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Towards Safe Cities & Resilient Communities

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DIFFERENT FLYING METHOD IN PRODUCING 3D MODELING RECONSTRUCTIONFOR SINGLE TREE USING AERIAL PHOTOGRAPH OF UNMANNED AERIAL VEHICLE

Suzanah Abdullah[1], Khairul Nizam Tahar[2]*, Mohd Fadzil Abdul Rashid[3], Muhammad Ariffin Osoman[4], Mohd Zulfadhli Mohd Noor[5]
[1,3]Faculty of Architecture, Planning and Surveying, University Teknologi MARA, Seri Iskandar Campus, Seri Iskandar, 32610 Perak, Malaysia
[2]Department of Geomatic Sceince, Faculty of Architecture, Planning and Surveying, University Technology MARA Shah Alam, Malaysia
[4,5]Geoinfo Services Sdn Bhd, Taman Melawati Kuala Lumpur, Malaysia
Email of corresponding author *: suzan156@perak.uitm.edu.my, nizamtahar@gmail.com, abrfazil@gmail.com, ariffin@geoinfo.com.my,
Email of corresponding author *: zulfadhli@geoinfo.com.my

Abstract – This paper shows the product of 3D model of single tree using different views of digital images. Typically, the users of 3D modelling become vital in certain applications that require measurement to determine the height, width, lenght, volume ofthe object. There are several technologiesused to produce 3D models but requirehigh cost. However, currently, with an advanced in technology development, an Unmanned Aerial Vehicle (UAV) is one of the emergence technologiesthat offers solution to overcome the issues with a higher quality of result. UAV is widely used for aerial photograph and commonly used for collecting data in both small and larger areasor larger and small scales. More importantly,this technology is also effecientinproducingthree-dimensional (3D) information with a higher resolution image. Thus, the current paper attempts to demonstrate the ability of the UAV technology for 3D extraction of single tree using different flying method. This research adapts aquantitative method that implement the experimental process in data acquisition of single tree. Convergent and stereo configuration are employed duringphotography fordata acquisition.This paper presents results of 3D modelling reconstruction of single tree taken by UAV DJI 4 Pro.
Keywords - UAV,3D model, Aerial Photograph, Single tree

1 INTRODUCTION

Typically, the 3D structure of plant is important for many ecology studies and forestry applications (Lindberg & Holmgren, 2017),which is the point cloud data that are used to reconstruct realistic 3D tree models (Huang et al, 2015). The interpretation of a tree is more difficult than building reconstruction (Gong et al., 2002)and artificial object (Lindberg & Holmgren, 2017) due to the natural variation in appearance and characteristics such as different sizes and shapes of trees. A few years earlier, 3D mapping technology becomes available for civilian application. Currently the technology of data acquisition for mapping has grown rapidly not only in terrestrial but also non-terrestrial measurements. The requirements of the technology mapping have increased since the usageof the UAV system(Tahar & Ahmad, 2012). This factor is influencedby the ability to save cost as well asable to collectdata fastand hasa higher resolution image of 3D model generation.

Recently, the use of UAV technology is almost in the line with the advance technology, particularly for aerial mapping technology. However, every technology or method in measurement always has its advantages and disadvantages.This is inaccordance with the goals and targets to be achieved during measurement. There are various methods used to generate 3D mappingin line with the demand and high developmentofmappingin various fields. Chang et al., (2015) and Grenzdörffer et al., (2008) mentioned that UAV has been used rapidly because it is much more flexible, weather independent and efficiently produce very high resolution orthogonal-corrected image and terrain data in 3 dimensional. Furthermore, this technology has the advantages such as real-time, high spatial and temporal data solutions as required by other disciplines (Hackney & Clayton, 2015; Ruzgiene et al., 2014). Moreover, Uysal et al., (2015) highlights the UAV is an alternative technology that can replace the terrestrial method for image acquisition in small area coverage. Due to that, this technology is more economical to use compared to the conventional aircraft, while it can reduce the labourcost, require less maintenance and flexibleduring thetake-off and landing area (Tuominen et al., 2015). In addition, this technology also is ableto immediately collect data and thus the data can be processed faster(Ruzgiene et al., 2014).

2 THE CURRENT APPLICATIONS OF UAV FOR 3D MODELLING

Aerial photogrammetry is defined as any images taken from the air using the specific camera mounted on the plane and is very useful in many different types of applications. In the last decade, photogrammetry has been used in community mapping and the use of aerial photogrammetry become an emergence of new trends in the geospatial industry for 3D model. The uses of 3D is an important product and demand in many applications such as building extraction (Frommholz et al., 2015; Andre Fischer et al., 1998; Xie et al., 2012), archaeology (Barsanti et al., 2012; Fabio Remondino, 2011; Gonizzi Barsanti et al., 2013), communication (Gool et al., 2002), visualisation and so on. Several methods in photogrammetry are used to generate 3D model using traditional methods such as Airborne LiDAR, telestrial laser scanning and ground survey. However, this method is considered very expensive for ground orthorectification (Rahmayudi & Rizaldy, 2016) especially for small study areas (Polat & Uysal, 2017). Currently, the development of UAV has become an alternative technology and replaced conventional method in produce 3D model. Furthermore, this technology becomes an attractiveselection for aerial photogrammetry in several areas(Silva et al., 2015) and can produce a large amount of 3D georeferenced data in a short space of time.

Therefore, the use of UAV technology has grown rapidly in the world of photography, slope mapping (Tahar & Ahmad, 2012) and security application (Ma'sum et al., 2014) as well as the private sector based on certain interests. In navigation area, UAV isused for mapping the aerial photograph for certain purposes. Moreover, the advantages of using UAV in aerial photograph is very sufficient since the data acquisition requires inexpensive process with high resolution data. Besides, itis able to fly under cloud cover and easier to handle than a manned vehicle (Ajayi et al, 2017). Recently, UAV representsapplication on vegetative health monitoring, precision agriculture, urban forestry, emergency management, biological and traffic monitoring (Ritter, 2014). In addition, Jannoura et al., (2014) and Xiang and Tian, (2011) have examined the abilities of UAV application in agriculture. This current paper attempts to explore the application of the DJI Phantom 4 Pro UAV technology to produce 3D model of single tree using the different methods of image captured. Specifically, this paper applies a rotar wing quadcopter 4 pro with the manual flight operation for image acquisition at an altitude 50m above ground level. It is also equipped with 8.8mm focal lenght and 72 dpi resolution DJI 4 pro camera operating in manual mode.

3 METHODOLOGY

In this paper, the experimentalapproach of quantitative method wasused to collect the data in different view of camera configuration in order to achieve the structural of single tree. The experimental process consists of four phases. Phase one dealt with the planning for selection of study area and software, phase two addressedthe data acquisition process using UAV DJI 4 Pro, while phase three wasthe most important part, that was thedata processing and finally, the phase four results and data interpretations (Figure 1). Thisstudywas conductedusing two types of camera configuration in the process of image acquisition: DJI 4 Pro camera in convergentand stereo configuration with altitude of UAV flying that was50m.

4 EXPERIMENT EXECUTIONS AND RESULTS

4.1 Planning

This study was carried out at 30m x 30m areas,located at the Bandar Universiti, which includes a single tree. The image processing was performed using Agisoft Photoscan software in order to produce 3D model and camera calibration. All parameters value from camera calibration wereapplied in 3D processes.

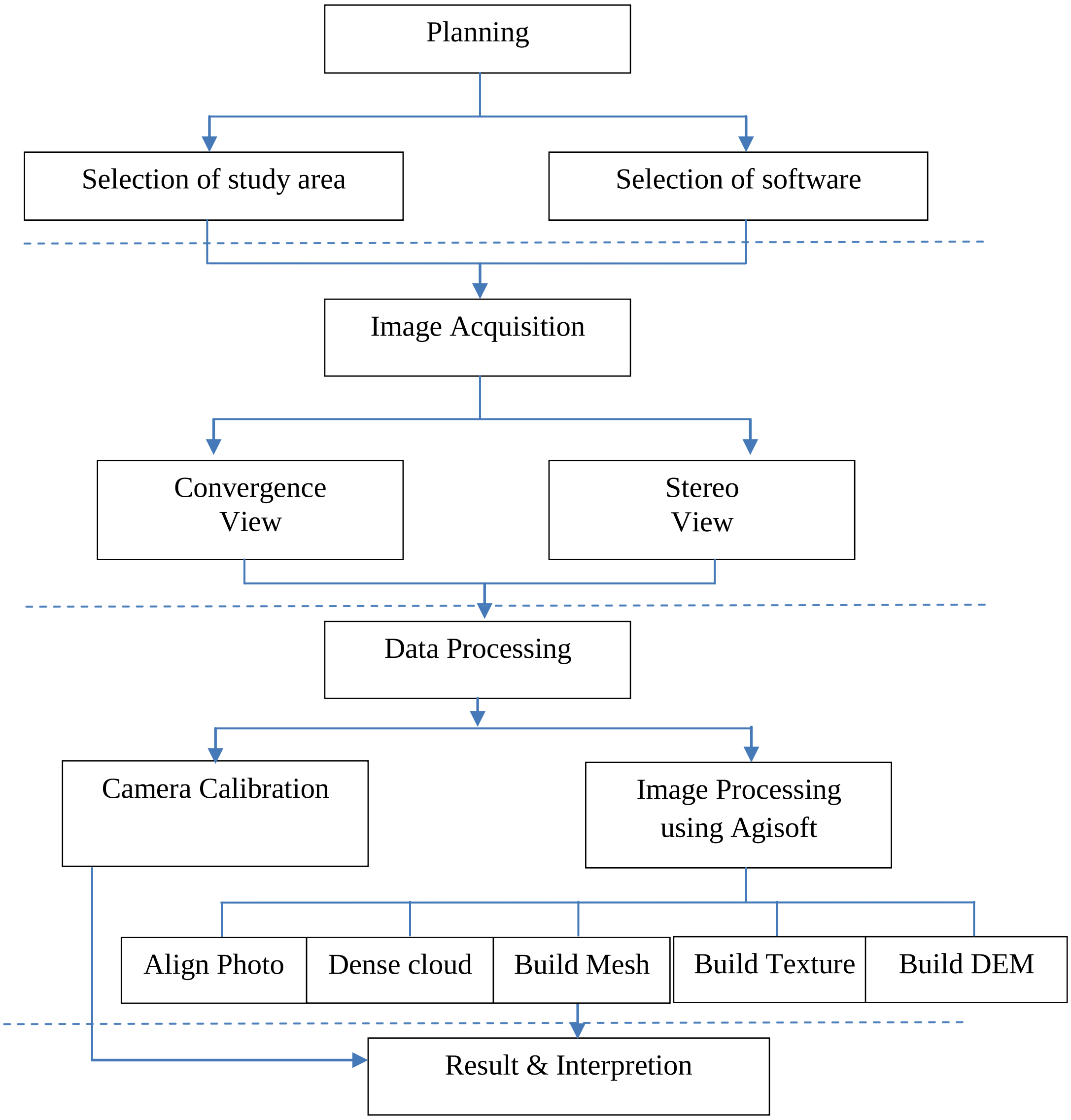


Figure 1 Four experimental stages in the 3D modelling of single tree

4.2 Image Acquisition

The images was taken using UAV DJI 4 Pro an altitude 50mabove the tree as shown in Figure 2. During image acquisition process, the aerial images were captured usingtwo methods such as convergent and stereo camera configuration. UAV was flown at the height of 50m for both convergent andstereoview. The 38 images for camera configuration in convergent and 50 images for camera configuration in stereo were acquired. The selected images per camera configuration were chosen for camera calibration process. The internal parameter values of camera calibration was used for the processing in order to generate 3D model of single tree.

4.3 Data Processing

4.3.1 Camera Calibration Process

Camera calibration process was implementedin order to determine the internal parameters of the UAV camera using Agisoft software. This software identified the midpoint of four main points by using algorithm and automatically generate parameter of camera.

Figure 2: Single tree

4.3.2 Processing of 3D for Single Tree

In this phase, digital image processing was conducted for both convergent and stereo images to produce the 3D model from UAV imagery using Agisoft Photoscan software. The aerotriangulation wasused to perform the production of 3D process.Moreover, all the process such as point cloud and texture creation should be executed before generatingthe 3D model. Figure 3 shows the process of creating 3D for both convergent and stereo camera configuration images using Agisoft software. The imageswere performed to align photo and continued to other processes such as build dense cloud, build mesh, build DEM and also orthomosaic. In addition, this software wasused to build 3D reconstruction, visualization, survey and mapping works.

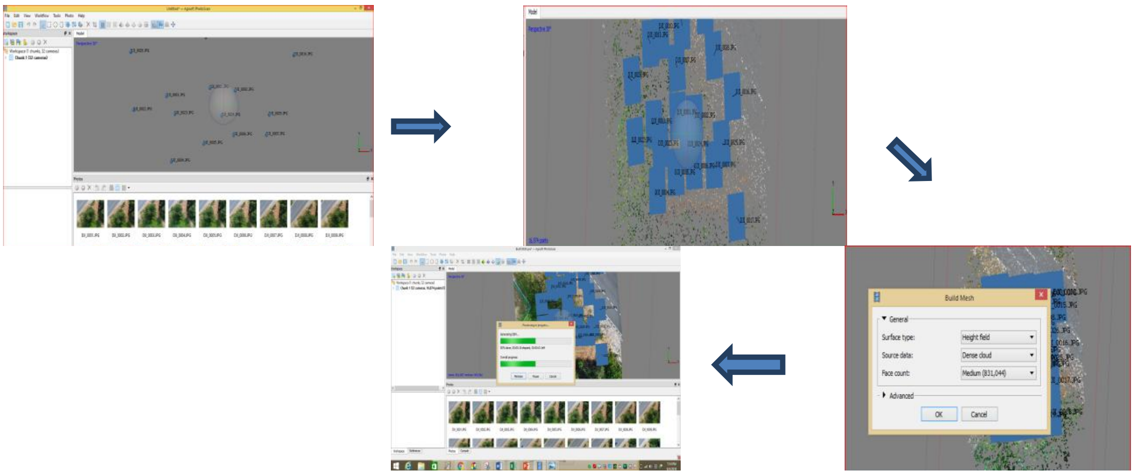


Figure 3: Process image using Agisoft Photoscan

The identification of tie point was conducted at the beginning of the process to align the digital photo automatically using invariant algorithm. This algorithm recognized the coresponding pixel point and shapethe pointto become a 3D model.The position orientation between relative point was obtained with the formation of point cloud. In this situation, the same pixel values of objects were recognized. The process of creating geometric model is formed between images and tie points based on the height values. However, the geometry model formation did not show the actual image condition until the process of 3D texturelike triangle network isproduced.

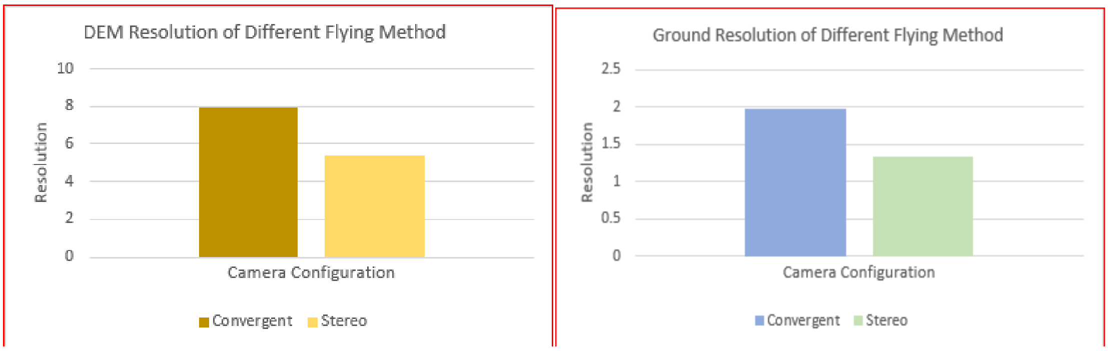
4.3.3 Result andInterpretation

The process of camera calibration is automatically generated using Agisoft Photoscan software. The camera calibration process for this software was performedautomatically and produce the internal parameter of the camera based on the image resolution. The internal parameter of the camera namely lens distortion (K_1, K_2, K_3 as well asdescentring distortion (P_1, P_2) should be in good condition before performing any measurements. The result of camera calibration of both images is stated in Table 1.

Table 1: Internal Parameter of UAV Camera

Parameter	**Convergence (mm)**	**Stereo (mm)**
Focal Length	8.8mm	8.8mm
Fx	2454.68	2454.28
Fy	1824.15	1833.37
K_1	0.00598955	0.00843669
K_2	-0.0273261	-0.0259487
K_3	0.0303845	0.0282228
P_1	-0.000759803	-0.000630832
P_2	0.00130984	0.00150525

The image of single tree was taken using convergent and stereo camera configuration. There are different result shownbetween both flying method convergent and stereo during data processing.The result shows the comparison DEM resolution and ground resolution of both flying methods. The resolution image of stereo configuration recorded 5.37cm/pixel values of DEM resolution compared to a convergence whichrecorded 7.92cm/pixelvalue of DEM resolution as shown at Figure 4(a). Besides, the ground resolution of stereo flying method recorded 1.34cm/pixel compared to convergent recorded 1.98cm/pixel shown in Figure 4(b).



(a) (b)

Figure 4: Reconstruction of 3D Model (a) DEM Resolution (b) Ground Resolution

In the rectification process, the intensity value for each pixel was sampled using equation of space resection, camera tilt, terrain relief and image displacement. Figure 5 illustrates the 3D model of single tree for stereo and convergence view. The 3D model of convergent view shows a better image compared to 3D model of stereo view. Although, the resoltion of stereo image was smaller than the convergent image, the production of 3D model by stereo image are less than satisfactory. However, the resolution depends on the parameter of the camera mainly focal length, resolution of camera and also flight altitude.

5 CONCLUSIONS

Digital rectification becomesimportantdue to the fact that image should be combined with digital maps.In producing the 3D model of object, orthophoto is animportant process to ensure that the distortion over the aerial photographs due to the method of data acquisition and the relief of the landisremoved . This wasformed from the stereophoto obtained from the surface with certain height and has been corrected with the point coordinates. The result shows method of convergent configuration is sufficient for the purpose of 3D modelling, while the method of stereo configuration is preferred for 2D mapping. However,the resolution image for both of the different flying method are acceptable in the GIS industry.

(a) (b)

Figure 5 Image of 3D Model (a) Stereo View (b) Convergent View

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