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Intensity Based Control for Automatic Braking System

Jebakumari M[1], Saravanagiri N[2]
[1]*(Associate Professor, Department of Computer Science and Engineering, Nehru Institute of Engineering, Coimbatore, India)*
[2]*(UG Scholar, Department of Computer Science and Engineering, Nehru Institute of Engineering, Coimbatore, India)*

Abstract: This paper investigates the effectiveness of brake light of a preceding vehicle in controlling and applying brake in one's vehicle. The safety of vehicles on road is a massively alarmed and exigent problem that threatens developing nations right now. Even as the number of vehicle users is increasing rapidly, the need for protecting vehicles along with persons inside has become indispensable. In most cases, drivers fail to perceive the presence of obstacles moving ahead and hence latency in responding immediately by applying brake leads to occurrence of collision. In this paper, an intensity based automatic braking system is proposed with the foremost aim of avoiding collision with the preceding vehicle in highways during night time. Furthermore, it is focused to prevent hitting at the rear end of a vehicle at front in a hard braking scenario. The system works by sensing the intensity of red light from the brake light of the preceding vehicle at the front, converting it to equivalent pressure in proportion to the intensity value, and thereby applying brake automatically. In the preliminary study, the intensity of red light at varying distances are measured and the findings are reported herein.

Keywords: Automatic braking, Brake light, Light intensity, Preceding vehicle

I. INTRODUCTION

The problem of vehicle accident is a part of an endless list of disaster that could occur anywhere, anytime. As stated by World Health Organization (WHO) in the context of road safety facts, almost 1.25 million people die on world's roads every year. Fast economic growth has paved the way for motorization and subsequent rise in road accidents. Though there are many ways to achieve safety on the roads, very few road safety measures are strictly pursued in developing countries which lead to further road disasters.

The collision avoidance system is an automobile safety system designed to reduce imminent possibility of an accident. These systems have been developed over time and the current smart systems in operation are highly expensive. They use electronic circuitry combined with distance sensors and other sensors to detect an impending crash. Upon detection being made, these systems respond by, either offering a warning to the driver about the imminent collision or taking action autonomously by automatic application of brake. At present, many of the intelligent vehicles, especially luxury vehicles, have monitoring systems comprising of speed sensors, anti-lock brakes, and the like; but these vehicles are not affordable to everyone. Hence, a cost-effective and proficient system is required for the safety of every vehicle user.

Mostly, along highways, accidents are rear end collisions rather than lateral vehicle crash or collision between opposite vehicles. Due to rain, snow or fog weather, the road becomes slippery and the vision too being poor, rear end collisions are liable to occur as the vehicle moving with high velocity may sideslip while braking. Several approaches to automobile crash avoidance systems have been proposed in recent times; however, such approaches mainly concentrate on steering maneuvering control. In addition, provision of only warning signals to the driver for activating the automatic braking forms the main part in such systems. Moreover, sensors placed inside a vehicle can caution its driver of any obstacle that could possibly lie ahead on the road. Some of the dangers that could be detected by these sensors include the proximity of the vehicle to other vehicles around it, and its exact distance from them. The ultrasonic sensor is modified to measure the proximity with reference to the preceding vehicle from the rear end. Most obtainable ultrasonic sensors for vehicles are permitted for approaching vehicle with comparatively low speed, whereas, the rough reading of proximity data cannot be applied directly, and hence an intelligent method is projected to process the distance sensed so that suitable cautionary signals can be given.

The rest of this paper is organized as follows: Section II brings to light the previous work found in literature regarding automatic braking control mechanisms and section III discusses specifically about automatic braking systems currently available. Section IV discusses about the proposed approach to detect and avoid forward collision. Section V presents results and discussions. Finally, Section VI concludes the paper.

II. LITERATURE REVIEW

An elaborate study of related researches concerning automatic braking systems for avoiding rear end collisions has been made and outlined below.

Ian Fletcher et al. [1] proposed an "Automatic Braking System Control" which described the use of computer assisted systems in a major step towards improving the safety and performance of vehicles and investigated the performance of potential strategies applicable to vehicle automatic braking system(ABS). The results showed not only the problems involved but the opportunities existing for the application of a smart control strategy.

A proposed work on 'Formulation of Braking Behaviors of Expert Driver toward Automatic Braking system' was presented by Wada et al [2] which suggested that a skillful driver's deceleration samples would be formulated using the proposed risk perception index along with visual information. It is shown that the formulated braking pattern could generate smooth deceleration profile for numerous conditions of relative velocity and brake initiation timing uniformly with simple calculation and without collision under certain assumptions. Nishi et al.[3] presented an approach of collision prevention using laser beams in which the system estimated the location of vehicle after one second and projected it onto the road plane by means of laser beams. Another approach based on Laser sensor which identified vehicles by using laser rays was proposed by Shanmathi et al. [4]. A Laser transmitter was connected to the laser sensor and a Controller Area Network (CAN) transmitted the information through Zigbee. But counter-action to shun collision was not incorporated in the system.

Shiqing et al. [5] proposed a mechanism of vehicle rear end collision prevention wherein the rear end collision avoidance is discussed based on a mathematical model. The system was setup with ranging sensors to obtain a critical safe distance between vehicles of different velocities and to make a comparison with a critical safe distance. The hypothesis here was , that, when two vehicles travel in same direction on the highway and if the rear vehicle is coming faster than the front vehicle , they would continue to be nearing closer and prone to collide. Therefore, to avoid collision, it was necessary to determine whether the relative distance was safe or not.

Kiml et al. [6] proposed a 'Radar and Vision Sensor Fusion for Automatic Emergency Braking ' wherein , a vehicle recognition algorithm based on radar and vision sensors was introduced along with its application to automatic emergency braking. As the radar systems used to detect both vehicles and road infrastructure- including tunnels and rails, it could not discriminate between a vehicle and a non-vehicle object. Hence, a vehicle recognition method based on shape and motion attributes was incorporated to improve vehicle detection.

Another autonomous navigation and collision avoidance system using smart phone sensors was proposed by G.Der khachadourian [7].It made use of a network of sensors in order to check the surroundings of a vehicle and detect the presence of obstacles by measuring the distances to other vehicles. However sensor integrity and software intricacy were the main issues that concerned the development of such systems.

Lopez et al. [8] elaborated on the automatic emergency braking systems of two vehicles of different make, under diverse parameters including vehicle speed , lighting , moving directions etc. This system described the main braking patterns and the occurrence of impact as a function of initial and final positions of the vehicle and speed. The braking patterns relied on both detection and decision making time and the braking efficiency. Collision speeds, effective level of deceleration and the significance of the transient phase were also shown.

Avinash et al. [9] proposed a "Pedestrian Collision Avoidance with Auto Brake" which aimed at avoiding pedestrian collision in road with a vehicle. The safety system employed here used image processing technique for pedestrian identification , and brake by wire method of automatic braking. The method used here was that when a pedestrian gets identified in the camera and once the collision seemed impending the vehicle's brake should be applied automatically. Aliyu et al. [10] developed an automatic microcontroller based crash avoidance system that utilized ultrasonic sensors for obstacle detection and distance measurement. Once safe separation distance had reached, induced braking was applied to bring the vehicle to a halt.

III. AUTOMATIC BRAKING SYSTEMS

Most of the collision prevention automobile safety methods are designed to lessen the possibility of accidents by incorporating automatic braking systems. These systems use electronic circuitry coupled with distance sensors and sometimes camera sensors to detect an imminent crash. Once the detection is done, these systems either provide a warning to the driver when there is an impending collision or take action autonomously without any driver input by automatic application of brake.

Some of the approaches make use of Laser-based systems which are expensive and unremitting operation would demand good power supply that might be impossible to implement in common vehicles and utility cars. A few other approaches employ wireless sensor networks and use sensors for sending and receiving signals from vehicles [11]. However, such systems have a high cost of implementation and are limited to electrical interference which could affect the proper functioning of the system [12]. Similarly Fuzzy Logic Controller–based automatic braking systems with complicated electronic circuitry are as well not cost-effective [13],[14]. Also, predictive vehicle collision avoidance system, using Raspberry-pi, employs the use of ultrasonic sensors to detect and measure the distance with respect to dynamic or stationary objects [15]. The sensors are embedded to detect obstacle in front of the vehicle as well as those present in the blind spot of the vehicle. Nevertheless, such systems are without any counter measure to keep away from collision.

Therefore, in order to surmount the drawbacks of these existing automatic braking systems a cost-effective system that can be affordable to ordinary man is proposed.

IV. PROPOSED METHOD

When a vehicle applies brake, the brake light which is placed at the rear side of the vehicle will start glowing. The intensity of that red light, in the range from 625nm to 740 nm, can be measured using a colour sensor since colour sensor produces a square-wave output whose frequency is proportional to the intensity of the chosen color. The basic mode of functioning of the system is that when the intensity of red light is very high, apply brake hardly and when intensity is less apply brake moderately.

Consequently, a system which is capable of measuring the intensity of the red light coming from the brake light of the preceding vehicle that applied brake plus generating an equivalent pressure in proportion to the intensity value measured is proposed as an alternate to the expensive approaches. The pressure generated would be used to apply brake by way of a stepper motor and a pulley.

The intensity based automatic braking system has the following components for effective functioning.

- The color sensor for sensing the brake light of a preceding vehicle.
- Key for switching the motor to indicate the speed of the vehicle.
- The microcontroller
- Motor Driver /controller
- Stepper motor Driver

The block diagram of the proposed system is depicted in Fig 1.

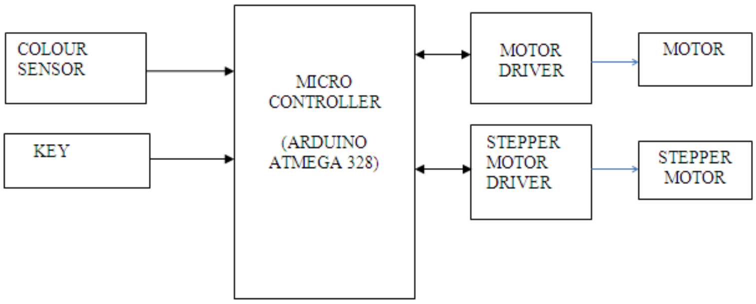

Fig. 1 Block Diagram of Proposed System

The Color sensor acts as a complete color detector which comprises of 4 LEDs for sensing the color of object and a TAOS TCS 3200 RGB sensor chip.

Motor controller/driver (L 298) is a dual full bridge driver that has a capability to bear high voltage as well as high current. It is capable of operating different loads like stepper motors, DC motors, relays etc. and here it serves to govern the performance of an electric motor in some predetermined manner.

The Arduino is an open source micro controller board based on microchip ATMEGA 328. The board is equipped with sets of digital and analog input and output pins that may be interfaced to various expansion boards and other circuits. Key is used to switch the motor whose speed indicates that of the vehicle. The speed of the motor is configured in two stages to indicate a fast motion of the vehicle and a slow motion of the vehicle. The speed of the motor is taken into account when braking is done in order to provide more security while braking. When the key is switched the microcontroller instructs the motor to run and the color sensor will start sensing. When it senses red color, it sends the intensity value to the Arduino board and the microcontroller checks the value of intensity against a range of intensities to find a proportionate pressure to apply brake; here in the experimental setup the speed of the motor represents the speed of the preceding vehicle and it is also taken into account for braking. That is, when the motor has a high torque, then braking pressure should be larger to stop the vehicle and the pulley should be capable of pulling to a large extent. In this case, the stepper motor would be making several clockwise rotations. A stepper motor is a synchronous, brushless, polyphase motor whose rotor position is understood to follow a controlled rotating field and precise positioning of steppers is simpler.

The light-to-frequency converter shown in fig.2, which is capable of reading an 8 x 8 array of photodiodes in the TCS3200 plays a major role in determination of intensity. Sixteen photodiodes have blue filters, 16 photodiodes have green filters, 16 photodiodes have red filters, and 16 photodiodes are clear with no filters. When choosing color filter, the TCS3200 can allow only one particular color to get through and prevent other colors. While selecting the red filter, only red incident light can get through, blue and green will be prevented. Likewise, when choosing blue or green filter, the corresponding light can go through.

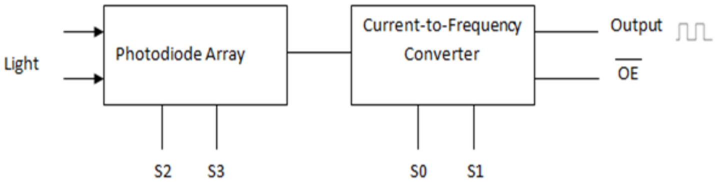

Fig. 2 Light-to-frequency converter

TCS 3200 has 4 types of filter: Red, Green, Blue and clear with no filter. The filter is selected based on the high / low of pin S2 and S3 on the module. The type of photodiode used is controlled by two logic inputs, S2 and S3 and for Red photodiode both S2 and S3 are Low.

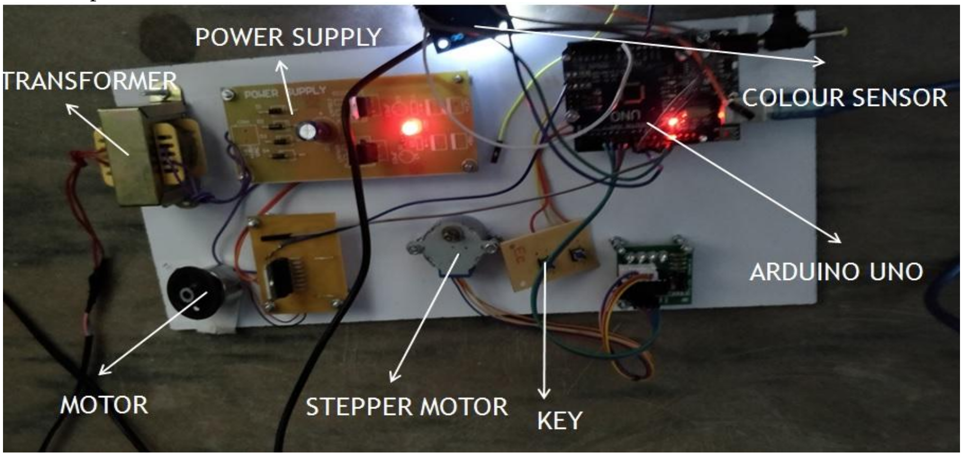

Fig.3 Snapshot of the Experimental Setup to measure intensity with varying distance

V. RESULTS AND DISCUSSIONS

Using the experimental setup , the intensity of red light was measured at different distances , analogous to varying distance between preceding vehicle and our vehicle, and based on the readings taken a chart (shown in Fig.4) is drawn . In the preliminary study, when distance was more than 5 cm , the intensity could be specified as high and clockwise rotations in the stepper motor were noticed.

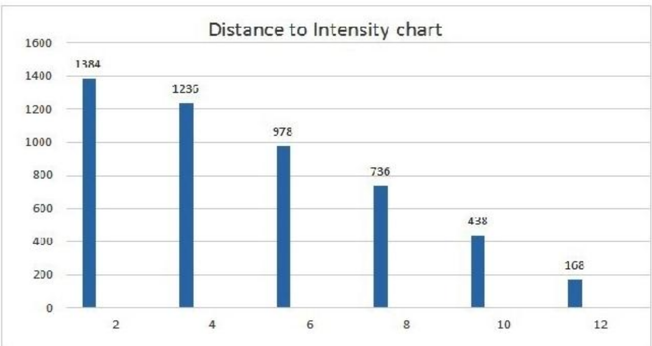

Fig.4 Chart depicting the variation of intensity with distance

When the distance was more than 10 cm the intensity became less as sensed using the colour sensor and clockwise rotations in the stepper motor were less. When the red LED source was placed far from the colour sensor, the low intensity recorded indicated the larger distance between the vehicles.

VI. CONCLUSION

The performance of automatic braking system based on intensity level of the preceding vehicle's brake light is studied by controlling a stepper motor. The promising results obtained by varying intensity levels at various distances and observing corresponding variations in the stepper motor rotations would prove effective in applying brake promptly. Now the system is only for vehicles with four wheels or more, that is, the vehicles which can balance themselves and the future work can be directed for two wheelers. With high performance color sensors, the distance at which color sensing starts can be more than 10 meters; hence security can be assured in speedy motions of the vehicle. Future work can also be directed to include emergency road blocking system which requires rerouting the vehicles if traffic is more in some routes and also in cases of urgent situation such as clearance of an ambulance from the road that needs to be notified to every vehicle travelling along the highways.

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