UAV Photogrammetry for Generating 3D Campus Model

by Cindrawaty Lesmana

UAV Photogrammetry for Generating 3D Campus Model

Muliady[1,b)], and Erwani Merry Sartika[1,c)], Cindrawaty Lesmana[2,a)] and Elizabeth[3,d)]

[1]*Department of Electrical Engineering, Universitas Kristen Maranatha, Bandung, Indonesia*
[2]*Department of Civil Engineering, Universitas Kristen Maranatha, Bandung, Indonesia*
[3]*Department of Visual Communication Design, Universitas Kristen Maranatha, Bandung, Indonesia*

[a)]Corresponding author: cindra@eng.maranatha.edu
[b)]muliady@eng.maranatha.edu
[c)]erwani.merry@eng.maranatha.edu
[d)]elizabeth.wianto@art.maranatha.edu

Abstract. Unmanned Aerial Vehicle (UAV) is increasingly popular as platforms for inspection, professional mapping, and modeling issues. UAV as a low-cost alternative to the classical manned aerial photogrammetry can survey buildings of various heights to take the necessary angle for a favorable photo. This paper presents results of using 3D reconstruction technique based on 2D pictures of a building taken by UAV. Automation and feasible image orientation create images to be processed in the latest developments of UAV image processing methods for photogrammetric applications, mapping, and 3D modeling issues. Images from a campus building construction in Bandung was taken for a case study using UAV with an attached camera. The images were processed to generate a 3D model of campus building using several integrated software. The integrated software was used to create image processing, mapping, orthophoto, and meshing. By using the proposed setting of altitude, overlapping percentage, direction of flight, the results show good quality of regenerated images which contain information of altitude and position of the building.
Keywords: UAV, 3D Modeling, Mapping, Photogrammetry

INTRODUCTION

Recently mapping technology not only requires to the recording position, size, and shape but also need to generate accurate and realistic 3D models. A number of surveys have concerning methods to create 3D models of buildings based on image processing[1, 2]. However, some researchers argued that the users of commercial aircraft were unreasonable to generate a model of a single building[3]. Thanks to effective and methodological development of technology, the role of documentation to generate 3D models can be conducted, although there is some limited ability of ground photography. UAV as a generic aircraft design to operate with no human pilot onboard is a low-cost alternative to the classical manned aerial photogrammetry[4].

UAV photogrammetry indeed opens various, new applications in the close-range aerial domain and introduces also a low-cost alternative to the classical manned aerial photogrammetry[5]. Many types of research indicate that UAV is affordable, reliable, and easy to use for geospatial information[6, 7]. The UAV photogrammetry and processing techniques provide a set of new tools for experts to capture, store, process, share, visualize and annotate 3D models in the field[8]. In this paper, UAV images of a campus construction are used to create a 3D model. The research is to develop procedures for the UAV data acquisition and processing that can lead to automated workflow and complete results.

CASE STUDY

The case study is a campus building which is the building under construction that located in Bandung, Indonesia. Drone DJI Phantom 4 Pro Obsidian was used to conduct an aerial survey of the campus building. The UAV was completed with camera sensor 20 megapixels with 1-inch depth to take photos above and around the campus. High precision 3 axis camera stabilization platform was added to allow smooth aerial photography. Furthermore, the drone specification can be seen in Table 1 and the camera parameters can be observed in Table 2. The integrated GPS system, such as position holding, altitude lock, and stable hovering was included to provide constant stability in flight. The project's parameters were projected planning, setting of altitude, overlapping percentage, and direction of flight to create orthophoto and 3D Models. The whole process of data acquisition and processing can be seen in Figure 1.

TABLE 1. Specification of the drone

Drone Specification	
Weight	1388 g
Diagonal size	350 mm
Max. flight speed	72 km/h
Max. flight time	30 mins
Max. height	6000 m
Operating temperature	0°-40°C
Range	6.4 km
Max. vertical speed	6 m/s up 4 m/s down

TABLE 2. Parameters of the camera

Camera Parameter	
Sensor size	**1-inch CMOS (16 mm diagonal)**
Focal	**8.8 mm**
Width	13.2 mm
Focal length	20 mm
Effective pixels	20 Megapixel

Flight Planning

The mission planning was done within three steps of setting, which were the area of interest, the required ground sample distance, and the parameters of the mounted digital camera. The take-off and landing operations were controlled from the ground by a pilot using a remote controller. However, the flight and data acquisition was set to be autonomous. During the flight, the UAV was observed with a control station using a mobile phone which shows real-time flight data such as position, speed, attitude and distances, Global Navigation Satellite System (GNSS) observations, battery or fuel status, rotor speed, etc. Most of the systems allow then image data acquisition following the computed 'waypoints' as can be seen in Figure 2, while low-cost systems acquire images according to a scheduled interval. The flying altitude was 105 meters in order to produce acceptable resolution images. The side lap and front lap were set to be 85%. Flight direction was 120 with 15m/s speed. The total number of images were 139 pictures. The sample of data acquisition from the UAV can be seen in Figure 3.

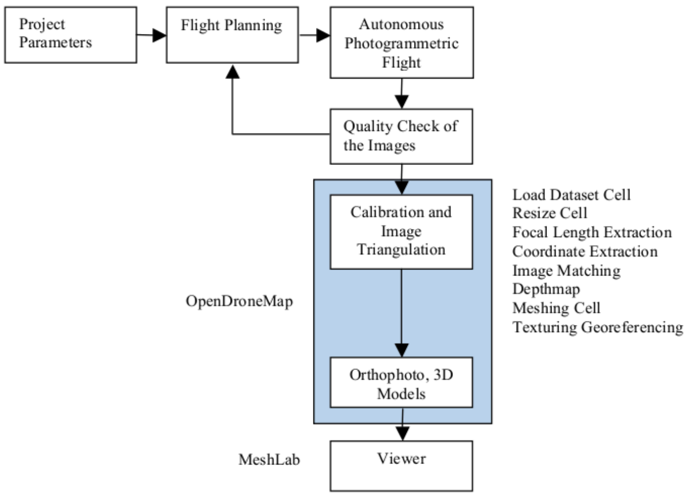

FIGURE 1. Workflow for processing of the UAV data

FIGURE 2. The input of the waypoints

FIGURE 3. Data acquisition sample from the UAV

Image Processing

Once a set of images has been oriented, OpenDroneMap the command line toolkit open source was used for mapping. In this stage, the images were resized, and the camera was calibrated, also the focal point and width were set for the correction of the images. The number of minimum fixtures was set to define how many points will be used from each image, and the images were a group using hybrid bundle adjustment. For the output preparation, there were several parameters should be set. The orthophoto can be set by using 2.5 mesh and the used of Patch-based Multi-view Stereo (PMVS) or Clustering View for Multi-view Stereo (CMVS). The number of vertexes can be defined in the mesh size and the color can be balanced in gauss-damping, global seam leveling, and gamma tone mapping. The results for orthophoto, a point could, and a 3D model was illustrated in Figure 4.

a. orthophoto b. point cloud c. 3D model

FIGURE 4. Image processing results

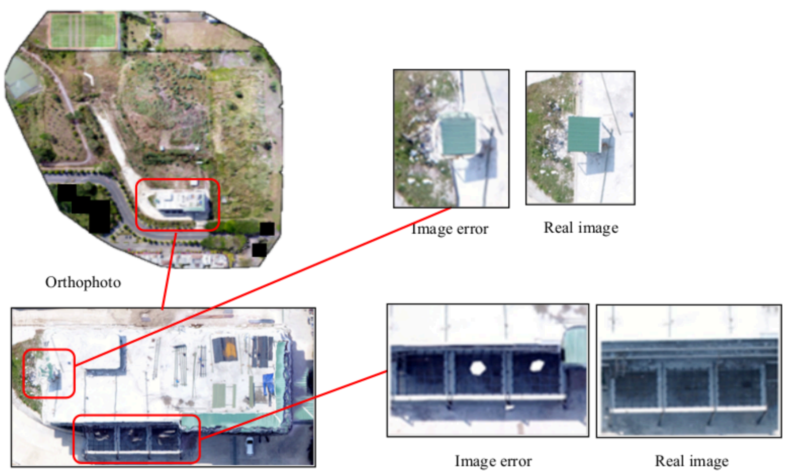

FIGURE 5. Some errors of analysis data

RESULTS

Using the acquired images, a building construction and area mapping were generated. In general, image processing can plot the whole area precisely. However, the visual comparison between UAV-images and OpenDroneMap-orthophoto (Figure 5) shows there are some unexpected errors from the detail of the analysis. For examples, a deep-set in the rooftop and some holes in the canopy can be diverse with the real image data from a drone. The neighboring points of the flight plan which defined to close to each other generate a miss-interpretation in the flight control software. During the flight acquisition, if one predefined data acquisition point was skipped or given higher the deviation standard in the processing image produce better mapping. Reducing the minimum feature in-depth map computation into 12000, 8000, and 5000 points were not processed significant mapping. The higher the minimum features affected lesser of the cloud points for the processing images not to the general mapping results. The higher minimum features and resize images can improve the output quality but those setting will higher the computer requirements and create a more extended calculation since the number of the minimum features will affect the quality and the accuracy of the image matching process.

CONCLUSION AND FUTURE WORK

UAV is becoming a cost-effective tool for building to the documentation and mapping with high-resolution data. The study shows that high-resolution aerial pictures can be acquired with the simple technique and texturing process. The integrated software was used to create image processing, mapping, orthophoto, and meshing. The insufficient number of images and misinterpret processing to affect the deviations of the result models. By using the proposed set of altitude, overlapping percentage, direction of flight, the results show good quality of regenerated images which contain information of altitude and position of the building. Further work will be devoted to the creation of full 3D models of buildings with more detail textures and complicated structures. A validation between UAV's mapping to the manual survey is also in the scope of the author's interest.

ACKNOWLEDGMENTS

This research is funded by Penelitian Dasar Unggulan Perguruan Tinggi from the Ministry of Research, Technology and Higher Education, Indonesia – 2018, under contract number 087.F/LPPM/UKM/III/2018. The research is also supported by Faculty of Engineering, Faculty of Arts and Design, and Research and Social Services Institute of Universitas Kristen Maranatha.

REFERENCES

1. F. Remondino, L. Barazzetti, F. Nex, M. Scaioni and D. Sarazzi, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. **XXXVIII-1/C22**, 25-31 (2012).
2. D. Kaimaris, P. Patias, and M. Sifnaiou, International Journal of Intelligent Unmanned Systems **5** (1), 18-27 (2017).
3. T. T. Bertram, T. T. Bock, A.G.Bulgakov and A.A.Evgenov, presented at The 31st International Symposium on Automation and Robotics in Construction and Mining (ISARC 2014), Sydney, Australia, 2014 (unpublished).
4. Y. Ya Ning, W. Kuo Hua, and H. Hui Yu, in *XXIV International CIPA Symposium*, edited by R. S. a. S. I. S. ISPRS Annals of the Photogrammetry (Copernicus, Strasbourg, France, 2013), Vol. II, pp. 331-336.
5. H. Eisenbeiss, The International Archives of the Photogrammetry - Remote Sensing and Spatial Information Sciences **37** (B1), 977-983 (2008).
6. I. Colomina and P. Molina, ISPRS Journal of Photogrammetry and Remote Sensing **92**, 79-97 (2014).
7. K. Themistocleous, Journal of Archaeological Science: Reports **14**, 774-781 (2017).
8. K. Themistocleous, A. Agapiou, and D. Hadjimitsis, in *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* (11th 3D Geoinfo Conference, 2016), Vol. XLII-2, pp. 45-49.

UAV Photogrammetry for Generating 3D Campus Model

ORIGINALITY REPORT

18%	11%	11%	10%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	etd.cput.ac.za Internet Source	2%
2	"Remote Sensing for Archaeology and Cultural Landscapes", Springer Science and Business Media LLC, 2020 Publication	2%
3	www.spiedigitallibrary.org Internet Source	1%
4	www.myfoodresearch.com Internet Source	1%
5	www.science.gov Internet Source	1%
6	Alessandra Cianciosi, Saša Čaval, Diego Calaon, Krish Seetah. "Integrated Remote Sensing to Assess Disease Control: Evidence from Flat Island Quarantine Station, Mauritius", Remote Sensing, 2022 Publication	1%
7	Submitted to Flinders University Student Paper	1%
8	Submitted to Universiti Teknologi Malaysia Student Paper	1%
9	www.iaarc.org Internet Source	1%
10	www.semanticscholar.org Internet Source	1%

11	H Ys, A D Simanjuntak. "The Performance of Permanent Magnet Core of Reducing Sag Voltage in Personal Computer (PC)", IOP Conference Series: Materials Science and Engineering, 2019 Publication	1%
12	Khairil Afendy Hashim, Anuar Ahmad, Abd. Manan Samad, Khairul NizamTahar, Wani Sofia Udin. "Integration of low altitude aerial & terrestrial photogrammetry data in 3D heritage building modeling", 2012 IEEE Control and System Graduate Research Colloquium, 2012 Publication	1%
13	Submitted to The University of Manchester Student Paper	1%
14	Submitted to Institute of Graduate Studies, UiTM Student Paper	1%
15	Yichen Yang, Xuhui Lee. "Four-band Thermal Mosaicking: A New Method to Process Infrared Thermal Imagery of Urban Landscapes from UAV Flights", Remote Sensing, 2019 Publication	1%
16	"Sensors and Instrumentation, Aircraft/Aerospace, Energy Harvesting & Dynamic Environments Testing, Volume 7", Springer Science and Business Media LLC, 2021 Publication	1%
17	Robbi Rahim, Darmawan Napitupulu, Heri Nurdiyanto, Usti Fatimah Sari et al. "Pixel image steganography using EOF method and	<1%

modular multiplication block cipher algorithm", IOP Conference Series: Materials Science and Engineering, 2018
Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		

UAV Photogrammetry for Generating 3D Campus Model

FINAL GRADE

/0

GENERAL COMMENTS

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5