RV College of Engineering, Bengaluru - 560059.

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Team No: 39

Title: High-Rise Facade Cleaning robot using Vacuum

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Theme: Manufacturing Processes

Introduction

Cleaning the facades of high-rise buildings is a labor-intensive and hazardous job, often requiring scaffolding or rope access. With urban infrastructure growing vertically, there's a pressing need for a safer, automated alternative. This project presents a robotic system designed to autonomously climb vertical, inclined glass surfaces using vacuum suction, performing effective and consistent cleaning without human intervention.

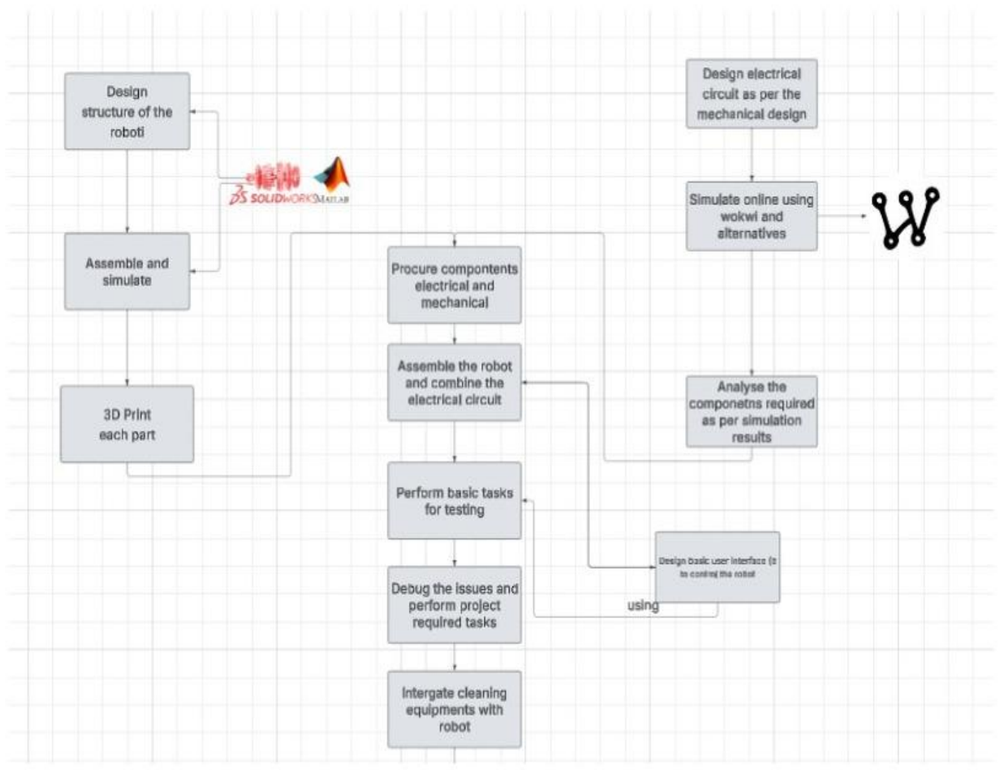
Problem Definition

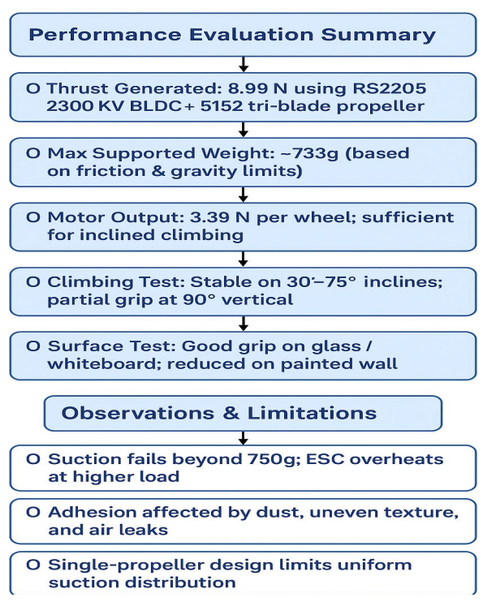
Traditional facade cleaning techniques expose workers to significant risks and demand high operational costs. The inefficiency, danger, and limitations of manual labor make it unsuitable for regular maintenance. The challenge is to develop a compact, efficient robot capable of navigating vertical, inclined, smooth surfaces (like glass) while ensuring stability, adhesion, and cleaning performance under variable environmental conditions.

Objectives

- To design and fabricate a lightweight chassis suitable for vertical climbing
- To integrate a suction system using a high-speed RS2205 2300KV BLDC motor with 5152 propeller to generate downward holding force.
- To implement mobility using 4 N20 6V 60RPM DC gear motors driven via dual L298N motor drivers.
- To deploy a power system based on a 12V 20A SMPS with LM2596 buck converters to supply regulated voltages to different components.
- To ensure electronic control using ESC for BLDC motor and microcontroller-based logic for motor direction and speed.
- To Test prototype stability and motion on inclined surfaces and observe suction effectiveness.

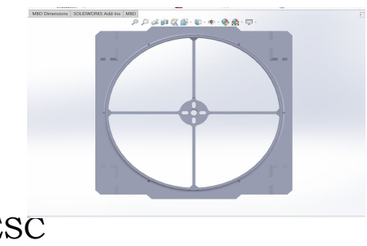
Methodology

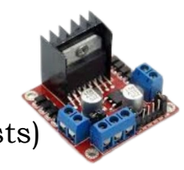




Tools used

- Design Software: SolidWorks (for 3D modeling and flow simulation)
- Programming: Arduino IDE (embedded C/C++)
- Microcontroller: Arduino Uno R3
- Motor Control: L298N Motor Driver Modules, 30A ESC
- Fabrication: FDM 3D Printer using PLA filament
- Measurement: Digital weighing scale (for thrust tests)
- Power Supply: 12V 20A SMPS, LM2596 buck converters
- Actuators: RS2205 2300KV BLDC Motor, N20 6V DC Gear Motors





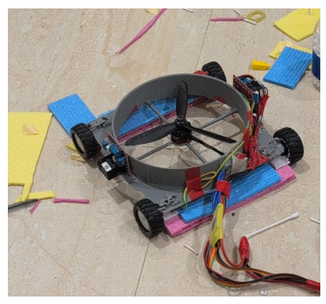
Results and Discussions

Performance Evaluation Summary:

- Thrust Generated: 8.99 N using RS2205 2300KV BLDC + 5152 tri-blade propeller
- Max Supported Weight: ~733g (based on friction & gravity limits)
- Motor Output: 3.39 N per wheel; sufficient for inclined climbing
- Climbing Test: Stable on 30°–75° inclines; partial grip at 90° vertical
- Surface Test: Good grip on glass/whiteboard; reduced on painted wall

Observations & Limitations:

- Suction fails beyond 750g; ESC overheats at higher load
- Adhesion affected by dust, uneven texture, and air leaks
- Single-propeller design limits uniform suction distribution
- Passive cleaning only – no scrubbing or water mechanism
- No autonomous edge detection or smart path planning.



Conclusions

The project developed a lightweight robot capable of cleaning inclined glass surfaces (30°–75°) using a BLDC-propeller-based suction system. The robot demonstrated stable movement and passive dry cleaning using a microfiber pad. While vertical (90°) adhesion remains a challenge due to suction limitations, the prototype is effective for sloped facades, solar panels, and glass awnings. Future improvements will target stronger vacuum sealing and enhanced cleaning performance.

References

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QR for Demonstration video

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