



# Design And Development Of Pole Climbing Robot

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**Abstract:** This paper details the design and development of a Pole Climbing Robot (PCR) engineered for inspection, maintenance, and surveillance tasks on vertical structures such as utility poles and communication towers. The robot's design features a spring-based gripping mechanism and a durable stainless-steel frame, ensuring adaptability to various pole diameters and surface conditions. Powered by geared DC motors and controlled by an Arduino Uno microcontroller, the robot achieves stable and efficient operation. Experimental results highlight its capability to carry loads up to 10 kg and climb at an average speed of 0.8 m/min. This innovation offers a safer and more efficient alternative to traditional manual methods, reducing risks in hazardous environments.

**Index Terms** -Pole Climbing Robot (PCR), Arduino UNO

## I. INTRODUCTION

The **Pole Climbing Robot (PCR)** represents an innovative solution designed to enhance safety and efficiency in various tasks such as utility pole inspections, bridge maintenance, high-rise building assessments, and infrastructure maintenance. By replacing manual climbing methods with robotic automation, the PCR significantly reduces the risk to human workers while improving inspection accuracy and reliability. This project focuses on developing a PCR capable of climbing vertical poles with diameters ranging from 70 mm to 120 mm. The robot employs a simple yet effective spring-based mechanism for gripping, climbing, and adjusting according to the pole's diameter. This ensures stable traversal and secure attachment to vertical surfaces. The PCR features a unique mechanism that leverages friction and motor control for ascending vertical structures. It is equipped with three wheels, positioned to grip the pole's surface, working in synchronization to create traction and enable vertical climbing. The robot's climbing efficiency is largely determined by the coefficient of friction between the wheels and the pole's surface. Geared DC motors, capable of handling loads up to 10 kg each, power the PCR. An Arduino microcontroller serves as the central processing unit, coordinating the DC motors' movements and adapting the gripping mechanism based on sensor data. The L293D motor shield interfaces between the Arduino and the DC motors, providing robust motor control, optimizing power distribution, and minimizing the risk of overheating. With its versatile design and advanced features, the PCR represents a significant advancement in robotic climbing technology. Whether for industrial maintenance tasks, surveillance operations, or exploration in challenging environments, this robot is poised to tackle heights with ease and efficiency.

## II. LITERATURE REVIEW

- A research paper on "Design and Fabrication of Wheeled Pole Climbing Robot" by Sohail Khan and S Prabhu, was analysed and Information on motor and battery placement, and mechanical design of the robot's interior parts was obtained.
- Insights on software for motor control and microcontroller selection was done based on by Ripin Zaidi M, Tan Beng S, Abdullah A B, Zahurin S.

- Working principle, specifications, programming, and sensor wiring of Arduino Uno. Working Principle of Arduino and Using it as a Tool for Study and Research, July 2018: Understanding the working principle, specifications, programming, and sensor wiring of Arduino Uno.

### III. METHODOLOGY

#### A.Design

The design process of the Pole Climbing Robot (PCR) focused on creating a robust and adaptable system capable of climbing vertical poles with diameters ranging from 70 mm to 120 mm. The outer frame was developed using stainless steel (Grade 304, 1 mm thickness), selected for its corrosion resistance, strength-to-weight ratio, and durability. The gripping mechanism was designed with a spring-based system to enable automatic adjustment to varying pole diameters, ensuring a secure and stable grip without manual intervention.

The robot employs three wheels arranged to maximize surface contact and friction for climbing stability. Geared DC motors (60 RPM, 12V) power the wheels, providing sufficient torque to support payloads up to 10 kg. The control system is centered around an Arduino Uno microcontroller, integrated with an L293D motor driver shield for precise motor control. Sensors, including an ultrasonic module, were incorporated to enhance obstacle detection and climbing safety. Bluetooth functionality, enabled via the HC-05 module, allows for remote operation through a mobile application.

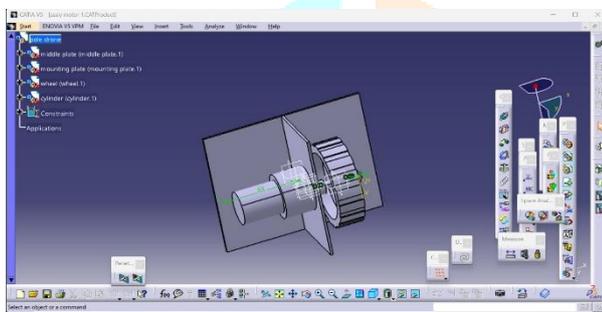


Fig 1: Wheel unit Assembly

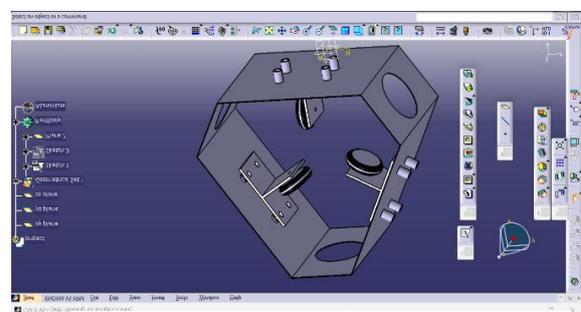


Fig 2: Robot Body Assembly

#### B.Materials

Following is the list of materials and dimensions of the fabricated parts.

Material	Part	Dimensions
Stainless Steel	Outer Frame	Grade 304, 1 mm thickness
Stainless Steel	Mounting Plates	150 mm × 100 mm
Mild Steel	Middle Plate	200 mm × 100 mm
Rubber	Gripping Mechanism (Pads)	Thickness: 5 mm
Plastic	Ultrasonic Sensor Housing	50 mm × 30 mm × 20 mm
Brass	Connectors for Wiring	Diameter: 10 mm
Spring Steel	Springs in Gripping Mechanism	Length: 70 mm, Diameter: 10 mm
Aluminium	Motor Mounts	120 mm × 60 mm
Nylon	Wheel Coating	Thickness: 3 mm

Table 1: List of materials and Dimensions of parts

### C. Fabrication

The fabrication process began with the selection of stainless-steel sheets, which were marked, cut, and bent according to CAD designs created in CATIA V5. Key components, including the outer frame, mounting plates, and motor supports, were manufactured using tools like grinding machines, bending machines, and TIG welding equipment.

Laser cutting was utilized for intricate parts like the middle plate to achieve precision. Components such as screws, bolts, and springs were assembled to ensure proper alignment and stability. Challenges encountered during the fabrication process included maintaining dimensional accuracy during bending and achieving precise alignment of the motor mounts. These were addressed through iterative adjustments and finishing processes like grinding and polishing.

### D. Electronics

Following is the list of the electronic components used in the circuitry and their functions.

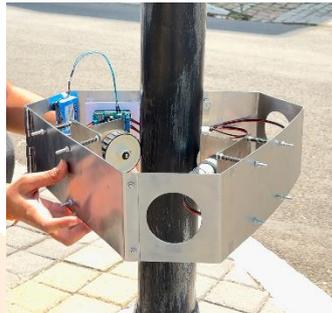


Fig 3: Pole Climbing Robot

Table 2: Electronic Components

Component	Configuration/Specification	Function
Arduino Uno	ATmega328P Microcontroller	Central control unit for managing operations
Geared DC Motors	12V, 60 RPM	Drives the wheels for climbing motion
Motor Driver	L293D Shield	Controls motor speed and direction
Ultrasonic Sensors	HC-SR04	Detects obstacles during climbing
Bluetooth Module	HC-05	Enables wireless communication and control
Power Supply	12V, 7Ah Lead Acid Battery	Provides energy for the robot's operations
Voltage Regulator	LM7805	Regulates voltage for stable microcontroller input
Push Buttons	SPST	Manual input for basic operations
LEDs	5mm, Red and Green	Indicators for power and status

### E. Programming

The Pole Climbing Robot's functionality is controlled by custom-developed code implemented on an Arduino Uno microcontroller. The programming includes motor control, sensor integration, and Bluetooth communication to enable precise operation and remote control. Libraries such as Servo.h and SoftwareSerial.h were used to streamline the development process. To avoid extending this paper with extensive code details, the complete source code and implementation instructions can be accessed at the following

GitHub Repository Link :

<https://github.com/narayanshastri/Arduinocodes/tree/main/Pole%20Climbing%20Robot>

### F. Testing

The robot was tested on poles of varying diameters (70 mm, 90 mm, and 120 mm) and materials (metal, wood, and concrete). Testing criteria included climbing speed, load capacity, grip stability, and energy efficiency. The robot achieved an average climbing speed of 0.8 m/min and successfully supported a payload of 10 kg without compromising stability. Performance metrics were further evaluated under different environmental conditions to simulate real-world scenarios, such as uneven surfaces and varying pole textures. The testing phase demonstrated the reliability of the gripping mechanism and the effectiveness of the control system, confirming the robot's suitability for applications in inspection, maintenance, and surveillance tasks.

## IV. APPLICATIONS

The Pole Climbing Robot has versatile applications in various fields. It is highly effective in utility maintenance, where it can inspect and repair electrical poles and communication towers, reducing human risks. In surveillance, the robot is suitable for monitoring high-risk industrial areas or tall structures. In the agricultural sector, it can assist in tasks like pest monitoring and fruit harvesting on tall trees. Additionally, it has applications in disaster recovery, enabling inspection and repair in post-disaster scenarios where manual intervention is unsafe. These applications make the robot a practical solution for tasks in challenging environments.



Fig 4: Power line Inspection and Maintenance

## V. RESULTS

The testing process revealed several key findings that demonstrate the Pole Climbing Robot's performance and reliability. The robot successfully climbed poles with varying diameters, including 70 mm, 90 mm, and 120 mm, made of different materials such as metal, wood, and concrete. It maintained a stable climbing speed of 0.8 m/min on average and consistently supported a payload of up to 10 kg without any performance issues. The gripping mechanism proved highly adaptable, securely adjusting to different pole diameters and surface conditions without requiring manual intervention. Testing in simulated environments with uneven textures and varying humidity further validated its stability and efficiency. During load-bearing tests, the robot demonstrated no slippage or instability, even under maximum load conditions. A detailed analysis of power consumption during operation showed efficient energy usage, enabling extended operation periods. The incorporation of ultrasonic sensors enhanced obstacle detection, ensuring smooth climbing motion and minimizing the risk of collision. Bluetooth-enabled remote operation added flexibility, allowing precise control from a mobile device.

Pole Diameter (mm)	Material	Load Capacity (kg)	Climbing Speed (m/min)
70	Metal	10	0.8
90	Wood	10	0.75
120	Concrete	10	0.7

Table 3: Test results on different poles of different materials

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