A STUDY ON GENERATING STEREO MOSAIC IMAGE USING VIDEO FRAMES

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ABSTRACT

Recently, generation of high quality video sequences utilizing a camcorder has been possible owing to advances in video equipment technologies. Generation of mosaic images from high quality video sequences has been attempted by a variety of investigations. Especially, among the matter of investigation, many investigators have been interested in study on 3D information construction. For constructing 3D information using aerial photograph or video sequences, left and right stereo images should be prepared in overlapping area. In video sequences, left and right stereo images may be generated by mosaicing left and right sliced images extracted in consecutive video sequences. Very important step among the data processing for stereo mosaicing is to determine motion parameters for each video frame image. These motion parameters so examine the geometrical relationship between consecutive frame images that image registration could be performed between consecutive frame images. Using registered images, stereo mosaic images are generated.

In this paper, methodology on determining relative orientation parameters in charge of the motion parameters using video frame images taken without GPS/INS geo-data is proposed. Because overlapping area between consecutive frame images taken in 30frames/1second frame rates is more than 90%, the proposed method make use of the process in step by step based on relative orientation, bundle adjustment and space resection algorithm using the aerial photography.

Using determined relative orientation parameters, image registration is performed and left and right stereo mosaic images are generated. The result of experiment showed the determined relative orientation parameters, the left and right stereo mosaic images and anaglyphic image for stereo mosaic images.

INTRODUCTION

Owing to increasing the camcorder user and convenience of usage, investigation on constructing the geographical information utilizing the camcorder data has been actively attempted. Among these investigations, generation of mosaic images from high quality video sequences has been attempted by a variety of investigations. Especially, many investigators have been interested in study on 3D information construction. Kumar(1998) proposed image geo-registration method that adding the geo-information included camera projection center in images taken by video camera. Generation method on stereo mosaic image utilizing two rotating camera was proposed by Huang & Hung(1998). 2D orthogonal projection for generation on mosaic image is used by Rousso(1998). Also generation on stereo mosaic image utilizing a rotating camera is performed by Peleg and Shum(1999). Shum used a local alignment technique for refining motion parallax in order to generation on seamless 2D mosaic image. Based on mathematic model for refining motion parallax proposed by Shum, Zhu(2001) generated the seamless stereo mosaic image using motion parallax technique and PRISM(Parallel Ray Interpolation for Stereo Mosaicing).

The generated stereo image may be utilized by a variety of fields such as cartography, environment monitoring and military field. Especially, stereo mosaic images can provide 3D geometry information as well as 2D geometry information.

In the stereo mosaic generation, two methods are used: method using exterior parameter of frame images acquired by GPS/INS data and using only geometric relationship between consecutive frame images without GPS/INS data. The one is called geo-mosaic and the other is called by free-mosaic. Both geo-mosaic and free-mosaic method need to

motion parameters examining geometrical relationship between consecutive frame images. The step on determining motion parameters is one of the very important processes.

In our study, methodology on determining relative orientation parameters by means of the motion parameters is proposed for generating on stereo mosaic images without GPS/INS data. This methodology could be applied by both geo-mosaic and free-mosaic method for determining the motion parameters. Because overlapping area between consecutive frame images taken in 30frames/1second rate is more than 90%, the proposed method make use of the process in step by step based on relative orientation, bundle adjustment and space resection algorithm using the aerial photography. The result of experiment showed the generated left and right stereo mosaic images using determined relative orientation parameters.

FREE MOSAIC FOR GENERATING ON STEREO MOSAIC IMAGE

Methodology

As showed in figure 1, steps of free mosaic are composed of relative orientation parameters determination, image registration, sliced image width determination, image slicing and stereo mosaicing. Relative orientation parameters are used as motion parameters that examine the geometrical relationship between consecutive frame images. Image registration is performed in model coordinates using the determined relative orientation parameters. After performing image registration, slice width per each frame image is determined by translation parameter between consecutive frame images in flight direction. Next, for generation on the left and right stereo mosaic images, left and right slice having different viewing angle from center in consecutive video frame images is sliced. Lastly, the left and right stereo mosaic image is generated by mosaicing the left and right slices according to stitching line that adjacent to each slice.

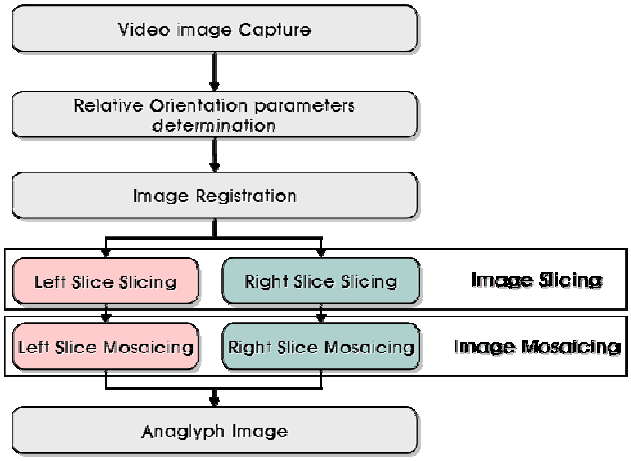

Figure 1 . Free mosaic methodology.

Relative Orientation Parameters Determination

Each frame image captured by video sequences taken in 30frame/second rate has overlapping area more than 80~90%. Stereo model for the relative orientation and bundle adjustment using these high overlapped images is unstable because of having too small B/H ratio. Owing to this problem, relative orientation and bundle adjustment couldn't be preformed exactly. Therefore, it is need to methodology on determining relative orientation parameters for high overlapped images. Figure 2 indicates the methodology.

Both flight information such as flight height and flight velocity and camera information such as focal length, CCD size and distortion parameters are so input that initial values to perform bundle adjustment and relative orientation are set. If overlapping area of stereo model is between 60% and 70%, stereo model is so stable that relative orientation and bundle adjustment is able to perform exactly. Therefore frame image interval that overlapping area of stereo model is less than 70% is so determined that stable stereo model is made as showed in figure 3. (ex : frame image interval : 10frame) In order to extract conjugate points needing to perform bundle adjustment, image matching is performed using composed stereo model as showed in figure 3. Correlation technique and least-squares matching algorithm are

used successively for image matching. Matching candidate points are so selected by regular distance in reference image (1st frame) that matching points are extracted by matching algorithm in target image (11th and 21th frame) as showed in figure 3. After performed the image matching, miss matching points may be existed. Owing to remove these miss matching points, relative orientation is performed. Miss matching point is removed by using constraints such as residual of measured points after adjustment, correction value of unknown parameters and accuracy of model coordinate in relative orientation.

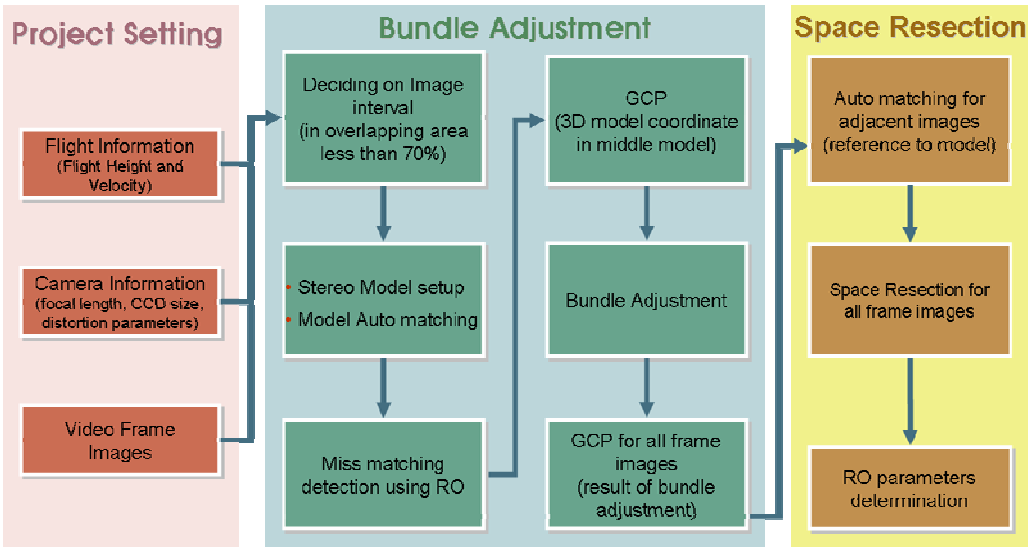

Figure 2 . Strategy on determining the relative orientation parameters.

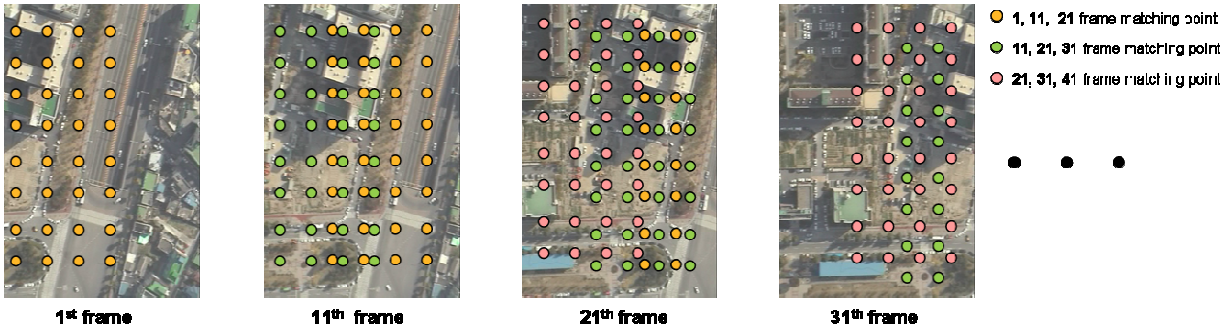

Figure 3. Composed stereo model and image matching points.

After performed image matching in all stereo models composed by image interval, bundle adjustment is performed in all stereo models. In order to perform bundle adjustment, ground control points(GCPs) are necessary. Therefore GCPs are selected by 3D model coordinates for conjugate point existing on middle model among all stereo models. Because GCPs are selected in middle model, origin of entire mosaic coordinate is a center of left image in middle stereo model. Figure 4 indicates 3D model coordinates of conjugate points used in all stereo models after performed bundle adjustment by using GCPs selected in middle stereo model.

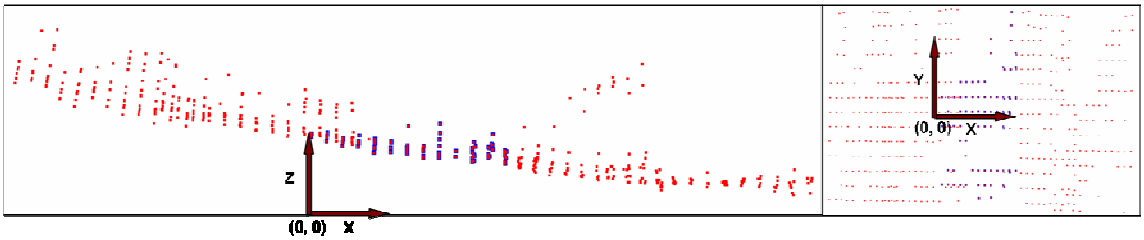

Figure 4 . 3D model coordinates of conjugate points used in all stereo models.

To determine the relative orientation parameters for each frame image between stereo model, each frame image is matched with left image of stereo model by using conjugate points used bundle adjustment, as showed in figure 5.

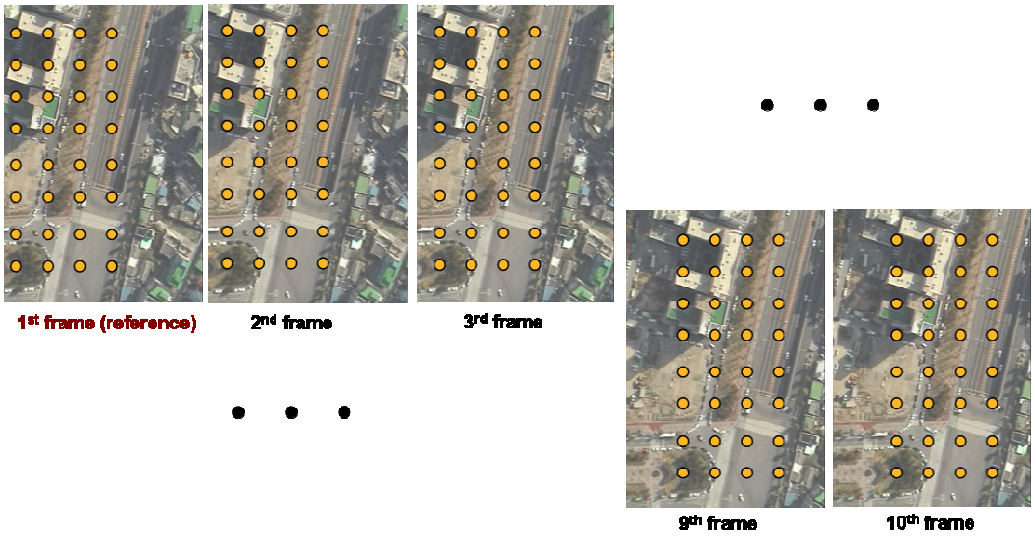

Figure 5. Image matching between each frame image and left image of stereo model.

After performed image matching between each frame image and left image of stereo model in all stereo model, relative orientation parameters for each frame image is determined by space resection algorithm using conjugate points having 3D model coordinates.

Image Registration

Image registration is performed by the relative orientation parameters for each frame image and by using collinearity equation. Registered image is generated by setting omega, phi, kappa angle in zero and by applying scale factor cause of variation on flight height for each frame image. Reference height for scale is a flight height of first frame image. The result of image registration is showed in figure 6.

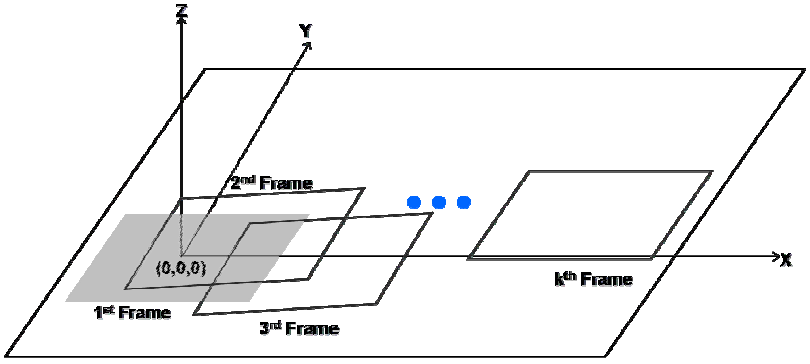

Figure 6. Result of image registration.

Image Mosaicing

Through the image registration, video image sequences are registered and transformed into vertical position using relative orientation parameters. For generating on left and right mosaic image, left and right sliced images are necessary. Left and right sliced images are extracted in dy offsets to the left and right of center of frame image as showed in figure 7.

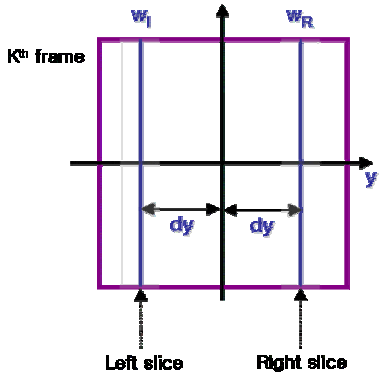

Figure 7. Location of left and right sliced image.

Left and right sliced image has the width cause of movement in flight direction. The width of sliced image in kth frame image is calculated by followed equation.

$$w_1 = \frac{|X_k - X_{k-1}|}{2}, \quad w_2 = \frac{|X_k - X_{k+1}|}{2}, \quad \therefore w = w_1 + w_2$$

Where, X_{k-1}, X_k and X_{k+1} is each translation parameter toward flight direction in (k-1)th frame, kth frame, (k+1)th frame.

After left and right sliced image is determined, left and right mosaic image is generated by stitching consecutive left and right sliced images.

EXPERIMENT

Equipment and Data

Video camcorder used to our experiment is a Sony DCR-110 model and this specification is showed as table 1.

Table 1 . Specification on Sony DCR-pc110

Category	Description
CCD size	1/6”
aperture	37mm
focal length	4.2~42mm
still image resolution	720pixel × 480 pixel
total pixels	1070K pixels
effective pixels	690K pixels

In order to extract frame images from video sequences taken in 30frame/1second rate, Premiere 6.0 software is used and 201 frame images are used in our experiment totally. Focal length in flight is nearly 15.7mm.

Relative Orientation Parameters

Relative orientation parameters determined by proposed methodology are showed as table 2 and table 3.

Table 2 . Relative orientation parameters on all stereo models

Frame No.	X(mm)	Y(mm)	Z(mm)	Omega(deg)	Phi(deg)	Kappa(deg)
1	12.894601	0.960789	17.102579	-2.561227	-16.131120	-0.834345
11	11.646556	0.558760	16.850279	-1.477776	-14.480385	-0.525661
21	10.239224	0.361494	16.566931	-0.585789	-13.194314	-0.308597
31	9.418985	0.419818	16.429215	-0.134034	-10.495457	0.199986
. .	. .	. .	. .	. .	. .	. .
101	-0.005044	0.001975	15.700010	-0.004990	-0.012296	-0.002379
111	-1.230826	-0.098664	15.754149	-0.356204	1.546402	0.209002
121	-2.439198	-0.152347	15.819156	-0.446420	3.191305	0.240745
. .	. .	. .	. .	. .	. .	. .
171	-8.478593	-0.380215	16.737170	-2.803724	11.452088	-0.469883
181	-9.697003	-0.627043	17.066213	-2.792187	12.948055	-0.692048
191	-10.920884	-0.627436	17.381322	-3.523839	14.426878	-0.835997
201	-12.172689	-0.784852	17.749142	-4.652236	15.822163	-0.821618

Table 3 . Relative orientation parameters on each frame image between first stereo model

Frame No.	X(mm)	Y(mm)	Z(mm)	Omega(deg)	Phi(deg)	Kappa(deg)
1	12.894601	0.960789	17.102579	-2.561227	-16.131120	-0.834345
2	12.770933	0.906459	17.075708	-2.454482	-15.970834	-0.797614
3	12.757950	0.938075	17.058320	-2.531676	-15.557806	-0.793572
4	12.593599	0.730627	17.056196	-2.051731	-15.472321	-0.711778
5	12.509256	0.873290	17.012398	-2.368609	-15.227225	-0.756420
6	12.374723	0.677454	17.007761	-1.898866	-15.072486	-0.652808
7	12.408969	0.531781	17.025735	-1.535832	-14.538248	-0.575204
8	12.230805	0.594797	16.980182	-1.649189	-14.495102	-0.588657
9	12.037377	0.632139	16.931299	-1.718958	-14.509373	-0.614329
10	12.001257	0.500992	16.942192	-1.388945	-14.113308	-0.574910
11	11.646556	0.558760	16.850279	-1.477776	-14.480385	-0.525661

Left and Right Stereo Mosaic Image

Figure 8 and figure 9 indicate left and right stereo mosaic image generated by processing composed with image registration, sliced image width determination, image slicing and stereo mosaicing.

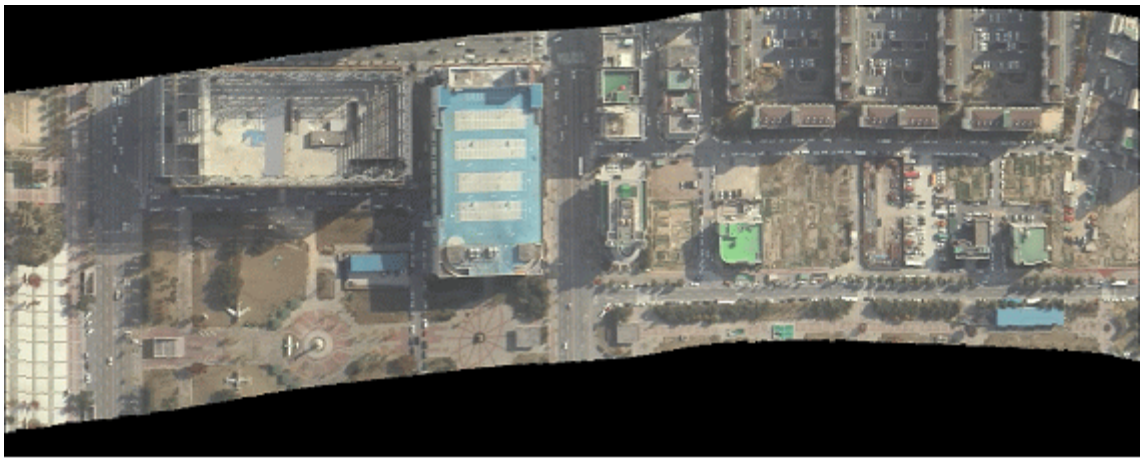

Figure 4. Left mosaic image.

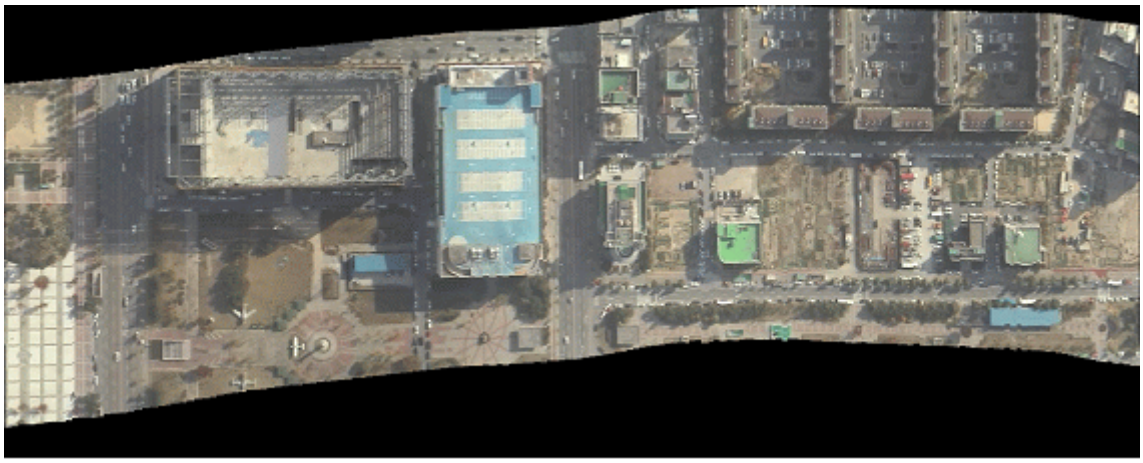

Figure 4. Right mosaic image.

Anaglyph Image

To generate anaglyphic image, we selected red band image for left and right mosaic image. For overlapped window area between left and right mosaic image, we carried out color composite that left mosaic image is composed to red color image and right mosaic image is composed to blue and green color image. The generated anaglyphic image is shown in Fig. 8. Through this image, we can view stereo with anaglyphic grasses. It was found that the anaglyphic image is viewed in stereo for 3D structures through 3D model coordinates.

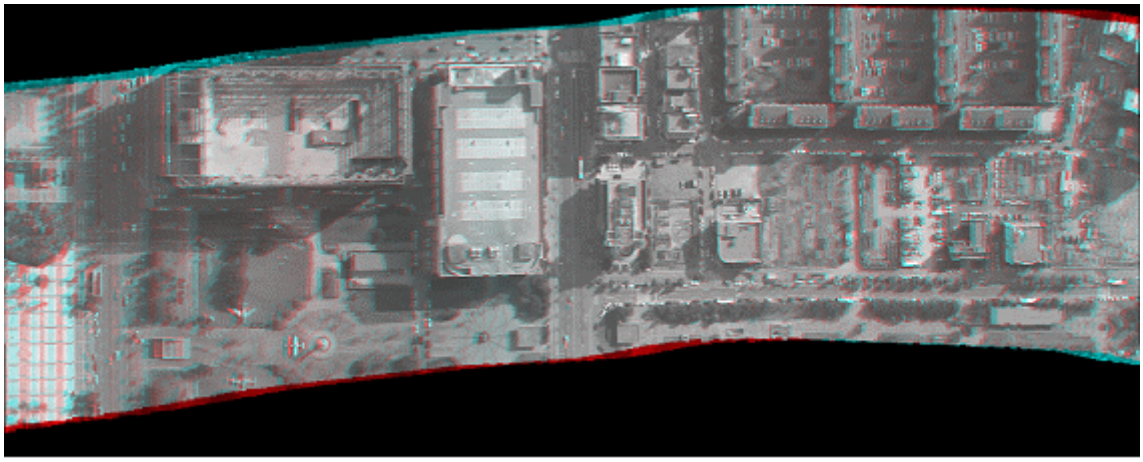

Figure 4. Right mosaic image.

CONCLUSIONS

In this paper, for consecutive frame images with overlapping area more than 90%, how to determine relative orientation parameters as motion parameters was proposed. As a result, seamless left and right stereo mosaic images were generated by using relative orientation parameters. Also as shown in anaglyphic image, we can see stereo viewing for 3D structure on model coordinates. The generated stereo mosaic image may be used in deciphering the flight area effectively through 3D viewing. Also proposed methodology is possible to process automatically, so proposed method have the advantage that stereo mosaic image may be generated as soon as taking video sequences.

Future work is to generate seamless stereo mosaic image using mosaic technique in advance and convert free-mosaic image into geo-mosaic image utilizing GPS/INS data.

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