Automatic Control Point Measurement and Photo Orientation via Matching with Control Patch

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Abstract: In this study, we employ the control patches, which have been created in previous photogrammetric projects, serving for the candidates of the control points that are likely to be found in the newly taken photos by utilizing image matching technique. Among others, the successful implementation of the above idea lies in the underlying factors: (1). Predicting the control patches and projecting them onto new photos; (2). Alignment of control patches with respect to the new photos; (3). Generating the equivalent ground elements of control patches versus the new photos for the purpose of correlation; (4). Developing effective matching methods and matching strategy; (5). Refining the exterior orientation parameters. What may show significance in this work comparing to traditional aerial-triangulation chain is that whenever at least three matched control patches succeed in a single photo, it follows that single photo orientation is applicable. The experiments suggest the potential efficiency of automatic control point measurement from control patch database and photo orientation by the proposed workflow.
Keywords: Control Patch, Matching Methods, Matching Strategy.

1. Introduction

Traditional aerial-triangulation has long relied on control points orientating the photo models into a ground-based coordinate system and reducing the distortion effect when tying photos by imperfect measurements. Field Surveying preparing for adequate number of control points and manual measurements of the control points afterwards on the photos cost considerably both in labor work and expense. The advent of digital photogrammetry by integrating the pros of image processing technique and rapid computation via the computer into photogrammertric discipline has made database-supplied control entities as well as the automation of control entity measurements truly possible by utilizing the so-called "Control Entity Database". The realizable and useful control entities consist of point, linear, and area features. The most popularly associated sources that could be utilized in the database include control patch (or chip), vector map, orthophoto, and DTMs. The successful experiments implementing the above control entities can be referred to OEEPE official publication No. 36 [1]. Inheriting the very similar idea of employing existing control entities, the authors try to utilize control patches, which have been created in previous photogrammetric projects with each selected feature point known in the object space as the center of the patch serving for the candidates of the control points that are likely to be found in the newly taken photos by means of image matching techniques. Under the condition when more than three control patches are to be successfully matched in a single photo, it follows that single photo resection is applicable which would simplify photo orientation bypassing routine aerial triangulation [2].

2. Methodology

To implement a workable system for the underlying tasks in this study, the following missions must be performed:

1) Predicting and projecting control patches onto new Photo

Based on the approximation of exterior orientation and ground coverage of photo, searching in the control patch database would lead to pick up the control patches that are likely to be found in the new photo. Back-projecting each control patch candidate onto new photo and evaluate the searching area where the conjugate point is situated.

2) Alignment of control patches

Since the flight direction of new photo is not necessary to be aligned with that of control patch, for fulfilling the requirement of area-based matching where target and searching windows need to be aligned to some extent, one has to check and decide the difference of flight directions between old patch and new photo, then rotate one of them for aligning purpose.

3) Generating the equivalent ground elements

For satisfying the operational consideration of correlation, the pixels of target and searching window must refer to the same ground size. Therefore, it is a necessity to adjust and assure the equal scale for both windows.

4) Matching methods and matching strategies

To increase the efficiency and reliability of image matching, the authors combine the normalized cross correlation (NCC) and least-squares matching (LSM) in an algorithmic fashion where NCC performs matching operation in all image pyramids while LSM only works in the highest resolution for achieving more accurate matching results. Furthermore, the matching in the last image level can be confirmed by comparing the NCC matching result with that of LSM.

5) Refining the exterior orientation Parameters

When applying image matching, the extension of searching area heavily depends on the uncertainty of exterior orientation. For too rough approximation of exterior orientation, image pyramids are arranged to ease the computational load by reducing the image scales, namely details. Due to going through degrading the feature significance, the signals in the original control patches may be weakened, leading to failure for image matching. Thus, it is crucial to identify the successfully matched control patches, even just few of them, by using collinearity condition and error detection solving for the orientation. Then based on the improved orientation parameters, if any, the prediction and back-projection of control patches and image matching can be run again with smaller searching area implying less signal degradation and hopefully more successfully matched control patches. .

By taking the above five aspects into consideration, we implement a system via the following workflow, shown in Fig. 1.

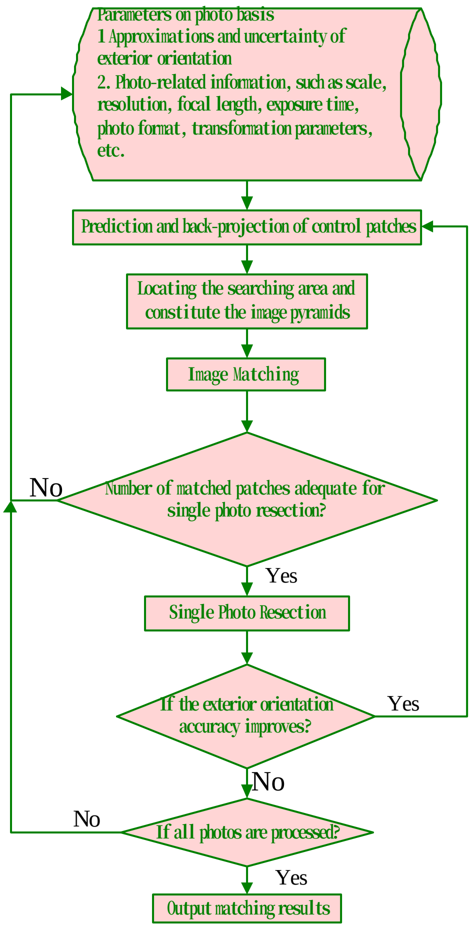

Fig.1 System workflow

3 Experiments

Two cases for experimental purposes are chosen and demonstrated as follows :

Case1:

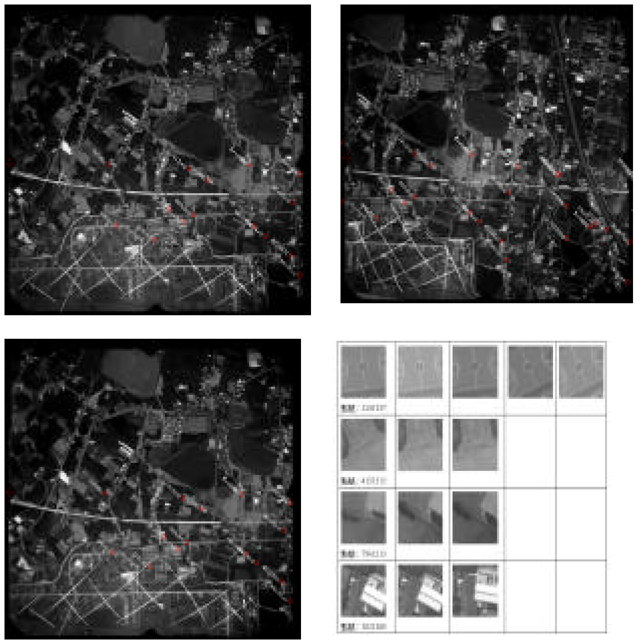

Fig. 2 Upper-left: Photo 4-28; Upper-right: Photo 4-29 Lower-left:Photo 4-30; Lower-right: examples of control patch set

Table 1.1 Case1: Configuration

	Scale	Ground resolution	Exposure time	No. of patch set
New photo	1/10000	25cm x 25cm	2002.10.19	
Control Patches	1/5000	7.5cm x 7.5cm	2000.06.30	38

Table1.2 Case1 : Groups of given exterior orientation

	Group1	Group2*	Group3	Group4
Accuracy of position	10m	10m	5m	1m
Accuracy of pose	3 degree	3 degree	1 degree	1 minute

Group2* applies refining the exterior orientation while other groups do not

Table 1.3 Case1: Successful ratio of matching (No. of successful matching patches/total involving patches) and time cost

	Group1	Group2	Group3	Group4
Photo 4-28	4/16	9/16	7/16	10/16
Photo 4-29	5/24	12/24	12/24	16/24
Photo 4-30	5/26	14/26	11/26	14/26
Relative time cost		1	0.55	0.46

Analysis:

1. The matching results, referring to table1.3, reveal that refining the exterior orientation, when

applicable, does increase the matching performance by collecting more successfully matched patches, comparing the Group1 with Group2 in table1.3.
2. The more accurate exterior orientation, the better matching results can be expected, comparing Group1, Group3, and Group4 in table1.3.
3. The failure cases of matching point to several factors including geometric distortion effect, weakened feature due to employing image pyramids, radiometric difference between old and new photos, and scene change [3].

Case2:

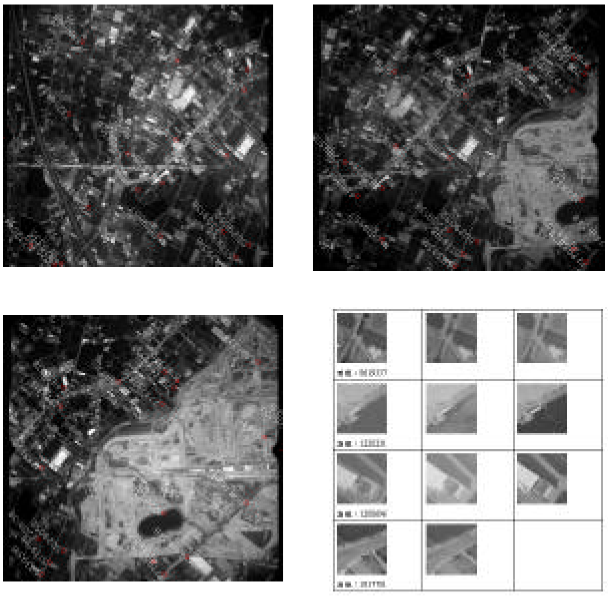

Fig. 3 Upper-left: Photo 4-31; Upper-right: Photo 4-32 Lower-left:Photo 4-33; Lower-right: examples of control patch set

Table 2.1 Case 2: Configuration

	Scale	Ground resolution	Exposure time	No. of patch set
New photo	1/10000	25cm x 25cm	2002.10.19	
Control Patches	1/10000	25cm x 25cm	2002.07.23	39

Table2.2 Case2 :Groups of given exterior orientation

	Group1	Group2*
Accuracy of position	10m	10m
Accuracy of pose	3 degree	3 degree

Group2* applies refining the exterior orientation while group1 does not

Table 2.3 Case2: Successful ratio of matching

	Group1	Group2
Photo 4-31	6/19	13/19
Photo 4-32	5/21	15/21
Photo 4-33	4/19	14/19

Table 2.4 Case2 Positioning accuracy in object space

	Horizontal error	Vertical error
Single Photo	10~15cm	15~20cm
Stereo pair	11~13cm	16cm

Analysis:
1.Comparing Group1 with Group2 in table2.3, it is confirmed again that refining the exterior orientation parameters does improve the matching performance.
2 Scene change and radiometric difference contribute most of failure cases that disapprove the matching [3].

4. Conclusions and Further Work

1). Conclusions

To conclude this study, we have the following observations about the proposed system:

1. Automation: The proposed workflow performs highly automatic operation by reading into the parameter file and run in a batch fashion until reaching the final output without human intervention.
2. Flexibility: The variations between old and new photos, such as scales, flight direction, can be accommodated by the system and are proven to be reliable.
3. Intelligence: Refining the exterior orientation via matched patches that satisfy the collinearity conditions shows the system with learning mechanism towards better predicting control patches and consequently promoting matching performance.

It is also found that the surface objects like building are not suitable matching candidates due to perspective geometric distortion. In addition, features with thinner texture, such as the end of road lane segment, are not likely to well preserve the original signal strength when going through image pyramids processing. Features of these kind need to be further analyzed with more cautious treatment for being control patches.

2). Further work

The further work immediately follows this study would consider testing the matching efficiency in mountainous areas which characterize the topography of Taiwan island. Besides, an interactive system allowing human intervention for providing approximation or checking results whenever necessary may more secure the whole operation chain.

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References

[1] Kirby, R.P., Hoehle, J., Dequal, S., Koen, L.A., and Rinaudo, F.,1996. European Organization for Experimental Photogrammetric Research. Official Publication No. 36.
[2] Shan, J., 2001. An Approach to Single Image Automatic Orientation and Point Determination by Using Ortho-Image and DTM, Photogrammetric Record, 17(98), pp.343-353.
[3]. Wu, Y.S., 2003, Automatic Control Point Measurement and Photo Orientation via Matching with Control Patch, Thesis, Department of Civil Engineering, National Taiwan University, Taipei, Taiwan.