A Simple Aerial Photogrammetric Mapping System Overview and Image Acquisition Using Unmanned Aerial Vehicles (UAVs)

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Abstract

Aerial photogrammetry is one of the Alternative technologies for more detailed data, real time, fast and cheaper. Nowadays, many photogrammetric mapping methods have used UAV / unmanned drones or drones to retrieve and record data from an object in the earth. The application of drones in the field of geospatial science today is in great demand because of its relatively easy operation and relatively affordable cost compared to satellite systems especially high - resolution satellite imagery. This research aims to determine the stage or overview of data retrieval process with DJI Phantom 4 (multi - rotor quad - copter drone) with processing using third party software. This research also produces 2 - dimensional high resolution image data on the research area. Utilization of third party software (Agisoft PhotoScan) making it easier to acquire and process aerial photogrammetric data. The results of aerial photogrammetric recording with a flying altitude of 70 meters obtained high resolution images with a spatial resolution of 2 inches / pixels.

Keywords: Aerial Photogrammetric, UAVs, High Resolution Image, Spatial Data

1. Introduction

Photogrammetry is an art, knowledge and technology to obtain data and information about an object and its surroundings through a process of recording, measuring and interpreting photographic images (Wolf, 1981). Mapping of the information on kepri island/ Batam city, Indonesia according in (Farizki & Anurogo, 2017; Aprilliyanti & Zainuddin, 2017, Sari & Lubis, 2017; Lubis, & Daya, 2017; Lubis et al., 2017).

Unmanned Aerial Vehicle (UAV) or commonly called Unmanned Aircraft, or in military terms called Drone is a flying machine that works with the remote control by the pilot or able to control himself, and able to carry the camera photo load (Rahardjo, 1989).

Nowadays, many photogrammetric mapping methods have used UAV / unmanned drones or drones to retrieve and record data from an object in the earth. This is because using a UAV / drone equipped with GPS for surveying from the air is very effective and cheaper when compared to renting an airplane as its vehicle (Nugroho et al., 2016).

The development of drone technology in Indonesia has been around since 2000, but it can't develop in accordance with expectations, because it turns out the development can not only be done by one agency only. The largest use of these unmanned aircraft was initially in the military field. But it is increasingly being used for civil (non-military) purposes such as mapping for various fields of application, monitoring, inspection, firefighting, non-military security or pipeline inspection.

The application of drones in the field of geospatial science today is in great demand because of its relatively easy operation and relatively affordable cost compared to satellite systems especially high - resolution satellite imagery (Colomina, & Molina, 2014). One of the benefits gained by using drone is to take pictures or aerial photographs which are then processed for mapping surveys purposes, so it can be used to support spatial data acquisition (Hidayat & Widartono, 2014).

Aerial photogrammetry is one of the Alternative technologies for more detailed data, real time, fast and cheaper. Unmanned aircraft used for mapping missions, monitoring and inspection of an existing operating target on the surface of the earth using UAV fully autopilot (full automatic control), so that object targets, flying height, flight path, and end lap and side lap between photos already in the program in such a way as to take the acquisition of data on the surface of the earth with parameters according to what we want, in this case for mapping aerial photographs that produce orthophoto output also adopted from the concept of conventional photogrammetry (Sari & Kushardono, 2014). Photogrammetry system is almost the same as remote sensing system. The Remote sensing system is a tool in researching the object without having to be directly related to the object under study (Anurogo *et al.,* 2015). Both systems are equally not in direct contact with the Earth surface object but different in the vehicle and the sensor used

Many advantages when monitoring is done with UAV, including investment and operational costs are cheap, data acquisition fast and flexible, and the resulting information can be more detailed than satellite data. In addition, because UAV can fly under the cloud, so the data generated free of cloud, also compared with satellite images that influenced by atmospheric conditions, image data from UAV more detail and sharper than satellite images data.

2. Research Method

The Research method is the step that must be done to complete the purpose of the research. The stages of this research consists of data retrieval, processing and presentment of data results. The vehicle used for aerial mapping in this research is Drone with Multi - copter type. The drone used in this research is DJI phantom 4. The vehicle used is shown in **(Figure 1).**

Figure 1. DJI Phanthom 4 used in this research

The first stage done in this research is data retrieval. Data retrieval is done with third party software. This data retrieval is done by determining the flight path of the vehicle. The determination of the flight path is to determine the height of the flying vehicle the magnitude of side lap and end lap which culminates in the effect of detail from the resulting image. The determination of the flying path is shown in **(Figure 2).**
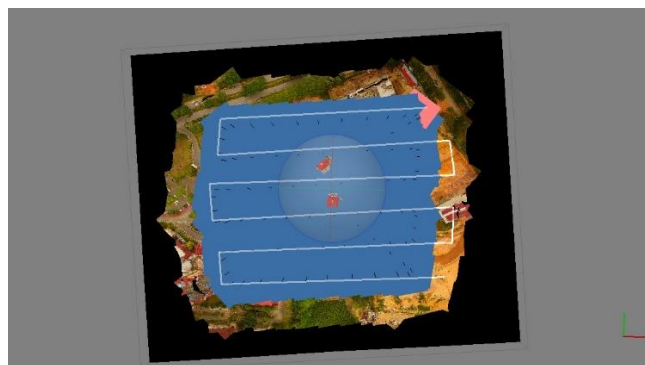

Figure 2. Flying path of drone

Data retrieval in this research is done in campus area at Batam State Polytechnic. Batam State Polytechnic is located in Batam Center, Batam City, Riau Island Province. It's between coordinates X: 394014 Y: 123592 until X: 394477 Y: 123434 On Universal Transverse Mercator (UTM) projection with World Geodetic System (WGS) datum 1984 Zone 48 Northern hemisphere. The location of this research is shown in **(Figure 3).**
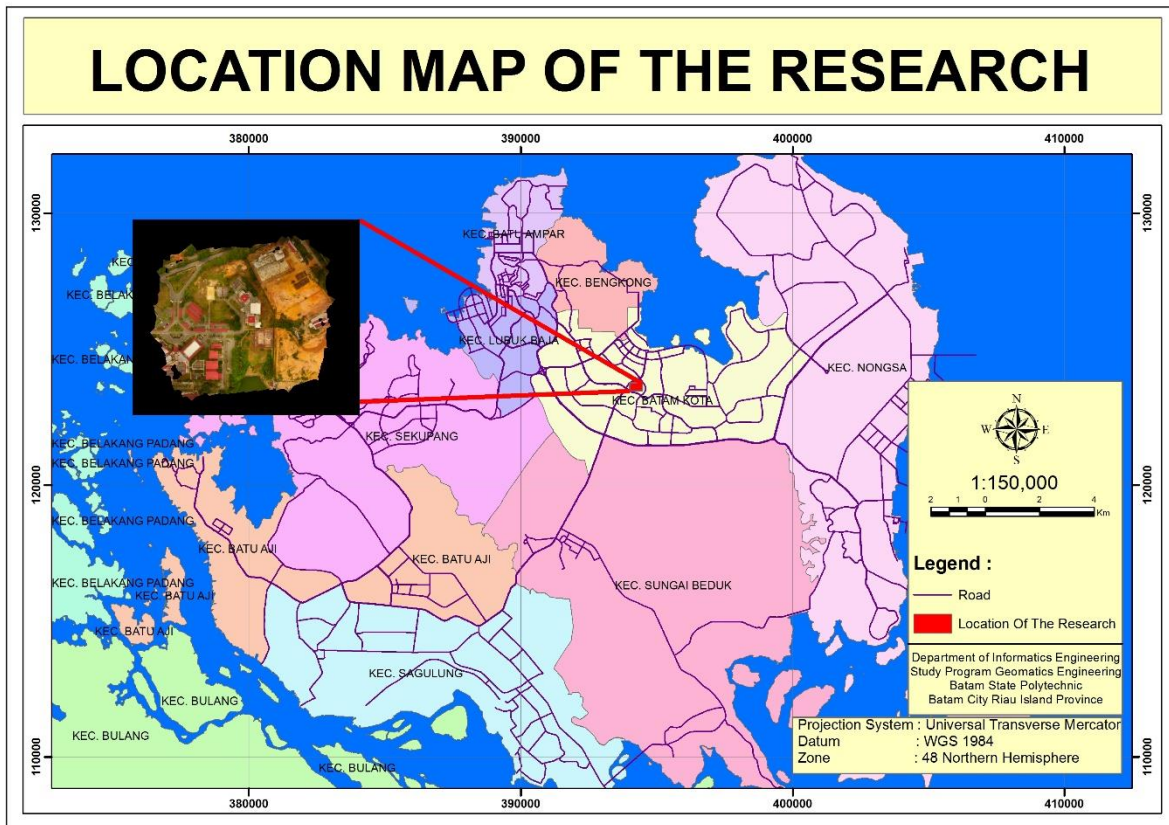
Figure 3. Location of the research

The result data with the drone vehicle are then processed by using Agisoft photoscan software program

3. Result and Discussion

The resulting data are then incorporated into the data processing software. The photo import and reconstruction stage of the flight path is the earliest stage, where here is a collection of survey photos in agisoft software and reconstructed in general photos by flight line automatically. From the result data obtained that the image of drone taking has 70% end lap and 80% side lap. Side lap and end lap is working to produce a stereoscopic image. Stereoscopic vision allows us to see an object from two different perspectives, like the aerial photograph taken from different camera positions. In the area of entanglement will be able to see three-dimensional earth surface image on a smaller scale, commonly called a model. That is why data mapping results by using this drone, in addition, can produce images with a very high resolution it also produce a three - dimensional view of the surface from recorded object.

Align photo is done to identify the points in each photo and make matching process of same point in two or more photos. The align photos process will generate the initial 3D model, camera position and photo in every recording, and sparse point clouds to be used in the next stage.

At align photo, Appear Accuracy and Pair Preselection. For accuracy, you can choose based on requirement. For an initial review such as viewing the overlapping coverage of the images during the survey, use accuracy low, while for the actual image production stage, use the highest accuracy. While the Pair Preselection option is used to help Agisoft in the process of aligning photos, If the photo has the default coordinates of the GPS Camera UAV (geotagged), use Reference mode. Whereas if the photo does not have a congenital coordinate (un-geotagged), use Generic mode. Or it could be compared between the two to see which one is more effective. Align photo on agisoft shown in **(Figure 4).**
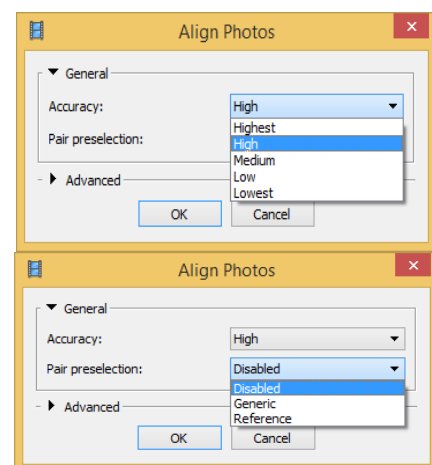

Figure 4. Agisoft align photo button

The next stage is the process of data rectification. Rectification is a re-exposure of a photograph so that the tilt of the image is lost and at the same time

adjusts the average photo scale to one another. Rectification of aerial photographs using Ground Control Point (GCP). With rectification, we make photos completely upright / without tilt and average scales are definitely in accordance with the desired scale of each photo. The photo shoots are generally equipped with elevation data that is comparable to the scale of the photo, but the height is expressed in rough altimeter readings, so it will give the average photo-scale price is very crude as well.

Ground Control Point (GCP) Input is done to provide the 3D coordinate reference (XYZ) to the result of aligning photo operation, so that the 3D model formed can be improved the geometric quality and finally able to produce Digital Elevation Model (DEM) and Orthophoto accurately according to the required specification. Generally, GCP input can be skipped in drone processing data, because usually the camera installed in the drone has a built - in GPS receiver that can be used as a reference coordinate. Usually built in GPS receiver in camera Drone has navigation grade specification (accuracy 5 - 25 meters or more), so it is less balanced with the level of detail orthophoto produced. Therefore, in order to obtain an orthophoto that can be used for well-detailed scale mapping, we need to include GCP obtained, among others, from a GPS receiver Grade Mapping (1 meter to centimeters) or Grade Geodetic (centimeters to millimeters). Import GCP shown in **(Figure 5).**

Figure 5. import GCP from GPS Receiver.

The list of coordinates stored in Agisoft is stored as a marker. But the position in the photo has not been defined, so the next task is to define the location of GCP in the photo. GCP that already entered will be displayed in the model as Markers.

The Dense Point Clouds processing is done after the alignment process and the GCP accuracy test is completed. At the time of making Dense Point Clouds will appear the choice of Quality and Depth Filtering. For Quality, there are options ranging from Lowest to Ultra High. The higher the quality, the longer processing time and the greater RAM memory allocation needed. while for the depth parameter filtering shows how the treatment of a suspected high point noise (outliers). Its characteristics are usually the value of its altitude is much larger or much smaller than the dots around it. While for Mild filtering is intended for the reconstruction of complex 3D models and has many details, and Aggressive filtering is intended for the reconstruction of 3D models that are

simple and do not have many details. Dense point cloud process is shown in **(Figure 6).**
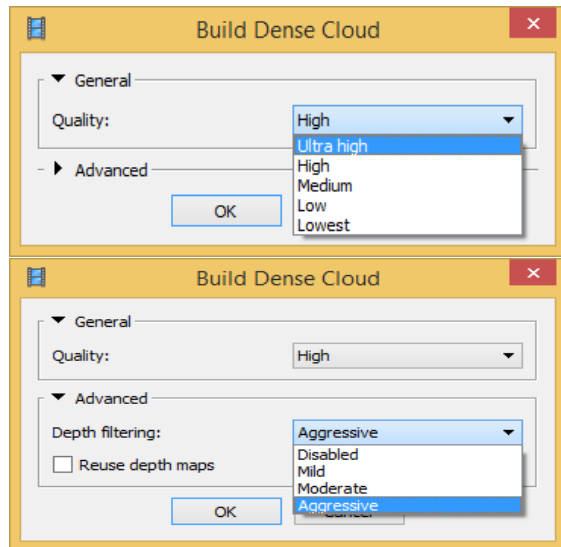

Figure 6. Dense point cloud process

The next stage is a 3D model or mesh. This is one of the main outputs of air photo processing in Agisoft. The 3D model will be used as the basis for making DEM both Digital Surface Model (DSM) and digital Terrain Model (DTM) and also orthophoto. At the time of build a mesh appeared Mesh Parameter option. For Surface Type, there are two options, Height Field and Arbitrary. Arbitrary is used for general 3D models such as buildings, sculptures and others. While the Height Field is used for earth surface objects such as Terrain, and spatial structures such as Pipe networks, cables, and others. Use Height Field to process orthophoto. For Source Data can use Dense Point Cloud from the previous processing stage. For Face Count parameters, there are options from Low, Medium to High. This Face Count determines the amount of mesh polygon to be generated. Face count High can generate mesh with millions of polygons which may later cause visualisation problems, therefore it must be determined wisely. In addition to the above three options, there are also two additional options are interpolation and point classes. For interpolation itself, there are two options, namely interpolated and extrapolated. Interpolated mode will allow multiple gaps between unprocessed photos to be interpolated automatically. The extrapolated option is not used in orthophoto processing. Build mesh process is shown in **(Figure 7).**
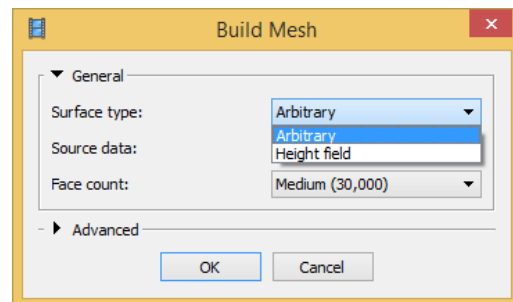

Figure 7. Build mesh process

The texture model is a 3D physical model of the appearance in the photo coverage area. Texture

models can be exported into various 3D model formats that can later be used to create 3D models via other desktop software. At the time of build texture model, appears Texture Parameter option. there are several options of mapping mode, ranging from Generic, Adaptive Orthophoto, Orthophoto, Spherical, Single Photo, Keep uv, while for texture size / count parameters can be used to detail texture with the consequence of texture file that the larger the size. For blending mode options, there are three choices, Mosaic, Average, Max Intensity and Min Intensity. Mosaic will consider the details in each photo to produce an orthophoto of balance in terms of colour and detail. The average option will use the average pixel value of each overlapped photo. As for max and min intensity use the maximum and minimum intensity of overlapping pixels. Build texture model process is shown in (**Figure 8)**.
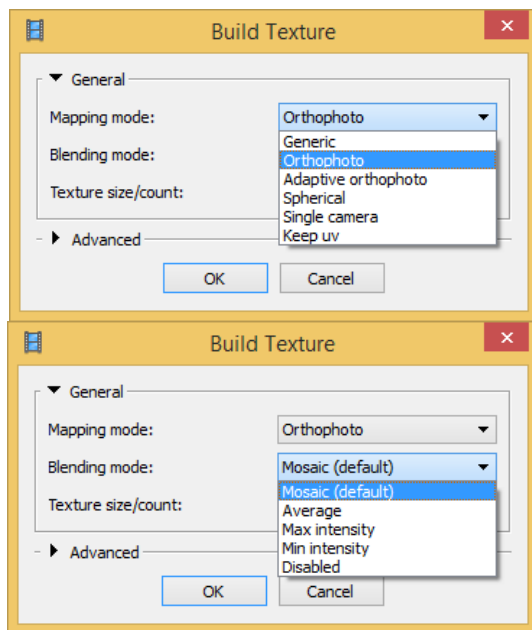

Figure 8. Build texture model process

The next step in Aerial Photogrammetric process using agisoft Photoscan is built digital elevation model (DEM). Digital Elevation Model is a digital field model in raster / grid format that is usually used in spatial analysis / GIS based raster. From DEM data can usually be reduced to elevation information, slope, aspect, to further modelling such as cut and fill, visibility, watershed and others. There are two DEM related terminology, namely DSM (Digital Surface Model / altitude calculated from surface cover of land, such as the roof of the building, the canopy of tree, bridge, etc) and DTM (Digital Terrain Model / altitude calculated from ground level). Build digital elevation model (DEM) process is shown in (**Figure 8)**.
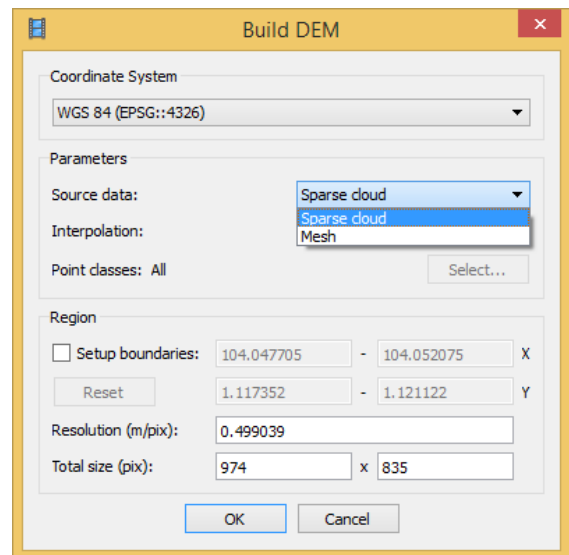

Figure 9. Build digital elevation model (DEM) process

The last step in an aerial Photogrammetric process using agisoft Photoscan is build an orthophoto. The Orthophoto is an aerial photograph that has corrected geometric error using DEM data and GCP data so that it can be utilised for the benefit of mapping without any scale inconsistency along photo coverage. Orthophoto can be made after making stage Dense Point Clouds, Mesh and DEM done.

At the orthophoto stage, the choice of Orthomosaic Parameter appears. For Projection selections, choose between geographic coordinates or planar / projected. For the Surface parameter, select the DEM generated from the previous step. For blending mode options, there are three choices, Mosaic, Average, Max Intensity and Min Intensity. Mosaic will consider the details in each photo to produce an orthophoto of balance in terms of colour and detail. The average option will use the average pixel value of each overlapped photo. As for max and min intensity use the maximum and minimum intensity of overlapping pixels Build orthophoto process is shown in **(Figure 10).**
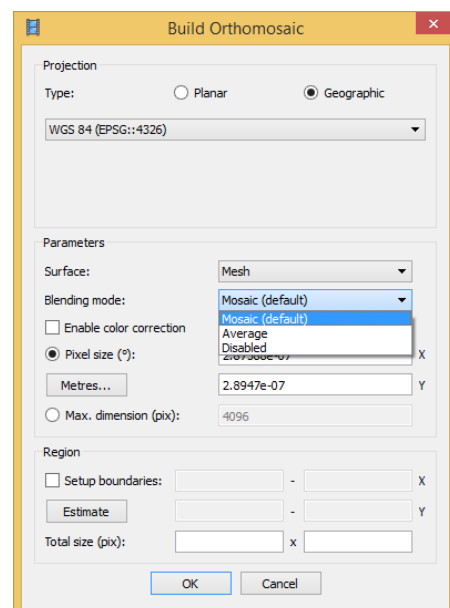

Figure 10. Build orthophoto process

The results of the aerial Photogrammetric in Batam State Polytechnic campus area produce 2 - dimensional high-resolution image data around the campus. The 2-dimensional high-resolution image data Photogrammetric in Batam State Polytechnic campus area shown in (**Figure 11)**.

Figure 11. High resolution image data in Batam State Polytechnic Campus Area

The results of aerial photogrammetric in this research also produced a 3-dimensional view of the prototype of the original picture of the earth's surface and also produced a surface model (DSM) of the recorded object. The 3 - dimensional view of the prototype of the original picture of the earth's surface and surface model (DSM) shown in **(Figure 12 and Figure 13)**.
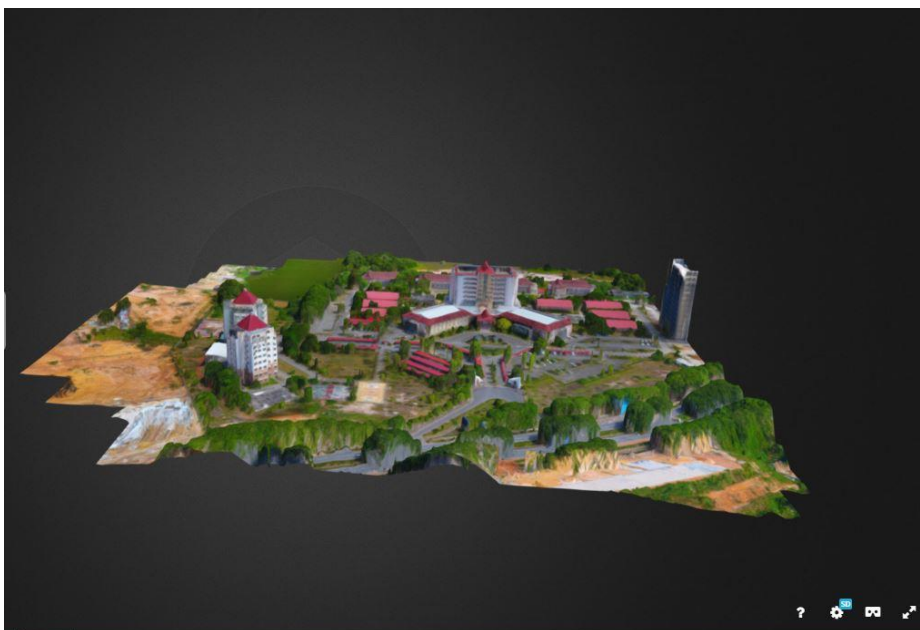

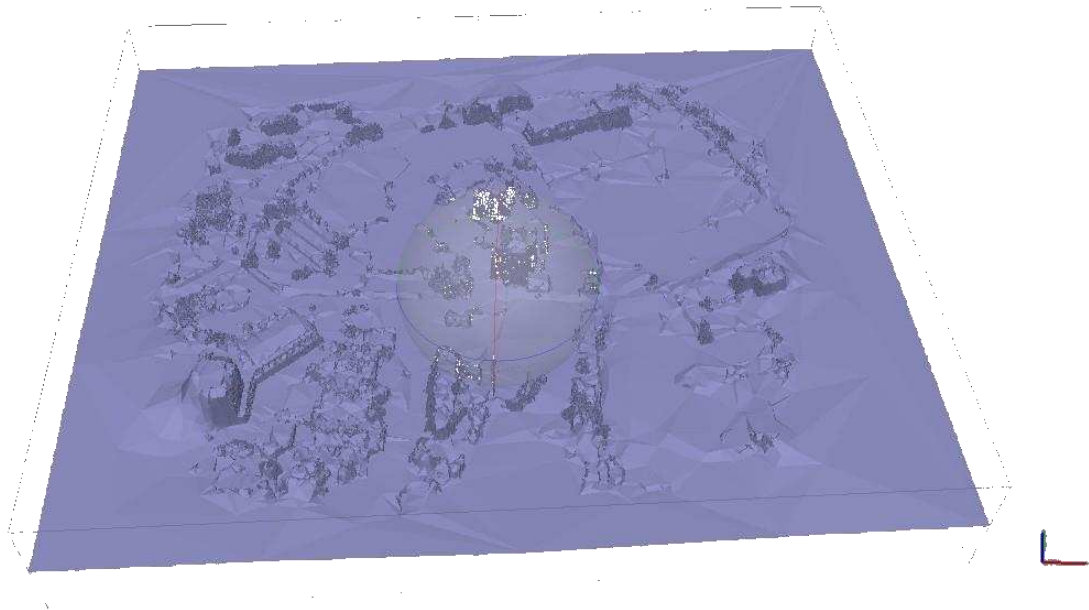Figure 12. 3 dimensional data of Batam State Polytechnic.

Figure 13. Digital Surface Model (DSM) of Batam State Polytechnic

Data recording of the aerial photograph, can then be used as reference data for other competence fields such as terrestrial measurement, land cover interpretation, GIS etc. Because the resulting data is data with a very high spatial resolution with the magnitude of spatial resolution of 2 inches/pixel so it can be used as a very good basic spatial data.

4. Conclusion

Mapping using an aerial photogrammetric tool will produce basic spatial data with a very high resolution. The spatial resolution of the aerial photogrammetric depends on the flying height of the vehicle during the recording. With the presence of third party software further simplify the acquisition and processing of aerial photography

References

Anurogo, W., Murti, S. H., & Khakhim, N. (2015). Analisis Perubahan Hutan Mangrove Dalam Penentuan Kawasan Rehabilitasi Dan Perubahan Stok Karbon Menggunakan Data Penginderaan Jauh (Di Teluk Banten, Serang Provinsi Banten). [Thesis]. UGM (ID): Universitas Gadjah Mada, Yogyakarta, pp. 1-99.

Aprilliyanti, T., & Zainuddin, M. (2017). Pemetaan Potensi Kekeringan Lahan se-pulau Batam menggunakan Teknik Sistem Informasi Geografis (SIG) dan Penginderaan Jauh. Majalah Geografi Indonesia, 31(1), 91-94.

Colomina, I., & Molina, P. (2014). Unmanned aerial systems for photogrammetry and remote sensing: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 92, 79-97.

Farizki, M., & Anurogo, W. (2017). Pemetaan kualitas permukiman dengan menggunakan penginderaan jauh dan SIG di kecamatan Batam kota, Batam. Majalah Geografi Indonesia, 31(1), 39-45.

Hidayat, F. N., & Widartono, B. S. (2014). Pemodelan Kenyamanan Jalur Sepeda Kampus Universitas Gadjah Mada Memanfaatkan Foto Udara Format Kecil. [Skripsi]. UGM (ID): Universitas Gadjah Mada, Yogyakarta, pp. 1-77.

Lubis, M. Z. Z., & Daya, A. P. (2017). Pemetaan Parameter Oseanografi Fisik Menggunakan Citra Landsat 8 di Wilayah Perairan Nongsa Pulau Batam. Jurnal Integrasi, 9(1), 9-15.

Lubis, M. Z., Anurogo, W., Khoirunnisa, H., Irawan, S., Gustin, O., & Roziqin, A. (2017). Using Side-Scan Sonar instrument to Characterize and map of seabed identification target in punggur sea of the Riau Islands, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology, 2(1), 1-8.

Nugroho, B. H., Suwardhi, D., & Harto, A. B. (2016). Analisis Parameter Orientasi Luar Pada Kamera Non-Metrik Dengan Memanfaatkan Sistem Rtk-Gps. Jurnal Ilmiah Geomatika, 21(2), 75-80.

Rahardjo, N. (1989). Penggunaan Foto Udara Untuk Mengetahui Kualitas Lingkungan Permukiman Di Kotamadya Magelang Dalam Hubungannya Dengan Kondisi Sosial Ekonomi Penghuni. [Thesis]. UGM (ID): Universitas Gadjah Mada, Yogyakarta, pp. 1-162.

Sari, D. P., & Lubis, M. Z. (2017). Pemanfaatan Citra Landsat 8 Untuk Memetakan Persebaran Lamun Di Wilayah Pesisir Pulau Batam. Jurnal Enggano, 2(1), 39-45.

Sari, N. M., & Kushardono, D. (2014). Klasifikasi Penutup Lahan Berbasis Obyek Pada Data Foto Uav Untuk Mendukung Penyediaan Informasi Penginderaan Jauh Skala Rinci (Object Based Classification Of Land Cover On Uav Photo Data To Support The Provision Of Detailed-Scale Remote Sensing Information). Jurnal Penginderaan Jauh Dan Pengolahan Data Citra Digital, 11(2).

Wolf, P. R., & Dewitt, B. A. (2000). Elements of photogrammetry: with applications in GIS (Vol. 3). New York: McGraw-Hill.