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Obstacle avoiding robotic vehicle with arduino and ultrasonic sensor

BalaKrishna K,
Asst Prof, Vignan's Foundation for Science, Technology & Research

Rachananjali K,
Asst Prof, Vignan's Foundation for Science, Technology & Research

CH.N. Narasimha Rao
Asst Prof, Vignan's Foundation for Science, Technology & Research

***Abstract*---**Obstacle detection and avoidance is one of the most challenging problems in the design of mobile robots. Without it, a robot movement would be very limited and flimsy. The obstacle detection and avoidance is like a built in intelligence that grants the robot the senses, which helps it to navigate in any unfamiliar environment without causing any physical damage to itself. In this project, an attempt is made to design an Obstacle Avoiding Robotic vehicle, which can sense the obstacles in its path, can evade them and can resume its running. This Robotic vehicle is microcontroller based and the obstacle detection and avoidance is done by using distance sensors or proximity sensors, which detects the nearest obstacle distance and sends commands to micro controller to maneuver the robot around the obstacle without making any collisions. Arduino Uno board is selected as the microcontroller platform and Arduino software is used for programming purposes. The robot is designed in such a way that it can cover the maximum area of provided space. The hardware used in this project is widely available and inexpensive.

***Keywords*---**Obstacle, Detection and avoidance, Microcontroller, Proximity sensors, Arduino.

Introduction

Robotics is the fastest growing research field in modern world. Right from their initiation from the early 1950s, the present day robots have been modified a long way and has contributed a lot to the advancement. Apart from all the other technological aspects and developments in their design and functionality, one thing that needs to be constantly looked upon is the mobility of the robots. In

the aspect of mobility, the term “obstacle avoidance” denotes the ability of robot to navigate in unknown environment avoiding collision with neighbouring objects. This obstacle avoidance in robots can make them flexible in dangerous environments and continuous human monitoring is not required. Robots imbibed with this technology can be put into various diversified uses, e.g, driverless vehicles, landscape surveying robots, autonomous cleaning robots, autonomous lawn mowers, smart room cleaners and supervisory robots in industries.

Methodology

There have been a number of attempts in designing obstacle avoidance robotic vehicles. We had reviewed different obstacle detecting robot mechanisms that are in existence and came across some very popular techniques such as wall-follower, edge detector and line follower. The drawback with all these methods is that the robot movement needs to be stopped when it is in front of an obstacle so as provide accuracy in measurement. So, smooth navigation is not possible. Also, the algorithms involved are far more complex. These problems can be solved by using a proximity sensor, which detects any obstacle present in front of it and a command is sent to the microcontroller. Due to which the navigation of robots can take place smoothly during the operation hence avoiding the collisions. The proximity sensors such as IR sensors, Ultrasonic sensor etc., can navigate the robot smoothly during the operation to avoid the collisions.

Design of the project

The ultrasonic sensor output is fed to Arduino uno microcontroller so as to process it to make decisions for safer navigation based on the code embedded into the controller. Based on the instructions already feed and the inputs from ultrasonic sensor the microcontroller takes autonomous decisions to dodge any collisions. The microcontroller is connected to a dual motor driver, which implements the decisions made by microcontroller. Fig 1 shows the block diagram of the obstacle avoiding robotic vehicle whereas Fig 2 shows the system design of the obstacle avoiding robotic vehicle.

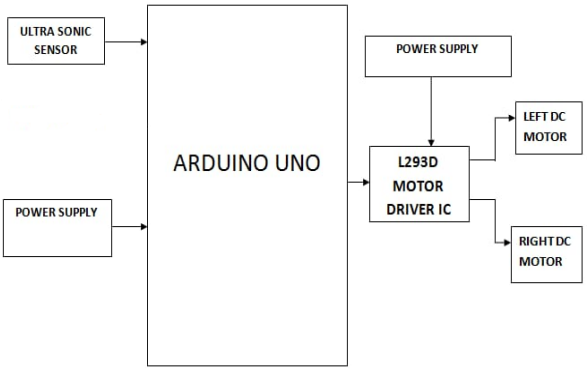

Fig-1: Block diagram

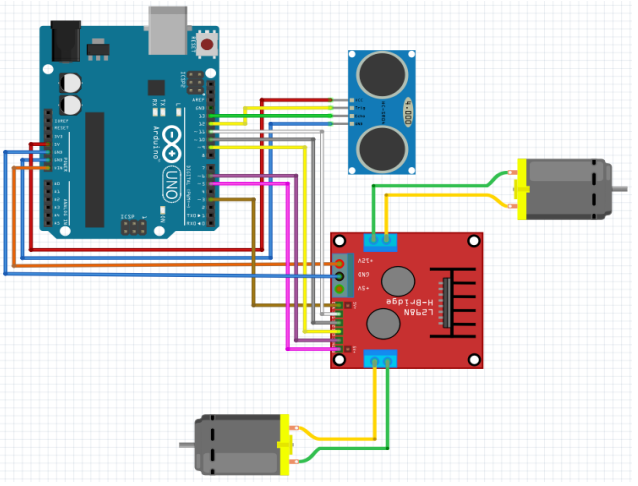

Fig-2: System Design

Components

Table 1 shows the major components used for implementing the obstacle avoiding robot.

Table No 1
Specification of components

S. No.	Component Name	Specification	Quantity
1.	Arduino Uno	-	1
2.	Ultrasonic Sensor	HC-SR04	1
3.	Dual Motor Driver IC	L293D	1
4.	DC Motors	12 V, 45 RPM	2
5.	L7805C Voltage Regulator	5 V	1
6.	Lead Acid Battery	12 V, 1.3 Ah	1
7.	Battery	9 V	1
8.	Bread Board	-	1

Arduino Uno

Arduino uno is a microcontroller based on ATmega328P. Of the available 14 digital I/O pins, 6 are used as PWM outputs and 6 analog inputs. The pin diagram of ATmega328P is shown in Fig 3. ATmega328P is a microcontroller created by ATMELA. Table 2 indicates the specifications of ATmega328P.

Arduino Uno Technical Specifications

Table No 2
Specification of Arduino Uno

Microcontroller	ATmega328P
CPU type	8-bit AVR microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Performance	20 MIPS at 20 MHz
Flash Memory	32 KB (0.5 KB is used for Boot loader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
External interrupts	2

ATMEGA 328P pin diagram

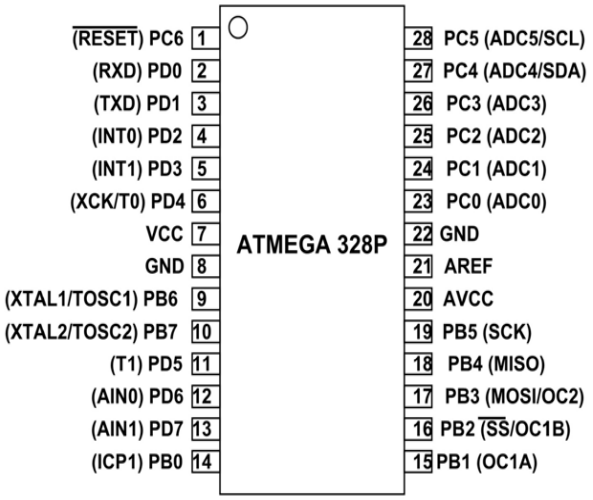

Fig-3: Pin configuration of ATmega328P-PU microcontroller

Ultrasonic sensor

The purpose of using ultrasonic sensor is to measure the distance between the vehicle and the obstacle. It measures the distance by emitting sound waves and converts the sound into electrical signal. It has two components transmitter and receiver. Transmitter is to emit sound whereas receiver received the reflected sound. The distance is calculated by the time it takes to emit the sound and again it is received by the receiver and the expression is given as

$$D = \frac{1}{2} T \times C$$

Fig-4: Ultrasonic sensor HC-SR04

In this project to implement obstacle avoiding robot HC- SR04 is used as ultrasonic sensor. Fig 4 shows the ultrasonic sensor.

HC-SR04 pin description
The pin details of HC-SR04 is given in Table 3

Table No 3
Pin details of HC-SR04

Pin Number	Pin Name	Description
1	Vcc	The Vcc pin powers the sensor, typically with +5V
2	Trigger	Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending US wave.
3	Echo	Echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the US wave to return back to the sensor.
4	Ground	This pin is connected to the Ground of the system.

HC-SR04 Specifications
The specifications of HC-SR04 is shown in Table 4.

Table No 4
Specifications of HC-SR04

Operating voltage	+5V
Theoretical Measuring Distance	2 cm to 450 cm
Practical Measuring Distance	2 cm to 80 cm
Accuracy	3mm
Measuring angle covered	$<15^0$
Operating Current	<15mA
Operating Frequency	40Hz

Motor Driver Module L239D

In order to drive the motor a 16 pin motor drive IC i.e. L239D is used which is capable of running two DC motors at the same time. Fig 5 shows the pin diagram of L239D. It contains two inbuilt H-driver bridge circuits that allow voltage to be flown in either direction.

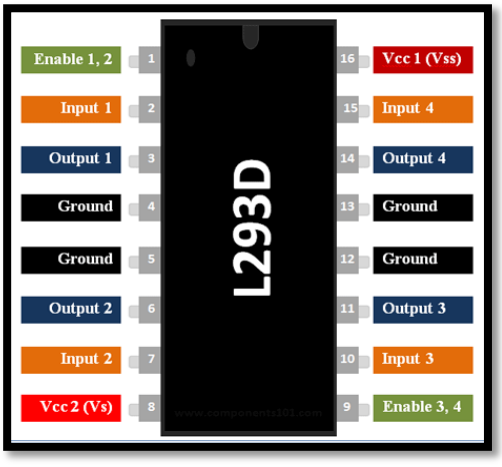

Fig-5: L239D dual motor driver

L239D pin description

Table 5 shows the pin details of L239D

Table No 5: Pin Details of L239D

Pin No	Pin Name	Description
1	Enable 1,2	This pin enables the input pin Input 1(2) and Input 2(7)
2	Input 1	Directly controls the Output 1 pin. Controlled by digital circuits
3	Output 1	Connected to one end of Motor 1
4	Ground	Ground pins are connected to ground of circuit (0V)
5	Ground	Ground pins are connected to ground of circuit (0V)
6	Output 2	Connected to another end of Motor 1
7	Input 2	Directly controls the Output 2 pin. Controlled by digital circuits
8	Vcc2 (Vs)	Connected to Voltage pin for running motors (4.5V to 36V)
9	Enable 3,4	This pin enables the input pin Input 3(10) and Input 4(15)
10	Input 3	Directly controls the Output 3 pin. Controlled by digital circuits
11	Output 3	Connected to one end of Motor 2
12	Ground	Ground pins are connected to ground of circuit (0V)
13	Ground	Ground pins are connected to ground of circuit (0V)
14	Output 4	Connected to another end of Motor 2
15	Input 4	Directly controls the Output 4 pin. Controlled by digital circuits
16	Vcc2 (Vss)	Connected to +5V to enable IC function

L239D Features

- Can run Two DC motors with the same IC.
- Individual control of speed and direction is possible
- Motor voltage Vcc2 (Vs): 4.5V to 36V
- Maximum Peak motor current: 1.2A
- Maximum Continuous Motor Current: 600mA
- Supply Voltage to Vcc1(vss): 4.5V to 7V
- Transition time: 300ns (at 5Vand 24V)
- Automatic Thermal shutdown is available
- Available in 16-pin DIP, TSSOP, SOIC packages

Circuit Description

The circuit diagram of obstacle avoiding robot is shown in Fig 6. As shown in the figure the Arduino Uno is fed from the output of ultrasonic sensor and accordingly the signals are given to L239D which drives the motor accordingly.

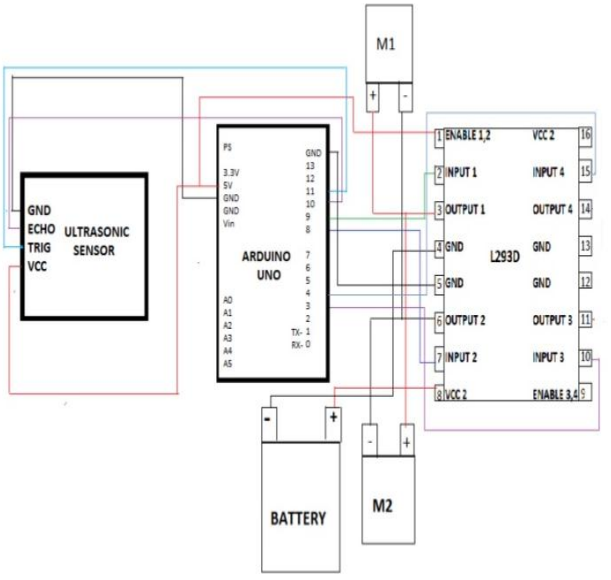

Fig. 6- Circuit diagram

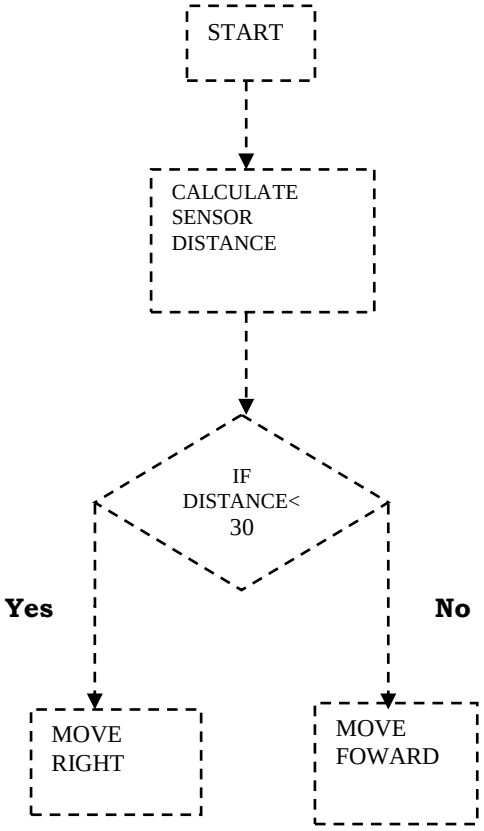

Fig-7 Flowchart

Fig 7 shows the approach followed by the ultrasonic sensor after measuring the distance and signal given to Arduino Uno board.

Fabrication

Whenever the robot is in operation the crystal oscillator on the ultrasonic sensor continuously emits ultrasonic waves through the transmitter and checks whether there is an obstacle. A predefined time is programmed to detect the obstacle. If there is no obstacle the ultrasonic waves won't return in the prescribed time making the robot to believe that there is no obstacle ahead and the vehicle continues in its desired path of motion. When the waves return back within the prescribed time, an obstacle is detected and the microcontroller sends commands to the motor driver ic to change the course of direction in order to avoid collisions and continue its motion. Fig 8 shows the real life implementation of obstacle avoiding robot.

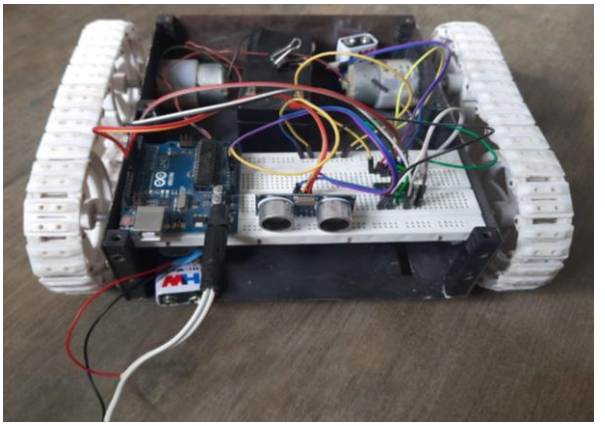

Fig.8 Implementation

Future scope

The developed model is a basic prototype which is budget friendly. In order to improce the accuracy three ultrasonic sensors can be used to cover wider region. In addition to it ultrasonic sensor placed on rotating servo motor can be used to sweep through a larger area. Also, otherwise it can be fitted with camera modules and AI can be implemented so that it can be used in real life applications, like on roads, judging other vehicles speed, pot holes, speed breakers, traffic light signals and even change lanes, which is same as the technology used in currently some of the most advanced autonomous driving cars made by tech giants. Further for military uses, it can be fixed with a GSM module or a radio module and be provided with a manual control, for even better maneuvers. We can conclude that this project of ours has a vast scope in future applications.

Conclusion

This paper presents a robot which detects and avoid obstacles in its path. Ultrasonic sensor HC-SR04 was chosen after reviewing many articles that pointed out the less accurate operation of IR and PIR sensor HC-SR501. The hardware project performed as per our expectations, and worked autonomously, that is, after feeding the code, it required no human interaction and could work on its own, even in unknown and dynamic environments.

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