroller generates an output, using the decision made by the fuzzy controller.

The digital output obtained is converted into an analog signal and provided to the ABS in order to control the speed of the vehicle. In case of a situation of danger of collision, the vehicle can also automatically come to a halt. In this manner, the vehicle is capable of differentiating a situation of actual danger from one that can be handled without the requirement of stopping the vehicle. [3]

PIC controls the activation and release of brakes. The brakes can be coupled with servo motor for autonomous braking when the system is activated. The block diagram is shown in the Figure 2.

When our vehicle moves faster than preceding vehicle then the collision is said to occur at some point of time. This time duration is found and compared to the braking time required to make the relative speed to zero. When Time-to-Collision time exceeds the braking time required, then the braking action is initiated.

(i.e.) Time-to-Collision < Braking time to bring relative speed to zero

As a result, the vehicle maintains a safe gap all the time and hence the rear-end crash is said to be prevented at any instant of time. [4] This gap is dynamically varied according to vehicle’s speed. When the vehicle comes closer to another vehicle then in layman’s term it can be understood that our vehicle moves at the speed equal to or lesser than the speed of preceding vehicle. Thus, at any speed the collision can be prevented using this algorithm. However, this algorithm is not meant to prevent crashes that occur to due to side collisions. Additional installations of sensors for blind-spot collision detection may fulfill this purpose with a slight modification in this algorithm. The algorithm is presented in detail in the upcoming sub-chapter.

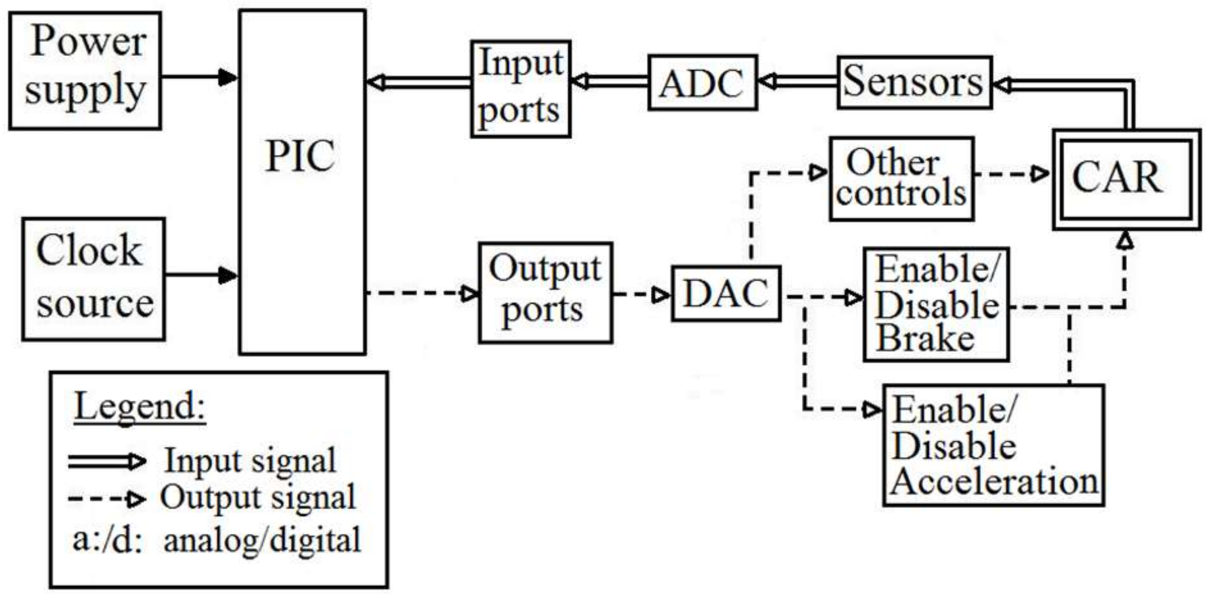

Fig -2: Block diagram

3.1 Algorithm

The following is the algorithm used in the proposed system and the process flow of the system is explained as a slow chart in the Figure 3.

- If distance(D) is infinite, that is no obstacle is found in the span of RADAR then actual input = required movement, no need of measuring relative velocity and no manipulation of actual input is required. Here, actual input is the speed of our vehicle presently. Here relative velocity = 0.
- In other cases, when distance is less than infinity, (depends on RADAR range) relative velocity of preceding vehicle is taken into account. The following cases are:

A. Distance is Close - INTIMATE ZONE
   i. Distance between the vehicles is small and Relative velocity is small.
   ii. Further acceleration is disabled and driver is issued with warning. This is done to instruct driver about collision so that he can opt for lane change without reducing speed.
   iii. Further reduction in distance between two vehicles caused due to deceleration of preceding vehicles puts the vehicle in Accident Prone Zone.
   iv. In this zone, no braking action is initiated.

B. Distance is extremely close - ACCIDENT PRONE ZONE
   i. Distance between the vehicles is very small and Relative velocity is large.
   ii. The braking action is initiated in this zone to prevent collision
   iii. The braking is done until the relative velocity between two vehicles becomes zero
   i.e. Speed of our vehicle <= Speed of preceding vehicle
   iv. This braking is done by ABS which has a lot of sensors to assist with proper braking.
   v. This braking is based on the braking time needed to bring the vehicle to zero relative velocity and that distance the vehicle covers during braking must be maintained between two vehicles.

C. Approaching a stationary obstacle
   i. Relative Velocity = Speed of our vehicle
   ii. Before our vehicle is about to hit the obstacle, it must be stopped.
   iii. This is also the same case of Accident Prone Zone and the braking is done until relative velocity becomes zero.
   iv. Thus, the system brings the vehicle to rest by completely stopping it.

D. Distance is far and no obstacle is detected
   i. Relative Velocity = 0
   ii. No action is taken and driver has full control over the acceleration and braking.
   iii. The system is inactive until any obstacle shows up in its way.

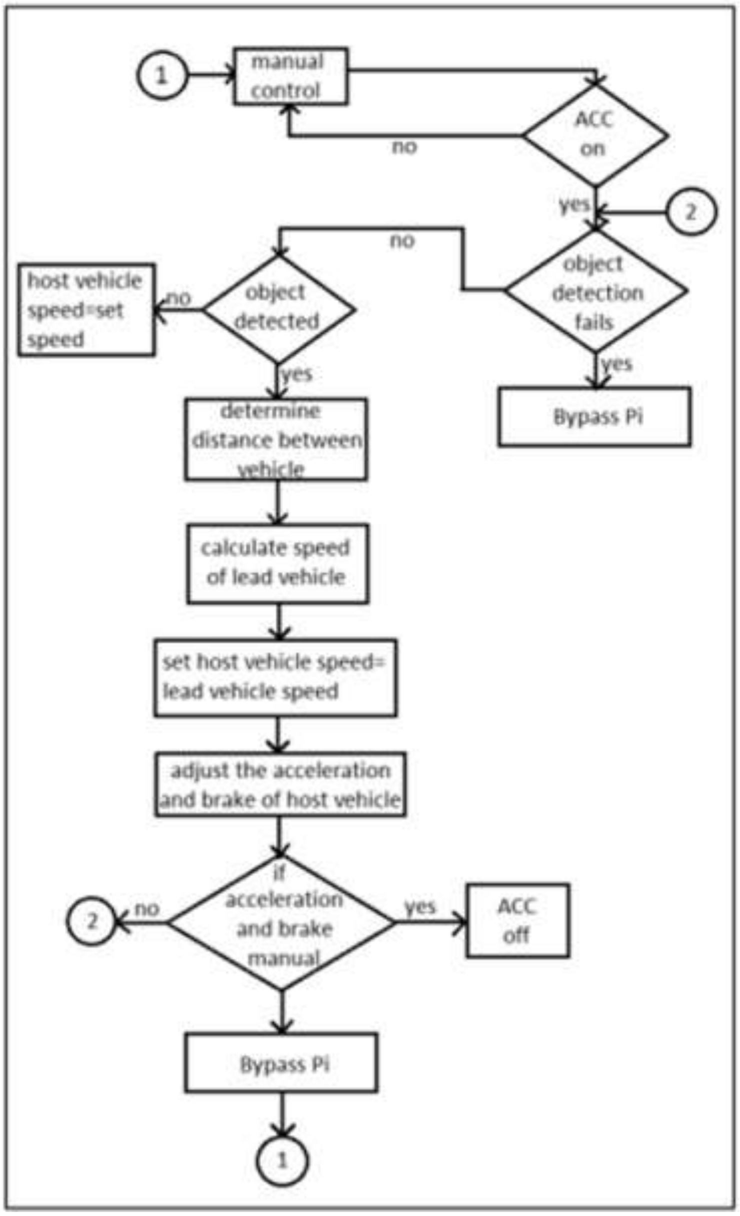

Fig -3: Process flow

4. EXPERIMENTAL RESULTS

The prototype model is designed using PIC microcontroller that works similar to an electric car. The PIC microcontroller is used to implement Fuzzy Logic and is programmed using Visual Basic. The graphical user interface of the VB-IDE provides intuitively appealing views for the management of the program structure and the various types of entities. An IR sensor can measure the distance of an object as well as detects the motion. These type of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations.

This sensor detects the objects in front of it and sends the signal to the PIC16F877A to slow down the vehicle correspondent to the opposite vehicle. If the vehicle has reached the braking time, then the controller stops the vehicle completely to ensure collision avoidance. If the IR sensor did not detect any obstacle, then the vehicle starts to move again until the sensor detects any other obstacle in front of it. The prototype model is picturized in the Figure 4 and the Visual Basic screen which is used for control operation is shown in the Figure 5. In actual model this entire operation is controlled by a single On-Board Computer.

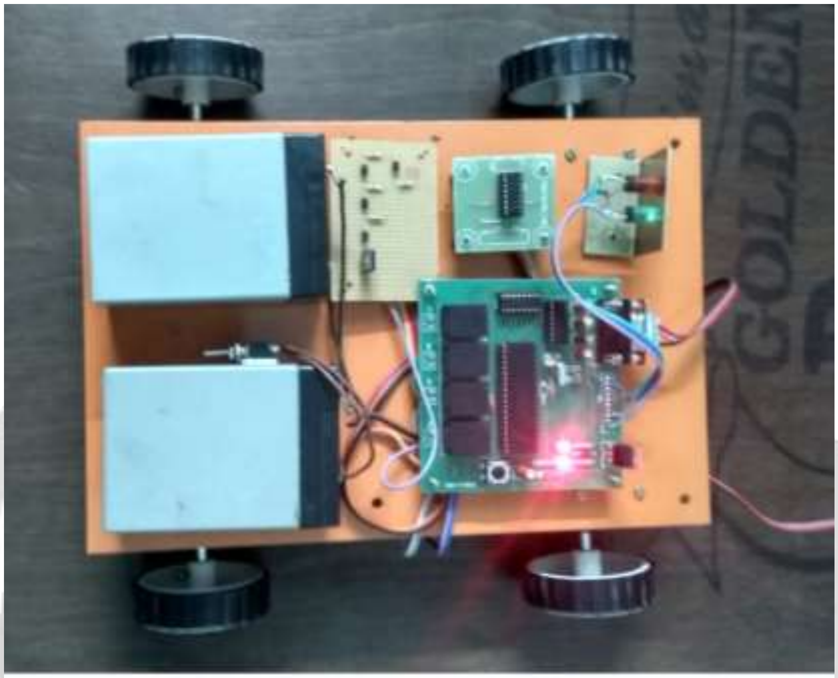

Fig -4: Prototype model

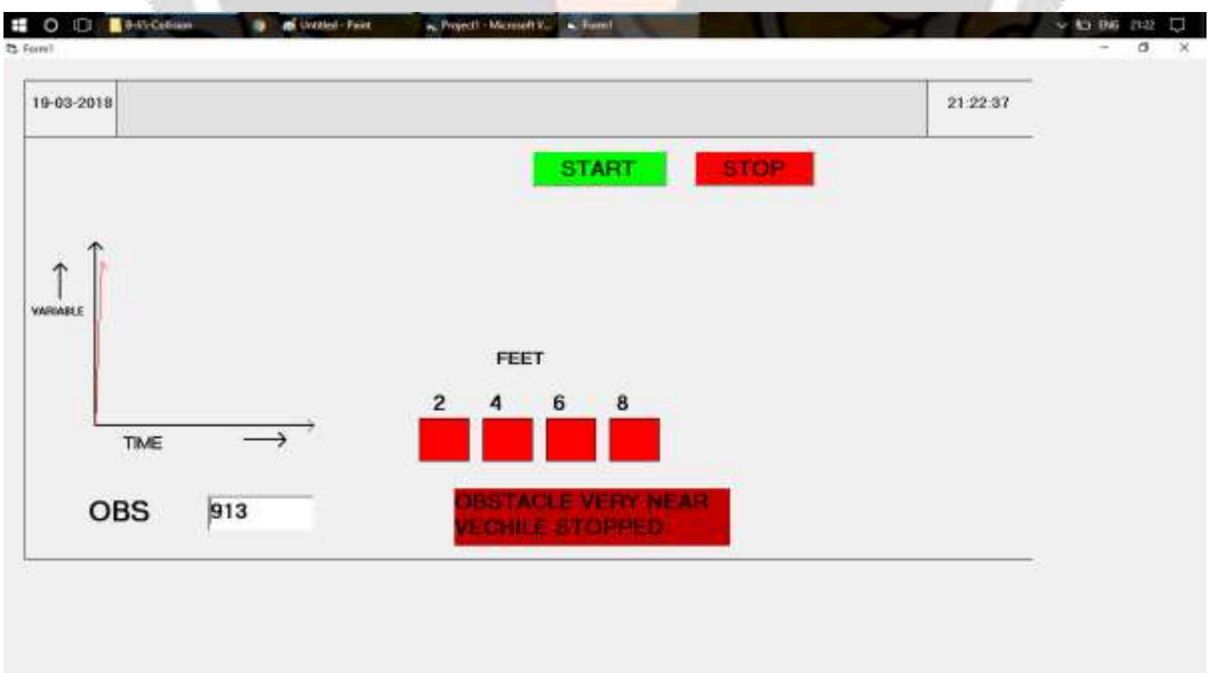

Fig -5: VB display screen

5. CONCLUSIONS

Collision warning and avoidance systems have the added complexity that they should be able to recognize a hazardous situation and communicate it to the driver. [5] The human factor issues are of great importance for CW/CA systems. Thus, the vehicle takes control during the time of autonomous braking and once the vehicle is safe to go, it gives the control back to driver. This can be implemented in any vehicle equipped with RADAR and ABS and can work with all vehicles with them. The algorithm is not distance based which makes it very effective to prevent rear-end collisions to 100% and vehicles can cruise at higher speeds without trading their safety.

6. REFERENCES

[1]. Butsuen, T. Nibe, T. and Seni, H. (1994) 'Development of a Rear-End Collision Avoidance System with Automatic Braking Control', JSAE Review, 15(4):335-340.

[2]. Adachi, K. (2006) 'Proposal of a target headway distance method and Applying this method to a car for adaptive cruise control system', Proceedings of the Japan Society of Mechanical Engineers, no. 06-52, pp. 23–28)

[3]. Kusano, K. and Gabler, H. (2012). 'Safety benefits of forward collision warning, brake assist, and autonomous braking systems in rear-end collisions'. Intelligent Transportation Systems, IEEE Transactions on, 2012, pp. 1546-1555.

[4]. Lee, K. and Peng, H. 'Evaluation of automotive forward collision warning and collision avoidance algorithms,' Vehicle System Dynamics, 2005, pp. 735-751.

[5]. Ararat, Aksun Giuvenc, B. (2005) 'Research on Recent Developments in CA/CW and Inter-Vehicle Communication Systems,' in AUTOCOM Workshop on Preventive and Active Safety Systems for Road Vehicles, Istanbul, Turkey.