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Line Follower Robot for Industrial Manufacturing Process

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Abstract: *Line follower robot is one kind of autonomous robot which follows a line until that line exists. Generally, the line is drawn on the floor. It can be either black or white. The line can also be normal visible color or invisible magnetic field or electric field. The robot follows the line by using Infra-Red Ray (IR) sensors. There are five IR sensors which makes it an IR sensor array. These sensors read the line and send that reading to Arduino and then control the robot movement. In this paper, the authors will explain about the robot design, implementation, coding, testing, problems they faced and their solutions.*

Keywords: *Line Follower, Arduino Uno R3, Adafruit Motor shield, IR sensor array, DC Power Adapter (9V, 2A)*

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I. INTRODUCTION

Line follower robot is autonomous that means it automatically follows a line which is pre-defined. Generally, it follows a black line on a white surface or a white line on a black surface. Some of the basic operation of a line follower is given below:

- Reading the pre-defined line by IR sensor array which is installed on the front-down side of the robot and sends those reading to the Arduino. The ATMega microcontroller which is built in on Arduino analyzes those reading and do the particular operations.
- The steering mechanism is simple in this robot. Three wheels are used, two wheels are on the back part connected with the motors and one independent wheel on the front-middle part of the robot.
- On Straight line, the speed is fast and on a turn, speed is relatively slow depending on turn angel. Good motor quality and good sensing quality will increase the robot movement performance.

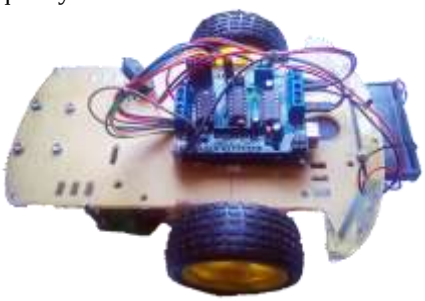

Fig. 1: Line Follower Robot

Line follower robot can be used in many industrial purposes. It can be used in carrying heavy and risky products. Radioactive products transportation inside a factory is very much risky for human life. A line follower robot can help in that section. Also in a hospital, it can monitor patient and inform Doctor on a critical situation. In restaurant business it can also help in many sections such as food servers and order taking jobs can be easily done by this kind of robot. In this paper, the authors are explaining the robot architecture, design, coding, implementation and other objectives. Robot structure and architecture is explained in section 2, Pin diagram and connections in section 3, programming subject in section 4, solution on robot path is discussed in section 5, future plans on section 6 and the conclusion in section 7 consequently.

II. LINE FOLLOWER ROBOT EQUIPMENT

This robot is made by several parts:

- Arduino Uno R3 and IDE
- Digital IR sensor array
- Adafruit Motor Shield

- DC motors
- Chassis board
- Power supply (9V/12V DC)

The IR sensor reads the line and sends the analog reading to the Arduino through the analog pin on Arduino Uno board (A0-A4 pin).On white line analog reading is less than 300 and on black line analog reading is greater than 600. The minimum analog reading is 0 and maximum is 1023 (10 bit binary). That reading distinguishes between black and white colors by which robot senses the line.

Arduino board and other devices get power supply through EXT_PWR pin on Adafruit motor shield by 9V DC battery. If 12V DC battery is used, then a 12V to 9V DC power supply converter also will have to use for device's safety.

1.1 Digital IR sensor Array

The line follower robot uses 7 array digital IR sensor array to sense the line. Among them, five IR sensors are used because there are six analog pins on Arduino. For balancing left and right side four sensors are used and one middle sensor for line detection. On each IR sensor, there are two diodes. One of them send Infra-red rays and another one receives it. If the receiver receives more reflected light than it is on the white surface and if receives less reflected light (or doesn't receive any reflected light) that means it is on the black surface. One IR sensor includes one infrared transmitter and one receiver. IR sensor array is the combination of five IR reflectance-sensors.

Fig. 2: IR Reflectance Sensor Array

The distance between the surface and the IR sensors array should be less than 5mm and distance between two IR sensors depends on line width. The sensors work well if it is shielded from ambient light.

The IR sensor array has been set up on the bottom side of the chassis. Those sensors are giving analog reading to Arduino depends on the IR ray reflectance. For accuracy left two sensors reading average and right two sensors reading average will decide the movement of the robot. A sample program is given below:

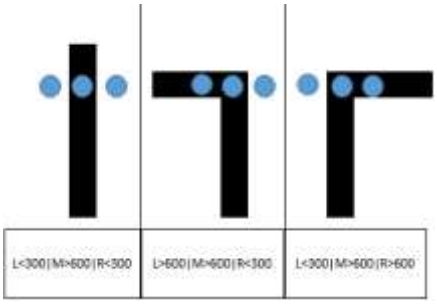

Fig. 3: Sample follower paths

If M>600 && L<300 && R<300 Move forward
If M>600 && L>600 && R<300 Turn Left
If M>600 && R>600 && L<300 Turn Right

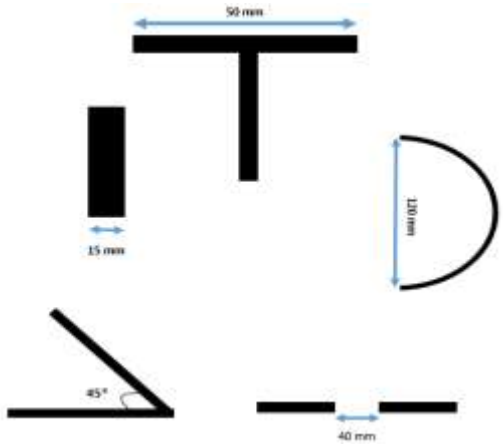

Fig. 4: Angle Detection methods for Sensor

According to the Fig: 4, the width of the line is 15mm. When it will find "T" shape surface, the robot will stop. The top length of the applied "T" shape is 50mm as the IR reflectance sensor's width. This is able to move 120mm diameter of the curve in a circle. It will be forwarded to the break point between two lines is 40mm. If the break point of two lines is larger than 40 mm, it may loss the path.

1.2 Arduino Uno R3

Arduino Uno R3 is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; by simply connecting it to a computer with a USB cable one can program it. It supports 5V DC to 12V DC. The safe power supply is 9V DC. Arduino controls the whole robot actions. The motor shield is placed above it. Motor shield's pins are connected to Arduino's pins.

Fig. 5: Arduino Uno R3

Arduino IDE is used for writing a program and inserting the code to the Arduino is done by USB cable which connects Arduino and computer.

Fig. 6: Arduino IDE

1.3 Adafruit Motor Shield

Authors have chosen the Adafruit motor shield because it suits well with Arduino. Moreover, it has some more quality with classification. There is four connection point for four motors. As authors used two motors, so among four points two points M1 and M2 are used.

The motor shield also has six analog pins (A0-A5). The IR sensors are connected to Arduino through this analog pins (A0-A4). Motor speed is controlled through this motor shield. It allows the motor to spin both clockwise and anti-clockwise. From the EXT_PWR point, external power supply is given by battery.
Arduino send instructions to motor shield and it controls the motors cause's four states.

a. Both motors are on and rotating forward causes forward movement.
b. Right motor is rotating forward and left motor is rotating backward causes a Right turn.
c. Left motor is rotating forward and the Right motor is rotating backward causes Left turn.
d. Both motors are off causes stop point of the robot.

Fig. 7: Adafruit Motor Shield

1.4 Motors and Wheels

Motors are very important part of this robot. Because the movement system is the main part of the line following. Some most important things are that both motors must be the same kind, speed, power supply and smooth. So choosing motors are very important as there are so many kinds of motors available in markets. Here the authors have used 4V DC gear motors. Wheels also have to be same size and radius. Wheel size effects on the robot speed.

Authors are using three wheels. Among them, two are connected back side of the chassis with motors and one wheel is independent and connected to the front side of the chassis.

1.5 Body and the Chassis

Robot body is another important thing. One can use many kinds of chassis but it should be kept in mind that chassis has to support all devices and also has to be strong. It can be made from glass, plastic, aluminum or any other lightweight materials.

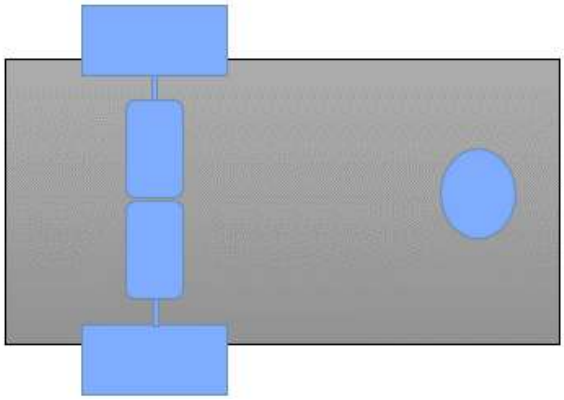

Fig. 8: Chassis Assembly

The authors have made car shape line follower robot. Devices are installed above the chassis and motors and sensors are installed below the chassis by screws. Nothing is installed permanently by any kind of glue.

III. ASSEMBLY AND PIN CONNECTION

The motor shield is placed above the Arduino connecting Arduino with motor shield. The IR sensor array gets 5V DC power supply from the motor shield's 5V pin, and sensors GND pin is connected to motor shield's GND pin. Sensors pins are added to shield's analog A0-A4 pins. External power supply is given through EXT_PWR pin.

	Device Pins	**Motor Shield Pins**
IR sensor	5V GND IR1 IR2 IR3 IR4 IR5 SEN	5V GND A0 A1 A2 A3 A4 D2
Motors	Left motor Right motor	M1 M2
Power Supply	9V DC	EXT_PWR

Table 1: Pin Specification

Chassis assembly according to pins are given below:

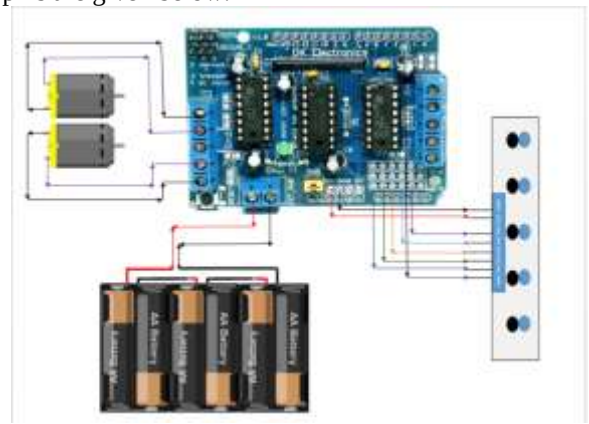

Fig. 9: Chassis Assembly

IV. SOURCE CODE

Arduino microcontroller has its own IDE for coding. It supports C as a programming language. Arduino IDE has its own facility to connect Arduino to computer via USB cable and passes enough current and code through it.

As the authors used Adafruit motor shield, there is a library for that motor shield. This library supports motor control functions. The main functional process is given below:

```
#include <AFMotor.h>    //Adafruit Motor Shield Library

AF_DCMotor motor1(1, MOTOR12_8KHZ );  //create motor #1 using M1 output on Motor Drive Shield, set to 8kHz PWM frequency
AF_DCMotor motor2(2, MOTOR12_8KHZ ); //create motor #2 using M2 output on Motor Drive Shield, set to 8kHz PWM frequency

void setup()
{
 delay(1000);
pinMode(A0,INPUT);
pinMode(A1,INPUT);
pinMode(A2,INPUT);
```

```
pinMode(A3,INPUT);
pinMode(A4,INPUT);
analogWrite(2,255);
}
  int sp=85;  // setting motor speed
void loop()
{
int l,r,t=100; //300 is the value that distinguish between black and white

int left;
int right;
int middle;
  l=analogRead(A0)+analogRead(A1);
  r=analogRead(A3)+analogRead(A4);
  middle=analogRead(A2);
  left=l/2;
  right=r/2;
if(left<t && right<t) //move forward
{
  motor1.setSpeed(sp);
  motor2.setSpeed(sp);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  l=analogRead(A0)+analogRead(A1);
  r=analogRead(A3)+analogRead(A4);
  left=l/2;
  right=r/2;
}
else if(left<t && right>t) //turn right
{
  while(left<t && right>t)
  {
  motor1.setSpeed(sp);
  motor2.setSpeed(sp);
  motor1.run(BACKWARD);
  motor2.run(FORWARD);
  l=analogRead(A0)+analogRead(A1);
  r=analogRead(A3)+analogRead(A4);
  left=l/2;
  right=r/2;
  }
}
else if(left>t && right<t) //turn left
{
  while(left>t && right<t)
  {
  motor1.setSpeed(sp);
  motor2.setSpeed(sp);
  motor1.run(FORWARD);
  motor2.run(BACKWARD);
  l=analogRead(A0)+analogRead(A1);
  r=analogRead(A3)+analogRead(A4);
  left=l/2;
  right=r/2;  }}
else if(left>t && right>t && middle>t) //stop
{
  while(left>t && right>t && middle>t)
  {
  motor1.run(RELEASE);
```

```
  motor2.run(RELEASE);
  }
}
}
```

V. LINE FOLLOWER PATHS

Line follower robot follows path drawn on the floor. The line will be mainly black on a white surface. If it occurs any line break on its way, the robot will go forward. If it finds a cross line, the robot will stop. Lines and robot movements can be changed by using programming code easily. Some lines are that the robot can follow:

Fig. 10: Sample path

The robot will follow a bad angle of 45° and cycle or bad curves. It will stop when it finds a cross black line.

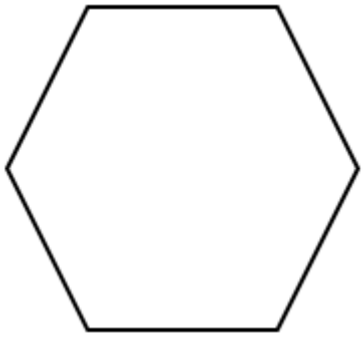

Fig. 11: Polygon shape Path

On any kind of Polygon, it can follow the line and maintain a particular speed.

Fig. 12: Cycle and Hard Curve

The line may have cycles and unwanted curves that it has to follow on narrow space or moving one room to another.

VI. FUTURE WORK

Line following robot based industrial manufacturing process in Bangladesh can play a vital role in the field of industry. Using this robot in the government organization and Manufacturer Company, especially the RMG sectors in Bangladesh, the cost for the manpower can be reduced. This line following robot can be used as carrying the load to deliver the goods from one place to another smoothly without any damage. If any type of goods mishandling occurs then that system can stop its routine function and call to the system administrator to check the occurred problem to repair.

For this purpose, a GSM module can be used to monitor the production process in real time basis. In real time basis, the functional work of any industry can be more efficient for supply chain management so that the industrial sectors of Bangladesh will take a place in international markets.

VII. CONCLUSION

Robotics has a significant role in global economy and everyday life. Another concern of robotics research is to be competitive and design patents for global industries according to their nature of applications. The demand of robotics technology is expanding in wide range of applications and human activities, especially for manufacturing, medical, service, defense, and consumer industries. The Designed robot has five IR sensors, Arduino microcontroller board, and Adafruit motor shield. Arduino mainly controls the robot to follow the line. This line follower robot is the prototype of robots for industrial use. By studying this one can build line follower robot for industrial use. Performance can be improved by using good materials and great sensing power also improves motor movement. The setup cost of line follower robot majorly depends upon the expensive machinery, land, and building and round the clock staff to maintain and use that machinery. In Bangladesh where the population is humongous and resources are scarce.

So, it becomes really difficult to set up such a capital extensive project without any financial supports from private sectors. Skilled staffs are also necessary for that. This is alternate to the existing system by replacing skilled labor with robotic machinery. This robot will be able to handle more goods in a manufacturing process in less time with better accuracy as well as lower per capital cost.

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