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Obstacle Avoidance and Navigation Robotic Vehicle using Proximity and Ultrasonic Sensor, Arduino Controller

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ABSTRACT
Obstacle Avoidance and Navigation Robotic Vehicle is an intelligent robot that automatically senses, scans and directs itself to overcome obstacles on its path. The system uses the proximity sensor and ultrasonic sensor to detect and locate obstacles on its path and navigates to an obstacle-free path. This technique is designed to sense obstacles on its path, apply brakes automatically, scans its environment and take a safe route in order to avoid unpredicted danger. This robotic vehicle is a microcontroller based system which is useful in automobiles as an intelligent vehicle assistant for safe driving. The system is designed using C programming language and Arduino Software (IDE) and uploaded on Arduino board. Ultrasonic sensor was used to detect an obstacle in front of the vehicle while the proximity detector/sensor to identify an obstacle behind the vehicle. The sensors send the data collected to the Arduino controller which compares and directs the motor-driver to move the vehicle.

Keywords: Arduino Microcontroller, Intelligent system, Robotic Vehicle, Ultrasonic sensor, and Proximity sensor.

1. INTRODUCTION

An obstacle avoidance and navigation robotic vehicle is an intelligent robot that senses an obstacle, maneuver it in order to move in a safe path to avoid collision. Obstacles on its path can automatically be detected intelligently through the use of sensors and subsequently avoid the obstacles by making decisions based on the codes that was set for it (Kirti, Sayalee,Shreddha, ans Sneha, 2016). A robot is a system or machine that can perform task automatically (Kirti, et al., 2016) and it's generally a combination of computational intelligence and physical machines (motors) (Vairavan et'al, 2018). According to Faiza, Susmita, Muhammed, and Dr. Bilkis (2017), obstacle avoidance in robots can bring more flexibility in maneuvering in varying environments and would be much more efficient as continuous human monitoring is not required.

We developed an obstacle avoidance and navigation robotic vehicle which can move without any collision by sensing obstacles on its way, applies a brake, scan through to detect a safe path and moves to the safe path with the help of micro-controller to process the data, ultrasonic sensors, proximity detectors and motor drive. The ultrasonic sensor detects obstacle (Munna Pandit, 2019), and also used to put down the time taken by the sensor to transmit ultrasonic beams and equally receiving the ultrasonic beams after hitting the surface. The proximity detection was used to automatically measure the distance between the path of the vehicle in order to sense the obstacles that are either in front or behind. It can show the distance and give a sound-light alarm in real time, and ensures that the vehicle runs safely and reduce the accident ratio. Dilip et'al (2016) noted that with this type of system, the vehicle will detect whether it is in a safe zone, warning zone or stop zone to park. If the vehicle is in some distance in stop zone, it will give a sign and the vehicle will apply brakes automatically, move back a little, scan around it and take a safe route in order to avoid unpredicted danger. Robots guided with this technology can be put into diversified uses, such as supervisor robots, military vehicles, surveying landscapes, autonomous cleaning, driverless vehicles, environments dangerous for human penetration, and automated lawn mower.

Different researchers have carried out similar studies in the past and some of the working principles and methods are discussed. As noted by Faiza et'al (2017), some of these works differ by selection of sensors, path mapping process and the algorithms applied to set the operational parameters.

Vairavan et'al, (2018) designed an obstacle avoidance robot vehicle which is controlled by ultrasonic sensor. The robot is made using ultrasonic sensor and it is controlled by Arduino microcontroller. Ultrasonic sensor fixed in front portion of the robot vehicle. The sensor gets the data from surrounding area through mounted sensors on the robot. The sensor sensed the obstacle and deviate its path to choose an obstacle free path. The sensor will send the data to the controller and compared with controller to decide the movement of the robot wheel. The robot wheel movement and direction will be based on the sensing of the ultrasonic sensor and also using a wheel encoder.

Iswarya et al. (2018) proposed a robotic vehicle that has an intelligence built in it such that it directs itself whenever an obstacle comes in its path and to protect the robot from any physical damages. This can be designed to build an obstacle avoidance robotic vehicle using ultrasonic sensors for its movement. A micro-controller (AT mega 328P) is used to achieve the desired operation. An ultrasonic sensor is used to detect any obstacle ahead of it and sends a command to the micro-controller. Depending on the input signal received, the micro-controller redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver.

Faiza et al. (2017) employs multiple sensors for enhancing the horizontal range of searching obstacles. These ultrasonic distance sensors work in combination to measure distance to the surrounding objects and detect the presence of obstacles if they are within the threshold distance. The inclusion of three sensors of the same kind provides more accuracy in obstacle detection as it widens the field of searching.

Kirti et al. (2016) proposes an autonomous robotic vehicle in which no remote is used for controlling the robotic actions. It intelligently detects obstacles present on its path through the sensors, avoid it and take decision on the basis of internal code that was set for it.

Pavithra and Subramanya (2018) proposed robotic vehicle that has an intelligence built in it such that it directs itself whenever an obstacle comes in its path. This robotic vehicle is built, using a micro-controller of AT mega 328 families. An ultrasonic sensor is used to detect any obstacle ahead of it and sends a command to the micro-controller. Depending on the input signal received, the micro-controller redirects the robot to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver. Some of the project is built with the IR sensors has its own application so in our project those application is not compactable so we are using ultrasonic sensor.

Mishi et al. (2017) designed a robotic car. Arduino Uno and Raspberry Pi were used together to control robot in this project. GPS was also used to trace the car and the distances between the obstacle and the path are measured. The data in the cloud was used without having to be online. Thus, the multi-motion system was controlled.

Kolapo et al. (2018) presented an obstacle detection and avoidance system for an unmanned Lawnmower. The system consists of two (Infrared and Ultrasonic) sensors, an Arduino microcontroller and a gear DC motor. The ultrasonic and infrared sensors are implemented to detect obstacles on the robot's path by sending signals

to an interfaced microcontroller. The micro-controller redirects the robot to move in an alternate direction by actuating the motors in order to avoid the detected obstacle. The performance evaluation of the system indicates an accuracy of 85% and 0.15 probability of failure respectively.

Based on the above assertions, we deduced that the ultrasonic sensor is one of the best techniques which is used to sense obstacle. Unlike the above projects, we combined the proximity and ultrasonic sensors to provide more accuracy in obstacle detection and measured the distance of objects either behind or in front in order to know whether the obstacles are within the threshold distance. We deemed it important to get a sensor that can measure how close the reading of object is to the true distance, and equally report smallest reading or change in readings. Equally when the system detects an obstacle, it moves back a little and scans its surroundings for a safer path to avoid any obstacle.

2. MATERIALS AND METHODS

2.1 Design of the System

At this stage, a proper understanding of the system was made. The practical way in which the system will work was both drawn and modeled. Various functional units that are very necessary for the system was identified and assembled for the commencement of the circuit design.

The circuit design of the system is the process of working out the physical form that an electronic circuit will take and the result of the circuit design process is the full instructions on how to construct the physical electronic circuit. Below depicts the circuit powered with 9V battery. The ultrasonic and proximity sensors are connected to the Arduino board, and the motor driver is also connected to the board through a relay switch.

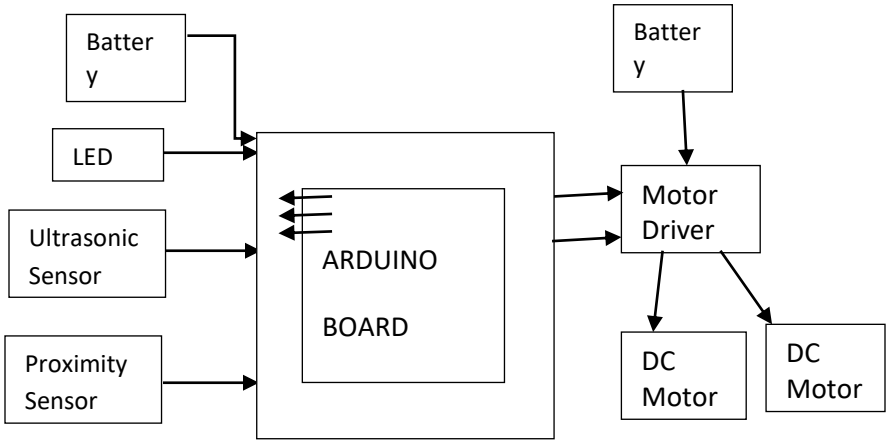

Fig.1 Circuit diagram for the sensors using Arduino controller

2.2 Arduino Uno Platform

Arduino Uno is a microcontroller board that uses ATmega328P microprocessor. It consists of 14 digital pins (input/output) of which (6 can be used as PWM outputs and 6 analog input pins), 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. To power the Arduino, either you use a battery, AC – to – DC adapter or using a USB cable to connect it on a computer. The rating should be 9V DC 100-500mA power adapter, with a 2.1mm barrel plug and positive tip. Beside the USB jack is a jumper with 3 pins. If the jumper is on 2 pins near the USB jack, it means you're powering through a USB cable; if it's on 2 pins near the DC jack, you are powering via a battery or wall adapter. The communication between the Arduino and the computer is done using the USB cable to transfer data serially. One advantage of Arduino Uno is its easy programmability. The Arduino programming is carried out in the Integrated Development Environment (IDE). The programming language selected is Embedded C language. Using signals from sensors, it helps to design robots and systems that affect the environment.

Fig.2 Arduino, USB Cable and Power Adapter

2.3 HC-SR04 Ultrasonic Sensor and Arduino Interface

According to Iswarya et al (2018), ultrasonic sensors are devices that use electrical–mechanical energy transformation to measure distance from the sensor to the target object. Ultrasonic waves are longitudinal mechanical waves which travel as a sequence of compressions and rarefactions along the direction of wave propagation through the medium. An Ultrasonic sensor is used to measure the distance to an object by using sound waves. It consists of four pins which are VCC (5v power supply), GND (Ground), Trigger pin gives TTL pulses (15us) and echo pin to get output from the sensor. There are two transducers, one for Transmit & the other to Receive.

Connecting Ultrasonic sensor to Arduino:

- Red wire is connected to +5V in Arduino
- Black wire is connected to ground in Arduino
- Yellow wire is the analog pulse which can be connected to analog inputs in Arduino.

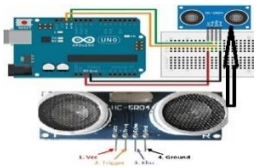

Fig. 3 HC-SR04 Ultrasonic Sensor and Arduino Interface Connection

2.4 VCNL4010 Proximity Sensor

The VCNL4010 proximity sensor is an ambient light sensor designed for short distance detection and works best at a distance of about 10 - 150 mm. It can be used on 12C microcontroller capability and 3.3V or 5V with no risk of damage. The VCNL4010 proximity sensor consists of three power pins and three data pins. The power pins are Vin, 3V0, and GND. The Vin is the power pin. It uses 3VDC for logic, so a voltage regulator is included on the board to take 3-5 VDC and safely convert it down. Power the board with the same power as the logic level of your microcontroller. 3Vo is the 3.3V output from the voltage regulator. GND is the common ground. The data pins are SCL, SDA, INT. SCL is the I2C clock pin and it connects to the microcontrollers I2C clock line. SDA is the I2C data pin and it connects to your microcontrollers I2C data line and it uses 3V or 5V logic. INT is the interrupt output used to give you an alert when the sensor detects something.

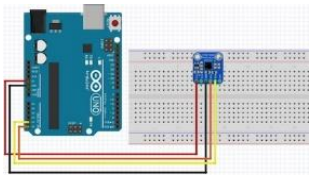

Fig.4 VCNL4010 Proximity Sensor and Arduino Interface Connection

2.5 L293D Motor Driver

The L293D Motor Driver IC allows Direct Current (DC) motor to drive on either direction. The Motor Drive is a 16-pin IC that controls a set of two DC motors simultaneously in any direction. That is, the single L293D IC can control two DC motor.

Fig.5 L293D Motor Driver

2.6 DC Motor

Esra and Sibel (2019) asserts that Direct Current (DC) Motor converts electrical energy into mechanical energy using direct current. They said that the DC motor is an electric machine that works with the principle of "A current carrying conductor is exposed to humid when it enters a magnetic field". There are 6 components of DC motor and they are coils, magnets, rotors, brush, stator and direct current source. The DC motor is used in this work to turn the wheels. The armature is placed in the magnetic field generated by the coils and rotated using direct current so that mechanical force is generated.

Fig.6 DC Motor

2.7 Working Principle

The obstacle avoidance and navigation robotic vehicle uses an ultrasonic sensor to detect any obstacle in forward direction. The ultrasonic sensor emits short and high frequency signal and the signal reflects an echo input to the sensor through the echo pin. When an object is sensed within its distance, the ultrasonic sensor sends information to the Arduino. The Arduino calculates the distance to the object. When this distance reduces to a certain level, the robot will interpret it to mean an obstacle on its path. It will stop, move backward a bit, scans its' left and right and then turns to the direction of more free space in front of it. Likewise, the back movement of the robot uses a proximity sensor to detect the presence of proximate objects. The proximity sensor emits a beam of electromagnetic radiation (light waves) to scan for objects in return signal. When it detects an object in its return signal, it sends a signal to the Arduino which instructs the robot to stop. The microcontroller controls the motors left, right, back, front based on ultrasonic signals.

2.8 Algorithm

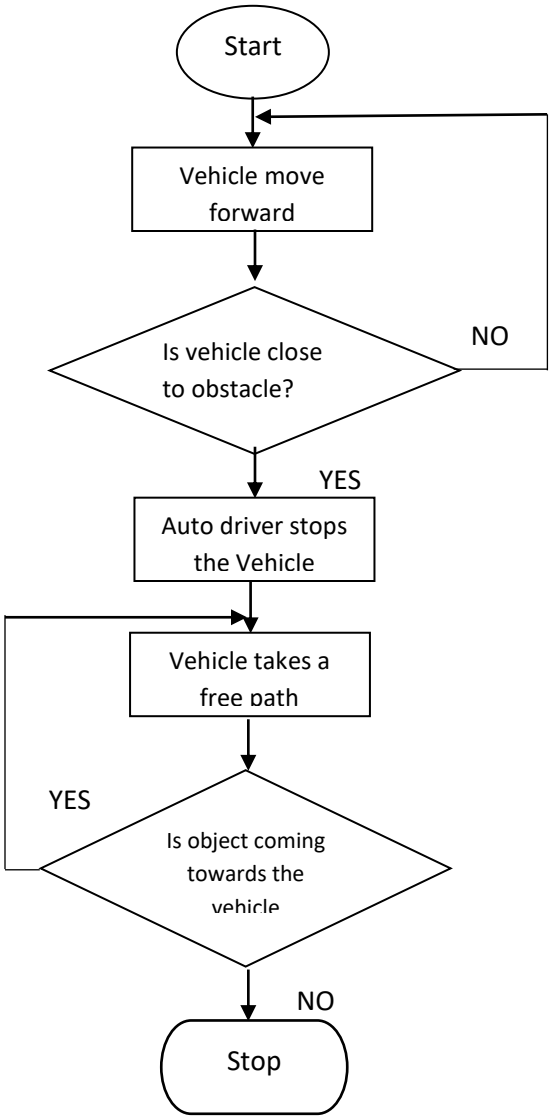

Fig.7 Obstacle detection and avoidance using Ultrasonic sensor.

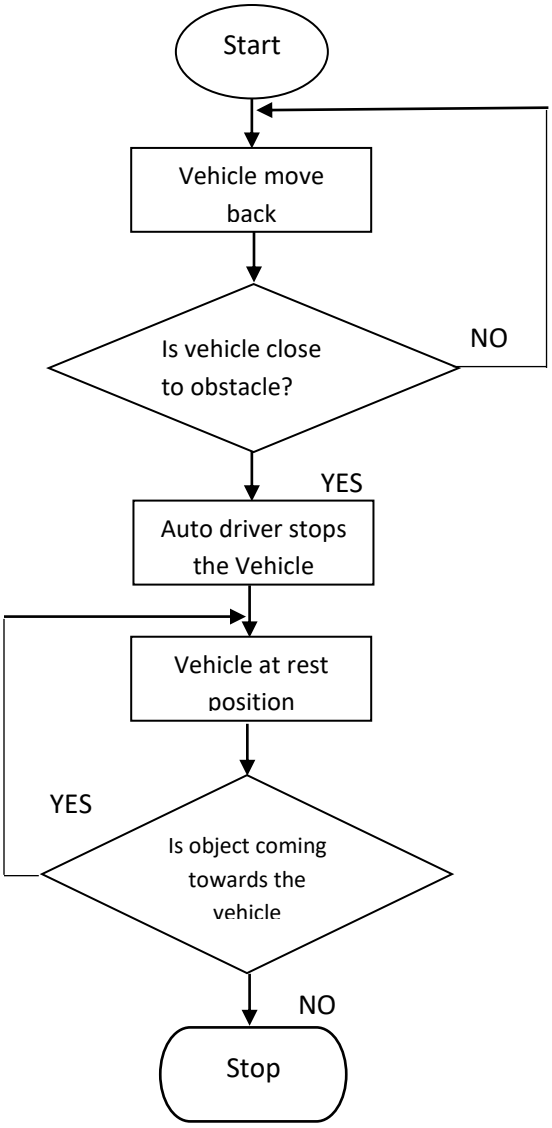

Fig.8 Obstacle detection and avoidance using proximity sensor.

2.9 Arduino Software (IDE)

The Arduino IDE is a software development platform that allows you to use the Arduino kits to write codes, compile the codes, and load the compiled codes directly into the Arduino Uno controller board. The controller board is used to communicate with the computer using serial communicator (USB connection). The data is transferred between them bit by bit. An adaptor is used to supply power to the controller board and a USB programmer is used to burn the hardware program (written in Arduino IDE) into the Arduino board. The programming for the system is done in C Language and uses various pre-defined header file.

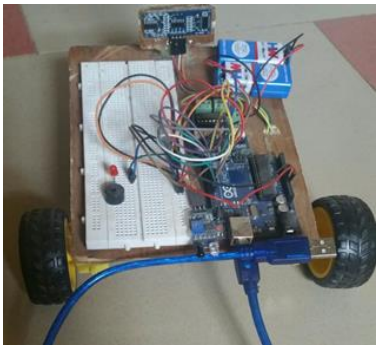

Fig.9 the prototype of the designed system

3. RESULT AND DISCUSSION

The obstacle avoidance and navigation robotic vehicle was developed and tested by placing obstacle at various distances across its path. The two sensors were evaluated individually since they were positioned in front and the back of the robot. The actual result was expected as the system was designed to detect an obstacle and apply brake, move back a little and scan its surroundings, to move the vehicle to a safe path. The test carried out showed that if the vehicle is on high speed, it will not stop before hitting an obstacle especially if the obstacle wasn't identified within some distance or if the obstacle is coming from the side lane. On the other hand, if the vehicle is on high speed and the obstacle is detected, the system does its job by applying brake (the vehicle starts to slow down until it stops and not just stop at a onetime application of brake), quickly scan around it and take a safer route. If the obstacle is a manageable one (example speed bump), the vehicle alternates the system and then crosses over the obstacle.

4. CONCLUSION

The goal of this paper is to design a robotic vehicle that is able to intelligently detect obstacle on its path and avoid it. This was done using the Ultrasonic and proximity sensors to detect obstacles, motor driver for the driving the DC motors, and DC motor is used for the movement of the robot with the help of the Arduino Microcontroller. The Arduino platform for data processing and its software counterpart on C programming language helped to communicate with the robot to send parameters for guiding movement. The result presented an accurate and efficient detection of obstacles and its maneuvering in order to assist vehicle driving. Obstacle avoidance is a very good application to be used in vehicle to prevent accidents and loss of life.

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