

UAV IMAGE FAST GEOCODING METHOD FOR DISASTER SCENE MONITORING

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ABSTRACT:

Recently, UAVs are being used in various fields such as photography, precision agriculture, remote monitoring, surveying, mapping, and disaster management. In particular, UAVs can acquire real-time data and access hard-to-reach areas, which is advantageous for rapid spatial information generation. Spatial information can be generated by mounting a camera on the UAV and performing the geocoding process of image data using the location/location information acquired from the GPS/INS sensor. The use of multiple GCPs during the geocoding process can increase the image position accuracy. However, since a lot of time is consumed for surveying, it is disadvantageous to be used in disaster fields that require urgent data generation. Therefore, in this study, fast geocoding process of UAV image using the minimum GCP is proposed. The results obtained through this process can be used as basic data for on-site monitoring and decision-making in disasters and emergencies.

1. INTRODUCTION

1.1 Introduction

Recently, the use of spatial information is increasing in the private sector as well as in the public sector such as land use and management, and map services. In particular, it is possible to present important basic information and standards by using spatial information when determining the behavior in everyday life or in a specific situation.

Spatial information data can be acquired through various platforms such as LiDAR, satellite, and UAV. Recently, interest in the use of UAVs, which are relatively efficient in terms of time, cost, and manpower required for operation, has increased compared to others.

By geocoding the data obtained from the UAV, it can be used in various fields such as road facility survey, cultural property survey, map production, disaster monitoring. Among these various fields of use, this study proposes rapid UAV image geocoding method by correcting external elements to generate basic data necessary for the decision making process in the disaster/accident field.

1.2 Bundle Adjustment

Bundle Adjustment is a method of determining the most probable value of the EOP(Exterior orientation parameters) and unknown ground coordinates using the ground control point and the photo coordinates of the point observed on each photo.

Bundle adjustment is classified as space resection and space intersection. Space resection is used when the location on the map is unknown, and the location is determined using 2 or 3 unknown points. Space intersection is a process of obtaining a 3D coordinate using six expression factors and x, y determined by space resection.

Mathematical model of bundle adjustment can be expressed as a collinearity condition as shown in the figure below.

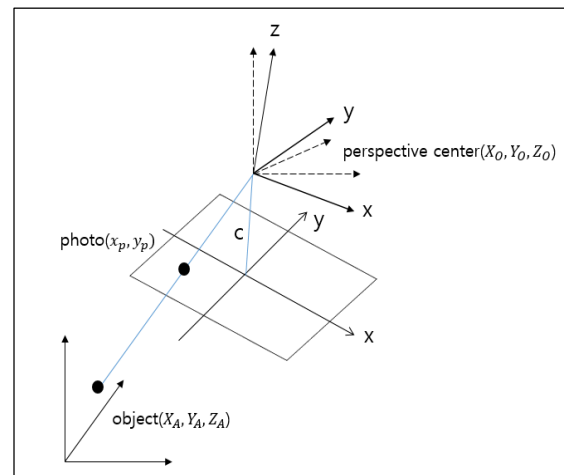


Figure 1 Collinearity Condition

The collinearity condition equation for the ground point j of the image I is equal to follow equations.

$$F_x = (\omega_i, \varphi_i, \kappa_i, X_{0i}, Y_{0i}, Z_{0i}, X_j, Y_j, Z_j) \quad (1)$$

$$x_{ij} = x_p - c \frac{r_{11}(X_A - X_0) + r_{12}(Y_A - Y_0) + r_{13}(Z_A - Z_0)}{r_{31}(X_A - X_0) + r_{32}(Y_A - Y_0) + r_{33}(Z_A - Z_0)} \quad (2)$$

$$F_y = (\omega_i, \varphi_i, \kappa_i, X_{0i}, Y_{0i}, Z_{0i}, X_j, Y_j, Z_j) \quad (3)$$

$$y_{ij} = y_p - c \frac{r_{21}(X_A - X_0) + r_{22}(Y_A - Y_0) + r_{23}(Z_A - Z_0)}{r_{31}(X_A - X_0) + r_{32}(Y_A - Y_0) + r_{33}(Z_A - Z_0)} \quad (4)$$

where c : Focal length
 (x_a, y_a) : Image coordinates
 (X_A, Y_A, Z_A) : Ground points coordinates
 (x_p, y_p, z_p) : Principal point
 (X_0, Y_0, Z_0) : Projection center coordinates
 $r_{11}, r_{12}, \dots, r_{33}$: Rotation matrix component

2. DATASET

2.1 Equipment

The UAV used in this study is DJI's Inspire 1 pro as shown in Figure 2, and the specifications are shown in Table 1. The DJI Inspire1 pro is a small-sized rotary wing UAV that enables automatic flight routing using apps such as smartphones. The camera used in the experiment is a Zenmuse X5 from DJI, which can be mounted on the DJI Inspire 1 pro, and can shoot 4,608 x 3,456 pixel images. Table 2 shows detailed camera specifications.



Figure 2 DJI Inspire 1 Pro



Figure 3 Zenmuse X5

Item	Contents
Max speed	18m/s(ATTI mode)
Max Flight Time	Approx. 15 minutes
Max Service Ceiling Above Sea Level	4500m(120m above take off point)
Max Tilt Angle	35°
Hovering Accuracy	Vertical:0.5m Horizontal: 2.5m
Weight	2870g

Table 1 Specification of DJI Inspire 1 Pro

Item	Contents
Focal length	15mm
Lens	F1.7-F1.6(default DJI lens)
Photo Resolutions	4608x3456
FOV	72°
Weight	530

Table 2 Specification of Zenmuse X5

2.2 UAV Image

The research site was selected as a National disaster safety research center located in Ulsan(Figure). The metadata of each image includes basic information such as the size, date, aperture, ISO, as well as focal length, latitude and longitude coordinates of the GPS, installed in the UAV, flight altitude, and posture angle.



Figure 4 Research Site

2.3 Ground Control Point

Ground control points survey were conducted to evaluate the accuracy of the study results. As shown in Fig., the targets were placed in the study area. GCP surveying was performed in RTK mode with high accuracy and very high processing speed, and coordinates with an accuracy of about 1 to 2cm were obtained.



Figure 5 Location of GPS survey



Figure 6 Used Target

3. FAST GEOCODING

3.1 GPS/INS

The GPS/INS sensor information provided by UAV itself was first analysed. Figure 7 shows the trajectory shoot with the UAV's x and y values. Figure 8 shows the amount of rotation in the x and y directions(roll and pitch). Figure 9 shows the height and the amount of rotation in the z direction(yaw).

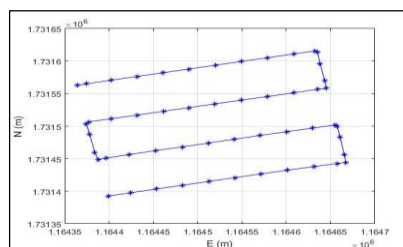


Figure 7 Trajectory

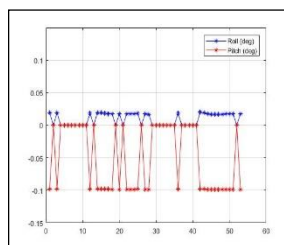


Figure 8 Roll and Pitch

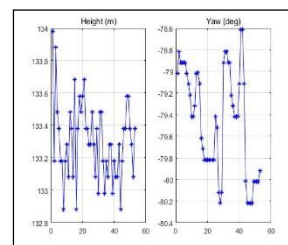


Figure 9 Height and Yaw

3.2 Influence of Corrected Parameters

The results of the correction for the initial EOP are as follows. It was confirmed that X and Y shows a random error, while Z and kappa shows a systematic error.

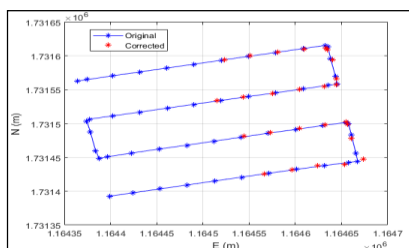


Figure 10 Trajectory

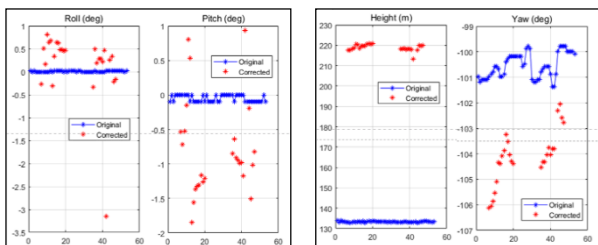


Figure 11 Roll and Pitch

Figure 12 Height and Yaw

Based on the above result, the correction parameters were divided to each case, and check the position accuracy. The following table shows the parameters to be corrected for each case.

Case	Correction Factor	Theoretical required number of GCPs
Case 1	EOP, f, xp, yp, k1,k2	6
Case 2	EOP, f, xp, yp	5
Case 3	EOP, f	4
Case 4	EOP	3
Case 5	X, Y, Z	2
Case 6	X, Y, Z, κ	2
Case 7	ω, φ, κ	2
Case 8	X, Y, κ	2
Case 9	X, Y	1
Case 10	Z, κ	1

Table 3 Theoretical required number of GCPs per correction factor

The maximum number of GCPs required in theory is 6. In this part, the experimental image was selected as CAM 17 with 12 GCPs in the image, and assume that there are 8 GCPs in each case.



Figure 13 CAM 17

Case	Pixel Error(pixel)
Case 1	rms = [3.55/6.01]
Case 2	rms = [2.17/4.82]
Case 3	rms = [1.54/1.88]
Case 4	rms = [1.73/1.97]

Case 5	rms = [62.93/55.10]
Case 6	rms = [7.75/7.65]
Case 7	rms = [2555.29/2602.36]
Case 8	rms = [10870.17/6225.38]
Case 9	rms = [2624.84/2818.07]
Case 10	rms = [102.32/102.24]

Table 4 Error for each case

In this process, it is confirmed that the case 4, case 6, and case 10 indicate 5cm, 23cm, 3m errors, respectively.

3.3 Influence of Number of GCPs

In disaster and emergency situations, it is difficult to survey a large number of GCPs. Therefore, the position accuracy of the image is confirmed when using a limited number of GCPs. Based on the results from the previous part, Case 4, 6, and 10 where 3, 2, and 1 GCP were required were used for analysis.

In order to shorten the time, instead of correcting all the images, a method of applying the correction values for one image to all the remaining images was performed.

The equation below shows the process of obtaining the correction values, and the table shows the correction values for Case 4.

Parameter	Correction value
ΔX	6.6282m
ΔY	-0.7649m
ΔZ	84.3671m
$\Delta\phi$	0.3827deg
$\Delta\varphi$	-1.5689deg
$\Delta\kappa$	-5.1871deg

Table 5 Correction value of each parameter

The results of each case through the above process are shown in the table below.

Case	Number of GCPs	RMSE
Case 4	3	2.0m
Case 6	2	1.9m
Case 10	1	7.4m

Table 6 RMSE for each case

3.4 Generate Geocoding Image

At the last step, a geocoding image was created based on the above result. Bilinear interpolation was used as the image rearrangement method.

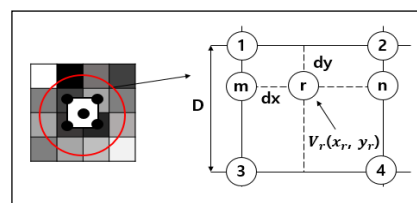


Figure 14 Bilinear interpolation

4. CONCLUSION

In this study, the fast geocoding process using a minimum GCPs was proposed in emergency situations such as disaster and accident sites. This process can reduce the time spent on GCPs surveying in the field, and it was confirmed that the generated image has adequate accuracy for field monitoring.



Figure 15 Usability review

The created image was reviewed for usability through open software QGIS. Therefore, it is considered that the result generated by the fast geocoding process can be sufficiently utilized as basic data for decision-making of initial response measures or recovery work in emergency situations. For the future study, geocoding image generating for rapid monitoring without GCP will be conducted.

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