

# Fabrication of Automated Wall Painting Robot using Pneumatic System

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**Abstract -** The increasing demand for automation in construction and maintenance activities has led to the development of innovative robotic systems aimed at improving efficiency, safety, and quality of work. This paper presents the design and fabrication of an automated wall painting robot using a pneumatic system. The proposed system utilizes compressed air as the primary actuation mechanism to drive the painting components, ensuring smooth and uniform coating over vertical surfaces. The robot is designed to operate with minimal human intervention, thereby reducing labor dependency and exposure to hazardous environments such as heights and chemical fumes.

The mechanical structure consists of a lightweight frame integrated with pneumatic cylinders, directional control valves, and a spray painting mechanism. The motion of the robot is controlled through a programmed sequence that enables vertical and horizontal traversal across wall surfaces. The pneumatic system offers advantages such as simplicity, cost-effectiveness, and ease of maintenance compared to electric or hydraulic alternatives.

The fabricated prototype demonstrates consistent paint application, reduced material wastage, and improved time efficiency when compared to manual painting methods. Experimental results indicate that the system is capable of achieving uniform thickness and coverage with reliable operational performance. This project highlights the potential of pneumatic-based automation in construction tasks and provides a foundation for further advancements in robotic wall finishing technologies.

**Keywords:** Wall painting robot, automation, embedded systems, surface coating, mobile robot, control system, construction robotics, paint spraying mechanism, sensor integration, efficiency optimization

## INTRODUCTION

Automation has become a cornerstone of modern engineering, particularly in construction and surface finishing processes where precision, speed, and safety are critical. Wall painting, traditionally performed manually, is a labor-intensive, time-consuming, and often hazardous task due to prolonged exposure to chemicals, working at heights, and inconsistent workmanship. To address these limitations, the development of an **automated wall painting robot using a pneumatic system** offers a viable and efficient alternative.

The proposed system integrates principles from Mechanical Engineering, Robotics, and Industrial Automation to design a machine capable of performing uniform painting operations on vertical surfaces. Pneumatic actuation is employed due to its advantages such as simplicity, cost-effectiveness, ease of maintenance, and reliable operation in harsh environments. The system utilizes compressed air to control linear and rotary motions, enabling precise control of the spray mechanism and movement of the robot across the wall surface.

The fabrication process involves designing a stable frame structure, selecting appropriate pneumatic cylinders, integrating a spray painting mechanism, and implementing a control system for synchronized motion. The robot is typically equipped with guiding rails or wheeled mechanisms to ensure smooth traversal, while sensors and control valves regulate the flow of paint and air pressure to achieve uniform coating thickness.

This innovation not only enhances productivity but also improves the quality of painting by minimizing human errors such as uneven coating and paint wastage. Furthermore, it significantly reduces health risks associated with manual painting and enables operation in inaccessible or hazardous environments. The system can be further enhanced with programmable controls and adaptive features for different wall dimensions and surface conditions.

In conclusion, the fabrication of an automated wall painting robot using a pneumatic system represents a significant advancement in construction automation, offering improved efficiency, consistency, and safety. This project demonstrates the practical application of engineering concepts to solve real-world industrial problems while paving the way for future developments in automated surface finishing technologies.

Here is a **clear, publication-ready “Materials and Methods” section** for your project on an automated wall painting robot using a pneumatic system. You can directly include this in your research paper.

## RELATED WORK

Automation in construction and surface finishing has attracted significant research interest due to the hazardous and labor-intensive nature of manual wall painting. Various approaches have been proposed to improve efficiency, safety, and quality using robotic systems.

Early developments in wall painting robots primarily focused on minimizing human effort and enhancing operational safety. These systems were designed as low-cost automated solutions capable of performing painting tasks on vertical surfaces with minimal human intervention. Most early prototypes utilized microcontrollers and simple mechanical frameworks to achieve basic automation [1].

Subsequent advancements introduced mobile robotic systems equipped with articulated mechanisms to improve coverage efficiency. These robots typically employed vertical scanning combined with horizontal traversal to ensure uniform paint application.

Additionally, sensors such as ultrasonic sensors were incorporated for obstacle detection and positional accuracy, enhancing system reliability [2].

Pneumatic actuation has been explored as an effective method for controlling paint spraying mechanisms. Pneumatic systems utilize compressed air to actuate spray guns via solenoid valves, offering advantages such as fast response, lightweight structure, and ease of maintenance. Several studies demonstrated that pneumatic-based systems provide smooth and consistent paint flow, making them suitable for automated painting applications [3].

Recent research has also focused on integrating computer vision and image processing techniques into wall painting robots. Vision-based systems enable robots to detect wall boundaries, identify obstacles, and optimize painting paths. This approach improves accuracy, reduces paint wastage, and enhances surface finish quality. Raspberry Pi-based systems have been successfully implemented to achieve autonomous operation using camera feedback [4].

In industrial applications, robotic painting systems are widely used, particularly in the automotive sector. These systems employ multi-axis robotic arms to achieve high precision, repeatability, and uniform coating. However, such systems are expensive and complex, limiting their applicability in small-scale or residential construction environments [5].

Despite these advancements, several limitations remain in existing systems. Many designs rely on costly components, complex control architectures, and electrical actuators.

Furthermore, limited research has been conducted on low-cost pneumatic-based wall painting robots suitable for practical deployment in small-scale applications.

## MATERIALS AND METHODS

### 1. Materials Required

The fabrication of the automated wall painting robot involves mechanical, pneumatic, electrical, and structural components. The major materials used are listed below:

### 1.1 Structural Components

- Mild Steel (MS) frame (for chassis fabrication)
- Aluminum sheets (for lightweight panels)
- Fasteners (nuts, bolts, washers)
- Guide rails or linear sliders

### 1.2 Pneumatic Components

- Pneumatic cylinders (double-acting type)
- Air compressor (5–8 bar capacity)
- Solenoid valves (2/2 or 3/2 type)
- Flow control valves
- Pressure regulator with gauge
- Air filter (FRL unit – Filter, Regulator, Lubricator)
- Pneumatic pipes and fittings

### 1.3 Painting System Components

- Spray gun (air-assisted type)
- Paint container (tank or reservoir)
- Flexible paint hose
- Nozzle assembly

### 1.4 Electrical & Control Components

- Microcontroller (e.g., Arduino/PLC)
- Relay modules
- Power supply unit (12V/24V DC)
- Limit switches
- Wiring and connectors

### 1.5 Mobility Mechanism

- DC motors or stepper motors
- Wheels or track system
- Motor driver module
- Gearbox (if required)

## 2. Methodology

The methodology includes fabrication and assembly of the robotic system.

### 2.2 Fabrication of Frame

- The chassis is fabricated using mild steel sections.
- Cutting is performed using power hacksaw or laser cutting.
- Welding (arc welding) is used for joining frame members.
- Surface finishing is done to avoid corrosion.

### 2.3 Installation of Pneumatic System

- Pneumatic cylinders are mounted vertically/horizontally based on required motion.
- The compressed air system includes:
  - Compressor → FRL unit → Solenoid valve → Cylinder
- Solenoid valves are connected to the control unit for automated operation.
- Flow control valves regulate piston speed for uniform painting.

### 2.4 Painting Mechanism Setup

- A spray gun is mounted on the moving platform.
- The paint tank is connected to the spray gun via hoses.
- Compressed air atomizes the paint to produce fine spray.
- Nozzle alignment ensures uniform coating
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### 2.5 Motion Mechanism Integration

- Wheels or tracks are mounted to enable robot mobility.
- Motors are fixed to the chassis and coupled with wheels.
- The system allows:
  - Vertical movement (via pneumatic cylinder)
  - Horizontal movement (via motor drive)

### 2.6 Control System Implementation

- A microcontroller (Arduino/PLC) is programmed to control:
  - Solenoid valve operation
  - Motor movement

- Spray timing
- Limit switches are used to define boundaries and prevent overtravel.
- Relay modules act as interfaces between controller and actuators.

## 2.7 Assembly of System

- All subsystems (frame, pneumatic, electrical, painting) are assembled.
- Proper alignment of components is ensured.
- Leak testing is performed for pneumatic connections.

## 3. Working Principle

The robot operates on the principle of **pneumatic actuation and automated control**:

- Compressed air drives the piston in the pneumatic cylinder.
- The piston motion moves the spray gun vertically.
- Simultaneously, motors control horizontal motion.
- The spray gun atomizes paint using compressed air, ensuring even coating.

## 4. Safety Considerations

- Maintain proper air pressure limits.
- Ensure leak-proof pneumatic connections.
- Use protective gear during testing.
- Proper insulation of electrical components.

## 5. Advantages of Pneumatic System

- Simple and cost-effective
- High speed of operation
- Low maintenance
- Safe in hazardous environments

## FABRICATION PROCESS

### Material Selection and Marking

Select suitable Mild steel and pipes based on design requirements. Mark the required dimensions on the material using measuring tools.



### Cutting of Material

Cut mild steel sheets and rods according to the marked dimensions using cutting machines such as a power hacksaw, laser cutter, or angle grinder.



### Frame Assembly

Arrange the cut and shaped mild-steel parts properly and align them according to the design layout.



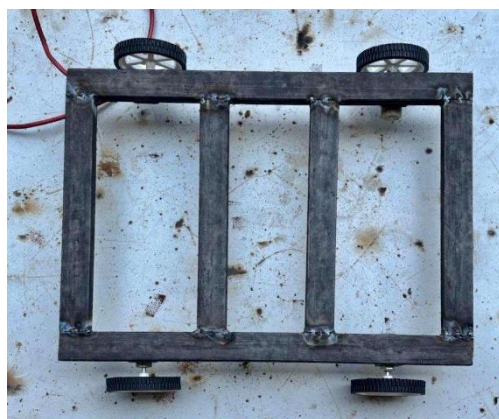
### **Welding Process**

Join the mild-steel components using TIG or arc welding to form the main chassis and supporting structures.



### **Grinding and Finishing**

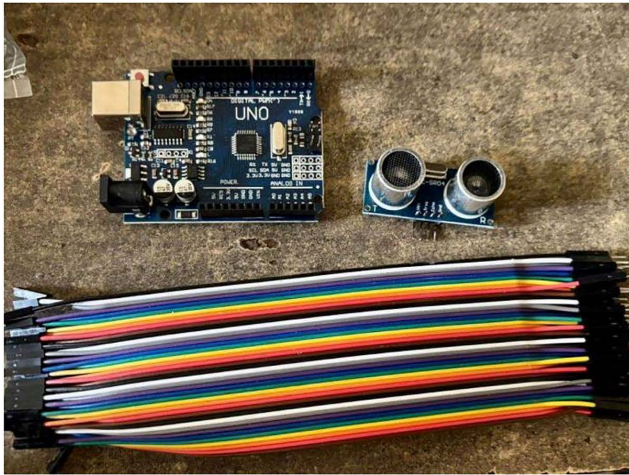
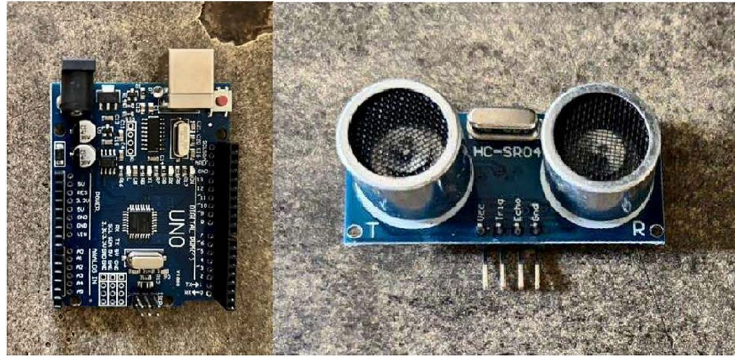
Remove welding burrs and rough edges using a grinding machine to obtain a smooth and clean surface finish.



### **Component Mounting**

Install wheels, motor, battery, sensors, and control system on the fabricated Mild-steel frame.





### Final Inspection

Check alignment, strength, and proper fitting of all components.



## RESULT AND DISCUSSION

The automated wall painting robot was tested on interior walls to evaluate its performance. The system successfully moved along the wall, maintaining a consistent distance from the surface, and applied paint evenly without significant streaks or gaps. The DC motors and wheels provided smooth movement, while the spray gun delivered uniform coating, showing that the design achieved its primary goal of consistent paint application. The robot reduced human effort and eliminated the need to work at heights or handle chemicals directly, improving safety for operators. The battery and control system allowed continuous operation for a reasonable period, and the sensors effectively prevented collisions with obstacles or wall edges.

## CONCLUSION

The automated wall painting robot successfully performs painting tasks efficiently, safely, and with consistent quality. By combining motors, sensors, and a spray mechanism, it reduces human labor and risk while delivering smooth paint coverage. Minor limitations with corners and uneven surfaces can be addressed in future designs. The system provides a practical and reliable solution for modern construction and interior painting projects. The system is designed to be user-friendly and flexible by integrating IoT for remote monitoring and control with a microprocessor that manages motor movements, sensor inputs, and spray settings. This automated wall painting robot is suitable for both residential and commercial applications, as it saves time and labor while improving the uniformity and quality of paint application.

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