A Sensor Based Robotic Model for Vehicle Collision Reduction

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***Abstract*— This work presents an integrated monitoring system to avoid accidents or collisions between vehicles from both (front and back) sides. It can be used to save human lives from a number of road accidents. To demonstrate such a low cost system, a distance sensors framework, microcontroller, remotely controlled unit using radio frequency, and an alarm unit are utilized. A navigation approach of the robot is also described based on the range sensors. To verify the presented strategy, the experimental test has been carried out in a real environment by moving robot between different vehicles and objects.**

***Keywords*— Accident avoidance system, Navigation, Remote control, Robots, Sensors network**

I. Introduction

To maintain a specific safe distance from another object is primarily about instructing a mobile robot to achieve the desired goal. In order to attain such objectives, one of the possible choices is to use the sensors. Robot programming is utilized to attain information about their environment by using the external sensors to allow for a more flexible execution. Recently numerous efforts have been put in the integration of multiple sensors into robot systems because advanced robots need more information about surrounding environment. This work also demonstrates on the multiple sensor system and mobile navigation. The mobile robot can get range information around itself from the distance sensors. This information is used for inspection of the environment around the robot like detection of an entity, notice of the danger of collision, and identification of object position. Worldwide, lot of people are killed and injured in road crashes every year. And even with all the developments in the motor vehicle safety technology, the number of people killed in the automobile accidents keeps on rising. Accident causes include: driver fatigue (frequently yawning, misjudging traffic situation, drunk driving, using of drugs), looking at somewhere else, playing with music, reading documents, using cell phones, driving in fog, and traffic high lights. Some precautions have been made for traffic accident safety issue which contains: Seat belt, child safety seat, air bag, speed limitation, and by physical change in vehicle design. We have assumed that by mounting sensors, light alarm, sound alarm, and vibration module in vehicle will represent an alarm sign to alert the driver. Vibration module will help to focus the driver in a noisy environment. This security system will help a great deal in increasing road safety and reduces collisions. In our system the vehicle can be controlled by human as well as automatically. The main issue for collision safety is to control the speed of vehicle. The natural tendency for self-protection is that drivers usually reduce the speed of vehicle in uncertain conditions for decision making. In this study, the speed of vehicle is automatically controlled by using distance measurement with the help of sensors. Manual mode contains same hardware and software for the vehicle which has been already placed in it. But for the prevention mode an extra hardware and software will be installed. The hardware for prevention mode is interrelated with the hardware of manual mode which includes: sensors, alarms, and control unit. When the prevention mode is activated, instructions are sent towards the predefined apparatus in the vehicle.

Actually, we have implemented our proposed system on a robotic model. Our unique work on a mobile robot is based on the sensor method which acquires information to update the robot position. When a mobile robot is in unknown environment, it will get position information from the sensors. According to distance information, the mobile robot maintains its goal without crashing. This robot is driven by two DC motors and robot does not require any human contacts other than using a remote control device for commands to the microcontroller. As soon as, the detection of a vehicle is confirmed light and sound alarms get activated giving a signal of detection. These alarms are very cooperative in case of one failure the other will indicate the presence. Here, methodical approach is established for the development of sensor-based robot which can be used for security purpose to prevent from the automobile accidents also it can be used in industrial applications for ranging purposes.

We are inspired from previous work on ultrasonic sensor based blind spot accident prevention system [1]. In [2] a deceleration control method of the automobile for collision avoidance based on driver's perceptual risk is discussed. The environmental information is given by the GPS and sensors. Numerous works on a remote controlled mini robot have been already being proposed [3]. Laser range sensors can also be used for object detection, measurements, and to get information about surrounding. A lot of study is proposed to control mobile robot based on information of the scanning laser range sensor [4]. Infrared sensor ring is used for line based incremental map building [5]. Navigation techniques are used to move a robot from one position to another as described in [6]–[8].

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A line follower is a mobile robot which traces a white line on a black surface by using infrared sensor and it is most commonly used system in industries for many applications [9], [10]. A dependable model vehicle for rear-end collision avoidance is described by following distance, driving speed of the proceeding vehicle, and driving speed of the succeeding vehicle even if an external disturbance is injected [11]. A nonstandard safety technology is demonstrated which assists drivers to enhance safely when the driver is physiologically impaired [12]. Intelligent transportation system (ITS) and collision warning system (CWS) have been presented for safety technologies to warn drivers of an impending collision event in advance [13]. A vision for future research is outlined in the area of intelligent driver training systems for enhancing road safety and also presents preliminary implementation [14]. A forward vehicle collision warning system by using seat vibrator interface is proposed in order to reduce the number of the traffic accidents and their injuries [15]. The basic architecture of an intelligent driver warning system has been explained which embodies an adaptive driver model for indirect collision avoidance [16]. The main design principles, obstacle detection, obstacle avoidance, and state estimation are discussed in 2005 DARPA Grand Challenge competition [17]. The technical status of the Intelligent Vehicle Systems (IVS) and Intelligent Vehicle Safety Technologies (IVST) are highlighted in [18], [19]. The rest of this paper is arranged as follows: this section described the introduction and related work in this area. Section II explains the overview of the system realization also modes of operation. Section III illustrates the brief description of overall working of the system and simulation results. Section IV indicates basic experiments that were conducted for results. Last Section describes the conclusion.

II. SYSTEM REALIZATION

This work presents a strategy to control motion of the manually controlled robot when the object is detected around the robot. The idea behind the development of such a system is that the controller receives the information from different sources and manages different actions; the entire system is based on sensor method. The system is divided into three main parts: sensors framework, security unit, and motor module as depicted in Fig. 1. Security unit is developed by a microcontroller (AT89C52) which forms the brain of the system. All the actions are taken by this unit or by commanding using this unit. A framework of distance sensors is utilized for mapping the surroundings. Our main objective is to prevent accidents from both forward and backward directions.

For this purpose, we make use of four distance sensors which will provide information about the environment from back and front. The arrangement of sensors on the robot is the critical issue to achieve accurate results. Therefore, two distance sensors are placed on the front of the mobile robot and others on the back side. Most of the automobile accidents happen in such a way; the vehicle hits the object from front side. Therefore, sensors at front cover this situation if one sensor fails then with the help of other sensor security action will be performed. With the intention of avoid collision from backward, sensors from the back side will send instructions about surroundings towards the security unit and safety functions are performed. In order to acquire better result, distance sensors are placed in such a way that horizontal movement occurs. All the results from this proposed system depends on signals generated by sensors. The security unit will monitor the object distance from the robot by using distance sensors; corrective action is taken by security unit when much smaller distance is identified which keeps the mobile robot away from the vehicle. A remotely controlled unit has been employed to send signals toward the microcontroller for motion of the robot. To verify our proposed system, a vehicle having four wheels with two DC motors is used. One motor is for frontward or backward rotation and second motor is for left or right movement. Initially, a map is built from the surroundings; if the object is in the range of sensors then respected security mode will be activated. The entire overview of collision avoidance system which is based on distance control and placement of sensors is illustrated in Fig. 2.

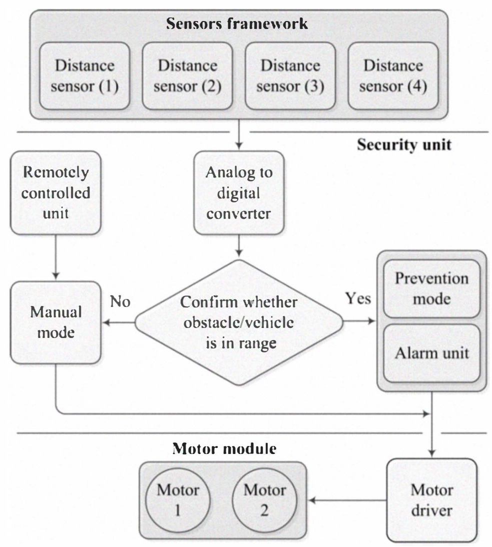

Fig. 1 System description

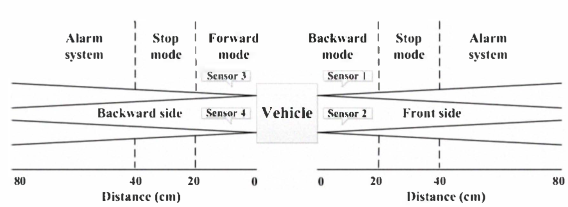

Fig. 2 Overview of collision avoidance system

Accident avoidance functions have been separated into two modes of the operation concerning information from the sensors: manual mode and prevention mode. The details of modes are described as follows:

1. Manual mode: This mode is the human interface mode. When the robot is in the manual mode then it is controlled by a remotely controlled unit. It can perform backward, forward, left, and right movements through the use of a key pad having four buttons; when the robot is switched into the prevention mode then the manual mode remains activated.

2. Prevention mode: With the intention of avoidance from collision between vehicles, commands are sent to different modules in this mode; this mode is automatically activated when an object will come in the range of sensors. In this mode forward, backward, and stop functions are performed. Sound and light alarms are automatically started in prevention mode when the object is in the range of 40-cm to 80-cm distance from both front and back sides. After the warning and before the robot is stopped; if the object is away from range of sensors robot turns off the warning and resumes its movement. Similarly, if the object is in front of the robot and came nearer to the robot at a distance between 20-cm to 40-cm; stop function is carried out. In order to activate backward function, object must be at a distance of less than 20-cm. To prevent collision from back side of the robot, the distance sensors from back give instructions to the security unit then respected security operations are executed. If front sensors and back sensors indicate the presence of the object then the security unit will command to stop the robot.

III. Overall Working

Additionally, this paper also focuses on the implementation of a system to control navigation of a mobile robot. The simulation model of the integrated monitoring system for accident prevention which has the function of monitoring, managing, and decision-making has been established as demonstrated in Fig. 3. To get better results from simulation, changeable analog voltage source is used to perform the same tasks as the distance sensors; this is accomplished in Proteus (simulation software). For analog to digital conversion of incoming analog signals from distance sensors, every signal is treated separately. This unique conversion is accomplished by giving commands to the address pins of the analog to digital converter (ADC0808). All components are tested one by one; for assimilation testing all components are interfaced and acquired the results. A microcontroller is used because of its simplicity for programming purposes. An array of hexadecimal numbers is the result of interfacing microcontroller and analog to digital converter; step by step voltages are varied and the output of eight bits digital data is noted. When the object is detected by any sensor; the eight bit coming data is compared with an early mentioned array of hexadecimal numbers. If it is from the array then prevention mode is automatically activated. In Fig. 4 "a" corresponds to the early mentioned array of hexadecimal numbers and analog to digital conversion is represented by "ADC"; while, "b", "c", and "d" indicate the digital eight bit values at distance of 20-cm, 40-cm, and 80-cm respectively. In pseudo code "getdata1" and "getdata2" are the eight bit digital data coming from front sensors while "getdata3" and "getdata4" are from back sensors. "motor1" indicates the direct current motor which is used for forward or backward motion. The alarm unit contains the sound and light alarms which are represented by "alarm" in the pseudo code.

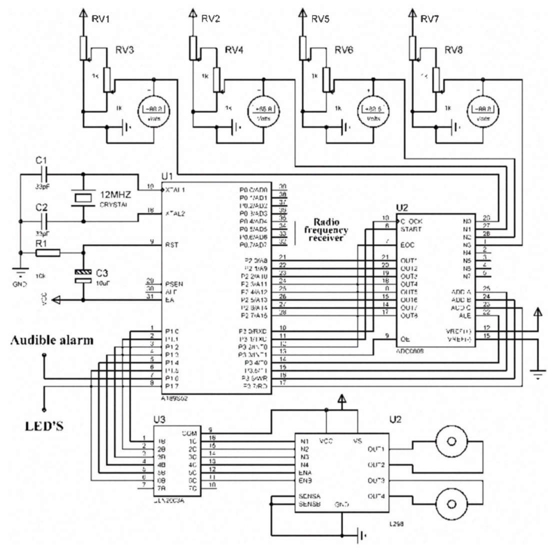

Fig. 3 Integrated hardware circuit

Security unit is developed by connecting remotely controlled unit, analog to digital converter, and motor module with a microcontroller. On-chip oscillator is used for microcontroller; analog to digital convertor uses clock frequency from the microcontroller. Remotely controlled unit has two main divisions: Transmitter and Receiver. The transmitter sends the encoded data from a keypad by the human using radio frequency; the receiver receives decoded data. Transmitter module contains an encoder (PT2262) and on a receiver side decoder (PT2272) is utilized. The receiver element is directly connected with the microcontroller and respected operation is performed from the information of a receiver element. Mobile robot gets distance information from sensors; this distance is between the mobile robot and object. As the output of distance sensors is in analog form; so, it is converted into digital data through analog to digital convertor module. After the conversion security unit performs its own functions regarding to the motion of the robot. A dual full-bridge motor driver (L298) is used to accept logic levels and drive the direct current motors. We made use of two enable pins of motor driver to enable or disable the motor independently. In order to give proper power to each unit, their divisions have been made: 5V for sensors, 9V for motor module, and 5V for controller board. The intact robot control system is implemented for experimentation as represented in Fig. 6.

```
a = 1...........b...........c...........d;
ADC = 1;
ADC = 0;
w = getdata1;
x = getdata2;
y = getdata3;
z = getdata4;
if w,x,y,z = 0 then
        manualmode();
     else
        for j = 1...........d
          do
            if w,x = 1...........b then
                    motor1P = 0 & motor1N = 1;
            else if w,x = b...........c then
                    motor1P = 0 & motor1N = 0;
            else if w,x = c...........d then
                    alarm = 1;
        for j = 1...........d
          do
            if y,z = 1...........b then
                    motor1P = 1 & motor1N = 0;
            else if y,z = b...........c then
                    motor1P = 0 & motor1N = 0;
            else if y,z = c...........d then
                    alarm = 1;
        manualmode();
go to 2
```

Fig. 4 Pseudo code

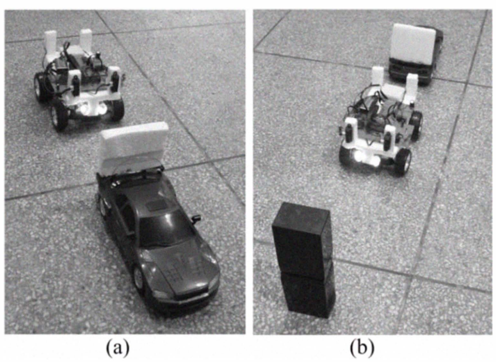

Fig. 5 Experiments: (a) Collision avoidance from front side of the robot, (b) object detection from back and front side of the robot.

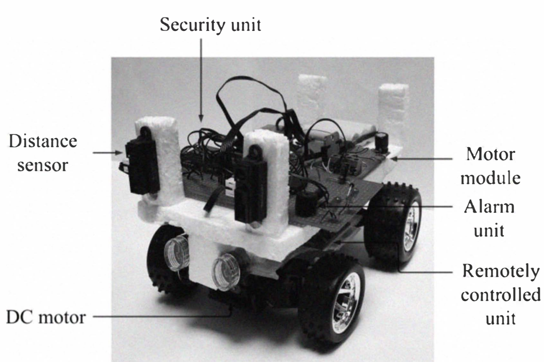

Fig. 6 Hardware device composition

IV. Experiments And Results

First approximation in the design showed the possibility of using two central sensors to control robot from back and front; but, several experiments showed that there was a problem when an object came from sides of the robot. Therefore, adding some more sensors to resolve this problem. The use of high sensitive distance sensors in robot increased its safety level and the integrated monitoring system showed good performance in the experiments. The experimental tests have been carried out in the real environment by moving the robot between different vehicles and objects as demonstrated in Fig. 5. By performing a series of tests, four curves are obtained which represents the characteristics of the distance sensors as shown in Fig. 7. Distance accuracy is measured by monitoring the robot. Curves are approximately similar with respect to the distance and output of the distance sensor. These experimental results indicate that the proposed method can be very helpful to avoid collision between the vehicles. It is supposed that if two vehicles come from the front and back toward the robot with much faster speed then there might be an accident. It can be minimized by mounting this accident avoidance security system in a number of vehicles. Therefore, the security system in every vehicle will take decisions for the object detection in the surroundings.

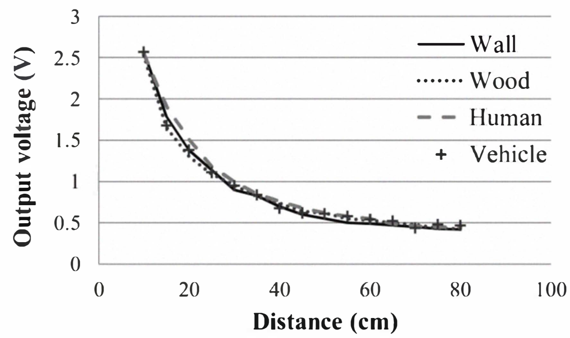

Fig. 7 Experimental results of distance sensor (GP2D12)

V. Conclusion

In this paper, a security system is presented to avoid accidents between the vehicles. It can be controlled by the human and automatic control system. The mobile robot architecture has been tested by moving it between different vehicles and objects. A navigation approach of the robot has also been applied based on range-sensors and remotely controlled unit. Furthermore, this work gives an idea that this distance monitoring system may be used in the robots to prevent collision between them as well in industrial applications to carry substances behind another moving object by following collision prevention methodology. Future work will focus on well-defined sensor architecture and improved version of accident avoidance security system. We will also explore such a kind of security system that would be helpful in the automobile overtaking.

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