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A VEHICULAR ACCIDENT DETECTION AND AVOIDANCE SYSTEM FOR PROTECTING PASSENGERS AND VEHICLES

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ABSTRACT

Considering the increasing number of traffic accidents in recent years, it is being accepted that traffic accidents have assumed exceptional dimension of a serious problem. Of the major causes of accidents, the driver has been recognised as the main cause of accident especially in Nigeria. As regards to human factor, it is concluded that not so much can be done to improve the level of alertness of drivers or reduce the level of stress experienced by drivers. Hence, Intelligent System is being deployed to vehicles to aid drivers to avoid collision. Existing Collision Detection and Avoidance systems have grown in complexity that the goal of easy integration and maintainability is elusive. This Research has developed a system of Robust Sensors and Actuators coupled to a Rugged Microprocessor to achieve a Low Cost but highly reliable Vehicular Accident Detection and Avoidance System using Ultrasonic Sensors installed in the front end of the vehicle. Analog proximity measurements for various collision hazards were taken and at 40 kilometer per hour and above, the system will be activated. The use of microcontroller for the generation of ultrasonic signal and the control logic enables the prediction of imminent collision when the vehicle approaches an obstacle within 7meters range, thereby enabling some controls which ensure a warning alarm and an activation signal to the automatic brake system when the collision range of 5meters is reached. With the embedded C program in the microcontroller, a visual liquid crystal display is equally incorporated to give situation report of the device surveillance activities. Based on Proteus 7.0 simulation software, the performance of the system is extensively evaluated and the results record satisfactory performance.

Keywords: Collision, Detection, Avoidance.

INTRODUCTION

In the later years after independence the number of vehicles subsequently increased but in the last two decades, it spreads drastically in every level of the society hence, safety becomes the main concern. Road accidents account a severe threat to the lives in both ways, physical as well as financial, even after digital control of vehicles. Many people lost their lives every year in vehicle collision majorly due to driver's inability to keenly observe the vehicles' vicinity while driving and in traffic condition [1]. The Federal Road Safety Commission, Nigeria (2008), reported that vehicle collisions are as a result of human error due to faulty decisions and actions by drivers. And these faulty decisions that result in motor vehicle crashes are attributed to ignorance of traffic regulations and procedures. In [2] Malo, W. stated that collisions have three causes : the vehicle, the driver or environmental conditions. But, 77 percent of all traffic collisions are caused by driver error leaving 23 percent for vehicle malfunction or environmental conditions, such as light, weather, road or traffic. The most common errors committed by drivers are excessive speed, failure to yield the right of way, following too closely, improper turns, improper passing and improper backing. The

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driver is the most important safety feature in any vehicle. Hence, the Vehicle Anti Collision Detection and Avoidance system is significant in improving safety design of vehicle and reduce driver error [3].

There have been many attempts through the years to develop an effective collision avoidance system that is practical for use. In an ideal world, the system should supply timely, accurate and easily interpretable collision avoidance information, warning of all other vehicles or other obstacles that are likely to impinge on its path. Several vehicular innovations have been implemented in recent years for protecting occupants in the cause of a collision. But advanced systems designed to prevent collision from occurring have barely passed the research and development phase. Even those that have passed the phase are not widely dispersed. In recent time, a Smart Cruise Control on S-Class Mercedes Benz vehicle is widely dispersed but of course very expensive. Most collision avoidance systems are non co-operative, that is detection is independent of whether other vehicles on the road are equipped with collision avoidance devices [4]. In this [4] the article explains that Fiat vehicle manufacturing company has developed an Autonomous Intelligent Cruise Control (AICC) system, called ALERT. The system uses a combination of sensors (laser radar, microwave radar, and a camera for blind spot monitoring), to detect obstacles in the road ahead. Vehicle control is performed through electronic braking and a throttle actuator. ALERT uses the Laser radar (lidar) as the distance sensor, while the microwave radar, which guarantees visibility in adverse conditions, is used as the collision avoidance sensor. As long as no target is detected, the AICC system provides speed control. If a target is detected, the AICC system switches automatically to distance control: it keeps the same speed as the target vehicle at a safe distance, which in turn is continually updated to account for changes in the vehicle's speed and in road conditions. Continuing with [4], A DISTRONIC system is installed in some Mercedes cars such as CLK, E, S, CL and SL Classes models as an accident detection and avoidance mechanisms. A radar sensor behind the radiator grille enables the system to maintain a constant distance to the vehicle in front. The proximity and cruise control system can also improve road safety levels.

In [5] Second generation Volvo cars are equipped with Collision Warning with Auto Brake (CWWAB) system which is a vehicle Collision Avoidance and Mitigation System. It is an active safety system that helps the driver to avoid or mitigate rear-end collisions. It uses forward looking radar sensors to detect obstacles ahead of the vehicle .When a high risk for a rear- end collision is detected, the system helps the driver by providing a warning and brake support. If the driver does not react in time and a collision is judged to be unavoidable, the system will automatically apply brake of the vehicle. This may not avoid the accident, but the consequences may be reduced. In [6] Butsuen, T., et al designed an Advanced Pre-Collision System to help reduce the crash speed and damage in certain frontal collisions only. The system included Driver Attention Monitor for alerting the driver if a potential hazard is detected ahead. Honda [7] cited that Honda Motor Company has developed a Collision Mitigation Brake System (CMS) that anticipates a collision based on driving conditions, distance to the vehicle ahead and relative speeds. It then uses visual and audio warnings to prompt the driver to take preventative action and also initiates braking if the driver fails to respond to the warnings. The system works in conjunction with the "E-Pretensioner" seatbelt retraction system. The CMS and E-Pretensioner systems use millimeter-wave radar to scan the road 100 meters ahead and calculate the likelihood of a collision by analyzing the distance between the vehicles, the relative vehicle speeds, and the anticipated vehicle path. If a collision is likely, the system has three staged modes to prevent or lessen the impact of a rear-end collision:

All these accident detection and collision avoidance systems are preforming satisfactorily to a large extent but they are expensive and imported. In this work a local accident detection and collision avoidance system which uses 45 KHZ ultrasonic signal is developed. Proteus software is used to simulate the system and record results. . This work system is cost effective and comparable to any system of its grade. Another added value to the system is the reliability factor which depends partly on the nature of the sensor being used. Ultrasonic sensors are not affected by atmospheric dust, rain, etc. It can work in adverse conditions without alteration in accuracy.

1. DESIGN OF ACCIDENT DETECTION AND AVOIDANCE SYSTEM

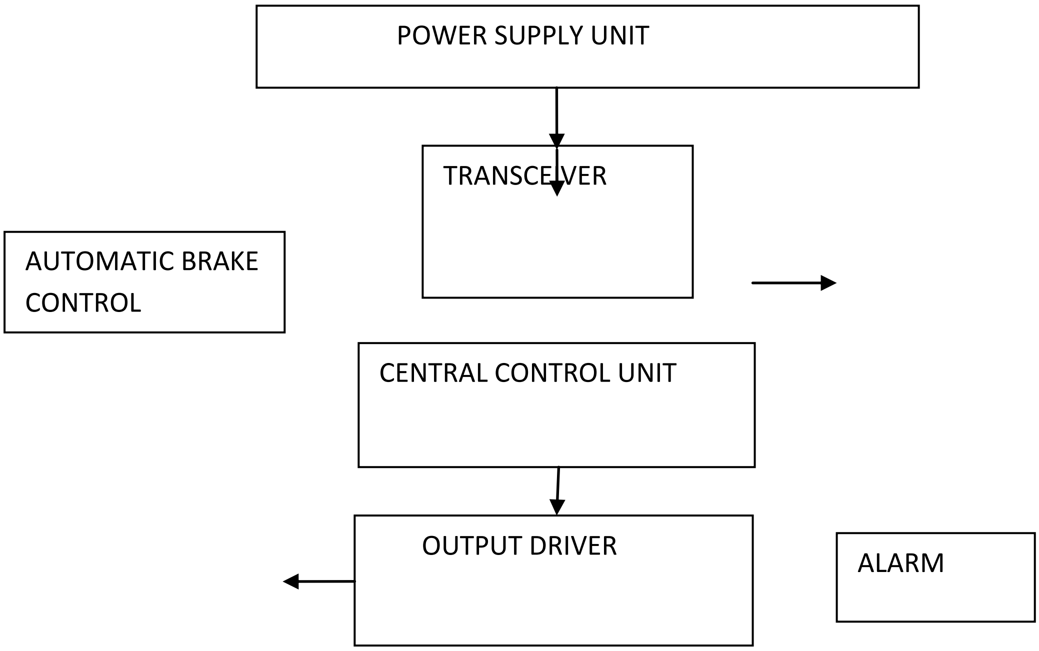

Figure 1: Block of Accident Detection and Avoidance system.

Several techniques are implemented to achieve very high accuracy in this work, a technique called the Phase Accordance Method is employed. Here the combination of Time of Arrival (TOA) and Angle of Arrival (AOA) methods are employed. In TOA method used here, the transmitter and the receiver are synchronized using wireless communication. The transmitter sends the ultrasonic signal to the receiver. Then the receiver compares the receiving times of the the ultrasound, and treats the time difference as the propagation time of the ultrasound. Also the system is able to predict the obstacle direction. The propagation time of the ultrasound is converted into the distance between the transmitter and the receiver. Although in this application, the transmitter and the receiver are fixed on the same car, the transmitted ultrasonic signal is reflected back by an obstruction which may be a vehicle or any other object the car must not collide with. Hence the arrival time of the signal is proportional to the distance between the vehicle and the obstruction.

On the other hand, AOA is a technique which is used to determine the direction of the incoming signal. In order to implement AOA method, two ultrasonic microphones are needed at the receiver. These two microphones are attached to the receiver board in parallel, separately at a certain distance. The signal reaches each microphone at different moment. With known values of the distance L between the vehicle and the obstruction and the distances between the transmitter and a receiver, using simple trigonometric rule, the angle of the incoming signal can be calculated.

RESULTS

The system as depicted in fig 1 is simulated using Proteus tool and the results are presented below. Table 1 and fig 2 depict the ultrasonic receiver response to obstacles at various distances. The receiver responded to the received signal from the simulated obstacle within 25 meter range by sending alert signal while the actual collision range is fixed at 5 metres. It was however discovered that there was no meaningful output from the receiver whenever obstacle was completely out of range. For obstacles close enough but still out of collision range,(about 7m) the receiver's signal arrival time was longer and the LCD displayed that Collision is Imminent. Multimeter test instrument was used on the simulation software to obtain data.

Table 1: Distance Against the Output Voltage from the Receivers Operational Amplifier

DISTANCE (in meters)	OPERATIONAL AMPLIFIER OUTPUT VOLTAGE (Volts)
5	6.33
10	4.27
15	3.31
20	1.25
25	0.47

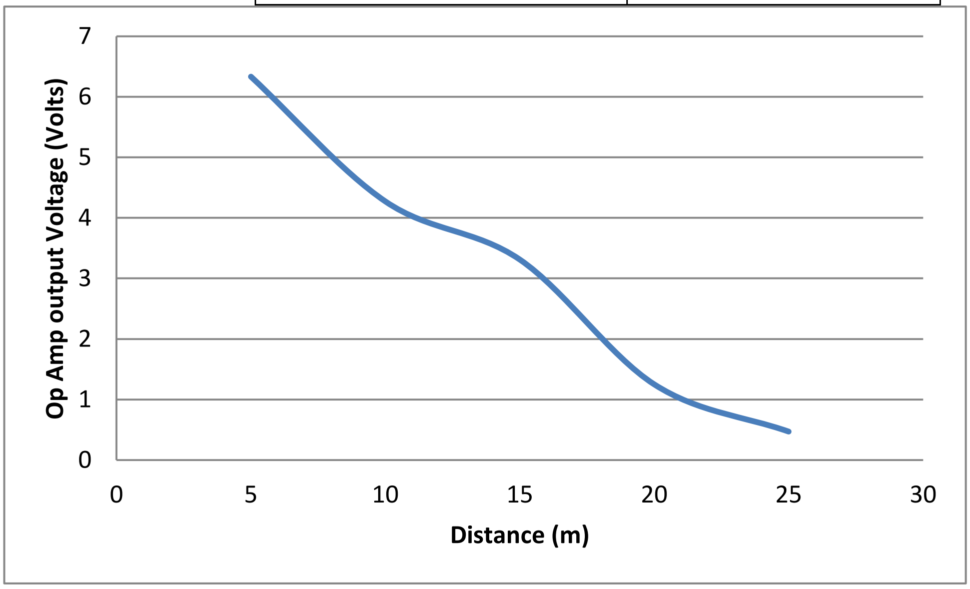

Figure 2: Ultrasonic Receiver Response to Obstacles at various Distances

This graph shows that the signal strength decreases with increasing distance. It equally shows a measure of linearity if points of best fit are chosen. At 5meters distance, the amplifiers output voltage (that is voltage amplification) is about 0.633V, this reduced to low voltage of about 0.043 at 25 meter distance. However, with collision ranged obstacle (5m), the microcontroller determines the possible direction of collision using the two receivers on both sides of the car. The following result is observed from the simulation: one, the dedicated car brake relay is automatically activated such that the car is made to slow down. At the same time a mild alert tone was heard while the liquid crystal display shows real time information of the situation. The reset switch doubles as the override switch. It disabled the entire system when made. Table 2 and fig 3 depict the ultrasonic receiver response to obstacles from various angles at various distances.

Table 2: Ultrasonic Receiver Response to Obstacles from Various Angles at Various Distances

Obstacle Distance (m)	Angle of Arrival (^{0})	Op-Amp Output Voltage (V)
5	83.2	6.33
10	86.6	4.27
15	87.7	3.31

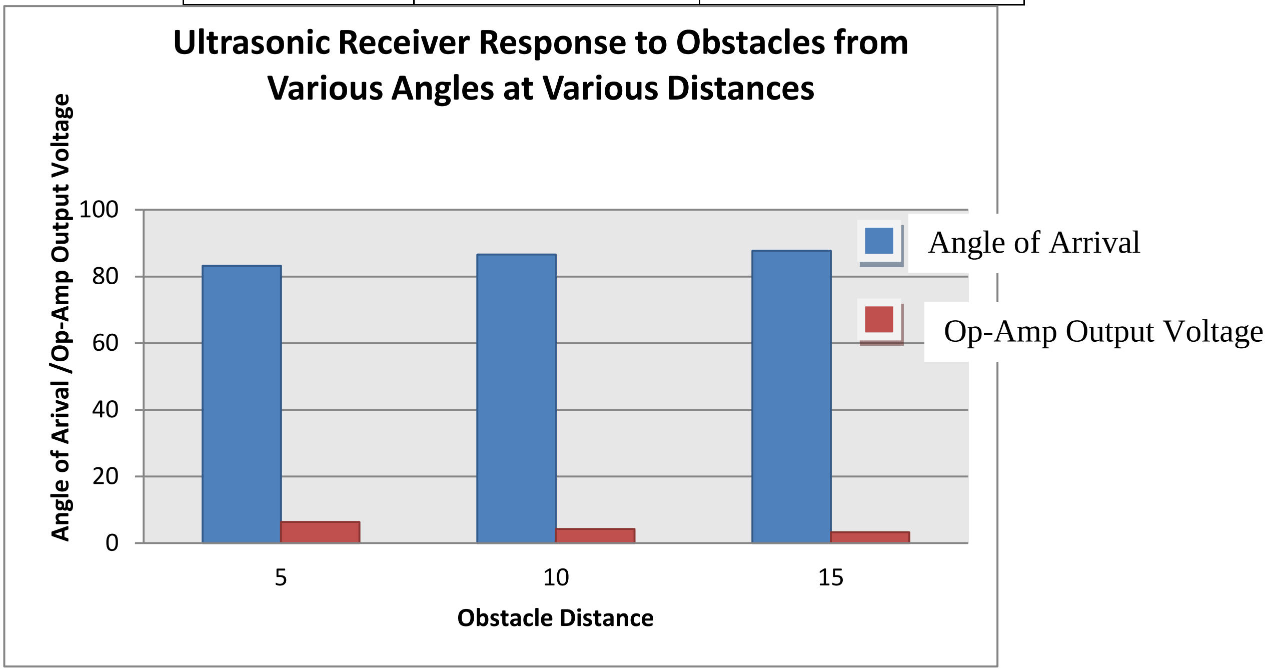

Figure 3: Ultrasonic Receiver Response to Obstacles from Various Angles at Various Distances

Table 3 and fig 4 depict the angle of arrival and receiver voltage and various receiver positions and fixed obstacle distance of 5 meters. The figure shows that the signal strength of the received signal reduces as the Angle from where the received signal arrives shifts away from the centre where the sensor has a direct 90 degrees angle to the obstacle. A shift of the obstacle away from the centre increases the vehicle to obstacle distance, as well as the Angle of Arrival which further reduces signal strength or Op amp output voltage.

Table 3: Determination of Position of Receivers (Obstacle Distance 5 meters)

Obstacle distance (m)	Transmitter to Receiver Distance (m)	Angle of Arrival (^{0})	Op Amp Output Voltage
5	0.2	87.7	3.31
5	0.6	83.2	6.33
5	1	78.6	8.32

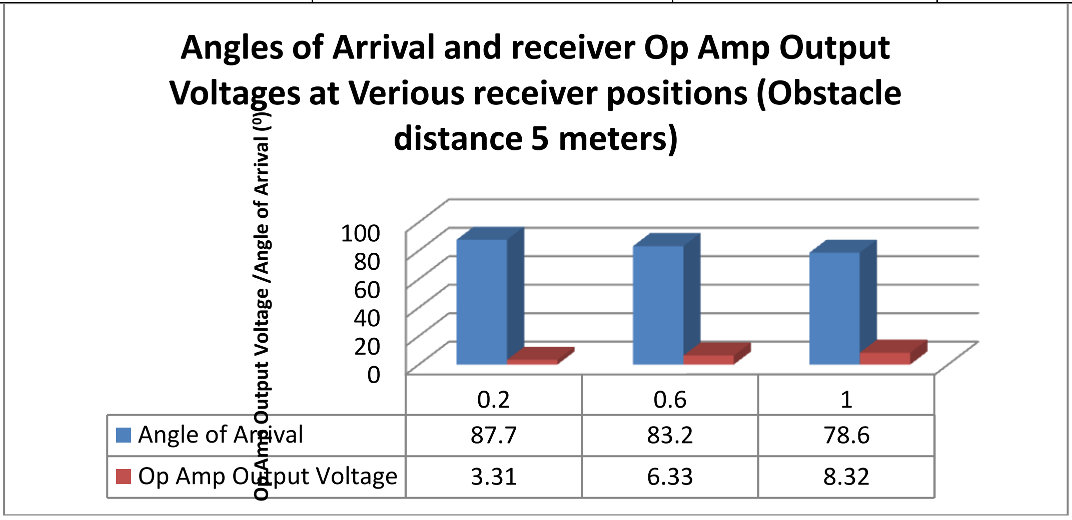

Figure 4: Angles of Arrival and receiver Op Amp Output Voltages at Various Receiver Positions (Obstacle distance 5 meters)

Table 4 and fig 5 depict the angle of arrival and receiver voltage at various receiver positions and fixed obstacle distance of 10 meters. The figure shows that the signal strength of the received signal varies with angle of arrival and transmitter to receiver distance

Table 4: Determination of Position of Receivers (Obstacle Distance 10 meters)

Obstacle distance (m)	Transmitter to Receiver Distance (m)	Angle of Arrival (^{0})	Op Amp Output Voltage
10	0.2	88.9	2.23
10	0.6	86.6	4.27
10	1	84.3	5.13

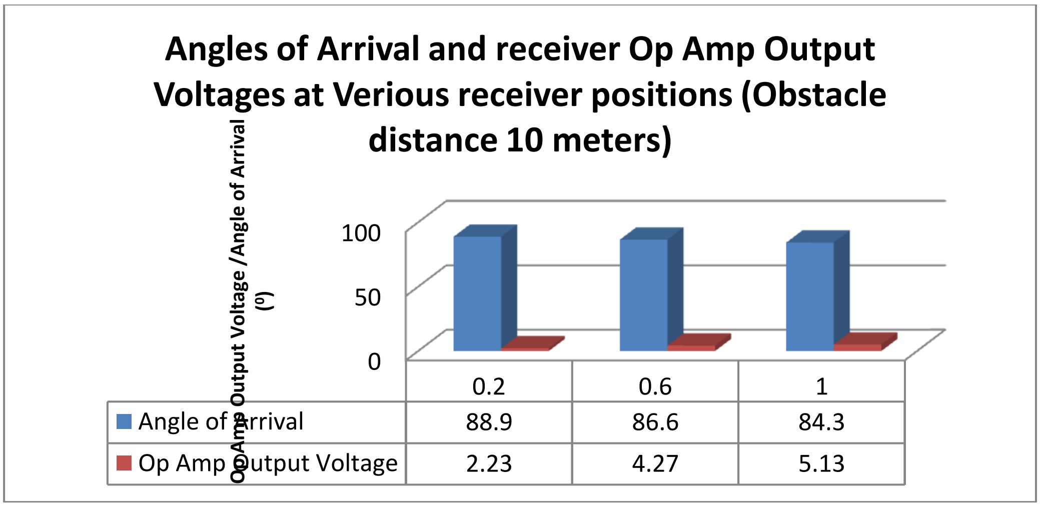

Figure 5: Angles of Arrival and receiver Op Amp Output Voltages at Various Receiver Positions (Obstacle distance 10 meters)

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CONCLUSION

The system has to a large extent performed according to design expectations and specifications. The obstacle's distance to the transmitter is predicted by the time of arrival of the reflected signal, while the approaching angle is also determined by the angle of arrival method so employed in the design which was helpful in determining the appropriate positioning of the receivers for optimal system performance. Furthermore, the use of double receivers enabled the prediction of direction of obstacle. Simulation possibilities were confined to the flexibility and rigidity of PROTEUS 7.0. In its flexibilities, all design components were available in its component library. On the other hand its rigidity limited the simulation of an obstruction to the use of contact switch even though all other variables were simulated.

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