Multi-Functional Line Follower

This project aims to address the issues of line following robots which are currently being used in many industries. It uses a systematic way to identify objects and avoid them by picking the object and placing it at a designated place. This robot uses sensors to identify the path it should follow and objects it should avoid. And uses a robot arm which is powered using motors to pick and place the object. It also uses two motors to power the wheels of the robot. This robot is made to solve problems which are currently being faced when using a line following robot.

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CHAPTER 01

1.1 Introduction

The aim of this project is to provide a way to the line following robot to be able to avoid objects in an intelligent way. Mainly in industries line following robots are used to transport goods from one place to another so it's important to not damage the goods. By avoiding objects, it can follow the path without any collisions so the goods it's transporting won't be damages by the collisions. It uses a robot arm in addition to traditional line following robot to pick and place the objects in its travelling route. For detecting an object, it uses an ultrasonic sensor and uses two Infrared sensors to detect the line. In addition to that it uses a LDR sensor to detect the light so when the night comes it turns on two lights at the front of the robot. By using these additional features this project can provide a more intelligent line following robot which can be used in many fields.

1.2 Features of the Product

- Line following
- Object detection
- Automated Object avoidance using pick and place process
- Automated arm control
- Power saving(usage of minimum number of motors and sensors)
- Automatic Night Light System

CHAPTER 02

2.1 Problem Identification

When considering the line following robot, it has no intelligence to detect an object or avoid it using any mechanism, it only uses two(depending on the usage) Infrared sensors to detect the line and follow it according to how its programmed but in real life when using a line following robot, it has to have some kind of intelligence in order to avoid objects. Because in real world robots won't get a clear line to follow. There can be many objects in its travelling route. So, one of the major problems line following robots have, is to detect and avoid an object which is in its travelling route. To solve this problem line following robot can pick and place the object it detected. It can use motors to control robot arm and sensors to detect the object. This project is developed to address this major issue with the above-mentioned solution.

2.2 Research and Design

- Feasibility study

  Market demand for a pick and place robots has been increasing for last couple of years in the local market. All the technical requirements can be bought from the local market for a fair price. Since both aspects are satisfied which were mentioned earlier it's the best time to proceed with this project.

- Identifying specific details of the design which must be satisfied

  For this particular robot which is designed to pick and place objects while following a line, needs to have sensors to detect the line and the object it should pick and place. In addition to that it should have motors to power the wheels and motors to control the movements of the arm. Best solution to detect the line is to use Infrared sensors since Infrared ray is sensitive to the color: black color absorbs the infrared rays and white color reflects the Infrared rays. Using this property of infrared rays, we can easily identify a black color line from a white color surface because black color won't be detected at the range which white color is detected. Using two Infrared sensors to detect the limit of black line and changing the direction of wheels according to it is the best solution to overcome the line following hurdle. For detecting an object ultrasonic sensor can be used because it can detect how long the object is from the robot, this is very important because robot arm has a range which it can pick and place ,so having the information of how long the object is from the robot can help a lot. LDR(Light dependent Resistor) sensors can be used to detect the light intensity to control the led bulbs used. Robot arm which has 4 degrees of freedom can be used to pick and place the object detected. Four servo motors can be used to control the robot arm end effectors. 2 gear Motors can be used to control the speed and the direction of the robot. To control the motors motor drivers can be used. A microcontroller is required to process the data taken from the sensors and perform an action according to the processed data, for that Arduino Uno board can be used. Two Lithium-Ion batteries (3.7v) can be used to power the robot. Lithium-Ion batteries are rechargeable thus it's suitable for this project.

- Identifying possible and alternative design solutions

  Instead of using an ultrasonic sensor another Infrared sensor can be used to detect an object. With this approach cost will be reduced because the IR sensor is less expensive, but it will limit the information which can be taken when detecting an object, Infrared sensor can only detect an object. It can't detect the distance to it.

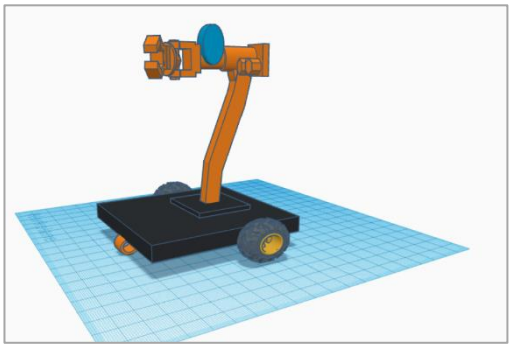
  Another solution to this problem is to use a camera to detect the line and the object. Using a camera can be a great alternative but it's an expensive sensor and also it will take a fair amount of time to program it because image processing is a complex task compared to detecting an object from IR sensors.

  If the objects which needs to be picked are metals, a magnet can be fixed to the end effector and used to attract the metal object without using another servo motor. But in this approach only metal objects can be picked up.

- Planning the design

  Chassis is used to hold the other components. Pick and place robot is placed on the chassis. It has a servo motor at the base to control the direction of the robot to rotate along z axis. Then it has two arms. Both have a servo motor attached to it at the shoulder of the arm. Right arm is used move the robot in the x axis or to go backward and forward. Left arm is used move the robot up and down or in the z axis. And the end effector is connected to both arms using two supporters. At the end effector there is another motor to grab and free the object. It moves in y axis. Two IR sensors faced towards the surface to detect the line. An ultrasonic sensor is placed at the front parallel to the chassis to detect objects. Lithium-Ion batteries are placed on the chassis along with motor drivers and the Arduino board. At the front, a caster wheel is used to hold the chassis. And two wheels connected to gear motors are attached to the back of chassis.

- Design



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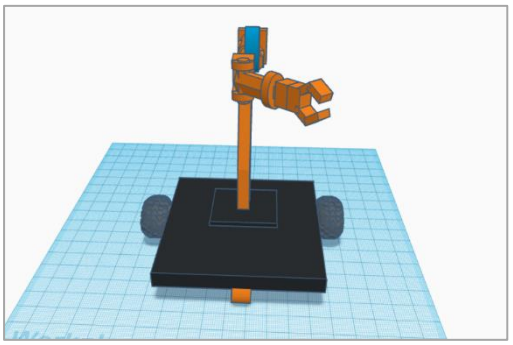
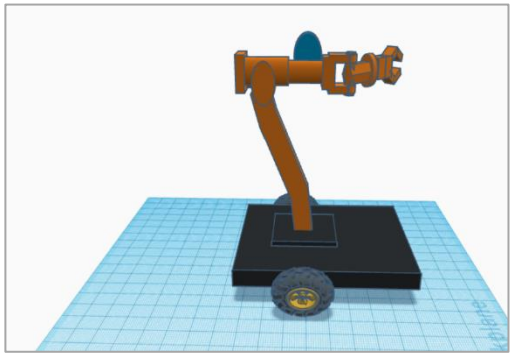


Figure 1



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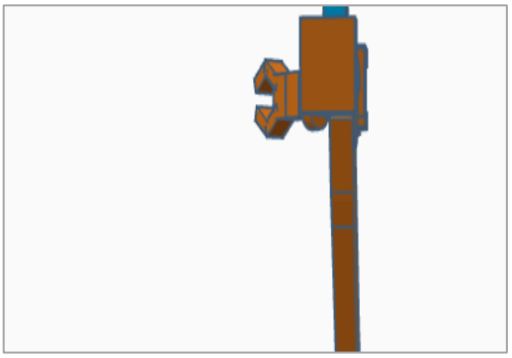

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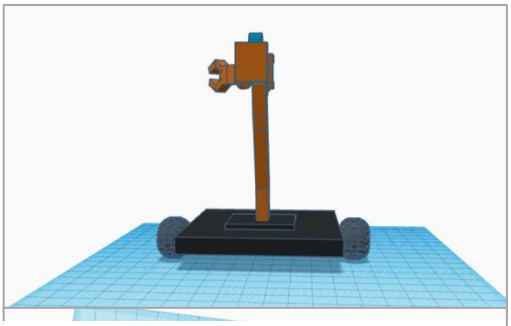

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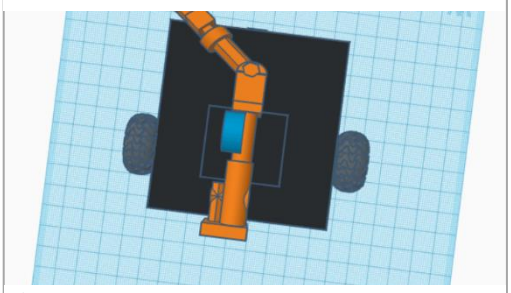

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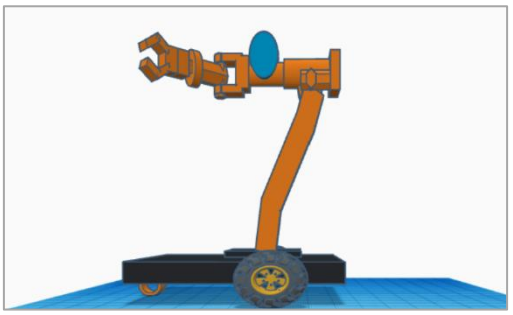


Figure 5

2.3 Building the Robot

- Required Components
  - Arduino Uno Board
  - L293D Motor driver
  - Gear Motors x 2
  - PCA9685 16-Channel Servo Driver
  - Servo Motors x 4
  - Robot arm
  - IR (Infrared Sensors) x 2
  - Ultrasonic sensor
  - LDR sensor
  - LED lights x 2
  - Robot Wheel x 2
  - Caster Wheel
  - Lithium-Ion Battery x 2 (3.7v)
  - Lithium-Ion battery holder
  - Jumper Wires
  - Small Breadboard
  - Rigi-Foam Board
  - Black Tape
- Building Steps

  Phase 1: Line Following system

  1. Make the car chassis from Rigi-foam.
  2. Glue gear motors to the chassis.
  3. Attach the L293D driver shield to the Arduino.
  4. Glue Arduino Uno board to the chassis.
  5. Connect gear motors to the L293D driver shield.
  6. Glue IR sensors at the front (which are face towards the surface)
  7. Connect IR Sensors to the L293D motor driver shield.
  8. Attach wheels to the gear motors.
  9. Glue the caster wheel at the front.
  10. Glue the battery placeholder with batteries to the chassis.
  11. Connect batteries to the motor driver shield.

12. Program Arduino to follow a line using IR sensor values.

Phase 2: Control the robot arm

13. Glue Ultrasonic sensor at the front parallel to the surface.
14. Connect Ultrasonic Sensor to the L293D motor driver shield.
15. Assemble the Robot arm.
16. Attach the robot arm to the car chassis.
17. Connect servo motors to the PCA9685 driver and glueing it to the arm.
18. Connect the PCA9685 to the L293D motor driver shield.
19. Add functionality to the Arduino to identify an object using ultrasonic sensors.
20. Add functionality to the Arduino to stop the robot after detecting an object.
21. Add functionality to the Arduino to pick the object and place it out of it's travelling route.

Phase 3: Automatic lighting system

22. Glue the LDR sensor on the car chassis.
23. Glue LEDs at the front of the chassis.
24. Add functionality to the Arduino to light the LEDs when the environment gets dark.

Phase 4: Testing the robot

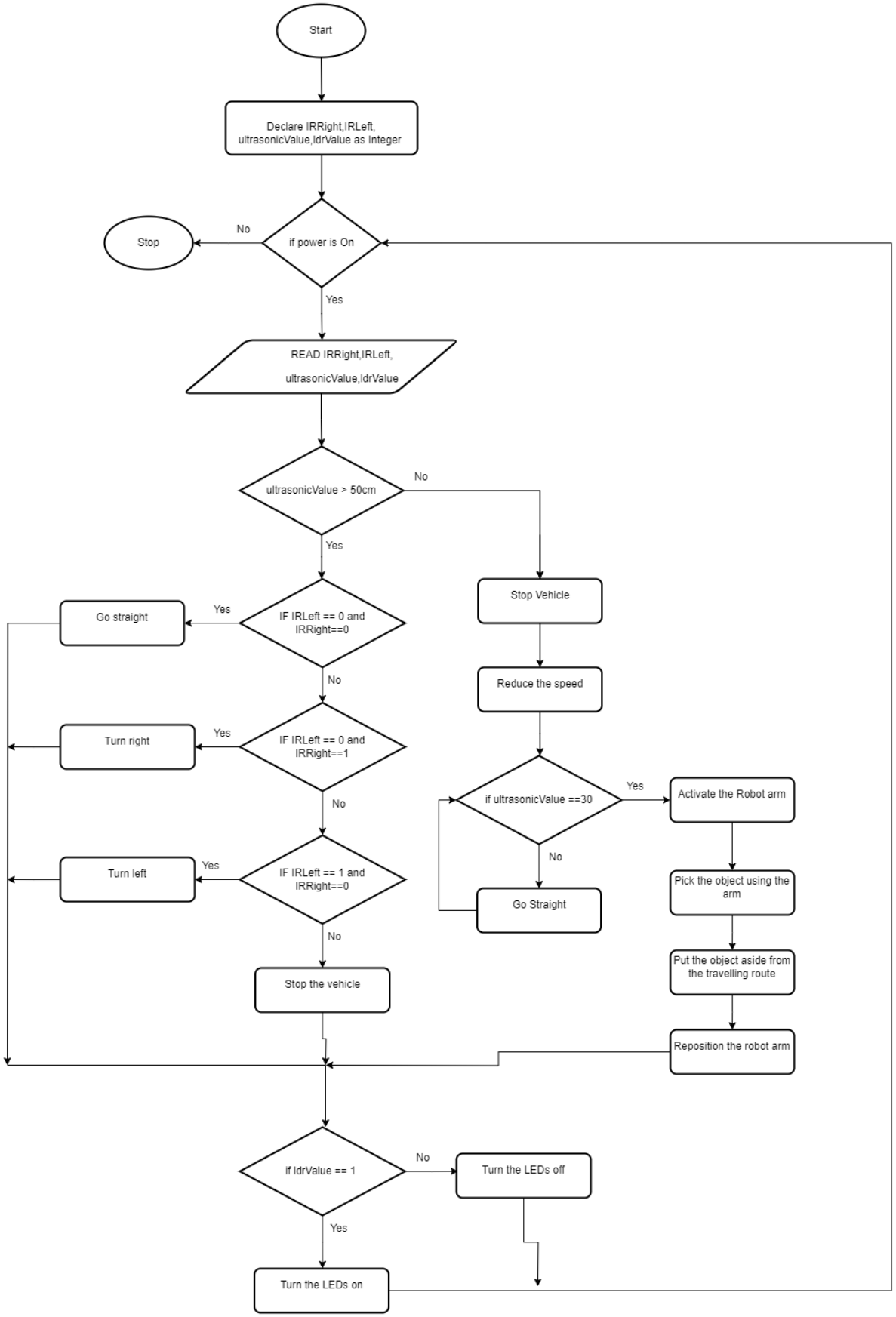
25. Test the robot to find errors.
26. Fix found errors.

2.4 Programming

- **Pseudo Code**

```
BEGIN
DECLARE IRRight,IRLeft,ultrasonicValue,ldrValue as Integer
WHILE power is On
        READ IRRight,IRLeft,ultrasonicValue,ldrValue
        IF ultrasonicValue is greater than 50cm THEN
                IF IRLeft is white and IRRight is white THEN
                        Go straight
                ELSE IF IRLeft is white and IRRight is black THEN
                        Turn right
                ELSE IF IRLeft is black IRRight is white THEN
                        Turn left
                ELSE
                        Stop
                END IF
        ELSE IF ultrasonicValue is less than 50cm THEN
                        Stop the vehicle
                        Reduce the speed
                        REPEAT
                                Go straight
                        UNTIL ultrasonic  is equal to 30cm
                        Activate the robot arm
                        Pick the object using arm
                        Put the object aside from the travelling route
                        Reposition the robot arm
        END IF
        IF ldrValue is High THEN
                Turn the LED lights on
        ELSE
                Turn the LED lights off
        END IF
END WHILE
END
```

- **Flow chart**


Start
Declare IRRight,IRLeft, ultrasonicValue,ldrValue as Integer
if power is On
No
Stop
Yes
READ IRRight,IRLeft, ultrasonicValue,ldrValue
ultrasonicValue > 50cm
No
Yes
Stop Vehicle
Reduce the speed
if ultrasonicValue ==30
Yes
Activate the Robot arm
Pick the object using the arm
Put the object aside from the travelling route
Reposition the robot arm
No
Go Straight
IF IRLeft == 0 and IRRight==0
Yes
Go straight
No
IF IRLeft == 0 and IRRight==1
Yes
Turn right
No
IF IRLeft == 1 and IRRight==0
Yes
Turn left
No
Stop the vehicle
if ldrValue == 1
No
Turn the LEDs off
Yes
Turn the LEDs on

CHAPTER 03

3.1 Results of the operation

Line following robot with the pick and place mechanism is obtained from the operation. The robot is able to follow a black line. It can detect an object and know the distance to the detected object. Once an object is detected robot arm is activated, then using its end effectors it picks the object and place the object out of its travelling route to clear the line, then follows the line again. It can travel in a normal speed. It has a precious and accurate movements and uses minimum amount of energy to do the designated tasks.

CHAPTER 04

4.1 Limitations, Recommendations and Conclusion

- Limitations
    - The robot can only pick objects within a specified weight range.
    - Only objects which can be fit in to the end effector can be grasped.
    - Speed has to be controlled to obtain smooth results from the robot thus it can take more time to perform the designed operation.
    - Ultrasonic sensor can only detect whether there is an object and the distance to it, it can't detect the type of object, so the processor has no information about the object that is going to be picked up.
    - Since Infrared sensors are used to detect the line, it can only detect black lines on a white surface so this robot can only function on a white surface with a black line.
    - For Light Dependent Resistor sensors to detect light, luminous object must be very close to the sensors.
- Recommendations
    - Using a camera to detect the line and the object is a more practical approach to solve this problem.
    - Image processing is used to detect what kind of object is detected. By using that information robot can decide whether the detected object can be picked. If the object cannot be picked a buzzer can be used to alarm or notify responsible individuals.
    - Adding a Bluetooth module to control the movements of the robot arm. In this way it can be used with different purposes.
    - Also adding Bluetooth capability to control the line follower is an additional feature which can be very useful in situations where the robot can't pick the object detected. Using Bluetooth controller, a responsible individual can control the line follower to avoid the object.

- Conclusion

This project aims to solve the problem of how to avoid an obstacle in a line following robots' path. This problem is solved with the help of a pick and place robot arm which is fixed to the line following robot. By using the mentioned sensors robot is able to follow the line and detect an object in its travelling route. When the line follower encounters an obstacle, it picks and place the object aside from its route. This project provides a clear and easy to implement solution to the abovementioned problem while considering the cost and power consumption.

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APPENDIX

Figure 11

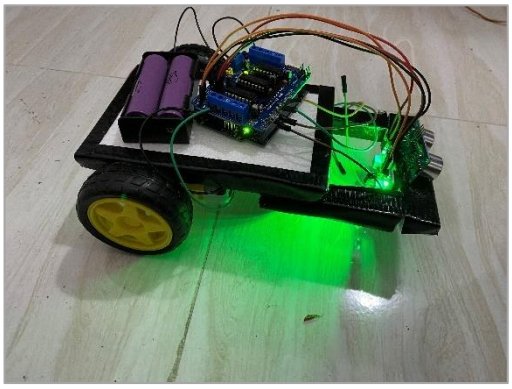
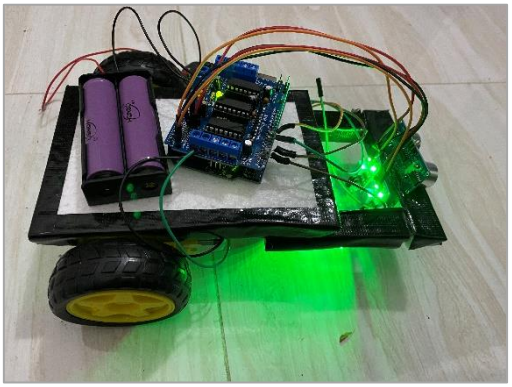


Figure 8



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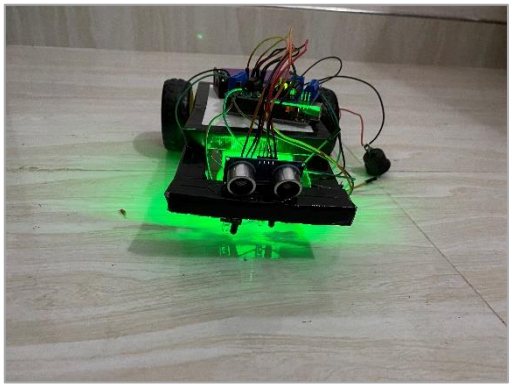

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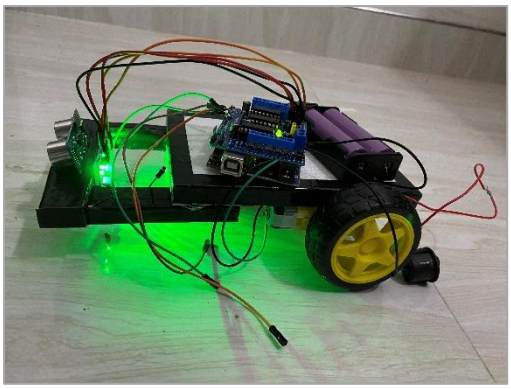

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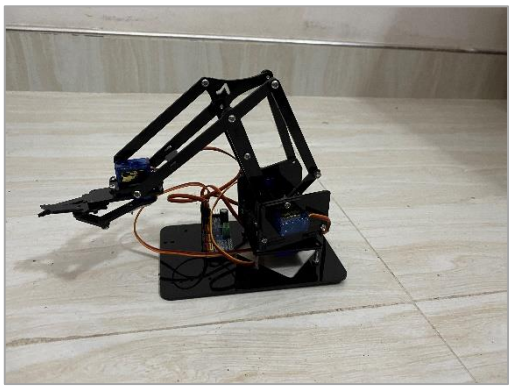

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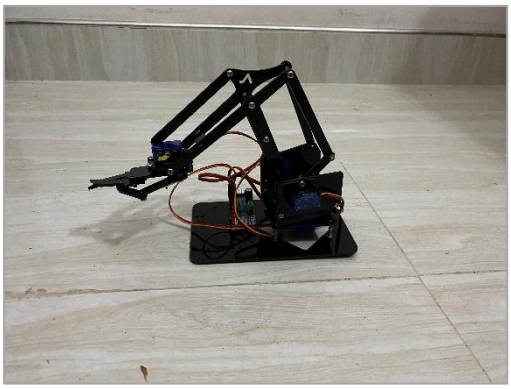

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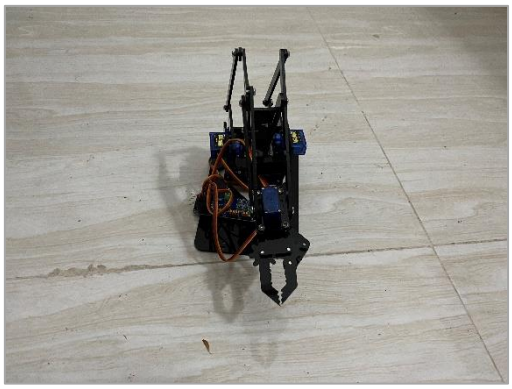

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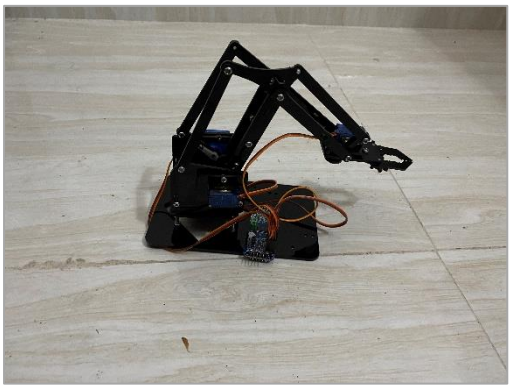

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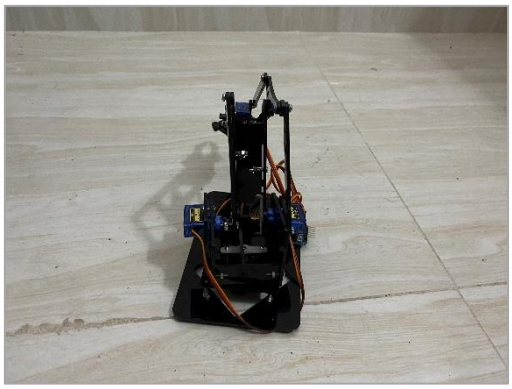

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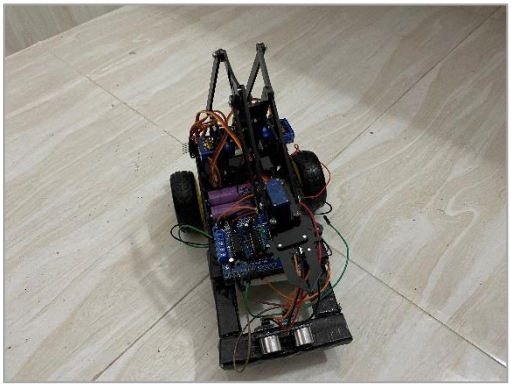

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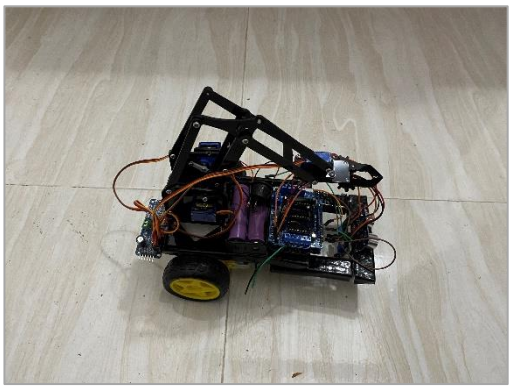

Figure 16