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"A MECHANICAL APPROACH TO WALL CLIMBING ROBOT"

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ABSTRACT

This project, titled "A Mechanical Approach to Wall Climbing Robot," presents the design and development of a wall-climbing robot that utilizes a suction-based adhesion mechanism powered by a high-speed brush-less DC (BLDC) motor. The robot employs a 2200 KV BLDC motor coupled with a 30 A Electronic Speed Controller (ESC) to drive a centrifugal fan that generates the negative pressure required for wall adhesion. This mechanical suction approach eliminates the need for magnetic or adhesive systems, enabling the robot to climb on a variety of non-metallic vertical surfaces such as glass, tiles, and painted walls. The locomotion system integrates lightweight materials and precisely designed wheel arrangements to ensure stability and efficient movement during vertical operation. The project focuses on achieving a balance between suction force, power consumption, and overall payload capacity. Experimental testing demonstrates that the proposed design can maintain strong adhesion and smooth mobility along vertical surfaces, validating the effectiveness of using a suction fan mechanism for wall-climbing applications. This work highlights a cost-effective and mechanically efficient solution for inspection, cleaning, and surveillance tasks in vertical environment.

Keywords: *BLDC, ESC, Robot, motor.*

I. INTRODUCTION

Wall-climbing robots are widely used in inspection, surveillance, cleaning, and rescue operations. Unlike conventional robots, they require special mechanisms to overcome gravity and move safely on vertical surfaces.

This project, "A Mechanical Approach to Wall Climbing Robot," develops a compact robot that uses a suction-based adhesion system. A 2200 KV BLDC motor with a 30 A ESC drives a centrifugal fan to create negative pressure, allowing the robot to stick to walls. Movement is achieved using two DC motors controlled by an L298N motor driver, while Bluetooth communication enables wireless control.

The project aims to provide a simple, low-cost, and reliable wall-climbing solution without complex sensors or control systems. The robot can effectively adhere to and move on smooth surfaces such as glass, tiles, and painted walls, demonstrating the potential of mechanical suction systems in wall-climbing robotics.

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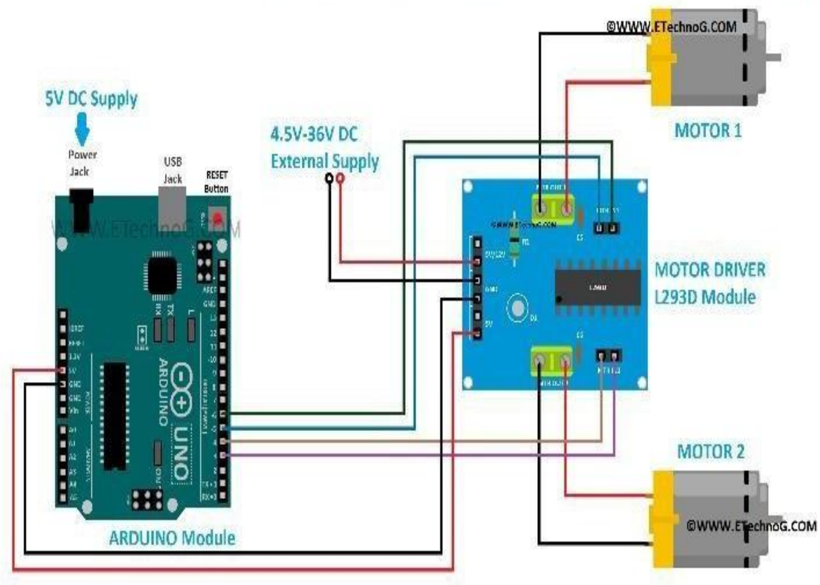

Fig.1. Circuit Connection Overview

II. LITERATURE REVIEW

The development of wall-climbing robots has gained significant attention due to their applications in inspection, maintenance, surveillance, and rescue operations. Various adhesion techniques have been explored to enable robots to move on vertical surfaces.

Early wall-climbing robots used **magnetic adhesion**, which provided strong attachment but was limited to metallic surfaces. Later, **vacuum suction systems** were introduced, offering the ability to climb non-metallic surfaces such as glass and tiles. However, many of these systems required bulky pumps and consumed high power.

Researchers have also developed **bio-inspired robots** based on gecko feet and insect claws. Although effective, these designs involve complex materials and control mechanisms. Recent studies focus on **mechanical suction-based approaches**, where BLDC-driven centrifugal fans generate negative pressure for adhesion while wheels provide locomotion.

This project follows the mechanical suction approach by using a **2200 KV BLDC motor, 30 A ESC, L298N motor driver, and Bluetooth control.** The design emphasizes simplicity, low cost, lightweight construction, and reliable wall-climbing performance on smooth surfaces.

III. METHODOLOGY

OVERVIEW OF METHODOLOGY The methodology for developing the wall-climbing robot is divided into the following steps:

1. Problem Identification and Objective Setting – Understanding the challenges in developing a wall-climbing mechanism using a suction system.
2. Literature Review – Studying previous works related to magnetic, suction, and bioinspired wall-climbing robots.
3. Conceptual Design – Designing a simple, lightweight mechanicalstructure with fan-based suction.
4. Component Selection – Choosing efficient components such as Arduino UNO, L298N motor driver, 2200KV BLDC motor, ESC 30A, HC-05 Bluetooth module, and 12V battery.5V
5. System Integration – Connecting all electrical and mechanical components for coordination and control.
6. Programming and Testing – Implementing Arduino code and

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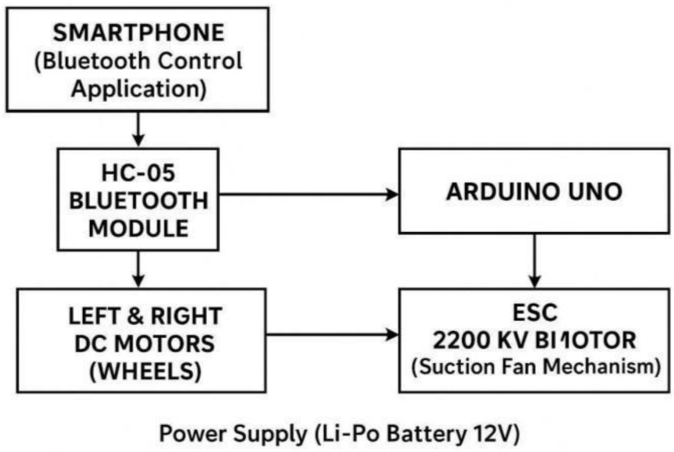

7.

Fig. 2. Block Diagram of Wall Climbing Robot

IV. EXPERIMENTAL SETUP

The experimental setup consists of the assembled wall-climbing robot, equipped with a suction fan mechanism powered by a 2200KV BLDC motor and 30A ESC, and two N20 DC geared motors for movement. The Arduino UNO acts as the main controller, receiving signals from an HC-05 Bluetooth module connected to a smartphone application. The robot is powered by a 12V Liion.

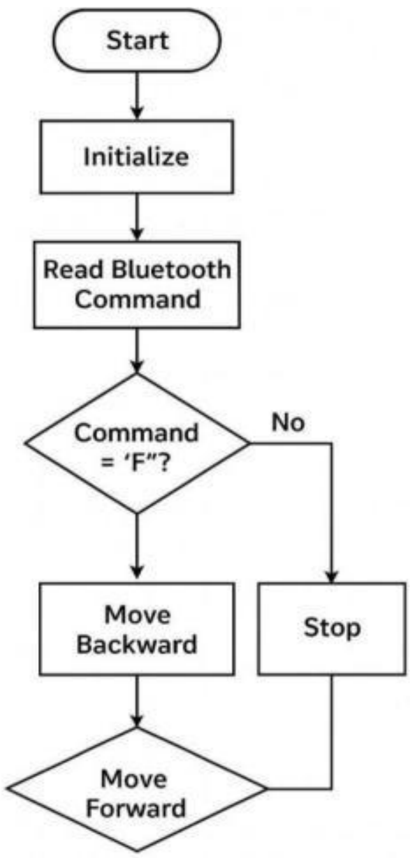

Fig. 3. : Experimental Setup of Climbing Robot

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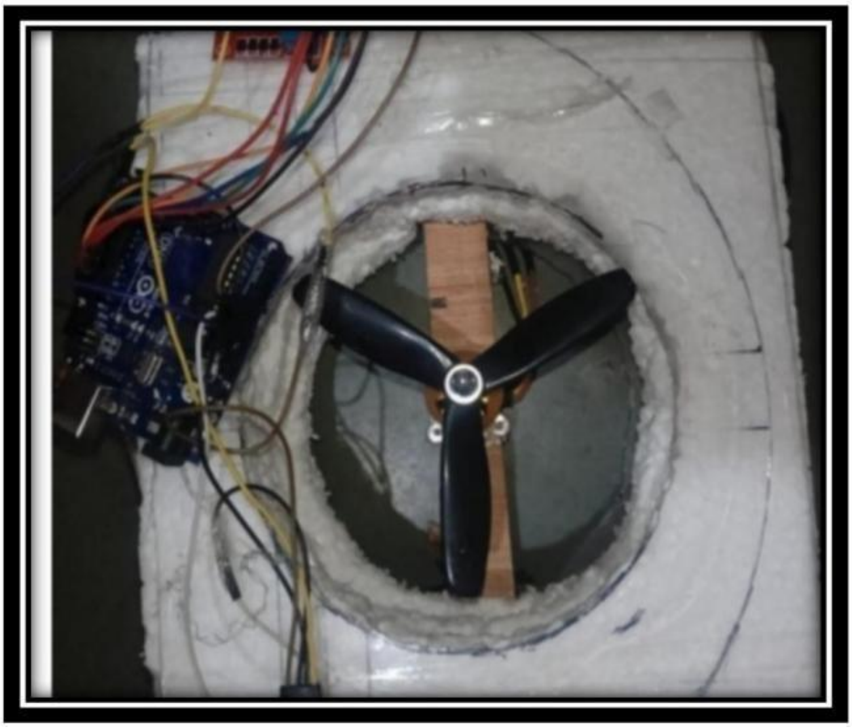

Fig. 4 (a) & (b) Actual setup with different view

V. RESULT ANALYSIS

The experimental results confirmed that the designed wall-climbing robot was able to successfully adhere to and move along vertical surfaces. The suction fan provided sufficient force to maintain attachment without slippage. The N20 DC motors, controlled by the L298N driver, delivered smooth locomotion under various load conditions.

The response to Bluetooth commands was quick and reliable, demonstrating effective wireless communication. The robot's structure, made of acrylic, proved to be both lightweight and sturdy, which helped improve climbing performance and reduce load on the suction fan.

1. The suction-based adhesion mechanism effectively holds the robot on smooth walls.
2. Power consumption remains within acceptable limits during continuous operation.
3. The mechanical design supports balanced weight distribution, improving stability.
4. Wireless control through Bluetooth offers reliable operation up to 10 meters.

VI. CONCLUSION

The wall-climbing robot was successfully designed using an Arduino UNO, N20 DC motors, a 2200KV BLDC motor, and a suction fan for wall adhesion. The robot was controlled witlessly through an HC-05 Bluetooth module and a smartphone. The lightweight acrylic chassis improved its climbing performance.

Testing showed that the suction system generated sufficient pressure (about 11.4 pa) for stable adhesion on smooth vertical surfaces. The DC motors provided smooth movement, and Bluetooth communication remained reliable up to 10 meters. The robot proved to be lightweight, compact, cost-effective, and easy to operate.

However, its performance is limited to smooth and clean surfaces, with relatively high power consumption and limited load-carrying capacity. Future improvements may include autonomous navigation, enhanced suction mechanisms, and the integration of cameras and sensors for advanced inspection applications.

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VII. FUTURE SCOPE

The wall-climbing robot developed in this project provides a strong foundation for future research and development in vertical mobility systems. Several improvements can be made to enhance its performance and expand its applications. The integration of AI-based control systems can enable autonomous navigation and intelligent decision-making. Camera and sensor modules can be added for inspection, surveillance, and monitoring purposes. The use of higher-capacity batteries can increase the operating time of the robot, making it more suitable for long-duration tasks. Future designs may also focus on developing multi-surface climbing capabilities, allowing the robot to operate effectively on rough, curved, or uneven walls. With these advancements, the robot can find practical applications in industrial cleaning, structural inspection, maintenance work, and search-and-rescue missions.

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