APPLICATION OF DRONE IN VISUAL INSPECTION FOR CONSTRUCTION PROJECT

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ABSTRACT

The construction industry has evolveed rapidly and advances with a variety of new technologies, especially in communications and computing abilities. As such, it has offered a drone as a tool. The drone previously has risen in military applications for spying and to get mapping area. Specifically to the construction project, the drone can be applied as a tool for visual inspections process such as area mapping, tracking work in progress, inspections of built up structure and locating and identigying construction defects . Ageing and fatigue of infrastructures has became a major concern especially for elevated highway and bridges where the service life is shorten . Therefore it requires an optimied procedure and the use of drones is explored within this study. .This study, aims at the application of technology which is drones for structural/construction inspection through visualisation approach. In order to achieve the aims of this research several objectives has been identified which is to explore , appraise and syntheisise relevant literature related to visual inspection specific focus on ability , usage, evolution, implementation requirement and success factor. Another objective is to explore and develop the proposed method of statement and risk asessment of drones and to establishes the sequences for visual inspection process. Lastly is to test and refine the proposed method of statement of application of drone for visual inspection in construction project.

ABSTRAK

Industri pembinaan telah berkembang pesat dengan pelbagai teknologi baru yang boleh membantu dan memudahkan , terutamanya dalam komunikasi dan kebolehan mengira . Oleh itu , ia telah menawarkan drone sebagai alat dimana penggunaan drone sebelum ini telah digunapakai dalam aplikasi ketenteraan untuk mengintip dan untuk mendapatkan kawasan pemetaan . Khusus untuk projek pembinaan, drone boleh digunakan sebagai alat untuk proses pemeriksaan visual seperti pemetaan kawasan , kemajuan kerja, pemeriksaan membina struktur dan mencari dan menilai jenis kecacatan pembinaan . Penuaan dan keletihan infrastruktur telah menjadi perhatian utama terutamanya untuk jalan raya dan jambatan di mana kira-kira kos yang paling besar adalah disebabkan oleh pembaikan dan penyelenggaraan. Oleh itu ia memerlukan cadangan prosedur yang optimis dan juga menerokai kelebihan penggunaan drone yang dalam kajian ini . Kajian ini dilaksanakan bertujuan sebagai penggunaan teknologi dimana drone digunakan untuk pemeriksaan struktur / pembinaan melalui pendekatan visualisasi . Bagi mencapai matlamat kajian ini beberapa objektif telah dikenalpasti iaitu untuk meneroka, menilai dan hasil thesis yang relevan dan berkaitan dengan pemeriksaan visual menumpukan khusus kepada keupayaan , penggunaan, evolusi , keperluan pelaksanaan dan faktor kejayaan. Objektif lain adalah untuk meneroka dan membangunkan kaedah yang dicadangkan bagi kenyataan dan risiko terhadap aplikasi drone dan untuk menetapkan urutan untuk proses pemeriksaan visual . Akhir sekali adalah untuk menguji dan memperbaiki kaedah yang dicadangkan bagi cadangan prosedur menggunakan drone untuk pemeriksaan visual dalam projek pembinaan itu sendiri.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Construction industry nowadays demanding a highly precise planning and work schedulling, effective management of project comes with with good specification, requirements and inspections of the project which can enable the overall optimization in time, cost and resources. In monitoring progress, therfore an effective and efficient approach is crucial to obtained in order to deliver quality. However, many the projects still engaging traditional method to monitor progress and conducting inspection. It has caused many disadvantages in the decision making such as poor documentation . As a result, the necessary data and information could not be captured accordingly . The situation gradually increase pressure on the project manager to shorten the delivery of time and decrease the cost involved in the process without decrease the quality of the product. By growing a pressure to shorten the project completion times plus the complexity of today's construction project and to increase productivity of commercially available the personnel needs a real-time data either to observe of progress, safety issues or visual inspection.In order for improvements in quality and efficiency of construction industry there also a needs of research for new technology that could help increase the work productivity and optimize cost efficiency. Basically with a help of technology either in communicating and computing abilities it will help person in charge to make a

better and proactive decision for the uprise problems and planning based on the data given and systematic documentation because that is the fundamental and challenging activity of the management hierarchy.

In Malaysian construction industry there is a lot of facilities and old strcutures as well as the deterioration of existing infrastructure components such as elevated highway ,bridges, pipelines, and dams have increased the demand for routine structural integrity assessments. While Ministry of Works have established guidelines regulating the inspection of these infrastructure components and evaluations often suffer from a degree of inaccuracy as a result of the inspection methods. Furthermore, limited human resources may decrease the thoroughness of these inspections. The application of technologies and robotic systems for structural monitoring and inspection may provide a successful means of improving the efficiency and accuracy of structural integrity assessments by assisting human efforts. This work describes the development of robotic system especially application of drones for the visual inspection. This system serves as a mobile platform for structural visual inspection and evaluation equipment. Drones or quadcoptors are small and exceptionally agile vehicles with maneuverability that permits both indoor and outdoor flight. The majority of quadcoptors are flown autonomously as drones or remotely by a human-operator. Applications of quadcoptors describes the dynamics of drones for monitoring of structures and maintenance for construction project.

From civil engineering areas, the drones could apply as a tools for visual inspections process either mapping area, working progress, inspections of high structure and to locate defects and cracks. Ageing infrastructures has become a major concern especially for elevated highway and bridges where roughly the life cost is due to repairing and maintenance. The consequences of neglecting routine inspections range from being minor to catastrophic. Even seemingly insignificant structures such as pedestrian walkways and footbridges require an inspection schedule. Bridges, tunnels, pipelines, and dams are all examples of large structures that require routine inspection and maintenance. Most of these structures are decades old and have had prolonged exposure to harsh environments and loads.Progresses in visual inspection look possible

in the direction of remote sensing and process automating. The use of drone could be of a particular interest as camera carriers and image transmitters. Drone could follow a predetermined path or could move by visual control and detects by the means of image or video of size and location of defects part.

Even with a systematic approach, maintaining an old structure is a formidable challenge. Structural deficiencies in ever-aging elevated highway structures and pipeline systems become increasingly likely to occur as time passes. Additionally, urban growth and development place greater demands on these structures and systems and create the need for further maintenance and construction. Inspections after potentially catastrophic events such as hurricanes, earthquakes, major vehicular accidents, and sabotage, are also necessary. The effectiveness of routine inspections is limited by manpower and funding. This study is to define advantages and limitations of application drones for visual inspection rather than conventional method which using skylift machines or human itself. It also to study the impact and changes in construction industry and to analyse the outcomes and impact in term of time, cost, human error and safety factor.

1.2 PROBLEM STATEMENT

The following questions arise in inspiring the problem identification :

1. For conventional method of visual inspection on high reach point it always have a current issues involving limitation of machinery such as skylift and human error.

2. Although conventional method of visual inspection must be an efficient way through out current time but still it can be questionable on :
    (a) Time effect
    (b) Cost impact
    (c) Efficiency in co-ordination
    (d) Legal documentation for court issues
    (e) Safety and health perspective
    (f) Business perspective

3. So this research is a study to attempt an answer for this problem and to proposed combining technology with construction area specifically in visual inspection area.

1.3 AIM AND OBJECTIVE

The aim of this research is to study and explore the drone technology in construction for structural/construction inspection through visualisation approach. To achieve the aim of this research, several objectives were identified and they are:

a) To explore , appraise and syntheisise relevant literature related to visual inspection specific focus on ability , usage, evolution, implementation requirement and success factor.

b) To explore and develop the proposed method of statement and risk asessment of drones and to establishes the sequences for visual inspection process.

c) To test and refine the proposed method of statement .

1.4 RESEARCH METHODOLOGY

Methodology also is a well planning for a reserach that starts from the beginning until the end of research. The problem of conventional method of visual inspection which is efficient way through out current time but still it can be questionable on time affect, cost impact and efficiency in documentation process or suitable methods that can meet the objectives can be carried out when the methodology is well planned and followed. There will be five pillars of research area that will generate to four phase of data control and process for each pillars and to tele back with aims and objectives of this research. The appropriate research design and research methodology will assist to achieve research objectives by clearly shown method of data gaining, data analysis and to generate the information and results.

1.5 SCOPE OF STUDY

With the given complexity of times constraints and complexity in gathering access to the company and the construction project, the following scope is prepared:

1) A roof and pipeline of 3- storey residential house with 10 years construct lifetime will be inspect using drones

2) Water tank towers of resindence which in defect and warranty period will be inspect in order to proposed standard operation procedure for visual inspection using drones

3) Testing and understand the limitation and flexibility method of statement and risk assesment for drones in site where the cycle is in construction stage and preferably in confinement area

4) Using drones for real time area mapping in open space area

5) Data collection related to aims and objectives

6) Middle level and top level management (operator,supervisor,engineer, project manager and client) respondents required to explain the nature of construction activity and progress especially in visual inspection process.

7) Develope the data (picture and video) documentation or report by using Pinnacles and Microsoft Softwares.

8) Theory that engaged in visual inspection is majority of structural knowledge and experience that align with a process of architects requirements.

1.6 SIGNIFICANT OF STUDY

The result of this study may exposed the application of drones in visual inspections for construction industry. The effectiveness of using drones might be questioned during the implementation and execution of visual inspection especially in a complexity projects but by having a real time data with the help of inutiative view and experience will allow personnel to act and decide for an action based on that situation. The new practise of using drones technology also is a substantal improvement in quality and efficiency compare to the traditional method which using a combination of skylift to lift human in order to reach the highest and difficult point of structures. Furthermore, using a drones in construction project also would help planner in a better project perception in planning process and can be extended to coordination activities by project manager and safety observation by safety personnel.Thus, it is an advantage by using new technology to eliminate others competative that using big and expensive machineries charges for Visual Inspection works and there could be certain high structures that are difficult or impossible to access without special equipment that a drone would have no problem with whilst maintaning safety measurement.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Building construction is to be an essential part and element of the construction industry in Malaysia and it forms about 67.6% of the overall construction work (CIDB, 2008). The new global challenges thus call for greater focus on building capabilities. Making strategic decision require new system or technologies that can measures in evaluating the succes of projects that will support contractors and managers to enhance their competative edge. It is very important for any personel involve in construction industry to adopt more effective and comprehensive evaluating methods to identify problems and innovative ways of delivering successful project

Another significant study conducted by Atkinson (1999), which divided the project into three stages. In view of the Figure 2.1 , which iilustrates these stages it can be seen that the first stage was the delivery stage. This stage focused upon the task of project managemnet and doing and to decide things wisely. The next stage was the post delivery that was concerned with the system and measured the benefits to the resultant organisation(direct benefits). The third stage was the post delivery which measured the benefits to a wider stakeholder community (indirect benefits)

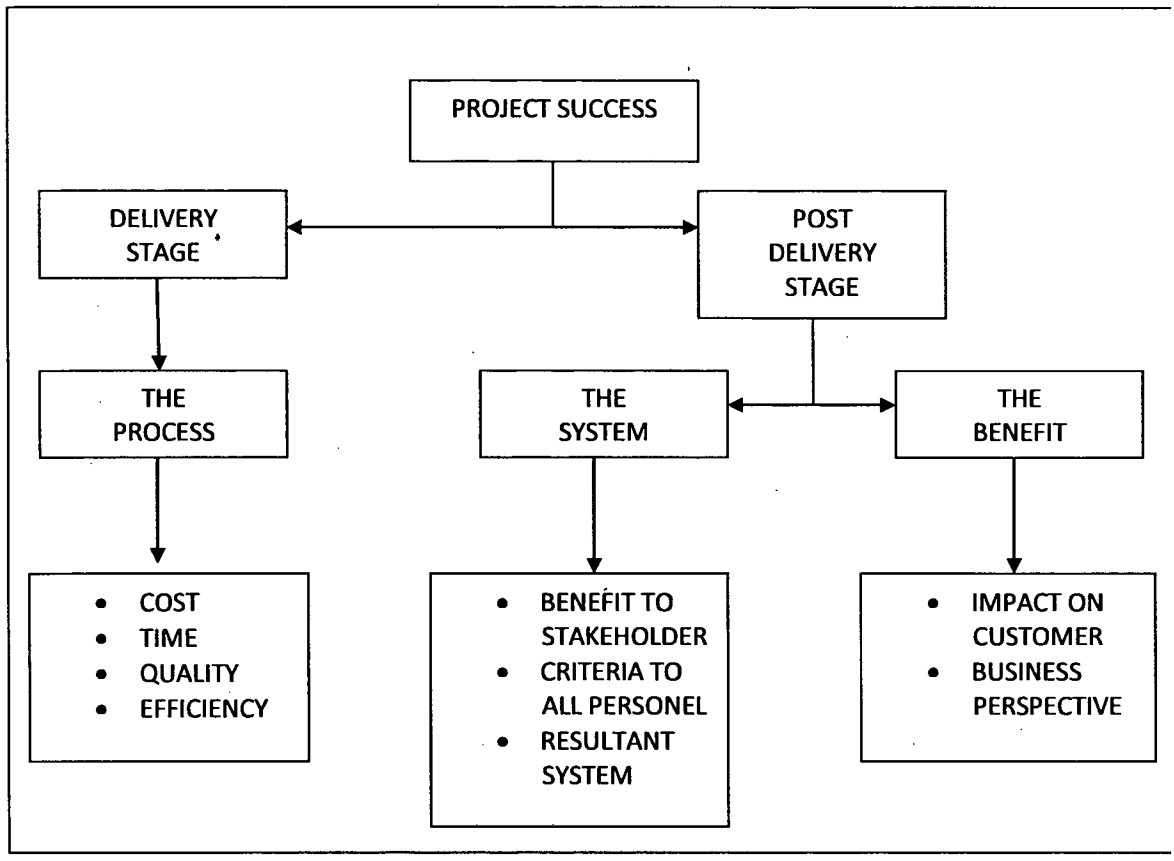

Figure 2.1 : Measauring Project Success (Atkinson, 1999)

Atkinson (1999), Shenhar (1997) and (2001) have made significant contributions to knowledge management and moved away from the conventional way in measuring the success by focusing only on time, cost and quality. Yet these studies have addressed projects of various industries rather than focused on construction projects. Since the success criteria will vary from project to project those measures do not address the issue of success in projects.

2.2 DEFECT BUILDING AND STRUCTURE CASES IN MALAYSIA

New houses with multiple defects are not a new scenario in Malaysia. This does not mean that the new built houses should always be defect-free. In the theory of manufacturing, a defective product is going to happen, be it as good as the quality control process is applied.Such cases also apply in the construction industry. In the meantime, many past studies related to defects in the building done in the post-construction, which includes the operation and maintenance of buildings. However, not many similar studies done in the design stage and during the construction phase. (N.W. Tanwil, 2009)

The construction industry plays an important role in the growth of the nation's economy. This sector is the engine of the country's economic development through the multiplier effects to other industries such as manufacturing, finance,education and others. By using a standard inspection the building inspector can provide objective data on the status of the building for the project manager. The system is seen as an effective evaluation and incentive system to encourage continuous quality improvement. However, analysis of scores has shown that the quality of construction has not increased. Therefore, has recommended several steps to achieve continuous quality improvement in the inspection methods of construction.

Besides, the evaluation of housing condition is also important to ensure the health and safety of the occupants. Structural failure may result in loss of life and property damage. According to the maintenance is significantly influence the building safety and health of residents. Therefore, assessment of building conditions is essential to obtain information related to carrying out maintenance work effectively. In addition, the quality of building construction also reflects the image of the people who involve in this project. Building defects is the non-fulfillment of intended usage requirements. Zuriani (2003) has describe six common defects occurs in the research such as crack, moisture, peeling off, painting defect, rust and rot.

Besides, it has classified generally 14 types of building defects such as leak, bend, rust, rot, moisture, sedimentation, crack and others. In addition, stated that there are some defects occur as the result of design errors, construction errors, and misuse of the buildings.

Based on analysis of concrete defects factors in Malaysia,stated that there are seven types of defects usually happen on concrete structure such as crack, failed jointing, leaking, corrosion of steel reinforcement, sedimentation, honeycombed and disintegration of concrete. According to there are five main factors of concrete strcuture defects which is design error, building material, geotechnique, construction errors and unpredicted errors. These study suggests the need to perform the buiding condition survey, particularly to the newly completed construction building, as one of the method in tracking the construction defects. This also help the industry to identify and prioritize the most defected components in supporting the continuos quality improvement process.

The condition of building component is evaluated using a Standard Building Inspection Code published by the Royal Institutional of Surveyors Malaysia (RISM) and Condition Survey Protocol (CSP) 1 Matrix. These code and protocol is a guideline to the Building Surveyor to assess any defect of building based on priority and condition. This matrix has its own scoring system to facilitate the examiner to assess the condition of building carefully and entirety. All defects identified are assessed and recorded on-site with the evidences (photos and plan tag). The score obtained from the scoring system determine the level of defects/component such as good, fair and dilapidated. Besides, the possible cause of the defects also identified.

From the news paper of **(The Star Online & Newspaper on 26 August 2004)** issue involve in Middle Ring Road 2 (MRR2), Works Minister Samy Vellu admitted in Parliament that defective design and lack of inspection was one of the reasons for the cracks in the Middle Ring Road 2 (MRR2).The steel placement did not follow the standard and specifications.Samy also said in reply to a question from Speaker Tan Sri Ramli Ngah Talib.Ramli had interrupted Samy Vellu when the minister was giving a technical explanation for the cracks on the MRR2 highway in reply to questions from Datuk Ismail Sabri Yaakob (BN-Bera) and other MPs.Samy Vellu said his ministry monitored bridges and flyovers but only the MRR2 was found to have serious defects

It is not a new thing that common structure in Malaysia needs to have schedule maintenance and most of all to have schedule inspection (Prof. Dr. Azlan, 2009). For MRR2 cases the verification of crack mapping and observation of new cracks or defects from Ministry of Works along with independent checker to verify of concrete strength measurement and to design check on pier crosshead and make sure to have finite element analysis of pier crosshead involved in order to make a document study of construction methods and contractual matters. Visual inspection and selective crack mapping for verification of previous test records and identification of new cracks or defects should have done before they proceed to process of In-situ hardness test using rebound hammer on selected locations to provide estimate of concrete quality and strength correlation .Core-drilling to extract concrete core samples from selected locations for strength and other relevant tests

2.3 OVERVIEW IMPORTANCE ROLE OF INSPECTION IN CONSTRUCTION

Inspection personnel must be highly trained to recognize specific signs ofdeterioration that can lead to structural failure. Any structure can have defects, which signify a loss of structural integrity, whether the structure is a highway bridge or an underground gas pipeline. Some signs of deterioration may be visually obvious such as corroding steel or large surface cracks. Other signs, such as bridge deck delamination,may require the aid of ultrasonic instruments, radar, other non-destructive methods, or invasive methods such as taking core samples. Methods of nondestructive testing are the most desirable form of inspection, as they leave the member under evaluation intact. (K.C Leong,2008)

For building and structure inspection it has many forms such as in visual inspection, construction, forensic, conditions of existing buildings, spesific buildings fault, pre-sale home and many more. But all forms mention is comes out in bigger perspective from construction quality control inspection and safety and health inspection. Inspection are meant to ensure construction site and the construction process do not violate the safety and health standards and regulations. In Malaysia safety and health standards and regulations are controlled by legistation and strictly enforced. Personnel who conduct and involved in inspection must be strict to ensure public safety and to control the requirements of structure specification or projects. For large and complex structures, building authorities in Malaysia require inspection or peer review of structural design so as to independently verify the design load criteria, local building code compliance and to ensure there is no serious errors are apparent.

For larger and more complex projects involving tight timeframe. They have large teams of specialists to carry out the detailed inspection and testing work to ensure strict compliance with standard and quality control as well as construction completion within the set timeframe.This specialist team works closely with the Project Consultants to ensure design variations are properly carried out within the quality control

requirements. Together with the Project Consultants, they are jointly responsible for obtaining the Certification of Occupancy. Building authorities also carry out Construction Quality Control Inspection to ensure compliance with statutory standards and regulations. For critical works, Tests are carried out by the authorities to ensure performance standards are acceptable. For those Tests that are carried out by consultants, full test results must be lodged with the authorities for checking and approval.