Implementation of Obstacle Detection and Avoidance Methodology for Low Cost Autonomous Vehicle

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Abstract
The objective of this paper is to describe a low-cost autonomous robotic car which can be run without any remote control or under any human’s guidance. Robot’s main advantage is that it can replace human force in high risk and dangerous job avoiding the risk of human life. The robotic car must be designed in small size, easily operable and of course of low-cost. Along with the obstacle detection and avoidance, this can also be a source of entertainment of people of all the age groups. It's further implication in different types of system can make it more useful. For instance, this small part can be added to the navigation system which can guide partially visually impaired persons, it can be added in an automatic wheelchair which can be used by physically handicapped persons, and it can be used for industrial purposes also where robots are used to pick and place some objects in defined places etc.

Keywords
Arduino; DC Motors; Obstacle avoidance; Reactive Model; Motor-Driver; Robot design concept; Ultra sonic sensor;

I. INTRODUCTION
In today’s era, in almost all the sectors robotic systems are present for carrying out different types of intelligent processes [1]. They perform smooth work in very less period of time and contributes in various factors like quality, time, safety, effectiveness, less error, reliability etc. [2]. In this twenty-first era, robotics is a very fast growing and interesting field [3]. Now a day’s many industries are using robots because it provides high level of performance, accuracy and reliability. Industries gained lot of benefits due to advancement in the robotic field because company loss has been reduced to a great extent since flawed products are trimmed down by robots to none [5]. This paper is basically obstacle detection and avoidance autonomous robot with multiple sensors, basically deals with detection and avoidance of the any type of obstacles which will come in front of the robot’s environment. This is an autonomous robot. In this system, three ultrasonic sensors are implemented to sense the obstacles which will come in its path. System will move in a particular direction according to the programming which is saved in the system’s micro-controller. Less number of dc motors means low power consumption [6] so we are using only two motors and motor driver for controlling the direction of the system and for supplying enough current to drive the motors for each wheel.

This project presents the small part of a work which can be extended further to develop much more advanced robotic systems. It has application in a much broader range such as food processing and packaging [7], industrial control [8], healthcare [9], home care [10] [11], driver-less vehicle systems [12] which can be useful for space projects, in bomb detection[13] or in such conditions which are harmful for humans to work [14], industrial purposes, in developing smart household products etc. So, on a long run, it can free the humanity from dangerous, repetitive fatigue work, dumb, annoying and humiliating works. Development of such robots require the developers to tackle some problems like selection of circuit components keeping in mind of light-weight model and which can give reliable & effective result and should also be inexpensive & user-friendly. The accuracy and preciseness of the robotic system very much depends on the sensor’s accuracy & precision and thus sensors [15] should be selected according to the work-space in which we want the robot to function. Ultrasonic sensor [16] is most suitable for detecting the obstacles plus it is of low cost and has high ranging capability. Any robot can also be controlled [17] by any android mobile or tablet, installing the android app which can be downloaded from Google Play store. Then the android application could be connected to the Bluetooth module and can send desired commands.
II. ROBOTICS AND ROBOTS

A robot is a machine which is designed to repeat one or more tasks continuously, with high speed and precision [18]. Robotics requires vast knowledge in mechanics, electronics, and software because a robot is a composition of mechanical parts, electronics parts plus it has also intelligence on the basis of which it takes decision. So, this intelligence in robots is embedded through the programming of the microcontroller which is used in it. The common characteristic of robots is that it is movable. Robots can be grouped generally as:

(i) Manipulator robots (for e.g. industrial robots)
(ii) Mobile robots (for e.g. autonomous vehicles),
(iii) Self-reconfigurable robots, the robots that can conform themselves to the task at hand.
(iv) Supervisory control and data acquisition (SCADA) robot is integration of software and hardware component that control any industrial processes locally or at remote locations monitor, gather, and process real-time operation.
(v) Selective Compliance Assembly Robot Arm or Selective Compliance Articulated Robot Arm (SCARA) for control any industrial processes.

III. BASIC ROBOT MODEL

Basically, human beings are made of five major components which can be compared to different parts of a robotic system:

(i) A muscle system that can move the body structure resembles to DC motors.
(ii) A body structure itself is equivalent to robot chassis.
(iii) A power source is required for human body to move likewise a battery source is needed for the system.
(iv) In our human body, many sensing parts are present like eyes, nose, skin, tongue, and ear. In the same way robotic system has many types sensors attached to it.

In human’s we have brain which manages and control the whole activity of the body and it resembles the microcontroller of the robot.

A. Hierarchical Model

This model approach mainly focuses on the robot’s behaviour’s planning. According to this, first the robot senses its environment and collects the information then plans the next action based on these sensor’s output (Fig. 1).

It’s design phase is analyzed by top-down approach to characterize the system’s behaviour. These robots are typically reflex agents which selects the specific action from the rules which are already saved in the system’s memory. Its basic working is that sensors collects information from environments, the data will be passed to microcontroller to process.

B. Reactive Model

This model system is decomposes the functions into behaviours and therefore it forms the multiple instances in which sensing & acting are the parts (Fig 2). In other words we can say that the sensing and acting activity are coupled together so that they can run concurrently.

IV. OVERVIEW OF THE DESIGN METHODOLOGY

We have done our project on an autonomous robot which can detect the obstacles in front of it and avoid itself from it therefore given the project’s name

obstacle detection and avoidance robot’. Our system basically performs three processes:
(i) Collects the information from the environment (through sensor).
(ii) Use & process the information (processing through codes in micro-controller).
(iii) Follow instruction to perform actions or works (output).

Major required components and technology,
- Microcontroller (Arduino)
- Ultra sonic sensor (HC-SR04)
- Motor-Driver (L293D)
- LCD (HD44780)
- DC Motors
- Arduino board programming technique
- Robot design concept

The basic block diagram of the proposed system is shown in Fig 3.

![Basic block diagram of the proposed system.](image)

**A. Ultrasonic Sensor**

Ultrasonic sensors are widely used for proximity detection purpose. To find the distance to an object, it uses sonar like bats or dolphins do. Here we are using HC-SR04 chip. Detailed sensors arrangement is shown in Fig 4. It has basically four terminals: Vcc, Ground, Echo and Trigger. We are using three sensors. The trigger pins are connected to the digital pin 3,4 &7 and echo pins are connected to the pins 2,5& 8, of the arduino board. To determine the distance of the obstacle, ultra-sonic sensor calculates the time interval by determining the time of sending the signal & time to receive the echo signal [20]. Its main advantage is that its operation is not affected by sun-light or black material, vibration, infrared radiation, ambient noise, and EMI radiation so can easily works in tough environment such as noisy, dusty or dark area. Besides, ultrasonic sensor is more reliable than infrared sensor and it is sensitive to specular surface but shorter range support.

Distance\((\text{cm})\) = Speed of sound is approximately 341 m/s in air.

\[ T = \text{time between sound wave is emitted and received. It is divided by 2 due to the sound wave travel to object and back to receiver.} \]

![Multiple sensors connected to Arduino.](image)

**B. Microcontroller**

Arduino is an open-source computing platform which means that its hardware can be purchased with some money but its software is of free cost. It is based on Atmega328 micro-controller. The Arduino board is programmed by using the Arduino programming language with the help of the Arduino development environment, by connecting the board with the system through a USB-B cable. Arduino boards can also be run stand-alone. A code editor is there with the common developer software features like syntax highlighting, brace matching, and automatic indentation, case-sensitive, camel-case type syntax etc.

The Arduino UNO is the most used in the Arduino family. It is a great choice since it is relatively cheap and very easy to set-up and it is the toughest board. "UNO" stands for ‘one’ in Italian language and it is named to mark the release of Arduino software IDE 1.0.Arduino UNO R3 is the latest version released in 2011 and it is the third revision of UNO boards. The main reasons of using Arduino are:

- Cheap: it is inexpensive as compared to other microcontrollers. The least expensive version can be assembled easily using hands and the pre-assembled Arduino modules itself is less costly.
- Cross-Platform Technology: this software can be used for windows, MAC & Linux operating system, while other micro-controllers are limited only to windows.
- Simple Programming: its programming is very easy and simple to use, and flexible too for advanced
users. It is just a simplified version of C. If we don’t know C, then also there is no need to worry as only a few instructions are needed to perform useful functions. Extensible software: it’s an open source plus can also be expanded to C++ libraries & AVR C is its basic so researchers wanting to understand the technology details can switch to AVR C programming language. AVR C code can be directly added into one Arduino programs if anyone needs to do so.

C. L293D Motor-Driver

Since Arduino can’t give sufficient current to drive the DC motors, so we need to use a driver. So motor driver L293D is used since it’s a current enhancing device, it can also act as switching device. To rotate motors, we connect its positive and negative lead to battery and it starts rotating but to rotate it in other direction without changing the circuit, we need a circuit called H-bridge. And this IC is nothing but the same bridge. L293D is an IC containing 16 pins. It can control two DC motors in any direction simultaneously. It means that we can control two DC motor with a single L293D I. Pin 1 and 9 are the two enable pins, enabling which we can drive the motors. For driving the motor on the left side we need to enable pin1 to high. And for right sided motor we need to make the pin 9 high. If anyone of the enable pin goes off, then the motor in the corresponding section will stop working. It’s like a switch. Pins2.7 on left and pin 15, 10 on the right are the four input pins in this IC. Input given high to the Left input pins will regulate the rotation of motor connected across left side and input given high to the right input pins of IC will make right sided motors to run. So, the simple logic is that the motors are rotated on the basis of the inputs provided across the input pins as logic 0 or logic 1. Driver needs 5 V to operate, so this internal voltage is given to the pin Vcc and it does not use this voltage for driving the motors. This IC has a separate provision to provide motor the required supply the pin VSS. If we want to operate a motor at 9V, then we need to provide a supply of 9V across this pin only. The maximum voltage for VSS is 36 V, so we can use this small IC to drive pretty big motors. It can supply 600mA of maximum current.

D. DC Motor

DC motor transforms the electrical energy into mechanical energy. Its operation relies on the principle that whenever a current carrying conductor is being placed in a magnetic field, then the conductor experiences a mechanical force. It basic fundamentals is based on Fleming’s left hand rule. In this project we have used 9V, 200Rpm 37mm Geared DC Motor which requires 9V for its operation, its speed is 200 RPM and is of 22mm in size. It is a great choice for projects that require high speed and torque. The motor’s two wires are connected to the output pins of the IC L293D.

Here, we have used LCD (HD44780 Controller-JHD 204A) which is a 20*4 module. It means that it can display 20 characters in each of the four rows i.e it can display 80 characters at time. It needs 11 input-output pins to interface it. It takes 39-43us to place a character and its execution on the display (Fig. 5). To clear the display and to move cursor to its starting position, it takes 1.53ms to 1.64ms time.

V. IMPLEMENTATION OF THE SYSTEM

A. Hardware Assembly

We are using Arduino Uno R3 which is based on ATmega328 single-chip microcontroller and it is created by Atmel in the mega AVR family. It acts as the brain of the system because it is the only member of the system which controls the whole process going through it. It is interfaced with the ultrasonic sensor module (Fig. 6), LCD, motors and the motor driver.
Ultrasonic sensor acts as the eyes of the system since it detects the obstacles coming in the path of the system and continuously measures the distance of the obstacle from the system (Fig 6). Here we are considering three distances (cm1, cm2, cm3) and the logic is that the program will detect the greatest distance & will give command to the system to move in that direction only. For the movement of the system we are using 2 dc motors which are connected to the micro-controller (Arduino board) through the motor driver (L293d). For the simplification of the system we are directly using the IC instead making the H-Bridge which consists of four transistors. The whole system movement will be control by this algorithm. The inputs are given by logic high and low from the Arduino according to the code.

<table>
<thead>
<tr>
<th>Input 1</th>
<th>Input 2</th>
<th>Input 3</th>
<th>Input 4</th>
<th>Motion</th>
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<tbody>
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<td>Low</td>
<td>Low</td>
<td>Forward</td>
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<td>Low</td>
<td>High</td>
<td>High</td>
<td>Backward</td>
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<td>Low</td>
<td>Right</td>
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<td>Low</td>
<td>High</td>
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C. Arduino IDE Software

For the programming, we are going to use Arduino IDE to develop & upload the code to the Arduino Uno. For its software, installation is not required. Only thing we have to do is that we have to download & extract it out and can save it anywhere we want to. Next we get our self an USB-B cable then we plug it into the Arduino while the other end is connected to the host system.

To start it, we require double clicking the Arduino.exe this will allow us to open the required IDE. Next step, we may need to choose the Arduino board and then we have to select the COM port for Arduino. After this we have to compile and upload the code for its further operation.

VI. CONCLUSION

This model works as per the coding done in the arduino board, it has three sensors to detect the obstacles very precisely but it should be modified adding IR sensor so that it could measure the depth plus navigational aids also should be added in this for better qualities and result. Proposed system has following qualities like Low cost, Low weight, Low power consumption, High execution speed, no effect of weather condition and its user-friendly. It can be modified for the navigation also. This technique can be employed in electronic wheel-chairs with intelligence and making devices for blind navigation system. It can also be used in driver-less vehicle system which requires obstacle detection, avoidance and measuring the distance of obstacle from the system.

REFERENCES


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