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Research on the Production of 3D Image Cadastral Map

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Abstract

Recently, Unmanned Aerial Vehicle (UAV), equipped with different high accurate remote sensing sensors acquiring various physical or geometric spatial information has many mature applications in different fields, such as environmental patrol, pollution monitoring, disaster prevention and relief, and mapping. High resolution imagery acquisition and spatial geometric information extraction is still the current major application for UAV.

The visual representation of traditional cadastral maps is still limited in 2D drawings. It seems insufficient to provide intuitive understanding of the variety of problems in high density residential areas. Even though the 2D cadastral maps can be overlapped on traditional semi orthophoto, it still represents in two dimensional map. It is very hard to represent land legal boundary and physical information on imagery preciously. Because 2D cadastral maps and 3D image-based model are produced separately, it is also a very challenge issue for the land boundary line to follow the variation of terrain surface. This study propose a 3D cadastral map production and update technology using UAV-derived imagery. This study overlaps the cadastral map with true orthophoto using 3D visualization technique which change the way for visual inspection of traditional cadastral map. In this study, digitized land corner coordinates from UAV-derived true orthophoto are verified by field survey data. The accuracy of these land corner points is proved to fulfill the requirement of cadastral map accuracy.

Key words: UAV, 3D cadastral map, true orthophoto

Introduction

The visual representation of traditional cadastral maps is still limited in 2D drawings. It seems insufficient to provide intuitive understanding of the variety of problems in high density residential areas. Even though the 2D cadastral maps can be overlapped on traditional semi orthophoto, it still represents in two dimensional map. It is very hard to represent land legal boundary and physical information on imagery preciously due to the height displacement and scale distortion of Quasi-orthophoto. Because 2D cadastral maps and 3D image-based model are produced separately, it is also a very challenge issue for the land boundary line to follow the variation of terrain surface. If the cadastral map is directly placed on the 3D image model, we only see a floating line in the 3D image model, and the feasibility of cadastral boundary visualization is extremely low.

A quasi-orthophoto image cannot be directly used to obtain any accurate geometric quantity, so it is necessary to acquire the geometric quantity from the stereo mapping in a three-dimensional drawing manner, such as an aerial surveying topographic map measurement process. However, in recent years, the rise of unmanned aerial vehicles combined with the principle of multi-viewpoint image processing has made it possible to produce true orthophoto and high-density 3D point cloud results directly. In combination with true orthophoto and 3D point cloud results, 3D image models can be produced by UAV aerial photogrammetry.

With the rapid development in the fields of UAV photogrammetry, 3D data such as 3D point cloud and 3D image model can be obtained using computer vision and multi-view technique. Finally, cadastral maps are used to provide semantic information about the land cover class and 2D spatial information of the boundary of the cadastral objects in study area to fulfill the producing 3D cadastral object by dense image matching and registration procedure. If it is true, the subjects and surrounding environment can be previewed when we purchase land and building or apply the engineering applications. In the future, the management and use of the cadastral map by related units can be more convenient if this technology can be applied to a land administration office or an engineering unit and then integrated with the GIS technology to combine the attribute data of the cadastral map.

Recently, the computer vision technique "Structure from Motion (SfM)"(Figure 1), the simultaneous determination of camera (interior and exterior) parameters and 3D structure, and bundle adjustment algorithm are available for UAV imagery to produce true orthophoto. The accuracy of each pixel in resulting imagery can reach 2~4 cm level after validating with ground check points which can meet the accuracy requirement of land parcel boundary corners for overlapping cadastral map. Therefore, the goal of this study aims to apply modern UAV photogrammetry technology to the production of 3D Image Cadastral Map based on true orthophoto.

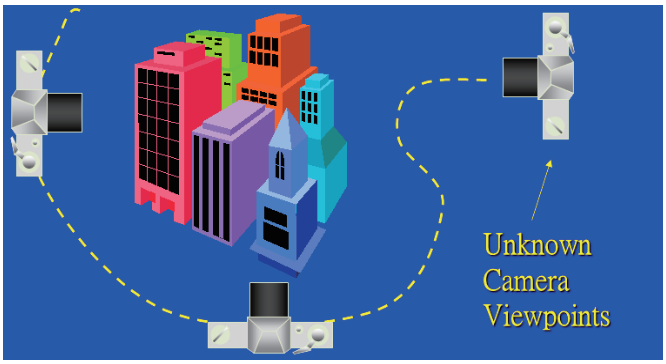

Figure 1. Structure from Motion (SfM)

Related Works

The cadastral map records the position, shape, and geographical status of each land in a fixed scale, and the quality of the cadastral map relates to the rights and interests of the people and the effectiveness of the use of state land management. The production of cadastral maps depends on cadastral surveys and is distinguished by surveying methods. The current cadastral maps are the graphical cadastral maps measured by the galvanometer and the numerical cadastral maps measured by the goniometers. Norm and accuracy are different. At present, the common scales are 1/500, 1/600, 1/1000, 1/1200, 1/2400, 1/3000, which include the cadastral maps from the Japanese era and retested, re-planned, and repaired cadastral map.

Therefore, this study proposes a 3D cadastral map production and update technology using UAV-derived imagery by applying SfM technology. In 1992, Tomasi and Kanade applied the affine factorization method to build shape and motion from image streams under orthography and SfM technology to estimate the multiple camera positions and moving path [1]. In 2016, the use of high-precision aerial UAV derived true orthophotos and three-dimensional point clouds for urban re-delineated mapping. According to the land readjustment applications based on the above high precision true orthophoto, the direct production of cadastral maps and land registration can eliminate the need to re-implement cadastral mapping and reduce the works of field survey [5].

In 2017, modern UAV photogrammetry technology had been applied to "three map-in-one" project to evaluate the feasibility of measuring coordinates of land parcel boundary corners on true orthophoto without field survey of these corners. Compare to traditional field survey, by utilizing this method, the efficiency of proposed method increase 77.22%. The cost decreases from TWD$ 360,000 to TWD$82,000 accordingly. The updated urban planning map, topographic map and Cadastral map by the proposed method can be integrated into geographic information system (GIS) for additional value-added applications [2]. In addition, the UAV-derived true orthophoto, three-dimensional point clouds, and three-dimensional image models results can provide precise pipe line geographic position and spatial coordinates to reduce the required human resources and increase the operation efficiency of pipe line measurement [4]. Compare to traditional field survey, the efficiency of proposed method increase 50% in time, decrease 60% in cost, and decrease 70% in human resource accordingly.

Study area and UAS photogrammetry procedure

1. Study area

In this study, we select the area near high speed rail station in the Wudong section of Quren District, Tainan City as the experimental area. Its geographic location is adjacent to the Tainan High-speed Rail Station and is still under development. The cadastral map used for the three-dimensional cadastral map production in this study was surveyed last year as shown in Figure 2.

Figure 2. Study area

2. UAS Survey and Route planning

The UAV for aerial imagery captured used in this study is the Phantom 3 Standard quadrotor unmanned drone produced by DJI (DJI). A total of 594 images were taken in the experimental area of this study. The relevant basic information is shown in Table 1. In this study, we setup 6 fiducial markers (as shown in Figure 1) as ground control points (GCPs) in study area to improve true orthophoto accuracy and to assure the coordinate system is TWD97[2010]. The fiducial markers are made by canvas with straight shape with proper size and contrast color with ground which can be recognized by UAV photogrammetry software.

Table 1 Phantom 3 Standard Specs

AIRCRAFT	
Weight	1216g
Diagonal Size	350mm
Max Ascent Speed	5m/s
Max Descent Speed	3m/s
Max Speed	16 m/s (ATTI mode)
Max Service Ceiling Above Sea Level	6000m
Max Flight Time	Approx. 25 minutes
Operating Temperature Range	0° to 40°C
Satellite Positioning Systems	GPS
Camera	
Sensor	1/2.3” CMOS Effective pixels: 12 M
Lens	FOV 94° 20 mm (35 mm format equivalent) f/2.8
ISO Range	100-1600
Electronic Shutter Speed	8 - 1/8000 s
Image Size	4000*3000
Still Photography Modes	a. Single Shot b. Burst Shooting: 3/5/7 frames c. Auto Exposure Bracketing (AEB): 3/5 bracketed frames at 0.7 EV Bias d. Time-lapse
Operating Temperature Range	0° to 40°C

To improve the accuracy of the 3D image model, the accuracy of the model must have matched with the accuracy of the cadastral map and the topographic map. The route planning is performed using the cross-tracking and the circular route. The side overlap ratios are all chosen to be 80%, and the height of aerial photography is 40 meters. There are 7 routes in total, as shown in Figure 3 (left). The purpose of the circular flying route is to take picture every 10 degrees to provide the texture of the building walls, and the aerial altitude is determined by the line conditions, as shown in Figure 3 (right). To improve the quality of the 3D image model to produce 3D cadastral maps, this study uses the total station measure the three-dimensional coordinates of four feature points of the building in the experimental area as shown in Figure 4.

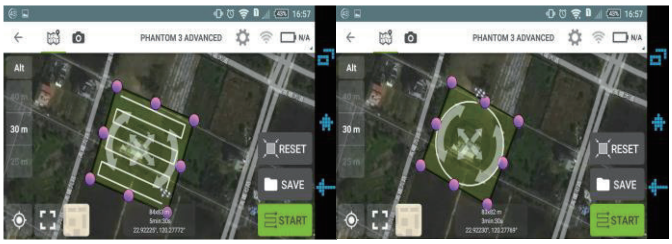

Figure 3. Cross-tracking and circular route.

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Figure 4. Feature points of the building in the experimental area

3. Image Processing

In this study, we use PhotoScan Pro software to process 594 photos and derive true orthophoto for study area as shown in Figure 5. The GSD of the true orthophoto is 3.48 cm/pixel. The height accuracy of 3D point clouds (figure 6) is about 5 cm/pixel.

Figure 5. true orthophoto for study area

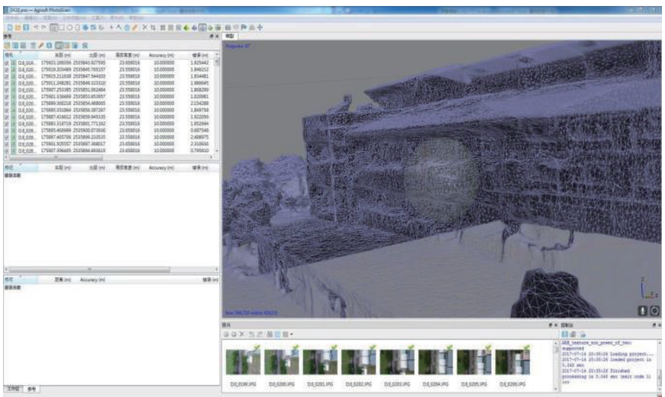

Figure 6. Point cloud of buildings in study area

Study of three-dimensional image cadastral map

1. Overlapping of true orthophoto image and cadastral map

To obtaining the true orthophotos, the location of the experimental area can be confirmed from the cadastral map. Then the two image files can be imported into the Global Mapper software, to adjust the cadastral map and true orthophoto appropriately to completes the overlay procedure as shown in Figure 7. In addition, to highlight the visibility of cadastral boundaries, we adjust the cadastral boundary color red. After completing the overlay of the cadastral map and the true orthophoto, we can enlarge the overlapping results of the buildings, to check whether the boundary of the cadastral map is consistent with the boundary of the building in true orthophoto as shown in Figure 8.

2. Production of Three-dimensional image cadastral map

Global Mapper software automates layer overlays of 3D image cadastral maps. When importing various drawing data, it is necessary to pay attention to the order of the layers importing. In addition, the numbering sequence of the layers needs more attention to smoothly attach the cadastral map to the surface of the 3D image model. The three-dimensional image cadastral map of the entire experimental area is shown in Figure 9. It can be seen from the figure that the cadastral boundary is able to closely adhere to the topographical surface and follow the variation of topography. On the other hand, to understand the fitting quality of the built-in cadastral boundary, the positive three-dimensional image of the building is enlarged and displayed as shown in Figure 10. It can also be seen from the figure that the cadastral boundary is also close to the building surface as the height of the building changes.

Figure 7. The overlapping of true orthophoto and cadastral map

Figure 8. Enlargement of overlapping result.

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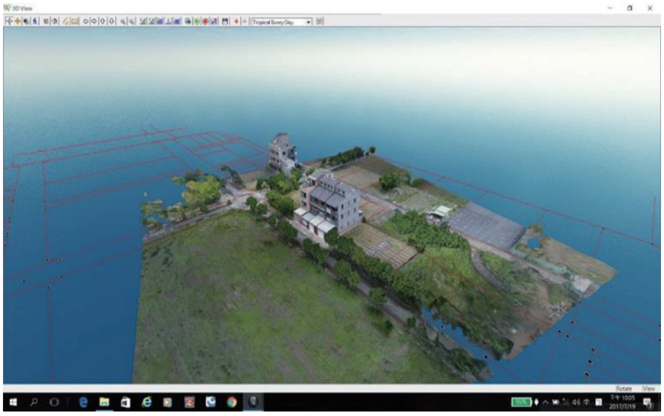

Figure 9. The three-dimensional image cadastral map

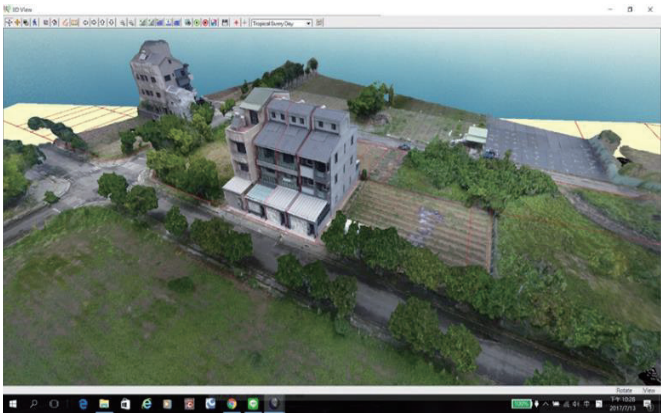

Figure 10 Three-dimensional image of buildings overlapped with cadastral boundary.

Conclusion

In this study, we conclude that, the proposed UAS photogrammetry procedure utilizes the 3D image model produced by true orthophoto high-density 3D point cloud results as a supplementary tool for production of 3D image cadastral map. The resultant three-dimensional image cadastral map has a high degree of visualization for providing land administration unit a way to demonstrate on the website for public inquiries and enhance the people's understanding of their land. According to this result, the indoor explanation to the people understand the status of the object and the cadastral situation.

References

[1] Tomasi C., Kanade T., 1992, Shape and Motion from Image Streams Under Orthography: a Factorization Method, International Journal of Computer Vision, pp.137~154.

[2] Tsung-Yi Lin et al, 2017, Assessment on thefeasibility of three map in one work using unmanned aerial system.

[3] Marr D., 1982, A Computational Investigation into The Human Representation andProcessing of Visual information,San Francisco, USA:W. H. Freeman, pp.86~156.

[4] Tsung-Yi Lin et al, 2017, Assessment on the feasibility of the Pipeline Survey using Unmanned Aircraft System.

[5] Hui-Ju Tsai, 2016, Assessment on the feasibility of urban land readjustment using unmanned aerial vehicle, Thesis, Chia Nan University of Pharmacy and Science.

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