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Feature-Based Image Stitching Algorithms

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***Abstract*—The method of joining images to make a panorama is known as image stitching. It is an enthusiastic research area in image processing and computer vision but still a challenging problem for panoramic images. A good number of researches had been carried out to develop different algorithms for image stitching in the last few years. Image stitching approaches is classified mainly in two groups: direct and feature based. Direct techniques evaluate pixel intensities of the input images and feature- based methods resolve an association among the images based on the extracted features of inputted images. A detail study on the state-of-the-art of feature-based image stitching approaches is presented in this paper. We have shown the performance of some of the feature-based image stitching approaches using images from Yale Database. In addition, we briefly discussed the challenges and possible future work of image stitching.**

Keywords—*panorama; image stitching; image features; corner and edge detection*

I. INTRODUCTION

The procedure of unification of several images to generate a single panorama image is called image stitching. It finds general applications in representing the wide objects either in natural scene or in microscopy. In panoramic stitching, an image set will have a logical amount of overlap to prevail over the deformation of lens and must contain sufficient measurable features. This set will also have reliable disclosure between two frames to curtail the chance of seam occurrence. In addition, the images of same scene can have different intensities, scale and orientation.

If the images are taken from the different places, then it may associate with parallax errors. Blind stitching can be done using feature-based alignment methods. But it can produce erroneous result. To overcome the parallax errors, we can use large camera system in a fixed disclosure.

Image stitching is a broadly used technique in various applications such as, image stabilization features, panoramas in maps and images of satellite with high resolution, images for medical solutions, high resolution multiple images, video stitching and object insertion.

This stitching method is mainly separated into three core sequences: image calibration, image registration and alignment, and image blending [1]. The aim of calibration is to reduce the differences between camera-lens combination and an ideal lens model. These differences are calculated from optical defects [2]. The image could be reconstructed to a 3D scene using the coordinates of the pixels and the intrinsic and extrinsic parameters of camera.

The extrinsic camera parameter and the linkage among the pixel coordinates of an image point with the corresponding coordinates, is made by intrinsic camera parameters. These topics are used to describe the position and direction of the camera reference frame. This frame must be compared with a world reference frame.

The calibration step is followed by image registration and alignment [3], [4]. Alignment is useful in matching an image when it transforms to another coordinate system. Here, the transformations of an image normally go through translation, rotation and scaling. Finally image blending technique is applied to ensure seamless transition from one image to another image by removing artifacts [4].

The most likely used alpha blending receives weighted average of two images and works really well during the time of alignment of image pixels through intensity shift. After that the images are united by the Gaussian pyramid blending at different frequency bands and filtered consequently.

This research highlights the state-of-the-art of feature-based image stitching approaches and its additional objective is to discuss the challenges of image stitching.

We have organized the rest of the paper as follows: different image stitching techniques are described in Section II. The performance evaluation of feature-based techniques is analyzed in section III. Section IV demonstrates the discussion of different feature-based techniques. Then in section V, the future works and challenges are presented. Last of all, Section VI draws the conclusion of this paper.

II. IMAGE STITCHING TECHNIQUES

Image stitching technique basically divided into two basic types: direct and feature-based.

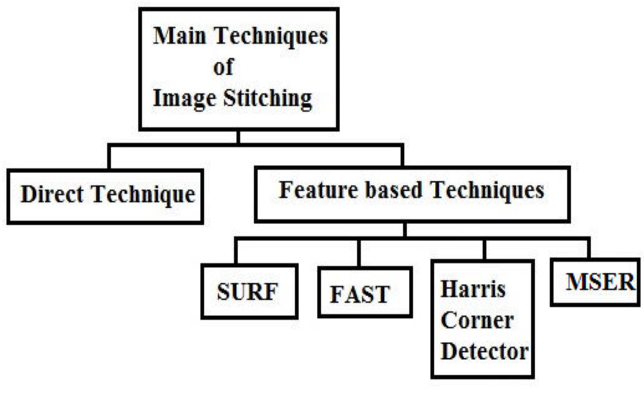

Fig. 1. Different types of image stitching techniques

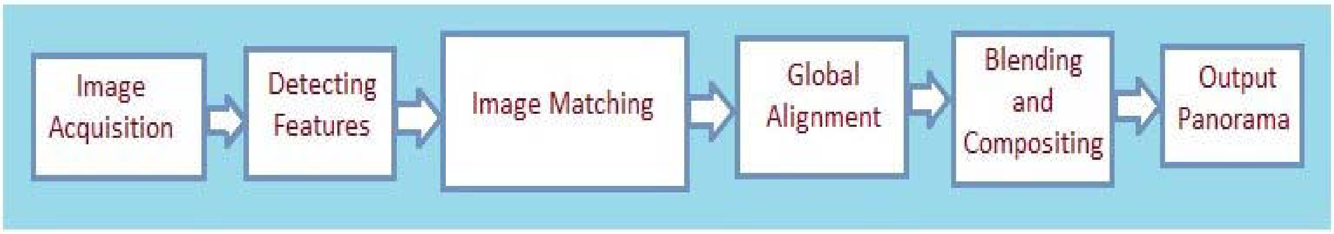

Fig. 2. Basic algorithm of feature based image stitching

A. Direct technique

The direct technique is dependent on the comparison of pixel intensities of the images and it decreases total differences among overlapping pixels [1]. The information from all the pixels is applied for the estimation of homography which is useful for the minimization of a particular cost function. Occasionally, Phase-Correlation is exploited to calculate the some homography parameters. Comparing each pixel with one another made the method as a complex one. It often uses any other available cost functions. But, in image scaling and rotation, these methods seem complex and invariant [5], [6].

There are some advantages of using direct method including optimal use of the information present in the image. This technique can evaluate the input of each pixel in the image but having an inadequate range of convergence is the biggest drawback of direct techniques [1].

B. Feature-based technique

Feature-based methods are more robust and quicker. It can recognize panoramas by automatic discovery of associations among the unsorted images [1]. To locate corresponding feature points between two images, it is necessary to compare every feature of different images of the local descriptors.

The feature-based algorithm consists of the following steps:

i. Image Acquisition

The first step of image stitching algorithm is the image acquisition which means image capturing by camera devices or acquiring from secondary sources.

ii. Feature detection and matching

For this purpose the following information are important: registration of image, stabilization of videos and reconstruction of 3D. These are necessary for matching the corresponding features between several views. Corners are matched to give quantitative measurement. It provides a rational matching for the image pairs based on rotation, translation and scaling [10], [11].

iii. Alignment

The most suitable method is photogrammetric method to merge many images of the identical scene in a perfect reconstruction of 3D scene and it is known as bundle adjustment [12], [13]. The purpose of alignment is to locate a reliable alignment parameter set which can decrease the miss-registration between every pair of images. It is very useful to widen the pair wise matching criterion to a global energy function [14].

iv. Blending and composition

Generally, when a few images are stitched together, one image is selected as the reference and then twisted all the images in the system (Coordinate system) of that location. The result is often known as a flat panorama [15], [16].

Image stitching can be applied on several projective layouts, for example, rectilinear projection, where the panorama is observed lying on a plane (two-dimensional) crossing a panosphere at a point [17], [18], [19]. Rectilinear projection uses cube faces with cubic mapping for viewing panorama and it demonstrates the cylindrical projection.

After plotting the source pixels against the ultimate composite surface, it is necessary to blend them for creating a panorama. Different blending methods are applied in image stitching. Feathering, image pyramid and gradient domains are some familiar blending procedures [19], [20].

Feathering is used for blurring the edges of features. From the two overlapping images, the average pixel values are evaluated for the blended regions [21]. Multi-band image blending is another well-known method that executes in the gradient domain.

Image pyramid blending is another important approach which represents the image using different frequency-band image set. Image pyramid gives numerous functional possessions for numerous purposes [22], [23], [24].

Below, we have represented some of the noble feature based techniques of image stitching.

i. SURF based approach

SURF (Speeded Up Robust Features) is known as local feature detector and descriptor [26], [27]. SURF descriptors are useful to find out and identify objects, faces, to restructure 3D scenes, to trail objects and to extort points of interest [28].

Juan et al [29] proposed an image stitching technique that combines the following algorithms: matching algorithm of image, modified SURF (Speeded Up Robust Features) technique, blending algorithm and multi-band blending. Using modified SURF, this technique gets feature descriptor of the image, then, finds matching pairs, verifies the neighbors using K-NN (K-nearest neighbor) and confiscates the mismatch couples using RANSAC and at last, regulates images using bundle adjustment and calculates approximately the accurate homography matrix and then blend images by multi-band blending.

Besides the above approach, Karthik et al [30] introduced a panoramic view using Invariant Moments and SURF Features. Wang et al [31] presented a unique method of image stitching using adaptive uniform distribution SURF.

ii. FAST feature-based approach

FAST (Features from Accelerated Segment Test) is a method of corner detection which extracts feature points and follows and plots objects in images [32].

Rosten Drummond introduced the FAST (Features from Accelerated Segment Test) approach [32], [33]. It identifies the interest points in images. The main reason was to work with FAST algorithm is to extend the significance point detector for the utilization of it in the real time applications of frame rate. The FAST detector evaluates the pixels around a point which is categorized as a corner depending on brightness or darkness. The FAST detector identifies too many features of neighboring which is counted as the major drawback of it. This FAST feature-based image stitching technique works with the FAST features. The system consists of following stages: detection, description and matching of features using FAST, image matching and then, application of Alpha blending method.

iii. Harris corner detector based approach

Harris corner detector used for this work because it is faster to detect the corners of the image and gives exacted corners of the images with different intensity or orientation. Extracting corner feature and using normalized cross-correlation of the local intensity values in particular points of matching them are the two main purpose of it [34].

Abdelfatah et al [35] presented an automatic image stitching process which is implemented using image sequences. It can determine a model that can convert points of one image to the other by a homography matrix because it contains correlated feature points between the two images. It gives the chances to overlap two images depending on the position of correlated feature points.

A window is positioned on an image. Then, the window is located onto a corner and it is stirred in different way which produces a huge alteration into the intensity. This mechanism is used by Harris corner detector. It is used for a probabilistic algorithm RANSAC that returns satisfactory results.

The RANSAC method is robust to estimate the homography and it is very effective even in the presence of lots of false matches. A linear gradient alpha blending can be used for blending for faster result. It removes the seams and discontinuities of the composite image and gives accurate outcomes.

iv. MSER feature based approach

MSER (Maximally Stable Extremal Regions) is a method for detecting blobs in images which was presented by Matas et al [36].

The intensity function of the region and the outer border defines the regions exclusively which directs to several key features of the regions which compile them functional. The local binarization is constant over a big variety of thresholds and the properties of it are as follows: invariance, covariance, stability and multi-scale detection.

This detector can find correspondences between image elements depending on different viewpoints. That's why, this method shows better performance in extracting a broad number of corresponding among image elements which is very useful for image matching. We have simulated this method as the feature detector for the feature based image stitching.

III. Performance Evaluation Of Feature Based Approaches

For performance evaluation of different feature-based image stitching techniques, we have done a simulation. For this purpose, we have collected a panorama image of size 1500×397 pixels from Yale Database [38].

We have made five input images (640×480 pixels each) from this original image using Microsoft Office Picture Manager. These images have some overlapping regions as well as repetitions. Then, we have inputted these images to generate the stitched image using four feature-based image stitching techniques [39]. After that we have compared theses stitched image with the original image.

In the table 1, we have demonstrated the accuracy rate of different feature-based image stitching techniques.

TABLE I. Performance Of Different Image STITCHING Techniques Based On Accuracy Rate

Image stitching techniques	**Extraction Detector**	**Accuracy Rate (%)**
SURF based Approach	SURF	95.99%
FAST based approach	FAST	50.74%
Harris corner detector based approach	Harris corner detector	94.68%
MSER based Approach	MSER	90.53%

The accuracy of the SURF based approach is 95.99%, FAST based approach is 50.74%, Harris corner detector based approach is 94.68% and MSER based approach is 90.53%.

So, the results confirmed the superiority of SURF based method. The Harris corner detector and MSER have given comparatively better results after SURF. But, FAST has shown the poorest output among all these approaches. Besides this, in Figure 4, we have presented all the output stitched images of these feature-based approaches.

IV. Discussions

A. Critical comments on SURF based Approach

The SURF based approach is not good enough at the illumination changes and viewpoint changes in images. So, development is needed for SURF during this kind of changes.

B. Critical comments on FAST based Approach

The main drawback of FAST detector is, it detects too many features. But, it is very important to concentrate about the main features of the images.

C. Critical comments on Harris Corner Detector based Approach

Harris corner detector can detect the features from noisy images. But, noise can corrupt a natural image during the time of capturing and transmitting. As a result, it becomes difficult to get the desired output. So, before detecting corners, de-noising should be done to get better results.

D. Critical comments on MSER based Approach

MSER has shown the highest sensitiveness to the changes due to blurring. It is needed to overcome this sensitiveness of MSER.

So, in the future researcher should concentrate on illumination and viewpoint changes, noise removal and changes due to blurring. We have applied the feature-based techniques for 5 panorama images but we think this number of images is not good enough. In the future, we will apply these methods on more images.

Fig. 3. Original image from the Yale Database

(a)

(b)

(c)

(d)

(e)

Fig. 4. Five input images which are generated from the original image of Fig. 3.

(a)

(b)

(c)

(d)

Fig. 5. Output stitched images determined by: (a) SURF based approach (b)FAST based approach (c) Harris corner detector based approach (d) MSER based approach

V. FUTURE WORKS AND CHALLENGES OF IMAGE STITCHING

After analyzing several approaches, we have come to know that, in the future, the image stitching can be improved and developed by taking hybrid technique which will use different approaches for better result [35]. Besides this, we can focus on the improvement of accuracy. On the other hand, there are many challenges in image stitching. Images are frequently changed by noise during the transmission and acquisition. So, filtering can be used for noise removal. Another problem is the elimination of the seams. For the removal of seam different methods have been proposed in the last two decades and we have a vision to work with seam removal.

VI. CONCLUSION

In this paper, we have briefly discussed about the image stitching technique and its three key steps calibration, registration and blending. Then, two main image stitching techniques namely, direct techniques and feature-based techniques are analyzed. We have also discussed the basic image stitching algorithm which consists of acquisition of images, detection of features, image matching, and global alignment and blending and composition. After that, we have discussed about different feature-based image stitching techniques: SURF based approach, FAST based approach, Harris corner detector based approach and MSER based approach. Then, we have done simulation and compared those techniques based on the performance and accuracy rate. The simulation results confirmed that SURF based method is better than any other methods. We have also conversed about the drawbacks of these techniques and discussed about the future works and challenges of our research.

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