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Image Stitching Algorithm: An Optimization between Correlation-Based and Feature-Based Method

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Abstract—**Image stitching detects several images of the same scene and then merges those images to generate a single panoramic image. This paper presents a framework to compare different kind of panorama-creation process, such as correlation-based method and feature-based method with a view to develop an optimum panorama. The evaluations are done by comparing the outputs with respect to the original ground truth along with computation time. We have done simulations by applying these two approaches to draw a satisfactory resolution.**

Keywords-panorama; imagestitching; image features and feature detection; correlation

I. Introduction

Image stitching is a mechanism for forming panoramic images. We know that over-lapping regions of input images may produce visible seam between images which is caused by the disparities in camera responses and illuminations of scene and errors in spatial alignment. Image stitching is a technique to locate and remove the seams of the overlapping areas of the input images and then blend together [1].

There are many methods to produce stitched image. Image stitching is less hardware-intensive but mostly software-based mechanism to generate a wide field of view image. It captures many regular pictures to cover up the whole viewing space and stitches together all the images to build a single image with a larger field of view [2]. Image alignment or registration of images, is a prerequisite for image stitching. Alignment or registration is the process of finding correspondence considering rotation, translation and scaling between two images of the same scene.

The categories of image stitching techniques can be generally classified into intensity based- or direct- and feature-based-method. Direct method is very functional for stitching images which have no overlapping region. Feature based method can be functional in small overlapping region. Image stitching using correlation is one of the most primitive stitching techniques, which is basically an intensity-based approach and suitable for images with overlapping or non-overlapping region [3], [4].To establish correspondences among a set of images, feature correspondence between two or more images are considered necessary, so, it is essential to identify a set of prominent points in each image [5].

In image registration, it is compulsory to align two or more images of a scene. The major steps, concerned in image registration or alignment tasks are: (i) feature detection; (ii) feature matching based on transformation functions using corresponding features in images; (iii) reconstruction of images using derived transformation function. For matching and recognition, the first step is to detect location of interests in the images. Then descriptors are computed and these need to be compared to find the association between images for matching operation. So, we should use feature detector and a feature descriptor for extracting features from images [6], [7].

The main objective of this paper is to give a guideline for optimum stitching to fulfill the satisfaction on diverse applications. We have structured the rest of the paper as follows: Section II describes literature review. In Section III, we have presented a brief depiction of the stitching algorithms. In Section IV, we have performed the performance evaluation on the obtained results. We discussed about applications of image stitching algorithms in Section V. Finally, we have turned the conclusion of the paper along with some future research directions in Section VI.

II. Literature Review

Many researchers have already been worked on image stitching. A thorough review on image stitching is presented below:

Yang et al [8] proposed an image mosaic method based on phase-correlation and Harris operator. Wang et al [9] presented an automatic panoramic image mosaic method based on graph model.

Adel et al [10] proposed an image stitching system based on ORB (Oriented FAST (Features from Accelerated Segment Test) and Rotated BRIEF (Binary Robust Independent Elementary Features)) technique and compensation blending. Szeliski [11] proposed a method of image alignment and stitching. Fatah et al [12] had a proposal of automatic seamless of image stitching method. Qiuet al [13] presented an algorithm based on SIFT

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(Scale Invariant Feature Transform) based feature matching and transformation parameters. Ostiak et al [14] presented a fully automated HDR (High Dynamic Range) panorama stitching algorithm where he used the SIFT based algorithm for the recognition of the corresponding feature points.

All methods have merits and demerits. With this view, in the current paper we have performed a comparative study on feature based- and correlation based-method to develop an optimum image stitching approach on the basis of application perspective.

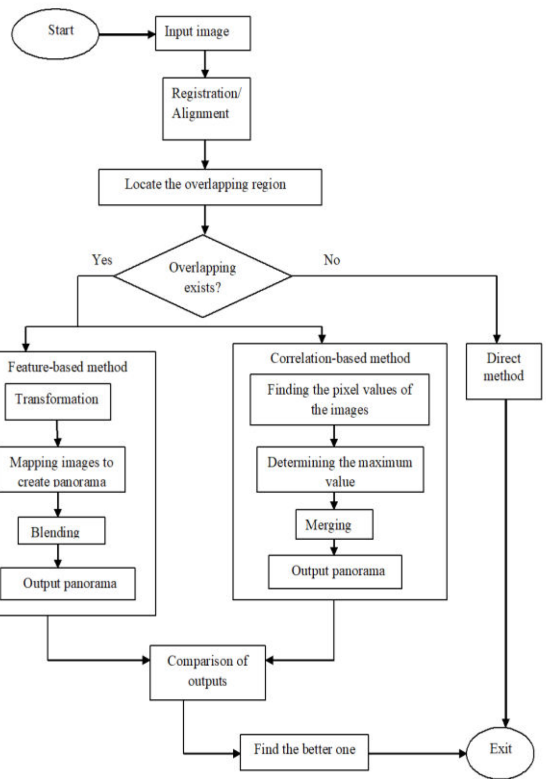


Figure 1. Flow diagram of our methodology.

III. METHODOLOGY

The methodology consists of the following steps:

A. Image Acquisition

The first step is acquisition of images which means capturing images by camera devices or acquiring from secondary sources.

B. Alignment

The reason of alignment is to locate are liable alignment parameter which can decrease the miss-registration between every pair of images. It is very useful to widen the pair wise matching criterion [15], [16].

So, here, we need to detect and match features between images $I(n)$ and $I(n\text{-}1)$.Then, we have to estimate geometric transformation T that maps images $I(1)$to $I(n)$ as follows[17], [18],

$$T = T(1) \times T(2) \times T(3) \times \dots T(n-1) \times T(n) \qquad (1)$$

In Eq. (1), $T(1), T(2), T(3), \dots, T(n-1), T(n)$are the geometric transformations of images $I(1), I(2), I(3), \dots, I(n-1), I(n)$, respectively.

C. Locating Overlapping Region

Locating the overlapping region is the next step. This is essential for the consequent features between several images [20], [21].If the overlapping region exists, then we can have two types of output: feature-based panorama and correlation-based panorama. But, if overlap does not exist, our method stitches the images directly one after another one.

D. Feature-Based Stitching

Generally, for creating panorama, one image is selected as the reference and then all the images are sequentially used for stitching. The result is often known as a flat panorama [22], [23].

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 pano-sphere at a point [24]. Rectilinear projection uses cube faces with cubic mapping for viewing panorama and it demonstrates a cylindrical projection [25], [26].

After plotting the source pixels against the ultimate composite surface, it is necessary to blend them for creating a panorama. Therefore, blending operation is a prerequisite for image stitching. Feathering, image pyramid and gradient domain are some familiar blending procedures [27].Blending operator forms a blend of two input images of the same size [28],[29]. Feathering is used for blurring the edges of features. From the two overlapping images, the average pixel values are evaluated for the blended regions. Multi-band image blending is another well-known method that executes in the gradient domain [30],[31],[32].

These magnitudes are used such that the output pixel values do not surpass the highest pixel value.

The resulting image $Q\,(i,j)$is calculated using the formula,

$$Q\,(i,j) = X \times P_1(\,i,j) + (1-X) \times P_2(i,j) \qquad (2)$$

In Eq. (2), P_1 and P_2 are the two input images. In some applications, X may also be a constant, thus allowing a constant offset value to be added to a single image. X is the blending ratio which determines the control of each input image points into output. X can either be a constant factor for all pixels in the image or can be determined for each pixel separately using a mask. The size of the mask must be identical with the size of the images [33].

E. Correlation-Based Stitching

We do not need to extract features in correlation-based stitching approach. This process depends on the relation between two images. It is variant to rotation, scaling and other transformation. For accurate preprocessed images, correlation approach is efficient to apply.

Determining the correlation values is the first step in this method. Matching interest points in two un-calibrated images is fundamental problem in computer vision. Correlations generally used in many applications that require matching parts of the images [34], [35], [36]. We have calculated correlation coefficient r between two images A and B using the following equation,

$$r = \frac{\sum_m \sum_n (A - A')(B - B')}{\sqrt{(\sum_m \sum_n (A - A')^2)(\sum_m \sum_n (B - B')^2)}} \qquad (3)$$

In Eq. (3), $\mathrm{A}' = \mathrm{mean}\ (\mathrm{A_{mn}})$ and $\mathrm{B}' = \mathrm{mean}(\mathrm{B_{mn}})$. After determining the maximum correlation value of the two images we have to find the maximum degree of column vector [37], [38].

Merging is the next step. When the source pixels are mapped onto the final surface, then these are blended in order to generate a panorama and the seam line adjusted to reduce the visibility of seams between two images[39], [40],[41].

F. Comparison

In this step, Feature-based panorama and Correlation-based panorama are compared with the Ground truth. The approach will move forward with the better result depending on the optimization of accuracy.

IV. RESULTS AND DISCUSSIONS

We applied our method on ten-image set and each image set consists of two images as inputs. We have prepared two input images (480×475 pixels each, for image set 1 to 8) from some original images using Microsoft Office Picture Manager. Besides these, we also used input images of other sizes (500×475 pixels for image set 9 and 700×475 pixels for image set 10).All these images have some overlapping regions as well as repetitions. Then, we have inputted these images to create the panorama using stitching techniques: feature-based panorama and correlation-based panorama [39]. All the outputs are generated using MATLAB R2017a with Microsoft Windows 10 platform, Intel Core i3, 2.00 GHz processor and 4.00GB RAM. During experimentation, we found that feature-based method consumes more time but correlation-based method takes less time. So, if these two methods are compared in term of speed, the correlation method is faster. Accuracies for the both methods are almost similar, as the images are mostly aligned from the initial stage. Figure 2 shows an image (which is used as a ground truth for the stitched image). This image is cut into two images with some overlapping and shown in Figure 3. Figure 4(a) shows the registration process on the basis of feature points. Figure 4(b) shows the overlapping region. Figure 4(c) presents the stitched image using correlation-based method and Figure 4(d) shows the stitched image for feature-based method. Similar to Figures 2-4, we have done the same operations in Figures 7-9 for an HDR image and in Figures 10-12 for a microscopy image. Figure 5 shows two images without any overlap region and Figure 6 presents its corresponding stitched image by direct method (simple stitching).

TABLE I. PERFORMANCE EVALUATION OF IMAGE STITCHING TECHNIQUES BASED ON ACCURACY RATE AND TIME

Input Image and its size	**Correlation-based Method**		**Feature-based Method**	
	Accuracy (%)	***Time (Sec)***	***Accuracy (%)***	***Time (Sec)***
Image Set 1 (480×475)	98.61%	0.3937s	96.44%	0.7166s
Image Set 2 (480×475)	98.86%	0.4672s	96.36%	0.9883s
Image Set 3 (480×475)	99.62%	0.4596s	98.16%	0.9081s
Image Set 4 (480×475)	99.71%	0.4011s	98.82%	0.8092s
Image Set 5 (480×475)	99.79%	0.4222s	99.05%	0.9951s
Image Set 6 (480×475)	99.09%	0.5716s	97.43%	1.6230s
Image Set 7 (480×475)	99.29%	0.8725s	98.53%	1.0128s
Image Set 8 (480×475)	99.29%	0.7938s	97.13%	1.7026s
Image Set 9 (500×475)	98.60%	0.7674s	96.65%	1.1427s
Image Set 10 (700×475)	99.59%	0.7571s	98.52%	0.9608s

We have used the following equation to calculate the accuracy:

$$\mathrm{Accuracy} = 1 - \mathrm{sum}(\mathrm{sum}(|(I_1 - I_2)|))/\mathrm{sum}(\mathrm{sum}(I_1) \qquad (4)$$

In Eq. (4), I_1 is the original image, I_2 is the resultant image of the experiment. Table I shows the performance (accuracy and computation time) of the stitching method.

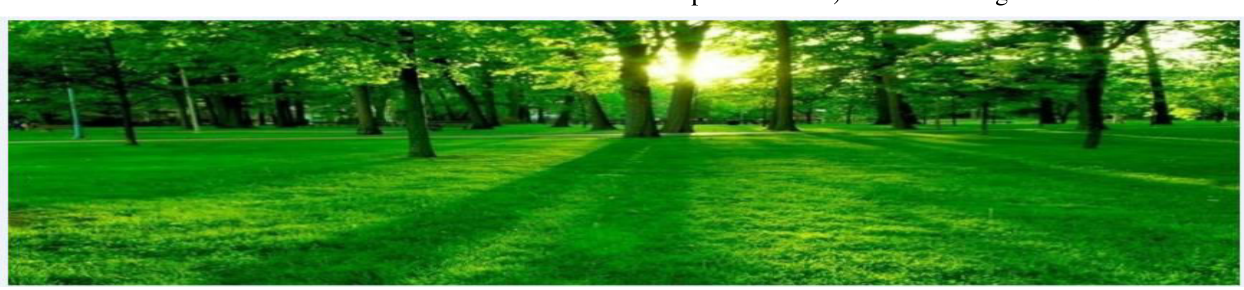
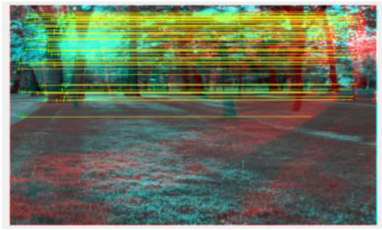
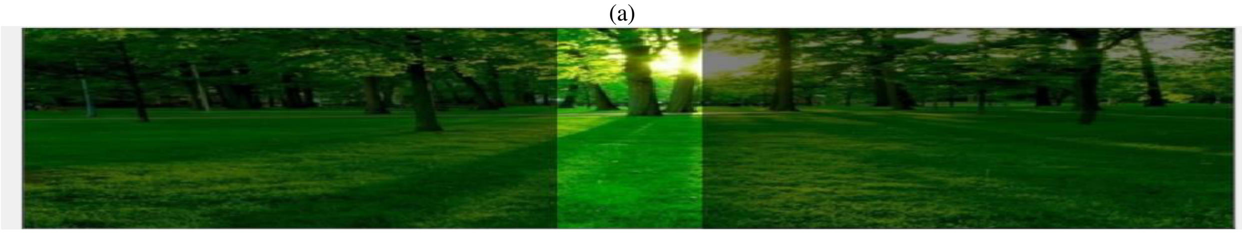


Figure 2. Original image (treated as ground truth panorama)

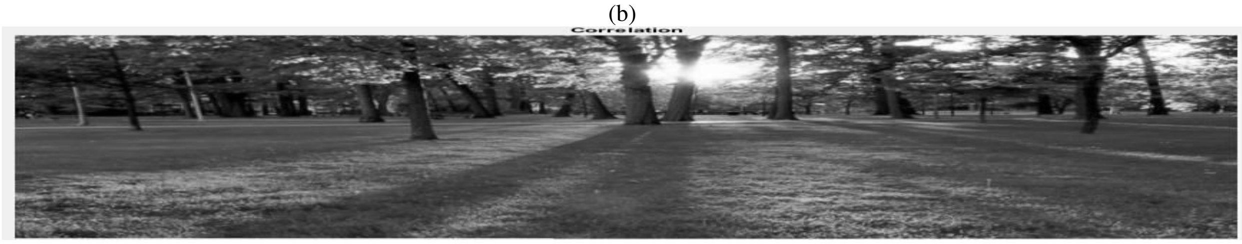
Figure 3. Two input images which are generated from the original image of Fig. 2 with some overlapping.



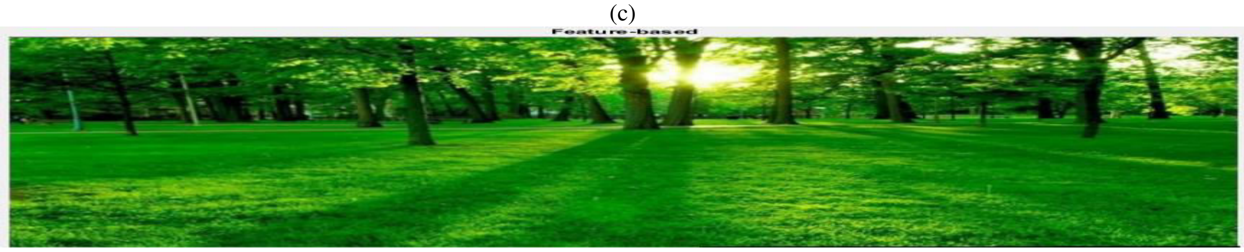
(a)



(b)



(c)



(d)

Figure 4. Outputs: (a) Aligned/ registred image on the basis of feature points,(b)Overlapping region, (c) Correlation- based approach, (d) Feature-based approach.

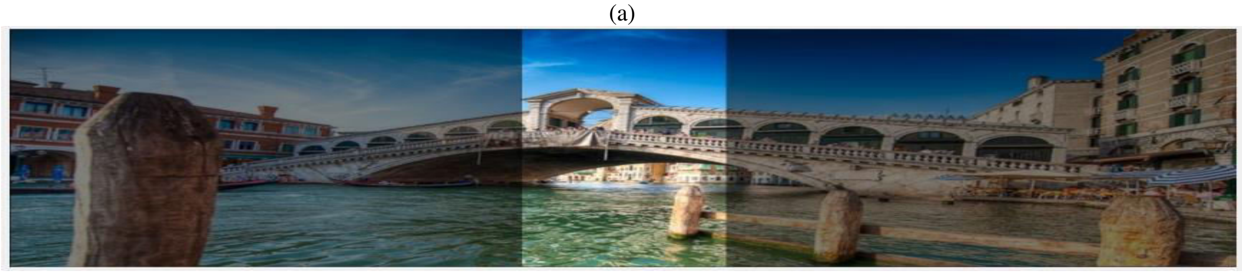
Figure 5. Input images

Figure 6. Output images:Direct Method

Figure 7. Original HDR image (treated as ground truth panorama).

Figure 8. Input images which are generated from the original image of Fig. 7 with some overlapping.

(a)



(b)

(c)

(d)

Figure 9. Outputs: (a) Aligned/ registred image on the basis of feature points,(b)Overlapping region, (c) Correlation- based approach, (d) Feature-based approach.

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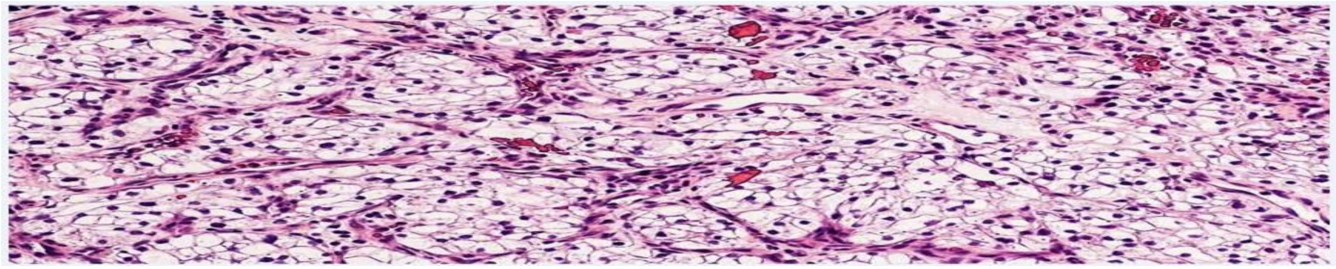


Figure 10. Original microscopyimage of renal cell carcinoma (treated as ground truth panorama).

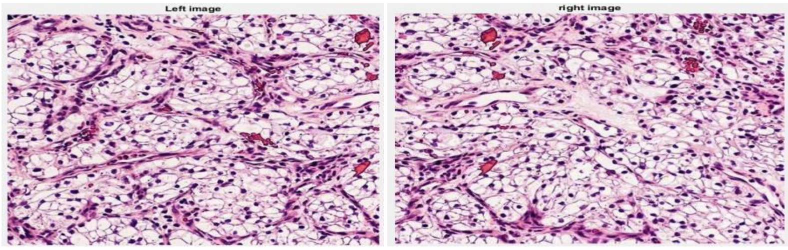
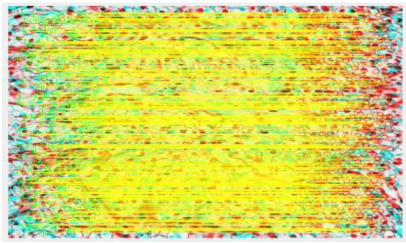
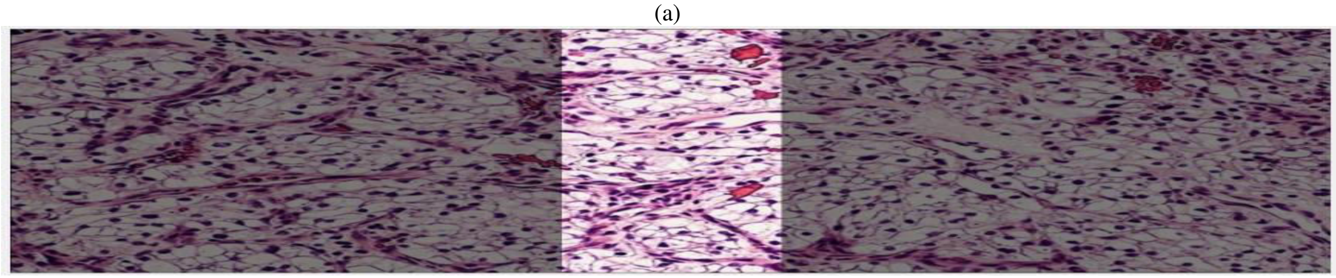


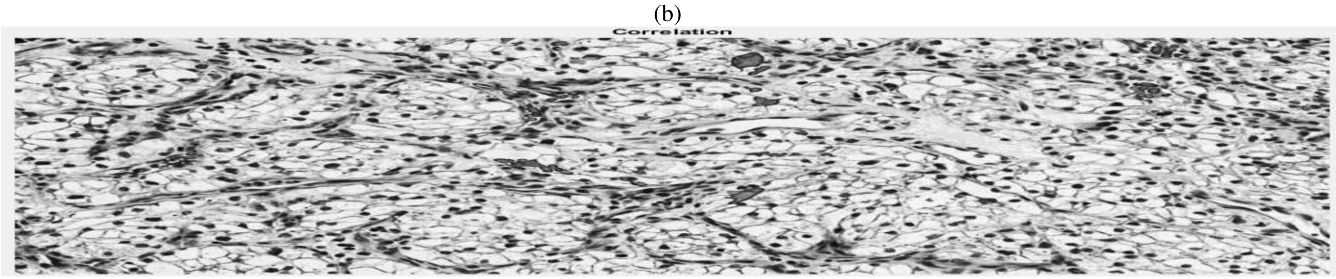
Figure 11. Input images which are generated from the original image of Fig. 10 with some overlapping.



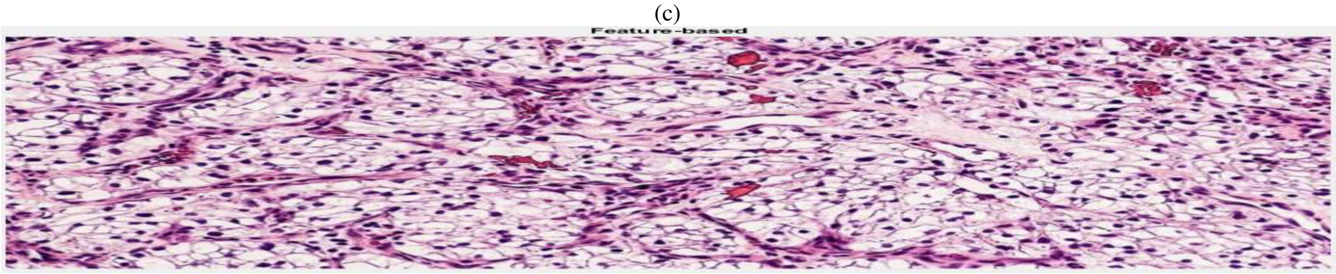
(a)



(b)



(c)



(d)

Figure 12. Outputs: (a) Aligned/ registred image on the basis of feature points,(b)Overlapping region, (c) Correlation- based approach, (d) Feature-based approach

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V. APPLICATIONS

Image stitching is mostly used in diverse applications, such as, image stabilization, HDR (High Dynamic Range) image mosaicing, high resolution photo mosaics in digital maps and satellite photos, medical imaging, multiple image super-resolution, video stitching, object insertion, microscopy image stitching and group photographs. In this paper, we have experimented with natural-, HDR- and microscopy-image and got satisfactory results.

VI. CONCLUSION AND FUTURE WORKS

Image stitching is the process of forming a high resolution stitched (panorama) image by combining two or more images together. These input images have some overlapping region with wide field of view to structure a segmented panorama. There are different algorithms for feature detection. Feature-based method uses feature descriptors and correlation-based method uses correlation values to create panorama.

In this paper, we have shown a framework to produce an optimized panorama image on the basis of application needs. We have thoroughly investigated feature-based and correlation-based with accuracy and computation time. Usually, feature-based method needs higher computation time. But correlation method is suitable if the two images are aligned that means registered. Features are very useful for good registration. So, for high quality output in somehow non-aligned environment feature-based method is the optimum choice.

High-quality panorama also depends on light exposure and distortion of lens. So, image calibration can be a supplementary part between acquisition of images and image registration. For good visual feeling we have used alpha blending method that can be replaced by a more robust technique. Another intricacy is photo distortion that arises from the perspective transformation and can be improved by lens distortion correction method.

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