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# A Review on Image Stitching and its Different Methods

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***Abstract-** Image stitching is the process in which different photographic images are integrated to form a new image with high resolution. Images are overlapped with wide field of view to form a segmented panorama. Normally, image stitching is performed with computer software. Most image stitching techniques require exact overlap between image and its exposures to give better result. Image stitching is widely used technique for recovering of original data from ripped data. Image stitching is used in forensic and investigation science for the reconstruction of torned paper which is a big problem. In image mapping, stitching of image is done to do the complete mapping of particular place. High resolution photo mosaics are formed through image stitching algorithms which are used in digital maps and satellite photos. Its a wide research area in computer vision and in photogrammetry. In this paper different image stitching techniques are discussed and explained how they works.*

***Keywords-** Image stitching, Panorama, Image registration, Image calibration, blending.*

## I. INTRODUCTION

Image stitching process can be divided into three main steps- image registration, image calibration, blending[1]. Image registration is a matching feature in a group of images and also it uses direct image alignment method for searching image alignments which minimizes the sum of absolute differences between overlapping pixels[10]. In direct alignment method, the image is calibrated to get good results. Also users are able to input only basic details of panorama for better matching stages. For instance, only neighbouring pixels are searched for better matching feature. As there are small group of features are available for matching purpose, so the searched result is more accurate and the execution is also faster. Variations in intensity are also present even when two images are perfectly registered. In order to reduce these variations and improves visual quality, a blending algorithm is used.

Image calibration is used to minimize the differences that occur between an ideal lens model and camera lens model that was used. Also some optical defects like distortion, exposure differences were reduced through calibration[3]. If feature detection methods were used to register images and absolute positions of the features were recorded and saved, stitching software may use the data for geometric optimization of the images in addition to placing the images on the panosphere. Calibration is used to calibrate the pixels that is to be stitched.

Image blending executes the adjustments that were detected in the calibration stage, combined with remapping of the images to an output projection. In between images, colours are also adjusted for the compensation of exposure differences and for compensation of deghosting and motion images, high dynamic range merging is done. Images are blended together and seam line adjustment is done to minimize the visibility of seams between images. Seam adjustment is done through gain adjustment method. This compensation is used to minimize the intensity difference of overlapping pixels. Image blending algorithm allots more weight to pixels near the center of the image. Straightening is another method to rectify the image.

Sometimes, after applying gain compensation some image edges are still visible due to unmodelled effects in images, they are vignetting, parallax effects due to motion of the objects, radial distortion, misregistration errors due to wrong modelling of camera.

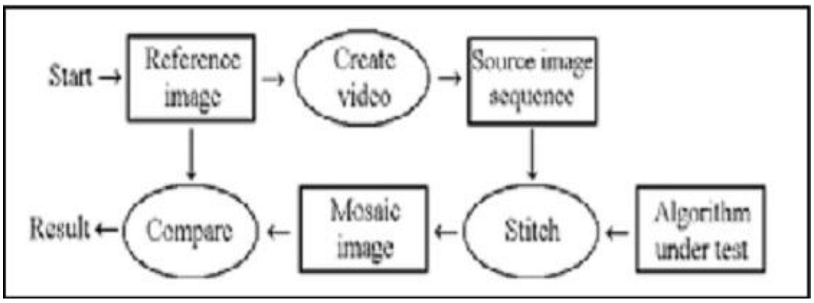


Fig. 1 The Process of Mosaic Quality Evaluation

## II. IMAGE STITCHING TECHNIQUES

Image stitching is the process of combining different photographic images to form in a single frame. Image stitching can be done through two different techniques[4].

 

- Direct techniques
- Feature-based techniques

In direct technique, pixel to pixel dissimilarity is minimized to do image stitching. While in feature-based technique, it works by extracting a set of features and then do the matching with each other[1].

### *A. Direct techniques*

In direct technique, each pixel intensities of image are compared with each other. The main advantage of direct technique is that it minimizes the sum of absolute differences between overlapping pixels. In this technique, each pixels are compared with each other so its a very complex technique. They are not invariant to image scale and rotation. Direct method optimally used the information gathered from the image alignment. It measures the contribution of every pixel in the image. The main disadvantage of direct techniques is that they have a limited range of convergence.
Direct Method uses information from all pixels. It iteratively updates an estimate of homography so that a particular cost function is minimized. Sometimes Phase-Correlation is used to estimate the a few parameters of the homography.

### *B. Feature-based techniques*

In feature-based technique, all main feature points in an image pair is compare with all features in the other image by using one of the local descriptors. For image stitching based on feature-based techniques, feature extraction, registration, and blending are different steps required for doing image stitching. Feature-based methods are used by establishing correspondences between points, lines, edges, corners or any other shapes. The main characteristics of robust detectors includes invariance to image noise, scale invariance, translation invariance, and rotation transformations. There are many feature detector techniques exist some of which are, Harris [6], Scale-Invariant Feature Transform (SIFT) [5], Speeded Up Robust Features (SURF) [6], Features from Accelerated Segment Test (FAST) [8], PCA-SIFT [7] and ORB [9] techniques.
The main advantage of feature based technique is that it is more robust against any type of scene movement occurred in image. This method is very faster and it has the ability to recognise panoramas by automatically detecting the adjacency relationship between an ordered set of images. These features are best suited for fully automated stitching of panoramas.
Feature based methods rely on accurate detection of image features. Correspondences between features lead to computation of the camera motion which can be tested for alignment. In the absence of distinctive features, this kind of approach is likely to fail.

## III. PANORAMIC IMAGE STITCHING MODEL

Image stitching is done when an image is passed through the five different stages and these stages are: image acquisition, feature detection and matching, image matching RANSAC translation estimation, global alignment, blending and composition, and output panorama.

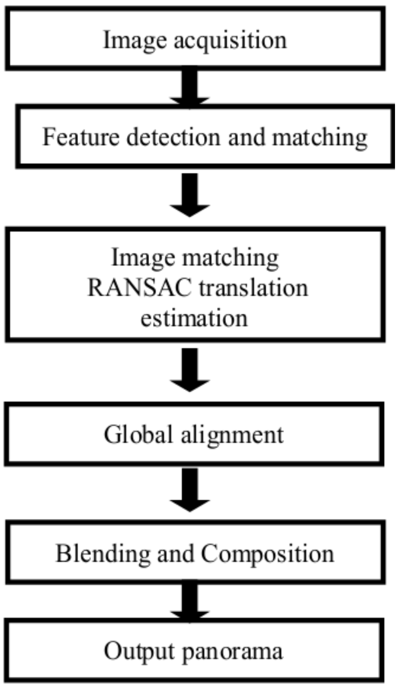


Fig. 2 The block diagram of general panoramic image stitching model

### *A. Image acquisition*

Image acquisition is the first step in image stitching. Image acquisition is the process of retrieving an image from some sources. After the image has been taken, various different methods of processing are applied on the image to perform different vision tasks which are required in today's image making. And if the image is not acquired satisfactorily then the achievable tasks are not performed well, even if some image enhancement technique is applied onto the images. Acquired images are assumed to have enough overlapping that the stitching can be done and also some other camera parameters are known.


Fig. 3 Image (A) and Image (B) represent Image acquisition in same scene with different angle

### *B. Feature detection and matching*

The second step in image stitching is feature detection which is the main part of image stitching process. In an image, features of the image are the elements of that particular image. The basic idea to do feature detection is that, the image can't be seen as whole an image but the special points in the image can be taken separately and then processed by applying feature detection methods[12]. Feature detection forms an important part of image stitching algorithm. The speed at which features in an image are detected is crucial in many applications, such as Visual simultaneous localization and mapping (SLAM), image registration, 3D reconstruction, and video stabilization which are essential to match corresponding image features between multiple views. The detected feature points need to be described separately so that the correspondence between multiple views can be computed reliably and efficiently. Real-time processing of the images requires the feature detection, description, and matching to be as fast as possible.

For better feature matching of image pairs, corners are sufficiently matched. Corners are the best features for matching. The most important feature of corner is that if there is a corner in an image then its neighbourhood will show an abrupt change in the intensity. Also, local feature descriptors describe a pixel in an image with its local content. There are many requirements of a local feature detector, such as it should be invariant to translation, rotation, scale, affine transformation, presence of noise, and blur.

In literature most widely used feature descriptors are SURF, PCA-SIFT, SIFT, HOG.

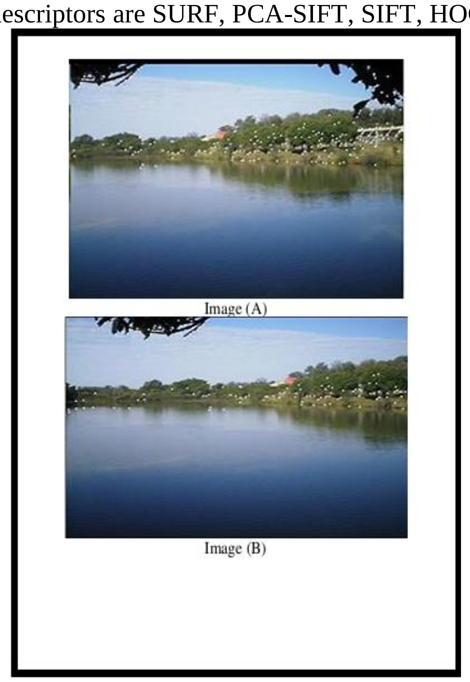


Fig. 4 Image (A) and Image (B) represent feature detection

### *C. Homography using RANSAC*

After performing feature detection, this information is used for image matching of all pictures. The main step of image matching is to find out that which pixel is a neighbour of another pixel, and find the correctly feature matching set for that image. RANSAC (Random Sample Consensus) is a non-deterministic algorithm, because it doesn't ensure to return acceptable results. It is used to estimate parameters for homography of a mathematical model from a set of observed data which contains outliners iteratively. RANSAC involves selecting four feature pairs randomly, compute homography H (exact), compute inliers, keep largest set of inliers, and finally it recompute least-squares H estimate on all of the inliers.

Fig. 5 Images after execution of RANSAC

### *D. Global alignment*

The most frequently used technique for global alignment is bundle adjustment, which is a photogrammetric technique used to combine multiple images of the same scene into an accurate 3D image. The main aim of this alignment is to find a globally consistent set of alignment parameters that minimizes the miss-registration between all sets of images. In this step, initially features of 3D location estimates is computed and also the estimates of camera location be computed. After that, bundle adjustment algorithm is applied to compute optimal values of the 3D reconstruction of the scene and camera positions, by minimizing the log-likelihood of the overall feature projection errors using a least-squares algorithm.

### *E. Blending and Composition*

The final step to stitch two images is to blend these images together. In blending, firstly a compositing surface is choosen, e.g., flat, cylindrical etc and then decide how to blend these images to form an attractive panorama[2]. For fewer image stitching, a natural approach is adopted in which one image is select as reference and then all other images are warp according to reference coordinate system. There are many different projective layouts on which image stitching can be used, such as rectilinear projection, where the stitched image is viewed on a 2D plane intersecting the panosphere in a single point.

To build a cylindrical panorama, sequences of images are taken with the help of a camera. If the focal length and field of view of the camera is known then each perspective of the image can be warped into cylindrical panorama. There are two types of cylindrical warping; forward warping and inverse warping. In forward warping, the source image is mapped onto cylindrical surface, but it can have holes in the destination image, therefore inverse mapping is used where each pixel in the destination image is mapped to the source image.

Fig. 6 Final images resulting from the blending of the two consecutive images

There are many different pixels blending methods used in image stitching, such as featuring image blending, gradient domain and Image Pyramid blending. Featuring image blending is a technique of smoothing and blurring the edges of the images, in which the pixel values present in the blended regions are weighted average from the two overlapping images. If all the images are taken at the same time and using high quality camera, this particular algorithm produces best results. Another approach for the multi band image blending is to perform it in gradient domain.

 

Another important approach of image blending is Image Pyramid blending; the image pyramid is actually a representation of the image by a set of the different frequency-band images. Image pyramid blending have many applications like image analysis, image enhancement, noise reduction etc.

## IV. CONCLUSION

In this paper, review of image stitching technique is done. Three main steps of image stitching: registration, calibration, blending the image is also discussed here. Direct technique and feature based technique for image stitching are also described. Furthermore, image stitching model is also described which consists of image acquisition, feature detection and matching, image matching, global alignment and, blending and composition.

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