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A Study of Active Brake System of Automobile

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ABSTRACT

There are many situations where the driver's response is not fast enough to apply brakes to stop and control the vehicle during emergency. So in such cases, there is an urgent need for an active brake system. Brake assist is an active vehicle safety feature designed not only to help drivers come to a stop more quickly during an episode of emergency braking but it automatically applies brakes in case the car in front of car comes too close. There are many sensors along with camera which continuously determines the speed of car in front of our car .If both cars come too close to each other, then brake assist first warns the driver and then apply 20% to 40% of braking capacity automatically and if still driver does not respond it activates emergency brake assist which applies 100% of braking power .During this ABS and EBD (sometimes ESC and TRACTION CONTROL) also comes into play which provides easy manoeuvre control to driver over vehicle.

Keywords: *Brake; Assist; Sensors; Anti-Lock Braking System; Electronic Braking System; Electronic Stability Control; Traction; Manoeuvre.*

1.0 Introduction

Hazardous overtaking maneuvers on 2 lane roads are often cause of severe traffic accidents. Developed driver assistance system aims at warning the driver in overtaking maneuvers, which cannot be performed without a conflict with an oncoming vehicle. The objective is to prompt the driver to abort the maneuver already during overtaking start or in an early stage of passing phase. If there is too little time to react, or driver doesn't react for other reason, system initiates an automatic braking intervention incorporated by Anti lock braking system and brakeforce distribution, which allows driver to drive back behind vehicle that has to be overtaken before oncoming vehicle reaches. This system includes camera, far range radar sensor, accelerator force feedback pedal, and electronic brake system. The distance between our vehicle and the oncoming vehicle is calculated continuously and if value is less than the threshold value then this system comes into action. During emergency braking case, beside different warnings, an automatic braking intervention is released in order to compensate driver's reaction time. [1]

The study predicts that current functionality of brake assist systems can reduce pedestrian fatality rates. The main advantage of the system are: 1)the impact energy is reduced , 2) leading to lower risk of injury and the secondary impact where the pedestrians hits the ground is mitigated. The system involves the working of brakes autonomously in a car prior to impact. Special sensors are used to detect the pedestrians on road. The pre-impact braking systems were assumed to activate the brake few seconds earlier and to provide a braking deceleration up to limit of road surface conditions, but never to exceed 0.6g. The sensor used to detect the pedestrians plays an important role. They have wide field of view so that there is no problem in sensing the pedestrians. For pre-braking system to work precisely the field of view is 40%. [2]

Once a combined vehicle (car-caravan) becomes unstable, it is very difficult for a driver to stabilize it especially under severe driving conditions, such as turning and braking. This is mainly due to the

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effect of the towed vehicle on the towing vehicle through the hitch jack-knifing. This effect makes handling characteristics of car-caravan combination different from that of a single vehicle. Therefore studies propose a control design concept for an optimum distribution of longitudinal and lateral forces of the four tires of towing vehicle. The mean objective of the control system were to stabilize the motion of an articulated vehicle utilising the tires entire ability in both longitudinal and lateral directions as well as to make handling characteristics of an articulated vehicle similar to those of single one. [3]

Braking process is a highly nonlinear process. The development of an intelligent control strategy of brake actuation pressure during braking and consequently the braking performed is studied. It can be done through dynamic control of brake actuation pressure according to demand by driver and/or ABS/ESC system. This can be studied by modelling the complex dynamic influence of braking regimes (applied pressure, sliding speed and brake interface temperature) versus the change of brake performance. Through the established functional relationship between inputs/outputs provides the possibilities for fill context adjusting of brake actuation pressure to driver demand as well as current and previous value of :1) the vehicle speed, 2) the brake applied pressure, and 3) braking torque. The proposed control system is implemented and experimentally verified using low cost Atmel Atmego 16 microcontroller. [4]

The purpose of this field operational test study is to assess visual attention allocation and brake reaction in response to a brake capacity forward collision warning. The truck driver's reactions immediately after the warning as well as a few second after the warning are analyzed both with and without taking into consideration the predictability of an event and driver distraction. BFCW systems interface should immediately direct visual attention forward threat and allow the driver to make a quick decision about whether or not to brake. The main purpose of study is to improve real world knowledge about the effect of brake capacity forward collision warning on visual attention and brake reaction for the application of effective working of system. In the tests, eye movement and reaction of driver is observed 15 seconds before warning and 15 seconds after the warning. There is a reaction time after the warning which should be minimised by considering all the potential reason for the effectiveness of system. [5]

Systems informing or warning a driver of an imminent collision with a pedestrian or automatically initiating braking have been introduced to the car market. One of the major challenges is to balance system performance against the possibility of undesired system activation. The distinction between desired and undesired system activation can be based on driver discomfort. Through studies driver discomfort can be inferred from brake onset, which refers to start of brake pedal depression, as the most intuitive way for a driver to resolve a conflicting situation. Time to collision (TTC) at brake onset, one of the recorded quantities, might be suitable measure for comfort zone boundaries as it is less affected by driving speed than other measures. Pedestrian speed is found to have a statistically significant influence on brake onset. For pedestrian speed of 1m/s, 90% of drivers braked before 2.6s TTC. For 2m/s this value was 2.2s. These values can be used to differentiate between desired and undesired system activation in the design of an "unjustified system response" test in the assessment of pedestrian safety systems. [6]

Brake reaction time is an important parameter for road safety. Previous research has shown that driver's expectation can impact reaction time when facing hazardous situation, but driving with advances driver assistance systems can help faster more efficient responses, but same time can require a monitoring task and evaluation process that may lead to automation complacency. The paper aimed to test in a real life setting whether automation complacency can be generated by collision warning systems and what components of expectancy can impact the different task involved in an assisted BRT process. More specifically four components of expectancy were investigated: 1) presence/absence of anticipatory info, 2) previous direct experience, 3) reliability of device, and 4) predictability of the hazarded determined by repeated use of system alerts. [7]

Driver braking behaviour was analysed using time series recording from naturalistic rear end conflicts, including events with or without visual distraction among drivers of vehicles. A simple piecewise liner model could be successfully fitted, per event, to the observed driver decelerations, allowing a detailed elucidation of when drivers initiated braking and how they controlled it. It was found that drivers initiated braking behaviour was strongly dependent on the urgency of the given rear end scenarios kinematics, quantified in terms of visual looming on lead vehicle on the driver's retina. From the previous research, brake reaction time is about 1.5 seconds but it was found that braking could be described as typically starting less that a second after the kinematics as typically starting less than a second after the kinematics urgency reached certain threshold levels, with even faster reaction at higher urgencies. [8]

Active vehicle stability control systems have played a major role in reducing the number of road fatalities over the past few decades. These systems assist the drivers to control the vehicle in harsh driving conditions, inspite of these safety systems road fatalities continue to claim lives. Therefore, further development of such safety enhancement systems is required.

Besides, new types of personal vehicle continue to gain popularity in market, such a hybrid and fully electric vehicles. This highlights the importance of development of active safety systems that are tailored for these particular types of vehicles. The data collected after various experimental study and conclusion comes out that prediction model consists of a double track vehicle model augmented with the vehicle dynamics. Integration of vehicle and wheel dynamics makes a separate traction control module unnecessary.

Therefore, the optimality of controller cam uses both torque vectoring and differential braking as actuation. The result confirms the effectiveness of the proposed controller in controlling the vehicle directional dynamics and the tire slip ratios. [9]

Two yaw motion control systems that improve a vehicle lateral stability have been studied by Jeonghoon Song and Woo Seong Che. These two yaw motion control systems are braking yaw motion controller (BYMC) and steering yaw motion controller (SYMC). BYMC controls braking pressure of rear inner wheel, while SYMC steers rear wheel to allow the yaw rate to track reference yaw rate. Several types of vehicles yaw moment controller (YMC, also known as ESP, electronic stability control programme or VDC, vehicle dynamic control) has been proposed and developed but among then, BYMC which controls brake pressure is widely studied and most famous because it does not requires any complicated hardware if vehicle is equipped with ABS and YMC. [10]

Electro-mechanical braking force actuators are considered to substitute conventional brake boosters in electric and hybrid-electric vehicles in the forthcoming years. Due to nonlinearities like stick-slip friction effects and parameter uncertainties on one hand and the need for precise tracking of the master-cylinder position on the other hand, the controller design is a non-trivial task. First the system is analyzed in detail, and then the main use-cases are identified. A model is set up and validated against test-rig measurements. A sliding mode control law for the braking-force actuator is derived from a sufficiently detailed model of the vehicles brake system dynamics. It features a simple structure with few controller parameters leading to a remarkably reduced effort in controller parametrization. Since the controller is robust with respect to the model uncertainties, no adaptation of the controller is needed during operation. [11]

Brake assist system was originally introduced to compensate for insuffiecnt braking rates due to unexpected driver reaction. It was found that, despite the ABS, the braking distance in critical situation was not significantly reduced. The reason was that drivers were not pushing the brake pedal strong and quick enough to achieve its full stroke. BAS and ABS proved to be efficient in reducing severity of pedestrian accidents in most case. The findings show that even though most of collisions could not have been completely avoided by implementing these systems, but their consequences would have been reduced in terms of estimated injury severity probability. The effectiveness of BAS+ABS systems for speed reduction increases when driver is unable to brake to full stroke of pedal because in such circumstances, with enough time and space, the system aids in reaching max deceleration available by vehicle. Due to all these advantages in reducing injury severity probability the brake assist system fitting is compulsory in European Union. [12]

The turbo braking assist utilizes the concepts governing turbo machinery and automotive engineering in order to achieve effective braking assistance for modern day disc as well as drum brakes. The principle involved encompasses the targeting of a jet of viscous fluid onto the blade of a rotor wheel. This jet of fluid retards the motion of rotor and in process damps or slows down the rotation of wheels. The major components involved are turbines, or rotor, pump, nozzle, enlarged brake fluid chamber, DOT 5.1 braking fluid. The function of pump is to enable increase of mass flow rate of fluid and also to ensure the continuity of fluid flow in entire circuit. A speed sensor is integrated along with circuit to activate pump only after reaching particular velocity as BA is not necessary at low speed. The turbo brake assist is a potential brake assist in high speed conditions thereby reducing work done by disc or drum brakes. [13]

2.0 Active Brake System

Now a day's cars have brakes on all wheels which are accomplished by a hydraulic system. Disc and drum brakes are two major types of brakes used in the vehicles. Most of the cars have disc brakes on front wheels and drum brakes on rear wheels. The explanation behind this is the fact that when the vehicle is under braking the momentum (weight) is transferred to the front part and hence the front wheels. Moreover, drum brakes are provided on rear wheels as it is possible that during heavy brakes much weight may come off the rear part, which might result in locking of rear wheels and will cause skidding of wheels. Some sports, and luxury vehicles uses disc brakes over all wheels to improve the performance. Most cars now have load sensitive pressure limiting valve which reduces the brake fluid pressure on rear brakes during heavy brakes and prevent them from locking up.

2.1 Brake hydraulics

The braking system consists of hydraulic circuit. This circuit has a fluid filled master cylinder and slave cylinders which are connected through pipes. The master cylinder is located near the brake pedal. When the brake pedal is pressed, the fluid inside the master cylinder is pushed which increases the pressure of brake fluid in the circuit. This increased pressure is transmitted to all the slave cylinders through the pipes, this further forces the piston out at each slave cylinder. As the result, the brake shoes rubs against the drums and the brakes are applied.

The combined pushing area of the pistons at slave cylinder is much greater than that of the piston at master cylinder. Due to this, the master cylinders' piston has to traverse few inches to move the slave piston by fraction of inch to apply the brake at wheels. Cars are sometimes fitted with two hydraulic circuits to provide the safeguard against failure of one hydraulic circuit. When the brake pedal is released the spring inside the master cylinder pulls the piston back to its original position and this in result reduces the pressure inside the pipes carrying brake fluid and brings it to normal level. The retracting spring pulls the brake shoes to its original position as the pressure at slave cylinder reduces. In this way brakes are released.

2.2 Power-assisted brakes

Modern cars have power assisted brakes to reduce effort needed to apply brake by the driver. For this the main source of such power is the pressure difference between the outside air and the inlet manifold. Servo units serve the purpose of assistance by creating the pressure difference. Direct acting servo is fitted between the brake pedal and the master cylinder.

2.3 Anti-lock braking system

The Anti-lock Brake system is an automotive safety system which permits the wheels of a vehicle to hold tractive motion on the road which is totally dependent to driver inputs while braking. The system prevents the locking state of wheels. Thus maintain the rotation of wheel and avoid uncontrolled skidding. The system uses the principle of limen braking and cadence braking. An ABS system consists of Electronic Control Unit (ECU), speed sensors for each wheel and hydraulic valves. The change in the rotational speed of wheels, due to driver inputs to brakes, is sensed by ECU through sensors. The ECU operates hydraulic valves and maintains the sufficient brake pressure on the brake callipers by reducing or increasing it, as per the situation, such that locking of wheels is prevented and makes them to move safely.

2.4 Electronic brakeforce distribution

The Electronic Brake Force Distribution is an advanced automotive braking technique that automatically regulates the distribution of brake force to each wheel depending upon various factors like weight, speed, etc. The system works parallel with ABS. The EBD system provides maximum break force to the wheel having maximum momentum so that the wheels stop simultaneously in a proper and safe manner. Most of the times, front part of the car majority of weight (weight of engine and other parts) so due to this EBD distributes less braking force to rear brakes, this prevents locking and hence skidding of rear wheels. Sometimes during initial phase of braking EBD distributes more braking force to rear wheels before the effect of weight transfer comes into action and becomes apparent.

2.5 Electronic stability control

The Electronic Stability Control is a computerised technology which improves the vehicle's stability by detecting the loss of steering control. The system measures the amount of steer and speed of vehicle continously.When the conditions of steer and acceleration mismatches for turning of the vehicle and driver losses the control over vehicle stability, the mechanism of system comes into play and maintain the appropriate brake force on wheels to match the rotational speed required for steering the wheels and makes driver to get the control back. ESC is continuously working in the background and monitors the steering angle and direction of vehicle. It continuously analyzes the driver’s proposed direction (determined through steering wheel angle subtended) to the vehicle’s absolute direction (determined through measured lateral acceleration). The ESC interposes only when it detects a possible loss of steering control. The ESC system works very precisely to make the ride safer.

2.6 Traction control system

Traction control system prevents the controllable spinning of wheels faster than another or than the required speed. It is always coupled with ABS and when the speed sensors detects wheel spinning faster, brakes are applied to that wheel so that proper traction is regained by the wheel. Moreover this braking action over one wheel will cause the transfer of power to the wheel axle with traction due to differential. Sometimes in 4 wheel drive vehicles, the traction control system also reduces engine power transmitted to the wheel which loses traction.

2.7 Active brake assist

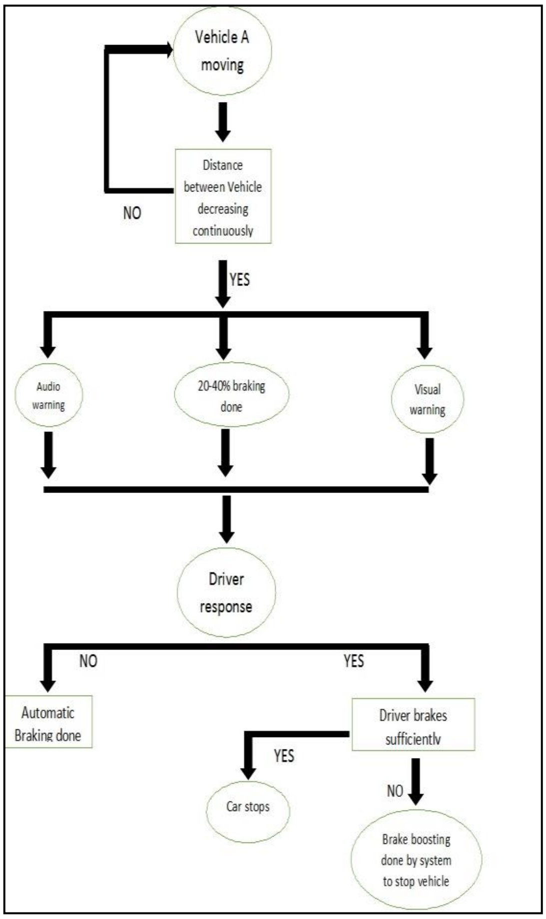
Reaction time of humans is comparatively less than the modern electronic sensors. The purpose of ACTIVE BRAKE ASSIST is to control and stop the vehicle in safe manner. Various studies and tests have revealed that different drivers react differently to critical situation. Some doesn’t press the brakes hard enough, some are hesitant at the beginning, and some are not even able to evaluate the situation properly.

A system indented to support the driver in emergency braking situation must be capable of identifying emergency situation as well as should apply the brake precisely and more accurately.

For this, sensors are provided along with the camera in the front part of car which monitors the speed of vehicle in front of our vehicle, if any emergency is detected and driver response is not good enough, then vehicle automatically applies the brake (20-40%) and gives audio visual warning to driver and even if driver doesn’t response properly it applies the 100% brake pressure, recognising the emergency braking manoeuvre.

This system along with ABS, EBD and ESP can not only reduce the braking distance up to great extent but also provide stability to vehicle.

Fig 1: Brake Circuit



3.0 Methedology

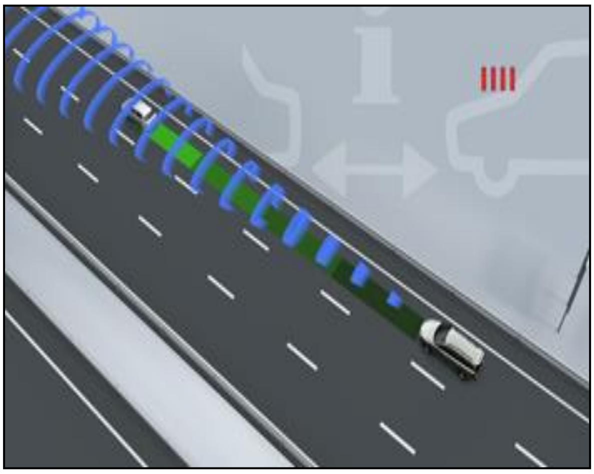
This experiment has been performed using a scale model of car which was being remote controlled and equipped with infra red sensors on front and rear side. Along with sensors, warning lights are provided on the rear side of car to indicate the vehicle behind our vehicle, that our car is under braking.

3.1 Case 1

The car in front of our car retards at a continuous rate and distance between two cars is decreasing to an alarming level.

For such cases, ACTIVE BRAKE ASSIST will first warn the driver if the two vehicles come too close. During this 20-40% brake force will come into action and audio visual warning will be provided to driver and even if driver does not respond and cars come further closer then 100% brake pressure is provided to brakes to stop the car and prevent any type of potential accident.

Fig 2: Vehile Time on Road [14]



3.2 Case 2

If during an emergency situation (that has been detected by Brake assist system) driver doesn't press the brake pedal hard enough to utilise the complete brake force .Then in such cases Brake assist system will automatically apply the brakes using 100% braking force to stop the car within the safe limits and safely.

3.3 Working principle

Brake assist use radar with help of long range infrared sensors and or cameras to scan ahead of the car for moving and stationary hazards. If a potential collision is detected, audiovisual warnings are provided to the driver and the brakes are primed ready for maximum application. This also allows the car to automatically apply the brakes to slow the car if the driver does not respond to repeated warnings and the system detects an unavoidable collision. Along with this, if in case brakes applied by driver is not hard enough then brake assist provides extra (or remaining) brake power. So we can say brake assist works in two ways or manners .First: provides extra braking power in emergency if brakes applied are not enough, second: it gives warning and automatically applies brakes if driver doesn't respond to emergency situation.

4.0 Result

When the distance between the vehicle and the object (or vehicle) is decreasing continuously with a rapid rate, the active brake assist system comes into play. Almost 20-40% of braking energy is utilised in automatic braking action with proper amount of brake boosting, during this the audio and video warning catches the driver's attention to respond towards braking. Still if the diver doesn't respond and the distance is in decreasing manner then complete braking energy is utilised automatically to stop the vehicle gradually and safely. This reduces the overall braking distance. It will negotiate many hazardous accidents which harshly harm human life, vehicle and environment resources.

5.Conclusions

The expected benefits of active brake assist are many, particularly given the kinds of situations that active brake assist is designed to address. Nearly 1.3 million people die every year on the world's roads and 20 to 50 million people suffer non-fatal injuries, with many sustaining a disability as a result of their injury. Road traffic injuries are the leading cause of death among young people aged 15-29 years and cost countries 1-3% of the gross domestic product (GDP). The Insurance Institute for Highway Safety (IIHS) in the United States has determined that the kinds of crashes relevant to brake assist are those where the driver saw a hazard, braked, but did not stop in time. Given this, the IIHS estimates that brake assist is relevant to 417,000 crashes per year in the United States only, including 3,080 fatal crashes. With the Active brake assist, all such situations can be easily controlled which endanger not only the human life but also the economical resources involved.

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