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Performance Evaluation of Gradient Domain and Pyramid Blending Used in Image Stitching Process with ORB Binary Descriptor

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Abstract: Panorama development is the basically method of integrating multiple images captured of the same scene under consideration to get high resolution image. This process is useful for combining multiple images which are overlapped to obtain larger image. Usefulness of Image stitching is found in the field related to medical imaging, data from satellites, computer vision and automatic target recognition in military applications. The goal objective of this research paper is basically for developing an high improved resolution and its quality panorama having with high accuracy and minimum computation time. Initially we compared different image feature detectors and tested SIFT, SURF, ORB to find out the rate of detection of the corrected available key points along with processing time. Later on, testing is done with some common techniques of image blending or fusion for improving the mosaicing quality process. In this experimental results, it has been found out that ORB image feature detection and description algorithm is more accurate, fastest which gives a higher performance and Pyramid blending method gives the better stitching quality. Lastly panorama is developed based on combination of ORB binary descriptor method for finding out image features and pyramid blending method.

Keywords : SIFT-Scale Invariant Feature Transform; SURF-Speed-up Robust Feature detector; ORB, pyramid blending.

I. INTRODUCTION

Image mosaicking process is related to stitching of images taken from wide view angle of a scene to improve the resolution. Image Stitching process is applicable in many areas like making Panoramas, Object removal, Video Compression, Video Stabilization and Object Insertion, etc. this process in short can be described defined by considering two sample images captured as I1 and I2, having partial common part or some overlapping area, W. These two images are combined into a single Image having Common overlapping parts [1]. The initial step in Panorama development is extraction of key image features in which, image key features are extracted from given captured images. Next step is Image registration which is related to the alignment geometrically for these set of captured images. After registration process image warping process used for the purpose of making correction in the distorted images. The images are basically placed on the bigger canvas by using registration transformations matrix obtained to get the final stitched result. and the time efficiency of the methods used in stitching process. By using adequate transformations matrix via an image fusion operation and combining the overlapped region image region it is possible to obtain a required form of mosaic. image stitching can be performed using the feature based and direct based method. Minimizing pixel to pixel dissimilarity comes into the direct method category [2]. While, the feature-based method is useful for detecting image features set, descriptors and similarity matching of these features with overlapped parts. [3]. Feature-based method starts with finding out image feature similarity of key feature points related to the input overlapped images. Property of the best image feature extractor is that it must have some important characteristics like invariance to scale, noise, rotation and translation transformations. Some of the Feature-based techniques are like [4], SIFT [3], SURF [5] and ORB [6]. The selection of the required feature extractor relies mainly on the type of the application. This paper describes use of ORB and other methods of feature detectors and descriptors and then matching those features of overlapped parts by applying homography matrix of RANSAC method and then by using domain gradient and pyramid blending techniques. The rest of this research paper has been organized in total seven parts. Section-2 highlights about literature review of image mosaic process. Section-3 briefs about some of the common techniques of features detection/description. Next Section-4 explains about the some blending techniques used in image mosaicing process. Further Section-5 is related to the evaluation of proposed image mosaicing process followed by the experimental findings shown in Section-6 and lastly Section-7 highlights about the summarized finding or conclusion.

II. LITERATURE SURVEY

This approach used by author Taeyup Song: Changwon Jeon; Hanseok Ko et al., in their suggested paper named" Image Stitching by Chaos-inspired Measure of Dissimilarity" [7)] is to overcome the issue of lighting modifications stemming from distinct exposures. This technique extracts key image feature points by SIFT and matches the next closest feature points by using the k-d search tree algorithm and k after extraction by the major feature-passing algorithm. In paper named "Perspective of distortion preserving image stitches " [8], the combination of local projection transformation with a similar space transformation from non-overlapping areas to non-overlapping areas is discussed.

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The precision of alignments and less deformation in relation to multi- perspective projection and maintenance. But more changes like reflection, rotation and rotation on the local geometries were not drawn into consideration in this method. In this field this algorithm can be developed.

The descriptor techniques are assessed in detail in [9]. Based on the metrics recognized as recall and precision, descriptors were assessed. The assessment of both sensors and descriptors is described in Paper [10]. The topic of this paper was to track images from a video stream and the sample data used were a set of still images of a video. This paper further defines the repeatability and accuracy version for measuring descriptor performance.

In order to set a elevated quality, elegance and composite image with cross-relation and mixing, Rankov et al. [11] suggested an approach. One image is simultaneously correlated to a composite. The blending takes place when the image is registered. The method described is quick because a lookup table method is used.

Suen et al. [12] described how the properties of the curved system can dismiss the non-consistency impact. They have produced a procedure that reduces the changes in the images curvature value entered and the mosaic developed image. This test experiment demonstrated that the cutting edges were noticeable. Also, even if there is a serious geometric error, the caused artefacts are unseen by selecting an optimal split between the initial images. Furthermore, their techniques ensure that faithfulness and transitional fidelity are easily controlled by just determining the area to be minimized. Many investigators are concerned with the image stitching issue and attempt to improve the image blending performance.

The two major contributors to image stitching issues were, for instance, provided by Uyttendaele et al. [13]. The first is a way to deal with objects moving related to different views of a time varying dynamic scene of image. The another way is a way of eliminating noticeable color changes. They showed a block-based adaptation technique, which shifts pixel numbers with a median weighted search results from close parts of the image.

The cost function was studied by Zomet and Peleg [14] and compares theoretically and practically their performance to different scenarios. In many apps, their method can be used, for example, panoramic imagery reconstruction, image blending and compression artefact removal.

In order to build satellite panoramas based on the image registration, Antony and Surendran [15] implemented a stitching technique. They aligned one image with another geometrically. The image stitching process then requires the orientation estimate generated by the process of resistration for seamlessly blending these images. Their images are suitable for every type of image, along with captured the satellite images. This scheme endorsed images of various sizes, including JPEG, TIFF, GIFF and PNG. The images with very distinct color situations were not performing very well. In order to avoid the problem, before applying the method, the two images should be normalized. The proposed system process time depends on size of the image. They also face problems like parallax and scene movement blurring or sparkling. The efficiency of multiple images in distinct sizes and sizes may be assessed by evaluating the execution period.

Adel et al [16] finally compared some of the image feature detectors which are suitable for image stitching. The testing was conducted by some of the Corner Detector and Good Features to track the adjusted entry levels, ORB , SURF, MSER ,FAST, SIFT methods. This test results have shown that the SIFT technique is the most robust but measurements takes more matching time . The ORB and MSER algorithms are both robust but ORB is the quickest. They also implemented a feature-based ORB-based scheme for stitching images in real time. The testing of the ORB in relation with SIFT and SURF was carried out. ORB is the quickest, most powerful, and very low memory requirement algorithm.

III. IMAGE FEATURE DETECTORS AND DISCRIPTORS

Two primary kinds of descriptors are available: a vector descriptor and a binary descriptor. Vector descriptors are SIFT and SURF while binary descriptors are ORB and BRIEF. Some of the most famous feature detectors/descriptors are excerpts studied in the following lines of text.

1**) SIFT**: David Lowe suggested SIFT [3] and subsequently enhanced in 2004. The vector descriptor is currently most frequently accepted. It comprises of four main steps: extrema detection of scale-space, localization of main key point elements, location assignment, and basic key point descriptor generation. The first step is the extraction of the key points on the basis of their strength, which is invariant with the orientation and scale of the DOG-difference of Gaussian. The incorrect points will be removed in the second phase. Then one or more orientation will be allocated to each key point in the previous stage. At the last stage, for each key point, a vector descriptor is made.

2) **SURF**: Bay et al. suggested the SURF algorithm [5]. It is based on SIFT, but performs for the extraction of features in a distinct manner. SURF builds on multifaceted space theory and enhances the calculations by using "integral images" to approximate the Hessian matrix and descriptor quickly. During the description phase, haar wavelets are used.

3**) ORB method**: this is created by Rublee et al [17] termed as Oriented FAST and Rotated BRIEF. In this case fast part is of The FAST keypoint identification and robust part is from principle of binary robust independent elementary features in short termed as BRIEF [18]. So these two techniques detector/descriptors are combined. It depicts in a binary string instead of the vector the features of the input image. In discovering reasonable key points, FAST and its versions are highly effective. In many real-time systems as portable augmented-reality, parallel tracking and mapping, this method can also be used. FAST uses only one parameter, namely the intensity threshold on a circular ring between the centre pixel and its adjoining images. FAST is restricted from not including a orientation guidance operator, such as the SIFT and SURF gradient histograms. The concept of providing large responses along the corners of FAST technique also acts as a bottleneck. BRIEF is an image patch that is created from the binary-intensity test sample space that uses the bit string descriptor. A highly efficient hamming distance is used in the assessment of the ORB descriptor for the computation of a binary string.

IV. IMAGE BLENDING METHODS

Blending is an essential step in mosaic image development. In the mosaicinig method, subject to changes in lighting environments, variations in camera exposure and because of geometrical orientation, the noticeable seams could be produced between the images. The technique for blending input images must be found to eliminate these created seams. The image fusion or method of blending can conceal these noticeable joins and lessen color distinctions between blended images, so that they build a stronger panorama. This section highlights some image blending mechanisms used in the image mosaicing method.

1) **Gradient Domain Blending**: This is a multi-band image blending alternative strategy used for gradient field activities such as a human visual system. In this phase, the principle of image gradients from each captured source image are reproduced in a second pass instead of using the original color values. Reconstruction of an image better suited to the gradients [19].

2) **Laplacians pyramid blends**: The pyramid is basically a multi-scale version of the image. This method is suitable for use in various apps such as image blending, image compression, image enhancement and noise reduction. The pyramid of the image is fundamentally a hierarchical image representation which relates in various representation to a set of photos. The lowest resolution is the highest level and the lowest level is the highest resolution. [20]. The two main repeated operations for the Laplacian pyramid are reduction and expansion. At first, decreasing the process of downsizing the image into distinct dimensions by expanding Gaussian to the reduced level and subtracting it from the image level [20].

V. THE PROPOSED STITCHING SYSTEM

A Feature-based system for generating panoramic images has been proposed in this study. At first, we began by using one of our image feature detection / description techniques to detect and describe image key features from the selected image pairs. The features using RANSAC homography method will be matched later. Finally, one of the blending methods is used to recognize the results. 1) Deleting functionalities from the overlapped images using one of the distinct feature detection methods for images and using the descriptor of those features. This suggested panorama design system is based on the previous steps. 2) The next step after the picture features have been detected and described, correspondence is made for these characteristics, based on the chosen descriptors. The RANSAC (Random Sample Consensus), basically deleting outliers / unwanted function items, is then used to find excellent correct features. 4) In order to eliminate the seam between merged images, blending is employed in the end. The ultimate quality chosen image with elevated seam quality is achieved by using the image blending technique. Details on the relevant building step of the suggested system have been emphasized in the subsequent sections. The stages of the projected panoramic image process in this paper are:

a. **Extraction and description of image Features**:

The objective of this particular step is to achieve the distinctive image key features of the used images under consideration. these features It is then compared to ascertain the' compatibility' of these images processed. A number of features are shared with overlapping images, and this information is used to identify transformative relationships. In this particular process, the number of detected feature points together with processing time required.

b. Obtaining Homography matrix by using RANSAC:

This is basically RANdom SAmple Consensus technique. The first step is to compare various image features extraction/detectors like the Harris detector, SURF ,ORB SIFT to the next step in the picture grabbing system to find the RANSAC Homography. The RANSAC technique method for deleting outliers or incorrectly collected points is used to reduce the computational time by using the homography estimate. This procedure chooses by bifurcating inliers and outliers the nearest comparable matching feature lines between the images. The nearby images are found. Basically, the RANSAC method comprises of four conditional nature feature pairs. It discovers Homographic Matrix H that is associated to the two-point mapping of the same projection centre. There are opportunities of multiple matches between several options and the other handled image for each chosen key point. This is the best way to match your image descriptors based on its distance [21].

c. Image Blending:

Input images that are overlapped must be blended at the start following positioning. In order to avoid noticeable seams between overlapping entry pictures, the image blending is used to develop a panoramic system for blending pixels' colours in overlapping regions.

VI. EXPERIENTIAL RESULTS

A. Experimental Sep Up

To test the performance of the algorithms the experiments have been done using a computer system having processor of 2.6 GHz with DDR3 4.0 GB RAM working on and O.S Microsoft' Windows 10 . In this experiment we have developed panorama using Python OpenCV ver 3.0 library.

(a)Data set1: image1 (b) Data set1:image2 (c) Final stitched image

Fig. 1. The first group of 2 input images [20]

(a)Data set1: image1 (b) Data set1:image2

Fig. 2. The second group of 2 input images [20]

Initially, we have analyzed some of the image features detection and description methods to test and comparison having the highest performance and the minimum processing time. Additionally, evaluation has been done for some of the basic used image blending methods to find out the highest stitching performance parameters quality. To test the system, we have used some of the data sets of image pairs. the first data set is having two images with 320x225 resolutions of each image (fig 1) whereas second data set having each image resolution of 480x320 (Figure 2).

Table 1: Performance analysis of feature extraction detectors for the first and second image of the first and second dataset							
Extraction Detector	Detected features		Time (s)		Total features	Total time (s)	Time(s) Per features For Altogether
	Image1	Image2	Image 1	Image2			
SIFT	996	887	2.20	2.88	1833	5.08	0.002771
SURF	488	455	0.34	0.56	943	0.77	0.000816
ORB	211	188	0.08	0.06	399	0.14	0.000350

Table 1 shows the summary of number of related extracted features and detection time of for different detectors under consideration for both image datasets one and two. From theresults shown in the Table-I, we have seen that SIFT and Harris method extracts the more number of image feature key points but it is seen that it also takes the more processing time as compare to all other

Table II: The feature matching time (seconds) of SIFT, SURF, ORB Detectors/Descriptors												
Dataset	Total Matching Features			Matching features(Inliers only)			Registration Rate%			Matching time s		
	SIFT	*SURF*	*ORB*	*SIFT*	*SURF*	*ORB*	*SIFT*	*SURF*	*ORB*	*SIFT*	*SURF*	*ORB*
DataSet1	814	415	90	644	388	88	79.1	93.4	97.7	1.233	0.511	0.213
DataSet2	688	479	85	633	412	78	92.0	86.0	91.7	1.712	0.712	0.211
Data set1,2	1502	894	177	1277	800	166	85.0	89.4	**93.7**	2.945	1.223	**0.424**

detectors/descriptors. But here it is seen that ORB fulfils the highest performance criteria similar to SIFT but has the advantage is that it takes the minimum computation time comparatively. features. Here it can be seen that SIFT takes long time to detect image features which do not to have sufficient information related for feature matching phase . The key points extracted using ORB method, even though fewer, but

TABLE III. The performance analysis of the FAST detector technique and different blending methods used for the first and second dataset.				
Similarity Parameters	Laplacian pyramid	Gradient domain	Laplacian pyramid	Gradient domain
	Data set 1		Data set 2	
PSNR	42.688	41.685	41.12	40.01
FSIM	0.686	0.612	0.622	0.601
EME	8.11	8.08	7.85	7.18

As shown in Table 2 which highlights about the number of key features matching and the matching time related to ORB, SIFT and SURF detectors /descriptors for data sets of the first and second images. As per the results obtained ,it is seen that SIFT method took the highest image features similarity matching timewhile ORB method took the least similarity matching time. From the results obtained shown in this case (table II) , it is found that the no .of image features detected is not a performance measure of actual full success but the image quality and performance of these detected features in similarity matching with the other image detected key it gives more accurate result than that of by SURF and SIFT. After matching step, the final step of is blending images with each other without visible seam. This can be done many ways of blending the images, like Gaussian pyramid and Gradient Domain blending.

B. The Performance Comparison Of The Obtained Mosaicing Images: we have tested the performance of our developed method by using some of the following parameters like [1]: PSNR ,registration rate and Feature similarity index .

1) **PSNR**: It is basically defined as basically the peak signal to noise ratio which is used to calculate and to find the quality of image reconstruction i.e after panorama development.[1]. The higher PSNR value of, better is the quality of the developed panorama.

2) **FSIM**: FSIM used to measure the two images similarity.

3) **Enhancement Performance Measure (EME):** It shows the quality enhancement of the algorithm.

4**) Registration Rate**: It is ratio of total matching features (inliers only) to the total inliers and outliers .

From the tested results as shown in the two tables shown above, it is noticed that pyramid blending has the highest PSNR as well as FSIM.

VII. CONCLUSION

In this paper, comparisons have been done between different image features detectors and related descriptors. It is seen that Some detectors under consideration has possibilities of losing many of their image features while matching, even though they are having possibilities of providing a high feature detection average. Combinations of multiple image feature detectors along with related descriptors are useful for optimizing the result outcomes obtained from them.in this paper algorithm for an efficient and robust image stitching is discussed. The process of Image stitching can be implemented by basic two methods i.e. the intensity domain or the gradient domain both of which are have been highlighted in brief description.

The objective of this research paper is to implement a model for panorama development giving high accuracy as well as quality along with consideration of minimum processing time as in many applications time is an important factor. Here comparison has been done for some image features detectors and extractors. lastly it has been found that binary descriptor, ORB, shows the better performance. Additionally, analysis has been done by using Two types for fusion of images i.e Gradient domain as well as Laplacian pyramid blending. The performance evaluation for some metrics measurement like PSNR, FSIM, EME, Registration Rate parameters has been done.

It is seen that Pyramid blending shows comparatively the best performance of the blending process as compare to Alpha bending for the highest image features similarity and giving minimum normalized error for the blended images. Comparatively Alpha feathered blending shows the poor performance. Lastly, the combination of ORB binary descriptor method along with Pyramid Blending gives the better related performance parameters and output results as compare to other blending methods. In the future, it has been have proposed the testing various blending or fusion techniques under various environmental conditions like noisy input images and variation of illumination conditions.

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