Rapid Mapping for Disaster Recovery (Case Study: Petobo, Palu)

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Abstract. In late 2018, there are spikes of natural disaster occurrence in Indonesia. This occurrence of these natural disasters happened simultaneously in a short period of time. Such events can possess as a threat to civil society. In order to encounter these events, there are needs to produce spatial data about the affected area. This data eventually will be used as primary spatial data for disaster impact analysis in support of the disaster recovery act. The usage of reliable primary spatial data can be obtained by the rapid mapping method. Rapid mapping is a method to produce maps in a short period of time for real-time applications, such as disaster impact analysis. Rapid mapping method emphasizes in generating quick mosaic from the recorded data within minutes right after data acquisition. In order to do such a method, data processing must be done with SFM algorithm on digital photogrammetric software. Results from this method is 1:1000 map (4.12cm/pix). Also, it yields a base product called large scale image product which can be used to generate initial line drawing for further mapping purposes, this method called OBIA (Object-Based Image Analysis) which could be conducted by using feature extraction with result a base map.

Keywords: Rapid Mapping, Disaster Risk Management, UAV.

1. Introduction

As a country highly vulnerable to disasters, Indonesia need any system that manage the reduction and response of every aspect of disasters. Any Implementation on this system has been made to reduce the impact because of the risk of a disaster such as landslide, earthquake and many man-made or natural disaster. Liquefaction and Tsunami strikes Petobo, a district at Palu, Sulawesi in 2019 and made a hugely significant impact on that city and also with their society, a respond plan to the disaster should be made and implemented in order to prevent for further losses caused by the events.

Disaster recovery efforts aim to restore peoples' lives and livelihoods, re-establish institutions, and foster sustainable development [1]. Disaster recovery as part of disaster management become an important issue as a failed disaster recovery process can undermines development of the affected country [1]. Failure of disaster recovery may cause further disaster impact as failed recovery contribute in amplify the disaster effect. Failed recovery resulting the disaster to becoming endemic, cause fuss in the country development, and cause heavy losses. Indonesia now faces a massive scale of disaster particularly in late 2018s that human activities must be adapted not only to reduce the change cause by the disaster itself but also to respond the aftermath.

In order to make the disaster recovery to be effective, disaster recovery need a plan that consider information regarding damages, losses, and existing resources. Such information can be displayed as spatial information and can be acquired with the advance recent development in surveying and GIS (Geographic Information System). As both have been used in response to many disasters that have been occurred.

Rapid Mapping Technology has been developed to help many mitigations and help many developments of the destructed cities as the impact of the disaster and also it helps many disaster relief programs.

Rapid Mapping Technology consists of the usage of a UAV (Unmanned Aerial Vehicle) to create a high-resolution image base map within an hour - day process. The technology behind this technology relies on the integration between the GPS and the acquisition of photographs, each photograph on this system has been processed with the location-based data and it is the most powerful key for a good mechanism to make the orthophotos rapidly. The software that was used to process the image data using the SFM (Structure from Motion) based software.

On rapid mapping process, as the post- processing method, the usage of OBIA (Object-Based Image Analysis) is being used for the object-oriented feature extraction process, this method using artificial intelligence to extract some features on the large-scale image product, the post-processing product that has to be achieved is to make a base map for thematic mapping purpose in order to sustain disaster relief management program.

2. Rapid mapping

Rapid Mapping is a procedure to provide geospatial data by combining immediate data collection and processing with a certain contextual aspect in order to give a quick overview about certain earth phenomena. Rapid mapping method emphasizes in generating quick mosaic from the recorded data within minutes right after data acquisition. Rapid Mapping is a procedure to provide geospatial data by combining immediate data collection and processing with a certain contextual aspect in order to give a quick overview about certain earth phenomena.

3. Data Acquisition

In recent years, Unmanned Aerial Vehicle serve as one of the alternatives for surveying and mapping activity. Particularly in disaster management activity. UAV systems offers many advantages, this system can be used in high risk situations, in accessible areas, and low altitude. Furthermore, UAV system also enabling data acquisition in cloudy weather condition as UAVs can fly below the clouds and has ability for fast data acquisition. The recent development of UAV technology also allows more precise flight from it estimated preflight planning with the usage of GPS system and flight controller. As for the ease of use, certain UAVs, multi rotor type allows vertical takeoff and landing, so it can eliminate the needs of runway. Also, commercial multi-rotor UAV product such as DJI enables the connection from smartphone to the aircraft for mission planning and ground control station.

For this research, DJI phantom 4 Proffesional has been used as it known for it ease of use and mapping capability. DJI Phantom 4 Pro is a multirotor or Vertical Takeoff Landing (VTOL) type UAV. The UAV has a fully complete installed fuselage consist of ESCmotor,propeler,BrushlessTx/Transmitter/ RemotRxReceiver, battery, GPS, IMU, and a camera properly mounted in 3-axis gimbal. The UAV also has main controller (flight controller) so it can enable the ability to autopilot through planned waypoint. The planning of flight waypoint are generated with mission planning software such as dronedeploy.

Figure 1. System Settings and Preliminary Check for DJI Phantom 4.

The UAV system consist of camera with 1” CMOS sensor with 20M effective pixels, camera lens with FOV of 84° and focus at 1 m - ∞, 5472 x 3648 image size, shutter speed in ranging from 8-1/8000 s, 3-axis gimbal system (pitch, roll, yaw), a 5870 mAh Lipo 4S battery with approximately 30 minutes flight time, and GPS/GLONASS positioning system.
The procedure of data acquisition begin with preflight check of UAV system and preflight mission planning. After that, aerial photo data acquisition with UAV is conducted and results 198 photos taken from the total of 71.934 hectares of area covered. Data acquisition with this method did not required a ground control points due to the existence of airborne-GPS that has been installed in the UAV. The airborne GPS yield the position of exposure point and has been geotagged in each photo.

4. Data Processing

The method for generating quick orthomozaic used in this research is structure from motion (SFM). SFM is a recent technological development in the field of photogrammetry that can yield a 3D model data in low cost and user-friendly method. As of conventional photogrammetry, SFM also need overlapping images from different perspective. The main difference in conventional and SFM method is that in SFM method the internal and external orientation is fully calculated simultaneously with bundle adjusment.
The process of SFM begin with identification of image keypoints. Keypoint or point of interest are common feature points identified in each image, then followed by creation of feature descriptor for each point. As this descriptor are unique for it decribe spatial relationship between images location in abitrary 3D coordinate system. The next process is bundle adjustment, the process to transform identified points coordinate into the same local 3D coordinate system, results in sparse point cloud. This point clouds then used for input to generate dense point cloud by implementing Clustering View for Multi- view Stereo (CMVS) and Patch Based Multiview Stereo (PMVS2) algorithm. CMVS used to decomposes large number of images into subsets or cluster of manageable sizes, while PMVS2 used to construct enhanced density point cloud [2]. Next, this density enhanced point cloud processed for 3D surface (mesh) reconstruction or rendering. Then, the mesh transformed from 3D coordinate into 2D coordinate, resulting an orthophoto image. In this research, SFM process conducted in Agisoft Photoscan, a commercial SFM software. In the software, batch process is used to automatically generate orthomozaic images with respect to processing parameters workflow for the batch process are as the following.

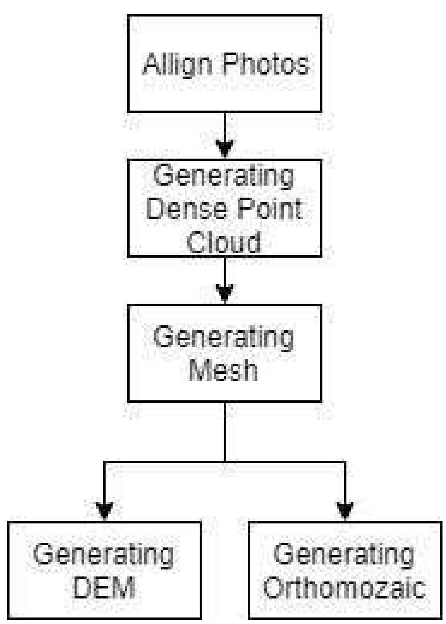

Figure 2. Orthomosaic and DEM Process Workflow.

5. Feature Extraction

A high-quality image product which has been delivered using UAV Photogrammetry acquisition and remote sensing process in order to make a map that has ground accuracy between 4 cm- 5 cm has enabled users to extract more information and more data which have correlation and usage in rapid mapping methods, OBIA which is known as the Object Oriented Image Analysis, according to [3], some features in photogrammetric and remote sensing software using this method to extract building information and analysis form of an object in imagery based on its pixels and clusters of its pixels.

Figure 3. The OBIA Image Segmentation.

In order to make a feature extraction beside using the manual-software digitizing method, with many handicapped conditions, feature extraction has more benefits because it has a less time-consuming strategy which the map results have more accurate segmentation for building or vegetation rather than using a manual-digitizing method. On this figure, the OBIA (Feature Extraction) workflow could be determined.

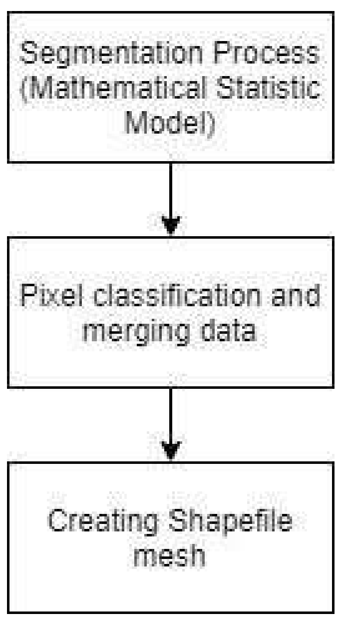

Figure 4. OBIA Image Segmentation Workflow.

The algorithm in OBIA process that been used to determine object features classification is using Edge Algorithm settings and intensity algorithm settings, the use of edge algorithm settings is more preferable because the intensity algorithm settings, classify each object using the edge pixels and the segmentation result in segmenting the edge of the objects. The process on these outputs are vector format or raster format in GIS which are useful to analyze the information about the impact or damage of the disastrous area.

6. Results and Discussion

The process of this research gained from the aerial acquisition using the DJI Phantom 4, results in geotagged images which been used for aligning image process, image matching process, and point cloud or creating mesh process in photogrammetry software such as Agisoft Photoscan. The location data for images geotagging are yields from airborne GPS data that results in errors as the following figure.

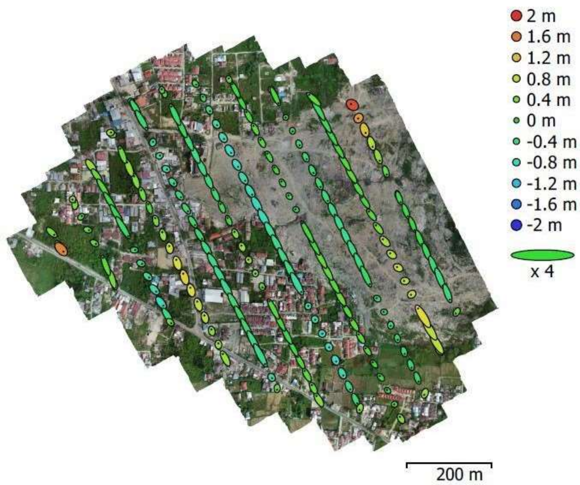

Figure 5. Camera Location Error.

The figure represents location error in error ellipse as vertical (Z) error represented in ellipse color and horizontal (X and Y) error represented in ellipse shape. Estimated camera locations are marked with a black dot. From the error estimation, the average camera location error as follow:

Table 1. Average Camera Location Error.

X (m)	Y (m)	Z/Vertical (m)	XY/Horizontal (m)	Total error (m)
2.777	5.097	0.502	5.805	5.827

The camera location error from the data acquisition are in the total of 5.827 m. This error is likely as the result of GPS-type that has been used. The GPS-type was used an airborne navigation type that only generate single point positioning or absolute positioning. Absolute positioning is expected to be less accurate, as the ionospheric delays which cause position error are not being estimated [4].

The orthomozaic process which was conducted with Agisoft Photoscan according to flow proccess as shown in figure 2 with processing parameters and processing time as follows,

Table 2. Agisoft Image Processing Parameter.

No	Process	Parameter	Elapsed Time
1	Allign Photos	Accuracy: Medium	38 minutes, 38 seconds
2	Build Dense Point Cloud	Quality: Medium	3 hours, 36 minutes, 10 seconds
3	Build Mesh	Surface type: Height Field Face Count: Low	7 Seconds
4	Build DEM	Interpolation: enabled	52 Seconds
5	Build Orthomozaic	Blending mode: Mosaic	Tentative (depends on hard drive)

The results on the process are DEM and Orthophoto in which the DEM shows the actual terrain model. Pair matching was done with medium parameters on matching each digital number between any photos, with result a point matching pair which found between the photos. Point dense cloud was made in order to interpolate the pair point of point cloud to make every detail on the terrain by using spatial interpolation methods.

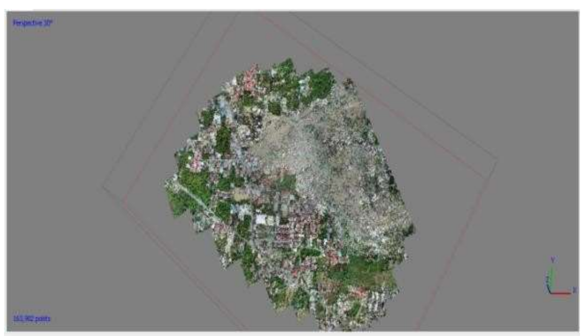

Figure 6. Point Cloud as a result from Image Matching Process.

Figure 7. Point dense cloud as a result from Interpolating Process.

By using point cloud, DEM and orthophoto could be erected because on this process each photo which were aligned using the bundle block adjustment with SFM (Structure from Motion) with the results are DEM and Orthophoto, the specification of this orthophoto, it have 4.18 cm/pix GSD (Ground Sampling Distance) and 1:200 scale orthophoto.

Figure 8. Orthophoto which was generated by SFM method.

DEM was made by interpolated point on surface by using point dense cloud interpolation.

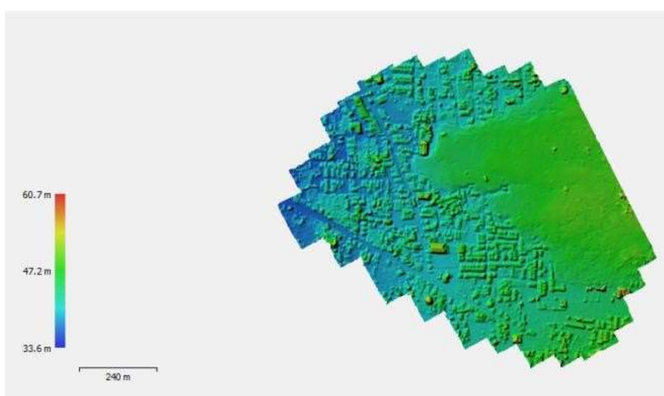

Figure 9. DEM which was generated from dense cloud.

The OBIA (Object-Based Image Analysis) process gave results such as segmented shapefile which gained from edge detection by its algorithm. OBIA (Object-Based Image Analysis) is being used because of its efficiency and fully-automated without any human-based segmentation which is time consuming rather than manual method, by using this method, rapid mapping could be run below one day processing time by using a high specification computer. The input data that were used in this process using the Geo-TIF format which was extracted using The SFM methods, in which the results were orthophoto and DEM (Digital Elevation Model), the feature extraction in OBIA was running in orthophoto processing, meanwhile, the contouring process was running in DEM processing.

Figure 10. Shapefile obtained from OBIA process.

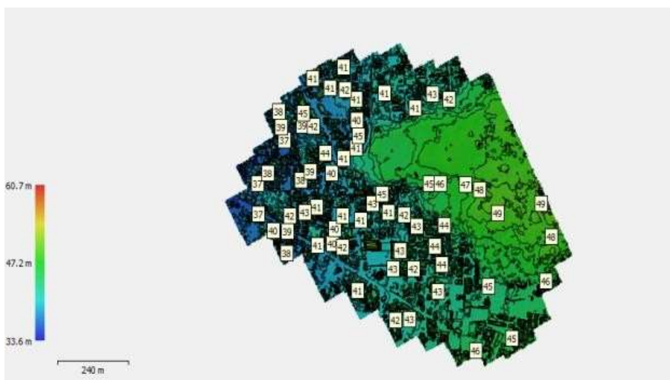

Figure 11. Contour Lines which was generated by using DEM interpolation.

7. Conclusions

The aim of rapid mapping is to produce spatial information data about disastrous or post disaster area within a day or hours. The process of rapid mapping consists of the data acquisition, data processing and data segmentation and analysis which results in base orthophoto and topograhic map for further mapping particularly thematic mapping purposes. The method is useful in disaster and planning management strategy in order to sustain disaster recovery. The parameter that have been used on this research including the medium-photo alignment as shown in table 2, low-photo dense cloud interpolation and low orthophoto process. OBIA was being used in object interpretation process in order to simplify the object identification process to assess the impact of the disaster in Palu, Petobo district.

8. References

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