Suitability of the PKNU 2 System for Generating the Ortho-photo Map

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Abstract: This system is capable of obtaining quantitative information from images using natural features on the ortho-image maps that correspond with those from topographical maps. However, the qualitative information can also be obtained because because of the excellent visibility of ortho-image maps. There are plenty of promise for the use of ortho-image maps in the next generation topographic technology because of its wider applicability within the field. In keeping with the cutting edge, we produced ortho-image maps by scanning a specified area in narrow sections using the PKNU 2: a multispectral digital aerial photographing system made by ourselves. We evaluated the precision of the ortho-image maps, and performed an evaluation of the PKNU 2 system's capacity to improve the equipment of the PKNU 2. Ortho-image maps were made using Ground Control Points (GCPs) which were obtained from digital maps and aerial photographs of the PKNU 2. Thus, we demonstrated that it was possible to produce the ortho-image maps, which has a good constant level rate of less than 1m. The PKNU 2 system needs to be improving in the sensitivity of level maintenance equipment in the evaluation in terms of performance. It is thus required to survey the GCPs precisely for an accurate study.

Keywords: ortho-image map, PKNU 2, digital aerial photographing system, GCPs

1. Introduction

Prior to this study, an ongoing investigation for the development of an aerial photographing system has conducted since June 2001 in the laboratory of Professor Chul-Uong Choi in Pukyong National University in Korea. Many studies have been conducted through the course of 6 test flights, in testing the effectiveness of this system in meeting the requirements of a complete and advanced Aerial Photographing system. Our finding: the PKNU 2 system has shown itself to be capable of reliable functioning even under the most extreme weather conditions. PKNU 2 was also successful in obtaining high-resolution images within 30m of ground resolution in linear area such as rivers, roads less than 50m and small areas after finding ways to improve its efficiency. By taking infrared images simultaneously it has also been made able to produce compound images of color and in the infrared spectral band, While most studies have been performed with the intent of improving the clarity and resolution of images, this study is focused on obtaining images that will be used for engineering projects with the need for a certain level of precision. We tested whether aerial weather photographs from PKNU 2 were worthy of engineering use and looked into the possibility of making an ortho-map with this system.

2. Experiments

2.1. The study area

The Sunsan country club (1,576,526㎡) and Jeiss country club(3,356,457㎡) in mountain 39-1 bunji Induk-ri Sandong-myun Gumi-shi KyungSangBukDo were the test areas for this study. This area's imagery was obtained through 18 sheets of images from the PKNU 2.

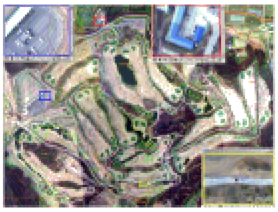

Fig. 1. PKNU 2 ortho-map of a golf course

2.2. Aerial photographing

Aerial photography of this site was performed on 30~31, March 2003. The range of photographing was a zone of Nakdong river (From uian-ri gaejin-myun goryung-gun KyungSangBukDo to Sunsan country club, Sandong-myun Cumi-shi with 82km length one-way).

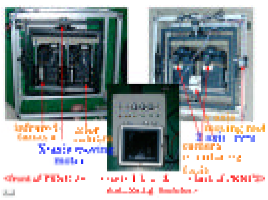

Fig. 2. PKNU 2 aerial photographing system

The equipment used in this study is a Digital multispectral camera (DCS 460C: 2sets, DCS460IR: 1set), Video camera, ultra light aircraft (Maverick 582) and Ground monitoring camera 2sets.

2.3. Image processing

The photographing area per one sheet of images is about 700,000㎡ (1,000m×700m×4band(R,G,B,NIR)) with 0.3m×0.3m of ground resolution. 17 images of the total of 160 images from PKNU 2 were used in this study. The area in size of 3㎞×2㎞ was taken by PKNU 2 to evaluate the possibility in practical use and the accuracy of PKNU 2.

2.3.1. Interior orientation

When you conduct Interior orientation of digital images obtained from PKNU 2, it is not required to input the value of fiducial marks differing from the analog image's processing. However, x,y coordinates and the size of pixels are required in the case of digital image processing. To rectify a lens distortion, tangential and radial distortions are determined in the laboratory and then factored into the data.

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Table 1. Rectification coefficient calculation values of radial distortions(radial direction units : mm, distortion units : ㎛).

9㎛, that is the pixel size mentioned in the specification of the Kodak DCS 460 was used in this study. Rectification of lens distortion is table 1. In general, while lens distortions come from tangent directions and radial directions, tangential distortions are so small in comparison with radial distortion that radial distortions were rectified mainly. Table 2 shows the value of lens distortions calculated precisely in our laboratory.

Although the same GCPs(Ground Control Points) are used in ortho-rectification of images, it' s different to come out the results after ortho-rectification according to "yes or no" of lens distortions' correction such as Fig. 5.

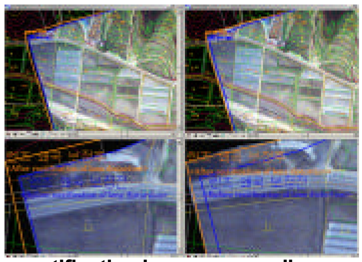

Fig. 3. Ortho-rectification images according yes or no of lens distortion' s correction.

2.3.2. Exterior orientation

33 GCPs and 66 connecting points were used for exterior orientation like Fig.6. From the minimum 11 points to the maximum of 23 points were used in each image. GCPs are created by images and Coverage converted from digital maps with 1/5000 from the National Geography Institute.

Fig. 4. GCPs and connecting points' arrangement map for exterior orientation

methods	total precision (unit: pixel)	Precision of GCPs(Unit: m)			Precision of images(Unit: pixel)	
		X	Y	Z	x	y
Before lens distortion's correction	5.5788	1.725	3.417	3.124	6.342	5.021
After lens distortion's correction	2.8409	1.787	2.170	2.819	2.211	2.366

Table 2. Precision of ortho-rectification (the pixel size after ortho-rectification: about 0.35×0.35)

End lap, that is lapping along the flight strip was normally held at approximately, 50%±22%. So there are some problems to keep the minimum lapping rate over 50%. Side lap, that is a lateral overlapping of adjacent strips was stable as 30%. Vertical location(Z) was kept the stable flight elevation as 789.53m±25.15m. Values of Omega, phi were 0.6。 ±3.29。 and -0.05。 ±1.49。 respectively. They are 94%, 100% in case of the maximum acceptable limit ± 5。 (Omega, phi) of level maintenance device of Zeiss DMC and RMK as a standard . They are 47%, 94% in case of the maximum acceptable limit ±3。 (Omega, phi) as a standard. So it is needed to improve the capability of level maintenance for movement direction of front and rear. However, Level maintenance device for movement direction of right and left was working stably.

2.3.3. Ortho-rectification

DEM(Digital Elevation Model) used in ortho-rectification was made by 1/5,000 land maps through Arcview software like Fig. 8. The result of ortho-rectification is in Fig. 9.

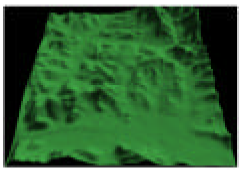

Fig. 5. DEM used in ortho-rectification

Fig. 6. Mosaic images of ortho images

We made an ortho image map of the total study area after ortho-rectification. Fig. 10 shows the result. The red line is a borderline of each image. Enlargement images show borderlines of each image on a large scale. It's possible to mosaic ortho images within 1m.

3. Conclusion

We investigated for the feasibility of producing ortho-maps by performing aerial photographing and making ortho images. The results of this study as follows:

First, GCPs were only obtained from digital maps in ortho image map's production using PKNU 2digital multispectral photographing system but it was possible to make it within 1m of horizontal location precision. It could be possible to get better results if GCPs would have been obtained by using GPS(Global Positioning System) instruments from now on.

Second, before and after lens distortion corrections of cameras installed in PKNU 2, precisions were 3.5~4 pixels and 1.3~1.52 pixels respectively. In results of ortho-rectification without lens distortion's correction were calculated 5.5788 pixels (about 2m) and 2.84 pixel (about 2m) respectively. So, lens distortion's correction before ortho-rectification has to be performed in every time essentially.

Third, automatic level maintenance module of PKNU 2 system are 94%, 100% in case of the maximum acceptable limit ± 5。 (Omega, phi) of level maintenance device of Zeiss DMC and RMK as a standard. They are 47%, 94% in case of the maximum acceptable limit ±3。 (Omega, phi) as a standard. So it is needed to improve the capability of level maintenance for movement direction of front and rear. However, Level maintenance device for movement direction of right and left was working stably. This is a feature caused that a light aircraft has much more moving in front and in the rear than moving right and left. So it is need to be improved to promote the equipment reformation projection hereafter.

Fourth, there are some problems to keep over 50% as the minimum overlapping rate by having interval control module of automatic PKNU 2 photographing system with average 50%±22% overlapping rate because the minimum continuous photographic interval of Kodak DCS 460 is 12 s, which is the time to store data. For this problem, Kodak DCS 460 camera 2 sets are operated and improved from 12 s to 6 s of interval.

Fifth, This study is for improving our PKNU 2 system to more precision controlling gear and evaluating the possibility of ortho image map's production using images from PKNU 2 system. Therefore, studies for precision GCPs' obtaining and land mapping of 3 dimensions are required more and more.

Acknowledgement

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