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Design of Collision Force Damping System for the Safety of Vehicles Using ToF Infrared LiDAR Sensor

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Abstract: *The collision force damping system is used to prevent passengers and vehicle from crushing accidents. This system damps collision forces by implementing of extending dampers. The damping assembly fixed in frontal part of the vehicle is attached with bumpers. It operated by microprocessor unit that has unique program for segregated collision situation in roadways. The collision segregated under four different condition it will satisfy all the accidental collision situation in roadways. It is using Solid-State ToF Infrared LiDAR CE30-A to predict the collision by measuring of the distance between primary and secondary vehicle and any obstacle in front of the vehicle and the primary sensing elements are change in distance with respective time, velocity and braking distance of vehicle. If the desired collision is sensed from the sensor it will give the signal to the microcontroller unit and it will extend or trigger the dampers to absorb crush force and also it will apply the brake to reduce generative force of the vehicle at collision. It will arrive all the kind of accidents which will make dangerous injuring situation. Finally, we can save the passenger from severe accident and also preserve the vehicle from unsustainable damages and crushing in accidents.*

Keywords: *Collision Force Damping System, Dampers, Microcontroller, Obstacle detection, Solid-State ToF Infrared LiDAR CE30-A*

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I. Introduction

The car designers now a day uses more of technological innovations in vehicle safety, the number of accidents continues to rise. This is especially true for intersection accidents. It has been reported that nearly 30% of the reported accidents in the India are due to intersection collision. Most of these accidents take place at rural areas. Intersection areas are not equipped with traffic signals or stop signs. As a result, it is recommended that an intersection collision warning system be implemented as a part of vehicle safety systems, thus reducing the number of accidents. To be most effective, such a system should have the capability of supporting real time systems that can warn potential drivers about an impending collision. It also should be adaptable to different types of intersection collisions.

1.1 Types of Motor Vehicle Collisions

The fact that you have been involved in a motor vehicle collision can be a traumatic experience. Cases involving high impact collision can be serious injuries to the parties involved and the details of the accident are often not remembered. However, your insurance company will want to recount the details of the collision in order to determine liability and damages. There are different types of motor vehicle collisions.

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1.1.1. Rear Impact Collision

Rear-impact collision, often referred to as being “rear-ended”, happens when one car in front of it is hit from behind. The most common causes of rear-impact collision are failure to leave proper stopping distance between cars. Insurance companies will almost always place fault upon Types of Motor Vehicle Collisions the driver of the car that rear-ends the other. For this reason, and for the safety of yourself and others on the roadway, a driver should always leave proper stopping distance between cars.

1.1.2. Side Impact Collision

A side-impact collision occurs where one car hits the side of another. This often happens as one vehicle is attempting to merge into another vehicle’s lane of travel or by a driver negligently running a stop signal, resulting in a “T-bone” collision. Severity of the collision varies based on the model of the vehicles involved, the speed of the vehicles, and the safety features present. Modern vehicles have safety measures which help to reduce injuries of the side-impact collisions including: side-impacting airbags and crumple zone that minimize the kinetic energy that is felt by the passengers of the vehicle.

1.1.3 Head-on Collision

Head-on collisions occur when the front of the vehicle strikes another vehicle or a stationary object. Head-on collisions are particularly dangerous because they often happen at the high rates of speed and are frequently caused when a driver falls asleep behind the wheel or is intoxicated, causing them to drift into the opposing lane of travel. Many states have taken preventative measures for minimizing the frequency of head-on collisions by implementing median barriers that act to prevent a vehicle from entering the opposing lane of travel, especially on the interstate highway system.

1.2Crash Protection Features

Crash protection features provide greater levels of injury projection to drivers and passengers in car crashes, they include:

Crumple zones

Modern cars protect drivers and passengers in frontal, rear and offset crashes by using crumple zones to absorb crash energy. This means that the car absorbs the impact of the crash, not the driver and the passengers.

1.2.1 Strong occupant compartment

The cabin of the car should keep its shape in frontal crashes to protect the driver and passenger's space. The steering column, dashboard, roof pillars, pedals and floor panels should not be pushed excessively inwards, where they are more likely to injure drivers and passengers. Doors should remain closed during a crash and should be able to open afterwards to assist in quick rescue, while strong roof pillars can provide extra protection in rollover crashes.

1.2.2. Side impact protection

Increased side door strength, internal padding, better seats can improve protection in side impact crashes. Most new cars have side intrusion beams or other projection within the door structure. Some cars also have padding on the inside door panels.

1.2.3 Seat Belts

Recent improvements to seat belt effectiveness include webbing clamps that stop more seat belt reeling out as it tightens on the spool pretensions that pull the seat belt tight before the occupant starts to move load limiters that manage the forces applied to the body in crash seat belt warning systems to remind you if seat belts have not been fastened.

1.2.4 Airbags

Airbags are designed to supplement the protection provided by seat belts when they are not a substitute. The best protection in frontal crashes is achieved using a properly worn seat belt in combination with an airbag.

II. Literature Survey

The existing approaches used for safety measure and preventing accidents are Emergency Braking System (EBS), traction control and stability control. Even infrared (IR) sensors are also widely used as proximity sensors and for obstacle avoidance, but not successful due to some drawbacks. System and approaches mentioned above employ different types of sensors to uniformly monitor the conditions and react quickly in emergency situations.

Sensors are vastly used for measuring distances, but different sensors have different characteristics:

- **Drawbacks of Emergency Braking Systems: -**

1. Inconsistent stop times: ABS can keep the direction of the car which helps us to avoid obstacles on the road without losing control of the vehicle. The ABS help's in reducing braking distances on dry or wet, but increases slightly when braking on snow or gravel.
2. EBS: This system works under particular speed limit and when brakes are applied in specific ways.
3. Delicate Systems: As we increase the mechanics there are more possibilities of system damages to occur. Sometimes its reported that disorientation for the ABS occur, in which the compensating brakes sensor, causes the vehicle to shudder, make loud noise or generally brakes worse.[1]

- **Drawbacks of infrared Sensors: -**

As different sensors have different characteristics, IR sensor has non-linear characteristics and this depends upon the reflectance properties of the object surfaces. Surfaces properties must be known in prior. Different surfaces react differently whereas some surfaces scatter, reflect, and absorb infrared energy which will not work properly to interpret the sensor output as distance measure.

2.1 The Existing Advance System Found in High End Cars

2.1.1 Cruise Control

Cruise control (sometimes known as speed control or auto cruise) is a system that automatically controls the speed of a motor vehicle. The system takes over the throttle of the car to maintain a steady speed as set by the driver.

2.1.2 Immobilizer

An immobilizer is an electric device fitted to an automobile which prevents the engine from running unless the correct key (or another token) is present. This prevents the car from being “hotwired” after entry has been achieved.

2.1.3 SRS Air Bags (Supplementary Restraint System Air Bags)

An airbag is a vehicle safety device. It is an occupant restraint consisting of a flexible envelope designed to inflate rapidly during an automobile collision, to prevent occupants from striking interior objects such as the steering wheel or a window, the sensors may deploy one or more airbags in an impact zone at variable rates based on the type and severity of impact.

2.1.4 The ACD System

The ACD system is based ion GPS based positioning and track detection. This has inherent problems as with GPS service and course acquisition, the best possible horizontal accuracy is 10m. This is inadequate for detection of rail tracks separated by a distance of 10-15 feet.

2.1.5 Collision Avoidance System

A collision avoidance system is an automobile safety system designed to reduce the severity of a collision. Also known as pre-crash system, forward collision warning system or collision mitigating system, it uses radar (all-weather) and sometimes laser and camera (both sensor types are ineffective during bad weather) to detect an imminent crash. Once the detection is done, these systems either provide a warning to the driver when there is an imminent collision or take action autonomously without any driver input (by braking or steering or both).

Collision avoidance by braking is appropriate at low vehicle speed (e.g. below 50 km/h), while collision avoidance by steering is appropriate vat higher vehicle speeds. Cars with collision avoidance may also equipped with adaptive cruise control, and use the same forward-looking sensors.

III. Collision Force Damping System

The collision force damping system used for preserve the passengers and vehicle in the accident. This system absorbs the collision force by means of damping system that is controlled by the unique electronic control system has microcontroller that will do all the operation by means of program.

The microprocessor receives the signal from the Solid-State ToF Infrared LiDAR CE30-A which is provided in the frontal potion of the vehicle after getting the signal that will send to the microprocessor. It will process the data and do the operation based on the program. The collision condition segregating in four different situation that will arranged in program. The microcontroller programmed by assembly languages based on the program only it can detect the situation. After the processing of signal, it will take decision to extending the damper and applying a brake in vehicle. [2][3]

Operating Variables in CFDS

The operating variable of the CFDS is tabulated below it shows all the parametric difference in collision condition. This table justify the different actions of system in different condition of collision.

Table 3.1: Operating Variables in CFDS

Condition	Primary Vehicle	Secondary Vehicle	Action Sensing Element	Action Time	Braking
1	Drive	Stationary	v,de/dt,d	Less	Enable
2	Drive	Drive	dx/dt,d	Moderate	Enable
3	Drive	Drive	v,de/dt,d	Very Less	Enable
4	Stationary	Drive	dx/dt	Less	Disable

Load and Speed Condition

This tabulation shows the relationship between system load and speed in collision damping system. It will show the need of specific system for specific condition of vehicle and collision.

Table 3.2: Load and Speed Conditions

Condition	High Vehicle Load	Low Vehicle Load
High Vehicle Speed	Hydraulic and Mechanic	Pneumatic
Low Vehicle Speed	Hydraulic	Pneumatic or Mechanical

IV. Methodology

The following steps are derived in this collision force damping system. It will start from the Solid-State ToF Infrared LiDAR CE30-A emitting rapid pulses of laser light that will reflected by the given object or obstacle in the front of sensor and it will received by the receiver unit in the Solid-State ToF Infrared LiDAR CE30-A and the microprocessor takes decision based on the received laser light.

The microprocessor sends a signal to activate the triggering unit it will trigger the damper to extend and also activate the braking of vehicle. Finally, the collision force damping system absorb the crushing energy of the vehicle at the moment of the accident. And the damper can be reused after the collision without any modification if it is a minor or sustainable accident.

The LiDAR instrument fires rapid pulses of laser light at a surface, some at up to 150,000 pulses per second. A sensor on the instrument measures the amount of time it takes for each pulse to bounce back. Light moves at a constant and known speed so the LiDAR instrument can calculate the distance between itself and the target with high accuracy. [4]

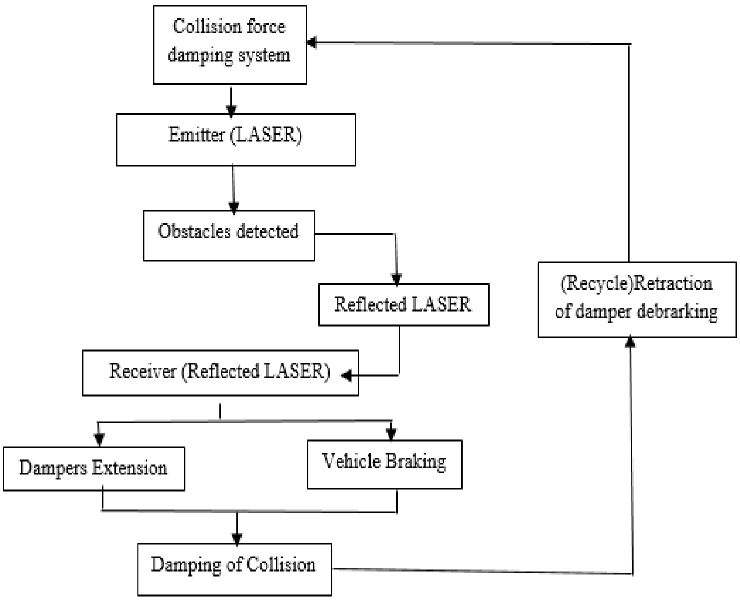

Fig.4.1. Flowchart of CFDS Methodology

V. Formula Used

The dynamic energy in a moving object, like a falling ball or a driving car, can be expressed as

$E= ½ \, m \, V^2$ (5.1)

Where

E= dynamic energy (J)

m= mass of object (kg)

v = velocity of the object (m/s)

In an impact like a car crash the dynamic energy from the object is converted to work. The equations can be combined as

$F \, s = ½ \, m \, V^2$ (5.2)

Or expressed as a function of the slowdown distance

$F = ½ \, m \, V^2 / s$ (5.3)

Or to express the slowdown distance

$s = ½ m V^2 / F$ (5.4)

Force produced by the spring

$F = s \times (L_i – L_f)$ (5.5) [5]

Where,

L_i – Initial length (m)

L_f – Final length (m)

s – Stiffness of spring (N/m)

Natural Frequency vibration,

$W_n = \sqrt{\frac{s}{m}}$ (5.6) [6]

Where

m – Mass of vehicle

The actual distance travelled by returning LASER light travelled is calculated as follow

Distance = (Speed of Light X Time of flight) /2 (5.7)

VI. Conclusion

The collision force damping system preserve the passenger and vehicle without any injuries and damages after testing of the vehicle with the damper it absorbs all the crushing energy before affecting the vehicle and passengers. And with increase in damping coefficient, maximum displacement of spring is decreasing with damping coefficient, maximum displacement of the spring is decreasing. With high damping, high acceleration is occurred when the spring attains maximum displacement in less time. Variation in stiffness is having negligible effect on the maximum displacement and with the increase in stiffness the spring is coming to rest within less time. So we can conclude that a vehicle generate an impact force at a given speed is less than the force produce by damper unit. Finally spring dampers of this system reduces and absorb the collision impact force considerably.

References

Proceedings Papers:

[1]. W Abe, G. and Richardson, J.A. (2006), Alarm timing, Trust and Driver Expectation for Forward Collision Warning System, Applied Ergonomics, 37: 577-586.

Journal Papers:

[2]. Wong, C.X., Daniel, M.C. and Rongong, J.A (2009) Energy Dissipation Prediction of Particle Dampers, Journal of Sound and Vibrations, 319 (1-2). Pp. 91-118.

[3]. A.Agyei-Agyemangl, G.Y. Obeng, P. Y. Andhol, P.Y(2014), Experimental Evaluation of the Attenuation Effect of a Passive Damper on a Road Vehicle Bumper, World Journal of Engineering and Technology, 2, 192-200.

Books:

[4]. Guide to the Collision Avoidance – A.N. Cockcroft.

[5]. GUPTA J.K and KHURUMI R.S (1981) "Text Book of Machine Design".

[6]. Dr.D.K.AGGARVAL & Dr.P.C.SHARMA (2004) "Machine Design".

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