IMAGE MOSAIC METHODS FOR UAV SEQUENCE IMAGES

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ABSTRACT: UAV (Unmanned Aerial Vehicle) captures high-resolution images at lower cost, more flexible and convenience; however, the field of views of UAV images is limited. Image mosaicking is the process of joining several overlapped images to form a single continuous image. So the process is a critical task for UAV images. In this paper, we proposed an automatic image mosaic based on SIFT (Scale Invariant Feature Transform) algorithm to extract invariant features which are constant in nature. The Random Sample Consensus (RANSAC) algorithm is used to remove mismatching. It divides all points to outliers and inliers. The outlier will be rejected by RANSAC algorithm and inliers will be used for producing mosaic image and get the panorama. In this research we used 36 sequence images with 70% overlap captured by a fixed-wing UAV. The proposed algorithm is applied for mosaicking and the results are compared with existing mosaic software such as Agisoft PhotoScan. The result shows that Agisoft has a faster processing time than SIFT algorithm. When Agisoft takes 191.074 seconds to process 36 images, SIFT algorithm process the same input images in 269.65 seconds. In comparison two methods of mosaicking, Agisoft is very convenience and can input several images and match them automatically, although mismatching of two images can interrupt the whole process. The results of Agisoft show some black area on the mosaic image because these area cannot recognized during image mosaic although SIFT algorithm shows accurate matching if there are enough feature points in the overlapped region. In conclusion, the SIFT algorithm can extract many feature points without consideration of image rotation and also the RANSAC algorithm certify the reliability of result. Comparing with Agisoft, SIFT algorithm is slow but has stability in rotation, scale changes, transformation and illumination changes.

1. INTRODUCTION

During the past decade, the number of applications of UAVs (Unmanned Aerial Vehicle) has increased in military and civilian operations such as sea floor exploration, vegetation mapping, and border security. Although UAV image collects high-resolution images with lower cost, the images cover small part of study area and there is limitation in field of view (FOV) as UAV flies low. Therefore, the visual field of UAV images is small and these images should combine together due to increase it. Image mosaic is a technology that fits many images which are overlapped. In image mosaicking, two or more input images are merged to generate a uniform image. There are four steps for image mosaic including: 1. Feature extraction 2. Image registration 3. Image warping and 4. Image blending. Corners are compared to provide a better feature matching for pairs of images. The best features to fit are corners because they are most fixed features over change of viewing angels. There are different detection algorithms to detect corners such as Harris (Mao et al, 2009), Susan (Fang, 2010), SIFT (Lowe, 2004), SURF (speeded up robust features) (Zhang et al, 2009) and Moravec algorithms (Wang and Fang, 2006). The selection of the method generally depends on the request.

Jiantao Bi et al (2014) proposed SIFT algorithm to extract the scale invariant feature points in UAV image for earthquake emergency. They used k-d tree, RANSAC algorithm and weighted mean for finding the matches, correct the mismatching feature points and merge images of the overlapped region, respectively. The results show the feature points can be detected by SIFT and the rotation, distortion and moving of image does not matter. In conclusion, the image mosaic can applied to prevent the secondary disaster and decrease damages. Yang zhan-long et al (2008) presented an automatic image mosaic method based on SIFT. They followed four steps including keypoint extraction and description, feature matching, homography estimation using RANSAC and image fusion. The results show the suggested algorithm is robust to scaling, noise, translation and rotation. Cheng Xing (2010) introduced a two-step optimization (local and global) method for mosaicking UAV sequence images which can improve the position of images and correct the homographies. They applied SIFT algorithm for extracting stable features and also an Extended Kalman Filter (EKF) was used to recover the homographies within local areas. Moreover, the position of each image was corrected by using Levenberg-Marquardt (LM) algorithm. The results show both steps of optimization improve the residuals of x and y between feature points and also decrease the RMS. In summary, this two-step method is appropriate for image mosaicking. Cheng Xing and Jingjing Huang (2010) proposed SIFT algorithm for extracting and matching sequence images of UAV. RANSAC algorithm and L-M algorithm were used to remove wrong matched Points and optimize the parameters, respectively. At last, the
sequence images mosaicking were completed. The results show the SIFT algorithm can extract features even in area with less information. Lastly, SIFT algorithm can create stable point which are significant to generate a correct mosaic; however, this algorithm is time-consuming. As the SIFT operator takes much time, Fuhua Song and Bin Lu (2013) improved the traditional SIFT algorithm aimed to increase speed and accuracy for mosaicking. They used best-bin-first (BBF) algorithm based on kd-tree for coarse matching and RANSAC algorithm was used to remove wrong match. The results show the proposed algorithm is faster with more matching rate. Luo Juan and Oubong Gwan (2009) compared three feature detection methods namely SIFT, SURF and Principal Component Analysis (PCA). They applied KNN (K-Nearest Neighbor) to find matches and RANSAC algorithm to reject wrong matches for all methods. The result shows SIFT is slow but has stability in rotation, blur, scale changes, affine transformation and illumination change.

This study aims to evaluate the capability of SIFT for mosaicking of UAV sequence images and compare this technique with the existing software of image mosaic (such as Agisoft PhotoScan). The finding of this study will be a prerequisite for different applications for military and civil users.

2. MATERIAL AND METHOD:

Fixed-wing J-HAWK UAV was flown on 10 April 2015 at altitude of 300m above the surface. The UAV capture a RGB image using Canon camera S100 with 12 Mega pixels. Each exposure produced about 320m x 370m ground coverage. The images were captured using a fixed-wing UAV around the Banquet hall located approximately at the south side of Universiti Putra Malaysia (UPM) campus with latitude 2°59’23”N and longitude 101°43’26”E. Figure 1 shows the image of fixed-wing J-HAWK UAV which was used in this study.

![Figure 1. Fixed-wing J-HAWK UAV](image1.png)

The images captured by UAV have an overlap of 70% and a side overlaps of 60%. Figure 2 shows two sequence images captured from a fixed-wing UAV with an overlap of 70%. As we can see, the white building is Banquet hall located in compose of UPM.

![Figure 2. Two sequence images from an UAV flight](image2.png)
2.1 SIFT Algorithm

Professor David G. Lowe (2004) from University of British Columbia developed SIFT algorithm to extract specific features, which are invariant to illumination, rotation, image scale and transformation from images. Figure 3 shows the flow chart of image mosaic using SIFT algorithm.

Figure 3. Methodology flow chart of image mosaic using SIFT algorithm

2.1.1 Keypoint extraction and description: Keypoints are selected based on measures of stability. The stable keypoint should be persistent to image distortion. The potential of keypoint are evaluated by using a Gaussian function such as difference-of-Gaussian (DoG). The input image is convolved by a DoG with various scales factors. Each sample point is compared to pixels of adjacent layers. If the central point is the maximum or the minimum, mark it as the extremum point. Lowe used Taylor’s theorem on extremum point of DOG to ensure precise position. Then Hessian matrix was applied to remove the edge response.

To ensure orientation to each keypoint based on local gradient, keypoint descriptor can represent relative to orientation for achieving rotation of feature points which is invariant. A key-point can produce the 128 (4x4x8 elements) data that finally develop 128-dimensional SIFT feature vector. Figure 4 shows the feature point detection of two images using SIFT algorithm.

Figure 4. Select feature points by SIFT algorithm

2.1.2 Feature matching by distance: The relationship between feature points in the reference image and input image will be evaluated in this step. Based on nearest neighbor, the finest candidate match for each feature point is founded. Figure 5 shows the matching of feature points including outliers.
11987 tentative matches

![Figure 5. Matching results (wrong matching points included)](image)

2.1.3 Homography estimation using RANSAC: Two feature points are matched when their difference is small, although mismatching may be created in this method. The RANSAC algorithm is used to correct these errors. It divides all points to outliers and inliers. The outlier will be rejected by RANSAC algorithm and inliers will be used to estimate model and evaluate the model by error rate. In general, the purpose of this step is to get a set of data points from inliers and reject outliers. Figure 6 shows matching results using RANSAC which there are 11987 tentative matches. After applying RANSAC, the wrong matches were removed and only 6893 (57.50%) matches inlier were left.

![Figure 6. Matching results by using RANSAC](image)

6893 (57.50%) inlier matches out of 11987

2.1.4 Image Mosaic and getting the panorama: Image mosaicking is a critical task for UAV images. In the SIFT algorithm, after RANSAC with homography model, the inliers matches are used for producing mosaic image. Figure 7 shows the panorama of image mosaic by two images using SIFT algorithm.
2.2 Agisoft Software

In recent years, several software has been created for image mosaic, such as PCI Geomatic, Bingo, Inpho and Agisoft Photo. The processing in Agisoft PhotoScan software is full automatic and comfortable; however, it is not free software and the result has issue of wrong display because some area cannot be realized over image mosaic (Jiantao Bi et al, 2014). The workflow in Agisoft is including: 1. Alignment of images 2. Dense cloud generation 3. Mesh generation 4. Add features and colors and 5. Export result.

3. EXPERIMENTAL RESULTS

Matlab software was used for the implementation of SIFT algorithm and all experiments have been performed on a PC with 8.00 GB RAM, Core(TM) i7-4790, CPU 3.60 GHz, 64-bit Operation System, with Windows XP Professional Edition. The algorithm was tested for a large number of images which have rotation and translation. In this test, 36 images are selected from an UAV flight to create mosaic image based on SIFT algorithm. Figure 8 (right) shows the mosaic image formed by using the SIFT algorithm, and RANSAC algorithm was applied to remove mismatching between the feature points. The result shows the suggested algorithm is robust to rotation and translation. Figure 8 (left) shows the panorama of image mosaic by 36 images using Agisoft PhotScan. The processing in Agisoft PhotoScan software is full automatic and comfortable although the result has event of wrong display because some area cannot realized over image mosaic. As we can see, in figure 9 black areas cannot recognize over image mosaic.

Figure 7. The panorama of image mosaic using SIFT algorithm (two images)

Figure 8. The panorama of image mosaic using SIFT algorithm (right) and Agisoft (left) using 36 images
Figure 9. The black area that cannot recognize in final result using AgiSoft

Table 1 shows the time recording of two methods of mosaic image named SIFT algorithm and Agisoft PhotoScan by using 2 and 36 images. The results show the processing time of SIFT algorithm was 269.65 seconds for 36 images although Agisoft shows faster performance where the whole steps are performed in 191.074 seconds using 36 images. This finding of this study is in agreement with previous study conducted by Jiantao Bi et al (2014) corresponding of time, Agisoft Photoscan has faster performance. Previous study as mentioned also discovered black area in final result of image mosaic using AgiSoft because these area cannot recognized during image mosaic.

<table>
<thead>
<tr>
<th></th>
<th>Number of Images</th>
<th>Time of Process (Seconds)</th>
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<tbody>
<tr>
<td><strong>SIFT Algorithm</strong></td>
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<td></td>
</tr>
<tr>
<td>2 images</td>
<td></td>
<td>4.18</td>
</tr>
<tr>
<td>36 images</td>
<td></td>
<td>269.65</td>
</tr>
<tr>
<td><strong>Agisoft PhotoScan</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 images</td>
<td></td>
<td>11.029</td>
</tr>
<tr>
<td>36 images</td>
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<td>191.074</td>
</tr>
</tbody>
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4. CONCLUSION

In conclusion, many feature points are extracted by the SIFT algorithm without consideration of image rotation. RANSAC algorithm can gain constant matching points and certifies reliability of results. In comparison two methods of mosaicking, Agisoft is very convenience and can input several images and match them automatically. On the other hand, due to the full automatic processing it cannot be interfered manually. The whole process may be disturbed by the mismatching of two images therefore image mosaic should start over. The results of Agisoft show some black area on the mosaic image because these area cannot recognized during image mosaic although SIFT algorithm shows accurate matching if there are enough feature points in the overapped region. Finally, SIFT algorithm is slow but has stability in rotation, scale changes, transformation and illumination changes.

References


