한국지형공간정보학회지
(Journal of the Korean Society for Geospatial Information System)
Vol.22 No.4 December 2014 pp.159-164

ISSN: 1598-2955 (Print)
ISSN: 2287-6693(Online)
http://dx.doi.org/10.7319/kogsis.2014.22.4.159

연구논문

고정익 무인항공기를 이용한 공간정보 구축의 활용성 평가

Availability Evaluation for Generation of Geospatial Information using Fixed Wing UAV

박영진* · 정갑용**
Park, Young Jin · Jung, Kap Yong

要 旨

최근 재해 예방 및 공간정보 구축 분야에 경제적이고, 효율이 높은 무인항공기에 대한 관심이 증가하고 있다. 그러나 무인항공기에 대한 높은 관심에도 불구하고 이에 대한 정확도 검증이나 활용성 평가에 대한 연구는 충분히 이루어지지 못하고 있다. 이에 본 연구에서는 고정익 무인항공기를 이용하여 DSM과 정사영상을 생성하고, GNSS 측량과 비교하여 정확도를 평가하였다. 연구를 통해 무인항공기에 의한 정사영상은 축척 1:1,000 수치지도 갱신에 활용이 가능함을 제시하였다. 또한 지상라이다를 이용하는 방법과 인력 및 시간의 비교를 통해 고정익 무인항공기의 활용성을 평가하였다.

핵심용어 : 공간정보, 고정익 무인항공기, 정사영상, 정확도 평가

Abstract

These days, inexpensive and high efficiency UAV of disaster prevention and spatial information has been given more attention. But studies about test of accuracy of UAV were not enough despite high interest. This research produced DSM and ortho photo and estimated accuracy by comparing coordinates with GNSS survey to evaluate outcome of fixed wing UAV. The ortho photo was found to make use of it to update 1/1,000 map. This research investigated spatial information construction using existing terrestrial LiDAR to suggest effectiveness of fixed wing UAV.

Keywords : Geospatial Information, Fixed Wing UAV, Ortho Photo, Analysis of Accuracy

1. Introduction

Spatial information included location information on natural and artificial object at the space and information on spatial perception and decision- making to produce added values in accordance with development of platform connecting all of things in the world with virtual space on internet. Meanwhile, Local areas of national land and topography made change very much often because of rapid economic development, changes of industrial structure, urban expansion by development and abnormal climate. These changes produced great problem at the supply of latest spatial information that was needed at effective control of national land and urban cities, spatial information related industries and social activities (Jung, et al., 2010; Kang, et al., 2010). Real time aerial monitoring system was continuously developed to take immediate action against emergent situation (Choi, et al., 2011). UAV(Unmanned Aerial Vehicle) refers to the flight vehicle that flies autonomously devoid of a pilot in accordance to the pre-input program while flight vehicle itself recognizes the surrounding environment and makes judgment (Oh, 2014; Yun, et al., 2014). UAV could get access to photographing area from time to time to take picture of various kinds of scales depending upon flight level and to do inclination photographing and video and to be very much useful (Kim, et al., 2010; Eugster et al., 2008). And UAV-based remote sensing enables user-controller image acquisition and bridges the gap in scale and resolution between ground observations and image acquired from conventional manned aircrafts and satellite sensors. It presents a cost-effective

Received: 2014.12.08, accepted: 2014.12.17

* 정회원 · 서일대학교 토목과 교수(Member, Dept. of Civil Engineering, Seoil University, profpark@seoil.ac.kr)
** 교신저자 · 정회원 · 충남대학교 대학원 토목공학과 공학박사(Corresponding Author, Member, Dept. of Civil Engineering, Chungnam National University, jungjusa@hanmail.net)

method that allows adapting image characteristics to the size of the observed objects, to the monitored processes, and to the speed of change within a landscape. UAV-based remote sensing yields the best possible spatial and temporal resolutions for the respective research application (d'Oleire-Oltmanns, et al,. 2012; Laliberte, et al., 2011; Aber, et al., 2010; Thamm, et al., 2006). In this research, multi sensor UAV was used to obtain data and to produce the precise DSM and ortho photo and to evaluate accuracy of the outcome. This research gave utilization of spatial information by comparing existing information with information using UAV.

2. Composition of Fixed Wing UAV

In this research, Fixed Wing UAV(UX5) was used to obtain real time images. UAV could be equipped with GPS, digital camera, radio antenna, pitot tube and other sensors. Fig. 1 shows fixed wing UAV used in this study.

GPS receiver measured time difference of signals from each satellite to convert into distance and to estimate location of the receiver. Mirrorless camera was used to take pictures with high resolution on the ground. The camera was equipped with APS (Advanced Photo System)-C type of sensor same as DSLR. The radio antenna could transmit airplane speed, altitude, coordinates and other flight data to radio modem of the ground controller by wireless communication, and pitot tube measured difference of the pressure between opening of front and that of side to monitor speed and altitude of the airplane and to be placed at eBox. Table 1 shows specification of the camera(http://uas.trimble.com/sites/default/files/downloads/trimble_ux5_datasheet_english.pdf).

Figure 1. Fixed wing UAV

Table 1. specification of the camera

Items	Specification
Name	Sony NEX-5R digital camera
Sensor	16.1 MP with APS-C sensor
Lens	Fixed-optics Voigtlander lens
Image size	4,912*3,261
Color	Standard color
Feature	Fixed lens increases the stability of the camera internal geometry

Figure 2. Camera

Figure 3. tablet PC

The ground controller was used to control UAV on ground to have software that could make plan and control table PC as well as UAV flight. The tablet PC connected modem to do wireless communication with UAV. Fig. 2 shows Camera and Fig. 3 shows tablet PC.

3. Data acquisition and construction of geospatial information

3.1 Data acquisition and processing

In this research, UAV was used to take aerial photograph of new town in Buyeo-gun Chungcheongnam-do. Buyeo-gun included residential area, farming area, mountains, riverside area and others. Fig. 4 shows study area.

217 cuts of photographs were taken to produce 3 dimensional model by using adjacent two photographs and to take picture of vertical lap 70% and side lap 70% to produce DSM(Digital Surface Model). Aerial images are imported to data processing module along with their locations, orientations, and

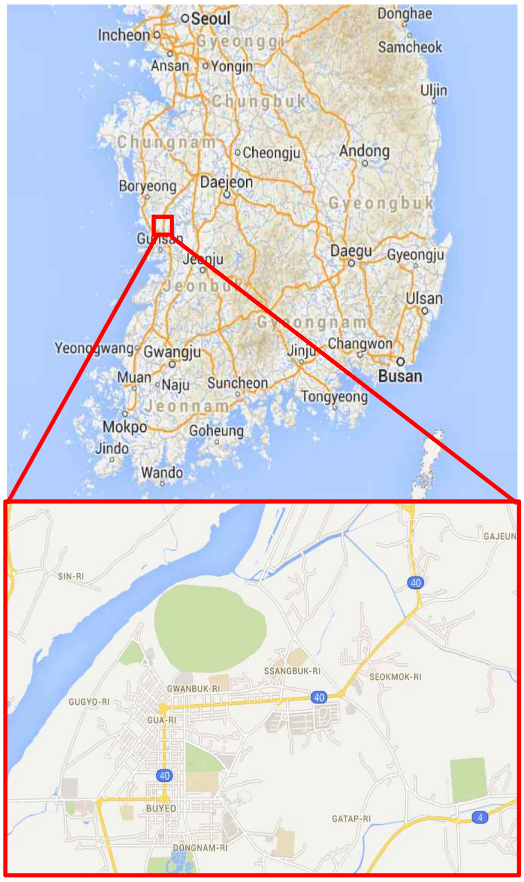

Figure 4. Study area

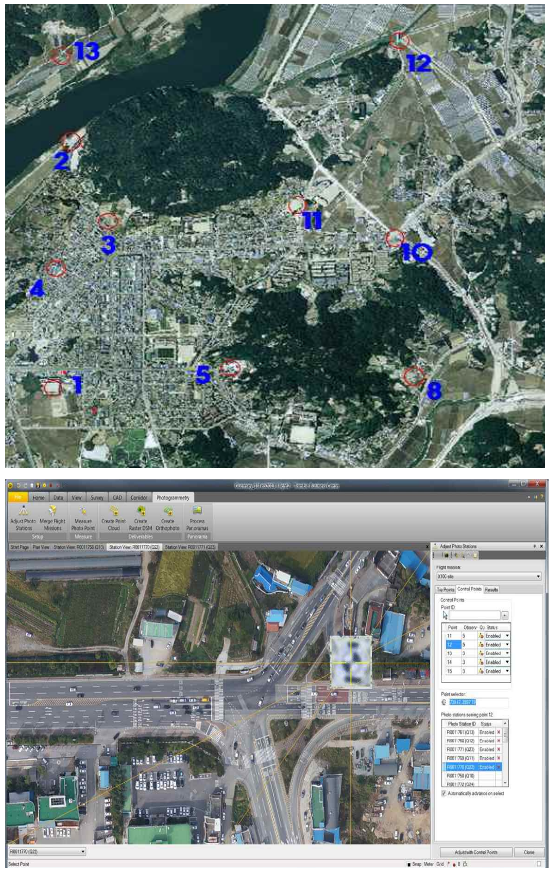

Figure 5. Location of GCPs and Registration screen of GCP

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. To correct for errors in the positions and orientations of the aerial images, we used photogrammetric methods to adjust the photo stations. This is done in data processing module first as an adjustment with photo tie points. This module automatically finds tie points in all available stations based on state of the art computer vision algorithms, and then the software adjusts the stations simultaneously for a best fit. Automatically matched photo tie points are distributed densely over the complete project, even in challenging low-texture terrain (Eisenbeiss, et al., 2006).

When the adjustment with tie points was complete, we could locate and register the GCPs easily. After the targets are registered, we ran a final adjustment in which additional processing steps such as full camera calibration, automatic quality assurance and blunder removal are performed by data processing module. We could verify the adjustment results quantitatively and independently based on any number of GCPs labeled as check points rather than being enabled in the adjustment with control points. After adjusting with control points, the stations display accurate perspective views, where surveyed data will align accurately in each image. Once the aerial images are adjusted, we could use the Measure Photo Point feature in data processing module to determine the Cartesian coordinate of a location in the image by simply selecting pixels in aerial and terrestrial images. This creates photogrammetry observations, and data processing module will automatically calculate the intersection of two or more observations to create a point in TBC(Trimble Bussiness Center). Fig. 5 shows location of GCPs and registration screen of GCP.

3.2 Construction of geospatial information

Aerial images are typically used to create 3D deliverables including ortho photos, DSM, and point clouds. In a final step, we specified parameters such as desired output products, resolutions and densities, and the software automatically creates 3D point clouds from adjusted photo stations. A raster DSM created from the generated point cloud is refined using sophisticated interpolation routines, noise filtering, edge modeling and outlier detection to achieve rich detail within surface models. Rigid Ortho rectification combined with outstanding geometric feature-based seamline-finding and radiometric balancing result in perfect looking seamless ortho-mosaics. Seams are adaptively blended according to image texture analysis. Radiometric single image corrections as well image group corrections are applied for perfect homogeneous colors and intensity. The ortho photo rectified aerial photograph by using DSM with buildings and bridges, and included plenty of objects into DSM to recover closed area. The ortho photo without closed area coincided with map at overlap to be suitable to 3 dimensional urban model. The rectification made correction of inclination and scale to unify a scale and to take plumb photograph without displacement. Fig. 6 and Fig. 7 show DSM and ortho photo.

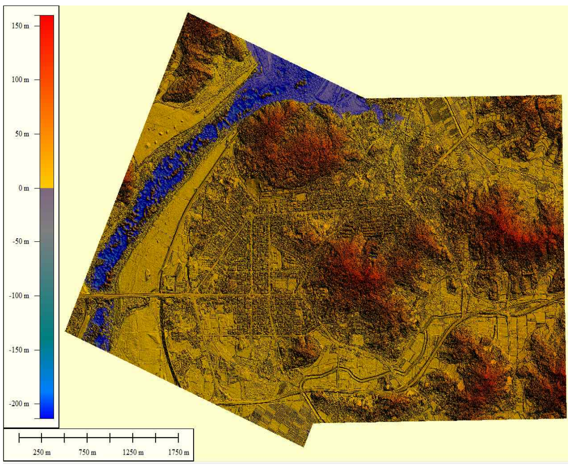
Figure 6. DSM

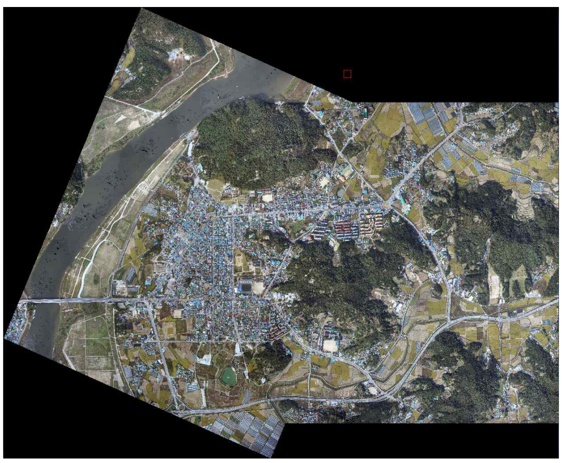
Figure 7. Ortho photo

After taking data of UAV, DSM of automatic processing could do 3 dimensional topographic analysis, production of contour, estimation of cross section, estimation of volume and other 3 dimensional space analysis to make use of GIS, and ortho-photograph image could be used for map production and update, change monitoring and others.

4. Analysis of accuracy and discussion

4.1 Analysis of accuracy

We selected ten of check points to estimate accuracy of the ortho photo and to measure reference points and to investigate coordinate values corresponding ortho photo. The check points were in Fig. 8 and difference between test result of reference points and coordinate values of the ortho photo was presented in Table 2 and N directional deviation ranged from 0.010m to 0.44m, and RMSE of ±0.034m had good accuracy and precision. E direc-


Figure 8. Check points

Table 2. Result of accuracy analysis

No.	Deviation (N)	Deviation (E)	Deviation (total)
1	0.040m	0.020m	0.045m
2	-0.020m	-0.035m	0.040m
3	-0.044m	-0.025m	0.051m
4	0.038m	0.050m	0.063m
5	-0.035m	0.047m	0.059m
6	0.025m	0.020m	0.032m
7	0.010m	-0.040m	0.041m
8	-0.035m	0.011m	0.037m
9	0.020m	-0.040m	0.045m
10	0.039m	-0.041m	0.057m
RMSE	±0.034m	±0.037m	-

tional deviation ranged from 0.011m to 0.050m, and RMSE indicated ±0.037m. Fig. 6 shows check points and Table 2 shows result of accuracy analysis.

At production of 1:1,000 scale digital map, research on various kinds of terrains and areas below than values smaller than standard deviation of 0.2m at the plane as well as max difference at the plane of 0.4m was likely to produce the digital map. In this research, overlap of both ortho photo and digital map was used to investigate use of special information made by fixed wing UAV. The field in the past was used to be four lanes road at comparison between existing digital map and ortho photo (Fig. 9). Large-scaled buildings were built up at rice paddy in the past to make change of topography (Fig. 10). The ortho photo using UAV could use to update the digital map.

Figure 9. Overlay of digital topographic map and ortho photo - 1

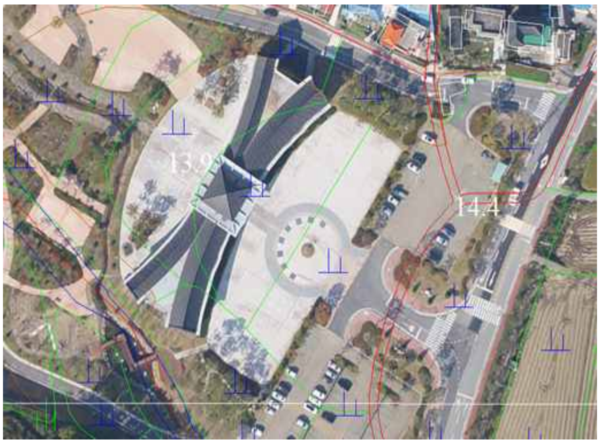

Figure 10. Overlay of digital topographic map and ortho photo - 2

4.2 Discussion

In this research, precise spatial information was able to construct using fixed wing UAV. We compared the working time and requirement man power between the existing method(terrestrial LiDAR) and UAV method to evaluate the utilization of spatial information about 1km^2 target area.

The terrestrial LiDAR required two persons, that is to say, one worker for body equipment and the other worker for installation and movement of data matching sphere ball, while UAV did one person only to put launcher and to obtain data. It took more than 4 hours to put and move territorial LiDAR more than 20 times to do scanning of place, and did 50 minutes for UAV to take photograph. UAV could automatically process data, while territorial LiDAR required plenty of time to do registration and modeling of scanning data. UAV would be reduce man power and time for construction of geospatial information in small area and area is increased as the difference in efficiency is determined to be larger. Table 3 shows comparison of terrestrial LiDAR and UAV.

Table 3. Comparison of terrestrial LiDAR and UAV

	terrestrial LiDAR	UAV
requirement man power	2 person	1 person
Data Acquisition	up to 8 hours	less than 1 hour
Data processing	up to 24 hours	less than 4 hours

5. Conclusion

In this research, fixed wing UAV was used to test the utilization of spatial information. The conclusions were followings.

(1) DSM and ortho photo was produced effectively using fixed wing UAV with GPS, digital camera and radio antenna.

(2) At test of exactness of spatial information, deviation(N) of 0.010~0.044m, deviation(E) of 0.011~0.050m and RMSE of ±0.034m and ±0.037m could produce and update 1/1,000 map by using fixed wing UAV.

(3) The sensor had much better access and promptness than conventional type of spatial information build up had, so that I t could save labor and time to produce true ortho photo of various kinds of terrains and to investigate into damages of natural disasters and to monitor local changes.

Acknowledgments

The present research has been conducted by the Research Grant of Seoil University in 2014

References

1. Aber, J., Marzolff, I. and Ries, J. B., 2010, Small format aerial photography: principles, Techniques and Geoscience Applications, Elsevier, p. 256.
2. Choi, K. A., Lee, J. H. and Lee, I. P., 2011, Development of a close−range real−time aerial monitoring system based on a low altitude unmanned air vehicle, Journal of the Korea Spatial Information Society, Vol. 19, No. 4, pp. 21−31.
3. d'Oleire−Oltmanns, S., Marzolff, I., Peter, K. D. and Ries, J. B., 2012, Unmanned aerial vehicle (UAV) for monitoring soil erosion in morocco, Remote Sensing, Vol. 4, No. 11, pp. 3390−3416.
4. Eisenbeiss, H. and Zhang, L., 2006, Comparison of DSMs generated from mini UAV imagery and terrestrial laser scanner in a cultural heritage application, Proceedings of ISPRS Commission V Symposium 'Image Engineering and Vision Metrology', pp. 90−96.
5. Eugster, H. and Nebiker, S., 2008, UAV−based augmented monitoring-real−time georeferencing and integration of video imagery with virtual globes, proceedings of the international archives of the photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII, pp. 1229−1236.
6. Jung, S. H., Lim, H. M. and Lee, J. K., 2010, acquisition of 3d spatial information using UAV photogrammetric method, Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography, Vol. 28, No. 1, pp. 161−168.
7. Kang, J. M., Zhang, C., Park, J. K., Kim, M. G., 2010, Forest fire damage analysis using satellite images, Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography, Vol. 28, No. 1, pp. 21−28.
8. Kim, M. G., Jung, G. Y., Kim, J. B. and Yun, H. C., 2010, Applicability analysis of UAV for storm and flood monitoring, Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography, Vol. 28, No. 6, pp. 655−662.
9. Laliberte, A. S., Winters, C. and Rango, A., 2011, UAS remote sensing missions for rangeland applications, Geocarto International, Vol. 26, No. 2, pp. 141−156.
10. Oh, S. H., 2014, A study on development of dual locking linkage for landing gear for the application to UAV, International Journal of Control and Automation, Vol. 7, No. 2, pp. 41−48.
11. Thamm, H. P. and Judex, M., 2006, The low cost dron - an interesting tool for process monitoring in a high spatial and temporal resolution, Proceedings of the ISPRS Commission VII Mid−Term Symposium "Remote Sensing from Pixels to Processes", pp. 140−144.
12. Yun, B. Y., Lee, J. O., 2014, A study on application of the UAV in Korea for integrated operation with spatial information, Journal of the Korean Society for Geospatial Information System, Vol. 22, No. 2, pp. 3−9.
13. http://uas.trimble.com/sites/default/files/downloads/trimble_ux5_datasheet_english.pdf