A New Method of Manifold Mosaic for Large Displacement Images

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Abstract In the traditional manifold mosaic, a single center strip is clipped out from each source image to create a large image. Therefore the displacement between neighboring views should be very small in order to fulfill effective strips cutting. In this paper, a method is proposed to create a manifold mosaic by images with relative large displacement by means of cutting out multiple strips in the overlap area according to the homography between images. These strips are then warped together to create a smooth mosaic. An improved RANSAC algorithm is also presented in order to improve the precision of homography calculation. Experimental results demonstrate the efficiency of the method.

Keywords manifold mosaic, displacement, homography, RANSAC

1 Introduction

In recent years, many researchers have focused on image mosaic and presented many methods. Among these methods, typical method can be divided into two steps: image registration, image blending.

In the image registration step, several source images should be registered together. The most typical ways to realize the registration of the source images are named as direct registration and feature-based registration. Both methods try some iterative ways to calculate the motion relationship between images. Direct registration[1–3] needs initialization either by correlation or by some user set correspondences while feature-based registration[4,5] can automatically detect and match the features in the source images. Thus feature-based registration is more convenient to be used than direct registration. In feature-based registration, RANSAC[6] is usually applied to get the homography between two images which is more robust for model fitting than other methods in the presence of many data outliers, e.g., Cho et al.[7]. However the initial putative match which is selected randomly during each iteration affects the efficiency of RANSAC.

In the image blending step, the registered images are blended to be a mosaic. First the pixels in the overlapped part of the final mosaic are selected from multiple images[2] or from only one image[8–10]. Then these pixels are blended together with some blending method, such as multiresolution spline mosaic[4,11]. Among the methods of selecting the pixel from only one image, manifold mosaic[8,10] integrates the motion relationship by finding the affine motion between images. Therefore it is more robust than other methods which simply calculate the pixel intensity differences, e.g., dynamic programming[8,9]. In manifold mosaic, a cut line that is vertical to the optical flows is first calculated and then a single narrow strip from the image center (center strip) can be cut out based on this cut line. These narrow strips from multiple images are warped together so that the optical flows in the warped strips are the same magnitude and parallel to camera motion direction. If there are enough images, we can finally get a mosaic after pasting all the warped cut strips together. Manifold mosaic can also generate some interesting mosaic, such as forward motion mosaic and tiled mosaic[12]. Feldman et al.[13] studied the distortion of manifold mosaic.

According to manifold mosaic, the smooth mosaic can be created by a dense image sequence or a video. Otherwise the relationship between neighboring views is hard to be described by affine transformation because the displacement between neighboring views is large. In this case the optical flows are quite different between neighboring views and it is hard to get a cut line that is vertical to all the optical flows. The center strip cannot be got without the cut line and then the images cannot be mosaicked.

In this paper, we present a novel way to implement mosaic by the images with large relative displacement. Our key idea is that a curved mosaic surface can be used to approximate the cylindrical surface during photographing. In the proposed method, the overlap areas are previously cut into multiple strips under the homography between images, then the mosaic can be created by warping these strips together so that a curved mosaic surface can be generated. Since the precision of homography will influence the efficiency of mosaic, an improved RANSAC method based on the modified median flow filter[14] is also presented in this paper to improve the stability of the random selection step of each RANSAC iteration.

The proposed manifold mosaic method achieves image mosaic in the following steps:

1) Image Registration: SIFT[15] is used to robustly detect and describe features and priority search[16]
is used to match the features. Then the improved RANSAC is used to get the homography between images.

2) Multiple Strips Pasting:

(a) Multiple Strips Warping: Multiple strips in the overlap part are cut out interleavingly according to the homography between images and warped together by the same method of traditional manifold mosaic;

(b) Rectification: The local distortions in the warped strips are eliminated with dense rectifying lines;

(c) Multiresolution Blending: The warped strips and the source images are incorporated into the multiresolution blender and blended sequentially.

In the following sections, the improved RANSAC algorithm and multiple strips pasting will be discussed in detail. Then experiments are presented and the whole paper is concluded finally.

2 Improved RANSAC Algorithm

Four initial putative feature matches are selected in the random selection step of each iteration in RANSAC[6], and a correct homography can be received after one iteration if they are the real inliers. However each feature will have more than one nearest neighbor after feature matching because of the similarity of the local patches. Therefore perhaps wrong match will be selected as the initial putative match in one iteration according to the random property of RANSAC. Then the weak homography of this iteration will be definitely generated which will generate the largest number of matches in all possibilities and the final homography will be weak.

Smith et al.[14] used a median flow filter to remove the wrong feature matches. The median flow filter consists of two parts: angle filter and length filter. Assumed each pair of correspondences connected to be a vector, the median flow filter tries to remove the vector whose angle and length are larger than the median values of its tightest n vectors among its k nearest neighbors. There are only four feature matches can be selected in the random selection step of each RANSAC iteration, and n tightest groups and k nearest neighbor vectors can be ignored. In this step, we use all the four feature matches and compare all of them. Fig.1 explains how this modification works.

Fig.1(a) shows the angle filter which is the first step to check the four feature matches in the modified median flow filter. The four green lines show that the directions of four vectors composed by the four correct corresponding feature matches. α stands for the median direction of these four correct vectors, while β stands for the median direction if there is a wrong vector L among the four vectors. The direction difference between each correct vector and α is not so large. However, when L exists, θ, which is the direction difference between L and β, is obviously larger than φ which is the direction difference between the correct vector and β. If θ is larger than a threshold, these four matches will not pass the angle filter.

To the four feature matches that do not pass the angle filter, a second check on length is needed. This is because there perhaps exist short motion vectors which cannot be determined with great certainty especially when noise is strong. Fig.1(b) explains the length filter. If all the four corresponding vectors (shown in green lines) are correct, we can get a median line M1. But if there exists a wrong vector L, then we will get a median line M2. The length difference between each correct vector and M1 is not so large. But when L exists, b, which is the length difference between L and M2, is obviously larger than a which is the length difference between the correct vector and M2. So if b is larger than a threshold, these four feature pairs will not pass the length filter and thus cannot pass the median flow filter.

![Fig.1. Modified median flow filter. (a) Angle filter. (b) Length filter.](image)

If the four randomly selected feature matches cannot pass the median flow filter, they cannot be selected as the initial feature matches to calculate a homography and this random selection step should try again. Conversely the next step of the iteration can execute. For details on homography calculation with RANSAC, please refer to Hartley et al.[6]

3 Multiple Strips Pasting

3.1 Multiple Strips Warping

Fig.2(a) shows the normal warping process by the images with relative large displacement. Assumed the reference image to be A, the warped image B' will definitely result in global resize effect after homography calculation. Fig.2(b) shows how the warp is done with the red rectangle in Fig.2(a). It is clear that B' is distorted since the cylindrically captured image is warped to a plane.

If the images can be calibrated first, they can be warped smoothly along the cylinder surface and then robust mosaic can be achieved. Since camera self-calibration is still not very robust, if we can warp the cylindrically captured image onto a curved surface, the distortions will be certainly smaller than that of simply warping to a plane. Traditional manifold mosaic is hard to achieve mosaic for images with relative large displacement because it cuts a single narrow strip from