UAV APPLICATION FOR UPDATING CADASTRAL MAP IN HOCHIMINH CITY

Le Van Trung[1], Le Trung Chon[1], Nguyen Huu Nhat[2]

(1)Ho Chi Minh City University of Technology, Viet Nam

(2)Geomatics Center, Viet Nam National University, Ho Chi Minh City, Vietnam

Email: lvtrungbk@gmail.com

Abstract

Using UAV (Unmanned Aerial Vehicles) to capture high resolution imagery for cadastral mapping can speed up the process of updating the cadastral maps at the different scale. The objective of this paper is to introduce the way in which UAV technology can be used to update the cadastral maps in Ho Chi Minh City. The current law requires the accuracy of the parcel boundary from the UAV based image approach must be compared with the existing terrestrial method. The results show that the evaluated accuracy of the 2.7 cm resolution image was 6.07 cm and the accuracy of the one with 1.8 cm resolution was evaluated to 4.81cm. The application of UAV for cadastral mapping covers 4 km2 of the Thu Duc district shows the spatial accuracy achieved and the potential of UAV technology for updating cadastral maps.

Key words: high resolution imagery, cadastral map, spatial accuracy, UAV

1. Introduction

To develop remote imaging techniques by UAV that is able to provide high resolution, real-time images for cadastral mapping and applications of land management is important items of Viet Nam's strategy in space research and applications until 2020 officially approved by the Prime Minister on June 2006, according to the Decision number 137/2006/QĐ-TTg. However, Viet Nam has been mainly using satellite images (taken from 500km to 900km altitudes) and images taken from aircraft for altitudes from 300m to 1.000m. The high-resolution imaging system based upon UAVs being capable of taking images from low altitudes ranging from 10m to 300m is highly demanded and promisingly applied in updating cadastral map in Ho Chi Minh City. Recent experimental studies [1-2] show that AUV can be used to monitoring the progress of construction works of urban rail project [3] and UAV technology can be applied to established large scale topographic map instead of the traditional method [4]

This study presents the experimental results of high-resolution remote imaging system based upon UAV conducted in Ho Chi Minh City. AscTec Falcon 8 system could operate flexibly and effectively to capture images when flying at low height. In addition, the Agisoft software is used for image processing to create orthoimage and 10 samples were processed to get the RMSE of the overall measurement in this case of the two standards (5cm and 7cm). The main contribution of this study involves the development of flight planning to capture aerial photos with high resolution that can be used to establish large scale cadastral map and shows the spatial accuracy achieved for updating cadastral maps.

2. Description of study area

The district of Thu Duc of HCM city covers an area of 47.8 km2, and 12 wards. Experimental imaging flights with flying altitude 70 m and ground resolution 2 cm/Pixel (Grade A standard) are presented in ward of Binh Tho (1,21km2) and Grade B for the partial coverage of Hiep Binh Chanh ward (3 km2) with flying altitude 100 m and ground resolution 5 cm/Pixel.

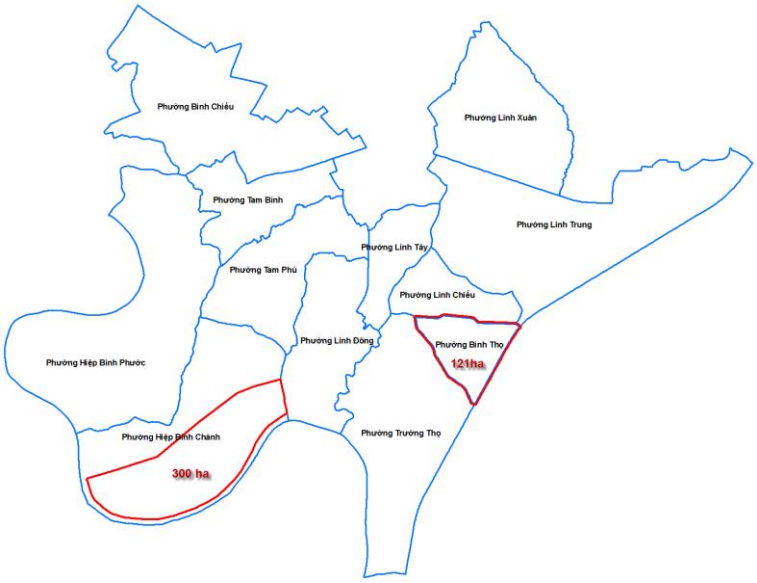
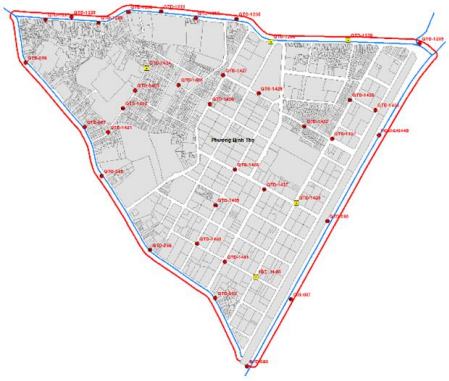


Fig. 1. Location of 02 wards of Thu Duc district in experimental imaging flights

The design research to develop a UAV based image approach for cadastral mapping included three main activities:

a) Develop the ground control points (GCPs) for ensuring the geo-rectification of the UAV imagery; The GCP distribution was created using a cadastral map and image from Google Earth. In total there were 40 GCPs (BT ward) and 23 GCPs (HBC ward) were done by using man-made marks



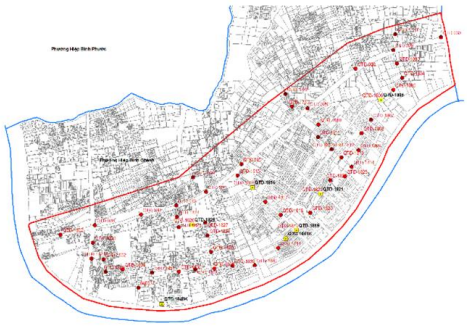


Fig. 2. Cadastral map and location of GCPs at BT ward **Fig. 3. Location of 23 GCPs at HBC ward**

b) Image acquisition: AscTec Falcon 8 system is used to capture images that flew for around 20 minutes for each flight to avoid the chance of the falling due to low battery, and charge the battery is a necessary for each flight. To complete the flights and collect 1912 images for Hiep Binh Chanh ward with autonomously flight; altitude:100m and overlap along track: 65% (flight direction) overlap across track: 60%. In the case of Binh tho ward (Grade A standard) to complete the flights and collect 10381 images with altitude: 70m, overlap along track: 90% (flight direction) and overlap across track: 80%

Fig. 4. UAV (Falcon 8) and facilities used for aerial photography

c) Evaluate the accuracy of results that applied in the case study area.

	Position error (cm)	Resolution (cm)	Number of images
Grade A (Binh Tho ward)	**5**	**2**	**10,381**
Grade B (Hiep Binh Chanh ward)	**7**	**5**	**1,912**

3. Results and discussions

From geo-referencing processing using Agisoft software, positional accuracy from the dataset acquired in this research can be analyzed: accuracy of the UAV image and accuracy of the parcel boundary resulted from UAV based image approach. 36 GCPs were used to produce the ortho-photo and 07 validation GCPs were used to check a quality image was generated. Thus, analysis on the report to evaluate the quality of the ortho-photo could be done. All photos are processed by Agisoft software and using ArcGIS to overlay ortho images with the parcel boundaries.

Fig. 5. Illustration on overlay ortho images with the parcel boundaries

Table 1 and Table 2 show the results that are used to evaluate the accuracy of the processed image.

- (X_0, Y_0) - coordinates of the GCPs,
- (X, Y) - coordinates of the corresponding GCPs on the ortho images,
- *n* - number of GCPs (n=7) is used to evaluate accuracy.

Mean squared errors of the X-axis:

$$m_{\Delta X} = \pm\sqrt{\frac{[\Delta X^2]}{n}} \qquad \Delta X_i = X_i - X_{0i}$$

Mean squared errors of the Y-axis:

$$m_{\Delta Y} = \pm\sqrt{\frac{[\Delta Y^2]}{n}} \qquad \Delta Y_i = Y_i - Y_{0i}$$

Mean squared errors:

$$m_{\Delta S} = \pm\sqrt{\frac{[\Delta S^2]}{n}}$$

Where: $\Delta S_i^2 = \Delta X_i^2 + \Delta Y_i^2$ *(i=1÷7)*

- The results show the horizontal mean squared error of the ortho images of Binh Tho ward is 4.81cm.

Table 1. Accuracy of the ortho images - Binh Tho ward

No.	Name	Coordinates of measured GCPs		Coordinates of GCPs on the Ortho		ΔX^2	ΔY^2	ΔS^2
		X_0 (m)	Y_0 (m)	X (m)	Y (m)			
1	BTH4	611262.5605	1199474.2207	611262.5190	1199474.1960	0.0017	0.0006	0.0023
2	BTH15	611052.8501	1199640.7462	611052.8070	1199640.7670	0.0019	0.0004	0.0023
3	BTH17	611188.3807	1199900.5004	611188.3490	1199900.4760	0.0010	0.0006	0.0016
4	BTH19	610760.6267	1199348.9990	610760.6630	1199349.0300	0.0013	0.0010	0.0023
5	BTH33	610611.5492	1199688.4199	610611.5720	1199688.4050	0.0005	0.0002	0.0007
6	BTH38	610186.9539	1200039.2176	610186.9910	1200039.1870	0.0014	0.0009	0.0023
7	BTH40	610659.8219	1200142.2279	610659.8210	1200142.1600	0.0000	0.0046	0.0046
				Sum		**0.0078**	**0.0084**	**0.0162**
				Mean squared error (m)		**0.0334**	**0.0346**	**0.0481**

- The results show the horizontal mean squared error of the ortho images of HBC ward is 6.07cm

Table 2. Accuracy of the Ortho images - Hiep Binh Chanh ward

No.	Name	Coordinates of GCPs are measured		Coordinates of GCPs on the Ortho		ΔX^2	ΔY^2	ΔS^2
		X_0 (m)	Y_0 (m)	X (m)	Y (m)			
1	HBC19	1197419.442	605022.605	1197419.459	605022.539	0.0003	0.0044	0.0047
2	HBC05	1197124.019	606477.724	1197123.993	606477.667	0.0007	0.0033	0.0039
3	HBC08	1197909.584	606823.019	1197909.618	606822.962	0.0012	0.0033	0.0045
4	HBC17	1198464.879	606983.382	1198464.853	606983.347	0.0006	0.0012	0.0019
5	HBC15	1198549.096	607621.674	1198549.134	607621.629	0.0015	0.0020	0.0035
				Sum		**0.0043**	**0.0141**	**0.0184**
				Mean squared error (m)		**0.0293**	**0.0531**	**0.0607**

By using ArcGIS to overlay ortho images with the parcel boundaries (vector file available is legal digital cadastral map) through the digitizing procedure, creating a map with parcel boundary as a second dataset that can update in cadastral map. 10 parcels per ward were analyzed to evaluate the accuracy the parcel boundaries that is performed by calculating the RMSE of the difference of the parcel from the digitizing procedure (UAV based image approach) and the direct measurement in the field (existing approach)

Fig. 6. Illustration on overlay ortho images with the parcel boundaries for updating the cadastral map

Based on Circular 25/2014 / TT-BTNMT, the position-position error of any two points on the boundary of the land plot indicated on the cadastral digital map compared to the actual field distance measured directly or indirectly from the same station should not exceed 4 cm in the field for the edges of a land parcel. Therefore, the coordinates representing the parcel boundaries from UAV based image approach and existing approach were processed to get the difference value between the 2 datasets. The results show that the RMSE of in total 10 samples were processed to get the RMSE (4.6 cm) of the overall measurement in this case of Grade A standard and in this case of Hiep Binh Chanh ward (Grade B standard) RMSE = 6.2 cm.

Fig. 7. Location of 10 samples at Binh Tho and Hiep Binh Chanh ward

4. Conclusions

In conclusion, experimental results are very promising and clearly demonstrated the capacity of UAV-based remote imaging system to provide high-resolution image (with resolution lower than 3cm in horizontal plane) for small areas with quite low cost. This opens a new way for cadastral mapping and applications of land management. UAV technology is most suitable and cost effective for urban areas, where cadastral maps need to be updated and produced data in a short period of time (on month cover 4 km2 of the Thu Duc district) with high accuracy (6.07 cm at HBC and 4.81cm at Binh Tho ward). By using UAV based image approach can produce the high-resolution images that show new infrastructure investments need to be updated and to avoid misinterpretation of parcel boundary.

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