International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

PLC -Controlled Automated Roller Wall Painting System

K M Vanitha[1], *Manoj Kumar*[2], *Paul Abhilash H*[3], *Mohan Babu J K*[4], *Samartha Shridhara*[5]
[1]*Assistant Professor, Dept. of EIE, Ramaiah Institute of Technology, Bengaluru, Karnataka, India.*
[2,3,4,5]*UG Scholar,Dept. of EIE, Ramaiah Institute of Technology, Bengaluru, Karnataka, India.*
Emails: *kmvanitha@msrit.edu*[1], *manojgns327@gmail.com*[2], *paulabhilash114@gmail.com*[3], *1ms22ei403@msrit.edu*[4], *1ms21ei047@msrit.edu*[5]

Abstract

Wall painting is a crucial but laborious process in construction and renovation, often requiring significant manual effort and time. Traditional painting methods involve human painters applying paint using rollers or brushes, typically resulting in fatigue, uneven coverage, material wastage, and health risks due to long-term exposure to chemical fumes. As buildings become taller and demands for high-quality finishes grow, the need for automation in painting becomes increasingly evident. To address these challenges, this study presents the design and development of an automated roller wall painting system governed by a Programmable Logic Controller (PLC). The system is engineered to ensure consistent paint application, optimize paint use, and reduce the reliance on manual labor. A lead screw mechanism enables the roller's vertical motion, while a motorized trolley facilitates horizontal advancement. Combined with a controlled paint flow system and sensor-based feedback, the solution is intelligent and responsive. The painting system is operated through a central PLC that interprets inputs from proximity sensors and controls the movements of the roller and trolley in a predefined sequence. Additionally, a Human-Machine Interface (HMI) allows real-time monitoring and control of parameters such as roller speed and paint flow. This ensures flexibility and adaptability to different wall sizes and surface types. The system's design makes it suitable for deployment in industrial and residential settings. Initial testing of the prototype revealed encouraging results. Paint was applied uniformly, transitions between vertical and horizontal motions were smooth, and sensors reliably triggered actions at the appropriate times. Paint wastage was minimized due to the precise control of paint delivery, and the roller only operated when required. These features contribute significantly to the system's cost-effectiveness and sustainability. The proposed solution, therefore, is a promising step towards automating one of the most repetitive and physically demanding tasks in the construction industry. It offers a practical alternative to manual painting, increasing operational safety, reducing costs, and ensuring higher-quality finishes. This system is a demonstration of how automation can be applied to everyday tasks to improve efficiency and quality.

Keywords: *Wall painting automation, PLC system, Roller mechanism, Human-Machine Interface, Paint efficiency, Industrial automation, Motion control, Construction technology.*

1. Introduction

In the construction industry, painting is considered one of the final but most essential activities that define the visual appeal and finish of any structure. While it may appear straightforward, the physical strain it imposes on workers is significant. Painters are required to work for long hours, often on scaffolds or ladders, repeatedly moving their arms and bodies to achieve uniform coverage. Such tasks not only slow down progress but also pose occupational hazards including musculoskeletal injuries and chemical exposure. Despite technological advancements in many areas of construction, murals have remained largely manual. The few available automated solutions are either prohibitively expensive or too complex for regular use. Spray-based robotic systems, for instance, require precise path planning and are sensitive to environmental conditions. Moreover, overspray and uncontrolled paint dispersion reduce efficiency and may even cause damage to nearby structures. This calls for a solution that is simpler, more targeted, and better suited to practical usage scenarios. The proposed PLC-based automated roller wall painting system aims to strike this balance between automation and practicality. By using a roller instead of a spray mechanism, the system ensures better surface contact, reduced paint loss, and greater control over paint application. The use of a lead screw mechanism allows the roller to move smoothly in the vertical direction, while a DC motor-driven trolley advances the system horizontally after every vertical pass. At the core of the system lies the PLC, which orchestrates the sequence of movements based on real-time input from proximity sensors. When a wall is detected, the PLC initiates the paint delivery and starts the roller's motion. Once a section is completed, it halts the vertical motion, moves the trolley, and resumes the process. This cycle continues until the entire surface is covered. An HMI panel allows the operator to view system status, make adjustments to key parameters, and choose between manual or automatic modes depending on the task at hand. This approach offers several advantages. It minimizes human effort, eliminates the need for constant supervision, and guarantees consistent application. It also enhances safety by keeping operators away from paint fumes and potential falls from heights. The system's modularity and programmability allow it to be customized to different wall sizes and painting requirements. This makes it not just a proof of concept, but a viable tool for real-world painting applications. Furthermore, the system has the potential to be integrated into smart construction sites as part of larger automated workflows. As the industry continues to embrace robotics, this solution aligns well with trends in labor optimization and digital fabrication. It also presents a unique opportunity to train workers on operating automated tools, improving skill sets in modern construction practices. The long-term impact could significantly reduce dependency on manual labor, especially for repetitive finishing tasks. This reflects the growing demand for scalable, safe, and reliable automation in building environments [1-5].

2. Related Work

Over the years, researchers and engineers have made significant efforts to automate the painting process using various mechanisms and control systems. Each solution attempted to address specific pain points such as the need for precision, safety, or speed. While some have been successful in limited settings, the search for a cost-effective, scalable, and accurate wall painting system continues. One of the earlier studies by Tambe et al. developed a low-cost automatic painting machine using a spray mechanism. It was compact and affordable but relied on manual configuration and lacked motion control accuracy. Similarly, Edake et al. proposed a painting robot using a conveyor and lead screw-based structure. While it offered better control, it remained limited to spray-based application, which is prone to overspray and requires constant calibration to ensure uniform coating. A more promising approach was taken by Valunj et al., who used a roller instead of a spray gun. Their machine achieved better contact with the wall surface and reduced material waste. However, it still lacked automation in trolley movement and required human supervision. A truly autonomous roller-based system remained unexplored at the time, mainly due to the challenges in synchronizing vertical and horizontal movements and integrating paint flow control. Watanabe et al. introduced a humanoid robot capable of mimicking human roller-painting techniques by using motion capture and force sensors. While impressive, the complexity and cost of such a system made it impractical for widespread use in construction. Their work highlighted the advantages of rollers over sprays, yet underscored the need for a simpler alternative. Inspired by this, our project simplifies the motion using mechanical components driven by a PLC rather than relying on AI-based imitation. Other studies explored the use of Internet of Things (IoT) features, where painting systems could be monitored and controlled remotely. Though useful in certain industrial applications, the reliance on wireless networks and sophisticated

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

hardware limited their use in smaller or developing market environments. Our system blends the best of these concepts: a roller mechanism for better application, PLC for reliable control, and HMI for operational flexibility without the complexities or cost overhead of advanced robotic systems [6-10].

3. System Design or Architecture and Methodology

To bring automation into the traditional and labor-intensive task of wall painting, this system has been carefully engineered with both mechanical and electronic precision. The architecture is centered around creating a sequence of operations that mimics human painting behavior but with the consistency and efficiency of a machine. At the core of this process is a Programmable Logic Controller (PLC), which acts as the brain of the entire system, ensuring that each step follows the correct order and is executed at the right time. Once the system is powered on, the user can select between manual or automatic mode using a simple and intuitive Human-Machine Interface (HMI) screen. This flexibility is crucial, especially during initial setup or testing, where certain components may need to be controlled individually. However, in most real-world applications, automatic mode is preferred, as it allows the system to take over the entire painting process with minimal human intervention. The sequence begins when the wall is detected by a capacitive proximity sensor, indicating that painting can commence. This sensor ensures that the system doesn't start unnecessarily or waste paint when there is no surface to cover. Once detection occurs, the compressor is activated to pressurize the paint flow system. After a short pause to stabilize the system, the lead screw mechanism engages, driving the roller upward or downward in a straight line along the wall. This vertical movement of the roller is critical to applying an even coat of paint. Sensors positioned at the top and bottom of the roller's range act like virtual limit switches. When the roller reaches either end, these sensors trigger the PLC to reverse the direction of movement, completing a full vertical cycle. This cycle is repeated multiple times to ensure complete coverage of the column currently being painted. These repeated up-and-down strokes simulate the way a professional painter would work, but with far greater precision and consistency. The use of sensors eliminates guesswork, ensuring the roller moves exactly when and where it should. This not only improves the final paint finish but also significantly reduces unnecessary paint consumption. Additionally, the entire mechanism is housed on a mobile trolley, making it easy to position the system against different wall sections. The coordination between the mechanical movements and electronic logic allows for a seamless and autonomous painting experience that maintains quality across large surfaces Shown in Figure 1.

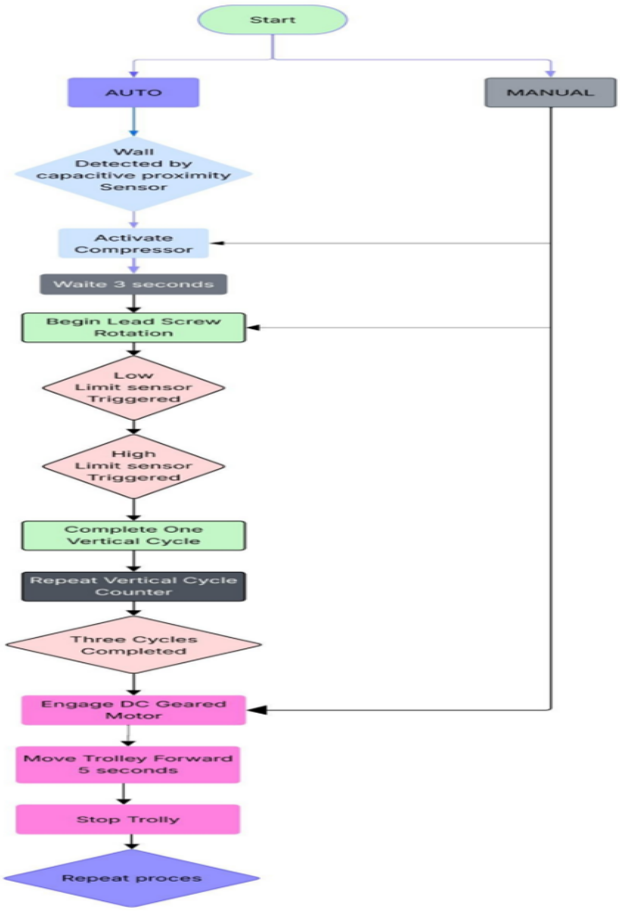

Figure 1 Flowchart outlining the sequence of operations in Automatic Mode, triggered by sensor input and controlled via PLC

Each full up-and-down movement is counted as one vertical cycle [11-15]. The system repeats this cycle three times before it engages the DC-geared motor, which propels the trolley forward along the wall. The trolley movement typically lasts five seconds, enabling the roller to reach the next unpainted section. After the lateral shift, the vertical painting process resumes, ensuring full column-wise coverage of the wall. This approach is efficient and minimizes missed or overlapped areas. Paint is pumped to the roller using a peristaltic pump, which provides steady and drip-free flow. This pump is synchronized with the roller's motion, preventing unnecessary paint delivery during idle time. The smooth and controlled delivery system also prevents splashes and paint wastage. The painting head is structurally designed for stability and ease of maintenance, mounted on a compact trolley that houses all electrical and mechanical components Shown in Figure 2.

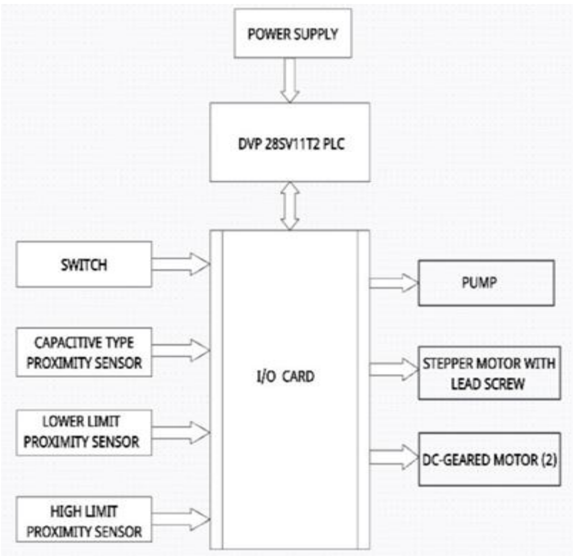

Figure 2 Block diagram of the control architecture showing sensor inputs, motor outputs, and how the PLC communicates with system components

All key control logic and decision-making are handled within the PLC. The I/O card receives digital inputs from the capacitive and proximity sensors and sends outputs to the compressor, stepper motor, pump, and DC gear motors. The Ladder Logic program defines all the conditions under which components activate or deactivate, ensuring there are no conflicts or unsafe operations. The HMI panel also plays a vital role, offering the operator real-time monitoring of the system, including fault status, roller direction, paint flow status, and current mode. In manual mode, the HMI allows the operator to individually activate each component for calibration, maintenance, or test runs. This dual-mode flexibility enhances operational safety and adaptability across different use cases [16]. The well-structured control and mechanical design make the system not only reliable but also scalable for larger projects Shown in Figure 3.

Figure 3 Physical prototype of the PLC-based automated roller wall painting system showcasing integrated pump, roller mechanism, and control unit

This system architecture blends intelligent automation with mechanical precision, creating a smart tool that can dramatically improve the speed, safety, and consistency of wall painting. Its real-world design ensures that even operators with minimal technical experience can run the system efficiently after basic training.

4. Implementation

4.1. Electrical Implementation and Control Panel

The electrical implementation of the proposed automated roller wall painting system revolves around the Delta DVP28SV11T2 PLC, which serves as the core controller. The system's electrical architecture integrates various sensors, actuators, relays, and motor drivers to achieve reliable automation and control. The PLC, a member of Delta's DVP-SV2 series, features 16 digital inputs and 12 digital outputs, which provide sufficient interfacing capability for multiple field devices. It is programmed using Ladder Logic and supports RS-232/RS-485 communication, enabling integration with an HMI for parameter configuration and monitoring. The system includes three proximity

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

sensors: two inductive sensors positioned to detect the upper and lower limits of the roller's vertical movement, and one capacitive sensor placed on the trolley to identify wall presence before initiating the painting sequence. The vertical motion is achieved through a NEMA 23 stepper motor, which is driven by a dedicated stepper motor driver and receives high-speed pulse signals from the PLC, allowing accurate positioning via a lead screw mechanism Shown in Figure 4.

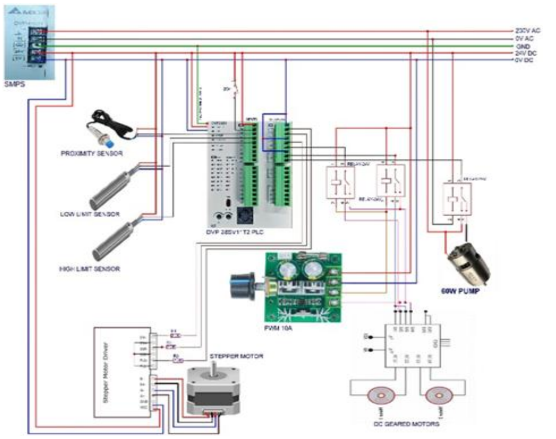

Figure 4 The horizontal movement of the trolley is controlled using a pair of DC geared motors. These motors are activated after the completion of a defined number of vertical strokes, ensuring systematic coverage of the wall in column-wise fashion. The paint delivery system uses a 60W peristaltic pump, controlled via a relay linked to the PLC, which dispenses paint only during roller movement to prevent dripping. A PWM controller ensures smooth motor operation and consistent flow control. Relays serve as intermediaries between the PLC and high-current devices such as motors and the pump. These relays are DIN rail-mounted and include indicator LEDs for easy status visualization and troubleshooting

The entire electrical subsystem is enclosed within a robust control panel mounted on the painting trolley, enabling ease of mobility and compact integration. This implementation ensures reliable automation with scalability for future upgrades, such as enabling vision systems or wireless communication for advanced control Shown in Figure 5.

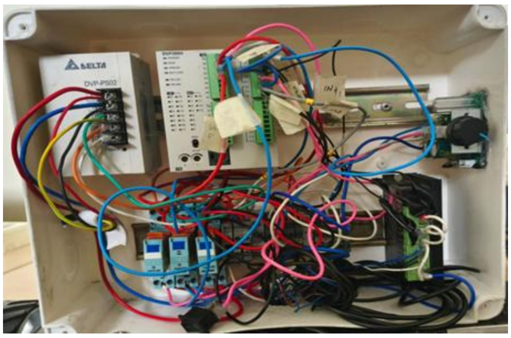

Figure 5 The control panel is powered through an SMPS unit, delivering both 24V DC and 230V AC as required by different components. All sensor inputs and actuator outputs are wired to the I/O terminals of the PLC via a structured terminal block arrangement for modularity and maintenance. An HMI touch screen is interfaced with the PLC using the Mod-bus protocol and allows users to set parameters such as roller speed, painting cycle count, and start/stop commands, offering real-time feedback and system diagnostics. The system's sensors feature IP67-rated housings, ensuring resilience against dust, moisture, and paint splashes, while built-in short-circuit protection enhances overall safety

4.2. Software Implementation

4.2.1. PLC Programming with WPLSoft 2.52

The automation logic for the proposed system was developed using WPLSoft 2.52, a programming tool tailored for Delta's DVP series PLCs. This software supports the development and simulation of control logic using Ladder Logic, which is widely adopted in industrial automation due to its visual and intuitive structure. WPLSoft enables offline simulation and real-time monitoring, facilitating efficient debugging and system verification before deployment. Communication with external devices is achieved through RS-232/RS-485 protocols, allowing integration with HMIs and other peripherals.

4.2.2. Ladder Logic

Ladder Logic was used to design the control program, enabling sequential operation of components such as stepper motors, DC geared motors, and the paint dispensing pump. Logic conditions were defined for sensor-triggered actions, stroke counting, and interlocks to ensure safe and synchronized operation. The modular structure of Ladder Logic made it easy

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

to modify parameters like vertical stroke count, timing delays, and motor control sequences, thus improving system flexibility Shown in Figure 6 & 7.

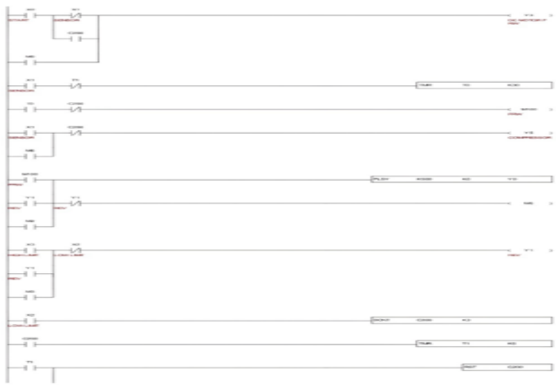

Figure 6 Programmable Logic Controller (PLC) Control Logic

Figure 7 Basic PLC Ladder Logic Circuit for Output Control

4.2.3. HMI Development with DOPSoft 4.00.16

The operator interface was developed using DOPSoft 4.00.16, a graphical HMI design software provided by Delta Electronics for their DOP series panels. The software enables intuitive design of user-friendly screens using drag-and-drop elements such as buttons, indicators, numeric inputs, and status displays. It supports standard communication protocols like Modbus RTU over RS-232/RS-485, ensuring reliable interaction with the PLC. Two primary HMI modes were implemented: Auto Mode and Manual Mode. The Auto Mode screen titled "AUTOMATIC ROLLER WALL PAINTING MACHINE" displays real-time controls and status indicators for the stepper motor, DC motors, and compressor. It includes directional control buttons (FRW, REV, OFF), a RESET function to clear alarms, and access to the Manual Mode screen. The Manual Mode screen provides direct control of individual components, allowing operators to test or operate motors and the compressor independently of the automated sequence. Controls for forward and reverse motion of both motor types and ON/OFF control of the compressor are available through labeled push-buttons. A HOME button ensures easy navigation back to the main interface. This dual-mode HMI design enhances usability, simplifies system maintenance, and supports both automated operation and manual overrides.

4.3. Result and Implementation

The developed automated roller wall painting system exhibited consistent and high-quality paint application across multiple trials. The PLC-controlled stepper motor and DC geared motors achieved precise, coordinated vertical and horizontal movements, resulting in uniform coverage with minimal streaking or overpainting. Real-time feedback from proximity sensors ensured accurate roller positioning and boundary adherence. The integration of timers, counters, and conditional logic in Ladder Logic enabled smooth sequencing and optimal paint dispensing, significantly reducing material wastage. The Human-Machine Interface (HMI) provided user-friendly configuration of operational parameters and real-time status monitoring, enhancing usability and fault detection. During extended operation, the system maintained reliable performance, responding effectively to simulated faults through automated halting and alert mechanisms. Paint coverage efficiency, with low power consumption and minimal dripping, demonstrating the system's practical viability Shown in Figure 8.

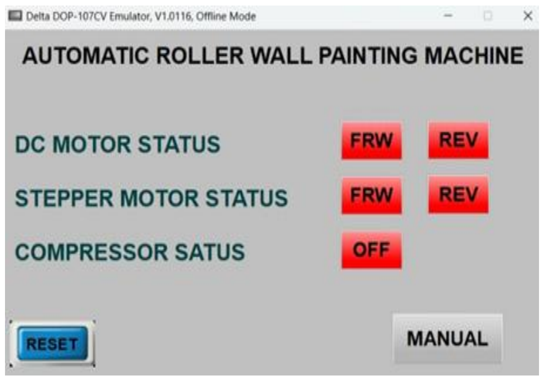

Figure 8 HMI Screen Showing Motor and Compressor Status

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

Minor limitations were observed on uneven surfaces, suggesting potential for future upgrades such as adaptive pressure control or vision-assisted alignment. Overall, the system fulfilled its intended objectives achieving automation, efficiency, safety, and scalability in wall painting applications Shown in Figure 9.

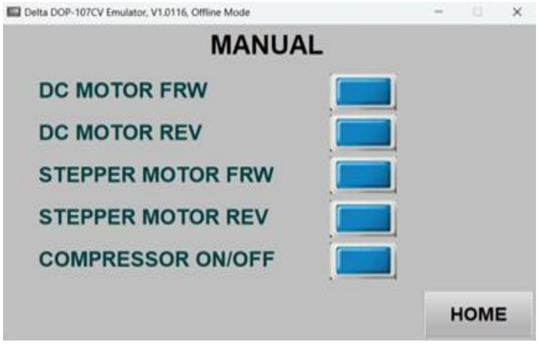

Figure 9 Manual Operation Screen of the Automated Wall Painting System

5. Results and Discussion

During the testing phase, the automated painting system performed admirably across various wall sizes and paint types. The roller applied a smooth and uniform coat in each vertical pass, with the lead screw ensuring accurate and steady movement. Unlike manual rollers, which are susceptible to uneven pressure and fatigue, the automated system maintained a consistent speed and contact pressure throughout the process. The sensor feedback loop worked effectively, allowing the PLC to initiate or stop painting only when the wall was present. This feature not only prevented unnecessary paint use but also reduced chances of spills or stains on nearby surfaces. The HMI interface proved intuitive and easy to operate, allowing users to modify settings even during runtime without restarting the system. Paint use was carefully monitored during testing. Compared to traditional methods, the automated system showed a marked reduction in consumption—up to 30% less paint was required for full wall coverage due to precision delivery and minimized overspray. Furthermore, the elimination of overspray also meant there was no need for protective masking or coverings in most scenarios, saving additional time and resources. From a labor perspective, the system reduced the need for skilled painters. One operator was sufficient to supervise and manage the painting of large surfaces, freeing up skilled workers for more complex tasks. The system's speed also translated into shorter project timelines, increasing productivity in commercial and residential painting projects alike. While the system performed well overall, certain improvements were identified. For example, implementing adaptive roller pressure based on wall texture could further improve performance. Additionally, using optical sensors or cameras for dynamic wall scanning might enable automated adjustments for uneven or decorated surfaces. These enhancements could be part of future development to further elevate the system's capabilities.

Conclusion

The development of a PLC-Based Automated Roller Wall Painting System represents a meaningful advancement in the automation of one of the most repetitive tasks in construction. By combining a roller-based paint application with sensor-driven motion control, this system delivers consistent results while minimizing human effort and material waste. It's simple yet effective design enables a wide range of applications, from home interiors to large industrial sites. Through thoughtful integration of sensors, actuators, and a programmable control unit, the system ensures that painting is carried out only when and where it is needed. The use of a lead screw mechanism for vertical movement and a motorized trolley for horizontal advancement creates a reliable and efficient painting cycle. The inclusion of a touchscreen-based HMI further enhances usability, allowing real-time control and adaptability to various job conditions. The prototype's performance in testing confirmed its ability to apply paint uniformly, adapt to various wall conditions, and operate with minimal supervision. Its modular design makes it easy to maintain and upgrade, offering potential for long-term adoption in the field. Moreover, its use of affordable components ensures it remains cost-effective for small- and medium-scale projects. As the construction industry continues to embrace automation, tools like this system will become increasingly vital. With further refinement, including enhanced surface detection and AI-based optimization, the painting robot could evolve into a

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 06 June 2026
Page No: 4236 - 4243
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0550

fully autonomous unit capable of handling complex environments. In its current form, it already presents a strong case for replacing manual painting in many applications. The project successfully demonstrates that industrial automation principles can be effectively applied to traditional trades, opening new possibilities for safer, faster, and more efficient work. The PLC-Based Automated Roller Wall Painting System is a step in that direction and lays the groundwork for future innovations in the field.

References

[1]. S. Tambe, S. Kadam, R. Bhavsar, and V. Rathod, "Design and development of low cost automatic wall painting machine," Int. Res. J. Eng. Technol., vol. 6, no. 3, pp. 4683–4686, Mar. 2019.

[2]. R. Edake, K. Pawar, and A. Ghodke, "Design and fabrication of wall painting robots," Int. J. Creative Res. Thoughts, vol. 12, no. 2, pp. 1043–1050, Feb. 2024.

[3]. V. Valunj, A. Kasar, A. Bhosale, and V. Phatangare, "Automatic wall painting machine," JournalNX, vol. 6, no. 5, pp. 127–130, May 2020.

[4]. A. Yahya, M. Zaini, and R. Rashid, "Multi-color wall painting robot for interior applications," J. Appl. Technol. Innov., vol. 8, no. 2, pp. 33–39, Apr. 2020.

[5]. K. Karthikeyan, A. Vignesh, and V. Pranesh, "IoT-based wall painting robot for pattern generation," in Proc. IEEE Int. Conf. Paradigms Eng. Comput. (PARC), Dec. 2022, pp. 512–517.

[6]. C. J. Teoh and S. Ragavan, "Paintbot: FPGA-based automated wall painting robot," in Proc. IEEE Int. Conf. Robot. Autom., May 2011, pp. 289–294.

[7]. Y. Watanabe, K. Fujita, and A. Nakamura, "Humanoid robot reproducing human painting action using compliance control," in Proc. IEEE-RAS Int. Conf. Humanoid Robots, Nov. 2022, pp. 112–117.

[8]. R. K. Megalingam, A. Muralidharan, S. Joseph, and V. Varghese, "Autonomous wall painting robot," in Proc. Int. Conf. Emerg. Technol. (INCET), Jun. 2020, pp. 1–5.

[9]. J. Al-Ayoub, M. Rahman, L. Alkurdi, and H. Zghoul, "Title pending," in Proc. 10th Int. Conf. Eng. Emerg. Technol. (ICEET), Apr. 2024.

[10]. K. Madhira, A. Nampally, S. Velpula, V. Pathuri, and P. Reddy, "AGWALLP: An automatic guided wall painting system using 2D plotter mechanism," in Proc. Int. Conf. Recent Innov. Eng. Technol. (ICRIET), Jul. 2017, pp. 1–5.

[11]. A. Yahya, A. Almalki, A. Majeed, and M. Nasser, "Multi-color IoT-enabled automatic wall painting robot," in Proc. Int. Conf. Mechatronics Syst. Control Eng. (ICMSCE), Feb. 2020, pp. 66–70.

[12]. V. Edake, A. Shinde, P. Pawar, R. Kolhe, and N. Bhujbal, "Design and fabrication of an automatic wall painting robot for high-rise construction," in Proc. Int. Conf. Robot. Autom. Constr. (ICRAC), Mar. 2024, pp. 120–125.

[13]. M. Pardeshi, S. Jadhav, R. Kamble, and A. Patil, "Development of semi-automatic painting machines for flat surfaces," in Proc. Natl. Conf. Adv. Mech. Eng. (NCAME), Oct. 2020, pp. 45–48.

[14]. S. Sneha and K. S. Kanth, "Automatic spray painting machine," Int. J. Innov. Technol. Explor. Eng. (IJITEE), vol. 8, no. 6, pp. 1103–1105, Apr. 2019.

[15]. N. Akash, M. Zohaib, R. R. Kumar, and S. C. A. Sri, "Semi-automated roller painting machine," Int. J. Res. Appl. Sci. Eng. Technol. (IJRASET), vol. 9, no. 8, pp. 325–326, Aug. 2021.

[16]. M. Abdellatif, "Design of an autonomous wall painting robot," Mechatronic and Robotic Dept., Egypt-Japan Univ. Sci. Technol., Feb. 2016.