A REVIEW APPROACH FOR SPRAY PAINTING WORK BY UNMANNED AERIAL VEHICLE (UAV)

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Abstract: *Safety and health issues keep on critical to the construction industry due to its working environment and the complexity of working practises. In Malaysia nowadays, the method of conventional painting work usually is using a platform or scaffolding, ladder, ropes and gondola. In term of safety and cost, conventional painting work is not only exposing workers to significant health and safety risks but also costly and labour-intensive. In addition, the working environment is not safe for the painter because mostly a painter work at a high level that can lead to fatal due to falling. This paper describes a better working environment for painting work by using Unmanned Aerial Vehicle (UAV) that can do the painting work in the construction industry. This project idea comes from a concept idea that emerges from a combination of two different technology which is Unmanned Aerial Vehicle (UAV) and Spray Painting. The spray painting using a UAV, expected will be suitable for industrial construction applications because of UAV can be variety of size especially at confine, narrow space, the height of building that gives limitation of space for the painter and importantly to avoid the need for scaffolding and ladders which is the safety of the painter at high-rise building due to fall is secure. This paper highlights the innovation idea of spray painting work using UAV.*

INTRODUCTION

People have been building things for construction for a long time. Construction has been around for centuries, and it should be around for many years more. Though, construction today is not the same as it was a thousand years ago and the same with painting work in construction. Most of the architectural buildings with concrete walls are finished with paint, unless marbles, bricks, or curtain walls that used as exterior enclosures. The conventional painting is costly and labour-intensive, and it especially exposes workers to significant health and safety risks. As with anything, things modernize and develop. Nowadays, things are moving faster than ever; new ideas, methods, and technologies are entering the construction industry every year, for instance, the use of Unmanned Aerial Vehicle (UAV) or usually can be recognized as a drone.

There is a various reason why drones have started to make such a big impact. A drone is not just for helping the actual labour process, and it also can replace labour at a particular job. The use of the drone has a huge role to play in the construction industry, and that role is proliferating. Drones have helped revolutionize the planning stages of construction, along with land surveying, data capturing and robotic painting. Robotic painting using a UAV has the potential to produce accurate (predictable and repeatable) painted appearance, to be low-cost, and to avoid the need for scaffolding and ladders [1]. These are just a few of the routines for drones in construction. Now with drones, the job can be done in no time and faster than before with no fatalities or injuries among the worker in construction works. The drone also can get up-to-date images as often as needed. That means users can get a real feel for how the build is progressing. Drones allow builders the chance to develop better plans, track progress and monitor any issues with the construction by providing an unrivalled wide-view of a site at a fraction of the cost [2].

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The UAV painting drone can autonomously spray paint the wall surfaces that has limitation of space for painter without the need for scaffolding and ladders. The primary purpose of this study is to gain the current issue on painting work that used a conventional method and innovate it to a better painting workplace by using painting drone that is relevant to the concept of industry revolution 4.0 in order to go toward futuristic and advanced construction for providing an efficient and safe working environment in this construction industry.

BACKGROUND TO RESEARCH

The construction industry plays a vital role in the growth of Malaysia's economy, and it is one of its key industries. However, the construction industry is also one of the most unsafe [3]. Scaffolding is a vital tool used on construction sites. In addition, an estimate of over 2 million or 65 per cent of construction sites uses scaffolding, including painting work [4]. The main role of scaffolding is to back up the building construction work at heights and places with unfortunate access, such as painting an external wall.

The UAV painting drone can eliminate the dangerous workplace that using a conventional method, safety issue of the painter and at the same time, speed up the painting work process. This project idea comes from a concept idea that emerges from a combination of two different technology which is Unmanned Aerial Vehicle (UAV) and Spray Painting. The spray painting using a UAV, expected will be suitable for industrial construction applications because UAV can be a variety of size especially at confine, narrow space and the height of the building that gives the limitation of space to the painter.

The UAV painting is motivated by the potential of safety, accurate and fast painting work. Furthermore, the UAV painting drone that has been custom fitted with an arm plus a spray. Painting using a UAV has the potential to produce actual (predictable and repeatable) painted appearance, to be low-cost, and importantly to avoid the need for scaffolding and ladders which is the safety of the painter at a high level due to fall is secure.

PROBLEM STATEMENT

Construction painters who apply paint, stain or any other coating to buildings or bridge is a dangerous work, with a risk of death or serious bodily injury. Like many other construction workers, painters risk injuries or death from falls from scaffolds and ladders. But there are also special dangers from exposure to toxic paints and solvents and lead poisoning. One way to overcome these problems is the UAV painting drone. Other countries have proved and started develop their own painting drone because the UAV painting drone can provide numerous benefits and save plenty of painter`s life. In Malaysia, most people still do not expose to this kind of technology and it is also not widely explored by the Malaysian researchers. Therefore, the technical information on how to build the UAV painting drone is almost unavailable. This research in conducted in order to solve the current issue in painting work that used a conventional method for a better working environment.

RESEARCH OBJECTIVE

Based on the problems of issues identified, three objectives have been formulated. The three objectives are a) to identify the dangers of conventional painting work, b) to find out is it a conventional method is slow and costly, c) to proposed an idea for spray painting work using an unmanned aerial vehicle (UAV).

SIGNIFICANE OF RESEARCH

This study could be used to wipe out the dangers of painting work due to an unsafe working environment. The Smart Unmanned Aerial Vehicle is a painting drone that can eliminate the dangerous workplace that using a conventional method, safety issue of the painter and at the same time, speed up the painting work process. This project idea comes from a concept idea that emerges from a combination of two different technology which is Unmanned Aerial Vehicle (UAV) and Spray Painting.

The finding of this research could be used to create a safe working environment by using UAV painting drone. The SUAV is motivated by the potential of safety, accurate and fast painting work. Moreover, the SUAV is a drone that has been custom fitted with an arm plus a spray. The spray painting using a UAV expected will be suitable for industrial construction applications because UAV can be a variety of size especially at confine, narrow space and the height of the building that gives the limitation of space for the labour to do the painting work. Painting using a UAV has the potential to produce actual (predictable and repeatable) painted appearance, to be low-cost, and importantly to avoid the need for scaffolding

and ladders which is the safety of the worker in a high level of building due to fall is secure [1].

The positive outcomes of this research can be used to create a new guideline associated with future technology in the construction industry that will give benefit to the country`s development such as the current issue on painting work. The use of high-level scaffolding, rope, ladder and gondola, which can cause accident and hazard to the health of the worker. This research will be expected to provide better painting work by using a painting UAV that is relevant to the concept of Industry Revolution 4.0 (IR 4.0). IR 4.0 is the latest phase of a manufacturing revolution that focus more to computerization enhancement and autonomous task completing through data and interaction or communication between devices or its more accustomed term the Internet of Things (IoT).

CONCEPTUAL FRAMEWORK

The innovative project will be conducted based on the conceptual framework as in figure 1.
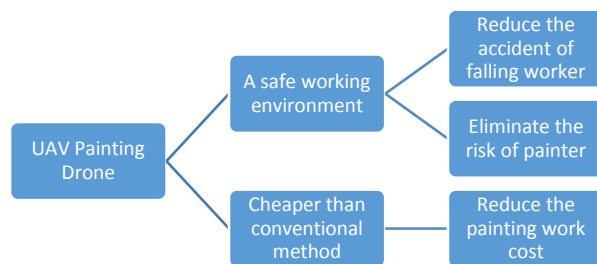

Figure 1: The flowchart showing the conceptual framework of the research

RESEARCH QUESTION

Based on defined problems issues, the research question is developed such are a) what the dangers in the painting work by conventional method, b) why the conventional method is slow and costly, c) how to reduce the danger in painting work?

LITERATURE REVIEWS

The literature review for the painting work covers two main topic which (a) and (b).

a) Dangers in conventional painting work

Conventional painting work are widely use nowadays, painting is a critical part of many residential, commercial and industrials projects. There are upsides to earning a living as a painter because it does not require expensive schooling, it offers job opportunity to the jobless, and there is generally no shortage of work. Yet, it also comes with downsides. As a physically demanding job, painting can take a toll on the body over time. There is also a constant risk of getting injured. In fact, construction and maintenance painters have one of the highest injury rates among any profession [5].

In early 2018, jobs that require climbing ladders, ropes, or scaffolds. In many of those occupations, workers suffer nonfatal workplace injuries from falls to a lower level resulting in days away from work. For example, roofers, painters, carpenters, and electricians and one of the occupations is painter that incurred injuries and illnesses from falls to a lower level at rates much higher than the rate for all workers. Painters were the most at risk to suffer nonfatal falls to a lower level in 2016. The rate for roofers was 86.9 cases per 10,000 full-time workers; the rate for painters was 75.0 cases per 10,000 full-time workers. Their rates far exceeded the rate for all workers combined of 5.1 cases per 10,000 full-time workers. [5]

In the current conventional exterior wall painting, a painter is hanging down from a rope fasten to somewhere in the rooftop and paints the wall with a spray gun or a roller while swinging from side to side like a clock pendulum and coming down from top to bottom. In such a high altitude with a simple connection to a single rope, the painter can be led to a fatal accident even with a small mistake. [6]

A study had shown that painting work in the construction industry by labor or painter that can cause an accident and long-term effect on the health of the labor. It was evident that painters had the highest rate of accidents involving 'fall of person' (32.2%) and painter also had the highest rate of 'contact with chemicals.' Hence there seem to be two specific hazards associated with painting: falling and exposure to paint. Although the latter represents only 3.5% of accidents, the long-term effects of exposure to paints and solvents are much more severe [7].

Falling of people is also one of the highest percentages happening accidents in the construction site. People working in the construction site has the risk exposed to fall in any place of the site, especially at a high level. Most of the worker falls from a higher level mostly resulted in death. The type of accident always occurs in construction which is fall from scaffolding. Moreover, according to the Occupational Safety and Health Administration, the most dangerous thing a worker can do is climb a ladder. At the same time, falls are also a critical cause of accidents with an annual average of 1042 cases in Malaysia. According to the Occupational Injury and Illness Classification Manual, falls can be grouped into 11 categories, there two cause falling of people during painting work;

- falls from ladders;
- falls from scaffolding or staging

Painting work in confined space also can be dangerous work, the operation performed in the confined space such as painting with a coating containing toxic or flammable substances that can explode because of the presence of contaminants on surfaces or in the atmosphere. Contaminants may be in the form of solids, liquids, sludges, gases, vapors, fumes, or particulates [8].

In addition, painter that exposure to construction paints and solvents leading to personal injury. Painter who spray paint with unhealthy fumes must be provided with protection. Some of these paints contain highly volatile chemicals with fumes that explode and catch on fire easily, so employers must also provide ventilation. This should usually come in the form of an exhaust that draws the fumes out of the confined space, according to the Federal Occupational Safety and Health Administration. This is a special danger that painters may face that can easily be ignored, resulting in a construction accident or illness [9]. There are number of health and safety risks that painters face [10], including: -

- Exposure to toxic fumes: Many paints, varnishes and solvents have high levels of VOCs (volatile organic compounds). Inhaling these toxic fumes can lead to neurological problems (such as "painter's dementia"), asthma, cancer, fertility problems and other health issues.
- Dust inhalation: Painters who work in construction sites may be exposed to dust from sanding, drywall installation and other work, which can lead to asthma as well as respiratory and sinus problems.
- Cancer: According to recent research, professional painters have a 20 percent higher overall risk of cancer and a 30 percent higher risk of bladder cancer.
- Back and neck injuries: Painting involves kneeling, bending, reaching and lifting. Such tiring work can lead to chronic injuries, especially in the back and neck.
- Accidents: Painters often work on scaffolding and ladders, which means a higher risk of falls. Additionally, they face the same hazards as other construction workers, such as exposure to damaging noise levels and dangerous machinery.

b) Conventional method output and productivity

Due to such a dangerous work environment and higher accidental rates it is difficult to retain skilled workers and their daily labor cost is higher than that of other construction crews. In addition, it is not easy to obtain consistent quality of the painting because of the unstable working position and movement of the worker thus yielding a big difference in productivity in accordance with the level of worker's skill and experience in the exterior wall painting. The conventional painting is a labour-intensive work which requires about fourteen laborers for painting one apartment building. Compared to other types of construction trades, the daily wage of exterior wall painters is relatively high because of the dangerous working environment. A field survey result indicates that labour cost is over 80% of the total painting cost [6].

In Korea, a researcher has conducted a study that total labor expense is generally four times higher than the sum of materials and indirect costs required for exterior wall painting in apartment buildings. Furthermore, the labor cost would be even greater when graphic specialists are hired to add graphic works such as artistic drawings, logos, and texts [6].

METHODOLOGY

Data collection for this research consists of desk study, interview and questionnaire survey. In this analysis, both qualitative and quantitative are

applied. In order to explore the meaning and importance of this research, qualitative analysis was carried out to find out challenges on painting process and contractors' knowledges on drone. Whereas, quantitative research was conducted to study the marketability of innovation idea.

Interview will be carried out where necessary. The target interviewee is personnel from construction and manufacturer. Other than that, would be mechanical engineering experts to seek and evaluate whether the proposal idea is relevant or vice versa.

Observation will be conducted during site visit to the construction site in order to identify the current issue of painting work and the productivity of painting work by labour. Photographs shall be taken. Conventional method will be analysed.

Questionnaires are the most commonly used tool in survey research. Questionnaires will be conducted to personnel in industry which is 30 respondents from construction personnel 20 respondent from manufacturer.

ANALYSIS METHOD

Analysis is done based on data collected in data collection method. The importance of analysis is to generate the idea of this innovation project. For this research, analysis is done through simulation and questionnaire survey.

    i.   Simulation

Simulation is done using 'Google Sketch Up Pro 2017' software together with, 'Keyframe Animation version 2 0.12' for animation aid. This software enables user to design in 3-dimensional (3D) products in any aspect on various templates such as architectural, mechanical, automotive etc. In simplest form, it is one of handy software. It is easy to use, supported Dxf, and come with user programming language as well as various aid modelling. Therefore, 'Google Sketch Up Pro 2017' is to illustrates both assemblies and performance of product.

    ii.   Questionnaire (Expected method)

Questionnaire shall be conducted to define the probability of marketing the product, SLSR. The survey will be distributed to contractor which involves with painting project via Google Form. Despite being able to creates survey, Google Form could generate graph data with ease. It is also a flexible and scalable input access from any device. Data from the survey will be analysed and referred as a setback to establish SUAV in the market of construction industry.

CONCLUSIONS

Technologies continue to evolve exponentially as the years have gone by that all industry players need to keep up and comply with the current market development or face getting left behind. Nonetheless, the construction industry must also use current technology in the construction process in order to gain benefits, especially in Malaysia.

Unmanned Aerial Vehicle or drone is a crucial technological asset. The use of a drone in the construction industry will increase in time because the drone can efficiently collect data of a high standard, significantly minimizing risk to the safety of human in the construction industry. Moreover, drone use in the construction industry has seen immense growth in recent years, and this looks set to carry on. With high technology improving for drones every year, drones are look set to help construction even more over the next decade.

The construction industry is evolving at a rapid rate, and with all the innovations and changes to traditional methods comes the need for greater efficiency in every aspect for the construction industry in the future. Previously in construction work, the uses of labor and scaffolding at high-rise building particularly painting works are one of the dangerous jobs and dangerous that could be fatal to the worker in order to complete the job. The safety, time and cost of doing that also one of the reasons the needs of the drone in the construction industry especially when involving human safety. Innovation on the drone for painting work is necessary to avoid that unwanted accident. In order to increase the efficient workflow and the safety of the labor in painting work, Smart Unmanned Aerial Vehicle needs to be developed and used in local or regional authorities to improve the standard of current construction industries in order to achieve the goals toward industry revolution 4.0

REFERENCES

[1] Vempati, A. S., Kamel, M., Stilinovic, N., Zhang, Q., Reusser, D., Sa, I., Nieto, J., Siegwart R., & Beardsley, P. (2018). PaintCopter: An Autonomous UAV for Spray Painting on Three-Dimensional Surfaces. *IEEE Robot. Autom. Lett.*, *3*(4), 2862-2869. Retrieved March 25, 2019, from 10.1109/lra.2018.2846278

[2] Natwilai, P. (2018, December 24). Using Drones in The Construction Industry - Geospatial World. Retrieved September 25, 2019, from

https://www.geospatialworld.net/blogs/using-drones-in-the-construction-industry/
Hook, J. (2016, November 21). Using Drones for Site Inspections. Buildsoft. Retrieved March 25, 2019, from https://www.buildsoft.com.au/blog/using-drones-for-site-inspections

[3] Abdul Rahim Abdul Hamid, Wan Zulkifli Wan Yusof and Bachan Singh. 2003. Hazard at Construction Site. *Proceeding of the 5th Asia-Pacific Structural Engineering and Construction Conference 26-28 August 2003, Johor Bahru, Malaysia.*

Systems, *4*(4), 49. https://doi.org/10.5772/5668

[4] Occupational Safety and Health (OSHA). 2011. Construction Focus Four: Fall Hazard, OSHA Directorate of Training and Education April 2011

[5] Bureau of Labor Statistics, U.S. Department of Labor, *The Economics Daily*, Roofers and painters had highest rates of nonfatal falls to a lower level in 2016 on the Internet at https://www.bls.gov/opub/ted/2018/roofers-and-painters-had-highest-rates-of-nonfatal-falls-to-a-lower-level-in-2016.htm (visited *June 10, 2019*).

[6] Kim, Y. S., Jung, M. H., Cho, Y. K., Lee, J., & Jung, U. (2007). Conceptual Design and Feasibility Analyses of a Robotic System for Automated Exterior Wall Painting. *International Journal of Advanced Robotic*

[7] Helander, M. G. (1991). Safety hazards and motivation for safe work in the construction industry. International Journal of Industrial Ergonomics, 8(3), 205-223. https://doi.org/10.1016/0169-8141(91)90033-i

[8] DOSH. (2010, January 1). Official Website Department of Occupational Safety and Health - Industrial Hygiene. Retrieved May 28, 2019, from http://www.dosh.gov.my/index.php/en/legislation/codes-of-practice/industrial-hygiene

[9] Oresky & Associates. (2014, August 22). Why Construction Painting Is Dangerous Work. Retrieved June 10, 2019, from https://www.oreskylaw.com/blog/why-construction-painting-is-dangerous-work/

[10] Januzzi, S. (2016, November 23). For Professional Painters, The Health and Safety Risks Can't Be Ignored | Shollenberger Januzzi & Wolfe, LLP. Retrieved June 10, 2019, from https://www.sholljanlaw.com/blog/2016/11/for-professional-painters-the-health-and-safety-risks-cant-be-ignored.shtml