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INNOVATIVE DRONE FOR EXTERNAL WALL PAINTING: A CONCEPTUAL STUDY

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ABSTRACT

The first step in this paper is towards developing a fully functional wall painting robot for external wall painting is taken. Design considerations based on previous research work are employed to conceptually design the most suitable robot structure capable of external wall painting specifically for high-rise building. The aim of this study is to develop an Innovative Drone for external wall painting specifically for high-rise building. There are a few objectives that need to achieve in this innovation project research which is to create an Innovative Drone for external wall painting design ideas. The second objective is to assemble the 3D modelling from improvise the design of Innovative Drone for external wall painting. Lastly, to suggest the marketability potential of Innovative Drone for external wall painting. Innovative Drone is a product that can reduce the problem on wall painting work and to reduce to exposes workers from danger due to the chemicals in paints which can cause eye irritations, asthma, and other negative side effects. The data was collected through secondary data, design thinking, product 3D modelling by using a SketchUp software. This innovation project focus on the improvement that made the painting process smooth and easy to operate which only require a minimum worker to operate and monitor the robot. Due to the limitations of time, cost and materials, there was no performance test conducted to test the performance of the innovation product. This innovation coincides with Sustainable Development Goal 9 which seeks to build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation.

Keywords: “Construction”, “Painting”, “Innovation”, “Robotic”

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INTRODUCTION

Wall painting is a necessary activity that ensures and completes the building's finishes, ensuring that it meets the intended quality and the requirements established for the building's purpose (Khubba, 2012). The wall painting is an important factor of the finishing touches since it ensures that the wall has a high-quality appearance therefore, the walls painting must be smooth (Padalkar et al., 2019). In addition to that, there are various common devices and equipment that help with typical wall painting activities, such as the brush, paint scrapper and paint roll, which make the process simpler and much more straightforward. However, there are a number of drawbacks to the wall painting equipment and materials that are currently on the market.

Construction and building are rapidly expanding industries, but there is a shortage of skilled workers, particularly for painting jobs. This is particularly important for multistorey buildings and riskier sites, where skilled workers are required for high-rise building wall paintings (Keerthanaa et al., 2018). Next, chemical in the paints can cause hazardous effects to painters. The painting procedure might irritate workers' eyes and lead to respiratory conditions like asthma (Keerthanaa et al., 2018). The chemical in that paints is harmful for human being. The painting procedure takes a long time, and the labourer gets bored after 8 to 10 hours of painting each day (Megalingam et al., 2020). Furthermore, the commercial painting process will cause human exposure to danger and life risking activities involved in wall painting such as hanging around those scaffold or ladder (Mahakud & Pattanaik, 2019). Falling from high places, such as ladders, scaffolds, elevated platforms are common accidents when painting. The causes for falls can be several, but among the most common are slips, trips, cluttered working spaces and using unstable ladders and scaffolds.

The scenario as it is presently illustrating the need for research into improvements for wall paintings machine or robot. This is because the wall painting equipment and tools that are currently available have a number of barrier and drawbacks. With the development of this Innovative Drone for External Wall Painting that is built specifically for high-rise buildings, it will be possible to improve the features of the wall painting robot.

LITERATURE REVIEW

This chapter will discuss numerous reviews of the literature that were gathered from earlier studies on paint and wall painting machines.

History of Painting Robot

Painting robots have been around since at least 1985 (Kiba et al., 1985). Industrial robots, including painting ones, were created to keep people out of "dangerous" jobs as well as increase productivity (Francis, 2019). Since their creation, robots have been working side by side with people in manufacturing companies. Early paint robots were hydraulic versions, which are still in use today but are of inferior quality and safety to the latest electronic offerings (Rola, 2017). In recent years, the painting robot has evolved past industrial use. Many inventors have taken on the idea of creating robots that can create works of art, rather than paint in just a solid colour. Besides making them more creative, others have looked for ways to make the robots affordable and accessible for commercial use in places such as interior wall painting

(Sorour et al., 2019). Industrial paint robots are intended to reduce the risk of human error caused by manual spraying by serving to standardise the distance and path the automatic sprayer performs. Paint robots are frequently used in combination with other automatic painting equipment to improve efficiency and consistency of the paint finish (Danthala et al., 2020).

Dependency on Workers for External Wall Painting Procedure

One of the largest industries in the world is construction and building. The building business is also expanding quickly in this rapidly world. However, there are not enough workers in the construction industry, even for painting jobs (Keerthanaa et al., 2018). This insufficient workers in the construction industry are because of the difficulty in the work. In construction industry, during the work for multistorey buildings or on sites, where there is more risky situation, high demand for skilled workers required including for the wall paintings work for high-rise building (Keerthanaa et al., 2018).

Issues with Chemical Wall Paint Exposure to the Painters (Health Issues)

Painting surfaces is done in masonry work not only for hygienic or aesthetic reasons, but also to water proof the surfaces and protect them from natural weathering and chemical attack from industrial atmospheres that cause from a corrosive chemicals (Chen & Tan, 2019). However, the paint itself also contains a mixture of chemicals that can cause harm. The painting process which cause the labour eyes irritations and also can causes respiratory disorders like asthma (Keerthanaa et al., 2018). According to Aitken et al. (2006), exposure, both via inhalation and skin contact, occurs notably during tasks involving physical handling during paint production, such as mixing ingredients (pigments, extenders, resins, additives), loading them into mixing equipment, adding solvents to mills, and cleaning equipment. He mentions that a monitoring of workers exposed to paints has shown elevated levels of paint compounds or their metabolites in blood and urine.

Issues with Safety of Painters at High-Rise Buildings

Construction site work is regarded as one of the high risky jobs in the country. Compared to other industries, the rate of accidents in the construction sector is increasing continuously. Numerous people who work on high-rise buildings are injured, died, or negatively affected every year as a result of accidents (Z.O et al., 2016). There are risks of falling from the hanging rope, slipping from the scaffolding, ill functioning of the harness resulting in fall of the painters and postures resulting in loss of balance, muscle strain, breathing disorders due to inhalation of powder paint and fumes (Singh et al., 2019). Thus, the process of painting the exterior walls of high-rise buildings demands a high level of expertise and experience. This is due to the numerous risks that painting high-rise structures presents to workers. Table 1 below shows the general description by the frequency of fatal construction accidents that have been recorded in the database by the DOSH. They were all fatal accidents involving labour at construction sites from the year 2013 to 2018 (Abdul Halim et al., 2020).

Table 1: Frequency by Types of Accident

No	Type of Accident	Number of Cases	Percentage (%)
1	Falling from heights	63	43.4
2	Struck by falling object	31	21.4
3	Struck by moving object or vehicles	18	12.4
4	Caught in between	11	7.6
5	Fall into opening or drowning	8	5.5
6	Electrocution	7	4.8
7	Environmental factors	4	2.8
8	Fire or Explosion	2	1.4

According to the data above, falling from heights has the highest incident in this period of four years with 63 fatalities or 43.4%. This is consistent with earlier studies that showed falls from heights to be the main reason for fatalities in the construction industry (Abdul Halim et al., 2020).

RESEARCH METHODOLOGY

The study technique that was employed is frequently what determines the type of data collected and the quality of those findings. The application of the "Innovative Drone for External Wall Painting" is being evaluated by using a qualitative mode since it provides a much more speed, flexible and efficiency approach. Secondary data review, design thinking and product 3D modelling development are the three (3) data collection techniques that will contribute as data collection strategies based on the qualitative references that will be used in this study.

Secondary Data Review

Secondary data is one of the procedures that has been designated as a qualitative method. This strategy involves reading and evaluating the articles in a systematic fashion, using either printed or electronic resources that are based on computer and electronic platform.

Design Thinking

Design thinking has been adopted by the author by using own understanding and thinking to produce innovative ideas. This paper's research is based in a theoretical and practical approach to the idea of "Design Thinking,". Design thinking phases includes the process from empathize, define, ideate, 3D simulation, test, and implementation process. Observations while watching the news on television and newspapers have also been considered to identify the main problems faced by employees.

Product 3D Modelling

In order to provide the clearest possible picture of the innovation project of the Innovative Drone for external wall painting, 3D modelling studies were used as an additional method. It involves in developing 3D sketches using SketchUp software, 2022.0 version. It serves the purpose of illustrating the innovative dimensions as well as other elements.

RESEARCH RESULTS

The results of the innovation project involving the Drone Innovative for external wall painting are the primary emphasis of this chapter, along with a description of the project.

The Development of Innovative Drone for External Wall Painting

Drone Innovative for external wall painting has qualities that are highly advantageous in growing construction industries that have systems that may provide the construction industry an edge. These features include some of the conceptual frameworks of the drone innovative wall painting that are being explored in this study include an automatic system and a LiDAR 3D scanner. Aside from that, the concept and primary goal of this innovation project was to create a robot that is both small and portable, so that it can be stored conveniently and moved about with relative ease. The design idea of the product comes with three colour schemes, red, grey, and black, which signify to the construction industry. The red, grey, and black colour scheme is part of the design concept of the product.

The Innovative Drone for External Wall Painting is a specific type of robot that was developed in converting inputs into useful outputs of an existing wall painting machine and equipment. The innovation was made with smart, time effective and safety to the construction industry, so they should be beneficial to the industry. The innovation was made with sustainability to the environment in consideration. The concept of an innovation project makes it much easier to avoid activities that could harm the environment, which is an important concern throughout the development phase.



**Figure 1: Conceptual SketchUp model of the proposed innovation
Proposed Materials and Components**

The characteristics of this product are the same as those of the previous innovation, which dealt with semi-dry materials. As a result of this condition, the innovative product may be able to deal with those types of materials as well as to dry materials.

Table 2: Proposed Materials and Components



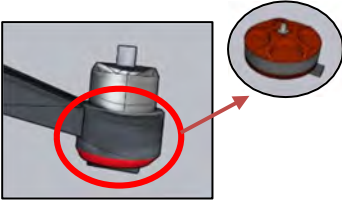

No.	Components	Description
1	Drone's Body and Frame	<ul style="list-style-type: none"> - High Quality Carbon Fibre Material - Carbon fibre were used in a variety of conditions as it is also highly resistant to corrosion and can sustain extremely high temperatures (Frackiewicz, 2023).
2	Drone's Body and Frame Coats	<ul style="list-style-type: none"> - The drone is coatings with Gentoo, a clear highly hydrophobic nanoparticle material to prevent issues brought on by the paint pouring onto the drone and its propellers. - If paint does get on the body of the drone, it can simply be clean by brush it off with a damp cloth or sponge.
3	Carbon Fibre Blades / Propellers	<ul style="list-style-type: none"> - Blades for drone propellers are often made of carbon fibre. - Carbon fibre propellers are more rigid, which reduces vibration and enhances the drone's flight performance while also making it silent.
4	Propeller	<ul style="list-style-type: none"> - This Drone Innovative used four (4) propellers in total by using a carbon fibre material.
5	Blades	<ul style="list-style-type: none"> - Two blades are sufficient for the drone and liquid, while larger and heavier drones require more blades for stability. The type of paint also affects the number of blades needed, with heavier paints requiring more blades for a smooth finish.
6	Brushless Motor	<ul style="list-style-type: none"> - The best motors for the Innovative Drone are ones that are strong enough to lift the drone, the paint, and the paint sprayer while also being able to generate enough thrust to keep the drone stable while in flight.
7	Mini Intelligent Battery	<ul style="list-style-type: none"> - Battery status is tracked and communicated in real-time by the integrated Intelligent Battery Management System, letting controllers to concentrate more on flying and less on checking the battery level.
8	Sensor	<ul style="list-style-type: none"> - The drone makes use of LiDAR to do 3D scanning.
		<ul style="list-style-type: none"> - LiDAR 3D scanner is a device that realizes three-dimensional space scanning based on LiDAR technology (Paulus et al., 2014).







9	Remote Controller	- The remote controllers used was a radio controller, which speaks to the drone via radio waves.
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Assembly Process of Innovative Drone for External Wall Painting

The drone innovative for external wall painting was assemble part by part to become one of the complete innovation products.

Table 3: The Assembly Sequence

No.	Figures of Assembly	Descriptions
1.		<p style="text-align: center;">Step 1</p> <p>The drone frame, motors, battery and battery compartment, camera and other sensors or attachments must all be gathered before beginning assembly.</p>
2.		<p style="text-align: center;">Step 2</p> <p>The drone frame is attached where the battery and other attachments have been installed in it.</p>
3.		<p style="text-align: center;">Step 3</p> <p>Start by attaching the motors to the drone frame. The motors and flight controller must be connected. The flight controller board should contain a connecting point for each motor. Information about precise wiring instructions can be found in the flight controller's manual.</p>
4.		<p style="text-align: center;">Step 4</p> <p>Connect the propellers to the motors. Ensure that the propellers are properly fixed in place and are rotating in the right</p>
		<p>direction relative to the respective motors (clockwise or anticlockwise).</p>

5.		<p style="text-align: center;">Step 5</p> <p>The propeller was attached to the drone's blades. By spinning and generating an airflow, drone propellers lift the drone by creating a difference in pressure between the top and bottom surfaces of the propeller.</p>
6.		<p style="text-align: center;">Step 6</p> <p>Installed the carbon fibre blades to the frame and body of the drone.</p>
7.		<p style="text-align: center;">Step 7</p> <p>The camera sensor was attached together to the frame. Install the LiDAR 3D scanner that is attached together with the sensor. Connect these gadgets to the proper flight controller ports.</p>
8.		<p style="text-align: center;">Step 8</p> <p>Prepare the spray paint container with the nozzle spray gun.</p>
9.		<p style="text-align: center;">Step 9</p> <p>Attach the paint container and paint pump to the drone frame. These components will hold and deliver the paint for the painting process. Connect the paint sprayer to the paint pump. The sprayer is responsible for delivering the paint onto the wall surface. Ensure that the connections are secure and properly sealed to prevent leakage.</p>
10.		<p>The assembling process is done, and the drone and controller can be used.</p>

Operational Process of Innovative Drone for External Wall Painting

The operational procedure of drone wall painting normally consists of several parts. Here is an overall explanation of how the system could function:

Planning and Preparation

In planning and preparation stage, the wall was inspected by analyse the wall's dimensions, texture, and condition before painted it. The measurements and any potential hazards or barriers were jotted down together. Next, a design to be used as a guide while painting the wall was generated by creating a digital overlay. The drone was setup properly and the operators will making sure that all the essential tools were included such as a paint container, nozzles, and a spray system. The desired paint or colours of paint were loaded into the drone's paint container.

Flight Preparation

The flight conditions were sets by established the boundaries and measurement of the wall that need painted. A digital boundary or the flight path coordinates was sets for the drone. A flight plan was created by finding the drone's ideal flight route to guarantee that the entire wall surface is covered. Factors like the wind, safety rules, and time constraints for flights were considered.

Operations

The drone was launched from a secure place and the professional operators need to making sure it is free of any obstructions or people. The external wall surface then painted by using the built-in spray system while controlling the drone to fly along the planned route. The operators managed to verify that the paint is being applied precisely and consistently while also continually keep an eye on the drone's location, the availability of paint, and the painting's overall quality. Any adjustments should be made as necessary when painting.

Post-flight

The surface of the paint was checked for any skipped areas, smudges, or flaws once the wall has been painted completely and revised as necessary. Next, the drone was landed and safely guided the drone back to the landing area by avoid any hazards. Lastly, the painting equipment's was regularly maintained and clean to avoid clogging and to prolong the equipment's lifespan including the drone. For improvements, examine and evaluate process was done for upcoming projects.

Marketability Potential of Innovative Drone for External Wall Painting

The Drone Innovative has a high marketability potential because it offers numerous advantages and opportunities to a wide range of sectors especially in construction industries. The Drone Innovative target market may include a construction and architecture sectors as the Drone Innovative can be used to paint new buildings or construction projects. Drones' efficiency and accuracy can be used by architects and construction firms to quickly paint large surfaces of wall.

Other than that, buildings maintenance sectors also categorized as market potential for the Drone Innovative. Facilities like factories, warehouses, and office buildings need periodic maintenance, which includes touch-up painting. Hence, the Drone Innovative can be an affordable and effective alternative for these maintenance jobs, particularly for difficult-to-reach places or big-scale projects for example, wall painting works for high-rise buildings.

Online Channels

Implement social media marketing to advertise the Drone Innovative by using online platforms like Instagram, YouTube, Facebook, and Twitter to reach the target audience. By sharing enticing photos and videos, interact with potential consumers, and execute focused advertising campaigns will attract the target market's interest to purchase it. Next, produce instructional and visually stimulating on own website postings, articles, and videos on buildings improvement tasks and wall painting process to increase natural traffic to the website. In online markets, the Drone Innovative can be lists on appropriate online markets like Amazon, eBay, or specialised online markets for industrial use products and machinery.

Offline Channels

Apart from market the product on the online platform, the offline platform is also very important to market this innovative product. Take part in events, exhibitions or marketplaces related to paintings, building innovation or technology will helps the product to be better known especially for the target markets. Next, the Drone Innovative can be publish in local newspapers, business publications, or journals devoted to building construction. The product can be features in articles or press releases to gain exposure and trustworthiness of the target markets. Other than that, conducting a live demonstrations and training sessions specifically for target market can give them an idea of how to use the product and its effectiveness. Indirectly, it can be helpful to explore collaborations with painting equipment suppliers, contractors, or building painters.

CONCLUSIONS

This paper introduces a cooperative external wall painting robotic device that combines automation and human innovation. The Drone Innovative, equipped with a LiDAR 3D sensor painting system, securely completes repeated painting tasks in high-rise buildings. This innovative system addresses sustainability, productivity, quality, and safety challenges, promoting a robotics industry and ecosystem. An Innovative Drone reduces the need for trained laborers, optimizes the painting process, increases production, and minimizes risks of falling from heights and exposure to dangerous paint compounds.

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Tarikh : 20 Januari 2023

Prof. Madya Dr. Nur Hisham Ibrahim
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