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3D Indoor Modelling Using UAV's Video

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***Abstract*:** 3D indoor modelling is a digital representation of the interior space in building to ensure the indoor space is in a good quality condition. The aim of this study is to assess UAV's video for 3D indoor modelling. The methodology in this study is divided into four phases namely planning and preparation, data collection, data processing, and result and analysis. The data is acquired using UAV in the form of video from two meters altitude. The accuracy is assessed through the comparison between actual measurement and measured data from Agisoft Photoscan software in which the assessment is better illustrated using root mean square error (RMSE). As a result, the 3D indoor model using UAV video is able to achieve accuracy up to ±5.3 cm. In conclusion, 3D indoor modelling using UAV video is feasible and can be beneficial for various purposes such as for architecture application.

***Keywords*:** Indoor; 3D Model; Dimension; Assessment; Qualitative

1. Introduction

Recent years show that Unmanned Aerial Vehicle (UAV) platform is a valuable source of data for inspection, surveillance, mapping and 3D modelling issues. UAV is a generic aircraft designed to work with no human pilot on board. The term UAV is commonly used in the geomatics community but other similar terms such as Remotely Piloted Vehicle (RPV), Remotely Operated Aircraft (ROA), Remote Controlled (RC) Helicopter, Unmanned Vehicle Systems (UVS) and Model Helicopter are also used often. The selection of UAV is based on size, weight, endurance, range, and flying altitude. One of the success factors for UAV lies in the possibility of equipping the platform with imaging sensor. This makes UAV particularly effective in surveillance, monitoring, and remote sensing application because of its capability of exploring inaccessible or dangerous area for human being (Remondino *et al*., 2011). Object modelling has received a great deal of attention recently since accurate 3D mapping and modelling of our environment have become prerequisite for different applications such as urban planning, 3D building modelling, archaeological documentation, environmental monitoring, pipeline inspection, infrastructure inventory and monitoring, landslide hazard assessment, open-pit mining, and indoor mapping. The demands of these emerging applications are increasing because of the limitations in financial and technical resources usually imposed by traditional mapping which is often expensive due to the usage of high-end data acquisition systems. Recent advances in hardware (low-cost high-resolution digital cameras, laser scanners, and navigation systems) and software developments have made it possible to conduct accurate 3D mapping without using costly mapping-grade data acquisition systems. Moreover, remarkable developments in Mobile Mapping Technology (MMT) have made accurate 3D mapping more feasible whenever required

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(El-Sheimy & Lari, 2015). 3D site modelling, particularly for indoor environments, poses significant challenges. From the object, modelling is to design, analyse and build 3D indoor modelling system that is capable of generating photo-realistic of the internal structure of multi-story buildings as well as the external structure of the building.

The project intended to assess 3D model indoor space using the data collected in the form of video. Basically, video is the combination of images in sequence to form a moving picture. A video transmits a signal to a screen and processes the order in which the screen captures should be shown. The many file formats in use for video differ primarily in the type of compression. Compression allows the video to be transmitted via a channel which the bandwidth is less than the raw data rate implied by the resolution and frame rate hence making compression an important process because even for a short video, there is a large amount of static images involved. It also enables the recipient is able to start displaying the video before the transmission is complete, a process known as streaming. 3D indoor modelling is a digital representation of the interior space in building to ensure the indoor space is in a good quality condition. Normally, 3D model is known to be carried out traditionally through sketching and drawing which could be time consuming. Basically, the dimension measurement of indoor structure such as height, width and long is often measured manually. However, these processes are time consuming and too complicated. Therefore, UAV has the potential as a tool to improve the method of data acquisition and processing in the field of 3D indoor modelling. Through this research, traditional 3D modelling could be replaced with a sophisticated method while maintaining the efficiency and accuracy of the data. Using the video from UAV, this problem can be resolved efficiently. The aim of this study is to assess UAV's video for 3D indoor modelling. Multi-rotor UAV is used for this project as a platform for the camera to capture UAV's video as a part of data collection. The UAV is selected because it fits the project's objectives. Additionally, data processing for this research includes the use of Agisoft PhotoScan software to create a 3D modelling. The area of this research is at Dewan Kuliah Besar, UiTM Shah Alam. The place is chosen because it corresponds to this project as the size is rectangular, close space area and there is no partition inside it.

Figure 1; The research area**.**

2. Research methodology

This methodology begins with planning and preparation including selection of study area, marking point, multi-rotor UAV, camera and camera calibration. Next step is data collection that consists of flight mission and UAV video capture. Then, data processing includes conversion of the video to images, image processing and visualizing 3D model from the processed images. The final step is data analysis that comprises analysis and accuracy assessment. Planning and preparation phase includes selection of study area, marking point, multi-rotor UAV, camera and camera calibration.

2.1 Selection of study area

This study is conducted at Dewan Kuliah Besar, UiTM, Shah Alam. The study area is located at Centre of Studies for Surveying Science and Geomatics. The place is chosen because it corresponds to the requisite of this project as the size is rectangular, close space area and there is no partition inside it.

2.2 Marking point

In this section, the first step to establish the marking point is to determine the best location for the marking point to be established by inspecting the structure of the building. The ideal criteria for placing the marking point are the location of the point can be easily found and the point is not blocked by obstacles, or to put it simply, the marking point can easily be distinguished in the picture taken using the camera The marking point is then established using total station through radiation technique. This technique can provide the position information includes bearing, horizontal distance, and vertical angle. For this study, sixteen marking points have been marked. **Figure 2** shows the point location for marking points that have been established. This is important for the data processing later. **Figure 3** shows the schematic diagram of field procedure where the total station coordinates will move to another marking point.

Figure 2; Marking Point.

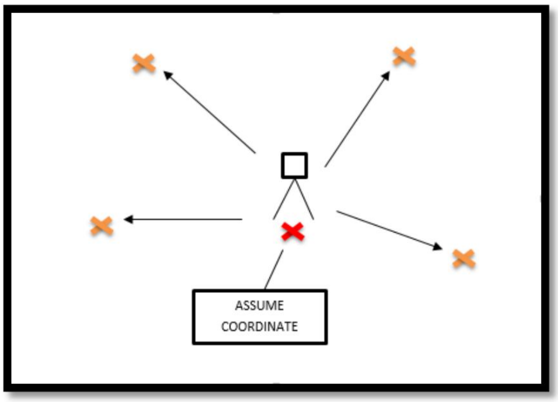

Figure 3; Schematic Diagram for Radiation Technique.

2.3 Camera calibration

Camera calibration is the process of finding the true parameters of the camera used for capturing photographs. Some of these parameters are focal length, format size, and principal point and lens distortion. Besides, nonmetric cameras are characterized by an adjustable principal distance, no film flattening or fiducial marks, and lenses with relatively large distortions. Calibration of a nonmetric camera allows at least some compensation to be made for systematic errors. The best techniques are looking at the shutter, focal point and lens used. The three of the main components must be in a good condition before the camera is ready to be used for this project. The accuracy of camera's parameter is the most important part in photogrammetry work and consequently, in completing this study. Without this step, the study cannot process 3D modelling. Then, the data is collected from the video captured using UAV to be used to process 3D indoor modelling. After planning and preparing work are completed, the phase of data collection can be started. The first step in data collection is UAV flight mission. The UAV is flown with the recording camera to get a video for data processing. The camera will record during the UAV flight.

2.4 Data Processing

The data processing starts by converting the video to image until visual 3D model as shown in the workflow in this section. The first step is to get the video record of Dewan Kuliah Besar in the UAV. Next, the video must be converted into images to allow them to be processed in the Agisoft PhotoScan software. Firstly, the video capture is extracted to convert it to series of images. The first stage is camera alignment. At this stage Agisoft PhotoScan searches for common points on photographs and matches them, as well as finds the position of the camera for each picture and refines camera calibration parameters. As a result, a sparse point cloud and a set of camera positions are formed.

The purpose of texture building is to inspect the texture before exporting the final product. The mapping mode offers few selection of methods but for this study orthophoto mode is chosen. This is because the orthophoto mode is capable of building texture for the whole object surface in orthographic projection. The orthophoto mapping mode also produces more compact texture representation than the Adaptive orthophoto mode at the expense of texture quantifying vertical regions. **Figure 4** shows the interface to perform build texture in AgiSoft Photoscan software.

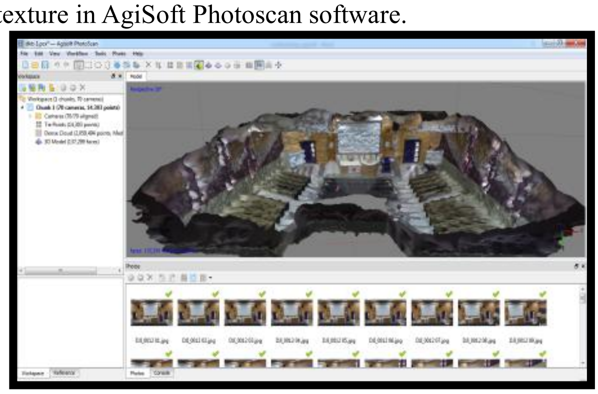

Figure 4; Build Texture.

3. Results and analysis

Marking point is used during data processing as a control to the accuracy of the output which is 3D modelling. In order to control the accuracy of 3D modelling, all images are processed using sixteen (16) marking points in this research. The location of the marking point must cover the structure of building and the marking point is placed while taking the ideal criteria of marking point establishment into account. The ideal criteria for placing the marking point are the location of the point can be easily found and the point is not blocked by obstacles, or to put it simply, the marking point can easily be distinguished in the picture taken using the camera. It is necessary in order to get as high accuracy output as possible. **Figure 5** shows the location of marking points.

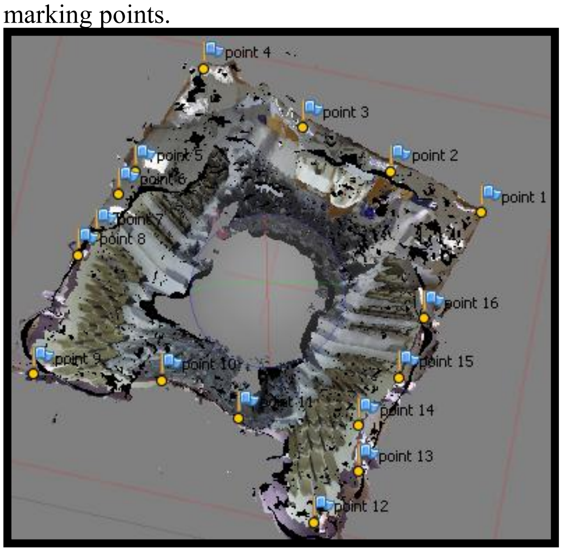

Figure 5; The Location Marking Point**.**

Radiation technique of total station observation is used in order to get coordinates. The total station also provides additional data such as bearing, horizontal distance, and vertical angle. From the collected data, coordinates are produced after the data have been processed. In this research, the coordinates obtained using the total station is the assumed coordinates. The collected data are calculated using trigonometry function while the elevation is calculated using the formula below:

$$SD = \frac{COS\ \alpha}{HD}$$

$$V = SD \text{ x } SIN\ \alpha$$

Where:

SD = Slope Distance

HD = Horizontal Distance

V = Vertical

α = Vertical Angle

Marker points are placed around the room area to obtain highest accuracy possible for the output. **Figure 6** shows twenty-eight marker points location.

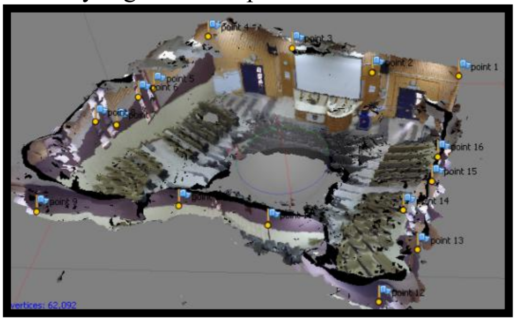

Figure 6; Markers Point**.**

To achieve the first objective of this research, 3D indoor modelling is generated from video capture. The images are processed through a set workflow commonly used for digital photogrammetry modelling consisting of photo adding, photo aligning, point marking, point cloud building, cloud mashing, and texture building. **Figure 7** shows the 3D indoor modelling.

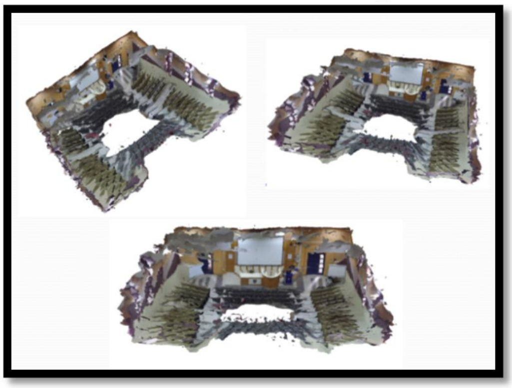

Figure 7; 3D indoor modelling**.**

In order to assess the measure distance of 3D modelling produced in this study, the root mean square error (RMSE) was carried out. The difference between measurement in Agisoft and actual measurement value from marking point has been identified. In short, this process has been carried out using Agisoft PhotoScan and Microsoft Excel so that the second objective of this research could be fulfilled. Twenty (20) samples of measurement have been measured on Agisoft PhotoScan software. The measurements have been marked at the same point as being measured on site. The comparison of distance between 3D model and measurement field checking also has been tested. The comparison was made between distance in software and on ground. Table

1 shows the residual for each sample.

Line	Measured (software) (m)	Actual (m)	Residual (m)
17-18	1.925	1.795	-0.130
19-20	3.598	3.675	0.077
21-22	1.266	1.360	0.094
24-25	1.976	2.050	0.074
26-27	0.612	0.600	-0.012
28-29	0.986	1.000	0.014
30-31	0.654	0.675	0.021
32-33	0.431	0.440	0.009
34-45	0.337	0.290	-0.047
46-47	0.462	0.450	-0.012
36-37	0.489	0.450	-0.044
38-39	0.491	0.450	-0.041
40-41	0.472	0.450	-0.022
43-52	1.101	1.200	0.099
44-45	0.302	0.295	-0.007
50-51	0.997	1.000	0.003
59-60	1.568	1.540	0.028
53-54	0.409	0.450	0.041
55-56	0.458	0.450	-0.008
57-58	0.441	0.450	0.009

Table 1. Residual for Comparison Measurement

Figure 8 shows the difference on actual measurement and software measurement. The value of the comparison could be analysed as illustrated in the graph where x-axis represents number of sample and y-axis represents residual. The graph shows 20 samples of measurements which the residual results are not the same because it is in different samples.

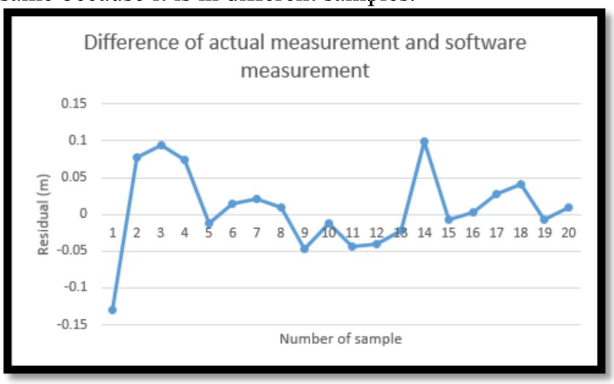

Figure 8; Difference of Actual Measurement and Software Measurement.

4. Conclusions and recommendations

In conclusion, the objectives are to capture UAV's video for 3D indoor modelling and to evaluate the 3D indoor model based on actual measurement. For example, the usage of multi-rotor UAV has accelerated the work on the field and save time on collecting the project's implementation, while the quality of the results can be maintained. In this study, the first objective was to capture UAV's video for 3D indoor modelling. To achieve this objective, 3D indoor modelling is generated using video capture. The image were processed through adding photo, aligning photo, marking point, building point cloud, mashing cloud, and building texture. The measured distance in 3D model and measured distance during field checking are compared and found to have difference. The comparison was based on the accuracy assessment, which is calculated using root mean square error (RMSE). The accuracy model in this study is about +0.053m. It can be concluded that UAV video can be used for 3D indoor modelling, for instance in architectural application.

Based on the research that has been done, there are some recommendations to improve the research for further study in photogrammetry field. The suggestions are to get the highest accuracy on 3D model output, to implement instruments with high accuracy for photogrammetry measurement, and to collect images from camera capture. Besides that, comparison between 3D models would lead to further analysis for the research of the same interest. Similarly, the comparison of different software would be able to determine the best software to achieve good quality 3D modelling.

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