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Automatically Guided Mobile Robot for Vision based Application

Mr. D.V. Khankal[1], Mr. G. S. Dave[2], Mr. R.M. Navale[3]
Department of Production Engineering, Sinhgad College of Engineering, Pune, India

Abstract— *In the present work automated guided mobile robot gain information about the environment from sensors, the microcontroller uses this information to activate all actuators. Autonomous vehicle operates in areas which are harmful to human or too small to enter. It is used in many industrial process operations also in surveillance and rescue operations. The research has been done on autonomous robot using different types of controllers, sensors, actuators etc. for different application. The autonomous robot moves automatically by avoiding obstacles to reach destination position. In this dissertation the infrared sensor detects the obstacle and gives this information to the Arduino mega 2560 controller which is used to control all activities. The CMOS camera is used for vision based applications. Motor driving shied compatible to Arduino is used to drive the motors, sensors etc. because it simplifies the interfacing work. Arduino programming and interfacing is based on C language so work with Arduino is very easy and user friendly in area of robotics. The accuracy of the system is reasonably high and the output of the system is quite acceptable.*

Keywords— *Master robot, slave robot, Arduino and path.*

I. INTRODUCTION

A robot is a reprogrammable, multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks. The technology associated with the robots is called robotics. A robot is a machine capable of being set up and programmed to perform a wide variety of tasks for which it must physically move itself or other objects. Most tasks that robots do are repetitive, difficult, or hazardous to humans.

A robot can be defined as a flexible versatile system, these include, mechanical structure to perform the manipulative tasks, a manipulator, and a power unit, to provide the necessary energy, a sensor to detect the manipulator state and environment characteristics, a control unit, to program the task operation and regulate the robot. The flexibility of a robot refers to the capability of reprogramming the operation of the system for a variety of tasks. The versatility of a robot refers to the capability of performing a variety of manipulation tasks. The design and operation of a robot requires integration of many different systems with a multi-discipline mechatronic approach.

Robot is an autonomous machine that taken the place of humans in many areas mainly in dangerous environments or in manufacturing processes etc. Today robotics is a rapidly growing field. As technology advances continuously, the robots are builds for various practical applications. Many robots do the jobs that are hazardous to people such as defusing bombs, mines and exploring shipwrecks. [1]

A. Objectives

The statement of the dissertation work is as follows: "To develop an autonomous robot to travel on predefined path avoiding obstacles while resuming the path". The robot shall have a built in camera to shoot the pictures and store for future use.

To start working on the dissertation, initially, some significant research is quickly reviewed. The main objective of this review was to identify which are the current trends in this application area, along with the state of art technology. Then in second phase, the vehicle aspects i.e. motion, steering, and control, the various sensors and transducers, and allied component suitable for the microprocessor are identified.

In the final phase, the following objectives are defined and step by step they are achieved through proper component interfacing and microcontroller programming gradually developed.

- To detect the hurdle in the path and avoid it using appropriate sensors.
- To capture images by camera on the way after specific interval of time.
- Storing the captured images in the microcontroller for further use.
- Interfacings and programming of motor drives, microcontroller, camera and sensors together.

II. VEHICLE LAYOUT

The proposed autonomous robot is a mobile robot. One of the required functions of this report is to trace the path, which is either defined or changed due to obstacles found in the predefined path. Though the speed of the mobile robot is anticipated very low, but still the vehicle is expected to have all the mechanical aspects like steering, differential in the rear wheels. Due to the mini atomization of the vehicle, instead of manufacturing the desired one, the toy vehicle is used as a robotic vehicle with few modifications.

A. Design

The salient features of the vehicle are DC motor drive, differential in rear wheels, the Ackerman steering mechanism installed in front wheels, and provision to keep batteries on vehicle. The disadvantage of using readymade toy vehicle is there is little space for any modification or amendment to incorporate. But still the compact construction has helped a lot while more given to design the classical algorithms for various subroutines in microcontroller. The Figure 1 shows the bottom view of the amended battery operated vehicle.

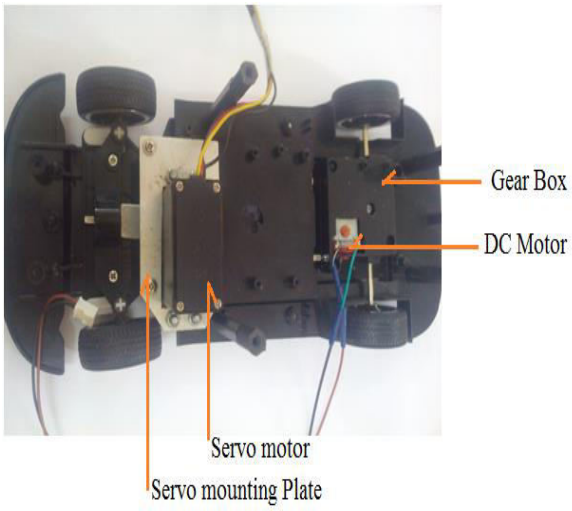

Figure 1: Four wheel chassis with rear wheel Drive

As shown in Figure 1, the bottom view of the vehicle with differential mounted with motorized rear wheels. The vehicle is radio frequency operated for direction change. This is altered and a servo motor is mounted for steering. This has introduced the stable steering as well as precision steering.

The vehicle is still required to be mounted with some of the important components like microcontroller, sensors, camera, Bluetooth etc. All these components are fitted on a light weighted aluminum plate. The block diagram showing the peripherals and data traffic is shown in Figure 2.

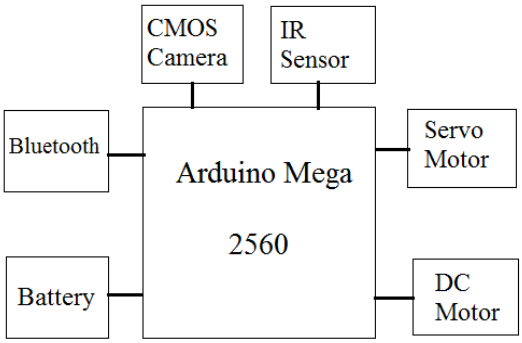

Figure 2: Completed Block Diagram for mobile robot.

B. Motor Drive

In this dissertation work, **Hitec HS-485HB servo motor** is used which is the most durable and reliable servo ever offered. It has a top ball bearing, heavy duty, high impact gears and high performance circuitry. HS-485BB offers all the required features like excellent centering and resolution.

The shaft of the DC servo selected is configured with the Ackerman steering mechanism. This enables to position to specific angular positions through command by the microcontroller. The DC servo maintains the desired angular position as long as the corresponding signal from microcontroller is fed to it. This coded signal has a corresponding position of the shaft. The DC servo motor has control circuits mounted with potentiometer on the other end of the shaft. The coded analog input to this servo position control mechanism is greater than the potentiometer output. The DC servo takes counter clock wise (ccw) turn and in case negative, the DC servo takes clock wise (cw) turn. The total angular displacement of the shaft of the motor is 180 degrees. The Figure 3 shows the photo of the selected servo. [2]

Figure 3: **Hitec HS-485HB Servo**.

Specification of servo motor

Speed (sec/60˚)	0.22(4.8V), 0.18(6V)
Torque (Kg-cm/Oz-in)	6/83.32(6V)
Size (mm)	39.8 x 19.8 x 38
Weight (g/oz)	45/1.59

C. Controllers

Arduino Mega 2560

The Arduino is not a microcontroller. It is a mini board based on ATMEGA AVR type microcontroller. There are different microcontrollers available in market such as PIC, ARM, 8051 etc. As compared to other controllers, Arduino programming is easy to use which is based on C language. Another advantage of the Arduino is that the different interfacing shields are readily available in market. These shields avoid complicated interfacing work. These interfacing shields are not available in other controllers. That's why the Arduino is used in this dissertation work. In this robot, Arduino motor driving shield is used.

Figure 4: Arduino Mega 2560

Specification of Arduino Mega 2560

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54
Analog Input Pins	16
DC Current per I/O Pin	40 Ma
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB
SRAM	8 KB
EEPROM	4 KB

Arduino Motor Driving Shield

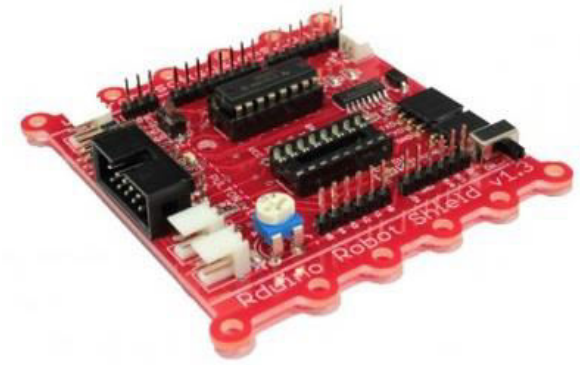

Figure 5: Arduino Motor Driving Shield

This shield is used to connect

- 2 motors (max upto 4 optional with an additional L293D),
- 1 line following sensor modules,
- 2 IR sensors, and
- 1 RF-pro module for wireless connectivity.

D. Obstacle Avoidance

There are different sensors available for obstacle detection such as IR sensor, Ultrasonic sensor, LASER sensor etc. Avoidance of the obstacles is important for autonomous robot to move from initial position to destination. [5]

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Ultrasonic Sensors

It works on a principle similar to the radar or the sonar, which evaluates the attributes of a target by interpreting the echoes from the radio or the sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. By using ultrasonic sensor the velocity and

the direction of a moving obstacle can be identified easily through the Doppler Effect. Ultrasonic waves are susceptible to temperature and humidity. These sensors are costly as compare to the IR sensor.

Laser Sensor

A laser sensor uses a laser beam to determine the distance to an object. It operates on the time of flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. Due to the high speed of light, this technique is not appropriate for high precision sub-millimeter measurements. It is expensive as compare to other sensors.

IR Sensor

The IR transmitter continuously generated an infrared signal of 38 KHz. When an obstacle comes in the path, the infrared signal reflects back from the object and is received by the IR sensor receiver. It generates a positive high signal with the help of the receiver circuit, when there is an obstacle in the path. In such a way the robot is able to detect and avoid the obstacle. IR sensor's speed is constant over a particular media and is used in most digital electronics. These are cheaper than any other type of sensor. In the dissertation, IR sensors are used.

TSOP-OBSD–Single

The TSOP (Thin Small Outline Package)-OBSD–Single is a general purpose proximity sensor. It is used for obstacle detection purpose. The module consists of an IR emitter and a TSOP receiver pair. The high precision TSO receiver always detects a signal of fixed frequency. Due to this, errors due to false detection of ambient light are significantly reduced.

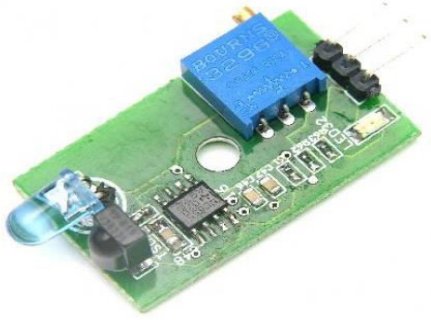

Figure 6: TSOP-OBSD Single type IR sensor

The module consists of 555 IC, working in a stable multi vibrator configuration. The output of the TSOP is high whenever it receives a fixed frequency and low otherwise. The on-board LED indicator helps user to check status of the sensor without using any additional hardware. The power consumption of this module is low. It gives a digital output and false detection due to ambient light is low.

Features of the sensor are:

1. Typical Maximum Range -20cm,
2. Modulated IR transmitter to avoid any interference,
3. Calibration preset for range adjustment, and
4. Indicator LED with 3 pin easy interface connector.

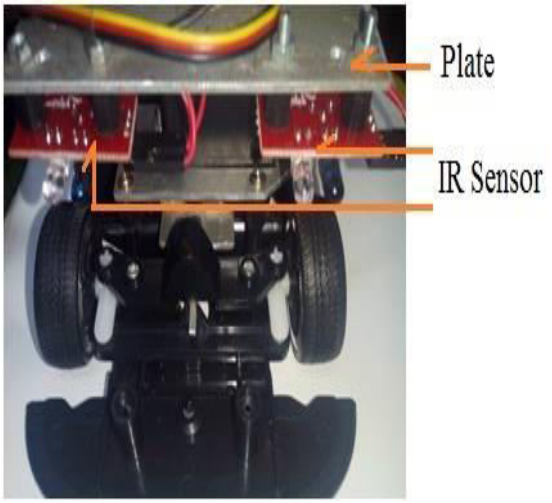

Figure 7: IR sensor mounted to the plate

E. Image Capturing

There are different cameras available in market such as CMOS camera, CCD camera, RC camera etc. CMOS (Complementary Metal Oxide Semiconductor) and CCD (Charged Coupling Devices) both are image sensor found in digital cameras. The CMOS camera is cheaper than the CCD camera. The CMOS sensor has superior power consumption as compare to the CCD sensor. The CMOS cameras have better battery life and can take more pictures. CCD camera gives slightly better quality picture than CMOS camera. But when picture quality is not big issue then the CMOS is a better option. In this dissertation simple CMOS camera is used. [3]

RSV5-C328 camera

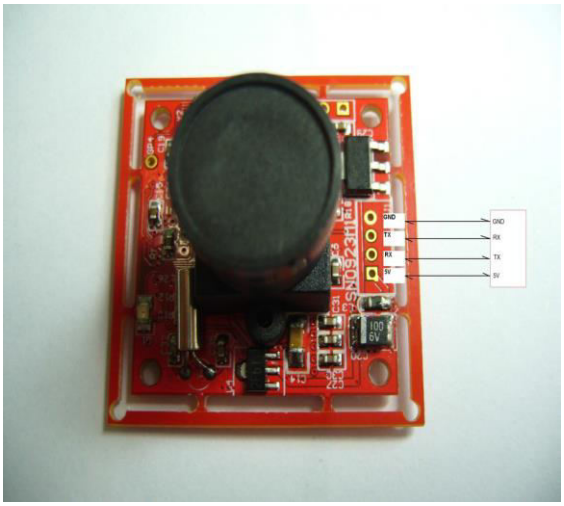

Figure 8: RSV5-C328 camera

The camera module has an on-board serial interface that is suitable for a direct connection to any host microcontroller UART or a PC system computer port. The camera is powered by 5V. RSV5-C328 camera is controlled by twelve commands. These commands are represented by two byte and four arguments. The complete command packet is always six bytes long. It is a low cost and low powered camera module for high-resolution serial bus security system.

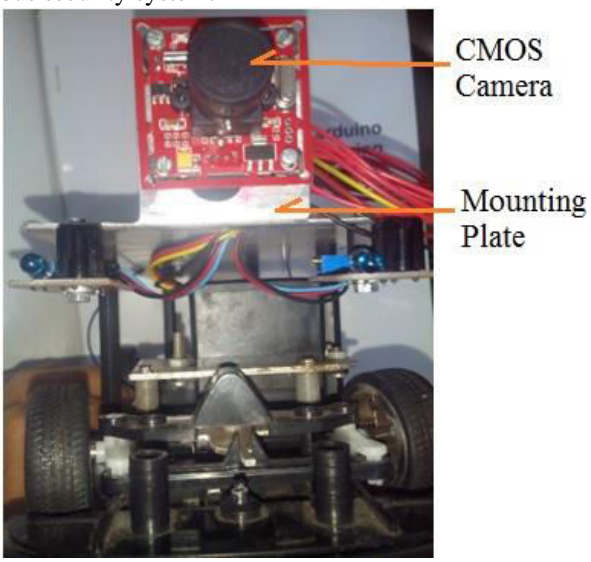

Figure 9: Camera Assembly

F. Wireless Serial Communication

The available technologies used for wireless communication are Bluetooth module, WiFi module, Zigbee module etc.

WiFi

WiFi is a local area wireless technology that allows an electronic device to exchange data or connect to the internet using radio waves. WiFi is better suited for operating full-scale networks because it enables a faster connection, better range from the base station, and better security than Bluetooth. It is more complex and requires configuration of hardware and software.

Zigbee

ZigBee is suited for high level communication protocols used to create personal area networks. ZigBee devices can transmit data over long distances by passing data through intermediate devices by using mesh technology. It is best suited for periodic or intermittent data or a single signal transmission from a input device. It precisely exchanges operational instructions. However, it cannot exchange much variety of data as compare to Bluetooth.

Bluetooth

Bluetooth technology is useful when transferring information between two or more devices that are near to each other and when speed is not an issue. It is best suited to low-bandwidth applications like transferring sound data with telephones or byte data with computers or keyboard and mouse. It is very simple to use and connect up to seven devices at a time. It is easy to switch between devices or find and connect to any device.

Both Wifi and Zigbee are used to long-range communication while Bluetooth is used for range up to 10 meters. In this dissertation a small size image is transferred over a small distance. Therefore, according to the application point of view, Bluetooth is more suited. AlsoBluetooth module is cheaper than other wireless module.

HC-06

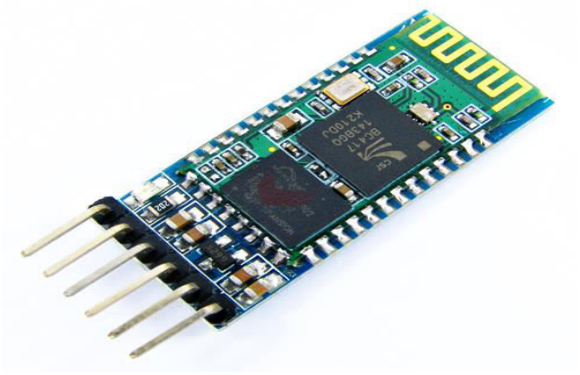

Figure 10: Bluetooth HC-06

The Bluetooth Trans receiver HC-06 is the latest Bluetooth wireless serial cable. It uses a HC-05/HC-06 module. These modems work as a serial RX/TX (Receiver/Transmitter) pipe. Any serial stream from 9600 to 115200 bps can be passed seamlessly from

one device to other. The remote unit can be powered from 3.3V up to 6V for easy battery attachment. All signal pins on the remote unit are 3V-6V tolerant. No level shifting is required. It support master and slave mode. The features of the Bluetooth are mentioned below:

1. CSR Bluetooth Chip Solution,
2. Bluetooth Spec v2.0+EDR Compliant,
3. Enhanced Data Rate (EDR) compliant with V2.0.E.2 of specification for both 2Mbps and 3Mbps modulation modes,
4. Full Speed Bluetooth Operation with Full Pico net Support and Scatter net Support,
5. Incredible small size with 3.3V input,
6. UART interface and with baud rate setup function,
7. Support for 8Mbit External Flash Onboard, and
8. Support for 802.11Co-Existence.
9.

III. Final Assembly of Robot

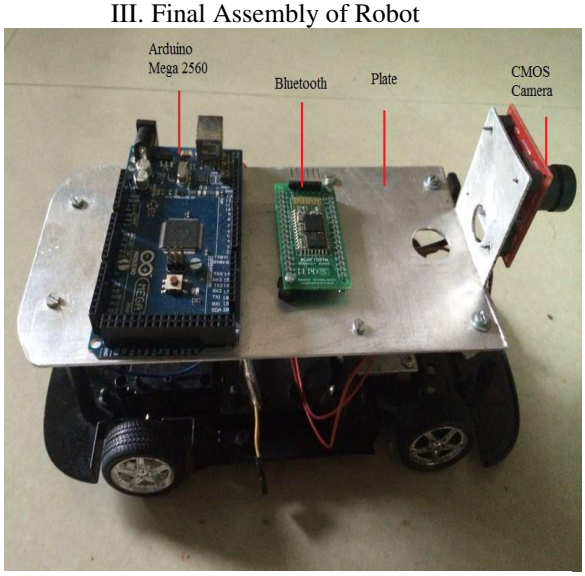

Figure 11: Assembly of automated vehicle

The assembly of automated vehicle is shown in Figure 3.11. It consist of Arduino mega 2560 which controls the activity of robot. It is four wheel robot employing IR sensor to avoid obstacles. For image capturing CMOS camera is mounted on robot. For serial communication Bluetooth is mounted. The servo motor mounted to angle the steering and DC gear mechanism for drive the robot. This is discussed already.

IV. PROGRAMMING AND EXECUTION

The main objective of dissertation to avoid the obstacles and communicate with other robot using Bluetooth. The programming pat of robot is divided in two parts. First is programming for obstacle avoidance and second is programming for communication between master and slave.

Obstacle Avoidance

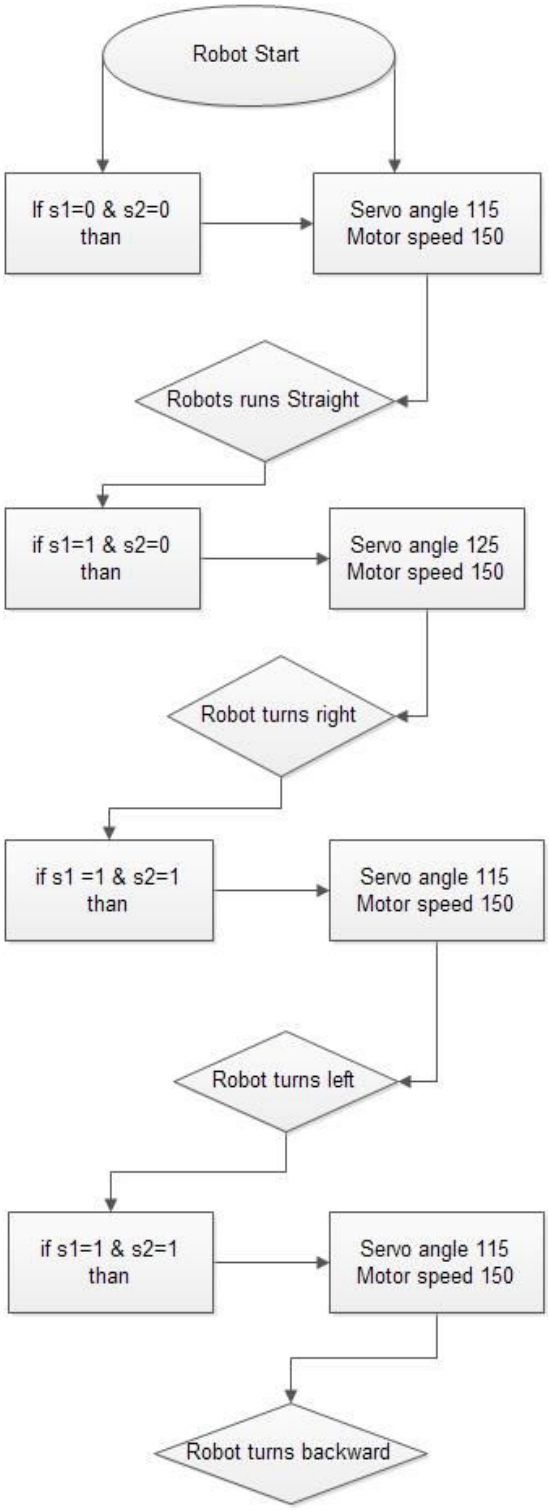

Fig 12. Flowchart on process of obstacle avoidance robot

V. RESULTS & DISCUSSION

The robot is moved on the predefined path. In this path 3 obstacles are placed. The behavior of the robot is compared with the predefined global path.

Obstacle Avoidance

The main task of the robot is to reach at end point by avoiding the obstacles and capturing the images of obstacles. The results of robot give outcomes as per requirements. The Figure 15 shows the path followed by the robot. The robot starts its motion at start point and stops at end point.

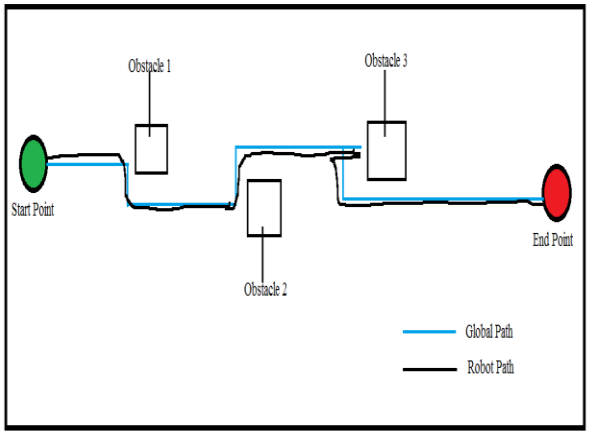

Figure 15: Path of Robot

Initially the robot continues to move in a straight line until the obstacle 1 come. When the robot come in front of obstacle 1 then left sensor of robot is activated and robot takes right turn after 1 second robot will take left turn and go straight till the obstacle 2 come. When obstacle 2 come then right sensor of robot is activated and robots takes the left turn for 1 second and again take right turn and go straight till the next obstacle come. At the obstacle 3 both sensors are activated and robot takes backward motion for 1 seconds, takes right turn for 1 second and finally takes left turn and go straight until end point come.

During the motion of the robot, the robot fails to take exact 90˚ during turning. At the time of backward motion the path of robot deviates from the global path. The exact path of the robot as per the global path can be obtained by implementing the control system in the system these control system would be P, PI, PID or Fuzzy etc

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5.2 Image Capturing

During the motion of the robot, the camera captures the images of obstacles the resolution of the camera is 640×480. The Figure 13 and 14 shows the image of 3 obstacles captured by camera.

The Figure 13 shows the photograph of obstacle 1. It is clear from the photograph it is image of white box.

Figure 13: Photograph of Obstacle 1

The Figure 14 shows the photograph of obstacle 2. It is photograph of a white bottle.

Figure 14: Photograph of Obstacle 2

CMOS camera is able to capture the images of the environment. In above Figures 13 and 14 are shows that images of the obstacles. The camera mounting on different positions, it is possible to take images of entire environment. Therefore it is used vision based operations. Above images are not clear because of low resolution of camera.

VI. SUMMARY

Arduino mega 2560 simplifies all robot activities, also increases accuracy of the robot. Image processing is not fast enough. Regardless, the error percentage is small enough to be acceptable. Achievements of the dissertation are shown below:

- The obstacle detection and avoidance done successfully on predefined path.
- The camera successfully captures the images after specific time interval and these images stored in to the microcontroller memory for future use.
- Programming and interfacing work, done by using Arduino mega 2560 board and its software.
- The Bluetooth interfacing for wireless communication is also done in this work.

Future Work

While designing an autonomous robot, there are many application related work is possible in areas of navigation, path planning, GPS guided robot, image follower robot etc. Out of which related future works are possible are shown below**.**

- Data can be transfer from one robot to other using wireless serial communication techniques such as GPS, WiFi, Bluetooth etc.
- Vision based guidance is possible in robot to navigate according to vision.
- By some modifications in driving mechanism of robot it might navigate not only on smooth surfaces but also it on rough surfaces.

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