Research Paper
Impact Factor - **2.262**
Peer Reviewed Journal

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

AUTOMATIC BRAKING SYSTEM IN ELECTRIC VEHICLES

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Abstract
Road Safety has become very important due to the increasing number of road accidents taking place every year. The prime reason for automobile related road accidents is due to the distraction of the driver. Thus, if a system is implemented so as to control or stop the motion of a vehicle when the driver is distracted, several number of road accidents may be prevented. Our paper introduces a system for speed control and automatic braking system in electric vehicles to automatically reduce speed or to apply brakes if the driver fails to react in time when the vehicles in the front slows down or stops. This system can mitigate the impact or avoid collisions during critical conditions by applying the brakes autonomously. This system will be effective in reducing the impact of collisions as the problems of inadequate or delayed braking due to the distraction of the driver can be avoided. The driver maybe distracted due to various reasons like inattentiveness, sleepiness, visibility and weather conditions, etc. Whatever the reason maybe, our system will first alert the driver about the existing obstacle(s) in front of the vehicle. If the driver fails to act accordingly on time to avoid an impact, our system will automatically reduce the speed of the vehicle to a safe speed with different levels of braking force to avoid or at least reduce the impact of the collision.

Keywords: Automatic Braking, Collision, Electric Vehicles.

I. Introduction

The main objective of this paper to design speed control and automatic braking system in electric vehicles to automatically reduce speed or to apply brakes if the driver fails to react in time when the vehicle in front slows down or stops. The primary function of automatic braking system is to mitigate the impact or avoid collisions during critical situations by applying the brakes autonomously. Usual road accidents happen when drivers applies inadequate, delayed or absolutely no brakes at all to avoid collisions. The most common reasons why drivers fail to apply on the brakes at the right time are distractions, inattentiveness, sleepiness, visibility conditions, weather conditions, etc. Automatic braking system is specifically designed to function properly on different sets of road scenarios. First, it alerts the driver of existing obstacles in front of a vehicle. If the driver fails to act accordingly on time to avoid an impact, the system will automatically reduce the speed of the vehicle with different levels of braking force to avoid or at least lessen the impact of the collision. Under certain circumstances like a sudden obstacle entering from the side of the road, the driver will not be able to react and apply brakes at all, in such cases collision with the obstacle cannot be avoided. In a vehicle with automatic braking system the vehicle will automatically attempt to reduce the velocity and thereby reducing the momentum and reduces the overall damage due to the collision.[6]

II. Literature Survey

Automatic braking is a technology for automobiles to sense an imminent collision with another vehicle, person or obstacle and to apply brakes to slow the vehicle without any driver input. Sensors are used to detect other vehicles or obstacles they can be radar, video, infrared, laser, ultrasonic or other technologies.

There is a threshold safe distance calculated by the system and if the driver fails to respond even when the vehicle crosses that region, then only brakes will be applied automatically. Many vehicles are provided with the option of turning on or off the automatic system based on their surroundings. In some automobiles even though they cannot be completely disabled, they can be limited to warning the driver about coming obstacle. Even this emergency braking initiates ABS which help the driver to retain the control over vehicle without any skidding. Automatic braking system is only effective if the mode of sensing the obstacles is reliable, or else any kind of false interpretation may cause a lot of damage.

An emergency braking system (AEBS) or autonomous emergency braking (AEB) is an autonomous road vehicle safety system which employs sensors to monitor the proximity of vehicles in front and detects situations where the relative speed and distance between the host and target vehicles suggest that a collision is imminent. In such a situation, emergency braking can be automatically applied to avoid the collision or at least to mitigate its effects. United Nations Economic Commission for Europe (UNECE) has announced that this kind of system will become mandatory for new heavy vehicles. A recent study suggests that if all cars feature the system, it will reduce accidents by up to 27 percent and save up to 8000 lives per year.

IJMDRR
E- ISSN –2395-1885
ISSN -2395-1877

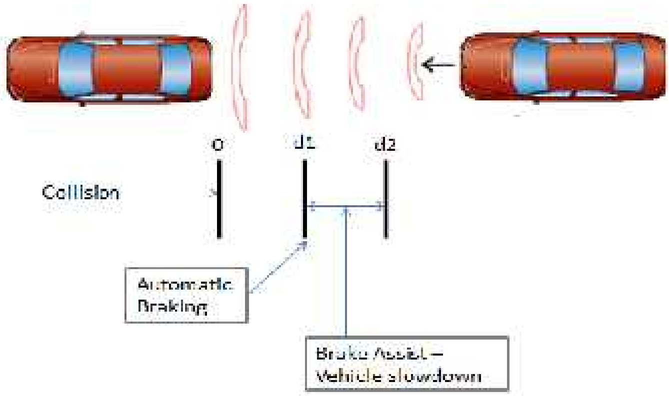

Figure 1. Basic Working of Proposed System

III. Proposed System

The proposed work is likely to control the speed of vehicle and automatically apply brakes. It is divided into three main steps:
1. Detect the object (Hurdle) from vehicle. 2. Control the speed of vehicle. 3. Automatic braking system.

A sensor mounted on the vehicle is used to detect obstacles in front of it. If there is no obstacle the vehicle is free to accelerate and decelerate according to the driver's choice. When an obstacle is detected and if the distance between the obstacle and the vehicle keeps on decreasing and if the driver does not apply brakes due to lack of attention, the system takes over and decreases the speed of the vehicle by using PWM technique to reduce the speed of the motor to avoid collision [1]. The basic working of proposed system is illustrated in Figure 1. When the distance between the obstacle and the vehicle is greater than a set value (say d2) it is considered that there is no obstacle or the obstacle is too far away. When the distance becomes lesser than set value (d2) the vehicle speed is reduced till the distance becomes another set value (say d1). During this period the driver is allowed to decelerate but acceleration of the vehicle is not possible. If the vehicle crosses the minimum distance (d1) the system brings the vehicle to a complete stop by applying full brakes.

IV. Stopping Distance

Braking distance is the distance a vehicle will travel from the point when its brakes are fully applied to when it comes to a complete stop. It mainly depends on separation between the two vehicles, difference in their velocities and friction coefficient (i.e. friction coefficient between the vehicle tires and the road)[6]. It is primarily affected by the original speed of the vehicle and the coefficient of friction between the tires and the road surface, and negligibly by the tires' rolling resistance and vehicle's air drag. The type of brake system in use only affects trucks and large mass vehicles, which cannot supply enough force to match the static frictional force.

Figure 2. Typical Stopping Distance

IJMDRR
E- ISSN –2395-1885
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The braking distance is one of two principal components of the total stopping distance. The other component is the reaction distance or thinking distance, which is the product of the speed and the perception-reaction time of the driver.This is shown in Figure 2. A perception-reaction time of 1.5 seconds, and a coefficient of kinetic friction of 0.7 are taken as standard but most people can stop slightly sooner under ideal conditions.

a. Total Stopping Distance

The total stopping distance is the sum of the perception-reaction distance and the braking distance.

$$D_{total} = D_{p-r} + D_{braking} = vt_{p-r} + \frac{v^2}{2\mu g}$$

A common baseline value of

$$t_{p-r} = 1.5s , \mu = 0.7$$

is used in stopping distance charts. These values incorporate the ability of the vast majority of drivers under normal road conditions. However, a keen and alert driver may have perception-reaction times well below 1 second, and a modern car with computerized anti-skid brakes may have a friction coefficient of 0.9--or even far exceed 1.0 with sticky tires.

Experts historically used a reaction time of 0.75 seconds, but now incorporate perception resulting in an average perception-reaction time of: 1 second for population as an average; or even a 2.5 second reaction time—to specifically accommodate very elderly, debilitated, intoxicated, or distracted drivers. The coefficient of friction may be 0.25 or lower on wet or frozen asphalt, and anti-skid brakes and season specific performance tires may somewhat compensate for driver error and conditions.

b. Actual Total Stopping Distance

The actual total stopping distance may differ from the baseline value when the road or tire conditions are substantially different from the baseline conditions or when the driver's cognitive function is superior or deficient. To determine actual total stopping distance, one would typically empirically obtain the coefficient of friction between the tire material and the exact road spot under the same road conditions and temperature. They would also measure the person's perception and reaction times. By the implementation of the automatic braking system it is possible to reduce the total braking distance considerably as the reaction time of the system is almost immediate and the thinking distance becomes negligible.

Figure 3. Improved Stopping Distance

The improved stopping distance by implementing the system is shown in Figure 3.The thinking distance is considerably reduced, in turn the overall stopping distance is also reduced.

V. Distance Measurement

The most important part of the system is to detect an obstacle such as a vehicle, person, animal etc. in order to sense an imminent collision.

Each car manufacturer has its own automatic braking system technology, but they all rely on some type of sensor input. Some of these systems use lasers, ultrasonic technology, others use radar, and some even use stereoscopic cameras. This sensor input is then used to determine if there are any objects present in the path of the vehicle. If an object is detected, the system can then determine if the speed of the vehicle is greater than the speed of the object in front of it. A significant speed differential may indicate that a collision is likely to occur, in which case the system is capable of automatically activating the brakes [8].After detecting the obstacle necessary commands and signals are passed to the control unit for further action.

VI. ECU and PWM Based Speed Control

In electric vehicles the electric motors propelling the vehicle is controlled by an Electronic Control Unit (ECU) or a Power Control Unit (PCU). Modern E.C.U.s use a microprocessor which can process the inputs from the various sensors in real-time. An electronic control unit contains the hardware and software (firmware). The hardware consists of electronic components on a printed circuit board (P.C.B.), ceramic substrate or a thin laminate substrate. The main component on this circuit board is a micro controller chip (CPU). The software is stored in the microcontroller or other chips on the P.C.B., typically in E.P.R.O.Ms or flash memory so the C.P.U. can be re-programmed by uploading updated code or replacing chips.[2] An electronic control unit controls power delivered to electric motor to ensure optimal vehicle performance. It does this by reading values from a multitude of sensors within the vehicle, interpreting the data using multidimensional performance maps (called lookup tables), and adjusting the parameters accordingly.The speed of the electric motor is controlled via Pulse Width Modulation(PWM). The ECU will increase or decrease the ON time and OFF time of the entire pulse time to vary the speed of the electric motor based on the accelerator input given by the driver. 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.(ie. The duty ratio of the PWM signal is varied). Duty ratio is the ratio of total ON time of the pulse to the sum of ON time and OFF time of the pulse [2].

VII. Programming

The behaviour of the system is completely based on the program uploaded to the control unit. The basic flowchart of the program used for the hardware prototype is shown in Figure 4.

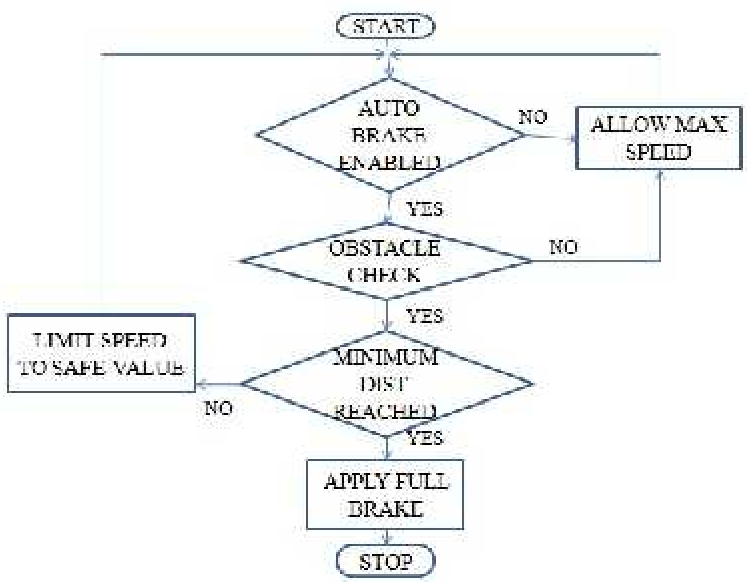

Figure 4. Flowchart of Program

Firstly the program checks if the system is enabled or not. If it is disabled maximum speed is allowed. Otherwise it checks for obstacles and if present, the vehicle speed will be limited to a safe value corresponding to the distance of the obstacle. If the obstacle is too close or if a threshold distance has been reached the vehicle applies full brakes and comes to a stop.

VIII. Hardware Prototype

The microcontroller used here Arduino Uno. A potentiometer is provided to accelerate and decelerate the connected vehicle respectively. It has been equipped with Warning Lights to notify the driver the reducing distance between the vehicle and an obstacle. The motor of the vehicle is interfaced to the Arduino Uno Microcontroller using an L298N Motor Driver Chip. An Ultrasonic Sensor has been connected to the Microcontroller to detect the presence of obstacles. It has a mode switch which can be used to enable and disable the system when needed.

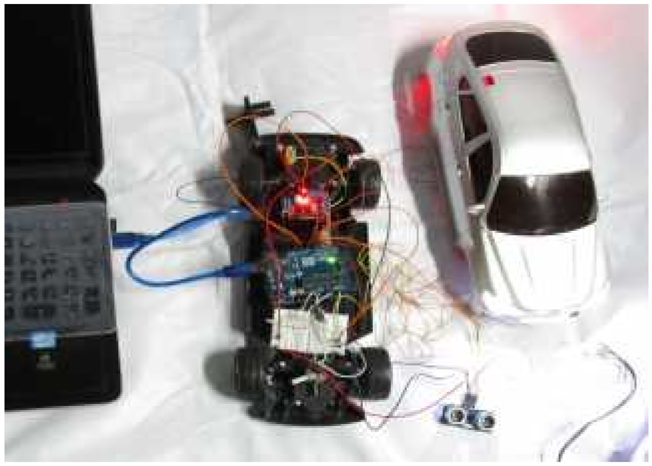

Figure 5. Hardware Prototype

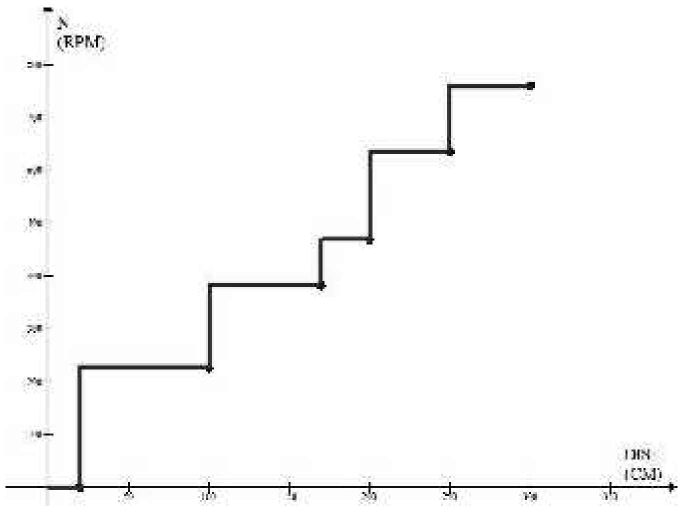

Figure 6. Hardware Prototype Results – Speed Limit in RPM versus Obstacle Distance

The prototype was tested and when the system was enabled the speed was reduced depending on the distance of the obstacle from the vehicle and imposed a speed limit. The vehicle was brought to a complete stop when the obstacle came too near to the vehicle. This is shown in Figure 6.

IX. Advantages

By the implementation of this system the stopping distance of the vehicle can be considerably reduced as the system has very fast response time. It can avoid rear end collisions of vehicles due to driver negligence. In the case of unavoidable collisions the system reduces the degree of damage. In control engineering aspect, the behaviour of the system can be change by modifying the program uploaded to the electronic control unit.

X. Future Scope

Rain sensors and day night sensors can sense the environment conditions the visibility and road conditions. In wet road conditions the friction coefficient between the tyres and the road decreases so the system can automatically further reduce the speed to new safe values. Also the seat belt pretensioners can be connected to the system. Pretensioner is to tighten up any slack in the seatbelt in the event of a crash to make sure a seatbelt restrains an occupant as early as possible in a crash, thereby reduce the load on the occupant in a violent crash.

XI. Conclusion

The advent of technology mainly focuses on reducing human effort in every field. This system may be considered as a step to reduce the mental and physical efforts taken by the driver to safely drive the vehicle. Even if our system may not prevent collisions in every critical scenario, it will definitely reduce the impact of collisions preventing loss of life. As the system can be made flexible, it can be suited for all kinds of vehicles and to the different traffic rules existing in different countries.

By the proper implementation of this system, the number of accidents occurring every year can be reduced by a considerable amount.

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