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Concept of Grip Assistive Braking on Four Wheelers

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ABSTRACT

Braking systems in all the segments of vehicles seems to be one of the most crucial developing systems. Many research and developments are carried out in terms of braking of a vehicle in order to enhance the braking efficiency and reduction in stopping distance. This article depicts the concept of assistive braking on four wheelers where we elaborately describe the Braking distance, Thinking distance and Stopping distance after which our concept of braking is proposed with all the technical aspects along with the various components and its efficiency in our real time use. This research article mainly focuses on technical aspects that aim to reduce the reaction time and reflex actions of the driver which in turn is used as a factor to reduce the stopping distance of the vehicle. Various types of biological reactions by a human are observed and then a particular muscular reaction is chosen as a source of intimation for our braking system. When an object is spotted by the driver, the reflex action takes place via a receptor, sensory neurons, spinal cord and from where the muscular reaction takes place. A unique steering with an array of grip sensors is designed and incorporated also with various functions of the vehicle but for this instance, we mainly focus on braking assistance of the vehicle. Thus the unique steering wheel plays the role of connection between vehicle and the driver.

Keywords-- Braking System, Grip Sensor, Unique Steering Design, Reaction Time, Stopping Distance

I. INTRODUCTION

Braking system is supposed to be one of the major performance deciding systems of a vehicle. Various industries and manufactures have come up with various braking systems that reduce the braking distance of the vehicle such concepts were practically performed in the real time vehicles. All the automotive manufactures have come up with various advancement in order to reduce the overall stopping distance. Y. Jang, et al. Have studied a portable walking distance measurement with 90% accuracy. Ultrasonic measurement and its results under various conditions is completely studied by C. C. Chang, et al. Amrutha S Raibagi have proposed a ultrasonic anti crashing system for automobiles where the ultimate source of instructions were obtained from the ultrasonic sensors (LV-MaxSonar) from which the expected results of anti crashing is obtained. Various on-road assistance for braking is provided along with the automobile manufacturers which inturn reduces the 90% of the accidents[1-4]. Industries have come up with various solutions in order to accomplish the efficient braking system to reduce the braking distance and a few companies out of their innovative research and development activities have stepped into the reduction of reaction time to apply brakes[1-7]. Automotive manufacturing giants such as Benz, Nissan, motors etc, have come up with automated braking where the obstacle is sensed via various types of sensors and then the vehicle speed is maintained in proportion to speed of the surrounding vehicle and braking is applied at the required instance without the knowledge of the driver. In the existing completely automated braking system, all the functions are carried away with the help of the industrial microcontroller that has the capacity to process the information about the surrounding objects at an instance[1-10]. Such completely automated braking systems seem to be cost inefficient and maintenance is a tedious process. Our concept of grip assistive braking system is supposed to be the system to reduce the reaction time and as a result to reduce the overall stopping distance of the vehicle. Assistive braking system is supposed to be the system that senses the signals from the muscular nerves of the palm and also from the distance measuring device at the front zone of the vehicle. This system also has a microcontroller but it just compares the signals from two different ends and then processes out as a single output wherein the brake is applied. The ultimate aim of this proposed system is to reduce the stopping distance by

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reducing the reaction time. A prototype is developed to prove the proof of concept of the proposed system.

II. STOPPING DISTANCE, BRAKING DISTANCE & REACTION DISTANCE AND ITS IMPACTS

Stopping Distance

"Stopping distance = Reaction distance + Braking distance"

$d = dr + db$

Where,

d - Stopping distance

dr - Reaction distance

db - Braking distance

Stopping distance is the overall distance covered by the vehicle once from the object is spotted till the vehicle comes to rest. An accident occurred by the vehicle can only be avoided if the overall stopping distance of the vehicle is reduced and not only by reducing the braking distance. On a recent survey it is recorded that most of the accidents occur due to larger stopping distance that includes either increase in reaction distance or braking distance.

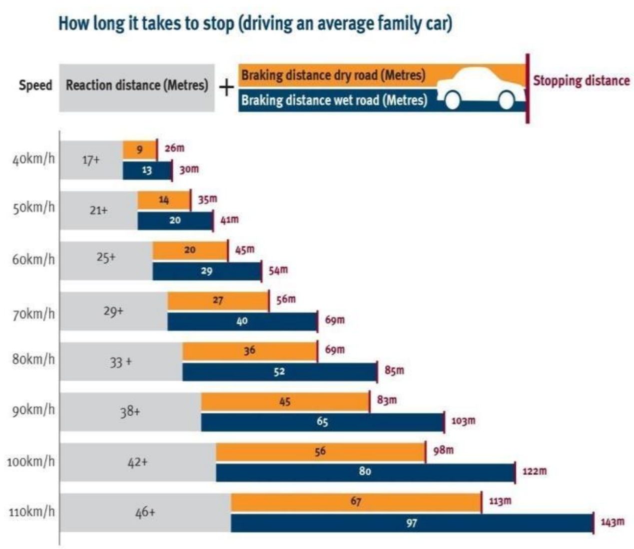

Figure 1: Overall Stopping Distance of vehicle at various speeds

Figure 1 Depicts the overall stopping distance of the vehicle with various speed conscious and also with various road conditions. It is clearly observed that reaction distance also plays a major role in the overall stopping distance of the vehicle. The overall real time braking performance of the vehicle depends upon the stopping distance.

Table.1 Speed vs Braking Distance

Speed	**Braking Distance**
2 times higher	4 times longer
3 times higher	9 times longer

Braking Distance

Braking distance is the distance covered by a vehicle from the point of application of brakes till the point of vehicle comes to rest.

Braking distance depends upon various parameters such as load of the vehicle, road conditions, climatic factors, type of brakes, use maintenance of the braking system and property of brake fluids. Various measures and developments have been implemented to reduce braking distance by various advanced technologies.

Braking distance is directly proportional to speed of the vehicle,

$db = s^2 /(250 \times Cf)$

Where,

db - Braking distance

s - Speed of the vehicle in km/hr

Cf - Coefficient of friction

Reaction Distance

Reaction distance is the distance covered by the vehicle within the reaction time. It is also a measure of how quickly an organism responds to a stimulus.

Reaction Time

Reaction time is the time taken by the driver to apply brakes from the point of identification of obstacles. Reaction time has been widely studied by researchers as it has various practical consequences. Slower the reaction time greater the impacts, quicker the reaction lower the impact occurs.

Table.2 Speed vs Reaction Distance

Speed	**Reaction Distance**
2 times higher	2 times longer
6 times higher	6 times longer

Reaction time depends upon various factors such as speed of the vehicle, age of the driver, mental state of the driver and climatic conditions etc. Table.2 depicts the speed and reaction distance relationship. Normally the reaction time is 0.5 to 2 seconds. Drivers between 45-54 years have the best reaction time in traffic due to their experience. Drivers between 18-24 years, younger people have sharper sense and moderate reaction time due to lesser experience in driving.

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$$dr = (s \times r) / 3.6$$

Where,
dr - Reaction distance
s - Speed in Km/hr
r - Reaction Time in Sec (Depends on age and mental condition of a driver)

III. CONCEPT OF GRIP ASSISTIVE BRAKING SYSTEM

Grip Assistive braking system is the system proposed to reduce the reaction distance. The major components comprises a distance measuring device, unique grip sensing Steering wheel, micro controller and electrical actuator. When an obstacle comes in the path of a fast moving vehicle, the time taken by the driver to respond varies from one driver to another, this small time makes the vehicle to travel more resulting in accidents. A braking system is designed to overcome the reaction time travel of a vehicle by implementing several electronic sensors and kits for accomplishing this braking action. Thus a vehicle safety parameter is achieved, decreasing the possibility of accident.

Working Phases

When an Obstacle is Spotted by the Driver

Due to visual stimulus we respond instantaneously without our knowledge and our effect or muscles will increase the pressure on the steering wheel which is much quicker than we apply pressure to brake pedals. As a result of reflex action due to obstacles we grip the steering wheel and from there we can obtain the input to the microcontroller.

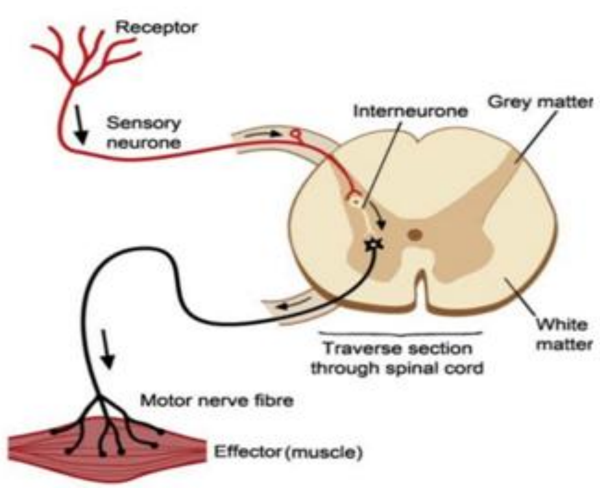

Figure 2: Reflex Action via sensory nerves

Figure 2 describes that, at the time of obstacle detection the receptor sends the signal via sensory neurons to motor nerves via spinal cord and as a result of reflex action the receptor (muscles) actuates. The receptor of the palm induces a gripping pressure on the steering wheel.

Distance Measuring Sensors-to Ensure the Straight Approaching Obstacle

To ensure the approach of the obstacle, Distance measuring sensors are placed in such a way that an object within a programmed range will be detected.

Microcontroller Processing

A microcontroller collects the data and compares it with the pre-programmed value. The weight of the vehicle, speed at that instance, and object distance from the sensor is feeded as input parameters. The instantaneous speed and obstacle distance is periodically measured at the time of gripping the steering wheel. These types of sensors are inactive all the time and it gets activated only when the grip sensor feeds the prescribed value of pressure. On comparison between the sensor values if the obtained results are within an prescribed limit, the output is false and no work is done. If the results are above the prescribed limits output signal is directed to an actuator/regenerating braking system as true and the braking takes place. Microcontroller will actuate the linear actuator connected to the pivot arm of the brake pedal, if and only if both the input signal is received true with AND logic.

Braking

Braking is applied either by means of Electric actuators or Regenerative Braking. An actuator is selected based on the force required to push the TMC(Tandem Master Cylinder) Piston. Regenerative braking signal is routed to the Motor controller of an electric vehicle. The actuator replaces the work of the brake pedal, thus resulting in braking of the fuel powered vehicle whereas the regenerative braking is the source of braking of electric vehicles.

Electrical Actuator - Fuel powered vehicles
Regenerative Braking - Electric Vehicles

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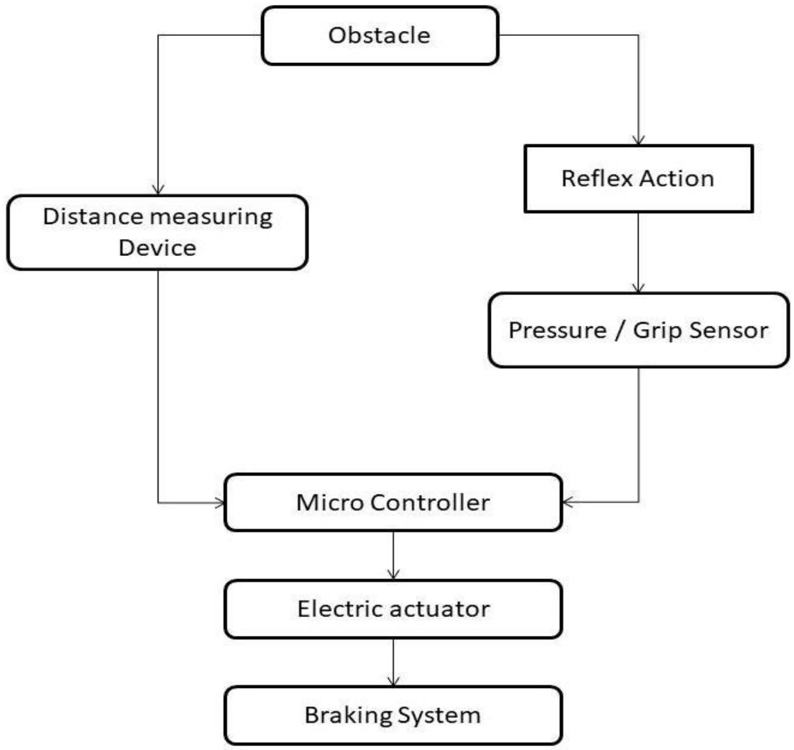

Figure 3: Overall Work flowchart

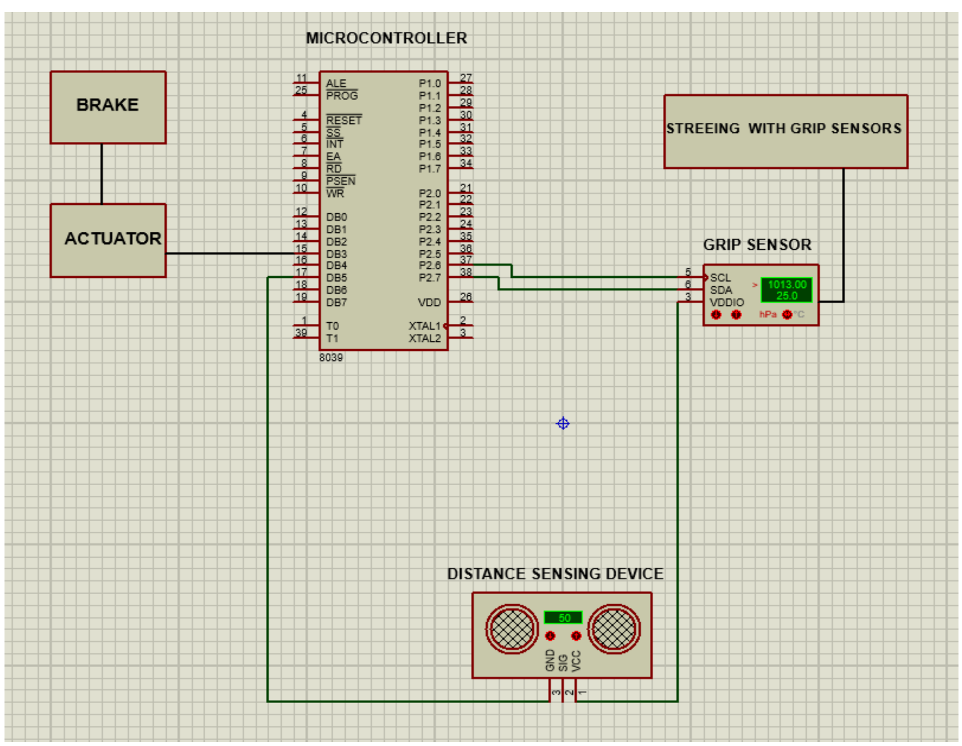

Figure 4: Proteus Circuit of proposed concept

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IV. UNIQUE STEERING DESIGN

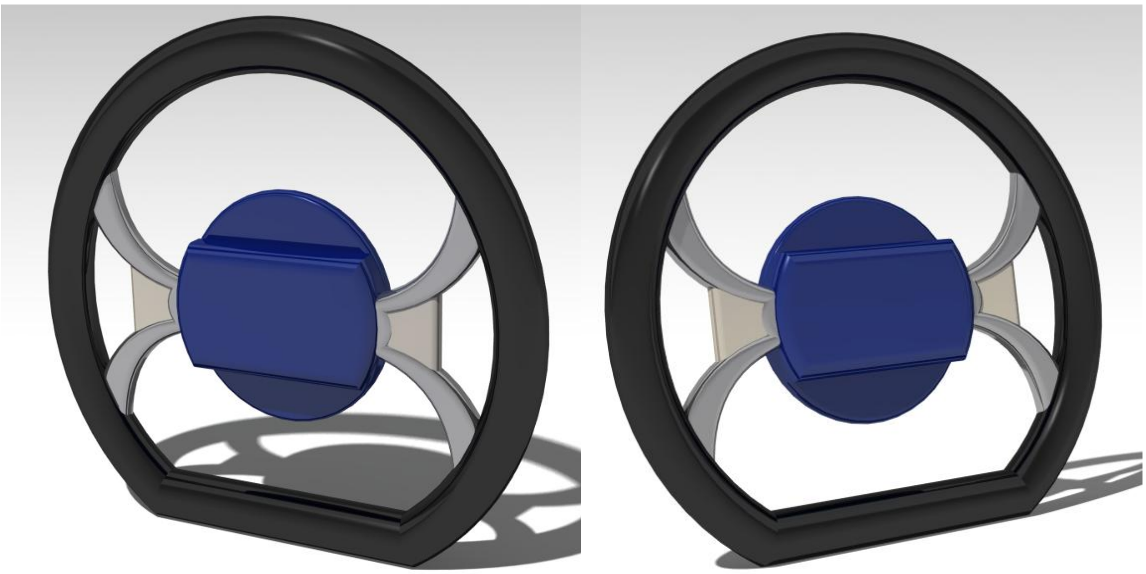

Figure 5: Unique Steering wheel with array of grip sensor designed with CATIA

Figure 5 shows the unique steering wheel with an array of grip sensors. This steering wheel is designed in such a way that it could be equipped with airbags and other infotainment devices. This type of steering wheel equipped with an array of grip sensors senses the pressure exerted by the driver at the time of approaching a sudden obstacle. This unique assembly gives out the most anticipated results from all around the steering wheel irrespective of position and method of driving. Other than braking assistance it is also equipped with other safety features such as one hand driving mode, alcohol sensing unit, driver alertness system and other safety functions. In such a steering wheel, an array of sensor assembly is designed to give out the pulse and pressure signal to the microcontroller within a fraction of time.

V. PROTOTYPE CALCULATION

In order to prove the theoretical improvement over conventional braking systems, a prototype vehicle is considered and the calculations are made with and without the Grip assistive braking system and the final results are compared. Moderate city riding values are considered for prototype calculations.

The prototype battery powered electric vehicle is equipped with an electrical actuator, regenerative braking, Grip sensitive steering wheel, Industrial Ultrasonic sensor and an industrial microprocessor.

The response time of all the components incorporated is identified and the total reaction time of this grip assistive braking system is calculated.

The response time of a selected ultrasonic sensor is below 26 millisecond.

In addition to reflex action by humans, the response time of several components were added and it turns to be (r') 0.03 seconds. The age of the driver is considered to be 20 -30 years.

Assumptions of prototype vehicle,

Table 3: Prototype vehicle parameters

Parameter	Value
Mass	850Kg
speed(S)	50Km/hr
Speed in m/s (v)	13.88
Coefficient of friction (C_f)	0.8
Reaction time of Driver to apply break(r)	0.8 sec

Stopping distance = Braking distance + Reaction distance

Braking distance,

$db = V^2/(2Cf \times g)$

$db = 13.882 /(2 \times 0.8 \times 9.81)$

$db = 12.3\ m$

Where,

db - braking distance (m)

v - speed in m/s

Cf - coefficient of friction

Reaction distance,

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dr= (s×r)/3.6
= (50×0.8)/3.6
= 11.11 m

where,
dr - reaction distance(m)
d - Stopping Distance of a vehicle(m)
s - speed in km/hr
r - reaction time of driver (s)

d = dr +db
d = 11.11 + 12.3
d = 23.41m

The stopping distance of a normal vehicle without equipping the Grip assistive braking system seems to be 23.41m for a vehicle moving at a speed of 50Km/hr.

Reaction distance after equipment of Grip assistive braking assistance,

dr' = (s×r')/3.6
dr' = (50×0.03)/3.6
dr' = 0.42 m

where,
dr' - reaction distance(m)
d' - Stopping distance of vehicle equipped with Assistive braking system
s - speed in km/hr
r' - reaction time of assistive braking system (s)
Δd - Difference in stopping distance

d' = db+dr'
d' = 12.3 + 0.42
d' = 12.72 m

The stopping distance of a vehicle with Grip assistive braking system seems to be around 12.2m.

d - d' = 23.41 - 12.72
Δd = 10.69 m.

VI. OVERALL RESULTS AND DISCUSSION

The mean difference on equipping Grip assistive braking system turns around 10.69m, it ensures that we could bring the vehicle quickly to rest before 10.69m than normal braking. This clearly depicts that the reaction time of a driver has a direct impact on stopping distance of the vehicle. The prototype calculation elaborates the theoretical outcome of the Grip assistive braking system. It is also prescribed that the Grip assistive braking system must be designed in such a way that the overall reaction time must be under 0.03 seconds. The obtained theoretical result will create a great environmental impact in terms of reducing the stopping distance of a vehicle and it ultimately reduces the accidental impacts in the society.

VII. CONCLUSION

The research article based on the concept of grip assistive braking on four wheelers to enhance the braking system of a four wheeler by the grip assistance placed in the steering as a result of this the stopping distance is decreased by reducing the reaction time. This is designed to overcome the reaction time travel of a vehicle by implementing several electronic sensors and kits for accomplishing this braking action. The main uniqueness of this research article is the microcontrollers are switched on only during the grip action where the array of gripping sensors are enabled in the steering when the distance sensing sensors are detected and directed to the actuators/regenerative braking for E-Vehicles and for fuel powered vehicles for the necessary braking to takes place. Thus the unique steering wheel plays the role of connection between vehicle and the driver. This proposed concept is achieved on practical implementation in real time prototype. The steering wheel design was carried out with CATIA V5. On equipping such braking systems on vehicles, a safer braking environment would be obtained and accidents could be avoided. The accuracy and the reaction time by the braking system will be enhanced to high precision. The reaction time will be further minimized with the equipment of further distance advancement technologies. The ultimate future development will majorly comprises research on various faster distance measuring devices and processing units. Advanced microcontrollers processing will be implemented to work at high speed. On implementing these features as a future scope the stopping distance is decreased by reduction in the reaction time.

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