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Autonomous Vehicle with Obstacle Evasion Capability

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Abstract

This paper involves the design and implementation of an obstacle-avoidance vehicle. The goal of this project is to build a vehicle that, when in motion, can recognize obstructions in its route and, in the absence of outside interference, alter course as essential. Based on sensor inputs, the robot determines the new direction to prevent a collision as the direction with the largest distance between the obstacle and the sensor. An ultrasonic wave sensor, which sends pulses to assess distance, was used in this implementation. In order to activate the obstacle avoidance attribute, the motor driver shield also regulates the movement of the DC motors for wheel movement and the servo motor for sensor movement. The orders are transmitted to the the Arduino micro controller chip, which manages the sensing and movement of the robotic vehicle and acts as its primary control unit. The robotic vehicle that was put into service was effective in picking out and avoiding objects that were in the ultrasonic sensor's direct view.

Keywords: Mobile Robot, Wheeled Robot, Robotics, Arduino, Obstacle Avoidance

INTRODUCTION

Background

Since it is the most simplest method of altering contemporary technology, robotics is an extremely fascinating field of study that is expanding quickly in our planet. I chose to work in the field of robotics and create an intelligent device to make life easier for people since robotics plays an essential part in the evolution of technology. An autonomous robot is one that can maneuver in an unstructured, foreign environment without assistance from other sources.

The robot's software intelligence, that allows it to assess its surroundings, identify impediments in its route, and navigate the environment by avoiding them, is what allows it to accomplish this. [1] Many robotic designs can be bought for use in the process of building an autonomous robot. The physical environment in which the robot will be operated is the primary consideration when picking the design to be employed. Drones, robotic automobiles, walking robots, and snake robots are a few examples of self-navigating robots.

The obstacle-avoiding robot has enough brains to cover the whole area of the available space. It also contains an ultrasonic sensor, which it uses to identify obstructions in its path and move in an obstacle-avoidance direction. The primary goal of this technology is its potential to significantly impact modern transportation by preventing accidents, which typically occur on crowded roadways when emergency brakes are applied. When this technology is installed in an automobile, it will automatically detect any objects—living or otherwise—that are in its path and, if needed, will apply breaks or veer into an unobstructed area [2-3].

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Research Problem

Obstacle avoidance is a fundamental required for any autonomous mobile robot. In order to avoid collisions while operating, a robot's navigation system in an unfamiliar region must include this obstacle avoidance purpose. An autonomous robot has to avoid collisions in order to shield the item and the robot from harm. Obstacle avoidance is required in some application fields, such as automated vacuum cleaners and airliners.

Robots operating in familiar environments with well-defined paths may encounter hurdles in their path due to unforeseen environmental changes. Therefore, the robot must possess the ability to adapt by evading obstacles and adjust as well The inability to plot an optimal course has made robots that can recognize and avoid things on pre-computed paths or those that arrive out of nowhere crucial. The robot's use of sensors to identify and avoid things is the answer to this trajectory problem, which increases the robot's independence because it no longer needs any outside help [4].

Motivation

The idea of an autonomous robot is not a new one. Every company that uses mobile robots to perform tasks would like the robot to be able to carry out its functions effectively without any external control. With the advancement in the GPS technology, achieving the independent robot movement is closer to reality- However, the concern of how the robot sees and interacts with its environment must be addressed before the robot is used. To address this concern, sensors are used to collect enough environmental data that the robot interprets for smooth navigation of the robot. This method of addressing the concern leaves three questions: is it possible for a sensor to collect enough data for collision-free movement? Also, is there a fast and effective method of interpreting this data to the robot? Lastly, after interpretation, can the robot react and make correct decisions as quick and precise as a human would in the same environment? In order to promote robot mobility without the need for humans, several concerns must be met [5].

Objectives

The purpose of this study is to build and develop a robot automobile that can navigate an uncharted area without encountering any difficulties.

The Objectives of the project are as follows;

- Using a preset threshold distance, the robot car should be able to identify obstructions in its along the way.
- After detection of an obstacle, the robot should be able to change its direction to a relatively open path by making an autonomous decision.
- The robot car should not require any external control during its operation.
- Real-time measurements of distance between the robot car and an obstacle should be allowed.
- The robot automobile ought to be able to function well in an area that it is unfamiliar with:

AUTONOMOUS OBSTACLE AVOIDANCE ROBOT

Arduino

Arduino is a popular open source manufacturing platform built on user-friendly hardware and software. It is made up of a programmable microcontroller unit and the Arduino Integrated Development Environment (IDE) which is used to write and upload codes to the Arduino board. The Arduino board is the physical microcontroller boards used for making electronic projects. Arduino boards have the ability to read inputs and outputs from them. You can send instructions to the microcontroller on the Arduino board and tell it what to do using the Arduino programming language (based on Wiring). Due to the open-source nature of the Arduino environment, codes are easily written and uploaded to the Arduino board. Arduino is written in Java so it can be run on Linux [6].

The key features of Arduino include;

- The Microcontroller boards are capable of detecting signals (analog or digital) from different sensors and convert the input into an output by triggering a response such as activating a motor, turning a LED on or off, and many other actions.
- The microcontroller board functions can be controlled by sending instructions to the microcontroller using the Arduino Integrated Development Environment.
- An external piece of hardware for loading code into the board is not requires unlike in some other circuit boards. Just a USB cable is required [7].
- It is simple to learn the Arduino programming language as it is a simplified version of C++. Arduino allows for a standard form factor, which breaks the functions of the board to a more accessible package (Figure 1).

DC Motor

A DC motor is a type of electrical motor that develops mechanical force by use of direct current (DC). The most popular kinds rely on magnetic forces generated by helical currents. Almost all varieties of DC motors contain an internal mechanism—electromechanical or electronic—that allows the motor's portion of the current to be periodically reversed. The stator and armature of a basic DC motor contain a fixed set of magnets, and the magnetic field is focused by one or more windings of insulated wire encircling a soft iron core. Large motors may have numerous parallel current routes, and the windings often have multiple rounds around the core (Figure 2).

The wire winding's ends are tied to a commutator. Through brushes, the commutator links the revolving coils to the external power source and allows each armature field to be powered in turn [8].

Ultrasonic Sensor

Four pins make up the sensor itself. The VCC pin receives 5 volts, and the Arduino's GND is linked to it. The TRIG and ECHO pins are designated by the names of the other two pins. The ECHO pin receives the signal that the object reflects after the Trig pin produces an ultrasonic pulse (Figure 3).

Figure 1. Arduino board.

Figure 2. DC Motor.

Figure 3. Ultrasonic Sensor.

In order to function, ultrasonic sensors need to create sound waves at frequencies that are too high for people to hear. The transducer on the sensor acts as a microphone to both transmit and receive ultrasonic sound. Additionally, they share and receive pulses using a single transducer.

In addition, the sensor computes the target's distance and records the duration required to transmit and receive an ultrasonic pulse. High-frequency sound waves go out and received in the center of an ultrasonic sensor's operation. The frequency range of these waves is 20 kHz, which is inaudible to humans. This is a condensed description of how ultrasonic sensors behave [9].

Servomotor

One kind of motor that has very accurate rotation is a servo motor. Typically, this kind of motor is made up of a control circuit that gives feedback on the motor shaft's present location. This feedback enables the servo motors to rotate extremely precisely. A servo motor is used when you wish to rotate an object at a certain angle or distance. It consists only of a basic motor that is driven by a servo mechanism. A motor is referred to as a DC servo motor if it is run by a DC power supply and as an AC servo motor if it is supplied by AC power. We will just be talking about how DC servo motors operate in this lesson.

There are several more varieties of servo motors that differ in the kind of gear arrangement and operating characteristics, in addition to these main classes. The gear layout that servo motors often have enables us to produce very high torque servo motors in tiny, lightweight designs. Owing to these characteristics, they find usage in several applications such as robotics, RC cars and helicopters, and toy cars. The majority of hobby servo motors are rated at 3 kg/cm, 6 kg/cm, or 12 kg/cm. Servo motors are rated in kilograms per centimeter, or kg/cm. The weight your servo motor can lift at a specific distance is shown by this kg/cm. For example: If the load is hanging 1 cm from the motor shaft, a 6 kg/cm servo motor should be able to lift 6 kg; the larger the distance, the lower the weight bearing capability. A servo motor's position is determined by an electrical pulse, and its electronics is situated next to the motor (Figure 4).

LN298N Motor Driver

Two DC motors may be synchronously controlled for both speed and direction thanks to the twin H-Bridge motor driver L298N. DC motors with a peak current of up to 2A and a voltage between 5 and 35V can be driven by this module. Two screw terminal blocks are located on the module for the motors A and B. The there is a screw terminal block for the ground pin, the motor's VCC pin, and a 5V pin that may be used as an input or output. The voltage applied at the motor's VCC determines this. A jumper may be used to enable or disable the module's built-in 5V regulator (Figure 5).

Figure 4. Servomotor.

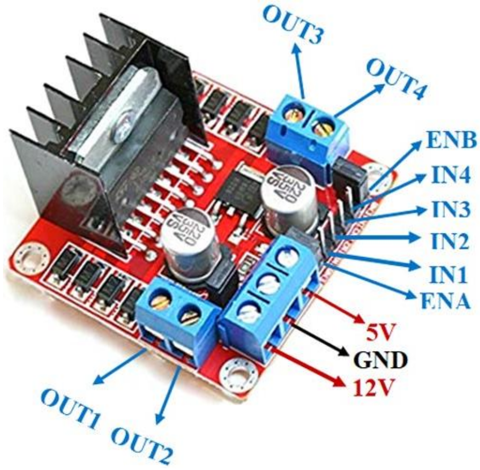

Figure 5. LN298N Motor Driver.

We may turn on the 5V regulator and utilize the 5V pin as an output, such as to power our Arduino board, if the motor supply voltage is up to 12V. However, we have to unplug the jumper if the motor voltage is higher than 12V, as those values will harm the onboard 5V regulator. Since the IC needs to be powered by a 5V source in order to function, the 5V pin will be utilized as the input in this instance.

Battery

This Li-ion Rechargeable Battery Pack is a 3s battery pack with a nominal voltage of 12.6 volts. With three cells linked in series, this battery pack has a 1200mAh capacity. A built-in BMS in the battery pack guards prevent short circuits, overcharging, and over discharging. Details 12.6V is the charging voltage. Current for Charging: 600 mA Pack Voltage Nominal: 11.1V Discharge Current: 1A and 500mA tests were performed. Max discharge current: 1.2 milliamperes Safety (Including BMS) Protection against Short Circuits Applications Overvoltage cutoff: 12.8V; Undervoltage cutoff: 9.2V(Figure 6).

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CONSTRUCTION

Connect the motor and wheels to the chassis by soldering the thick red and black wires to the positive and negative terminals of the motors then attach them to the chassis. Attach the switch, battery clip, SG90 Servo Motor and Arduino UNO to the chassis- After this mount the LN298N Motor driver into the chassis.

- Attach the LN298N Motor Driver to the two DC motors.
- Join Arduino pins IN1, IN2, IN3, and IN4 to LN298N pins.
- Join Arduino pins 5V, GND, A1, and A2 to the ultrasonic sensor pins VCC, GND, TRIG, and ECHO.
- Attach Arduino pins 5V, GND, and 10 to servo pins VCC, GND, and SIGNAL.

The motor terminals of the L298N motor driver module are where motors are attached. Three more connections are present on the motor driver, one of which is 12 volts and attributed to the battery. To power the Arduino board, 5 volts are connected to "Vin" on the Arduino board, and the GND terminal is linked to both the battery's negative terminal and the Arduino board's Grounds pin (Figures 7 and 8).

Figure 6. Battery.

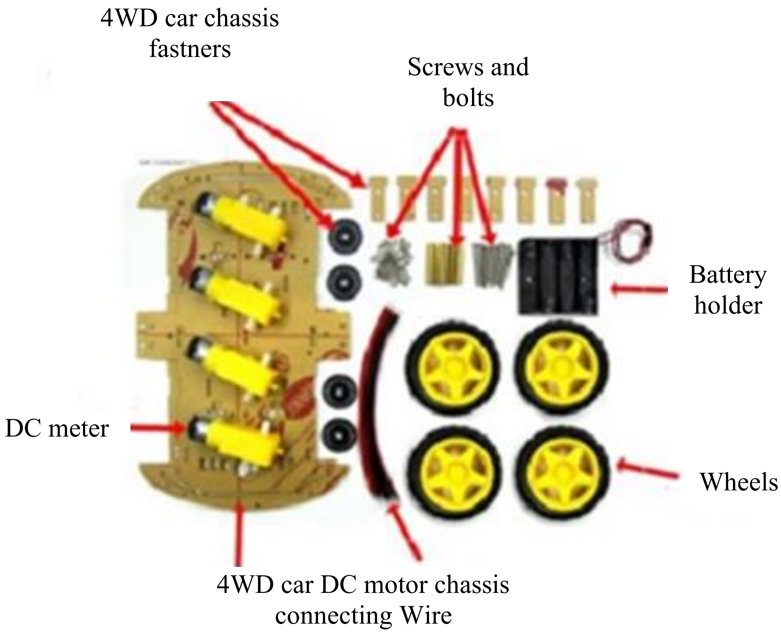

Figure 7. Robot Chassis.

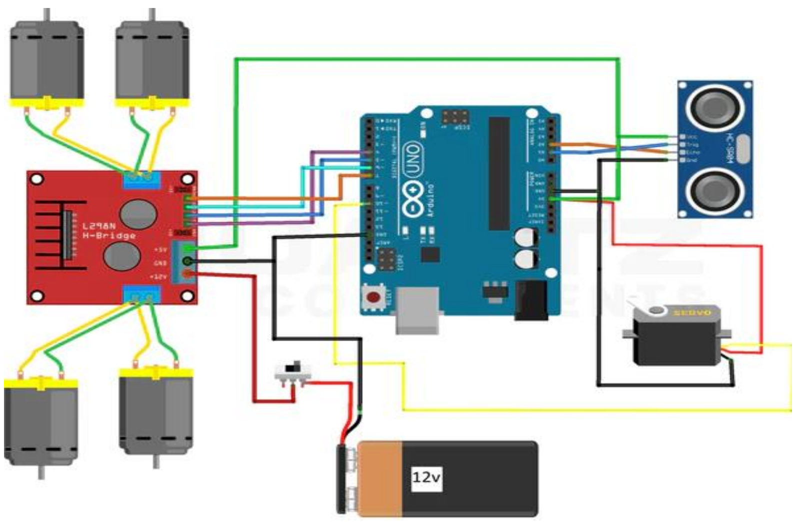

Figure 8. Circuit Diagram.

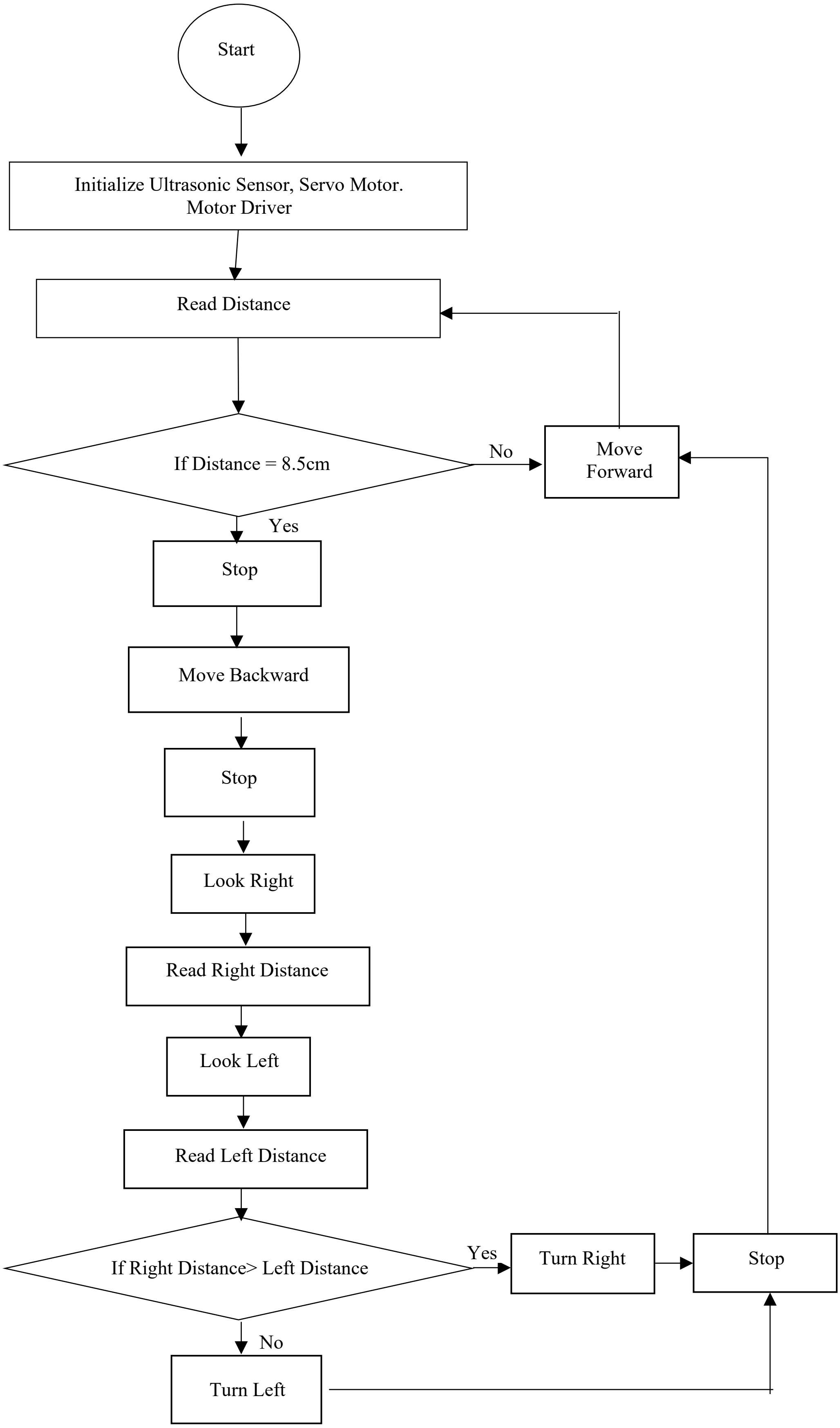

Figure 9. Flowchart of working.

WORKING

An autonomous obstacle avoidance vehicle utilizes a network of sensors, processing units, decision-making algorithms, and actuation mechanisms to navigate its environment independently. Cameras, lidar, infrared, ultrasonic, and other sensors offer real-time information on the environment around the vehicle.

This data is then processed by onboard computers, which employ sophisticated algorithms to interpret the information, identify obstacles, and assess potential risks. The vehicle's system of controls decides how to maneuver around obstacles while keeping the vehicle on its planned trajectory based on the data that has been studied.

Path planning algorithms calculate safe routes, taking into account factors such as obstacle size, distance, and dynamic changes in the environment. Actuation mechanisms translate these decisions into physical movements, adjusting the vehicle's speed, direction, and trajectory to avoid collisions. Throughout this process, the vehicle operates within a feedback loop, continuously monitoring its surroundings and adjusting its actions in real-time. This adaptive responsiveness enables the vehicle to navigate safely through dynamic environments while avoiding obstacles effectively (Figure 9).

CONCLUSION

This article demonstrates a self-governing obstacle avoidance vehicle utilizing an Arduino microcontroller, an ultrasonic sensor for object detection, a motor driver for DC motor command, and DC motors for the robot's wheel movement. The robot's testing environment and the quantity of impediments in the test space are two aspects that impact the developed robot's effectiveness.

The performance and accuracy this robot majorly depends on the sensor used and the number of sensors used. The ultrasonic sensor used is for commercial applications and it can easily encounter interference.

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