



AN OBSTACLE DETECTION AND AVOIDANCE ROBOT VEHICLE

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Abstract

The use of robot vehicles for public transportation will reduce congestion levels and improve traffic flow. Obstacle avoidance is one of the most important aspects of robot vehicle. Without it, robot movement would be very restrictive and fragile. In this paper obstacle detection and avoidance robot vehicle which can detect obstacles in its path and maneuver around them without making any collision was designed. This robot vehicle can redirect its movement whenever an obstacle comes in its path so as to protect itself from any physical damages. The ultrasonic sensor was used to sense the object in front of the vehicle and send the signal to the micro controller unit. Depending on the input signal received, the micro-controller redirects the robot vehicle to move in an alternate direction by actuating the motors which are interfaced to it through a motor driver. The Arduino board was selected as the microcontroller platform and Arduino Software was used to carry out the programming. When the robot vehicle was placed in different environments, it was found that the robot vehicle was able to detect and avoid obstacle with an average accuracy of 83.62%.

Keywords: Avoidance, Detection, Microcontroller, Robotic, Sensor.

Introduction

In today's world robotics is a fast growing and interesting field. Autonomous Intelligent robot is a robot that can perform desired tasks in unstructured environment without continuous human guidance. A robot which is a modern-day invention is a machine which acts according to the decision-making ability provided by artificial intelligence or may be controlled by pre-programmed computers. Mobile robots have the ability to recognize objects in its surrounding whenever it moves in a real environment but the need for an obstacle detector and avoidance is needed since most enveloping mobile robots/vehicles are programmed to operate

on their own without human help. The challenge faced by vehicles that are auto driven or made to follow a map system is that when there is no human tracking, the vehicle sometimes is less effective and also in the modern world where expensive vehicles are built and traffic rate of the globe has been on the increase, the need for an obstacle detection and avoidance mechanism is needed. In recent times, mechanism has been put in place for the detection of obstacle; the ability of the obstacle to be avoided has not been nearly emphasized.

The obstacle detection and avoidance are primary requirement of this autonomous robot and this obstacle can be detected and avoided with the help of certain sensors and

programs. The robot gets information from surrounding area through sensors mounted on it. The ultrasonic sensors are used for obstacle detection because it transmits the ultrasonic waves from its sensor head and again receives the ultrasonic waves reflected from an object.

Obstacle avoidance robot was design to allow robot to navigate in unknown environment by avoiding collision (Bhagat, 2016). According to Duino-Robotics (2013), the term “obstacle avoidance” denotes the capability of robot to navigate over an unknown environment without having any collision with surrounding objects, obstacle avoiding robot senses obstacles in the path, avoid it and resumes its movement.

Shoval et al. (2000) developed a computerized obstacle avoidance system for the blind and visually impaired. The device used is called GuideCane, which is a wheeled device, pushed ahead of the user via an attached cane. When the GuideCane detects an obstacle it steers around it. The user does not need to actively scan the surrounding/environment manually because multiple sensors that face directions are used, which covers large area regardless of the user's orientation. The user immediately feels this steering action and can easily follow the new path of the GuideCane without any conscious effort. The obstacle avoidance algorithm provides full autonomy for local navigation, thus allowing the user to fully concentrate on the less time-constrained tasks of global path planning and localization.

Stachniss and Burgard (2003) introduced coverage maps as a new way of representing the environment of a mobile robot. Coverage maps store for each cell of a given grid a posterior about the amount the corresponding cell is covered by an obstacle. Using this representation, a

mobile robot can reason accurately about its uncertainty in the map of the environment than with standard occupancy grids. The system combined properties of strategies to find an optimal tradeoff between the evaluations functions used. Choosing appropriate vantage points in this system is a problem.

Rajarajan et al. (2011) developed a collision avoidance system for automobile using embedded system. The system uses ultrasonic sensor to sense object in front of the vehicle and gives signal to the micro controller unit. Based on the signal received from the ultrasonic sensor, the micro controller unit sends a signal to the braking unit to apply the brake automatically as per braking and throttle control logic fed into the microcontroller unit. To avoid collision, brake is applied by means of actuators, distance measuring sensors and electronic control module but if an object is found within the braking range, collision avoidance system (CAS) will not have enough distance to decelerate and take steer.

Kumari (2012) presents a software implementation of obstacle detection and avoidance system for wheeled mobile robot. The system makes use of infrared sensors and microcontroller. The guidance system uses infrared sensors for obstacle detection, range determination and avoidance. In this system, three infrared sensors are used for left, front and right sensing. The input signals are received from sensors circuit and Atmega32 microcontroller was operated, according to the received sensor's signal. It was highly resistant to ambient light and nearly impervious to variation in the surface reflectivity of the detection object but the distance sensors used does not read at a faster rate.

An Obstacle-Avoidance Control for an Autonomous Omni-Directional Mobile Robot

Based on Extension Theory was designed by Pai et al. (2012). The robot designed was based on both fuzzy and extension theory. Fuzzy theory was applied to tune the Pulse Width Modulation (PWM) signal of the motor revolution and correct path deviation issues encountered when the robot is moving. Extension theory was used to build a robot obstacle avoidance model.

Although, the system offers high mobility, motion path correction and obstacle avoidance capability but it is complex.

Kumano et al. (1996) developed a real time obstacle avoidance system for autonomous mobile robots using a stereo vision sensor. It was based on stereo measurement without any search of the corresponding points to match them. The system can detect ghost object and can make advance decisions of its movement but reflected rays of light can confused the system.

Woon (2014) developed a fuzzy logic based controller for obstacles avoidance robot. The obstacle avoidance controller has two inputs and two outputs system. The inputs are two proximity measurement of the obstacles distance, and the outputs are the velocities of the two wheels. The robot was driven by two independent direct current (DC) motors. The ultrasonic sensors are mounted at left, front and right side of the mobile robot which detects the obstacles within the range of 3 cm to 300 cm. The system cannot avoid situations that are harmful and cannot adapt to changes in the environment. It cannot work for extended period of time without intervention from human or a need for power supply.

Balasubramanain et al. (2014) introduced the controlling of robot using joysticks, mobile and laptop using the Arduino board. The robot consists of Arduino board, an L293D interface circuit and a motor driving

system. The controlling devices are connected to the Arduino board. The Arduino board sends signals to the interfacing board L293D which controls the motor driving system.

An obstacle avoidance robot which can detect obstacles in its path and maneuver around them without making any collision was designed by Tabassum et al. (2017). The system worked on Arduino microcontroller and it employs three ultrasonic distance sensors to detect obstacles. The system can be disturbed with external factors such as air and humidity of environment due to the type of sensor used.

The purpose of this study is to develop an obstacle detection and avoidance robot. In this work, ultrasonic sensors are used to detect and avoid collision with unexpected obstacles. The significant contribution expected through this study is an optimal autonomous control system that will automatically detect and avoid the unknown objects.

Design Methodology

Design Considerations

- (I) Multiple Sensors: Different sensors were used, facing different directions, which cover large area regardless of the user's orientation.
- (ii) Adaptation: The system can adapt to changes in the environment.
- (iii) Power Supply: External power (battery) was used to give power to the whole system for extended period of time.
- (iv) Mechanical Design: A low complexity and low power consumption wheeled robot was used. A two wheeled robot was used in order to move the robot on the uneven surface.

Architecture of an Obstacle Detection and Avoidance Robot Using Microcontroller (ODARUM)

The architecture of an obstacle detection and

avoidance robot using microcontroller is presented in figure 1. The system comprises of eight components namely the Arduino board, Breadboard, L293D motor driver, jump wires, Rotors, buzzer, ultrasonic sensors, and 9volt battery.

The ultrasonic sensors which detects obstacle were placed on the breadboard together with the buzzer, which makes sound when obstacles are detected and the L239D microcontroller, which controls the rotor for the wheel. The Arduino (micro

controller) gives the appropriate power for the motor controller and sensors and the whole system was powered by a nine volt battery. Three ultrasonic distance sensors were used that provided a wider field of detection. The robot was fully autonomous and after the initial loading of the code, it requires no user intervention during its operation. When placed in unknown environment with obstacles, it moves and avoids all obstacles with considerable accuracy.



Figure 1: An Obstacle Detection and Avoidance Robot Using Microcontroller

Components of the Architectural Design

The proposed system architecture is shown in figure 1:

- (i) **Arduino Board:** The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as pulse width

modulation (PWM) outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; it works when connected to a computer with a USB cable or power with an AC-to-DC

- adapter or battery.
- (ii) **L293D:** This is a dual H-bridge motor driver integrated circuit (IC). In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.
 - (iii) **Breadboard:** A thin plastic board used to hold electronic components that are wired together.
 - (iv) **Jump Wire:** This is an electrical wire which is normally used to interconnect the components of a breadboard internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.
 - (iv) **Nine-Volt or 9-volt Battery:** is used to give power to the whole system.
 - (v) **Buzzer/beeper:** is an audio signaling device, which may be mechanical or electromechanical. The buzzer beeps a sound when the ultrasonic sensor detects an obstacle.
 - (vi) **Ultrasonic Sensor:** Determines the distance to an object by measuring the time taken by the sound to reflect back from that object. The frequency of the sound is somewhere in the range of ultrasound; this ensures more concentrated direction of the sound wave because sound at higher frequency dissipates less in the environment. A typical ultrasonic

distance sensor consists of two membranes. One membrane produces sound, another catches reflected echo. Basically, they are speaker and microphone. The sound generator generates short (the length is a couple of periods) ultrasonic impulses and triggers the timer. Second membrane registers the arrival of the sound impulse and stops the timer. From the timer's time it is possible to calculate the distance traveled by the sound. The distance to the object is half of the distance traveled by the sound wave.

- (vii) **Rotor:** This is a moving component of an electromagnetic system in the electric motor, electric generator or alternator. Its rotation is due to the interaction between the windings and magnetic fields which produces a torque around the rotor's axis. The rotor is responsible for moving the wheels of the avoidance system robot.

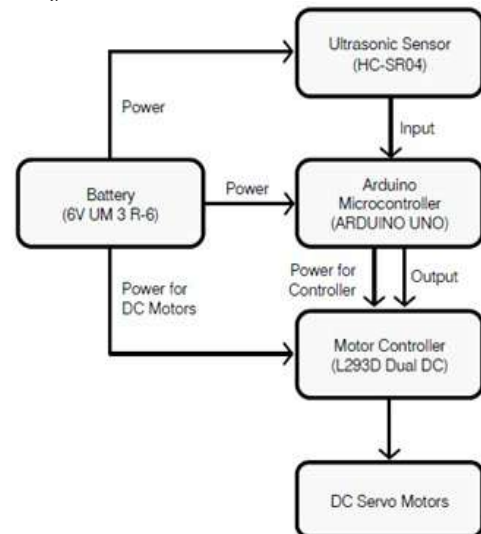


Figure 2: Block diagram of the System

The Robot Algorithm

Figure 2 shows the working principle of the obstacle detection and avoidance system.

Step 1. The artificially intelligent robot gathers facts about a situation with

help of sensors.

- Step 2. The robot then compares this information with stored data.
- Step 3. The robot decides based on the significance of the information.
- Step 4. The robot runs through different actions that are possible amongst the collected information.
- Step 5. The robot predicts what action will be most suitable based on the collected information.
- Step 6. The robot then executed the suitable action and moves accordingly.

The Detection Algorithm

- Step 1. The Middle sensor calculates distance using ultrasonic sensor.
- Step 2. The Ultrasonic sensor detects the obstacle
- Step 3: The buzzer beeps to signal an obstacle

The Avoidance Algorithm

- Step 1: If Middle Sensor Distance less than 30cm, the robot calculates the right and left sensor distance
- Step 2: The robots compares the results of

the right and left sensors

- Step 3: The robots moves to the one with the longest value between them.

Implementation

ODARUM was implemented using C language; this is the default and recommended language for coding Arduino boards.

The reasons for using the implementation tools are:

- (i) The Arduino IDE supports the languages C and C++ using special rules to organize code.
- (ii) The Arduino IDE supplies a software library called Wiring from the Wiring project, which provides many common input and output procedures.
- (iii) A typical Arduino C/C++ sketch consist of two functions that are compiled and linked with a program stub *main()* into an executable cyclic executive program.

Figure 4 shows the screenshot of an Arduino C software code which was used in implementing the system.

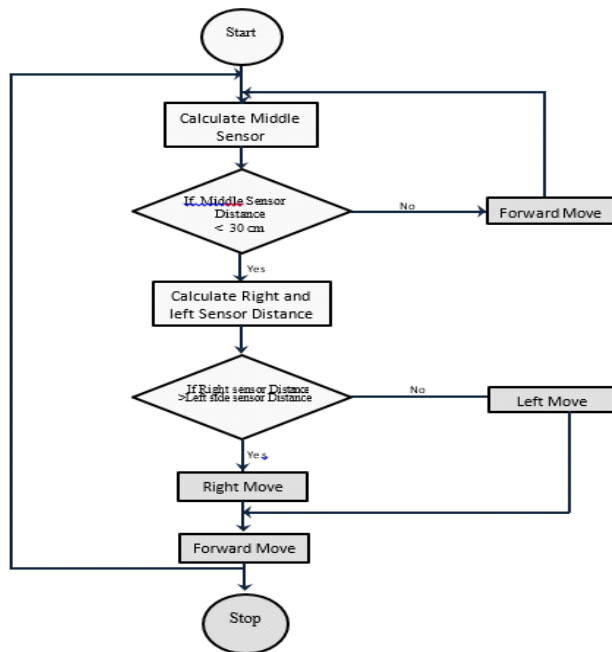


Figure 3: Flowchart of the system

Simulation using V-REP

The results were gotten through simulation, using Virtual Robot Experimentation Platform (V-REP). The environmental results are generated using the robot component, the sensor numbers, strengths and their respective ranges. V-REP works

hand-in-hand with the C language used in coding the Arduino board, so that the results can be simulated. Figure 5 shows the V-REP Interface of the robot under simulation while figure 6 shows the screenshot of the V-REP interface results.

```

Obstacle_Detection_working
//front sensor
const int FtrigPin = 13;
const int FechoPin = 12;
long Fduration;
//right sensor
const int RtrigPin=9;
const int RechoPin=8;
long Rduration;
//Left sensor
const int LtrigPin=3;
const int LechoPin=2;
long Lduration;

//int LED_pin = 13;
int minimumDuration =4000;
int tooNear = 1000;

const int inputPin1 = 4; // Pin 15 of L293D IC

```

Figure 4: Arduino C Software code

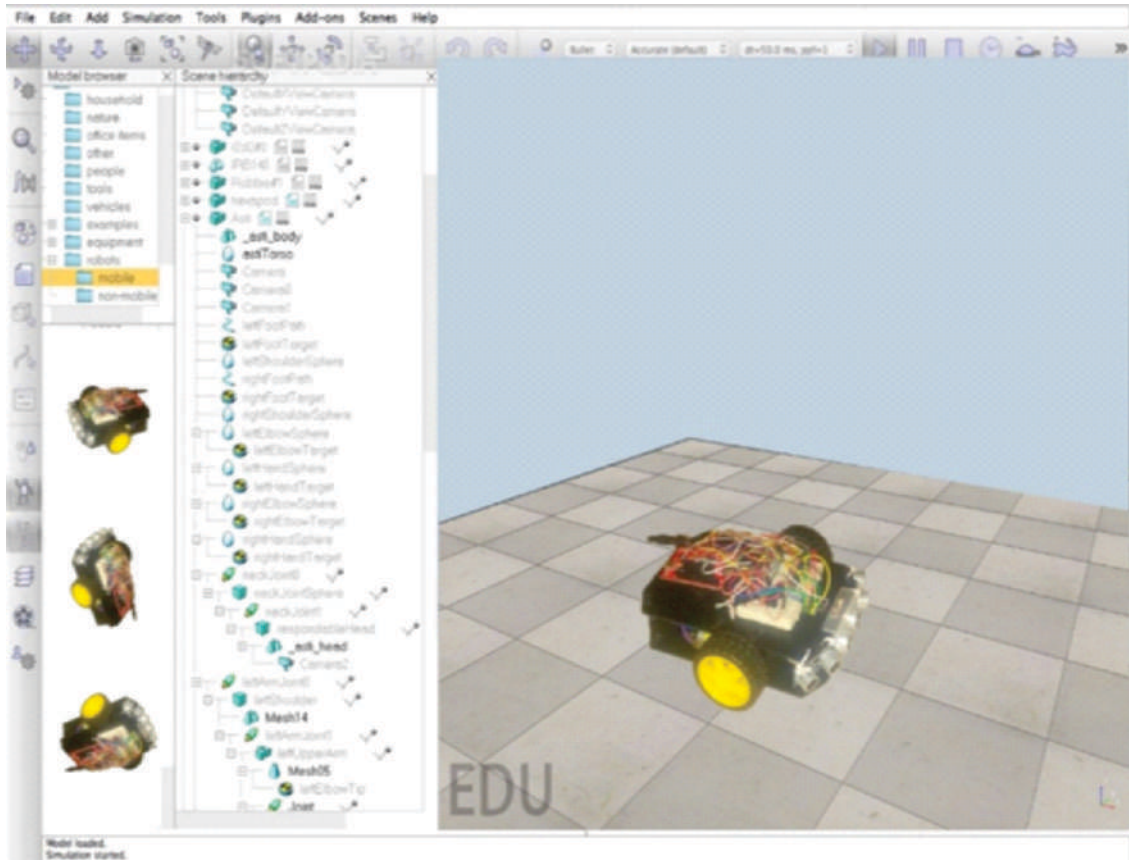


Figure 5: V-REP Interface showing robot under simulation.

Environment	Type of obstacle	Detected	Avoided	Accuracy
Well-III	Single solid obstacle	Yes	Yes	100%
Dimly-III	Single solid obstacle	Yes	Yes	100%
Well-III	Uniform Shaped surface	Yes	Yes	100%
Dimly-III	Uniform Shaped surface	Yes	Yes	80%
Well-III	Non-Uniform Shaped surface	Yes	No	79%
Dimly-III	Non-Uniform Shaped surface	Yes	No	67%
Well-III	Double solid obstacles	Yes	Yes	78%
Dimly-III	Double solid obstacles	Yes	Yes	65%
Average =				83.62%

Figure 6: V-REP Interface showing results

Results

A robot that can successfully detect and avoid obstacles was designed and constructed. It was found that given a number of obstacles, the robot was able to detect and avoid the obstacle with an

average accuracy of 83.62%. The equation for calculating the accuracy is given below. The numerator signifies the total number of times the robot was able to avoid the obstacle it faced. The denominator signifies the total number of test cases.

Table 1: Result of Robot under Simulation

Environment	Type of obstacle	Detected	Avoided	Accuracy
Well-lit	Single solid obstacle	Yes	Yes	100%
Dimly-lit	Single solid obstacle	Yes	Yes	100%
Well-lit	Uniform Shaped surface	Yes	Yes	100%
Dimly-lit	Uniform Shaped surface	Yes	Yes	80%
Well-lit	Non-Uniform Shaped surface	Yes	No	79%
Dimly-lit	Non-Uniform Shaped surface	Yes	No	67%
Well-lit	Double solid obstacles	Yes	Yes	78%
Dimly-lit	Double solid obstacles	Yes	Yes	65%
Average=				83.62%

Table 1 calculates the average accuracy of the robot when tested against various environments, number of obstacles, and the situations when the obstacle was detected and avoided. Figure 7 shows the Obstacle Detecting and Avoiding Robot.

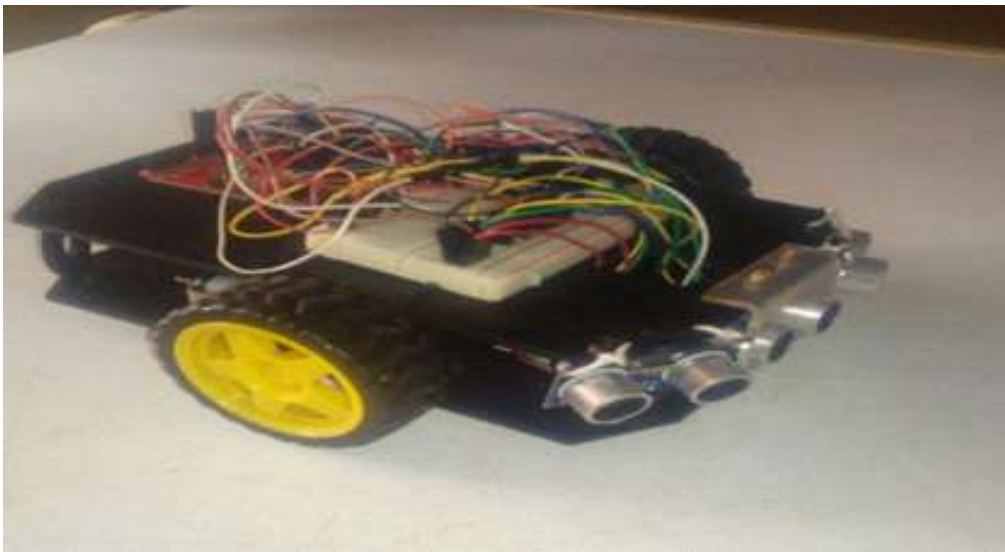


Figure 7: The Obstacle Detecting and Avoiding Robot

Discussion

An obstacle detecting and avoiding robot using microcontroller was developed. The work attempted to overcome the problem faced with avoiding obstacle on the path of a robotic vehicle. The outcome of using the obstacle detecting and avoiding robot using microcontroller include:

- (i) The system enables easy mobile robot navigation.
- (ii) In a real-life wheeled vehicle, it can avoid obstacle in its path.
- (iii) It facilitates proper parking and takes off of vehicles

Conclusion

In this work, an obstacle detection and avoidance robot was designed. This robotic vehicle can move in different directions like forward, backward, left and right when it senses its environment. The aim of this work is to create an autonomous robot vehicle which will intelligently detect the obstacle in its path and avoid it based on information received by its sensors. The robot is built on the Arduino platform for data processing and its software counterpart helped to communicate with the robot to send parameters for guiding movement. For obstacle detection, three ultrasonic distance sensors were used that provided a wider field of detection. The robot is fully autonomous and after the initial loading of the code, it requires no user intervention during its operation. When placed in an unknown environment with obstacles, it moved while avoiding all obstacles with considerable accuracy.

In future, it might also be necessary to explore other sensors like LIDAR which uses light to perceive its environment; implement the design on a bigger model; and also design a robotic system that can avoid situations that are harmful.

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