Panorama Images Stitching on Android Phones

D.Gansawat, W.Sinthupinyo
Image Technology Laboratory,
National Electronic and Computer Technology Center
112 Phahonyothin Road, Klong Luang,
Pathumthani 12120, Thailand

***Abstract*-** **The objective of this paper is to present algorithm to create panorama images from stitching image sequences taken by camera on mobile phone with the Android operating system. The images for stitching to create panorama are captured in a fixed linear spatial interval and the orientation information are obtained from the sensors on the Android mobile phone. The processing method involves image warping to cylindrical projection coordinates, image matching based on SURF (Speeded Up Robust Features) method as the feature detection and neighboring pairs alignment using RANSAC (RANdom SAmple Consensus) algorithm. The average weighted linear blending is applied to remove the transition between the aligned images. The presented image stitching algorithm is successfully able to create panorama image on the Android mobile phone.**

I. INTRODUCTION

Panorama images offer a wider view of the scene compare to a single snapshot hence the viewers would feel more immersive experience in the scene. Nowadays, panorama image stitching feature has been widely included in many digital cameras and image editing software. However, implementation of the panorama image stitching on the mobile phone especially on the Android mobile phone remains limited and open for a new idea. The main objective of this work is to implement the panorama creation on Android mobile phone that does not require the user to manually capture the image sequences as the mobile phone is able to determine where images should be captured. The user can move the camera on the mobile to where the mobile will automatically capture the pictures to be used for the panorama image creation. These indicators use the orientation sensor that is built in the mobile phone. The captured images used for the processing are down sampled by factor of 8 to increase the computational efficiency. The panorama images can be considered as synthetic wide-angle camera hence, the projective transformation of the collected images are estimated by warping each perspective images into cylindrical coordinates with the known focal length [1]. Next, feature detection and matching based on SURF method [2] is used instead of SIFT (Scale Invariant Feature Transform). SURF method is chosen though it possesses less accuracy compare to SIFT, however it is faster than SIFT [3]. Therefore it is more suitable for implementation on the mobile phone. The SURF descriptors are matched and the neighboring pairs are aligned using RANSAC [4]. After the images are aligned, the average weighted linear blending [5] is applied to compensate for exposure differences and misalignments to produce seamless output panorama image. Finally, the panorama image is cropped and displayed.

The algorithms used in this work are described in detail in the section II, and section III presents the implemented results. Conclusion is addressed in section IV.

II. PANORAMA IMAGE STITCHING ALGORITHM

The procedure we used in the implementation of panorama image stitching on android mobile phone includes: A. Images acquisition; B. Images warping onto cylindrical coordinates; C. Features detection and matching based on SURF method; D. RANSAC and E. Image blending which can be described as Fig.1. More details of each step will be discussed in the subsections A - E.

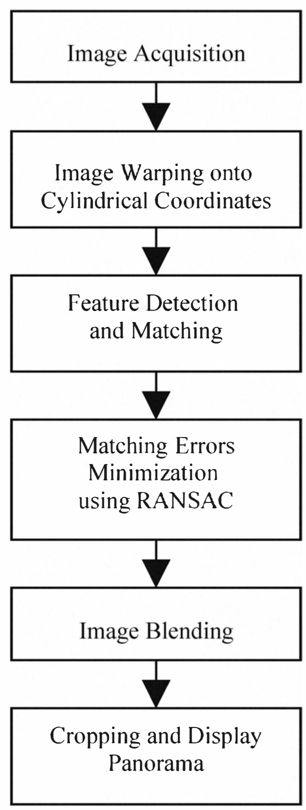

Fig.1. The entire process of panorama image stitching.

A. Images acquisition

The captured images are assumed to have enough overlap with each other, the camera parameters are known and the focal length is to be a fix value. The shooting process of the image sequences is designed using orientation sensor information and timer, so that the user only needs to move the camera spatially and the pictures will be captured automatically with sufficient overlaps. Each input image is resized to size 640x480 pixels.

B. Image warping to cylindrical coordinates

In this step each perspective image with the known focal length is warped into cylindrical coordinates to compensate the distortion as the panorama image has a wide angle of view. Fig.2 illustrates the image warping to cylindrical coordinates.

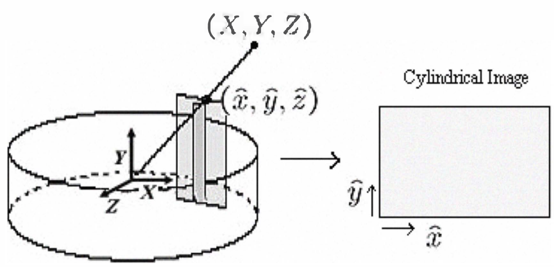

Fig.2. Illustration of image warping to cylindrical coordinates.

The procedures used for image warping based on cylindrical projection transform are described as following

1) Warping arbitrary point in 3-D space (X,Y,Z) onto the unit cylinder

$$(\hat{x},\hat{y},\hat{z}) = \frac{1}{\sqrt{X^2+Z^2}}(X,Y,Z) \qquad (1)$$

2) Converting points to cylindrical coordinates

$$(\sin\theta, h, \cos\theta) = (\hat{x},\hat{y},\hat{z}) \qquad (2)$$

3) Computing the cylindrical image coordinates

$$(\hat{x},\hat{y}) = (s\theta, sh) + (\hat{x}_c,\hat{y}_c) \qquad (3)$$

where s is the focal length of the camera and $(\hat{x}_c,\hat{y}_c)$ is the origin defined in the unwrapped cylinder.

C. Feature Detection and Matching

SURF method is fast scale invariant feature detection. It uses an approximation to the hessian which is the matrix of partial derivatives to find key points in the image. SURF approximates these partial derivatives using binary masks. The binary masks are convolved with the Integral image to find the features. The integral image is constructed by summing all pixels above and to the left of the current pixel. It describes the feature detection of image faster than SIFT about 3 times. An example of calculated SURF descriptors between two image pairs is shown in Fig.3. Fig.4 shows an example of calculated SIFT descriptors between same image pairs as in Fig.3.

After the features are detected using SURF method, the feature correspondences between given image pairs are matched by considering the nearest Euclidean distance search over the entire features that are detected. The Homography (H) model of the projective transform is set up an equation with the unknown parameters of H as described in Equation (4)

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} \qquad (4)$$

The transformation is described by homograph matrix with the parameters *a, b, c, d, e, f, g, h,* and *i*. The scaling factor *i* can be set to 1, hence there are 8 unknowns to be solved.

Fig.3. Corresponding SURF descriptors in the two image pairs.

D. RANSAC (RANdom Sample Consensus)

This step is to estimate a model of consensus set that minimizes matching error. The idea is to compare the probabilities that this consensus set of inliers/outliers generated by a correct image match or a false image match. RANSAC loop involves

1) Randomly selecting a seed group of points on which to base transformation estimate.
2) Computing transformation from seed group.
3) Finding inliers to this transformation
4) If the number of inliers is sufficiently large, re-computing Least-squares estimate of transformation on all of the inliers.

Fig.4. Corresponding SIFT descriptors in the two image pairs.

E. Image Blending

The previous stages realize image stitching in geometry, the aligned images still have obvious seam in the overlap regions. The average weighted linear blending which is simple and fast is used in this paper. In the average weighted blending, the values of features in overlap region are equal to the weighted average values of matching images, which can be shown as follows

$$p = \frac{d_l}{d_l + d_r} p_l + \frac{d_r}{d_l + d_r} p_r \qquad (5)$$

where d_l is the distance between the pixel in overlap region to the border of the left matching image, and d_r is the distance between the pixel in overlap to the border of the right matching image. After the image blending process, the computed panorama is cropped and displayed.

III. Implemented Results

The result of computed panorama before cropping is shown in Fig.6. The cropped panorama is shown in Fig.7 (a). The panorama image stitching is implemented on the Samsung Galaxy S-I9003 mobile phone. A set of images containing 3 photos captured as input shown in Fig.5. The computational time is 52 seconds to compute the panorama on the mobile phone. The computed panorama using proposed image stitching method is compared with panorama computed using PhotoStitch by Canon shown in Fig.7 (b).

Fig.5. Thumbnails of 3 photos captured as input.

Fig.6. Panorama computed from 3 images captured before cropping.

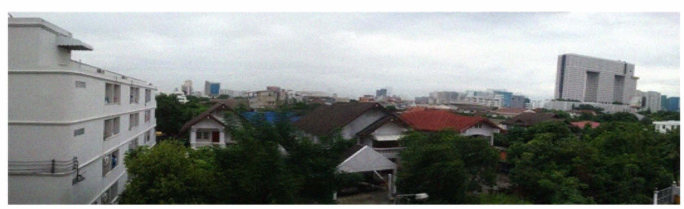

Fig.7 (a). Cropped panorama computed from 3 images captured using proposed image stitching method.

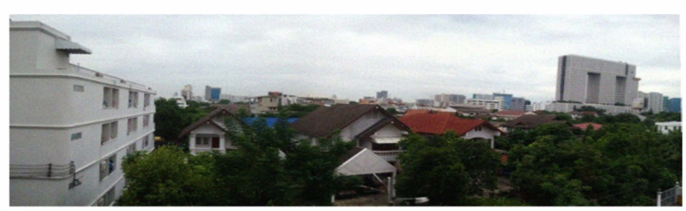

Fig.7 (b). Cropped panorama computed from 3 images captured using PhotoStitch software by Canon.

IV. CONCLUSIONS

The automatic panorama creation on Android mobile phone is successfully implemented using an image sequences captured by camera on the mobile phone. The automatic panorama image stitching involves the image warping onto cylindrical projection coordinates. Then it follows by feature detection and feature matching based on SURF method. The matching error is minimized using RANSAC. Then the seamless aligned image is computed using the average weighted linear blending.

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