DTM GENERATION WITH UAV BASED PHOTOGRAMMETRIC POINT CLOUD IN LAMPHACHI RIVER

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***Abstract*—**This research aims to evaluate the efficiency of terrain digital terrain model (DTM) with aerial photo and photogrammetric point cloud. The study area is located at Lamphachi river in Kanchanaburi province of Thailand. The DJI PHANTOM 4 PRO flight was conducted with 559 aerial photographs at 120 m altitude. The ground control points were set at 8 points. Agisoft Photoscan software is used to create point cloud and CSF (Cloth Simulation Filtering) algorithms for point cloud modification.The parameters are CR (Cloth resolution), maximum iteration and classification threshold that the values were 1.0, 500 and 1.0 respectively. The results of this study were as follows: Root Mean Square Error (RMSE) was compared with 407 checkpoints, including in channel sandbars and river banks is 135 points, 119 points and 153 points respectively. The result of study found that RMSE of the channel sand bars and river embankment is 1.24 meters, 2.18 meters and 1.56 meters respectively. Outcomes of the study show that it is possible to use the UAV Photogrammetry data as map producing, surveying, and some other engineering applications with the advantages of low-cost, time conservation, and minimum field work

***Keywords*—** *UAV, Point cloud, DTM*

I. INTRODUCTION

The Digital Terrain Model (DTM) is an important topographic product and essential demand for many applications. Traditional methods for creating DTM are very costly and time consuming because of land surveying. In time, Photogrammetry has become one of the major methods to generate DTM. Recently, airborne Light Detection and Ranging (LiDAR) system has become a powerful way to produce a DTM due to advantage of collecting three-dimensional information very effectively over a large area by means of precision and time (Polat and Uysal, 2015). However, the main disadvantage of aerial manned platforms such as airplanes is being expensive, especially for small study areas. During the last decades, low-cost Unmanned Aerial Vehicles (UAVs) are used to pass this handicap. Nowadays, the use of UAVs is increasing day by day due to its advantages at cost, inspection, surveillance, reconnaissance, and mapping (Remondino et.al., 2011).

DTM can be described as a three – dimensional representation of a terrain surface consisting of X, Y, Z coordinates stored in digital form. It includes not only heights and elevations but other geographical elements and natural features such as rivers, ridge lines, etc. A DTM is effectively a DEM that has been augmented by elements such as breaklines and observations other than the original data to correct for artifacts produced by using only the original data. With the increasing use of computers in engineering and the development of fast three-dimensional computer graphics the DTM is becoming a powerful tool for a great number of applications in the earth and the engineering sciences.

In this study the generation of DTM with UAV based photogrammetric point cloud and its accuracy analysis is presented.

II. STUDY AREA AND DATA

A. Study area

The study area is 0.638 km^2. (Figure 1) The area adopted for this study is lower part of the Lamphachi river in Kanchanaburi province of Thailand. The terrain is flat, flooded and the river is bent. The riverbank area is covered with bamboo and is planted with sugarcane and vegetable crops.

Fig. 1. study area, lower part of Lamphachi river

B. Data

The methods concerning data acquisition comprised aerial photogrammetry and surveying techniques. In concrete terms aerial photogrammetry using a quadcopter UAV (DJI PHANTOM 4 PRO) flight was conducted with 559 aerial photographs. Flights altitude over terrain was 120 m above ground level.

For georeferencing purposes, we used ground control points (GCPs) measured with Real-Time Kinematic (RTK) (Figure 2 (a)) which used to find coordinates and elevation data for 8 ground control points (GCPs) (Figure 2(b)).

(a)

(b)

Fig. 2. Real-Time Kinematic (RTK) surveying (a), position of 8 ground control points (GCPs) (b)

III. METHODOLOGY

A. Image Processing

The image processing procedures involves photo alignment, create markers and point cloud generation. These processing were performed using the Agisoft PhotoScan software, which is a 3D scanner software based on digital photogrammetry, which uses photos from multiple digital cameras to rearrange. And then the image is a 2D map and then processed to create a 3D point cloud. The GCPs were used for georeferencing and adjust for mapping error.

The final result of processing get 11,666,340 for 3D point clouds and point density is 14.1189 points/m^2 (Figure 3)

Fig. 3. Image of 3D point clouds (11,666,340 points)

B. Cloth Simulation Filtering (CSF)

Separating point clouds into ground and non-ground measurements is an essential step to generate digital terrain models (DTM). Many filtering algorithms have been developed. However, even state-of-the-art filtering algorithms need to set up a number of complicated parameters. The cloth simulation filtering (CSF) algorithm implemented to produce DTM from 3D point clouds (Zhang et al., 2016). The assumption of CSF algorithms that the cloth is soft enough to stick to the surface, the final shape of the cloth is the DSM (digital surface model). However, if the terrain is firstly turned upside down and the cloth is defined with rigidness, then the final shape of the cloth is the DTM (Figure 4).

The advance parameter that has been used in this study for point cloud modification are 3 parameters:

- CR (Cloth resolution) refers to the grid size (the unit is same as the unit of point clouds) of cloth which is used to cover the terrain. The bigger cloth resolution you have set, the coarser DTM you will get.
- Max iterations refers to the maximum iteration times of terrain simulation. 500 is enough for most of scenes.
- Classification threshold refers to a threshold (the unit is same as the unit of point clouds) to classify the point clouds into ground and non-ground parts based on the distances between points and the simulated terrain. 0.5 is adapted to most of scenes

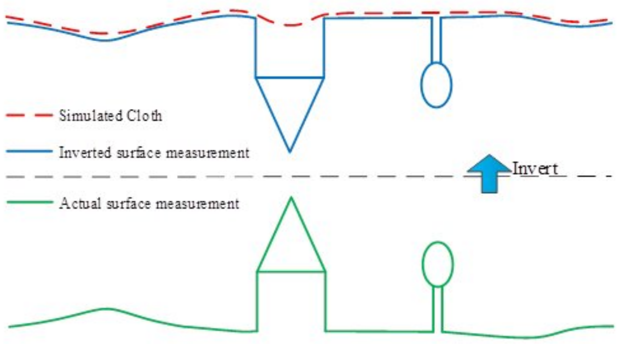
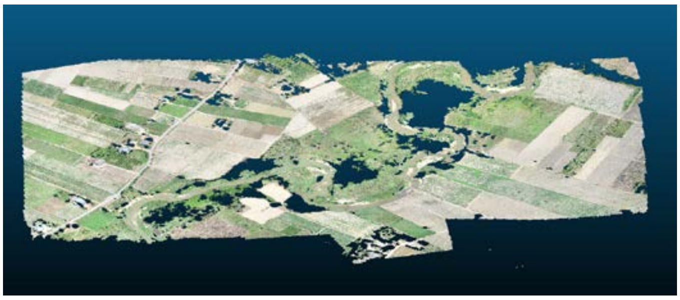
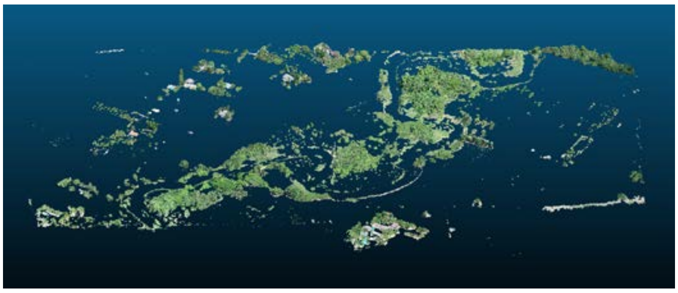


Fig. 4. Overview of the cloth simulation algorithm (Zhang et al. 2016)

The parameters are cloth resolution (CR), maximum iteration and classification threshold that the values were 1.0, 500 and 1.0 respectively. As the result, CSF algorithms can be separated 9,079,298 points as ground points (Figure 5(a)) and 2,586,986 points as non – ground points (Figure 5(b))



(a)



(b)

Fig. 5. 3D point cloud as ground points (a), 3D point cloud as non-ground points

IV. RESULT AND ANALYSIS

The obtained ground points are used to generate a 0.3 m resolution DTM. In order to get root mean square error (RMSE) of elevation data was compared with 407 checkpoints (Figure 6), including in channel sandbars and river banks is 135 points, 119 points and 153 points respectively. The equation of RMSE following equation (1)

$$RMSE = \sqrt{\frac{\sum(Elev_{DTM} - Elev_{checkpoints})^2}{N}} \quad (1)$$

Where $Elev_{DTM}$ is the elevation value from the generated DTM, and $Elev_{checkpoints}$ is the elevation value from check points. N is the number of check points.

The result of study found that RMSE of the channel sand bars and river embankment is 1.24 meters, 2.18 meters and 1.56 meters respectively.

V. CONCLUSION

This paper indicates the capability of UAVs, which is an alternative data collection technology, in a geomatic application in a small area by means of DTM generation with. Comparing with traditional manned airborne platforms, they reduce the working costs and minimize the danger of reaching to risky study sites, with sufficient accuracy. In fact, the UAV

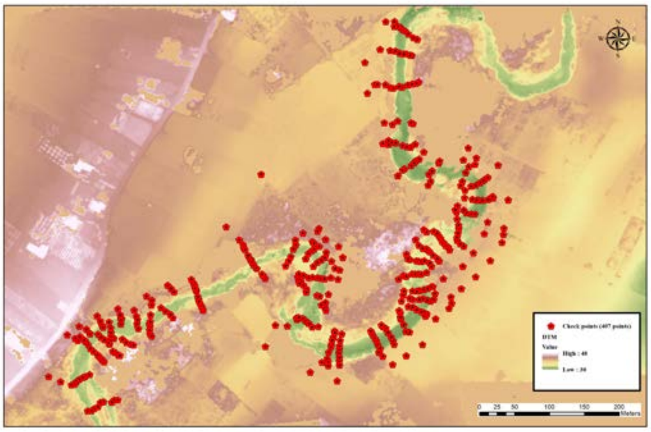


Fig. 6. DTM and the position of 407 check points

systems have lots of advantages (low-cost, real time, high temporal and spatial resolution data, etc.) which are very important for not only geomatic but also various disciplines. The application indicates that the UAV combined digital camera systems can allow to collect usable data for geomatic applications. The study shows that UAV based data can be used for DTM generation by photogrammetric techniques with a vertical accuracy. It can be stated that the UAV Photogrammetry can be used in engineering applications with the advantages of low-cost, time conservation, minimum field work, and competence accuracy. Moreover the created 3D model is satisfactory to realize topography with texture. On the other hand, except GCP some parameters such as weather, vibrations, lens distortions, and software directly affects the process and model accuracy. Beyond all these, the UAVs system is not fully automated and still needs a user decision. Future studies may offer an automated approach for UAVs that minimizes the user attraction.

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