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Accurate and Precision Monitoring using Unmanned Aerial Vehicle in Construction Engineering

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ABSTRACT

One of the monitoring work in a construction project is preparing a pictorial progress report to obtain a clearer and up-to-date information for a construction site. Usually, the pictures taken at the side view and inside the building cannot depict the entire construction site area due to constraints and visual limitations. This study utilized UAV technology to assist the control and monitoring of weekly construction work progress at the construction site through the visual image recording of the entire construction site. The study was conducted by recording images using the UAV Photogrammetry technique weekly for a month for the entire construction project site. Images recorded each week are then processed using pix4DMapper software to produce orthophoto images to illustrate the entire study area. All orthophoto images were then analyzed to determine weekly work progress and the most active and inactive areas from the first week to the week. The study found that UAV technology can help in monitoring construction work visually and can plan construction activities in a more organized manner.

Keywords: Construction, monitoring, progress project, unmanned aerial vehicle

1. INTRODUCTION

Monitoring and development progress is the most important task in development project management [1-7]. Every team member needs information, timely and accurate development projects, whichever they are now with a predetermined plan, whether deadlines are met, colours can be measured and followed safely [8-10]. Traditionally, digital cameras are used to record images at development sites with coverage area limited to the senses. Constraints are encountered when describing the entire construction area in a short time due to the inability to take pictures of the entire construction area from the point of view outside the reach of the senses [1].

Unmanned aerial vehicle (UAV) is increasingly used in different applications, such as mobile surveillance, environmental monitoring and as-built surveys in the construction field [3]. UAV is light, small in size, easy to control, less time, and less energy to fly across wide areas or long distances [6]. UAV technology allows for safe capture images, produces a mosaic image using pix4D software, and analyses the progress percentage by visual information or surpassing traditional methods [8]. This study focuses on using UAV technology as an alternative to digital cameras to capture images of the construction area at an altitude of 40 m from the ground level. The orthophoto image produced every week for a month can help monitor the progress of work on the construction site more easily and quickly.

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2. METHODOLOGY

This study was conducted on the construction area of 112 units, two-storey Terrace House in Phase R23-1, Lot PTD 14418, Pagoh Education Hub, Mukim Jorak, Muar District, Johor Darul Takzim, as shown in Figure 1.

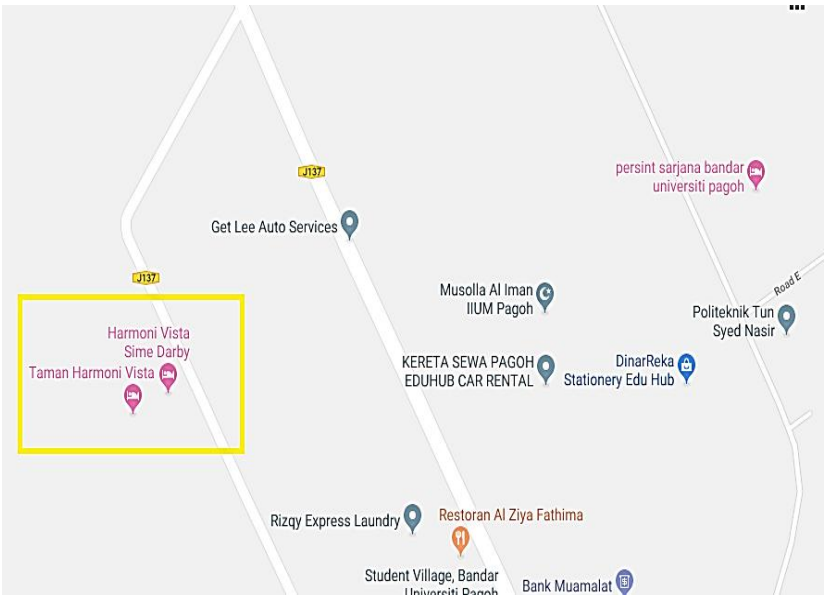


Figure 1. The location of the study area.

Initially, a comprehensive overview of the study area was made to identify the best and most appropriate methods to produce orthophoto images. The Pix4DCapture application software and the Phantom 4 Pro V2.0 UAV aircraft are used together to plan flight patterns and determine flight heights that will directly impact flight duration and coverage area. The altitude is one of the most important parameters for an UAV, especially during critical manoeuvres such as landing or steady flight [2]. Therefore, the altitude of the UAV must be high enough to prevent any collision. It also affects the speed of UAVs and image overlap rates to meet the requirements of photogrammetry techniques for the production of orthophoto images.

2.1 Data Collection

Data collection is a systematic approach to gathering and measuring information from various sources to get a complete and accurate picture of an area of interest [9]. The smartphone must be connected to the remote controller and UAV before activating the DJI Go. DJI Go is an app used to ensure that the UAV camera is connected with Global Positioning Systemic (GPS) so that the UAV can fly. This action was done by performing the Coordinate Calibration Setup to make sure the UAV accepts the GPS. This step will simplify the handling support of the navigator of the flight system. In regard to the safety concept for the use of such a flight system, the "come home function" guarantees a safe landing when the connection between the ground station and the flight system is interrupted. It can be checked in the DJI Go app before opening the Pix4DCapture Software.

In the Pix4DCapture process, a project file was created to start a grid mission. A grid mission was selected to produce the 2D map, and the coverage area was adjusted in flight time 5 minutes 39 seconds at an altitude of 40 m above ground level, covering an area of 115 m × 120 m (Figure 2). The camera was automatically adjusted to be vertically 90° to snap the images to obtain the plane view of the whole area. Data collection was completed every week for one

month at the same location on 18th October 2019, 25th October, 1st November 2019 and 8th October 2019.

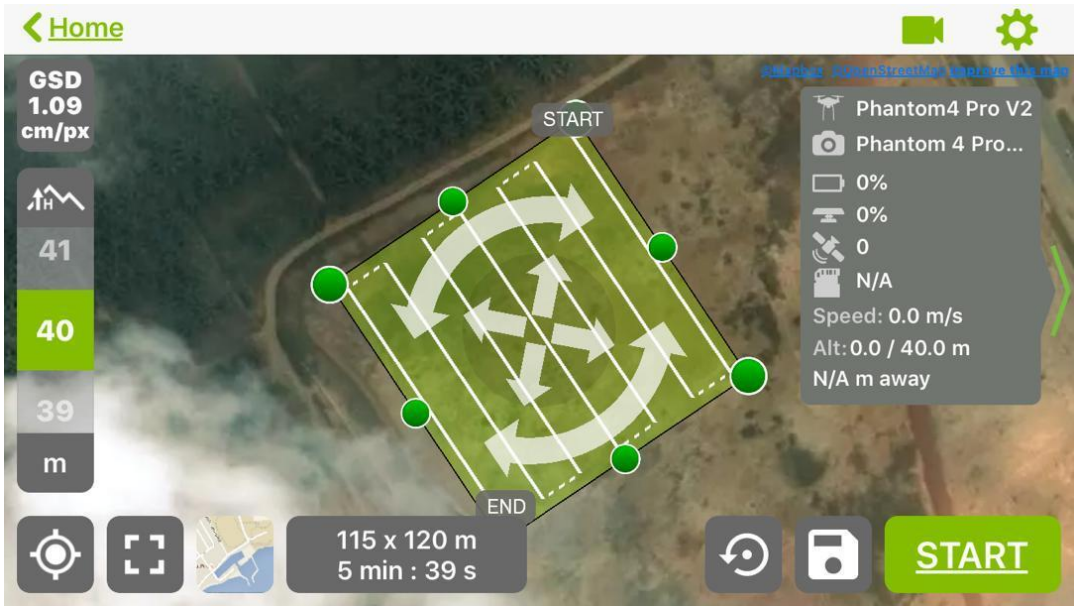


Figure 2. Pix4DCapture in data collection.

2.2 Image Processing

UAV Image processing was performed by uploading 85 images into a computer to be processed using Pix4DMapper software by adopting photographic techniques. This process involves selecting the appropriate template where the UAV flight location will appear in the map view section, as shown in Figure 3. The UAV flight interval is displayed on the window screen. Sequential processing involves Initial Processing, Point Cloud & Mesh, Digital Surface Model and finally Orthophoto production as the ultimate goal of image processing. The orthophoto images were used in the analysis of weekly construction progress. The analysis involves the comparison between each orthophoto image with construction site planning.

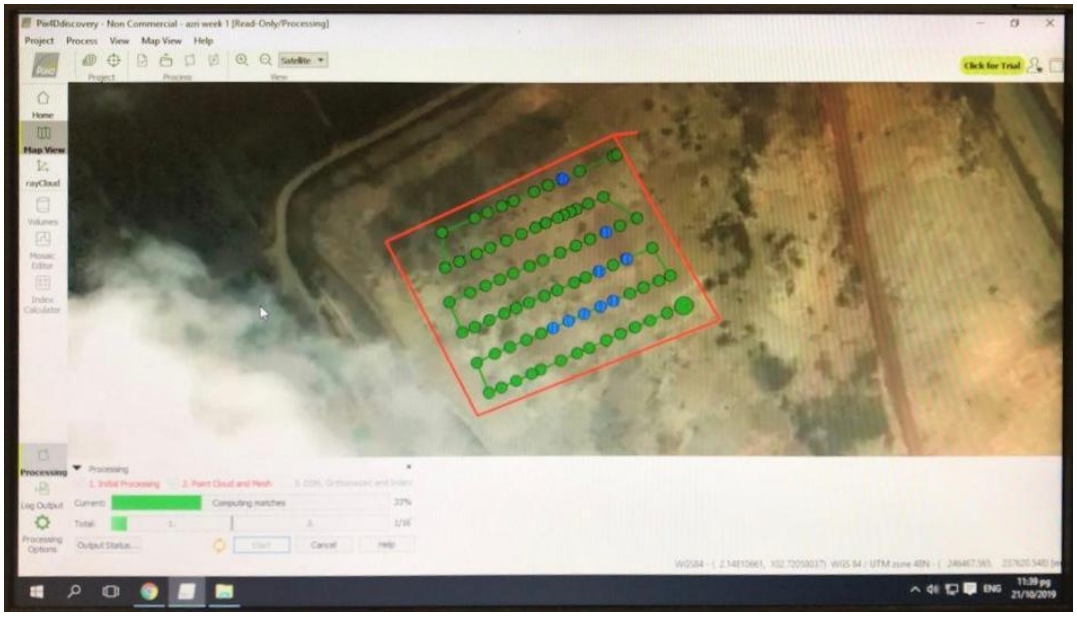


Figure 3. The map view section during image processing.

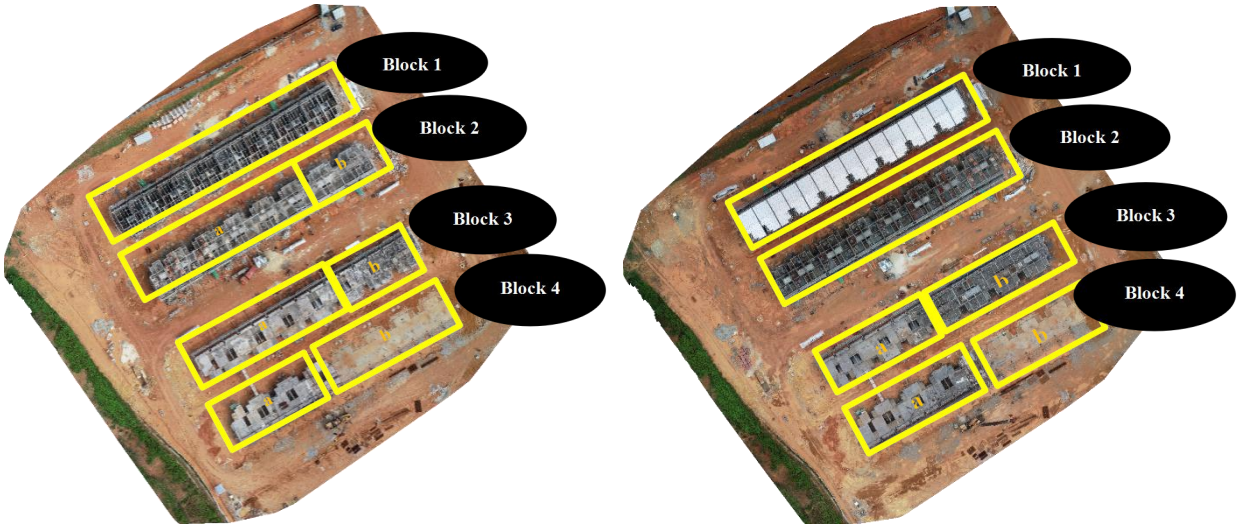
3. RESULTS AND DISCUSSION

Based on the whole picture over the four weeks, differences were observed from week one to week four, visualized by percentage. Figures 4 and 5 show the view of the construction site from the first week to the fourth week. Block 1 is the most active area. The marked areas—(a) and (b)—are areas where only weekly is found. In part 2 block is an active area, where what was seen was marked. The marked area of (a) and (b) show the percentage of each week, where the first week was 0%, the second week 15%, the third week 70%, and the final week was 90%.

Block 3 was a relatively active area because the work travel was more concentrated in Blocks 1 and 2. The percentage showed the marked areas of (a) with (b) show the first week at 0%, the second 5%, the third 30% and the fourth 70%. The last one is Block 4, a less active area as depicted in Figures 5 and 6.

(a) (b)

Figure 4. The view of the construction site (a) the first week on 18th October 2019 and (b) the second week on 25th October 2019.



(a) (b)

Figure 5. The view of the construction site (a) the third week on 1st November 2019 and (b) the fourth week on 8th November 2019.

3.1 Percentage of the Construction Progress

Based on overall images from week one to week four, the project progress percentage increased and constant from week one to week four. For the whole project, it is clear that Block 1 is the most active area and the progress showed from week one to week four indicated that 100% of the work focused on Block 1. Based on the visual observation, the percentage for Block 1 progress that involved water tank slab, upper roof beam, and roof trusses on week one was 0%. In the second week, the percentage increased to 50% for Block 1. By the third week, Block 1 increased up to 70 %, and in the fourth week, Block 1 was 100% complete. As for other blocks, the same approach was used. Figures 6 to 9 show the images from the top view of the construction building.

(a) (b)

Figure 6. The image of Block 1 in (a) week one (no progress yet) and (b) week two, brickworks complete after one week for upper roof beams and water tank slab, shows that 8 unit houses have been installed with water tanks.

(a) (b)

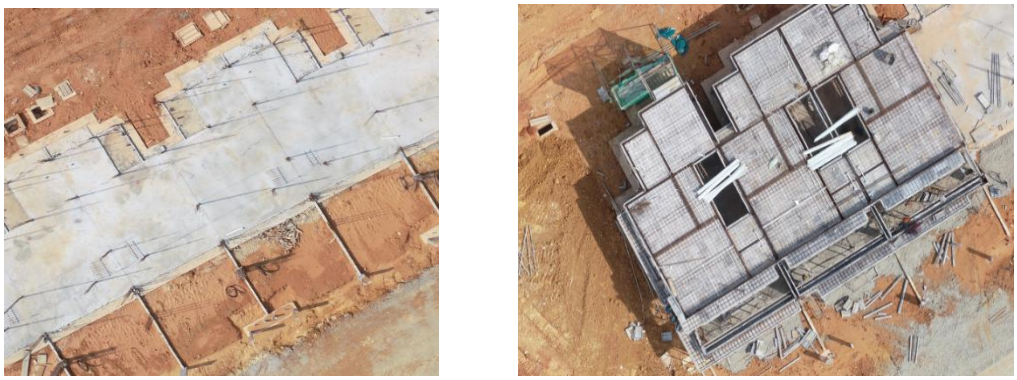
Figure 7. The image of Block 1 in (a) week 3, roof trusses are underway, and all houses complete installation of a water tank and (b) week 4, complete installation of roof trusses for first layer roof.

Finally, based on visual information, there are many differences to be seen compared to the original progress of the project site. Table 1 shows the duration of progress at the construction site. Accurate information can be gathered quickly and put to work on projects right from the start.

Table 1. The progress duration at a construction site

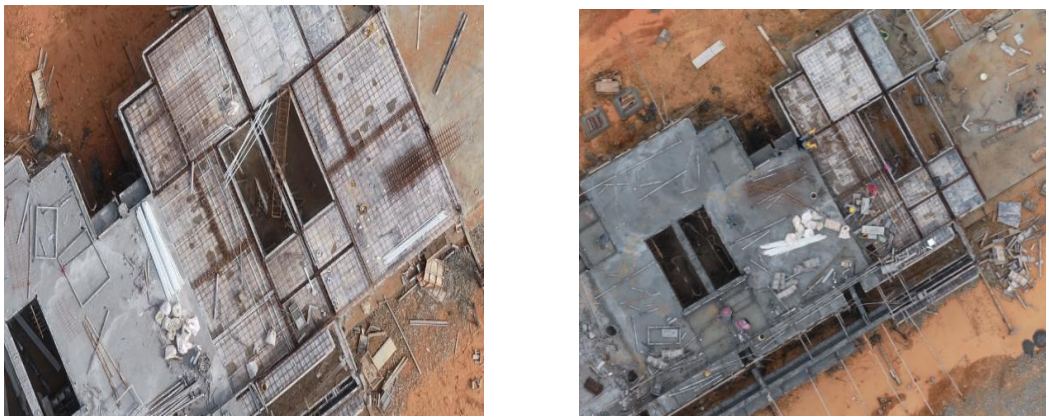
No	Task Name	Duration (days)	Start date	Finish date	Target (%)	Complete (%)
	GD. FL. Column, 1st. FL. Slab & Beams					
1	Block (Unit)	182	19-05-19	16-11-19	90	69
	Bk 1 (15 unit)	30	25-08-19	23-09-19	100	100
	Bk 2 (15 unit)	10	24-09-19	03-10-19	100	100
	Bk 3 (15 unit)	10	04-10-19	13-10-19	100	100
	Bk 4 (15 unit)	10	14-10-19	23-10-19	100	35
	1st. FL. Column & Roof Beam & Water Tank Slab					
2	Block (Unit)	178	02-06-19	26-11-19	75	54
	Bk 1 (15 unit)	16	15-09-19	30-09-19	100	100
	Bk 2 (15 unit)	10	04-10-19	13-10-19	100	100
	Bk 3 (15 unit)	10	14-10-19	23-10-19	100	50
	Bk 4 (15 unit)	10	24-10-19	02-11-19	100	0
	Upper Roof Beam					
3	Block (Unit)	171	16-06-19	03-12-19	62	44
	Bk 1 (15 unit)	7	01-10-19	07-10-19	100	100
	Bk 2 (15 unit)	7	14-10-19	20-10-19	100	100
	Bk 3 (15 unit)	7	24-10-19	30-10-19	100	0
	Bk 4 (15 unit)	7	03-11-19	09-11-19	57	0
	Staircases					
4	Block (Unit)	187	07-06-19	10-12-19	53	52
	Bk 1 (15 unit)	16	01-10-19	16-10-19	100	100
	Bk 2 (15 unit)	16	14-10-19	29-10-19	100	100
	Bk 3 (15 unit)	16	24-10-19	08-11-19	88	100
	Bk 4 (15 unit)	16	03-11-19	18-11-19	25	0
	Roof Furniture					
5	Block (Unit)	271	30-09-19	26-06-20	20	16
	Roof Trusses	111	30-09-19	18-01-20	39	32
	Bk 1 (15 unit)	16	08-10-19	23-10-19	100	100
	Bk 2 (15 unit)	16	21-10-19	05-11-19	100	30
	Bk 3 (15 unit)	16	06-11-19	21-11-19	6	25
	Bk 4 (15 unit)	16	22-11-19	07-12-19	0	0

Table 1 shows that overall construction images taken at the location at an actual site from week one to week four, visualized by visual percentage, demonstrated that Block 1 is the most active because all works focus on that block. Besides that, the active category is Block 2, where the area is restricted only to certain items, while Block 3 is moderately active with only 5 or 6 units of the houses were focused on every week. Finally, Block 4 showed as the less active area because there is no work done in the first week, and only 2 or 3 units of houses work were completed in other weeks. The weekly progress percentage showed that the first week 0%, the second week 5%, the third week 15%, and the fourth week 30%. Figures 8 and 9 show the less active area.



(a) (b)

Figure 8. The image of (a) the first week for Block 4, all level 2 related works have not been implemented and only the foundation can be seen, and (b) in the second week for Block 4, 3 unit of houses were complete to level 2, 3 unit houses have installed reinforcement for level 2, and 9 unit houses are still pending for level 2.



(a) (b)

Figure 9. The image of (a) the third week for Block 4, shows 5 unit houses has complete their slab to level 2, 2 units houses have installed reinforcement for slab level 2, 8 unit houses still pending for slab level 2, and (b) in the fourth week, 7 unit houses have complete slab to level 2, 1 unit house has installed reinforcement for slab level 2 and 7 unit houses are still pending for slab level 2.

4. CONCLUSION

In conclusion, this study proposed an alternative method of monitoring the construction progress activities using orthophoto images from UAV. Accurate weekly construction progress can be identified based on the building level and structure at each level. This progress was then compared with the construction planning schedule. The proposed method showed as a convenient way to monitor project progress. This method is better than the existing method because it helps the site engineer or site manager easily capture the progress.

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