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Research Article

Design and Implementation of Intelligent Mobile Robot based on Microcontroller by using Three Ultrasonic Sensors

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Abstract

In the final year, with the development of industry and technology it became necessary to design the robots specially within dangerous regions that are difficult for human to reach. The autonomous clever robots are robots which can perform required tasks in unstructured ambiences without ceaseless human steering. In this paper an intelligent mobile robot was designed to avoid obstacles depending on threshold method that is used a three ultrasonic sensors: the first is located on the right, the second is on the front and the third is on the left and the microcontroller (Arduino UNO). The robot gets the information from surrounding area through mounted sensors on the robot, through frequency signals that were continuously emitted by the ultrasonic sensors. These signals are reflected back when the obstacle is detected which then considered as input to the sensors through echo pin. The objective of this research is to design and implement the intelligent mobile robot which can be performed required tasks in unstructured ambiances without incessant human guidance.

Keywords: *Microcontroller, three ultrasonic sensors, mobile robot.*

1. Introduction

A robot was a machine which can perform many actions (Thomas R. Kurfess, 2005). The robots can be designed to be able to act by providing them with artificial intelligence or by direct human control, like remotely-controlled bomb-disposal robots and robotic arms. However, between these extremes the majority of robots is located, being controlled by pre-programmed computers (J. Grefenstette and A. Schultz, 1994).

At present, robotic technology has become more significant. A plenty industries were tried to enhance their machinery weapons. Year by year, these technologies are developed to make certain an excellent consequence. Lately, with the passage of time, a plenty mechanical robots are created to help a peoples which running their daily life. Robots of mobile were a two wheeled robot dais. The mobile robot is a two wheeled robot dais. In the front area of the robot, there is an ultrasonic sensor for introspecting the environment. A robots have an ultrasonic sensor which is forward of it to introspecting forward ambience. A sensor of ultrasonic will be trigger a signal to a major controller (Khairul A'alam Bin Abdul Ghani,2015). The aim of this work is to design and implement an intelligent mobile robot for difficult places and dangerous that humans cannot reach it. And by using three ultrasonic sensors to avoid collision, it can be adjust the movement of a robot to get expected track and obstacle avoidance. The vehicle may be controlled across DC motor after detecting object.

2. Literature Survey

- Sharayu Yogesh Ghangrekar, *et al*., (2009): As a navigation which must be free of collision and most optimal for the vehicle that autonomous to maneuver from a source to its destination, the planning of path in robotics can be defined. The focus of this dissertation on building a path planning algorithm for an all-terrain vehicle (ATV) used for travelling in a forest or open field. For this algorithm, the novelty is that it does not simply create a pathway between a source to its goal, but the navigating from source to its goal must makes sure that the vehicle covers the entire field area. To understand its surrounding, the robot uses Ranging and Laser Detection (LIDAR) for data collection. This data is used for building a path on the fly as the robot proceed and building a virtual map of its surroundings.
- A. Salam Al-Ammri & Iman Ahmed, (2010): To convert from a non-holonomic robot to holonomic robot the wheels of Omni-directional can be allowed to a robot for this. A robot which uses normal wheels is a non-holonomic robot. Wheels

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of the holonomic Omni-directional can overcome this problem. A combination of different computational (software) and physical (hardware) elements which integrate the subsystems of the robot of mobile to work in one unit is suggested. In terms of the components of hardware, the robot was mainly constructed from these components: controllers, servo motor, three infrared sensors (IR) are mounted on the frame of robot, batteries, frame and three omni-directional wheels. Software involves an application which is a tiny embedded (TEA) program used for doing the tasks of mobile robot to control its behaviour. As collision detectors, IR sensors are used in the robot. The equation of motion is used to compute various proposed cases; description of these cases is motion of one wheel, two wheels and three wheels with various velocities, orientations and value.

- Andrej Babinec, *et al*., (2013): They describe a reactive navigation. The objective of the reactive navigation is to describe the behavior of the robot based on the values of actual sensor which is collision-free. For ultrasonic sensors the original method was designed. In the method simulation of the model of mat lap of our robot was also used. A real mobile robot works laser rangefinder instead of sonars in order to appear independent on the source of the measurements of the distance.
- Ms. D.D Jadhav, *et al*., (2015): The suggested a driverless vehicle which has an on board GPS module that is able of driving the vehicle from one point to another without human operator. This system makes use of a embedded system depend on the technologies of GPS and GSM. When an authorized person sends the predefined message on the external SIM, the vehicle should be started. Current location is sent by smart vehicle on the predefined mobile number. For autonomous robot the obstacle detection is required. For obstacle detection the ultrasonic is most suitable and has high ranging capabilities, and it is low cost. The microcontroller is the heart of the system, it is interfaced between GPS receiver and GSM module.
- Hammam A. Alshazly and M. Hassaballah., (2016): Based on the AT-mega 8535 microcontroller, an embedded system was designed and implement, and it is used for controlling a mobile robot. It can provide a system of control which uses Bluetooth as a standard technology for connecting (send/receive data to/from) remote devices by interfacing a Bluetooth module into the suggested embedded system. To measure the distance between the robot and any obstacle the mobile robot is provided with a sensor, in its path and taking the proper action to avoid crashing, using various programming languages. The robot was made visually interactive by four bit LED_S to monitor the outputs of the I/O ports.

3. Proposed System

The proposed system, as illustrated in fig (1), consists of a three ultrasonic sensor that are interfaced with Arduino UNO microcontroller board and mobile platform. An autonomous robotic vehicle, for controlling the robotic actions, no remote is used. It astutely discovers obstacles introduced on its path through the sensors, avoid it and take decision on the basis of internal code which were set for it. The platform that was used is Rover 5. This robot consists of two DC motors. Each motor is supplied with a gearbox. The encoders generate pulse signals which can be used to measure the speed and direction of the motors(Dr. Mohamed Jasim Mohamed and Mustaffa waad Abbas,2013).

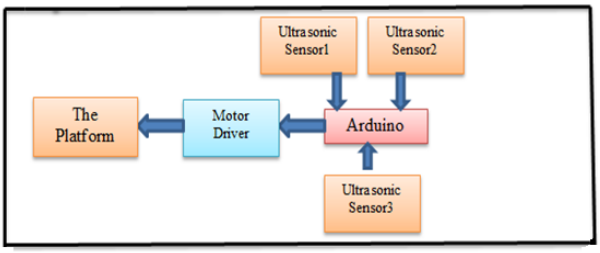


Figure 1: Design of a proposed system

3.1 Definition of Ultrasonic sensor

Sensor is a mechanical/chemical/electrical device which maps an environmental attribute to an measurement of quantitative. To collect information about the world it is used. Each sensor is based on the principle of transformation that is the conversion of energy from one form to other form (Khairul A'alam Bin Abdul Ghani,2015). To detect the distance from the obstacle to robot, the ultrasonic sensor is attached. To govern distance of an object, the sensor uses sonar. The range is from 2 cm to 400 cm or 1 to 13 feet (Surbhi Verma,2016). Ultrasonic sensors transmit the waves of ultrasonic from its head of sensor and again receive the waves of ultrasonic reflected from an object. To detects the position of the object by measuring the length of time from the transmission to reception of the sonic wave (Khairul A'alam Bin Abdul Ghani,2015).

By Echo signal, its output is highly perturbed, due to this the output never goes low if Echo is not received. According to the user aspirations the parameters of timeout are needed to alter the output. Its trigger input pulse width is 10 µS and resolution is 0.3 cm(Surbhi Verma,2016).

To receive the energy of ultrasonic, an ultrasonic sensor ordinarily uses an adapter which produces an electrical output in response to received ultrasound energy. For human hearing the normal frequency range is roughly 20 to 20.000 hertz. The waves of ultrasonic sound are sound waves which are above the range of human hearing, thus, have a frequency above 20.000 hertz. An ultrasonic may be considered when a frequency is above 20.000 hertz (Khairul A'alam Bin Abdul Ghani,2015).

3.2 Hardware of a Threshold Method

With an Arduino UNO development board on the microcontroller is placed, the robot is built with DC motor through motor driver board that provides power to the actuators. This DC motor is connected

with Arduino board. To move robot in different directions: forward, left, right and backward, actuators are used to it (Kirti Bhagat, Sayalee Deshmukh, Shraddha Dhonde and Sneha Ghag,2016).

This motor driver module is based on L298N H-bridge a high current, high voltage dual full bridge driver manufactured by ST company. Each of them, it can be driven to voltages up to 46V and DC motors 2A. A driver could be controlled the direction of rotation and the speed of both motors. By supplying low with high signals to the control input pins. It consists of on-board 5V regulator, filter capacitors, protection diodes and over temperature protection(sparkfun,2000).

For the design of robot, three ultrasonic sensors have been used for obstacle detection and avoidance, the first ultrasonic sensor is located on the right, the second on the front and the third has been on the left. frequency signals were continuously emitted by the ultrasonic sensors. This signals are reflected back when the obstacle is detected which then considered as input to the sensors through echo pin(J Borenstein,1988).

As shown in fig (2) and table (1), after connecting between the Arduino and three ultrasonic sensors, the code of Arduino has been downloaded. After that, by opening a serial monitor the action of an ultrasonic sensors has been tested to see a transmitted data.

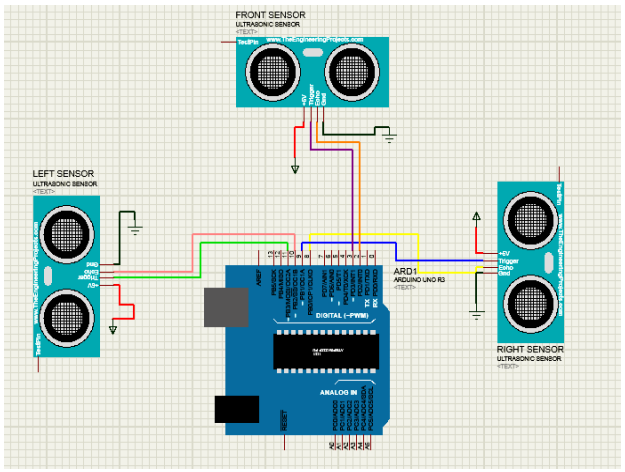


Figure 2: Connecting between three ultrasonic sensors and an Arduino

Table 1: Connecting between three ultrasonic sensors and an Arduino

Arduino pin	Ultrasonic sensor wire
3	Purple: trig1
2	Orange: echo1
9	Blue: trig2
8	Yellow: echo2
11	Green:trig3
10	Pink:echo3
GND	Black: ground
5V	Red: power

3.3 Software of a Threshold Method

Firstly, the Trigger and Echo were initialized as low and pushing the robot in forward direction. Echo pin has been given input as high to microcontroller when obstacle is detected. For calculating the time of distance from the barrier, the pulseIn() function has been used. Every time, the pin has been waited to go high and starts timing the function. After that, when pin goes to low the timing will be stopped. It returns either the pulse length in microseconds or when complete pulse was not received within the timeout 0(Rui Santos,2014). It converts into a distance, after determining the time. The robot will be taken forward if the distance to the object is moderate, but if the distance of object is not moderate, the robot checks right and left. The robot will be taken right if the right distance is greater than left, otherwise, the robot will take left turn.

By using Arduino software the implementation of obstacle avoidance strategy for robot include the writing and compilation of program. It includes a simple hardware platform on which microcontroller was placed as well as a free code editor that has a one click compile or upload feature. To program the microcontroller found on the board, the Arduino programming language which depends on the processing is used. The output of the comparator is given to the microcontroller, and by giving the power through DC motor it moves actuators in right or left direction(Kirti Bhagat, Sayalee Deshmukh, Shraddha Dhonde and Sneha Ghag,2016).

Fig (3) shows the threshold method of obstacle avoidance flow chart. The process of obstacle avoidance is initiated by serial connection on digital pins of the Arduino. Ultrasonic sensor pins are defined. The pin mode and baud rate must be set, after all these definitions. Check the status of the robot to identify the direction of the robot without colliding with obstacles. After that, the Arduino enters the loop to check the direction of robot each time, if there is any barriers in its path, in this situation the robot would be measured the distance and check the right, left and front at all times. After that, the robot is sent in the direction of the larger distance. Table (2) shows several of Arduino's significant commands and the action of its. That uses in barrier avoidance program.

Table 2: A significant instructions and their action for the obstacle avoidance

Instruction	Action
#include <SoftwareSerial.h>	Enable serial communication on digital pins of an Arduino.
#define TrigPin	Define Trigger of Ultrasonic Sensor as No. pin of an Arduino
#define EchoPin	Define Echo of Ultrasonic Sensor as No. pin of an Arduino.
Serial.begin(baudrate);	Put a baud rate for serial data transmission.
Serial.println(data);	Print a data to a serial port.
digitalWrite(digital pin, status);	if digital pin was low or high value to work an ultrasonic sensor.
reading[i]=analogRead(distance); delay(0.05);	i= No. of readings in 0.05 seconds.
If (distance < || ≥ value): digitalWrite(digital pin, status);	Determine the robot motion to avoid hitch.

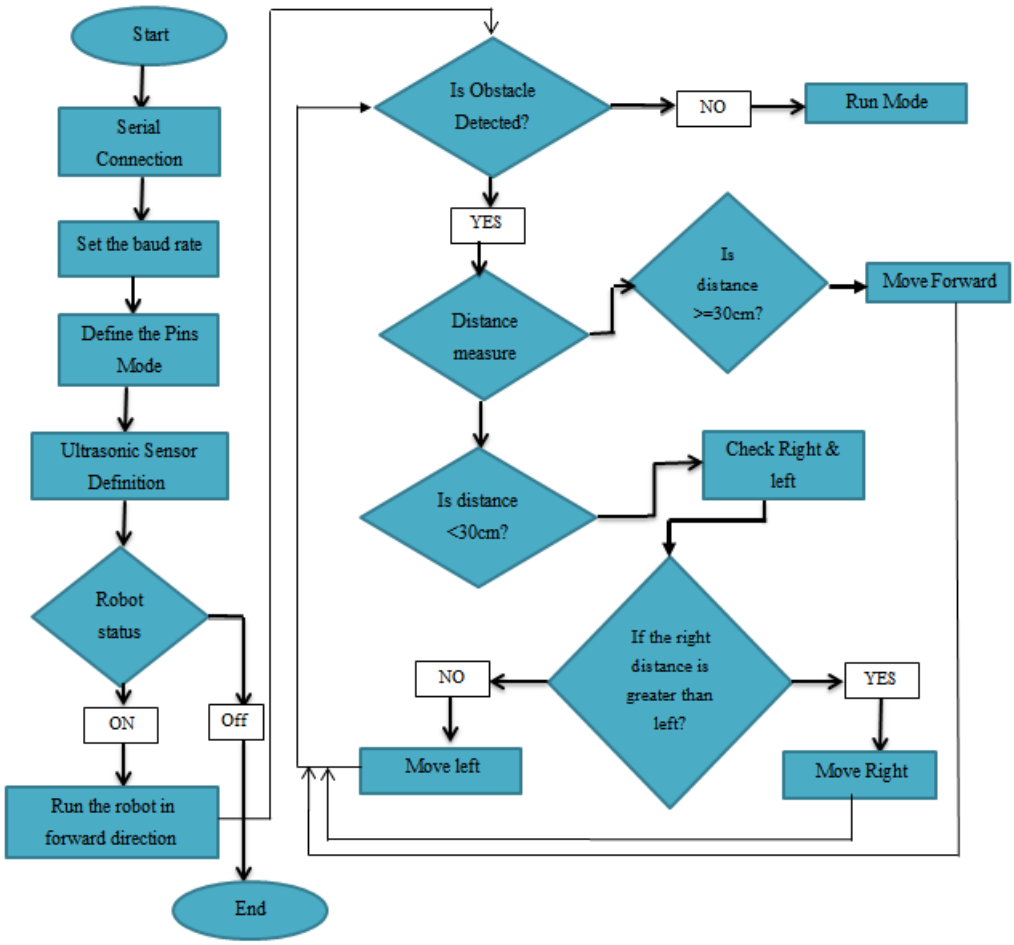


Figure 3: Flow Chart Threshold Method Obstacle Avoidance

4. Simulation and Practice Model

Fig (4) shows how the obstacle avoidance circuit was design and simulated by using Proteus software. According to the program all ultrasonic sensor generates a trigger signal that will receive echo pin of ultrasonic sensor.

The algorithm runs to manipulate the desire distance for obstacle detection. After that, the motor rotation direction for movement of the robot is controlled.

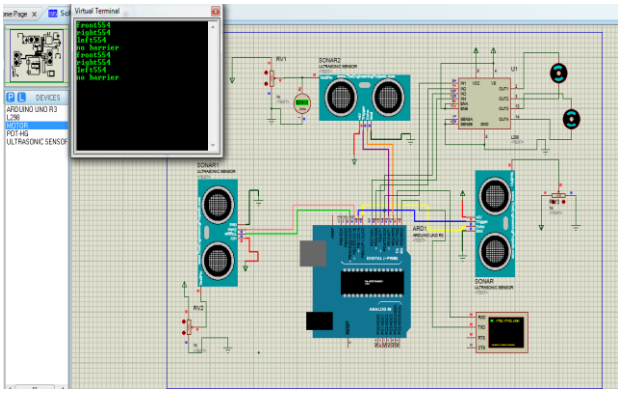


Figure 4: Model of simulation

The program loaded to Arduino microcontroller kit and the practical control system model was built, as shown in fig (5).

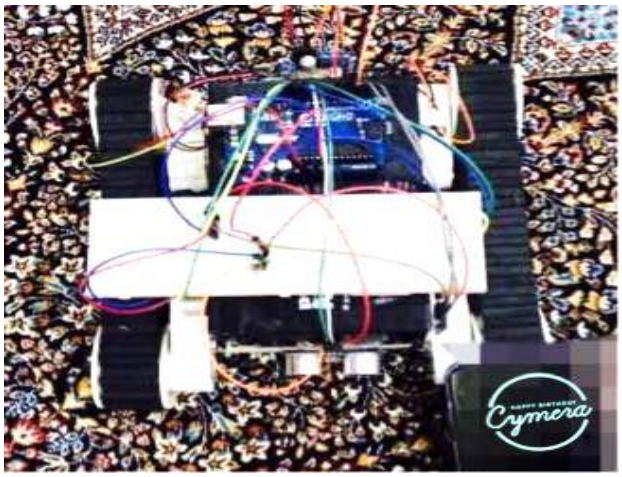
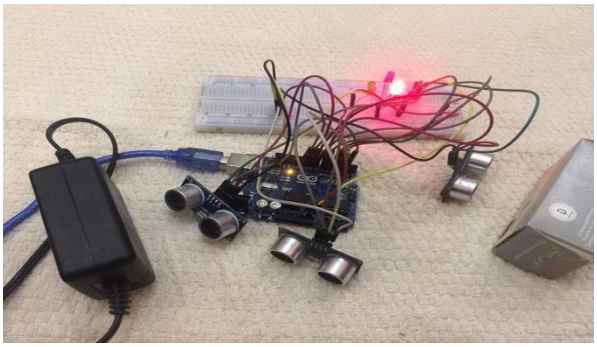


Figure 5: Practical threshold method

5. The Results

An obstacle avoidance circuit is dependent on Arduino UNO microcontroller that is a cerebrum of the system which is performed the tasks of the interfacing with

ultrasonic sensors. Fig (6) shows the implementation of an obstacle avoidance circuit which consists of three ultrasonic sensors which are interfaced with Arduino microcontroller. An output is given at a LED. The distance between the obstacle and the sensor is measured by the sensor when the object is put near the sensor, the LED is grown and goes OFF when an object is away from sensor.



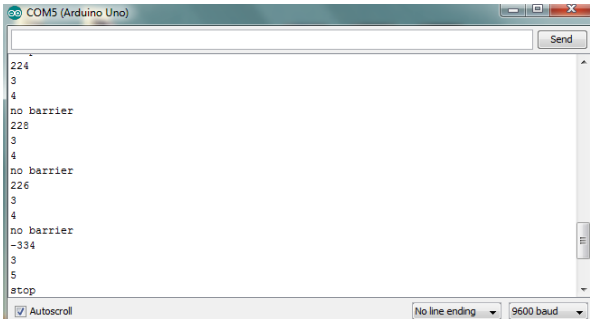
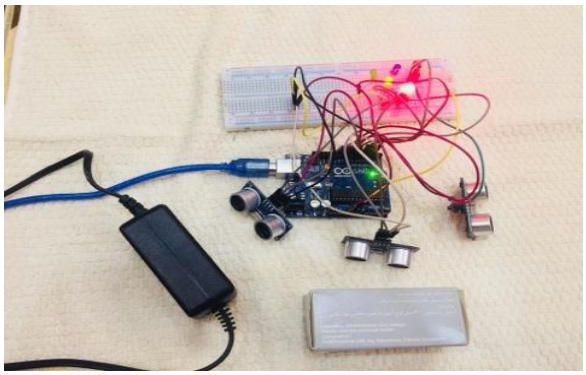


Figure 6: Implement hitch Avoidance Circuit without any Obstacle and The Robot Move Forward

Without any obstacle, the robot move forward. When a robot was powered on, both the motors for the robot will normally run and it is moved to front. At this time, an ultrasonic sensor continuously computes a distance between a reflective surface and a robot. The robot measures the right and left distance when the distance between the robot and the obstacle is less than 30 cm. In this case, a greater right distance was found. The left wheel motor was inverted in direction, and the right wheel motor was normally operated as illustrated in fig (7). In this case, a robot is rotated towards the right. This rotation is continued until a distance between any obstacle and a robot is less than 30 cm once again. The process is continued forever and the robot keeps on moving without hitting any obstacle.



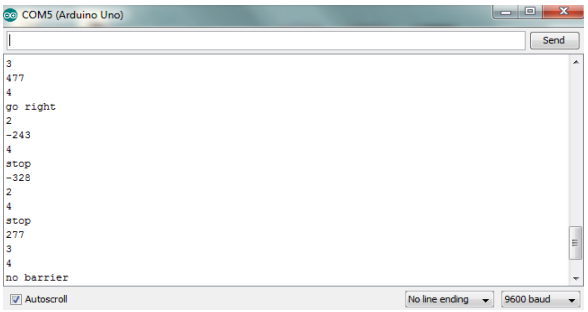


Figure 7: Implement Obstacle Avoidance Circuit with Obstacle and the Robot Move Right

An Arduino board is connected with DC motor through motor driver board (pin4, pin5, pin6, pin7) that provides power to the actuators. To move a robot forward,left, right and backward directions, an actuators are used to it. In table (3) The brief description of inputs pins for movement of robot is given.

Table 3: Inputs Pins for Movement of Robot

Motion	Pin 4	Pin 5	Pin 6	Pin 7
Forward	0	1	0	0
Backward	1	0	1	0
Left	0	1	0	1
Right	1	1	0	0

In table (4) the different distances that can be measured by using three ultrasonic sensors and the movement of robot.

Table 4: Measured the Distances by Using Three Ultrasonic Sensors and the Movement of robot

Distance of Front Ultrasonic Sensor (cm/s)	Distance of Right Ultrasonic Sensor (cm/s)	Distance of Front Ultrasonic Sensor (cm/s)	Movement of Robot
-350	3	9	Stop
228	3	4	Forward
3	477	4	Right
2	3	288	Left

Conclusion

A nice solution of dangerous and tricky places which humans can not be reached and made a specific tasks, a proposed system is provided by this study. By using three ultrasonic sensors, a robot takes the left, right, front movement in depending on the sensing signal. With helping of a two gear motor that making a movement of the Robot is smooth.

Reference

Thomas R. Kurfess (2005), Robotics and Automation Handbook, CRC Press.

J. Grefenstette and A. Schultz (1994),An Evolutionary Approach to Learning in Robots Machine Learning Workshop on Robot Learning, New Brunswick.

Khairul A'alam Bin Abdul Ghani (2015) Obstacle Avoidance Mobile Robot.

Sharayu Yogesh Ghangrekar (2009), A Path Planning And Obstacle Avoidance Algorithm For An Autonomous Robotic Vehicle, Univ. of Nor. Carol.

A. Salam Al-Ammri and Iman Ahmed (2010), Control of Omni-Directional Mobile Robot Motion, Al-Khwar. Eng. J, Vol. 6, No. 4, PP 1 – 9.

Andrej Babinec, Anton Vitko, František Duchoň and Martin Dekan (2013), Navigation of Robot Using VFH+ Algorithm, *Int.* Journal of Mechanics Engineering and Automation ,vol. 3,pp. 303-310.

Ms. D.D Jadhav., Komal Jadhav, Kajal Shinde and Anjali Sonawane (2015), Autonomous Vehicle with Obstacle Avoidance and Tracking, Int. J. for Research in Applied Science & Eng. Techno.,vol. 4, pp. 2321-9653.

Hammam A. Alshazly and M. Hassaballah (2016), An Embedded System for a Bluetooth Controlled Mobile Robot Based on the ATmega8535 Microcontroller, *Egyptian Computer Science J.,vol. 40, pp. 1110-2586.*

Dr. Mohamed Jasim Mohamed and Mustaffa waad Abbas (2013), Practical Application and Construction for Mobile Robot, Eng. &Tech. Journal, Vol.31, Part (A), No.14.

Surbhi Verma (October 2016), Android App Controlled Bluetooth Robot, Inter. J. Computer Applications, Vol. 152, No.9, pp. 0975 – 8887.

Kirti Bhagat, Sayalee Deshmukh, Shraddha Dhonde and Sneha Ghag (February 2016), Obstacle Avoidance Robot, Inter. J. Science, Eng. and Techno. Research, Vol.5, No. 2.

(2000, Jenuary). Dual Full-Bridge Driver, ST. [online] https://www.sparkfun.com/datasheets/Robotics/L298_H_Bridge.pdf..

J Borenstein (1988), Obstacle avoidance robot using ultrasonic sensors, IEEE, J. on Robotics and Autom.,Vol.4, No. 2.

Rui Santos (2014), Complete guide for Ultrasonic sensor HC-SR04. [online] http://randomnerdtutorials.com/complete-guide-for-ultrasonic-ssensor-hc-sr04/.