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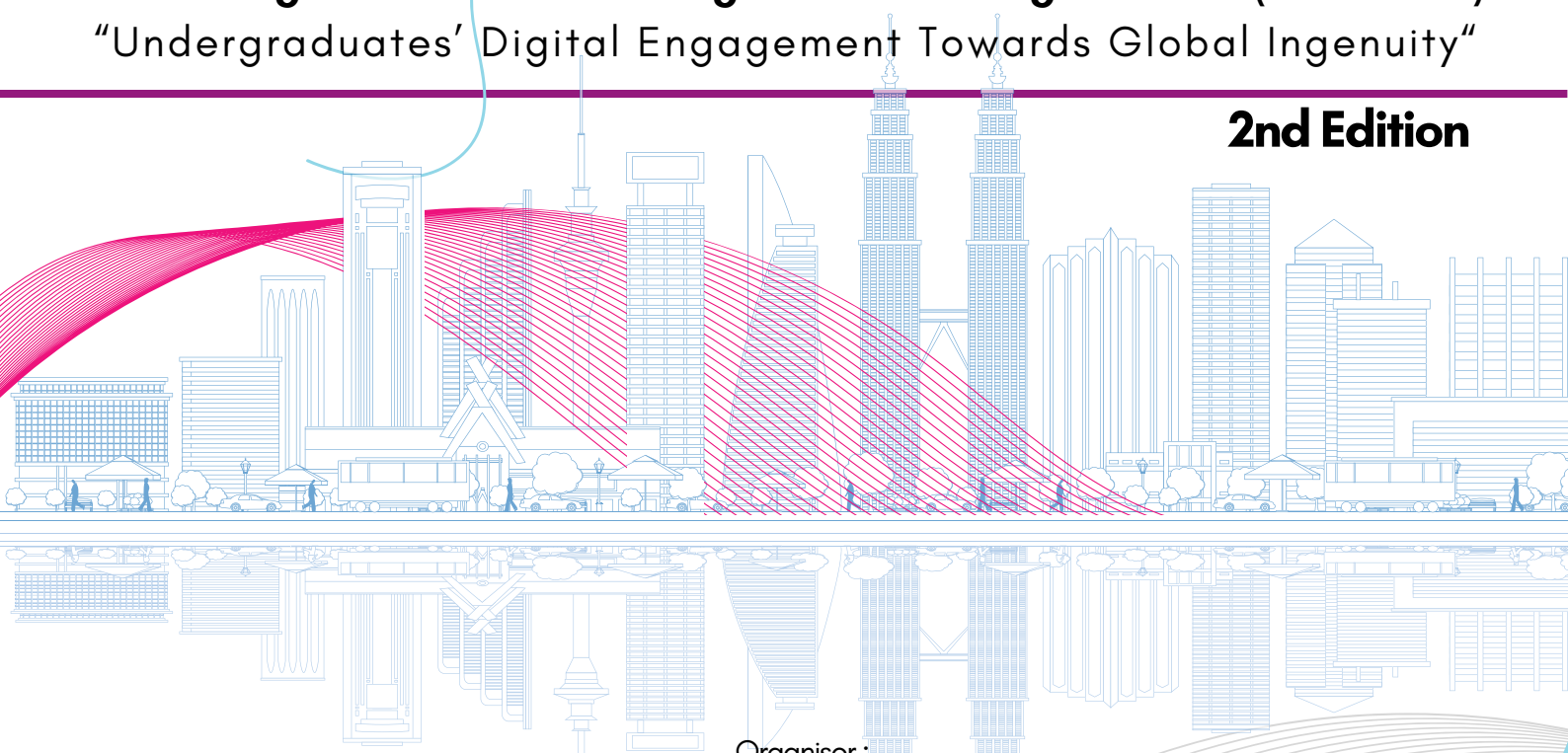
Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)

"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition



Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

Bauchemic (Malaysia) Sdn Bhd

Universitas Sebelas Maret

Universitas Tridinanti (UNANTI)

Publication date :

November 2024

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Perpustakaan Negara Malaysia Cataloguing in Publication Data

No e- ISBN: 978-967-2776-42-0

Cover Design: Muhammad Anas Othman
Typesetting : Arial

e-ISBN: 978-967-2776-42-0

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e-ISBN: 978-967-2776-42-0

ROBOTIC CEILING PAINTING

Syahir Mazlan[1*], Noor Rizallinda Ishak[2]

[1 2] Department of Built Environment Studies and Technology, College of uilt Environment, Universiti Teknologi MARA Perak Branch, Seri Iskandar Campus, 32610, Seri Iskandar, Perak, MALAYSIA

*syahirmazlan614@gmail.com

Abstract
This innovation project is focused on robotic ceiling painting. Robotics is the study of man-made devices that can move on their own, whose motion must be modelled, planned, sensed, actuated, and controlled, and whose behaviour may be altered by "programming". The theme for this project is Sustainable Development Goal 9, which stands for "Industry, Innovation, and Infrastructure." The purpose of the project is to develop a robotic system specifically designed for ceiling painting tasks. The research objectives are to identify the specific safety hazards and risks that make traditional manual ceiling painting unsafe, to determine innovative concepts that could help speed up or minimize the time needed for the ceiling painting procedure, to develop a robotic ceiling painting system that can efficiently ease human labour in finishing ceiling painting activities, and to suggest the marketability of the proposed robotic ceiling painting. The research method includes a comprehensive data collection process that includes desk study, simulation, and literature review. Literature evaluation provides a basis for identifying knowledge gaps by examining previous research on creative concepts, safety hazards, and ceiling painting techniques. The desk study makes use of information from the literature research to come up with creative ideas for painting ceilings more quickly and to assess solutions according to criteria including viability, safety, efficiency, and affordability. To see and analyse the robotic ceiling painting process, the simulation phase makes use of modern technologies, software SketchUp is utilised for 3D modelling. The project is evidence of the building industry's commitment to growth and its acceptance of new technologies to address traditional issues. The application of robotics to the painting process not only improves efficiency but also lowers environmental impact, creates a safer work environment, and raises the overall quality of the project.

Keywords: *Robot, Ceiling painting, Innovation, Building Finishes, Technology*

1. INTRODUCTION

Ceiling painting significantly enhances a building's interior aesthetics, making it a vital part of the construction industry. This task is crucial for residential, commercial, and industrial projects. A CPRS (Ceiling Painting Robot System) is a robotic device that paints ceilings or other vertical surfaces according to preprogrammed instructions (Omar, 2018). In industrial and commercial buildings, where ceilings are frequently high and challenging to paint manually, robotic ceiling painting might be useful. While robotic ceiling painting is still a developing technology, painting contractors are beginning to offer this service for industrial and commercial properties (Induspray, 2023). Robotic ceiling painting offers a faster means of applying paint and can cover large areas to finish the task quickly.

Manual ceiling painting poses several challenges, including hazardous working conditions and significant health risks due to exposure to volatile organic compounds (VOCs) in paints.

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The process often leads to respiratory issues, eye injuries, and long-term health problems for workers (Megalingam et al., 2020). Additionally, the physical demands of the job, such as repetitive motions and working overhead, result in fatigue, muscle strain, and joint stiffness (Keerthanaa et al., 2013).

The increased demand for painters, along with a limited pool of competent workers, presents considerable problems in the process of painting ceilings (Megalingam et al., 2020). A lack of competent painters causes delays, increased expenses, and poor quality in large-scale projects or restoration work. The physical demands of ceiling painting, such as repetitive labour, stretching, bending, and reaching aloft for lengthy periods, cause weariness, muscular strain, and joint stiffness in painters. The laborious and time-consuming nature of ceiling painting, as well as the requirement for painstaking attention to detail and several coats of paint, adds to the difficulties (Iniyan & Prabakaran, 2022). The reliance on manual work for ceiling painting tasks poses considerable obstacles and restrictions. Traditional manual processes need professional painters applying paint in the above position, requiring physical exertion, precision, and ability. To solve these issues, robots and automation can assist in the development of an autonomous ceiling painting robot that can assist the company in painting with greater precision and speed than human workers (Megalingam et al., 2020).

This project aims to develop a robotic system specifically for ceiling painting, addressing the limitations of manual labor. The research focuses on four main objectives: identifying safety hazards in traditional ceiling painting, exploring innovative concepts to speed up the process, developing a robotic system to ease human labor, and assessing the market potential of the proposed system. The study emphasizes the advantages of robots in the construction sector, such as increased speed, accuracy, and productivity, while reducing manual labor.

In the implementation of industrial robots for painting applications, the project emphasizes using the IRB1400 ABB Robot. This 6-axis industrial robot, known for its flexibility and wide communication capabilities, is suitable for various tasks such as welding, cutting, assembly, and painting. The fundamental robotic system integrates mechanics, controls, and sensor architecture, encompassing the design and structure of manipulators, arms, end-effectors, and actuators Sensors collect data to help the robot interact with its environment and monitor internal conditions, while the controller manages movements based on sensory input. The project ultimately aims to enhance painting quality, increase safety, and reduce costs through efficient paint usage (Ijeoma et al., 2012).

Comparing robotic ceiling painting to conventional methods highlights the advantages of automation, such as improved cost, time, quality, and safety metrics. The integration of human and robotic labor, advancements in safety, human-machine interfaces, and design methodologies are essential for the economic viability of robotic systems. Intelligent spraying robots, equipped with sensors and algorithms, can precisely apply coatings, enhancing efficiency. The literature review underscores the growing importance of robotics in construction, citing benefits like increased cost-effectiveness, efficiency, and safety, paving the way for further automation and productivity improvements in the industry.

In conclusion, the literature underscores the growing importance of robots in the construction industry, citing benefits like increased cost-effectiveness, efficiency, and safety. The development of robotic technologies offers practical solutions to the industry's challenges, paving the way for further automation and productivity improvements.

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2. MATERIALS AND METHODS

A design framework is a systematic approach or set of guidelines that serves as the foundation for the design process. It provides a systematic and organised method to design a product, service, or system, ensuring consistency, efficiency, and effectiveness in design work. Figure 1 shows the research flow of the innovation project. The research phase starts with a comprehensive literature review, observation of the innovation, and evaluation of the project. followed by the development of the research problem, research question, and research objectives. Finally, the development of robotic ceiling painting.

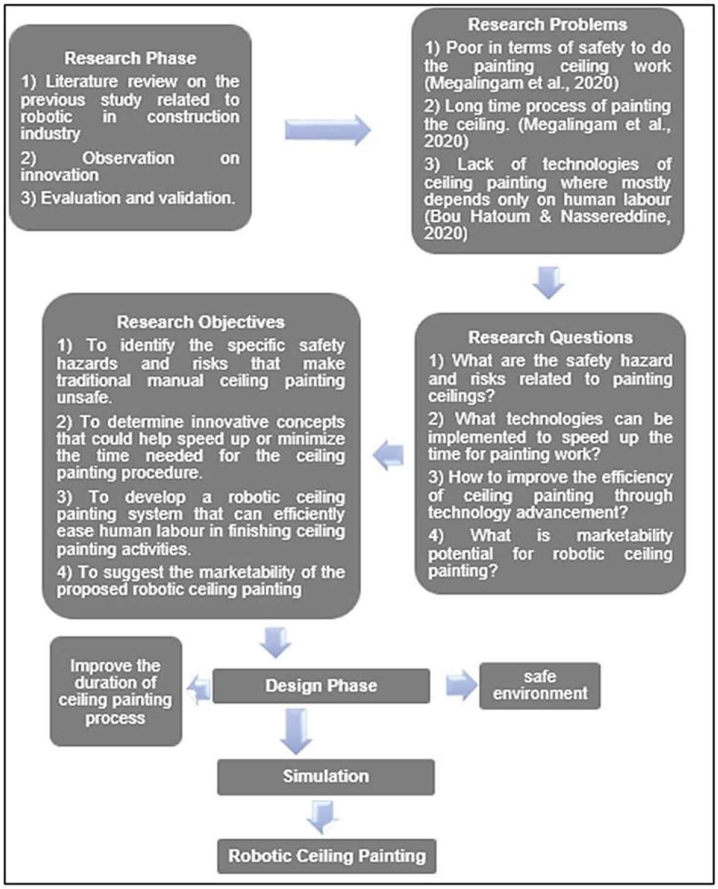

Figure 1. Research Flow of the Innovation Project

3. RESULTS AND DISCUSSION

Performance of Proposed Innovation Product

A product's performance plays a critical role in determining its marketability and penetration. Businesses may maintain their competitiveness in their marketplaces and grow and progress over time with the help of product innovation. It is often known that a company's ability to innovate is essential to its long-term success. The innovative product Robotic Ceiling Painting will continue to be relevant and beneficial to project participants in the construction industry with the addition of performance-based features. Table 1 shows the comparison and analysis of the manual spray-painting method, human-PictoBot and researcher innovation product.

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Table 1. Comparison and analysis of the manual spray-painting method, Human-PictoBot, and research innovation product

Items	Manual Painting	Human- PictoBot	Robotic Ceiling Painting
Working time	3 hours / 100m2	2 hours / 100m2	1.5 hours / 100m2
Quality	Hard to get consistent finish	Consistent finish	Very consistent finish
Convenience	Profoundly difficult task	Less climbing bending & reaching	No need to climb
Safety	Highly dangerous working at height, and close to the hazardous chemicals	Low safety concerns: eradicate fall risks, low paint dust	Higher safety
Man – power	Labour – intensive 2-3 workmen	Low labor intensity (1 operator)	1 Operator only

4. COMPONENTS OF THE ROBOTIC CEILING PAINTING

The figures below show the detailed components and the dimensions of Robotic Ceiling Painting. Figure 2 shows the detailed components of the robotic arm consisting, of a LiDAR sensor, ultrasonic sensor, nozzle, and steel robotic arm.

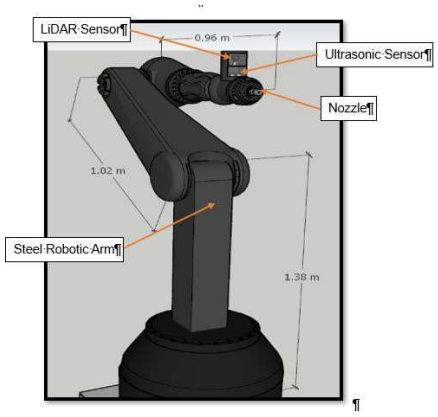

Figure 2. The dimensions and names of components in the robotic arm

Meanwhile, Figure 3 shows the detailed components of the in-body part of the Robotic Ceiling Painting from the front view consisting of a touchscreen display (LCD), steel body, and tyres.

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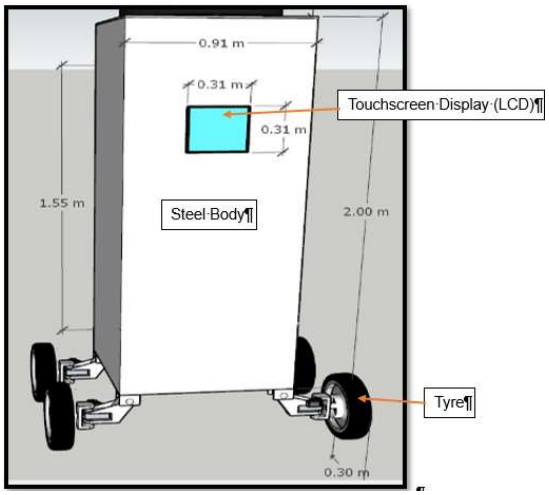

Figure 3. The dimensions and names of components in the body part of the Robotic Ceiling Painting from the front view

Finally, Figure 4 shows the detailed components of the in-body part of the Robotic Ceiling Painting from the back view consisting of a pumping system, transparent door, AC motor, and paint reservoir

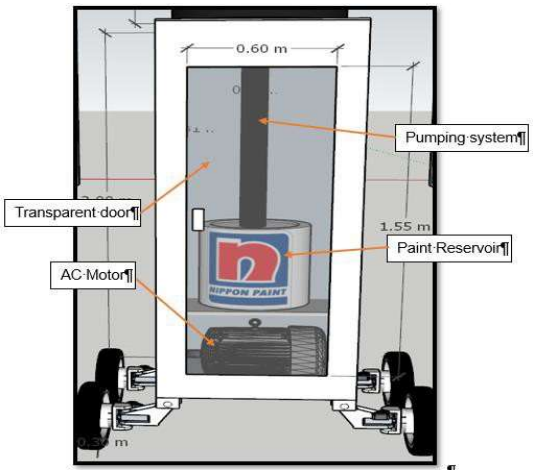

Figure 4. The dimensions and names of components in the body part of the Robotic Ceiling Painting from the back view

5. CONCLUSION

The robotic ceiling painting innovation project marks a significant advancement in addressing sustainability, safety, and efficiency issues within the construction sector. Integrating robotic technology into the Industrialised Building System (IBS) offers numerous advantages, aligning with broader sustainable development goals. This project began by recognizing the innovative implications of IBS, particularly in Malaysia's building sector, reflecting the government's early efforts since the 1960s to adopt advanced building methods. The necessity of shortening project cycles, boosting productivity, and optimizing investment returns underscored the importance of automation and robotics. Focusing on robotic ceiling painting highlighted its functional and aesthetic benefits, especially in commercial and industrial settings with challenging ceiling access.

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This innovation aligns with Sustainable Development Goal 9, emphasizing sustainable industrialization, resilient infrastructure, and fostering innovation. The comprehensive study revealed significant benefits, such as increased productivity, enhanced safety, reduced labor costs, and minimized material waste. The robotic ceiling painting project demonstrates the construction industry's commitment to growth and the adoption of new technologies to solve traditional challenges. By improving efficiency, reducing environmental impact, enhancing workplace safety, and elevating project quality, robotic ceiling painting exemplifies how technological advancements can drive sustainable development, transform industry standards, and create opportunities for a more robust and efficient future in the evolving construction sector.

6. ACKNOWLEDGMENT

Special thanks to the International Virtual Undergraduates Competition on Technological Innovation (iVUTI 2024) committee for creating a platform for students to share their knowledge and build up networking.

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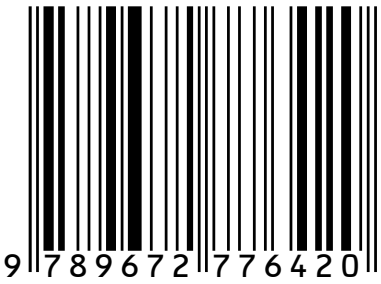

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