STAIR CLIMBING ROBOT

Project report submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

By

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UNDER THE GUIDANCE OF

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JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

May, 2021

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DECLARATION

We hereby declare that the work reported in the B.Tech Project Report entitled **"Stair Climbing Robot"** submitted at **Jaypee University of Information Technology, Waknaghat, India** is an authentic record of our work carried out under the supervision of **Dr. Emjee Puthooran .**We have not submitted this work elsewhere for any other degree or diploma.

SHUBHAM SINGH
171052

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

<Signature of the Supervisor>
Dr. Emjee Puthooran
Date: 22-06-2021

Head of the Department/Project Coordinator

ACKNOWLEDGEMENT

I would like to express my gratitude for guiding me throughout the project. I also feel thankful and express my kind gratitude towards our **H.O.D (Dr. Rajiv Kumar**) for allowing me to conduct “**Stair Climbing Robot”** project. The mentioned project was done under the supervision of **Dr. Emjee Puthooran** . I thank all participants for their positive support and guidance.

I feel thankful to the college staff for giving me such a big opportunity. I believe I will enroll in more such events in the coming future.

Shubham Singh

171052

LIST OF ACRONYMS AND ABBREVIATIONS

M2M	Machine-to-Machine
IEEE	The Institute of Electrical and Electronics Engineers
EEE	Electrical and Electronics Engineering
3D	Three Dimensional
PVC	Polyvinyl Chloride
U-PVC	Unplasticized Polyvinyl Chloride
DC	Direct Current
WBS	Work Breakdown Structure
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization

LIST OF FIGURES

ABSTRACT

Home robots are an excellent choice to support this aging society. The document states that the robot is designed to climb and descend stairs for the elderly. The robot consists of a moving body, a forearm and a rear arm that go up and down the stairs. The main body is equipped with two brushless DC motors (BLDCM) and its driving path drive, spur gears for torque amplification, two DC motors for driving two levers, and a DSP board as a control center. The roller chain is connected to the rubber block and is used to generate friction with the ground and the ladder for movement. Properly adjust the distance between any two rubber blocks to fix the edge of the ladder. The direction of the robot's movement is determined based on the speed difference between the two BLDCMs and the information from the ultrasonic sensor. Experiment by climbing a flight of stairs to a height of 150 mm.

CHAPTER 1

INTRODUCTION

Ladder is ubiquitous in the built environment. They were developed for humans to easily cross large vertical distances. However, in natural disasters such as fires or earthquakes, ladders cause major problems for vehicles and robots, and there is a great demand for mobile devices. For example, a robot that can climb stairs can help people with walking difficulties perform search and rescue missions in cities. In this project, we intend to create a robot that can easily climb stairs. There are different types of stair climbing robots, such as "legged robots", "orbital robots" and "wheel robots". We focus on building wheeled robots using a rocker bogie mechanism that can climb 150 mm high stairs.

Fig.1.Rocker Bogie Stair climbing robot

Each type of mobile robot has its unique advantages and disadvantages. In the case of legged robots, they can adapt to too many types of unstructured environments, but they can stabilize themselves because different legs can be oriented in independent configurations. However, these robots are inherently complex and relatively slow. Wheeled robots may be related to the low speed of locomotives because the robots on their feet move faster due to their rolling motion. Wheels have always been the easiest way to make cars move. And the fastest way to travel. In terms of speed, this is also the most effective way to travel. The implementation is usually very simple and does not require complicated techniques such as vector control or additional joints to set up the robot movement. [1]

This report is about autonomous robots climbing stairs.

1.1. Identification of the need

This product is designed for those who want to reach hard-to-reach places. The main purpose of this product is to independently climb any type of ladder to reach the top, but it can easily become a terrain robot.

1.2. Definition of the problem

The main task of the team is to design and build a robot that independently climbs the first 19 steps of the law school (Building D). Or, you can climb any type of ladder by yourself.

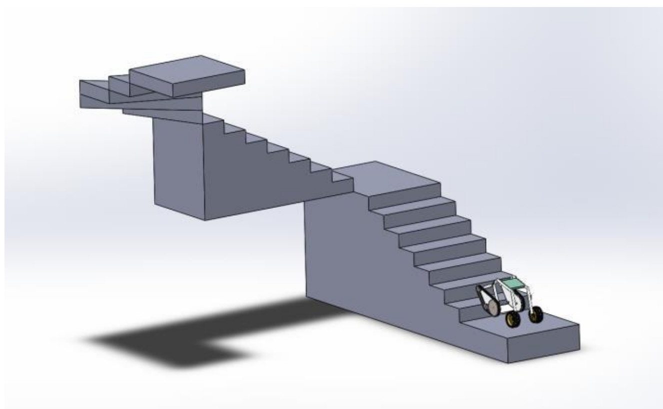


Fig.2. Illustration of Robot and Stairs

1.2.1 Standards and constraints

The robot is manufactured with all original electrical, electronic and electromagnetic equipment and complies with all IEEE, CE, IEC and ISO standards. Wire in a safe way to avoid danger to users. The power supply for the system. And a 12 volt DC motor.

CHAPTER 2

MAKING OF ROBOT

2.1 WORK PLAN

2.1.1 Work Breakdown Structure (WBS)

2.1.1.1 Stair Climbing Robot

- **Electrical**
  - Order/Manufacture Parts
  - Assemble
  - Test
- **Programming**
  - Creating a control Algorithm
  - Motor Control
  - Implementing
  - Coding
  - Test
- **Testing**
  - Testing all the system

\

2.2 Components Used

2.2.1 Components :

ARDUINO UNO- The microcontroller behaves like the brain of a robot. The movement of the robot is determined by the microcontroller. In this system, we use a microcontroller called Arduino UNO, which contains an ATMEGA 328P microcontroller IC. .Arduino has its own programs, which are written in read-only memory (ROM). The C program is very easy to implement Arduino UNO programming.

Fig.3. Arduino Uno Board

B- BLUETOOTH MODULE (HC-05) The HC-05 module is an easy-to-use Bluetooth SPP (Serial Port Protocol) module that was developed for transparent wireless serial connection establishment. This is a highly qualified module with Bluetooth EDR (Enhanced Data Rate) 3Mbps modulation at full 2.4 GHz

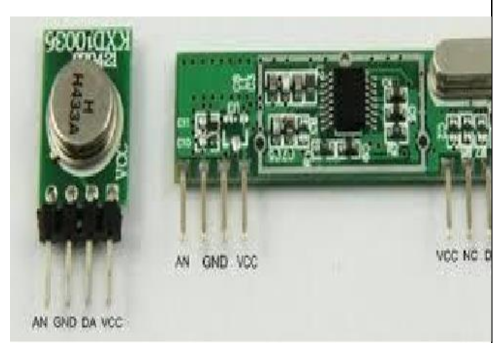


Fig.4. Bluetooth Module

MOTOR DRIVER (L293D) - The motor driver IC is used to control the DC motors. It is also connected to the microcontroller and the circuit. It is a typical motor driver or motor driver IC that allows the DC motor to run in either direction. You can control a set of two DC motors in either direction at the same time.

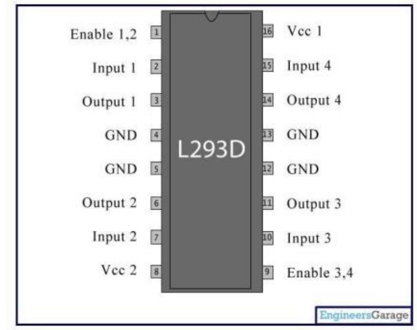


Fig.5. L239D IC

POWER SUPPLY- The Arduino Uno can be powered by an external power supply unit with a 9-12 V battery. The external power supply (not USB) can be powered by a DC power supply unit (wall wart) or battery. Connect the center positive 2.1 mm connector to the power connector on the board. The battery cable can be plugged into the Gnd and Vin connections of the power connector.

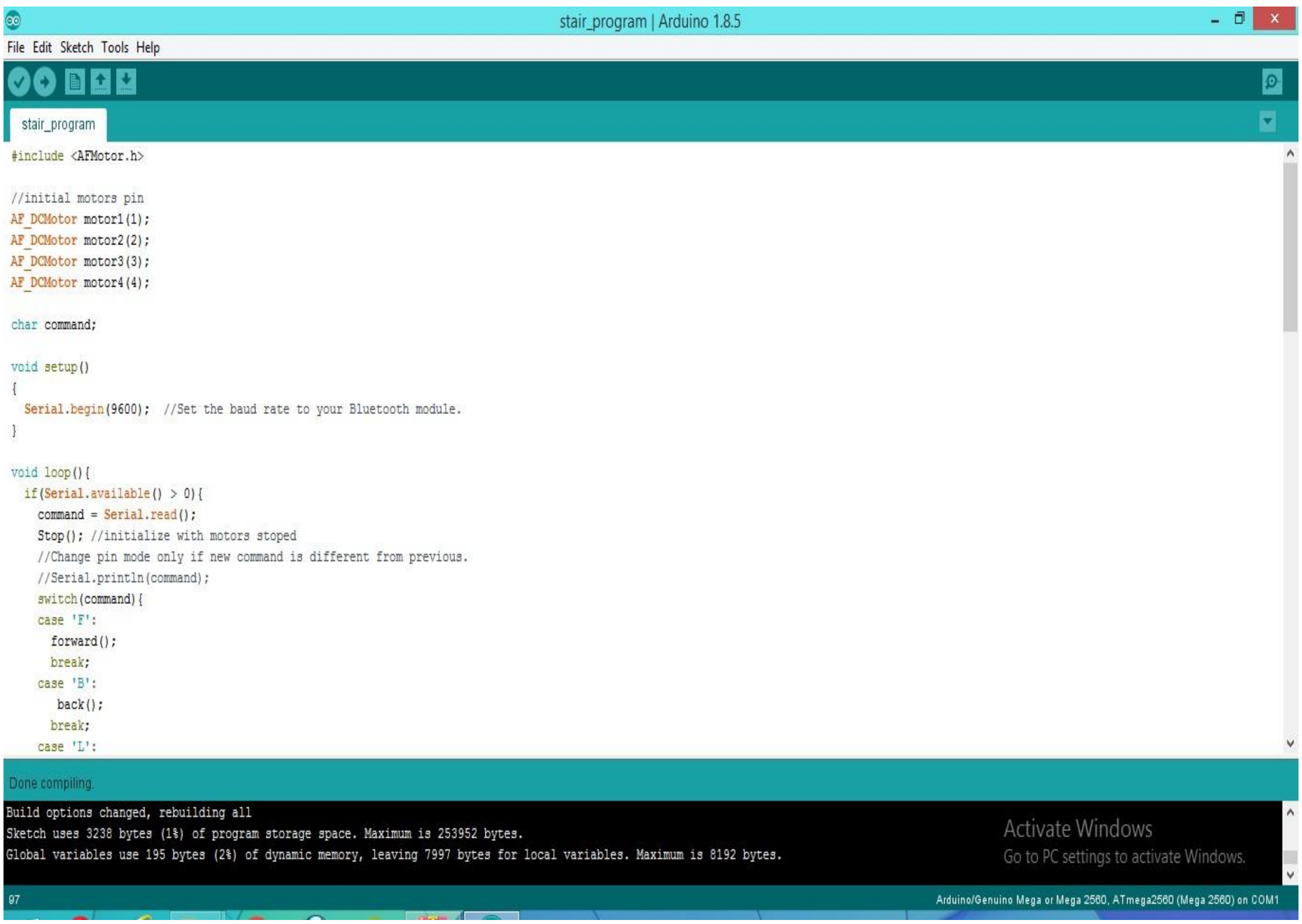
Fig.6. Power supply components

PLASTIC WHEELS We provide a cheap solution that is powerful enough for combat robots, yet light enough to be practical. For the lightness and economy of the rover, we chose commercially available plastic wheels with rubber bands depending upon the calculations.

Fig.7. Plastic Wheel

2.2.2 Software Used

Arduino IDE 1.5, the Arduino Integrated Development Environment-or Arduino Software (IDE)-includes a text editor for writing code, a message area, a text console, a toolbar with buttons for general functions, and many menus. Arduino and real hardware are used to download and communicate with the program. The environment is written in Java and is based on Processing and other open source software. Run the compiled machine code from C, C++, or any other language that has an Arduino compiler. Command system.



2.2.3 Methodology

Since our goal is to manufacture the robot with the "rocker bogie" mechanism, we follow its methodology, theoretically explained in the following steps:

1. To be able to climb stairs more evenly, only one pair of wheels needs to be in the upper position. Therefore, in order to determine the dimensions of the bogie links, the first pair of wheels must be placed horizontally as shown in Figure 2 and the second pair must be placed just before the climb begins. [2]

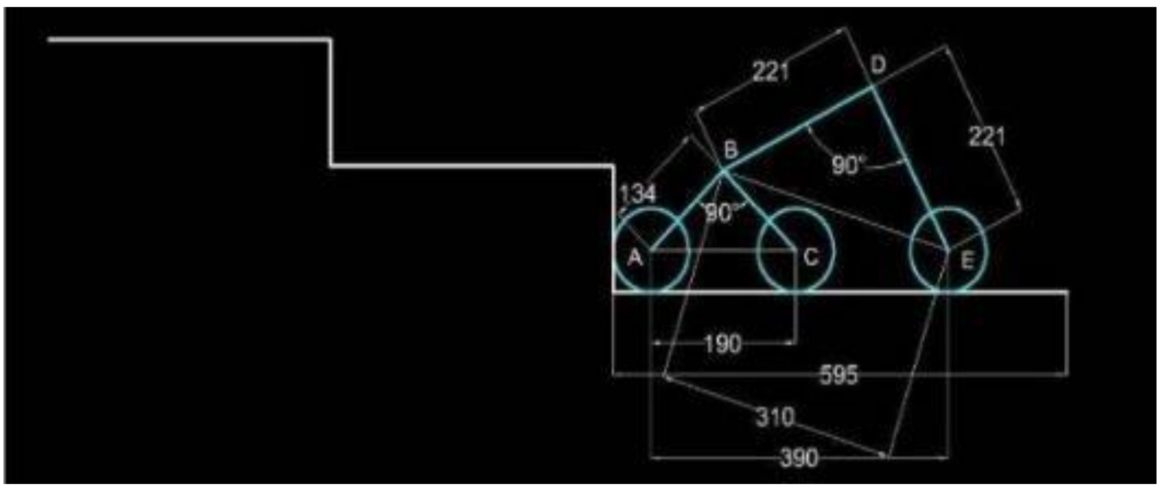


Fig.8. Measurements of the robot

2. The distance between the first and second wheel is calculated with the CAD software (190 mm). In the right triangle ABC, assume that the lengths AB and BC are x. Now with Pythagoras on the triangle ABC (Figure 3)

$AC^2 = AB^2 + BC^2$

$190^2 = x^2 + x^2$

$190^2 = 2x^2$

x = 134 mm Therefore, AB = BC =134 mm

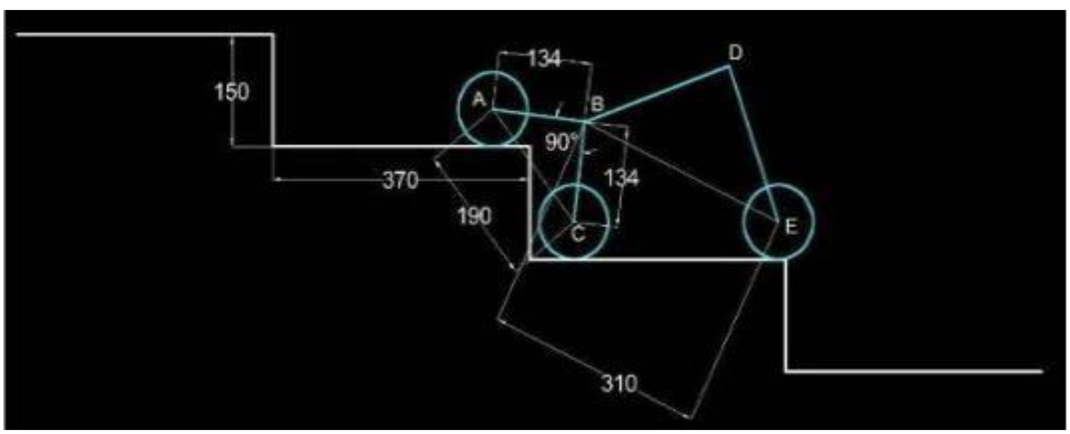


Fig.9. Measurements of the robot

3. Accordingly, in order to determine the dimensions for the reversing lever, two pairs of wheels must first be brought into the horizontal position, while the third pair of wheels has to almost finish its ascent before the first pair of the wheels starts through this Placement of the wheel results in the dimension of the link BC (311 mm) Now consider ΔBDE (Figure 4), $BE^2 = BD^2 + DE^2$ $311^2 = 2y^2$ y = 221 mm Therefore, BD = OD = 221 mm (Figure 4. The entire mechanism was drawn with all these lengths and angles in mind.

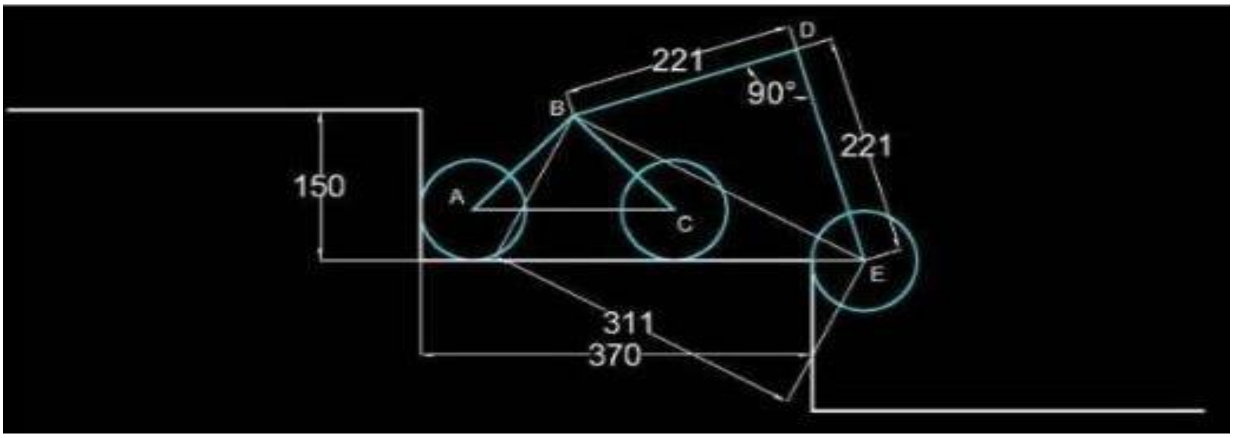


Fig.10. Measurements of the robot

2.3 PHYSICAL ARCHITECTURE

2.3.1 Physical Structure

There are 3 important aspects to this part; Weight, strength, economy. Our robot has to be as light as possible to meet our target budget. The heavier the robot, the more expensive motors we will need. The product selection is also an important point. Major subsystems and selected their materials to achieve the best strength-to-weight ratio. [3]

2.3.1.1 PIPE FRAMEWORK

PVC pipes are chosen to connect the entire robot together. The main reason for this choice is that PVC pipe is lightweight and has the durability that we need. They are also cheap and easy to pick up.

2.3.1.2 TANK TRACK BODY

TTB is the first part that interacts with the stairs, so it's a sizable part. This subsystem consists of 3 parts, wheels, PVC pipe and belt. TTB works as a simple pulley system. The belt climbs stairs with the supplied rotation through wheels. and the plate holds these parts as a unit. The materials selected from these parts are listed below:

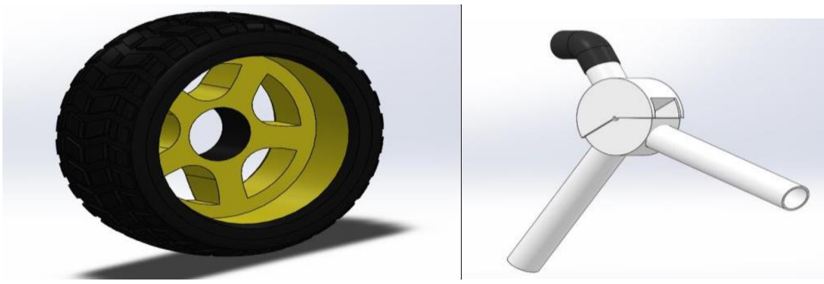
a. Pipe: PVC

b. Wheel: Rubber

2.3.1.3 SUPPORTING COMPONENTS

In addition to these subsystems, there are also support devices such as linkages, rear wheels, etc.

Fig.11. Supporting angle with tyres.



A connector is provided for connecting the upper zone so that the TTB can be easily moved. This common design was printed with a 3D printer and added to the system.

The joint consists of 2 parts and these parts are connected with the help of a shaft and a nut, so the lower joint can move comfortably in the upper joint.

Motors

DC motors are on the rear support wheels and TTB rear (tank truck tank base) are at this point the TTB rear wheels are the main beams of the system. The rear support motors help you get on and prevent you from slipping backwards. To select an optimal DC motor, a torque calculation is required.After finding the required torque, the DC motor can be found in the market. [4]

12V 80 RPM 42mm Geared DC Motor

Working voltage range: 12V
Speed: 80 RPM / Min
Motor diameter: 36mm
Reducer diameter: 42mm
Weight: 230gr

Fig.12. Stepper Motor

2.3.2 Interface Design:

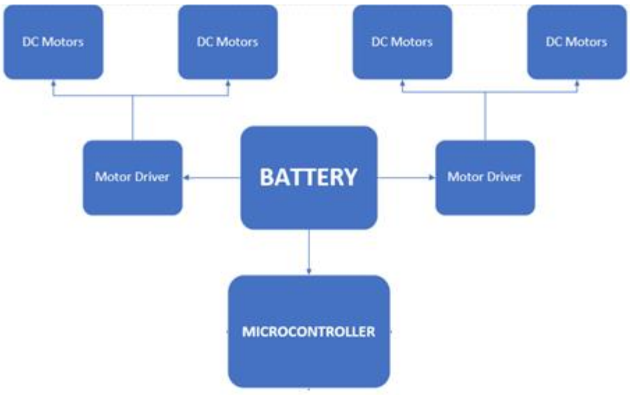


Fig.13. Interface Design

Implementation of Circuit on Breadboard

We interfaced L239D Motor driver IC with Arduino Uno Board using breadboard circuit and then uploaded our code successfully on Arduino Uno.

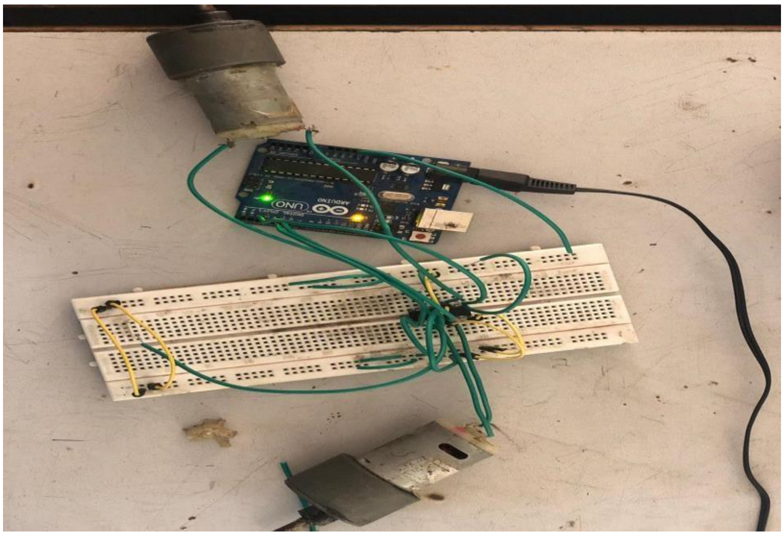


Fig.14. Interfaced Arduino Uno with L239D IC

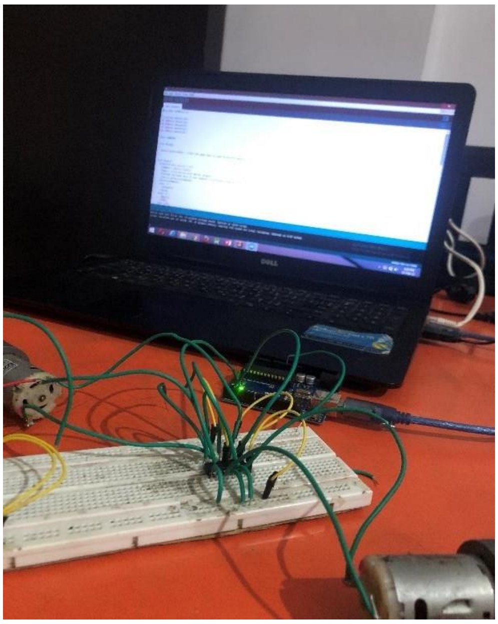


Fig.15. Uploading the code on Arduino board

CHAPTER 3

CHALLENGES OF STAIR CLIMBING ROBOT

There are five fundamental issues involved in climbing steep natural terrain: hardware design, control, sensing, grasping, and planning. A substantial amount of work needs to be done in each of these areas in order to develop a real climbing robot.

3.1 Hardware Design

Effective equipment design can improve the performance of robots and can often solve all other basic problems more easily. Although the early use of hardware solutions helped to maintain balance, which in turn limited the terrain that may be associated with robotic bicycle systems, it has long been used to handle natural tilts of up to 50 degrees, descents of up to 75 degrees, and Overcome obstacles on small uneven terrain. Passive suspension or rape. There are a variety of robots suitable for climbing vertical dummies to choose from. The vast majority of these robots abuse certain surface characteristics to manipulate these devices, adding weight and complexity, which hinders development and limits potential applications.

3.2 Control

The control problem of climbing robot is mainly divided into three parts: balance support, end-point sliding control and end-point force control. These three parts are closely connected. The center of gravity of the robot's mass and the contact force with traditional components must be controlled. The sliding control in these contacts is directly determined by the direction and magnitude of the contact force. Existing control methods, such as considering the workspace plan, can shape the template to create a static control plan for the climbing robot. However, several different methods can be used to extend these systems to achieve better performance. An endpoint sliding controller that is stable relative to the arc of the contact surface, not just the contact point. [5]

3.3 Sensing

In order to operate and control it, the robot must be prepared to recognize the introduction of its body relative to the gravity vector, the area of its center of mass, the relative area of the contact surface from the end of its appendage, and the advantages it possesses. Used to contact common elements; in order to control the robot, it must also be able to find new prey and describe its characteristics, which may require assessing the degree of slippage in the contact group. The purpose of obtaining and using these data and controlling, managing and organizing calculations is a test problem. Existing building structures are available in order to develop standardized procedures for each situation.

3.4 Grasping

A climbing robot's performance depends on its ability to handle "prey" or elements on a regular raised surface. So far it has been found that the handling of the planes is special, depending on the special properties of the surface, for example exceptionally smooth surfaces, pins or handles, cannot be used to handle any normal elements. In this area, the problems associated with dealing with conventional dams are further investigated. Pick up or hold an object (also called "fixation"). Research on the subject dates back to 1876 and it has been shown that a flat element can be immobilized with at least four frictionless point constraints. A critical idea in this area is the "frictional connection", characterized as a grip that "can counteract all movements of the article, since the end effector can adequately apply enormous forces when walking in". Be that as it may, so that the assignment of a climbing hold does not require a frictional connection in order to be a valuable hold. As a result, the methods for selecting, displaying and advancing the handles must essentially be extended to climbing robots. There are several types of holds in the script of human climbers, in this order the holds are first divided into two classifications, the implicit one for cavities, ridges and various defects in the generally uninterrupted vertical rock formations, and the implicit one for vertical some illustrations of striking Flats and split handles are shown in the picture.The script gives an uncomfortable idea of the quality and use of all shaft types in terms of criteria such as apparent safety, the amount of torque that can be applied in a clamp, and the amount of erosion in the "point of force". . “This master instinct is not only subjective, but it is also clear that human climbers need additional handling when preparing for special cases. "There are as many different types of grippers as there are approaches to gripping them," says Long. “However, this instinct can be used as a first step to decide important quantitative criteria for the choice of grip and rationalization. A look at the earlier chip-scaled font on the automatic grip assembly reveals some other crucial opposites between the two uses which would be essential for future exploration. In the present case, many climbing holds are small, hence the fingers that are used as part of a climbing hold , usually large in relation to the object to be handled. Long-term climbing robots will provoke the idea of overcoming many new problems.

CHAPTER-4

ADVANTAGES & DISADVANTAGES

4.1 ADVANTAGES:

1. The swing trolley can climb stairs very stably, depending on the exact size of the stairs..
2. The robot can be controlled wirelessly through the Bluetooth module..
3. This is an ecological robot.
4. The global mobile robot market is expected to grow significantly in the next two decades, surpassing the industrial robot market in terms of volume and revenue.
5. The design is simple and reliable.
6. When the surface is uneven, all six wheels carry the same load, which is very useful when the robot moves on a surface that looks like dry sand.

4.2 DISADVANTAGES:

1. At high speeds, it will experience a frontal collision between wheels and obstacles, resulting in impact force acting on the front wheels. This impulse can damage the car.
2. In order to pass large areas and uneven terrain without the risk of overturning, these robots move slowly and overcome obstacles, forcing the wheels to lift each part of the suspension over the obstacles one by one..

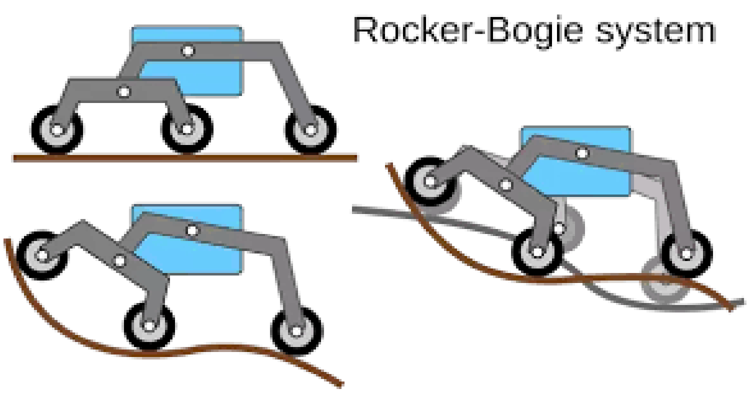


Fig.16. Rocker Bogie system

CHAPTER-5

APPLICATIONS

1) Military targets or security robots in urban environments, where climbing stairs and mobility are important components of the mission. Robots are not just robots that climb stairs, they can also work in terrain where wheeled robots can be used.

2) For disaster control and urban search and rescue tasks, it is usually necessary to place sensors or cameras in dangerous or inaccessible places. Before potentially dangerous areas, you can better understand the situation.

3) Entering different departments, it can even be converted into a wheelchair to transport patients from one place to another independently.

Fig.7. Rocker bogie-based wheelchair

4) In terms of school, transportation and ease of use, even children will marvel at the miracles of science.

5) It can also be used to transport materials economically.

6) Main applications are national security surveillance, mine clearance, danger awareness and agriculture.

RESULT

As stated in the purpose of the paper, the goal of my work is to develop a stair-climbing robot that can climb stairs with a height of at least the outer radius of the wheel with legs. Confirmed by experiment. We tested the robot to climb a ladder consisting of a series of ladders of different heights and widths. The time of these tests is recorded and analyzed to evaluate the performance of the robot. The illustration shows the lifting of the robot. The stairs are 13 cm high and 30 cm wide. It can be seen from the figure that the axis of the front wheel of the robot rotates slightly relative to the axis of the rear axis. The legs grab the front bar and slide it. As shown in the previous section, the proposed drive concept significantly reduces the friction coefficient required between the wheels and the ground. Continue to tape all the wheels with electrical tape.

CONCLUSION

The paper describes the design, modeling, modeling, manufacturing, and testing of a stair climbing robot based on a new paradigm of wheel design called casters. The robot was developed using an interdisciplinary design method. It is statically safe in terms of load application and material selection, and the robot mechanism can climb stairs to the outer radius of the robot. So far, we have been able to eliminate wheel slip when lifting, which was successful after adding the tire tread to the rubber on the casters. This improves traction and provides a higher coefficient of friction required to obtain the required friction torque. Turn over the body of the robot and make "good" contact with the ground. Simulations and experiments were carried out on three road shapes. In all cases, the robot can move on rainy, uneven terrain while maintaining a horizontal position. This allows the wheels to form independent wheel pairs, avoiding skidding when testing on different unstructured terrain.

REFERENCES

[1] Jeremy Bloom; Learning Arduino: Tools and Techniques for Magic Engineering, 2002.

[2] Lambert M. Surhon, Mariam T. Tenno, Susan F. Henssonow, Rocker Gods; Betascript Publishing, 2011 Magazine

[3] Akash Asalekar1, Akash Choraj2, Bhushan Jagdale3, Design und Herstellung von Treppensteigerrobotern, Band: 04 Ausgabe: 07 | Juli-2017 International Journal of Engineering and Technology Research (IRJET)

[4] Y. Muske, S. Patil, S. Deshmukh, "MBD Modeling of Robot Climbing Stairs with Tilting Cart Mechanism", 101743, Issue 1, Issue 12, Scitech No. 267-273, ISSN: 2349-6002, 2015, International Journal of Innovative Technology Research.

[5] N. Yadav, B.Bhardwaj, S. Bhardwaj, "Analysis of Rocker Arm Suspension System Design and Accessibility of Front Loader Vehicle Implementation", e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 12, 3rd edition. III, PP 64-67, Mai-Juni 2015, IOSR Engineering and Civil Engineering Journal.

APPENDIX-A

ARDIUNO CODING

```
#include <AFMotor.h>

//initial motors pin
AF_DCMotor motor1(1);
AF_DCMotor motor2(2);
AF_DCMotor motor3(3);
AF_DCMotor motor4(4);

char command;

void setup()
{
  Serial.begin(9600);   //Set the baud rate to your Bluetooth module.
}

void loop(){
  if(Serial.available() > 0){
    command = Serial.read();
    Stop(); //initialize with motors stoped
    //Change pin mode only if new command is different from previous.
    //Serial.println(command);
    switch(command){
    case 'F':
      forward();
      break;
    case 'B':
       back();
      break;
    case 'L':
      left();
      break;
    case 'R':
      right();
      break;
    }
  }
}

void forward()
{
  motor1.setSpeed(255); //Define maximum velocity
  motor1.run(FORWARD); //rotate the motor clockwise
  motor2.setSpeed(255); //Define maximum velocity
  motor2.run(FORWARD); //rotate the motor clockwise
  motor3.setSpeed(255);//Define maximum velocity
  motor3.run(FORWARD); //rotate the motor clockwise
  motor4.setSpeed(255);//Define maximum velocity
  motor4.run(FORWARD); //rotate the motor clockwise
}

void back()
{
```

```
  motor1.setSpeed(255); //Define maximum velocity
  motor1.run(BACKWARD); //rotate the motor anti-clockwise
  motor2.setSpeed(255); //Define maximum velocity
  motor2.run(BACKWARD); //rotate the motor anti-clockwise
  motor3.setSpeed(255); //Define maximum velocity
  motor3.run(BACKWARD); //rotate the motor anti-clockwise
  motor4.setSpeed(255); //Define maximum velocity
  motor4.run(BACKWARD); //rotate the motor anti-clockwise
}

void left()
{
  motor1.setSpeed(255); //Define maximum velocity
  motor1.run(BACKWARD); //rotate the motor anti-clockwise
  motor2.setSpeed(255); //Define maximum velocity
  motor2.run(BACKWARD); //rotate the motor anti-clockwise
  motor3.setSpeed(255); //Define maximum velocity
  motor3.run(FORWARD);   //rotate the motor clockwise
  motor4.setSpeed(255); //Define maximum velocity
  motor4.run(FORWARD);   //rotate the motor clockwise
}

void right()
{
  motor1.setSpeed(255); //Define maximum velocity
  motor1.run(FORWARD); //rotate the motor clockwise
  motor2.setSpeed(255); //Define maximum velocity
  motor2.run(FORWARD); //rotate the motor clockwise
  motor3.setSpeed(255); //Define maximum velocity
  motor3.run(BACKWARD); //rotate the motor anti-clockwise
  motor4.setSpeed(255); //Define maximum velocity
  motor4.run(BACKWARD); //rotate the motor anti-clockwise
}

void Stop()
{
  motor1.setSpeed(0); //Define minimum velocity
  motor1.run(RELEASE); //stop the motor when release the button
  motor2.setSpeed(0); //Define minimum velocity
  motor2.run(RELEASE); //rotate the motor clockwise
  motor3.setSpeed(0); //Define minimum velocity
  motor3.run(RELEASE); //stop the motor when release the button
  motor4.setSpeed(0); //Define minimum velocity
  motor4.run(RELEASE); //stop the motor when release the button
}
```

APPENDIX-B

BLUETOOTH MODULE CODING

```
int val;

int nb;

void setup() {

// put your setup code here, to run once:

Serial.begin(9600);

pinMode(9,OUTPUT);

pinMode(8,OUTPUT);

pinMode(7,OUTPUT);

pinMode(6,INPUT);

}

// put your main code here, to run repeatedly:

void loop()

{
```

```
if(Serial.available()>0)

{

int data= Serial.read();

Stop();

if(data=='R')

{

digitalWrite(9,HIGH);

digitalWrite(8,LOW);

digitalWrite(6,HIGH);

digitalWrite(7,LOW);

}

else if(data=='L')

{

digitalWrite(9,LOW);

digitalWrite(8,HIGH);

digitalWrite(6,LOW);
```

```
digitalWrite(7,HIGH);
}else if(data=='F'){
digitalWrite(9,LOW);
digitalWrite(8,HIGH);
digitalWrite(6,HIGH);
digitalWrite(7,LOW);
}else if(data=='B'){
digitalWrite(9,HIGH);
digitalWrite(8,LOW);
digitalWrite(6,LOW);
digitalWrite(7,HIGH);
}
}
}
void Stop()
{
```

```
digitalWrite(9,LOW);

digitalWrite(8,LOW);

digitalWrite(6,LOW);

digitalWrite(7,LOW);

}
```