BUILDING A FAST SOLUTION FOR PROCESSING AERIAL IMAGE DATA TAKEN FROM SMALL UNMANNED AERIAL VEHICLE (UAVs) IN DISATER OR EMERGENCY SITUTATIONS

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ABSTRACT

In this research, the authors focus on problem solving UAV image mosaicing to quickly create map image to serve on these special situations. In which proposes a new UAV image matching algorithm with some of improvement to enhance speed and stability of UAV images image mosaicing.

The approach in this paper is based on the combination of image pyramid technique, feature-based matching and area-based matching and take into the characteristics of aerial photography approach to give optimal solutions for quickly establishing an map image data from the UAV.

1. INTRODUCTION

After every disaster or in an emergency situation in a certain area, the need of having a map image that area as soon as possible has a high practical significance. Due to the limits of the aerial imaging system, general photographic cameras can only capture scenes from a local area rather than the global distribution in disaster. Therefore, it is necessary to compose all collected UAV images detailed in disaster area into a panorama, in order to fulfil expert's requirement in making decision under emergency condition.

Automatic mosaicing UAV data is a process that makes numbers of UAV images join together into a panoramic, which could cover a lot of scopes. Image mosaic technology is more mature in worldwide excellently. In the literature, the steps involved in the image mosaicing procedure are as follows: 1) Feature extraction, 2) Feature matching, 3) Determining transformation 4) Image registration. In that, the second step is the most important, has greatly affected to the accuracy of the final results and takes the most time. Especially with aerial images have high resolution and large image size thus must have specific techniques to ensure that the processing speed is close to real time. Among these techniques, "coarse- to-fine" (Changming Sun, 1997) are used more popular. The main idea is to create multi-level of a pyramid image then finding correspondences between the two input images on each level from the higher level to low-level (original image corresponding to level 0). The advantage of this method is high accuracy and stability due to the process of finding and matching is executed repeated on many different spatial resolutions ranging from low to high. However, it is synonymous with the time factor will be limited.

A different approach of the authors is using pyramid method with only an intermediate level as a basic to shrink the search space of features on the original image. Simultaneously we also take advantage of the aerial image characteristics (E.g the coverage, the terrain elevation difference) to create a integrated matching method: area-based and feature-based methods. An abbreviated version of the algorithm Random Sample Consensus (RANSAC) are also used to remove outliers to ensure the accuracy, time and enhanced stability in matching aerial images.

2. RETATED WORK

2.1 Image matching techniques

The various image matching methods can be divided into two categories including: Area based matching and Feature based matching.

Area based matching determines the correspondence between two image areas according to the similarity of their gray level values. The cross correlation and least squares correlation techniques are well-known methods for area based matching. This method is usually only effective when used individually in case of small changes in brightness and geometric distortion between two images. The cross-correlation matching result is not stable with this distortion. Matching with least-squares method is often used when matching the location has been determined approximate. A drawback of this method is the high computational time.

Feature based matching determines the correspondence between two image features. Most feature based techniques match extracted point features as opposed to other features, such as lines or complex objects. The feature points are also commonly referred to as interest points. Poor contrast areas can be avoided with feature based matching.

2.2 Pyramid method

The pyramid is a data structure consisting of the same image represented several levels, at a decreasing spatial resolution each level. The matching process is performed at each level of resolution. The search is first performed at the lowest resolution level and subsequently at each higher level of resolution.

There are different resampling methods available for generating an image pyramid. Theoretical and practical investigations show that the resampling methods based on the Gaussian filter, which are approximated by a binomial filter, have the superior properties concerning preserving the image contents and reducing the computation time.

3. OUR APPROACH

The model of proposed algorithm (Figure 1) includes 3 main steps: Feature extraction, Feature matching and image registration.

Algorithm:

• ***Input****: left, right Image*

• ***Output****: Image map (panoramic image)*

• ***The steps are:***

1) Feature extraction (*Find features on an intermediate level of pyramid and the original image.****)***

a. Create image pyramid level k (k is pre-defined) from the Left and right image.

b. Find features on each image at k-level.

*c. Each of feature in k-level, back to the original image to determine the corresponding region of space (ROS) containing this feature (****shrink the search space of features****).*

d. Find best features (use the NMS: No Maximum Suppression to get maximum of the local area) in each ROS on both the original images.

2) Feature matching

a. Coarse matching: Using ***integrated matching method****: area-based and feature-based to find correspondences on two images.*

b) Use an ***abbreviated*** *RANSAC algorithm to remove the mismatched pairs.*

3) Image Registration

a. Determining transformation matrixes for each UAV pairs (Homography $H_{i,i-1}$)

b. Registering UAVs to Map

c. Blending to eliminate color difference in overlap area.

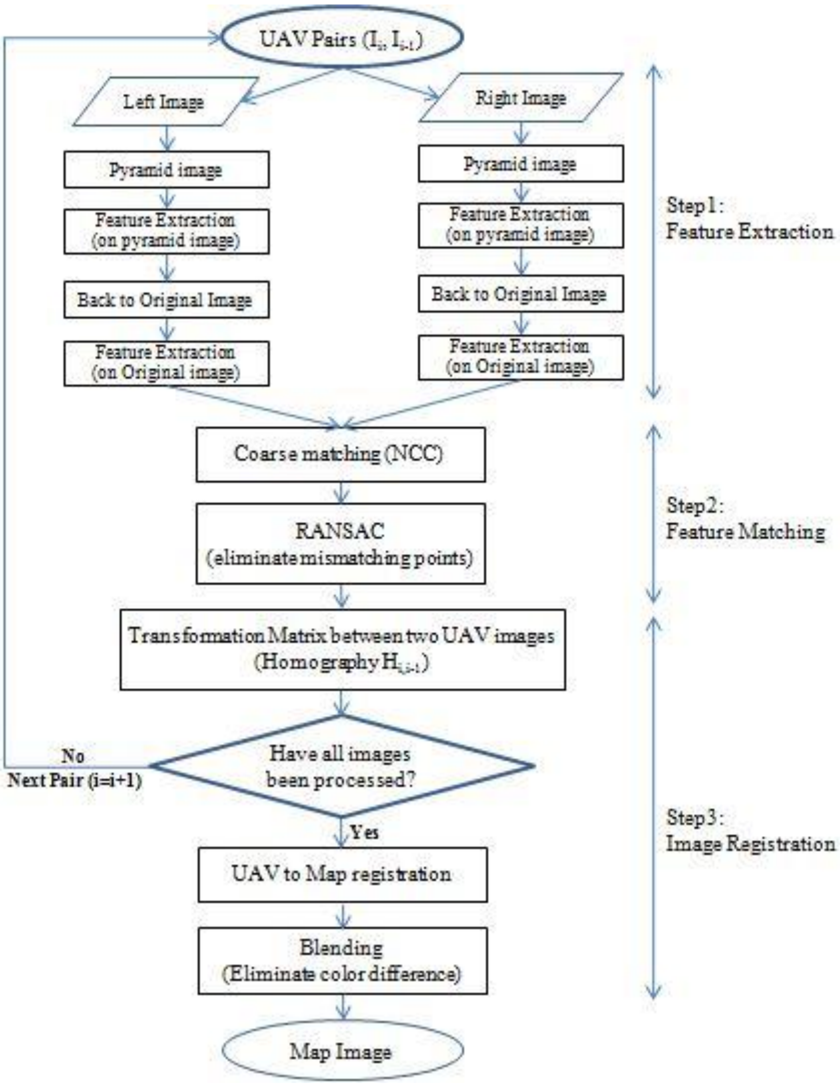

Figure 1: Flowchart of the UAV image mosaic.

Step 1: Feature extraction

In this step the we will select a corner detection algorithm and uses image pyramid technique to speed up execution.

Selecting Corner detection algorithm: In a recent research and analysis (Fabio Remondino, 2006), Harris corner detection algorithm is simple in calculation, high stability and good robustness, even if the image exists rotation and gray change, it can also accurately find out the corner of the image. It is suitable for digital image mosaic in the feature extraction stage.

Use the pyramid technique to speed up the feature extraction: Due to aerial images often have large size so if uses. If use the corner detector operator on whole image will take a long time. The idea is create pyramid image from orgininal image, find features on this level then determine the features on the original image respectively.

The question: "*How to determine the feature on the original image correspond to feature on the pyramid image?*" (Figure 2).

Each pixel in the pyramid image is averaged by Gaussian convolution mask (5*5 pixels) on the original image. Thus the correspond features only determined in a window with size is calculated by the following formula:

$$W= 2^{level} + 3* \sum_{i=1}^{level} 2^{i-1} \qquad (1)$$

Now, the the search space of features is shrinked from *(Width*Height)* to *(W*W)*. For example: With normal size of an UAV image is $15*10^6$ (5000*3000). If using pyramid image with level 2 then the search space now is only 169 (13 * 13).

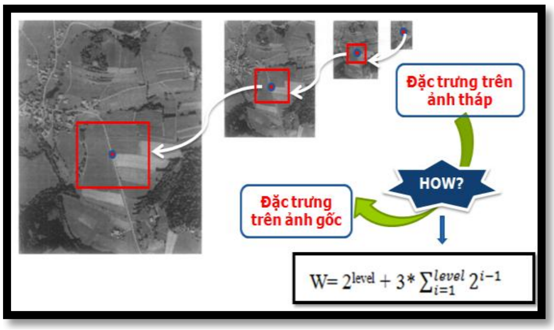

Figure 2: Shrink the search space of features in pyramid technique

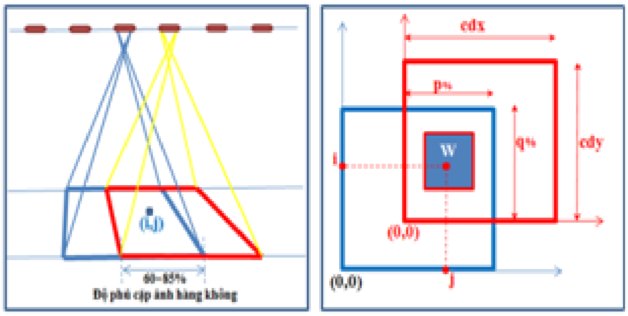

Figure 3: Integrated matching method

Step 2: Feature matching

Coarse matching: In this paper we using integrated matching method: area-based and feature-based to find correspondences on two images. The main idea base on the coverage between two images: for each feature points (i, j) on the left image, we can determine the size of the window on the right image contains corresponding interest points (Figure 3) and choose a feature in this window which has maximum NCC (Normalized Cross Correlation) value with that feature point (i,j).

Note that there is still a certain number of mismatching points after *Coarse matching*, it's necessary to eliminate the mismatching points for precision of image registration.

Use RANSAC algorithm to remove the mismatched pairs achieved from Coarse matching step: We proposed an abbreviated version of this algorithm in (Dao Khanh Hoai-2014). The main idea is find a projective transformation (with eight unknown parameters) show relation between two images. First choose random 4 pairs to get initial value of 8 parameters and then use the initial value to divide all the data into inlier and outlier; finally, recomputed and re-estimate the parameters of the function by all the interior points.

Step 3: Image Registration

Determining transformation matrixes for each UAV pairs (Homography Hi,i-1): This is easy to get $H_{i,i-1}$ from inliers get from RANSAC step in each image pairs (I_i and I_{i-1}).
Registering UAVs to Map: At first, we select a UAV image as a reference image (M) and transform the other images into the coordinate system of the reference image. There are many registration types. Here we choose center image as reference image (Figure 4) to reduce accumulated error of the transformations between consecutive images.

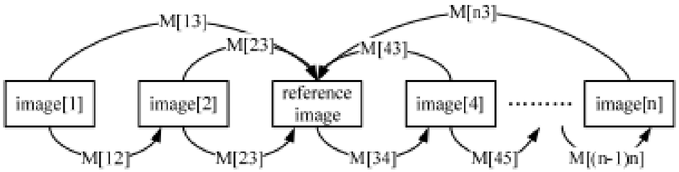

Figure 4: Illustration one of Registration Types

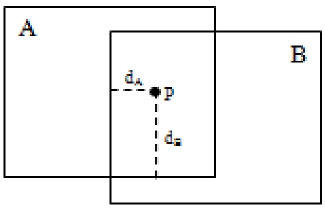

Figure 5: Blending Illustration

However, If there exists a transformation error in each $H_{i,i-1}$, these errors are multiplied and result in a significant error. To resolve the problem we used a method proposed by Yuping Lin (2007) to find a way to establish correspondences between the UAV image and the map and refine the homography by using these correspondences.

Blending to eliminate color difference in overlap area: For each pixel P in overlap area, the new intensity value Ip is determined by:

$$I_P = \frac{I_P^A dA + I_P^B dB}{dA + dB} \quad (2)$$

Where I_P^A is a pixel value in image A, I_P^B is the corresponding pixel value in image B, and d_A and d_B are the shortest distances to the edges of areas A and B respectively (Figure 5).

4. EXPERIMENTAL RESULT

We show results on two data sets. The UAV image sequences are taken by UAV Trimble UX5. The aerial images are taken by Vecxel Ultracam XP. The size of the each UAV image 4912 × 3264. In each UAV to Map registration step, we select at least 30 Harris Corners in the UAV image as samples. We require Inlier tolerance is lower than 3 pixels. Table1 show index statistics of the experiment with 12 UAV images. Where totalRMS is root mean square of inlier tolerances; Match time is sum of Coarse and RANSAC matching time.

Table 1. Index statistics of the experiment

Image sequence	**Left Features**	**Right Features**	**Feature points of Coarse match**	**Numbers of RANSAC interior points**	**totalRMS (pixel)**	**Match time/s**
1-2	286	272	184	113	1.02969	8.187
2-3	272	256	176	94	1.1387	7.937
3-4	256	254	163	103	1.06398	7.407
4-5	254	240	160	108	0.852953	7.297
5-6	240	238	149	88	0.962533	6.907
6-7	238	233	149	37	0.991547	6.78
7-8	233	239	160	64	0.838336	6.735
8-9	239	225	146	40	1.01702	6.844
9-10	225	231	146	116	1.23061	6.297
10-11	231	232	150	96	1.09167	6.484
11-12	232	239	153	115	0.925411	6.609
Image Registration time/s: 5.625						

We can see from the table 1 that the UAV panorama has a high accuracy, and doesn't take much time. That means UAV image mosaic system is able to meet the requirements for disaster emergencies and can be used in cities with paroxysmal disasters. Figure 6 is the mosaic rendering with 12 UAV images, Figure 7 is the mosaic rendering with 15 UAV images before blending, Figure 8 is the mosaic rendering with 35 aerial images are taken by Vecxel Ultracam XP in experimental area.

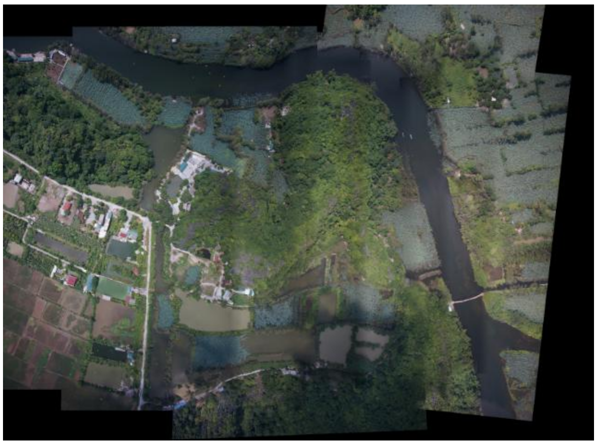

Figure 6: Mosaic with 12 UAV images

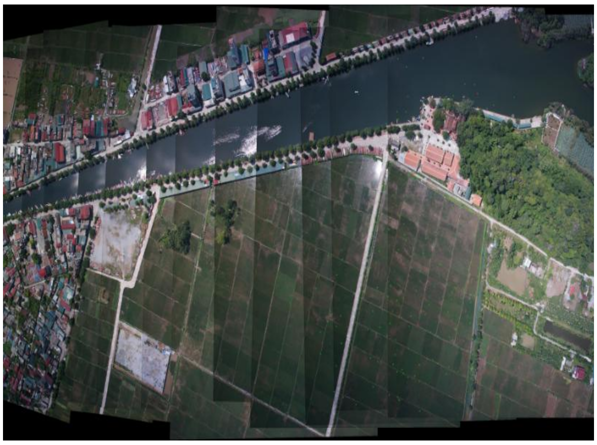

Figure 7: Mosaic with 15 UAV images before blending.

Figure 8: Mosaic with 35 aerial images

5. CONCLUSION

"*Automatic UAV image processing*" is big problem which we are implementing. This paper solves a problem in that stage. Proposed algorithm has new features that using integrated matching method, image pyramid technique and take into the characteristics of aerial photography to reduces computation time. The experimental results able to meet the requirements for disaster emergencies. In the near future, we continue improving the speed of mosaicing with some parallel solutions.

6. REFERENCES

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