

DESIGN AND FABRICATION OF A STAIR-CLIMBING LOAD-CARRYING ROBOT WITH GRIPPER MECHANISM



A Thesis By

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APPROVAL

This is to certify that the project on "Design and Fabrication of a Stair-Climbing Load-Carrying Robot with Gripper Mechanism" by Shoeb Muntasir Sifat (ID No: ME2103025508), Md. Rayhan Mir (ID No: ME2101023132), Md. Rumman Islam (ID No: ME2201026075), Md. Nadim Khan Chowdhury (ID No: BME1801014035), Abu Shaker (ID No: ME2201026211) has been carried out under our supervision. The project has been carried out in partial fulfillment of the requirements of the degree of Bachelor of Science (B.Sc.) in Mechanical Engineering of the year 2025 and has been approved as to its style and contents.

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DECLARATION

We, the undersigned, do hereby solemnly declare that the work presented in this project report is the outcome of our own sincere effort, research, and investigation. To the best of our knowledge, this report has not been previously submitted, either in part or in full, to any university, academic institution, or organization for the award of any degree, diploma, or certificate. We further confirm that all sources of information and data used in the preparation of this report have been duly acknowledged and cited, and that this work does not violate any existing copyright laws or intellectual property rights. Moreover, we accept full responsibility for the content of this report and undertake to indemnify the university or any other concerned authority against any claims, losses, or damages that may arise as a result of a breach of the aforementioned declarations.

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ABSTRACT

Robotics plays a vital role in modern engineering, particularly in applications involving automation, material handling, and operations in complex environments. This project presents the design and development of a Stair Climber Robot with Gripper, capable of navigating staircases and uneven surfaces while handling objects. The robot is powered by a 12V DC gear motor and three 3.7V batteries, with an Arduino Nano serving as the central control unit. Ultrasonic sensors detect stairs and guide the robot's movement, while an MG995 servo motor adjusts the front wheel for smooth ascent or descent. A force sensor triggers the gripping mechanism, controlled by SG90 servo motors, enabling secure object handling. Wireless control is achieved using a NodeMCU module integrated with the Blynk IoT platform, and motor direction is managed via a relay module. Mechanically, the robot employs a three-wheel series configuration with a belt-driven system for coordinated movement and torque transmission. The system effectively combines mechanical design, sensor integration, embedded systems, and IoT-based control, making it suitable for applications in material transport, hazardous environments, and research in autonomous robotic mobility.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Robotics has become an important field in modern engineering due to its wide applications in industries, rescue operations, logistics, and automation. One of the major challenges in mobile robotics is enabling robots to move efficiently in complex environments such as staircases, uneven surfaces, and multi-level structures. To address this challenge, this project presents the design and development of a Stair Climber Robot with Gripper, capable of climbing up and down stairs while also handling objects.

The proposed system uses a 12V DC gear motor with 100 RPM to generate the required rotational energy for robot movement. The robot is powered by three 3.7V batteries, which provide sufficient and stable power to the microcontroller, sensors, motors, and communication modules. The core control unit of the system is an Arduino Nano, which processes sensor data and controls the mechanical actions of the robot.

To detect the position and direction of stairs, two ultrasonic sensors are used. These sensors continuously measure distance and help determine whether the robot is approaching an upward stair, downward stair, or flat surface. Based on this information, an MG995 servo motor adjusts the position of the front wheel. When an upward stair is detected, the servo lifts the front wheel to assist climbing. When a downward stair is detected, the servo lowers the wheel to provide stability during descent. If no stair is detected, the wheel remains in its normal forward position.

The robot is also equipped with a force sensor mounted on the top frame. This sensor detects the presence of an object placed on the robot. When force is detected, the Arduino activates the gripping mechanism. The gripper consists of four gripping elements, controlled by two SG90 servo motors, allowing the robot to securely grip and hold objects.

For remote control and smart operation, a NodeMCU module is integrated into the system. The robot is controlled wirelessly through a smartphone using the Blynk IoT platform. Directional control of the 12V gear motor is achieved using a relay module, which allows the motor to rotate in both forward and backward directions based on user commands. This enables smooth and reliable movement of the robot.

Mechanically, the robot uses a three-wheel series design. The front wheel series is responsible for stair detection and directional adjustment, the middle wheel provides balance and support, and the rear wheel is directly driven by the 12V gear motor. Power is transmitted from the rear wheel to the front wheels using a belt mechanism, ensuring coordinated movement and sufficient torque during stair climbing.

Overall, this project demonstrates an effective combination of mechanical design, sensor integration, embedded systems, and IoT-based control. The Stair Climber Robot with Gripper is suitable for applications such as material handling, assistance in hazardous environments, and research in autonomous robotic mobility.

1.2 Problem Statement

Conventional In many real-world environments such as warehouses, hospitals, construction sites, and disaster-affected areas, robots are required to move across uneven surfaces and multiple floor levels. Conventional wheeled robots are generally limited to flat terrains and are unable to climb stairs or safely descend them. Additionally, most mobile robots lack the ability to detect stair direction accurately and adjust their mechanical structure accordingly, which increases the risk of instability and damage.

Another major challenge is the handling and transportation of objects in such environments. Manual lifting and carrying of goods in stair-based structures can be time-consuming, unsafe, and inefficient. Existing robotic solutions that combine stair-climbing capability with object gripping mechanisms are often complex, expensive, or unsuitable for small-scale and educational applications.

Furthermore, the absence of smart remote control and real-time monitoring limits the flexibility and usability of robotic systems. Many robots do not provide user-friendly wireless control or fail to integrate sensor-based automation with IoT platforms.

Therefore, there is a need to design and develop a cost-effective, reliable, and smart stair-climbing robot that can:

- Detect upward and downward stairs automatically,
- Adjust its wheel mechanism to ensure stable movement,
- Grip and carry objects safely,
- And be controlled remotely using a smartphone through an IoT platform.

1.3 Objectives

The objectives of this project are formulated to address the limitations of conventional mobile robots in stair-based and uneven environments, while integrating intelligent sensing, control, and IoT technologies for enhanced functionality.

- To design an autonomous stair-climbing robot capable of navigating stairs and uneven surfaces where conventional wheeled robots fail.
- To implement intelligent sensing and control using ultrasonic sensors, servo motors, and microcontrollers for stable and adaptive movement.
- To develop a force-sensor-based gripper for automated object handling and material transportation.
- To enable IoT-based remote control and monitoring using NodeMCU and a smartphone interface for versatile real-world applications.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

Stair-climbing robots have been an active area of research in mobile robotics due to their importance in environments where elevators or ramps are unavailable. Such environments include residential buildings, warehouses, hospitals, industrial plants, and disaster zones. Traditional wheeled robots are efficient on flat surfaces but face serious limitations when encountering stairs, uneven terrain, or sudden height variations. To overcome these challenges, researchers have explored various mechanical designs, sensing techniques, and control algorithms [1].

Different stair-climbing mechanisms have been proposed in the literature, including tracked systems, legged robots, hybrid wheel–leg designs, and articulated wheel mechanisms. Tracked robots offer good traction and stability but are generally bulky, heavy, and energy-intensive. Legged robots provide high adaptability to terrain but require complex control systems and precise coordination, making them costly and difficult to implement. As a result, wheeled and hybrid mechanisms have gained popularity due to their simplicity, lower cost, and ease of control [2].

Several studies have introduced tri-wheel and adjustable-wheel mechanisms to enable stair climbing. These systems use servo motors or mechanical linkages to change wheel orientation during stair ascent and descent. Such designs improve stability and reduce the risk of slipping while maintaining a compact structure. Sensor-based detection plays a crucial role in these systems. Ultrasonic sensors and infrared sensors are widely used to detect stair edges, height differences, and obstacles, providing real-time feedback to the controller for decision-making [3].

In addition to mobility, object handling has become an essential feature in modern robotic platforms. Research has shown that integrating a gripper mechanism allows robots to perform tasks such as pick-and-place operations, material transportation, and assistance in hazardous environments. Servo-controlled grippers are commonly used due to their accuracy, low power

consumption, and ease of integration with microcontrollers. Force sensors have been employed in several designs to detect object presence and regulate gripping force, ensuring safe and reliable handling of goods [4].

Recent advancements in embedded systems and communication technologies have led to the integration of IoT and wireless control in robotic systems. Microcontrollers such as Arduino are widely used for sensor processing and actuator control, while Wi-Fi-enabled modules like NodeMCU enable remote operation. IoT platforms allow users to control robots through smartphones, monitor sensor data in real time, and improve system flexibility. This approach reduces the need for manual operation and enhances user interaction [5].

From the reviewed literature, it is observed that while many systems address stair climbing or object manipulation individually, fewer designs successfully integrate stair navigation, object gripping, and IoT-based control into a single low-cost system. This project aims to bridge this gap by combining an adjustable wheel-based stair-climbing mechanism, a force-sensor-based gripper, and smartphone-controlled IoT functionality, resulting in a compact, efficient, and practical robotic solution [6].

CHAPTER 3

METHODOLOGY

3.1 Methodology

The methodology of the Stair Climber Robot with Gripper project describes the systematic approach followed to design, develop, and implement the robotic system. The overall methodology is divided into hardware design, software development, sensor integration, control strategy, and testing.

Initially, the mechanical structure of the robot was designed to support stair climbing and object handling. A three-wheel series mechanism was implemented, where the rear wheel is driven by a 12V DC gear motor to provide the required torque. The middle wheel offers balance and support, while the front wheel is mounted on an adjustable mechanism controlled by an MG995 servo motor. Power from the rear wheel is transmitted to the front wheels using a belt drive system to ensure coordinated motion during stair climbing.

The electronic hardware was then integrated into the system. An Arduino Nano was used as the main controller for sensor data processing and actuator control. Two ultrasonic sensors were mounted at the front of the robot to continuously measure distance and detect stair edges. Based on the sensor readings, the Arduino determines whether the robot is approaching an upward stair, downward stair, or flat surface. According to this decision, the front wheel position is adjusted to assist safe ascent or descent.

A force sensor was installed on the top frame of the robot to detect the presence of an object. When force is detected, the Arduino activates the gripping mechanism. The gripper consists of four gripping elements operated by two SG90 servo motors, allowing the robot to securely grip and release objects automatically.

For motion control and remote operation, a NodeMCU module was integrated with the system. The robot is controlled wirelessly using a smartphone through the Blynk IoT platform. User commands received from the Blynk application are transmitted to the NodeMCU, which controls relay modules to change the rotational direction of the 12V DC gear motor. This enables smooth forward and backward movement of the robot.

Power management was achieved using three 3.7V rechargeable batteries to supply stable voltage to the motors, sensors, and control units. Finally, the system was tested under different conditions, including flat surfaces, upward stairs, downward stairs, and object gripping scenarios. Sensor readings, wheel movement, gripping performance, and wireless control were evaluated to ensure proper functionality, stability, and reliability of the robot.

3.2 Block Diagram

This is the block diagram of proposed system. We used here Three pcs 3.7v Battery to make sure power supply for all sensors and Microcontroller. Here Arduino Nano is used here to detect the position of stair using 2 Ultrasonic sensors, when stair will be detected one MG995 Servo motor will change the position of front wheel to up then robot can move to upper direction on Stair. In this arduino also read a force sensor value, when force will be detect in the top of robot then it will think that some goods is place on his frame so it will grip that goods by using 4 gripping element that will be controlled by using two SG90 servo motor.

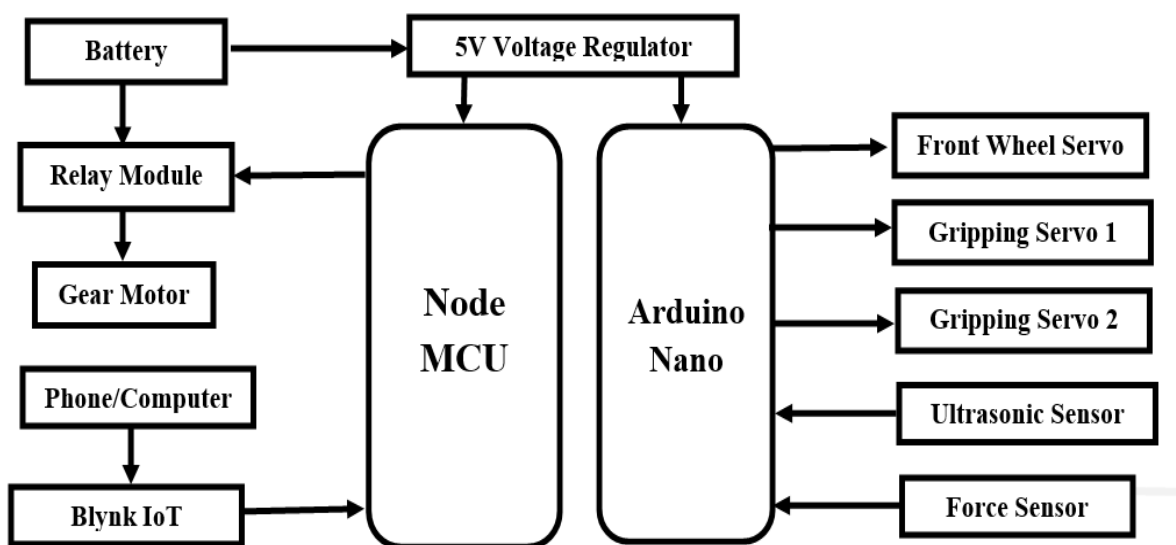


Fig 3.1: Block diagram of Proposed System.

One node MCU is used here to control the movement of this robot from smart phone by using Blynk IoT platform, Here we have to relay that will switching at a time to change the rotational direction of 12V Gear Motor and this command will be send from blynk app user, this Robot can go forward and backward smoothly.

3.3 Circuit Diagram

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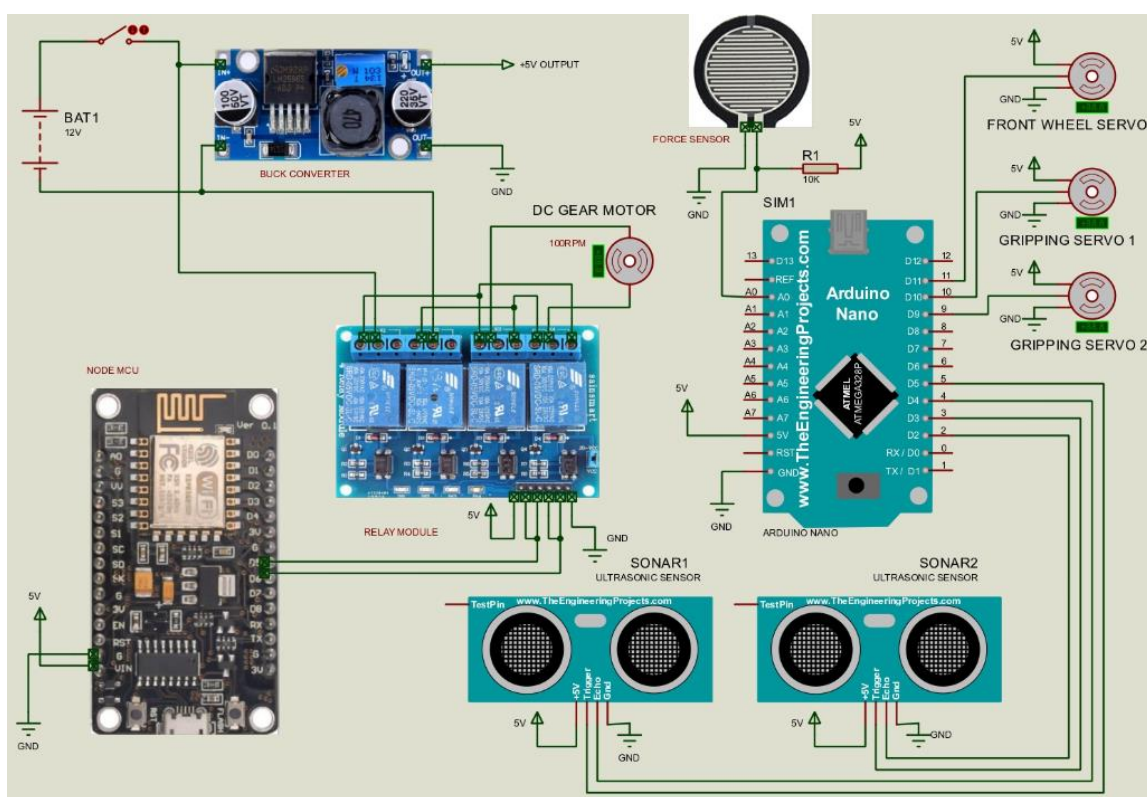
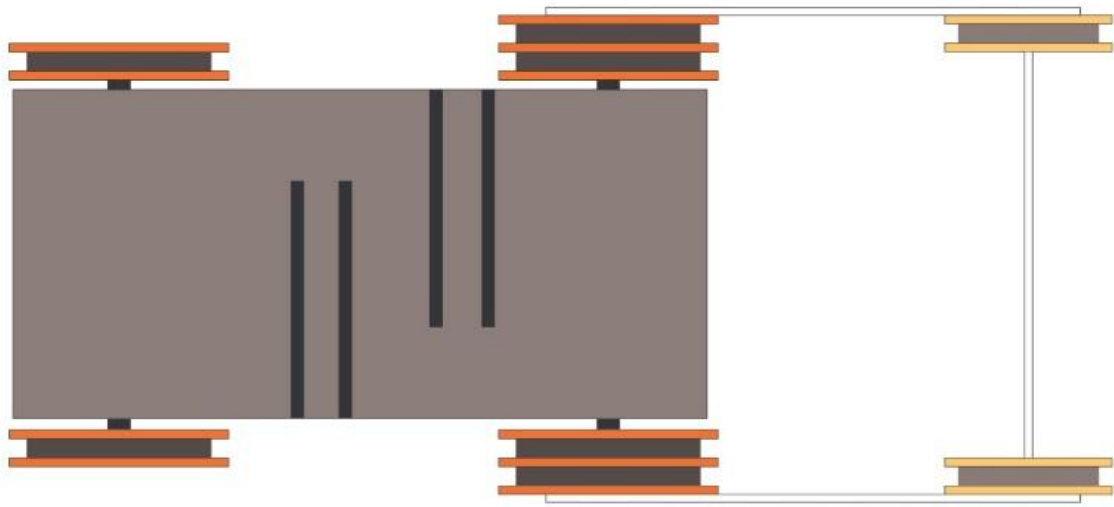


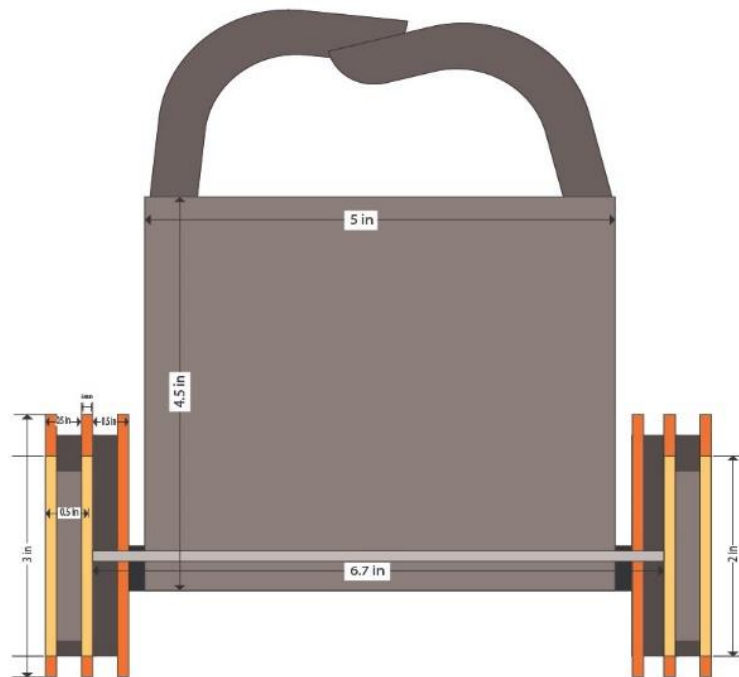
Fig 3.2: Circuit diagram of Proposed System.

One node MCU is used here to control the movement of this robot from smart phone by using Blynk IoT platform, Here we have to relay that will switching at a time to change the rotational direction of 12V Gear Motor and this command will be send from blynk app user, this Robot can go forward and backward smoothly. Here our robot have three serial of wheel, front serial will make decision to go lower, level, Higher stair, Middle serial wheel will make support and back side wheel will take necessary force from 12V gear motor and transfer that force to others wheel by using belt from back to front.

3.4 Isometric Model



Top view



Front view

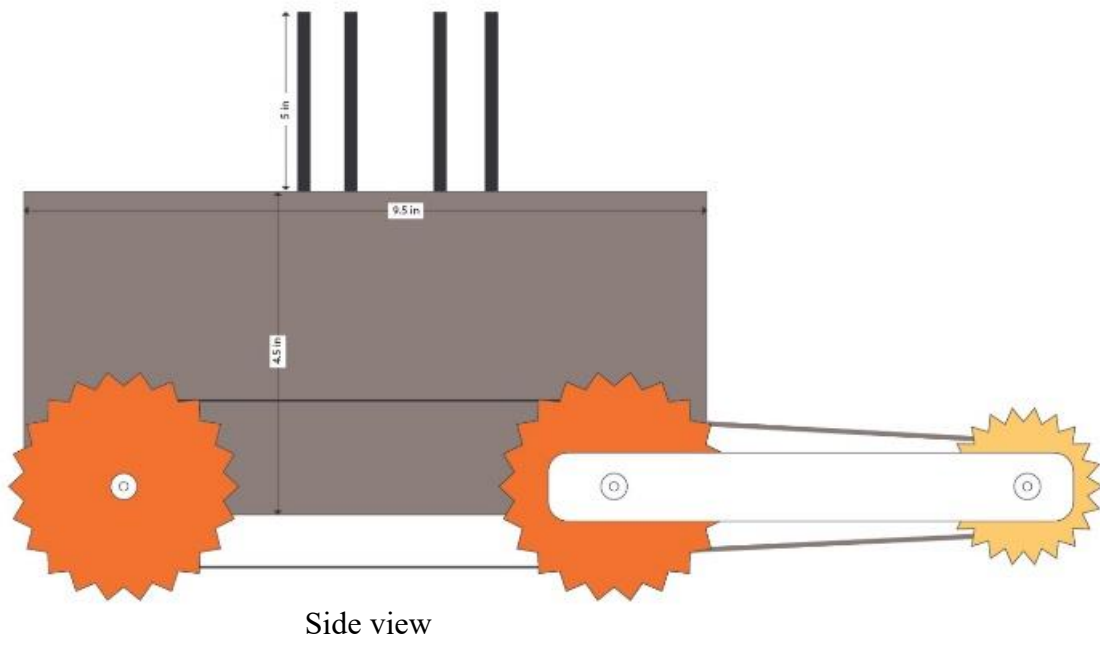


Fig 3.3: Isometric Model.

3.5 Full Overview



Fig 3.4: Full Overview of Proposed System.

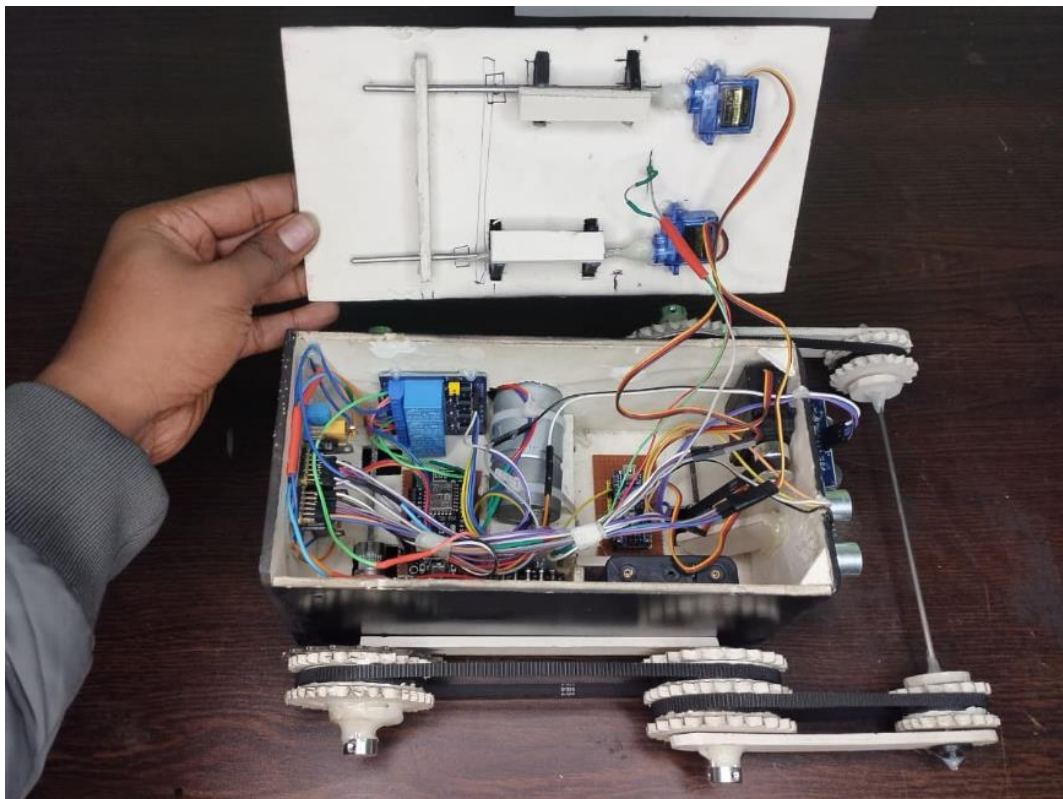


Fig 3.5: Inner View of Proposed System.

3.6 Working principle

The working principle of the Stair Climber Robot with Gripper is based on sensor-driven decision making, servo-controlled mechanical adjustment, and IoT-based remote operation. The robot operates by continuously monitoring its surroundings, identifying stair conditions, adjusting its wheel mechanism, and performing object gripping tasks as required.

When the robot is powered on, the Arduino Nano initializes all sensors and actuators. The two ultrasonic sensors mounted at the front of the robot continuously measure the distance to the surface ahead. If the measured distance indicates an upward stair, the Arduino processes this data and sends a control signal to the MG995 servo motor, which lifts the front wheel to an upward position. This adjustment allows the robot to climb the stair smoothly. If a downward stair is detected, the servo motor lowers the front wheel to provide proper support and stability during descent. When no stair is detected, the front wheel remains in its normal forward position for movement on flat surfaces.

The robot's movement is driven by a 12V DC gear motor mounted at the rear. The rotational motion from this motor is transmitted to the front and middle wheels through a belt mechanism, ensuring synchronized wheel movement and sufficient torque for stair climbing. Directional control of the motor is achieved using relay modules, allowing the robot to move forward or backward as required.

Simultaneously, the force sensor mounted on the top frame continuously monitors any load placed on the robot. When a force above a predefined threshold is detected, the Arduino interprets this as the presence of an object. In response, it activates the gripping mechanism. The gripper, controlled by two SG90 servo motors, closes the four gripping elements to securely hold the object. When the force is removed or a release command is given, the gripper opens accordingly.

Wireless control is achieved using a NodeMCU module connected to the Blynk IoT platform. User commands sent from a smartphone are received by the NodeMCU and translated into control signals for motor direction and robot movement. This allows real-time and flexible operation of the robot from a remote location.

Overall, the robot functions through the coordinated operation of sensors, microcontrollers, motors, and IoT communication, enabling it to climb stairs, handle objects, and move efficiently in different environments.

3.7 Final Project

The final project successfully presents a Stair Climber Robot with Gripper that integrates mechanical mobility, sensor-based automation, object handling, and IoT-based remote control into a single functional system. The robot uses a 12V DC gear motor with a belt-driven three-wheel mechanism for smooth movement on flat surfaces and stairs, while an adjustable front wheel controlled by a servo motor adapts to stair conditions using ultrasonic sensor feedback. An Arduino Nano manages sensor data and actuator control, including an automated gripper mechanism activated by a force sensor, while a NodeMCU enables wireless control via the Blynk IoT platform. Testing under various conditions confirmed stable stair navigation, reliable object gripping, and responsive remote operation, demonstrating a cost-effective and practical solution for stair climbing and material handling applications.

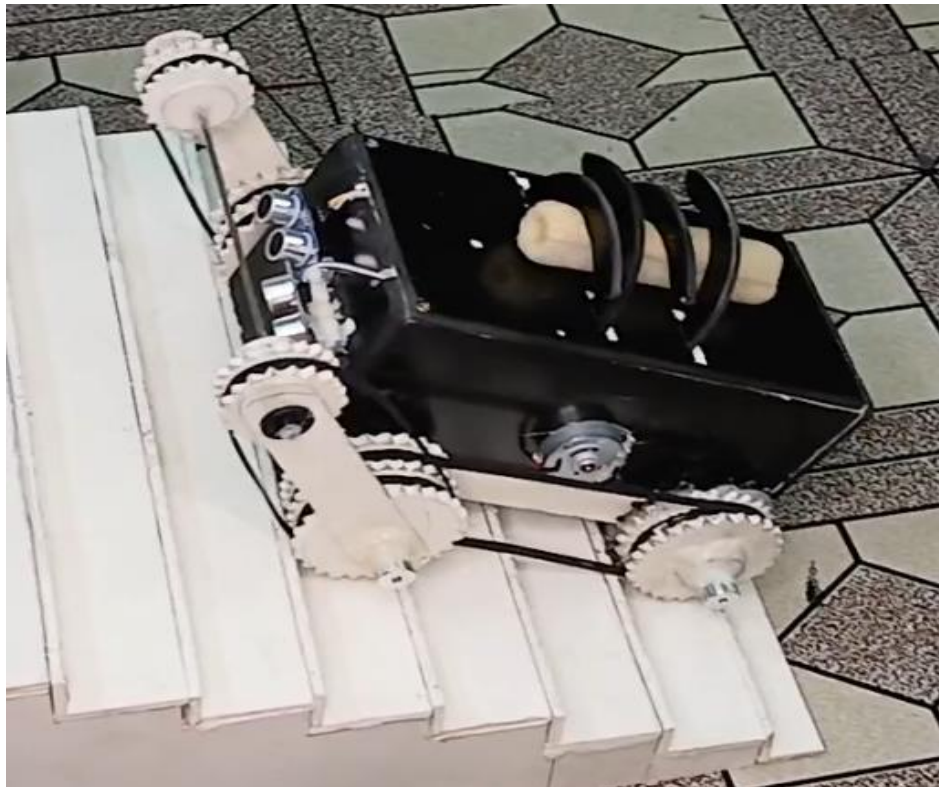


Fig 3.6: Robot moving up with Load.

3.8 Cost Analysis

Table 1: List of Component with Price

Sl. No	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
1	Arduino Nano	ATmega328 microcontroller, 16 MHz, 14 Digital I/O, 8 Analog inputs	1	350	350
2	NodeMCU (ESP8266)	ESP-12E Wi-Fi module, 80/160 MHz, 4 MB Flash, UART/I2C/SPI	1	450	450
3	HC-SR04 Ultrasonic Sensor	Range: 2–400 cm, Accuracy: ± 3 mm, 5V operation	2	110	220
4	MG995 Servo Motor	Torque: ~ 9 – 11 kg·cm, Metal gears, PWM control	1	400	400
5	SG90 Micro Servo Motor	Torque: ~ 1.8 kg·cm, 180° rotation, 5V supply	2	150	300
6	12V DC Gear Motor (100 RPM)	Voltage: 12V DC, 100 RPM, High torque, Gear reduction	1	1500	1500
7	2-Channel Relay Module	5V logic, Optocoupler isolation, SPDT relays	2	150	300
8	Force Sensitive Resistor (FSR)	Sensing area $\sim 1.5 \times 3.8$ cm, Force range ~ 0.1 – 10 kg	1	1000	1000
9	Rechargeable Li-ion Battery (3.7V)	18650 or equivalent, 2000–3500 mAh	3	150	450
10	Belt & Pulley Set	Transmission belt, pulleys for drive	1	1700	1700
11	Voltage Regulator Circuit (5V)	DC-DC Convert to 5V for Arduino & Servos	1	400	400
12	Chassis & Mounting Hardware & Others	Wires, resistors, headers, screws	Required	2000	2000
				Total	9,070/=

CHAPTER 4

HARDWARE ANALYSIS

4.1 Hardware

The hardware section of the Stair Climber Robot with Gripper describes the physical components used to build the system and their functional roles. The hardware is designed to ensure reliable stair climbing, object handling, and wireless control while maintaining a compact and cost-effective structure.

The core processing unit of the system is the Arduino Nano, which is responsible for reading sensor data, processing control logic, and driving the servo motors and gripper mechanism. For wireless communication and IoT-based control, a NodeMCU (ESP8266) module is used. It enables remote operation of the robot through a smartphone using the Blynk IoT platform.

To drive the robot's movement, a 12V DC gear motor (100 RPM) is used at the rear wheel to provide sufficient torque for climbing stairs. The direction of motor rotation is controlled using relay modules, allowing the robot to move forward and backward smoothly. Motion from the rear motor is transmitted to the front and middle wheels using a belt drive mechanism.

Stair detection is achieved using two ultrasonic sensors mounted at the front of the robot. These sensors measure distance to detect upward and downward stairs and provide real-time data to the Arduino Nano. The position of the front wheel is adjusted using an MG995 servo motor, which enables the robot to climb or descend stairs safely.

The object handling system consists of a force sensor mounted on the top frame of the robot. This sensor detects the presence of an object placed on the robot. Once detected, the gripper mechanism is activated. The gripper uses two SG90 servo motors to control four gripping elements, allowing secure gripping and releasing of objects.

Power to the entire system is supplied by three 3.7V rechargeable lithium-ion batteries, which provide stable voltage to the motors, sensors, and control units. Voltage regulation circuits are used where necessary to protect sensitive components.

Overall, the selected hardware components ensure efficient mobility, accurate sensing, reliable gripping, and flexible wireless control, making the robot suitable for stair-based material handling and research applications.

4.2 Arduino Nano

The Arduino Nano is a compact microcontroller board based on the ATmega328, operating at 16 MHz and offering multiple digital and analog I/O pins. In this project, it serves as the central control unit, reading sensor data, executing control logic, and driving servos and a DC motor. Its onboard USB interface enables easy programming and debugging.

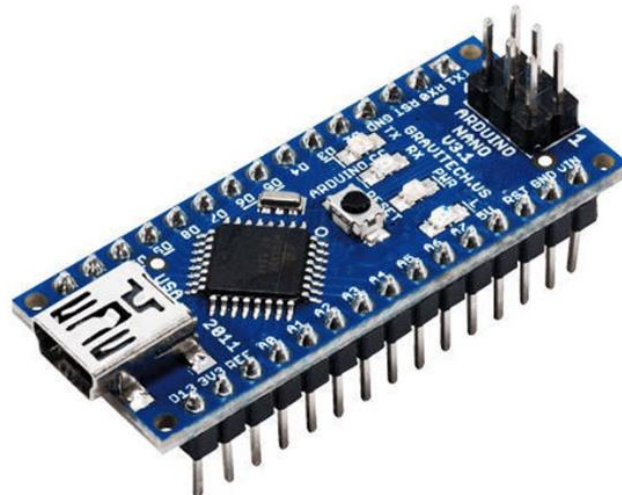


Fig 4.1: Arduino Nano.

4.3 NodeMCU (ESP8266)

The NodeMCU is a Wi-Fi-enabled microcontroller based on the ESP8266, designed for IoT applications and supporting communication protocols such as UART, I2C, and SPI. In the Stair Climber Robot, it connects the system to the Blynk IoT platform, enabling wireless control and monitoring via a smartphone.



Fig 4.2: NodeMCU (ESP8266).

4.4 HC-SR04 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor measures distance by emitting ultrasonic waves and calculating the echo return time, with an effective range of approximately 2–400 cm. In this project, two sensors are mounted at the front of the robot to detect stair edges and determine whether the robot is approaching an upward or downward step.



Fig 4.3: HC-SR04 Ultrasonic Sensor.

4.5 MG995 Servo Motor

The MG995 is a high-torque, metal-gearred PWM servo motor capable of delivering approximately 9–11 kg/cm of torque. In this robot, it adjusts the angle of the front wheel assembly based on stair detection, enabling upward or downward tilting to improve stability and stair-climbing performance.



Fig 4.4: MG995 Servo Motor.

4.6 SG90 Micro Servo Motor

The SG90 is a lightweight micro servo motor widely used in small robotics and hobby electronics. It operates on a 5V supply and can rotate up to 180°, offering precise control for compact mechanisms. In this project, two SG90 servos are used to operate the gripper mechanism. These servos control the motion of the gripping elements, allowing the robot to open and close the gripper to pick up and hold objects securely. Their compact size and low power consumption make them suitable for integration into the robot's gripper assembly.



Fig 4.5: SG90 Micro Servo Motor.

4.7 12V DC Gear Motor (100 RPM)

The 12V DC gear motor used in this project is a geared electric motor designed to provide a balance between speed and torque. Operating at approximately 100 rotations per minute (RPM), the motor offers sufficient torque to drive the robot's wheels and overcome resistance while climbing stairs. The built-in gearbox reduces the high speed of the electric motor to a lower speed with greater torque, which is necessary for reliable locomotion on uneven surfaces. The motor's rotational direction is controlled via relay modules, enabling both forward and backward movement.



Fig 4.6: 12V DC Gear Motor (100 RPM).

4.8 2-Channel Relay Module

The 2-channel relay module is an electronic switching device that allows low-power control signals from a microcontroller to switch higher-power circuits such as DC motors. Each relay on the module includes optocoupler isolation for noise protection and safe operation. In this robot, the relay module is used to change the rotational direction of the 12V DC gear motor. By energizing specific relays, the polarity of the motor supply is reversed, allowing the robot to move forward or backward as commanded by the user through the Blynk app.



Fig 4.7: 2-Channel Relay Module.

4.9 Force Sensitive Resistor (FSR)

A Force Sensitive Resistor (FSR) is a sensor whose resistance decreases when pressure or force is applied to its surface. It provides a simple and effective way to detect the presence and relative magnitude of force. In the Stair Climber Robot, the FSR is mounted on the robot's top frame to detect when an object is placed on it. Once a force above a certain threshold is detected, the microcontroller triggers the gripper mechanism to close and hold the object securely. FSRs are chosen for their simplicity, light weight, and ease of interfacing with microcontrollers.



Fig 4.8: Force Sensitive Resistor (FSR).

4.10 Rechargeable Li-ion Battery (3.7V)

The robot is powered by 3.7 V rechargeable lithium-ion battery cells, typically in the 18650 form factor, which offer high energy density and stable output. Multiple cells are combined to supply reliable power to the Arduino, NodeMCU, sensors, and actuators, ensuring continuous operation.



Fig 4.9: Rechargeable Li-ion Battery (3.7).

4.11 Belt & Pulley Set

The belt and pulley set is a mechanical transmission system used to transfer rotational motion from the driven DC gear motor to other wheels of the robot. It consists of pulleys mounted on the motor output shaft and the driven wheels, connected by a flexible belt. This arrangement helps distribute torque evenly to multiple wheels, improving traction and stability, especially when climbing stairs. The belt system also reduces mechanical complexity compared to individual gear trains for each wheel.



Fig 4.10: Belt & Pulley Set.

4.12 Voltage Regulator Circuit (5V)

The voltage regulator circuit is a DC–DC converter that boosts the battery voltage to a stable 5 V required by the Arduino Nano, NodeMCU, sensors, and servos. It ensures a consistent power supply despite battery voltage fluctuations, improving system reliability and preventing unexpected resets.



Fig 4.11: Voltage Regulator Circuit (5V)

CHAPTER 5

SOFTWARE ANALYSIS

5.1 Software

- Arduino IDE
- Proteus Professional 8

5.1.1 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a versatile, cross-platform software used to write, compile, and upload programs, known as sketches, to Arduino microcontrollers. It provides a user-friendly code editor with features such as syntax highlighting, auto-formatting, and a built-in serial monitor for real-time debugging of sensors and actuators. Arduino programs typically include two main functions: `setup()`, which runs once to initialize the system, and `loop()`, which executes continuously to control the device's operations. The IDE supports a wide range of Arduino boards, including the Arduino Nano used in this project, and allows users to select the correct board and communication port for uploading programs. It also offers extensive library support, enabling easy integration of motors, sensors, servos, and communication protocols, including IoT platforms like Blynk. In this project, the Arduino IDE is used to process data from ultrasonic and force sensors, control MG995 and SG90 servo motors for stair climbing and gripping, and manage the motion of 12V geared motors through relays. Its simplicity, open-source nature, and strong community support make it an ideal choice for robotics projects, combining programming, electronics, and control in a single platform.

5.1.2 Proteus 8 Professional

Proteus 8 Professional is a comprehensive electronic design automation (EDA) software suite developed that, integrates schematic capture, circuit simulation and PCB (Printed Circuit Board) layout in one unified environment. It is widely used by students, hobbyists and engineers to design and test electronic circuits virtually before committing to physical prototypes, helping reduce development time and cost. Its simulation engine supports mixed-mode SPICE analysis along with microcontroller co-simulation, allowing users to load actual firmware (e.g., Arduino, PIC, ARM, 8051) into virtual components and observe real-time circuit behavior. This makes it valuable for embedded system development and debugging.

The software includes powerful tools for schematic capture, enabling designers to draw complex circuit diagrams with a drag-and-drop interface and extensive component libraries that include thousands of parts. Once the schematic is done, Proteus transitions seamlessly to PCB design with features like constraint-driven layout, autorouting, multi-layer support and 3D visualization, so users can view boards in a realistic 3D environment before fabrication. It also offers integrated documentation features such as customizable bills of materials and project notes.

Proteus 8 Professional's Virtual System Modelling (VSM) bridges hardware and firmware design by letting you simulate embedded systems with peripherals and interactive elements (like switches, displays and sensors) directly on the screen. Advanced debugging tools such as virtual oscilloscopes and logic analyzers aid in analyzing circuit performance. Although more common in academic and hobbyist communities, Proteus remains a versatile all-in-one solution for electronic design and prototyping.

CHAPTER 6

RESULT & DISCUSSION

6.1 Result

The Stair Climber Robot with Gripper successfully demonstrated its intended functionality, integrating stair navigation, object handling, and IoT-based control. During testing, the robot was able to detect both upward and downward stairs using ultrasonic sensors. When an upward stair was detected, the MG995 servo motor adjusted the front wheel to an inclined position, allowing smooth ascent without slipping. Similarly, during stair descent, the servo lowered the front wheel to maintain stability, while on flat surfaces, the front wheel remained in a neutral position for normal movement. The force sensor effectively detected objects placed on the robot's frame, triggering the SG90 servos to close the gripper and securely hold the object. The release mechanism also functioned reliably when the object was removed or a release command was given. Wireless control using the NodeMCU and the Blynk IoT platform allowed the robot to respond accurately to smartphone commands, including forward, backward, stop, and gripping actions, with minimal delay. The relay modules efficiently controlled the direction of the 12V DC motor, enabling smooth and controlled movement. The three 3.7V rechargeable batteries provided stable power, ensuring uninterrupted operation of sensors, microcontrollers, and servos. Overall, the robot performed integrated tasks efficiently, demonstrating stability on stairs, reliable object handling, and effective wireless control. The system proved to be compact, cost-effective, and practical for small-scale material handling and educational applications, fulfilling the design objectives successfully.

6.2 Final Result

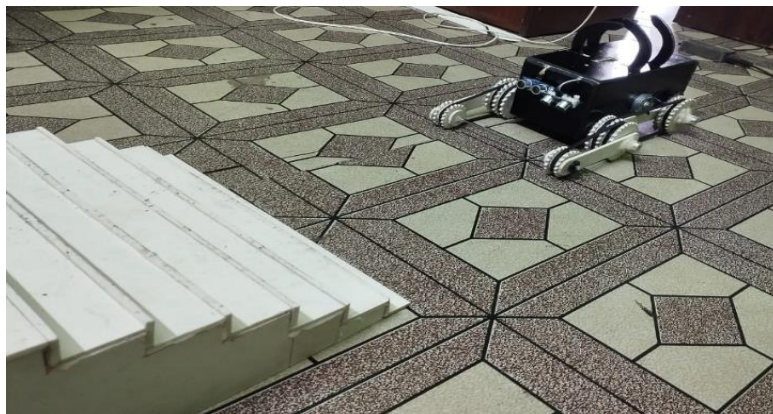


Fig 6.1: Robot is ready to Run.

6.4 Data Table

Table II: Load vs Climbing Scenarios:

SL	Load (gm)	Climb Success	Time(s)	Slipping
01	100gm	Yes	11	No
02	200gm	Yes	13	No
03	300gm	Yes	16	Minor
04	400gm	Yes	17	Minor
05	500gm	No	-	Yes

Table III: Step vs Load Scenarios:

SL	Step Height (mm)	Load (ml)	Time(s)
01	10mm	300ml	1.5
02	20mm	300ml	2
03	30mm	300ml	2.2
04	40mm	300ml	2.5

Table IV: Dimension:

SL	Parts	Height (Inch)	Width (Inch)	Long (Inch)
01	Body Frame	4.5	5	9.5
02	Wheel	3	0.5	3
03	Small wheel	2	2	0.5
04	Gripper	2.5	0.5	3
05	Stair	1	2	15

Table V: Power Consumption:

SL	Component	Operating Voltage	Max Voltage	Current
01	Arduino Nano	5	20 V (VIN limit)	19–30 mA
02	Node MCU (ESP8266)	5	10 V	70–170 mA
03	Ultrasonic Sensor	5	5.5 V	15 mA
04	MG995 Servo Motor	4.8–7.2 V	7.2 V	500 mA
05	SG90 Micro Servo Motor	4.8–6 V	6.5 V	100–250 mA
06	12 V DC Gear Motor	12 V	14 V	300–800 mA
07	4-Channel Relay Module	5 V	6 V	70–80 mA
08	Force Sensitive Resistor	3.3–5 V	5 V	1 mA

6.5 Discussion

The Stair Climber Robot with Gripper project demonstrates the effective integration of mechanical design, sensors, and IoT control in a single robotic system. During testing, the robot successfully climbed stairs, gripped objects, and operated wirelessly. Ultrasonic sensors enabled stair detection, while the MG995 servo adjusted the front wheel for smooth movement, improving balance and reducing slipping. The tri-wheel design and belt-driven rear wheel proved effective.

The gripper system reliably handled small to medium-sized objects using a force sensor and SG90 servos, though limited servo torque reduced performance with heavier items. Remote control through the NodeMCU and Blynk platform functioned well, and relay modules correctly controlled motor direction. Some limitations included reduced performance on steep or narrow stairs and higher battery consumption. Overall, the project met its objectives and demonstrates a practical, low-cost robotic solution, with scope for future improvements.

CHAPTER 7

CONCLUSION

7.1 Conclusion

The Stair Climber Robot with Gripper is a compact robotic system that integrates mechanical design, sensors, and IoT-based control. The robot uses ultrasonic sensors to detect and climb stairs safely, while a servo motor adjusts the wheel angle to maintain stability during ascent and descent. A force sensor-based gripper enables the robot to detect and hold objects for basic pick-and-place tasks. The system is controlled using an Arduino Nano and NodeMCU, with wireless operation achieved through the Blynk IoT platform. Experimental results show reliable performance on flat surfaces and staircases of different heights, with minor limitations related to load capacity, steep stairs, and battery life. Overall, the project demonstrates a cost-effective and practical robotic solution suitable for undergraduate learning, educational demonstrations, and basic research applications.

7.2 Advantages

The Stair Climber Robot with Gripper offers several notable advantages that make it a practical and efficient solution for stair navigation and material handling:

Autonomous Stair Navigation: The robot can detect and climb upward and downward stairs using ultrasonic sensors, eliminating the need for manual assistance and reducing the risk of accidents.

Integrated Object Handling: The force sensor-based gripper allows the robot to detect and securely hold objects, enabling automated pick-and-place operations.

Wireless Control via IoT: Integration with the NodeMCU and Blynk IoT platform allows remote operation through a smartphone, providing convenience, flexibility, and real-time control.

Compact and Lightweight Design: The use of a three-wheel series mechanism and lightweight materials makes the robot portable and suitable for indoor environments.

Cost-Effective Implementation: The system uses readily available components such as Arduino Nano, SG90 servos, and 12V DC gear motors, keeping the overall cost low without compromising functionality.

Energy Efficiency: The use of rechargeable Li-ion batteries provides a stable power supply while minimizing the need for frequent recharging, enhancing the robot's operational duration.

7.3 Limitations

- Despite the Stair-climbing performance depends on stair dimensions; irregular or varying stairs can affect stability and movement.
- Ultrasonic sensors may give inaccurate readings in reflective or cluttered environments.
- Battery-powered operation limits working time and reduces load-carrying capability during continuous use.
- The gripper is suitable only for lightweight objects and cannot handle heavy or irregular shapes.
- Wireless control via the Blynk platform depends on stable internet connectivity and lacks advanced autonomous decision-making.

7.4 Application

The Stair Climber Robot with Gripper has a wide range of practical and educational applications due to its ability to navigate stairs, handle objects, and operate wirelessly. It can be used for material handling in multi-level buildings, such as offices, libraries, or warehouses, transporting small objects or packages between floors and reducing human effort. The robot also serves as an effective educational and research tool, helping students and researchers understand robotics, automation, sensor integration, and IoT-based control systems, including stair climbing mechanisms and servo-driven actuators. In controlled environments, it can assist individuals with limited mobility by carrying lightweight objects across stairs. Additionally, with minor modifications, the robot can be used for inspection and monitoring, carrying sensors or cameras to examine staircases, indoor areas, or confined spaces that are difficult for humans to access. It also serves as a practical demonstration and prototyping platform, showcasing the integration of autonomous navigation, gripping mechanisms, and wireless control, which can inspire the development of more advanced robotic systems for industrial or domestic applications. Furthermore, in small educational labs or warehouses, the robot can be used for small-scale logistics automation, moving components or samples and demonstrating automated material handling processes. Overall, the robot's combination of mobility, sensing, and IoT-enabled control makes it a versatile platform for practical, educational, and research applications where autonomous stair navigation and object manipulation are required.

7.5 Future Scope

The Stair Climber Robot with Gripper has significant potential for enhancement and broader applications. Future work can focus on improving payload, autonomy, sensing, and adaptability for practical use.

- Increase payload capacity with stronger motors or improved gripper design.
- Enhance stair detection using infrared, ultrasonic, or LIDAR sensors.
- Implement autonomous navigation with path planning and obstacle avoidance.
- Improve power management with larger batteries and energy-efficient components.
- Add cameras and sensors for inspection, monitoring, or surveillance.
- Adapt the robot for delivery, inspection, or assistance for elderly/differently-abled individuals.
- Use the modular design for educational and research experimentation.

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APPENDIX

Stair Climbing Robot Control Blynk Programming Code:

```
// 📌 Blynk Template Info
#define BLYNK_TEMPLATE_ID "TMPL6cKjFHeqJ"
#define BLYNK_TEMPLATE_NAME "Car Movement Control"
#define BLYNK_AUTH_TOKEN "vdS6nfYimcPpztliaSEXclQdy0Yxp5oI"

#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

// 📌 WiFi Credentials
char ssid[] = "Nadim";
char pass[] = "25802581";

// 📌 Relay Pins
#define RELAY1 D5 // GPIO13
#define RELAY2 D6 // GPIO15

// 📌 Virtual Pins
#define VPIN_RELAY1 V0
#define VPIN_RELAY2 V1

// Relay 1 Control
BLYNK_WRITE(VPIN_RELAY1)
{
  int value = param.asInt(); // 1 or 0
  digitalWrite(RELAY1, value ? LOW : HIGH);
}

// Relay 2 Control
BLYNK_WRITE(VPIN_RELAY2)
{
  int value = param.asInt(); // 1 or 0
  digitalWrite(RELAY2, value ? LOW : HIGH);
}

void setup()
{
  Serial.begin(9600);

  pinMode(RELAY1, OUTPUT);
  pinMode(RELAY2, OUTPUT);

  // Turn relays OFF at startup
```

```

digitalWrite(RELAY1, LOW);
digitalWrite(RELAY2, HIGH);

Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
}

void loop()
{
  Blynk.run();
}

```

Stair Climbing Robot Servo Motor Programming Code:

```

#include <Servo.h>

/* ----- Servo Objects ----- */
Servo mg995Servo; // Ultrasonic-controlled servo
Servo servo1;    // FSR servo 1
Servo servo2;    // FSR servo 2

/* ----- Ultrasonic Pins ----- */
const int trig1 = 2;
const int echo1 = 3;
const int trig2 = 4;
const int echo2 = 5;

/* ----- Servo Pins ----- */
const int mg995Pin = 9;
const int servo1Pin = 10;
const int servo2Pin = 11;

/* ----- FSR ----- */
const int fsrPin = A0;
const int forceThreshold = 200;

/* ----- Obstacle Distance ----- */
const int obstacleDistance = 12;

/* ----- Ultrasonic Function ----- */

```

```

long getDistance(int trigPin, int echoPin) {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  long duration = pulseIn(echoPin, HIGH, 30000);
  if (duration == 0) return 999;

  return duration * 0.034 / 2;
}

/* ----- Setup ----- */
void setup() {
  pinMode(trig1, OUTPUT);
  pinMode(echo1, INPUT);
  pinMode(trig2, OUTPUT);
  pinMode(echo2, INPUT);

  mg995Servo.attach(mg995Pin);
  servo1.attach(servo1Pin);
  servo2.attach(servo2Pin);

  mg995Servo.write(0);
  servo1.write(90);
  servo2.write(0);

  Serial.begin(9600);
}

/* ----- Loop ----- */
void loop() {

  /* ===== Ultrasonic Logic (MG995) ===== */

```

```

long distance1 = getDistance(trig1, echo1);
long distance2 = getDistance(trig2, echo2);

if ((distance1 > 25) && (distance2 > 12)) {
  mg995Servo.write(0);
}
if ((distance1 > 25) && (distance2 < 12)) {
  mg995Servo.write(45);
}
if ((distance1 < 25) && (distance2 < 14)) {
  mg995Servo.write(90);
}
if ((distance1 < 25) && (distance2 > 12)) {
  mg995Servo.write(90);
}

/* ===== FSR Logic (SG90 Servos) ===== */
int fsrValue = analogRead(fsrPin);

if (fsrValue > forceThreshold) {
  servo1.write(0);
  servo2.write(90);
} else {
  servo1.write(90);
  servo2.write(0);
}

/* ===== Serial Monitor ===== */
Serial.print("U1: ");
Serial.print(distance1);
Serial.print(" cm | U2: ");
Serial.print(distance2);
Serial.print(" cm | FSR: ");
Serial.println(fsrValue);
delay(200);
}

```