Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography
Vol. 36, No. 3, 197-202, 2018
https://doi.org/10.7848/ksgpc.2018.36.3.197

ISSN 1598-4850(Print)
ISSN 2288-260X(Online)
Original article

Construction of Coastal Surveying Database and Application Using Drone

Park, Joon Kyu[1)]· Lee, Keun Wang[2)]

Abstract

Drone has been continuously studied in the field of geography and remote sensing. The basic researches have been actively carried out before the utilization in the field of photogrammetry. In Korea, it is necessary to study the actual way of research in accordance with the drone utilization environment. In particular, analysis on the characteristics of DSM (Digital Surface Model) generated through drone are needed. In this study, the characteristic of drone DSM as a data acquisition method was analyzed for coastal management. The coastal area was selected as the study area, and data was acquired by using drone. As a result of the study, the terrain model and the ortho image of coastal area were produced. The accuracy of UAV (Unmanned Aerial Vehicle) results were very high about 10cm at check points. However, concavo-convex shapes appeared in very flat areas such as tidal flats and roads. To correct this terrain model distortion, a new terrain model was created through data processing and the results were evaluated. If additional studies are carried out and the construction and analysis of terrain model using drone image is done, drone data for coastal management will be available.

Keywords: Characteristic Analysis, Coastal Surveying, Drone, DSM, Ortho Image

1. Introduction

As technologies have been advanced, drone can acquire high-level flight information (location, attitude, altitude, etc.) at low cost (Moon and Lee, 2016; Park and Um, 2016; Turner, *et al*., 2016). In addition, based on the built-in GPS (Global Positioning System) / IMU (Inertial Measurement Unit) sensor, it is possible to acquire images by performing an automatic navigation flight along a given flight path (Sim, 2016). There are hardware and software environments to utilize drone, and it is confirmed that efforts to utilize drone in various fields have been conducted (Cho *et al*., 2015; Lee *et al*., 2016). Therefore, in the field of geography that performs various researches such as mapping, surface analysis, and natural disaster analysis through remote sensing and digital image processing, drone can be substituted for existing expensive observation equipment and data collection procedure (Lague, *et al*., 2013; Casella *et al*., 2016; Kim, *et al*., 2016).

As a study to use drone, flight control using small computer, correction of drone photographed image, and utilization in urgent mapping field were conducted. Photogrammetric studies using drones and related studies have also been conducted including accuracy evaluation and usability evaluation. However, there is a lack of research on the characteristics of DSM (Digital Surface Model) generated by drone. In this study, the characteristic of drone DSM as a data acquisition method was analyzed for coastal management. Fig. 1 shows study flow.

Received 2018. 06. 12, Revised 2018. 06. 26, Accepted 2018. 06. 28
1) Member, Dept. of Civil Engineering, Seoil University, Republic of Korea (E-mail: jkpark@seoil.ac.kr)
2) Corresponding author, Member, Dept. of the Multimedia Science, Chungwoon University, Republic of Korea (E-mail: kwlee@chungwoon.ac.kr)

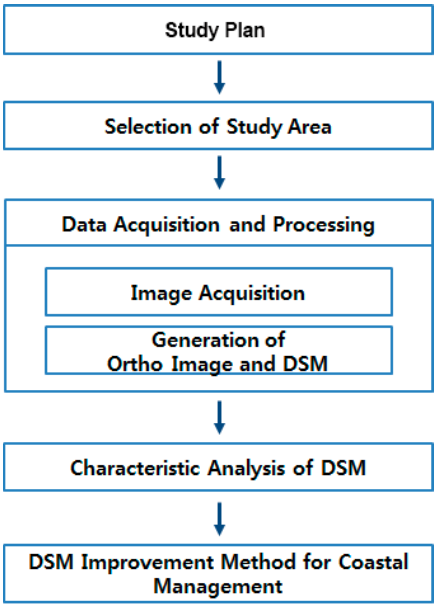


Fig. 1. Study flow

2. Study Area and Data Acquisition

In this study, Shinan-gun located in the coastal area was selected as the study area. Shinan-gun is a coastal area where the coastal survey is performed periodically due to the large difference in tides between the western and sea regions. Fig. 2 shows location of study area.

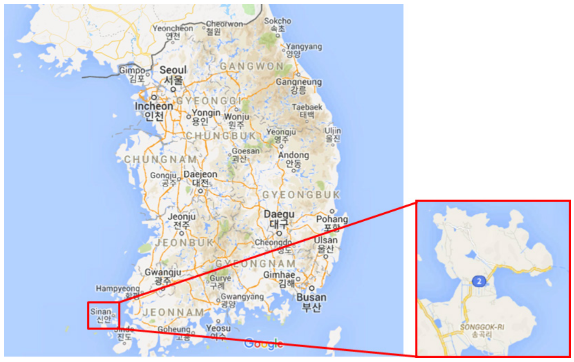


Fig. 2. Study area

UX5 HP, a fixed wing drone, was used for aerial photography of the study site. UX5 HP is equipped with various sensors such as GNSS (Global Navigation Satellite System), IMU and pitot tube, and the digital camera. Fig. 3 shows UX5 HP and Table 1 shows specification of UX5 HP (Trimble Inc, 2018).

Fig. 3. UX5 HP (Trimble Inc, 2018)

Table 1. Specification of UX5 HP (Trimble Inc, 2018)

Items		Specification
Drone	Type	Fixed wing
	Weight	2.9 kg
	Wingspan	1 m
	Material	EPP foam
	GNSS	L1/L2 GNSS (GPS, Glonass, Beidou, Galileo Ready)
	Endurance	35 min
Camera	Name	Sony A7R
	Sensor	36 MP with APS-C sensor
	Lens	Fixed-optics voigtlander lens
	Image size	7,360 x 4,912
	Focal length	25 mm
	Color	Standard color
	Feature	Fixed lens increases the stability of the camera internal geometry

The study area was about 2 square kilometers, the flight height was 400 m, and about 200 raw images were taken. The GSD (Ground Sample Distance) of the image was 8cm. Two adjacent images (overlapped 80 %) were used to create three dimensional model. In order to improve the accuracy of the results, the PPK (Post Processed Kinematic) method was applied and The GCP (Ground Control Point) was installed on the coastal roads at five intervals of 500 m. GCP measurements were performed using VRS (Virtual Reference Station) method, and height was obtained by ellipsoidal height. Fig. 4 shows location of GCP.

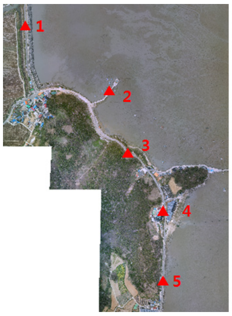


Fig. 4. Location of GCP

3. Data Processing

The geometric errors of the UAV's (Unmanned Aerial Vehicle) result are caused by the location of the UAV and the inaccuracy of the orientation sensor. The photogrammetric method was used to correct for these errors. The errors were adjusted in the data processing module with the tie points based on computer vision algorithms automatically. The software used for data processing is TBC (Trimble Business Center), and Fig. 5 shows the data processing screen.

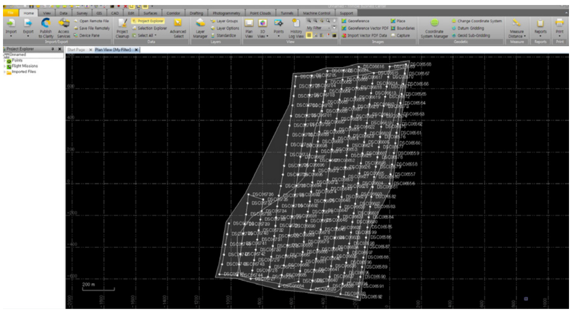
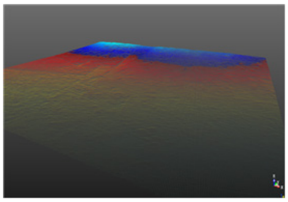


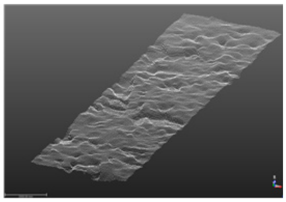
Fig. 5. Data processing screen

After tie points extraction, we could measure the GCPs easily. After the GCP measurements, the orientation was performed. After orientation step, the station displays a precise perspective in which the surveyed data is accurately aligned on the image. Once these images are adjusted, the data processing module can use the luminosity function to select pixels in the aerial and terrestrial images to determine the Cartesian coordinates of the image's location. The ortho image and LAS (LASer) format DSM were generated through data processing. Figs. 6 and 7 are shown data processing results.

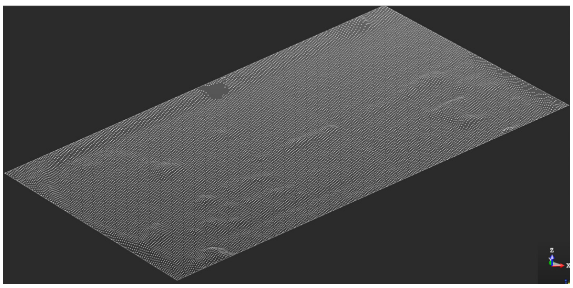
Fig. 6. Ortho image



(a) Area A



(b) Area B

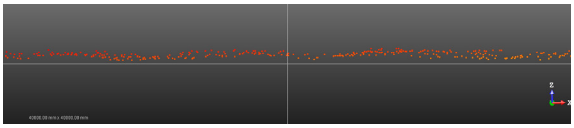


(a) Area C

Fig. 7. DSM

4. Characteristics Analysis of DSM

Area A is tidal area, area B is road and area C is soil ground in Fig. 7. As shown in Fig. 7, the unevenness appears in the DSM of a very flat area like tidal area and road area. On the other hand, the soil ground area did not show such irregularities. This phenomenon is due to the difficulty in extracting tie points in the processing of aerial photographs in tidal and road areas. The actual tidal area and road area are very flat, and there is no such unevenness. The unevenness in the data processing results was about 10 cm. Fig. 8 shows the section of A, B area and Fig. 9 shows the TIN (Triangulated Irregular Network) generated using the DSM about area A.



(a) Area A

(b) Area B

Fig. 8. Section of area A and B

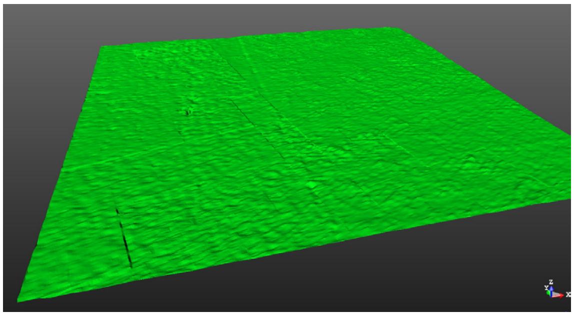


Fig. 9. TIN generated using the DSM – area A

The similarity of neighboring segments is evaluated by combining the slope differences of distance Dx, altitude difference ∆h, and angle θZ along the scan line direction. Only when all three of these similarity measures are within the threshold, the two adjacent segments are considered similar and are associated with the edge of the similarity graph. Eqs. (1), (2), and (3) are related to related to segmentation method using line segment is as follows (Zhang *et al*., 2003).

$$D_x = \min \sqrt{(b_x - a_x)^2 + (b_y - a_x)^2} \quad \forall a \in A, \forall b \in B \tag{1}$$

$$\Delta h = \min |b_z - a_z| \quad \forall a \in A, \forall b \in B \tag{2}$$

$$\theta Z = \arctan \frac{BE_z - BS_z}{BE_y - BS_y} - \arctan \frac{AE_z - AS_z}{AE_y - AS_y} \tag{3}$$

Where, A and B are adjacent segment, AE, AS, BE, BS are corresponding endpoints. Point cloud editing software was used to adjust the spacing of point clouds, remove noise, and configure the TIN. The resolution of the TIN is set equal to the resolution of the raw image. Figs. 10 and 11 show the result of the unevenness improvement.

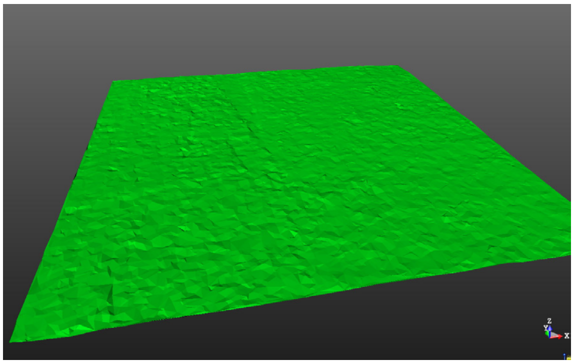
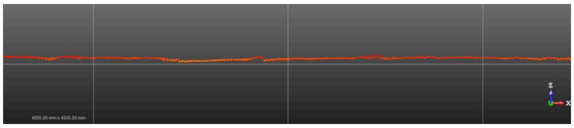
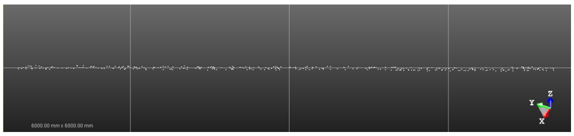


Fig. 10. Result of the unevenness improvement – area A



(a) Area A



(b) Area B

Fig. 11. Improved section

In this study, the accuracy was evaluated to show the applicability to the improved DSM. For the evaluations, 10 reference points constructed from the reference data constructed through the A - area water depth survey were compared. An attempt was made to compare the results of VRS surveys with the modified DSM for accuracy assessment. However, it was compared with the water depth survey results due to the difficulty of VRS observation in the tidal area. The terrain model of ellipsoidal height generated by water depth survey and the terrain model generated by UAV are overlapped. And compared the height values of the checkpoint locations. Fig. 12 shows locations of check points and Table 2 shows the accuracy evaluation results for 10 checkpoints.

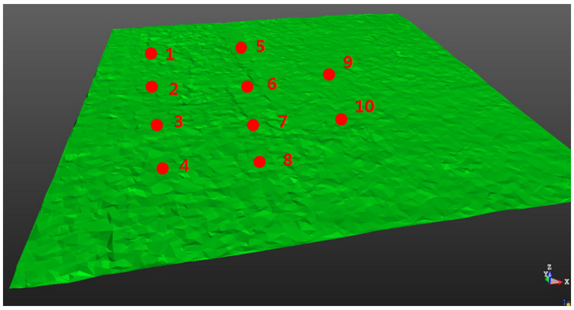


Fig. 12. Locations of check points

Table 2. Accuracy evaluation results

Check point	Height deviation (m)	
	Before correction	After correction
1	0.24	0.11
2	0.17	0.08
3	0.16	0.06
4	0.26	0.09
5	0.21	0.10
6	0.19	0.11
7	0.23	0.09
8	0.18	0.07
9	0.19	0.08
10	0.24	0.08

As shown in Table 2, the deviation of the checkpoints about after correction are about 10 cm and these results indicate that the DSM produced by the drone is available. In this study, the raster DSM was created in order to more effectively use the point cloud type DSM generated by drone for shoreline management. Fig. 13 shows the raster DSM and Fig. 14 shows contour.

Fig. 13. Raster DSM

Fig. 14. Contour

The point cloud type DSM generated by using the drone was characterized in that the flat surface was not flat, but the DSM improvement was able to solve this problem. The accuracy evaluation of the improved DSM suggested the applicability of coastal surveying and data base construction of drone DSM. The contour data shown in Fig. 14 can be used as a basis for the coastal surveying database.

5. Conclusion

In this study, the characteristic of drone DSM as a data acquisition method was analyzed for coastal management. The conclusions are followings.

1. The ortho image and the point cloud type DSM about study area were generated effectively by drone.

2. The characteristics of the drone DSM were analyzed and found that the flat surface appeared uneven.

3. The point cloud was edited and improved to create a new DSM. Assessments were performed to ensure accuracy of about 10 cm.

4. Research has identified the characteristics of the drone DSM and suggested ways to improve these problems. It will be used as a way to surveying and management the coastline in the future.

Acknowledgments

This work has supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. NRF-2018R1C1B6004021)

References

Casella, E., Rovere, A., Pedroncini, A., Stark, C.P., Casella, M., Ferrari, M., and Firpo, M. (2016), Drones as tools for monitoring beach topography changes in the Ligurian Sea (NW Mediterranean), *Geo-Marine Letters*, Vol. 36, No. 2, pp. 151-163.

Cho, S., Bang, E., and Kang, I. (2015), Construction of precise digital terrain model for nonmetal open-pit mine by using unmanned aerial photograph, *Economic and Environmental Geology*, Vol. 48, No. 3, pp. 205-212. (in Korean with English abstract)

Kim, C., Kim, H., Kang, G., Kim, G., Kim, W., Park, C., Do, J., Lee, M., Choi, S., and Park, H. (2016), Shipborne mobile LiDAR(Light Detection and Ranging) system for the monitoring of coastal changes, *Economic and Environmental Geology*, Vol. 49, No. 4, pp. 281-290. (in Korean with English abstract)

Lague, D., Brodu, N., and Leroux, J. (2013), Accurate 3D comparison of complex topography with terrestrial laser scanner: Application to the Rangitikei canyon (N-Z), *ISPRS Journal of Photogrammetry and Remote Sensing*, Vol. 82, pp. 10-26.

Lee, G.S., Choi, Y.W., Lee, M.H., Kim, S.G., and Cho, G.S. (2016), Reconnaissance surveying for cultural assets using unmanned aerial vehicle, *Journal of the Korean Cadastre Information Association*, Vol. 18, No. 3, pp. 25-34. (in Korean with English abstract)

Moon, H. and Lee, W. (2016), Development and verification of a module for positioning buried persons in collapsed area, *Journal of the Korea Academia-Industrial Cooperation Society*, Vol. 17, No. 12, pp. 427-436. (in Korean with English abstract)

Park, J. and Um, D. (2016), Analysis of positioning performance according to the condition of multi-constellation GNSS, *Journal of the Korea Academia-Industrial Cooperation Society*, Vol. 17, No. 4, pp. 567-572. (in Korean with English abstract)

Sim, G. (2016), Metadata design based on vector type geospatial information standard for the collection and management of inundation map, *Journal of the Korea Academia-Industrial Cooperation Society*, Vol. 17, No. 5, pp. 42-48. (in Korean with English abstract)

Trimble Inc. (2018), Trimble UX5 aerial image solution, *Trimble*, http://www.trimble.com/agriculture/ux5 (last date accessed: 17 March 2018).

Turner, I.L., Harley, M.D., and Drummond, C.D. (2016), UAVs for coastal surveying, *Coastal Engineering*, Vol. 114, pp. 19-24.

Zhang, K., Chen, S.C., Whitman, D., Shyu, M.L., Yan, J.H., and Zhang, C. (2003), A progressive morphological filter for removing nonground measurements from airborne LiDAR data, *IEEE Transaction Geoscience and Remote Sensing*, Vol. 41, No. 4, pp. 872-882.