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Availability Evaluation of Unmanned Aerial Vehicle for the Cadastral Confirmation Survey

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Abstract
Cadastral surveying is that branch of surveying which is concerned with the survey and demarcation of land for the purpose of defining parcels of land for registration in a land registry. The development of high production land survey methods such as Unmanned Aerial Vehicle, and GNSS technology procedures have given rise to questions as to what are acceptable procedures for conducting cadastral surveys. The purpose of this study is to investigate the application of the UAV(Unmanned Aerial Vehicle) for cadastral confirmation surveying and propose ways to apply it for cadastral surveying. Actually, ortho image using UAV had been applied for topographical mapping as a standard technology nowadays, but it had not been use for cadastral confirmation surveying relatively. Recently, the advancement of UAV and the development of geospatial information technology encourage capturing the high resolution imagery, but for the actual applying it for cadastral surveying, the institutional problems, standard procedures for cadastral boundaries' extraction with aerial photogrammetry should be arranged in advance. Hence, the fusion method of the ortho image with cadastral confirmation information to revitalize the Geospatial information industry should be actively considered.

Keywords: UAV, Cadastral Confirmation Survey, Accuracy Analysis, Availability Evaluation

Introduction

Cadastral system is one of the important elements to form the basic unit of society, hence the accurate cadastral information should be provided. The registration record matched with the actual status when the data produced from field survey, however, the difference are appearing with time passing by[1][2]. In order to solve the inconvenience of the land management due to the differences between the cadastral map and the real world, it is important to find an efficient survey method with not only less time, human resource and cost, but also can guarantee the accuracy of parcel location and usage on the whole country[3][4].

The Since the method of cadastral survey settled with registered boundary, although the real boundaries have not changed but the cadastral inconsistency have occurred many boundary disputes[5][6]. Accordingly it became necessary that the cadastral resurvey and correct land boundary information.

In order to set the land boundary, cadastral surveying within a small area may have economic advantages but the efficiency of that method would drop dramatically within a wide area[7][8]. However it was provided the opposite result when the spatial information acquired using satellite, digital aerial photography and LiDAR. Eventually the efficiency different may occur by the target area and survey methods[9][10].These days, inexpensive and high efficiency UAV of spatial information has been given more attention. But studies about test of accuracy of UAV were not enough despite high interest. It presents a cost-effective method that allows adapting image characteristics to the size of the observed objects, to the surveyed process[11][12]. The study for setting up the new land boundary, while there were many research using aerial image. Researches that present a ways to set the boundaries of the land were in the "A Study on the Generation of Sewer Facility Map Using Digital Imagery and Cadastral Maps", "A Study on a Parcel Boundary Establishment –Focused on aerial photogrammetry-" and so on[13][14]. But application of aerial image is not enough to indicate the utilization of UAV.

In this study, images of study area was captured by using the UAV, and throughout the data processing, ortho image of the study area was generated. And comparison between ortho image and cadastral map was performed for propose ways to apply it for cadastral confirmation surveying with UAV. Figure 1 shows the study flow.

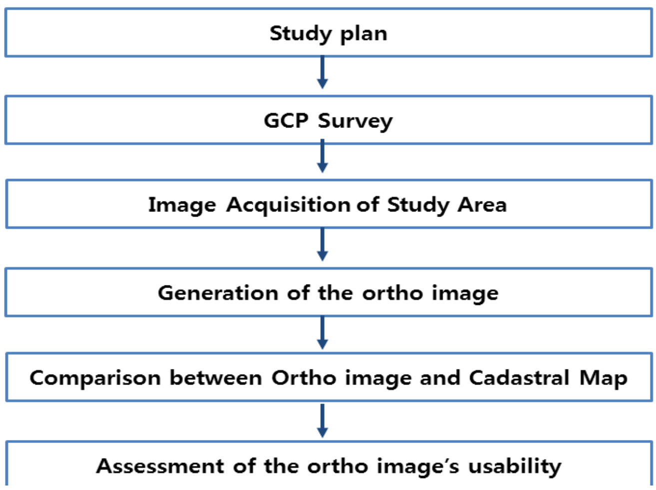

Figure 1: Study flow

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Image Acquisition using UAV

Wonju was selected as a study area. Because cadastral confirmation survey of that area was performed for cadastral resurvey project and cadastral map of the area was renewed. Figure 2 shows the study area.

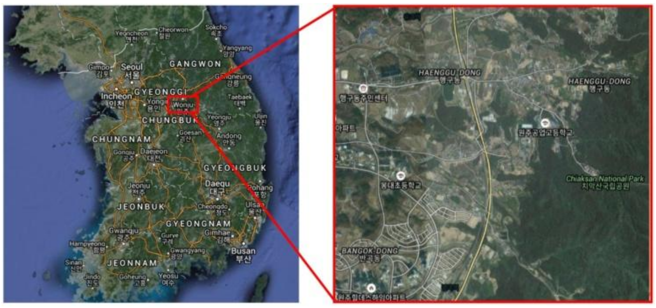

Figure 2: Study area

For this study, Trimble UX5 equipped with various sensors to acquire the spatial information was used. UX5 is made of GPS, digital camera, radio antenna, and pilot tube and other sensors. We used the digital camera of Sony NEX-5R which was calibrated for the photographic survey. As the camera was equipped with the sensor of APS(Advanced Photo System)-C type which is similar to DSLR, the high sensitivity/low noise image shooting was possible. In addition, the radio antenna is designed to transmit the flight data such as speed, altitude and coordinate wireless to the radio modem on the ground controller. In addition, the pitot tube was to monitor the speed and altitude of aircraft by measuring the difference between pressures in the holes made in the front and sides.

The areal image using UAV acquired in study area for the generation of ortho image. The Images were taken to produce 3D model by using adjacent two photographs and to take picture of vertical lap 80% and side lap 80% to produce DSM(Digital Surface Model). Aerial images are imported to data processing S/W along with their locations, orientations, and camera calibrations. Geometric errors in the raw images from an UAV are significant as a result of the dynamic platform from which they are captured and the imprecision in the UAV's position and orientation sensors. Total 807 images were acquired of 4km^2 area in 50 minutes and 5 GCP(Ground Control Point) were surveyed for the accuracy improvement. Figure3shows GCP and Table 1 show coordinates of GCP.

Figure3: GCP

Table 1: Coordinates of GCP

No.	X(m)	Y(m)	H(m)
1	522224.735	288006.318	208.825
2	522138.948	287905.560	197.940
3	521474.756	288462.424	215.224
4	520689.827	289145.917	227.098
5	520722.884	288902.205	226.972

GCP surveying was performed by VRS(Virtual Reference Station) method. The datum of GCP coordinates was KGD2002(Korea Geodetic Datum 2002). The KGD2002 determination was based on the ITRF2000(International Terrestrial Reference Frame 2000) and GRS80 ellipsoid with the reference epoch of 2002.0.

Generation of Ortho Image and Comparison with Cadastral Map

Aerial images acquired UAV were used for the generation of ortho image. Data processing software TBC(Trimble Business Center) was used. TBC is a desktop application that processes and adjusts combined surveying data sets of GNSS and aerial photogrammetric observations[12]. Aerial images are imported to data processing module of TBC (Trimble Business Center) along with their locations, orientations, and camera calibrations. Geometric errors in the raw images from an UAV are significant as a result of the dynamic platform from which they are captured and the imprecision in the UAV's position and orientation sensors. Figure 4 shows data processing using TBC and Figure5 shows the ortho image by UAV.

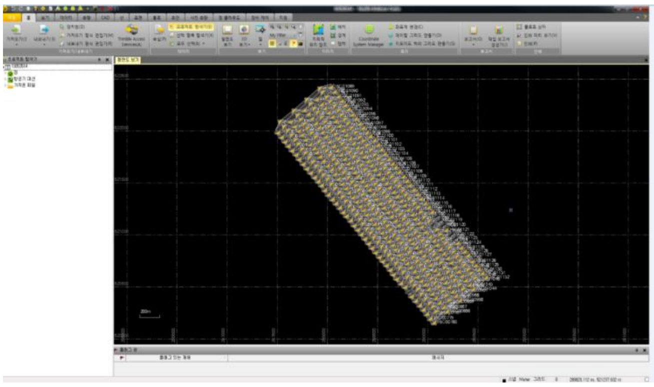

Figure4: Data processing using TBC

Figure5: Ortho image

In this study, cadastral map created by confirmation survey using GNSS and Totalstation was compared with ortho image for investigating of UAV ortho image's usability. Figure6 shows overlapping of the ortho image and cadastral map.

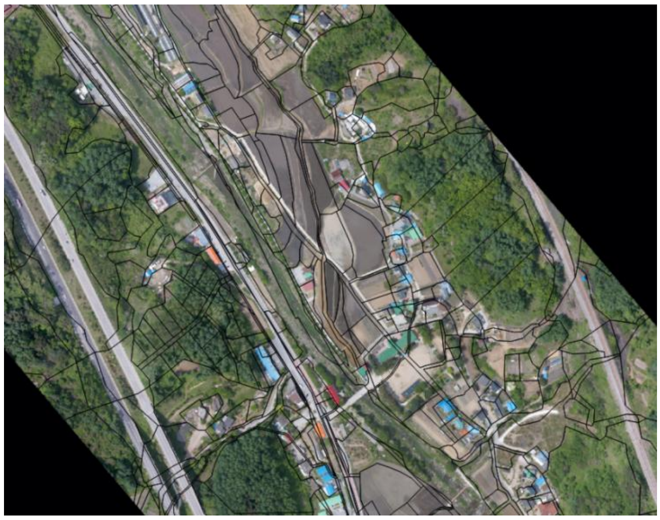

Figure 6: Overlapping of the orthoimage and cadastral map

As shown in Figure 7, it can be found visually about result of cadastral confirmation survey efficiently. For evaluation of UAV ortho image, accuracy analysis was performed using survey result about 3 parcels. Figure7 shows location of parcel and Table 3 shows coordinates of each parcels by GNSS, TS surveying and ortho image. Figure8 shows result of accuracy analysis.

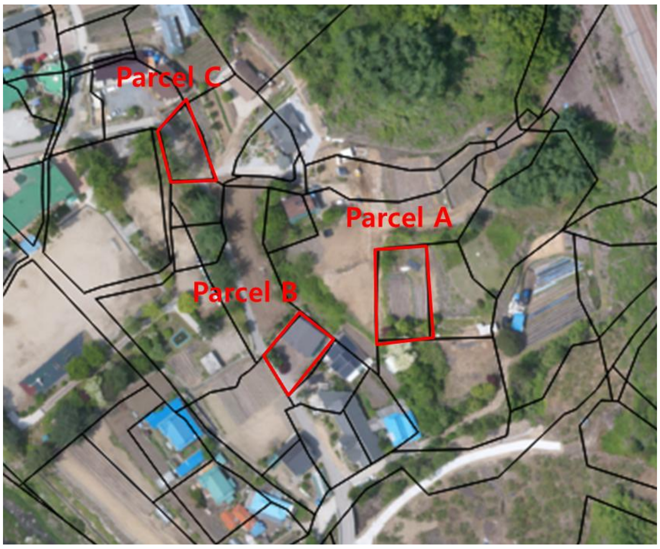

Figure7: Location of parcels

Table 2: Coordinates of each parcels

Parcel	GNSS, TS Survey		Using Ortho Image	
	X(m)	Y(m)	X(m)	Y(m)
A	521632.91	288313.62	521632.82	288313.7
	521645.65	288351.66	521645.58	288351.71
	521618.54	288325.02	521618.63	288324.97
	521628.03	288358.33	521628.11	288358.25
B	521573.91	288419.94	521573.88	288419.89
	521557.64	288421.34	521557.71	288421.43

	521562.84	288440.54	521562.77	288440.61
	521575.71	288438.12	521575.79	288438.21
C	521565.34	288497.42	521565.28	288497.33
	521568.01	288514.22	521568.1	288514.29
	521533.77	288162.27	521533.85	288162.34
	521532.03	288496.05	521532.11	288496.14

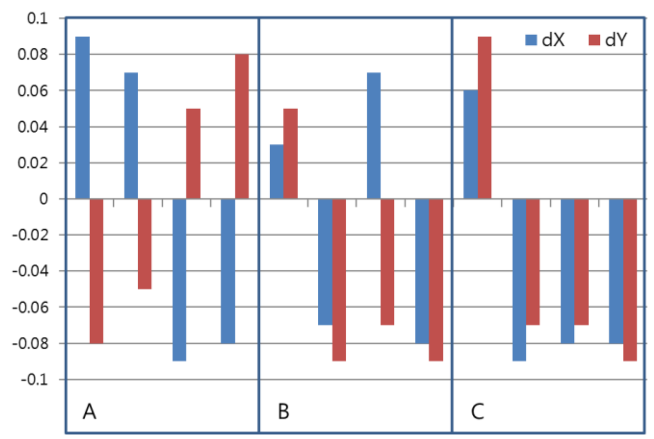

Figure8: Results of accuracy analysis

Results of deviation by UAV ortho image showed 0.03~0.09m compared with results of GNSS and TS. These are value within the allowable error about cadastral confirmation survey according to the cadastral Enforcement Regulation. Table 3 shows allowed error by the enforcement regulation of cadastral surveying.

Table 3: Allowed error by the enforcement regulation of cadastral surveying

Case	Allowed Error
Cadastral Triangulation Point	<0.2m
Subsidiary Cadastral Triangulation Point	<0.25m
Boundary Point	<0.10m

However, it is difficult to determine the actual boundary in the ortho image. Through further study, if the method for determination of land boundary will proved, cadastral confirmation surveying using ortho image can be possible. And ortho image could be save the time and cost for cadastral surveying.So, there is a need for further study in the future about effective determination of land boundary. In addition, the fusion method of the ortho image with cadastral confirmation information to revitalize the Geospatial information industry should be actively considered.

Conclusions

In this study, the application of the UAV for cadastral confirmation surveying was performed and propose ways to apply it for cadastral surveying. Wonju was selected as a study area because cadastral confirmation survey of that area was performed for cadastral resurvey project and cadastral map of the area was renewed. Cadastral map created by confirmation survey using GNSS and Totalstation was compared with ortho image for investigating of UAV ortho image's usability. It can be found visually about result of cadastral confirmation survey efficiently. For evaluation of UAV ortho image, accuracy analysis was performed using survey result about 3 parcels. Results of deviation by UAV ortho image showed 0.03~0.09m compared with results of GNSS and Totalstation. These are value within the allowable precision about cadastral confirmation survey. However, it is difficult to determine the actual boundary in the ortho image. Through further study, if the method for determination of land boundary will proved, cadastral confirmation surveying using ortho image can be possible. So, there is a need for further study in the future about effective determination of land boundary. In the future, ortho image could be save the time and cost for cadastral surveying such as confirmation, reconnaissance, boundary restoration and so on. Hence, the fusion method of the ortho image with cadastral confirmation information to revitalize the Geospatial information industry should be actively considered. As IT(Information Technology) is growing up, the people looking for more convenience device for safety, easy and low cost. In this point, UAV may be a new alternative to traditional aerial photogrammetry.

Acknowledgments

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