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Automatic Image Stitching Using Feature Based Approach

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ABSTRACT : *Image stitching is the process of generating a high resolution panoramic image from multiple overlapping images of same field. It plays an important role in the field of computer vision and image processing. Image stitching has variant applications and magnificent research works. This paper represents a method of image stitching using feature based approach. The main objective of this work is to improve the accuracy of image stitching, especially in different illumination scenarios. This approach has employed adaptive histogram equalization for contrast enhancement and alpha blending method for improving the image stitching quality. Various features detectors like SURF, FAST, Harris and MSER are applied to find the features. Modified RANSAC algorithm is used to estimate the geometric transformation of input images. Experiments show very promising results.*

KEYWORDS - *Contrast enhancement, Feature transform, Histogram equalization, Image blending, Image stitching, RANSAC, SIFT, SURF.*

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I. INTRODUCTION

Image stitching is a process of combining some overlapping image of same scenario. There are many researchers worked with image stitching. Everyone tried to improve the quality of image stitching. Extracting features and matching images are the main challenges in this regard [1].

There are many robust and popular feature detectors used in feature based method such as Speedup Robust Features detector (SURF) [2], Harris detector [3], Scale Invariant Feature Transform (SIFT) [4], Bage of Features (BOF) [5], Features from Accelerated Segment Test (FAST) [6], Principal Component Analysis SIFT (PCA-SIFT) [7] and Oriented FAST and Rotated BRIEF (ORB) [8].

This experiment shows better results of image stitching for various types of images like different illumination level images, various scaled images, rotated images and so on. In this work, adaptive histogram equalization is applied for adjusting contrast of input images. For extracting feature points, various available feature descriptors such as SURF, FAST, Harris, and MSER are used.

There are many applications of image stitching. In medical science, it is used in the field of diagnosis of cardiac, retinal, pelvic, renal, abdomen, liver, tissue disorders, etc [9]. It has many other applications such as in virtual reality, remote sensing, video stitching, digital maps, satellite photos for high resolution and so on [10][11].

II. RELATED WORKS

Image stitching plays very important role in various fields of computer vision. There are many real life problems in computer vision related with it. Many researchers have been working for the solution of these problems. In image stitching, the main challenge is to improve accuracy and efficiency.

Adel et al. [1] presented a image stitching system based on ORB algorithm to introduce a high-quality image with least computation time. They manipulated the implementation of different feature detectors and image blending methods to improve the quality of the stitching system.

L. Tu et al. [12] preprocessed input images to enhance the useful information by histogram equalization. They used respectively to the SIFT and AFSIFT algorithm to find the extraction and matching features points. Their experimental result for blur and illumination change images showed that the original image pre-processed by histogram equalization increased the number of matching features points rapidly. This can be helpful for the subsequent image mosaic, image recognition and so on.

Tianyun Wang et al. [13] proposed an efficient preprocessing method for feature based image stitching. They used multi-scale image enhancement as a preprocessing step of feature matching. SIFT descriptor and RANSAC algorithm were used for feature matching. Their experimental results demonstrated that the proposed method is better than existing methods on feature based image stitching.

M. Daud et al. [14] proposed a method of pre-processing to promote the quality of feature matching of images which are extremely illuminated. They evaluated the accuracy of SURF feature descriptor in feature matching between images of extremely illumination levels. They remapped a cumulative histogram to images by computing fusing histogram from input images. Their experimental results showed that the accuracy of the feature matching is improved in extreme illumination scenario.

C. Murtin et al. [15] developed a unique approach known as 2D-SIFT-in-3D-Space. They used Scale Invariant Feature Transform (SIFT) to attain robust three-dimensional matching of image sub-stacks. They stitched thick high-resolution laser-scanning microscopy image stacks.

Ma, Xiaomin, et al. [16] proposed a fast and high-quality image stitching method. They used FAST detector to detect the features of all the simulated images and described by Fast Retina Key-point (FREAK). They used hamming distance as a feature similarity metric and RANSAC to achieve the optimal affine transformations. A weighted average blending algorithm was used for image blending.etc.

III. PROPOSED METHOD

In this proposed method, feature based techniques are applied. There are mainly three steps involved: A) Image pre-processing, B) Image registration and C) Image stitching with blending process. The pre-processing step is the initial process for image stitching. The goals of this step are to re-size and enhance the contrast of images. The registration step is the core part of the method which aims to find the feature points and transformations to align overlapping images. The target of blending process is to produce seamless panoramic stitched image from input images. Major steps of the proposed method are shown below in **Fig. 1**.

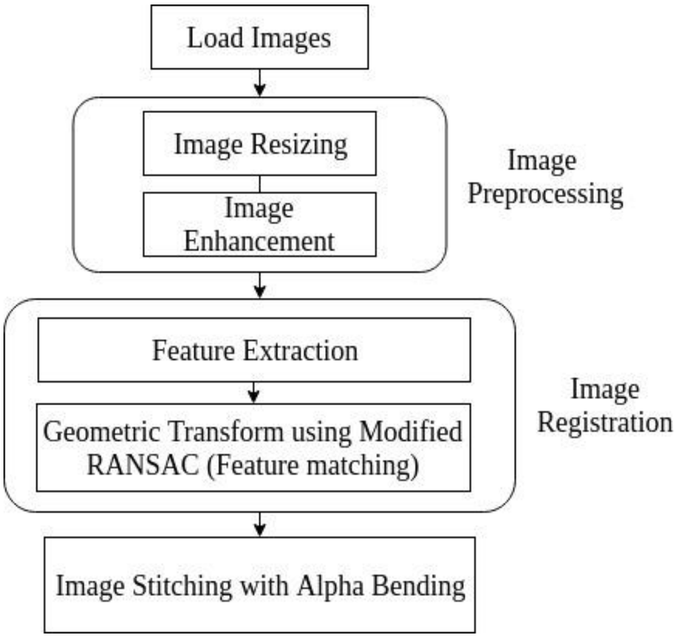


Fig. 1: Major steps of the proposed method of Image stitching

A. Image Pre-processing

Image Preprocessing is the initial step of image stitching but it is very useful to improve the efficiency and accuracy of image stitching. If images are of different size, then images can be re-sized if needed. This step is necessary for various contrast levels images to equalize their contrast. Image enhancement is also done in this step. It is the process of adjusting images to produce suitable format for display or further image analysis. Here, we made image enhancement by adjusting contrast among images for better feature extraction. Adaptive histogram equalization is applied for contrast enhancement. Flowchart of image preprocessing and experimental results are shown in **Fig. 2** and **Fig. 3** respectively.

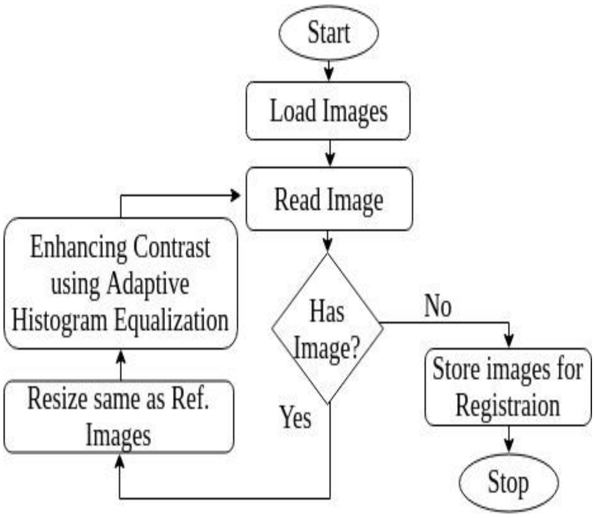


Fig. 2: Flowchart of image preprocessing

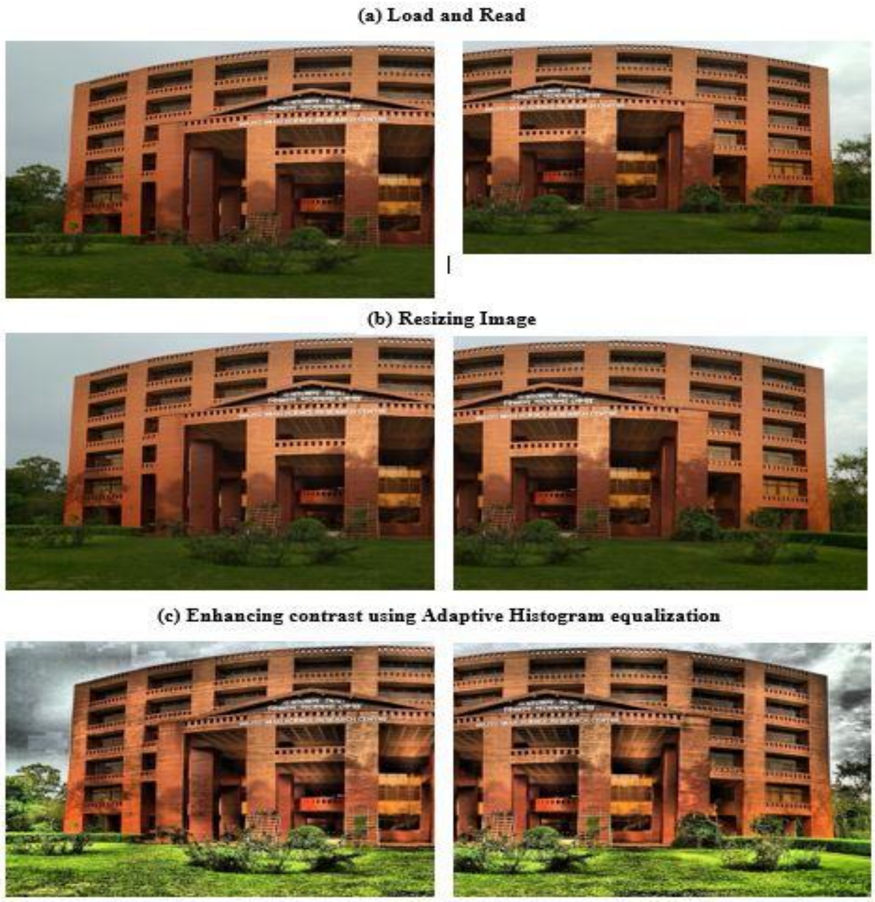


Fig. 3: Simulation of image preprocessing

B. Image Registration

Image registration is a core part of image stitching. The target of image registration is to find geometric transform between images. The processing of aligning two or more images which are captured from different perspectives of same scenario is defined as image registration. The steps of Image registration process is given in the flowchart in **Fig. 4.** Here, M-estimator SAmple Consensus (MSAC) algorithm is used for estimating geometric transform from matching point pairs. Experimental results of image registration are shown in **Fig. 5.**

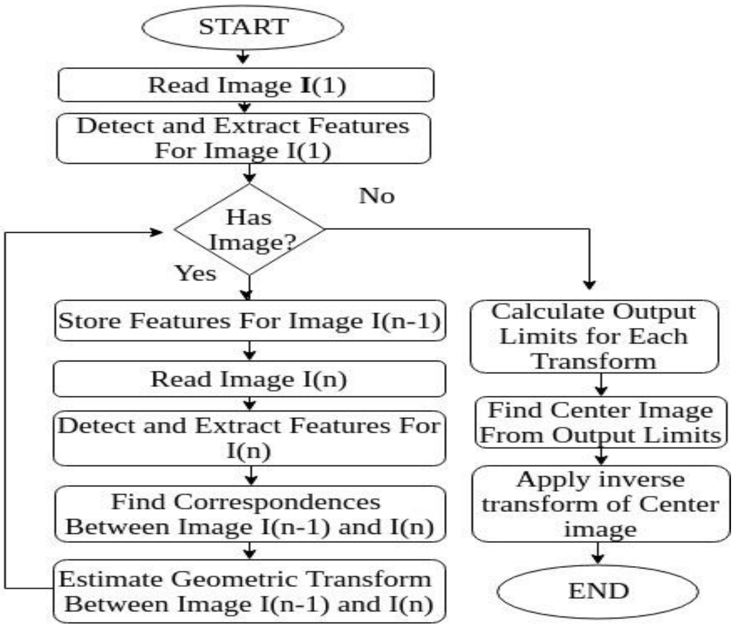


Fig. 4: Flowchart of image registration

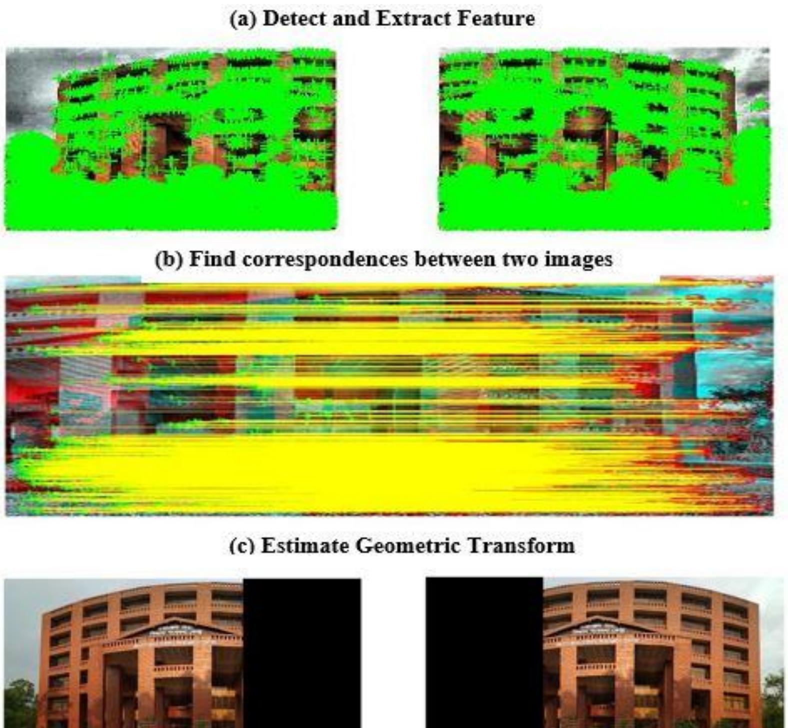


Fig. 5: Simulation of image registration

C. Image Stitching with Blending

Image blending is the final step. It is necessary to produce seamless stitched image. There are some methods of image blending. We used Alpha blending method for image stitching. The steps of creating panorama using image stitching with Alpha blending are shown in the flowchart of the **Fig. 6.** Experimental results of image stitching with Alpha blending are shown in **Fig. 7.**

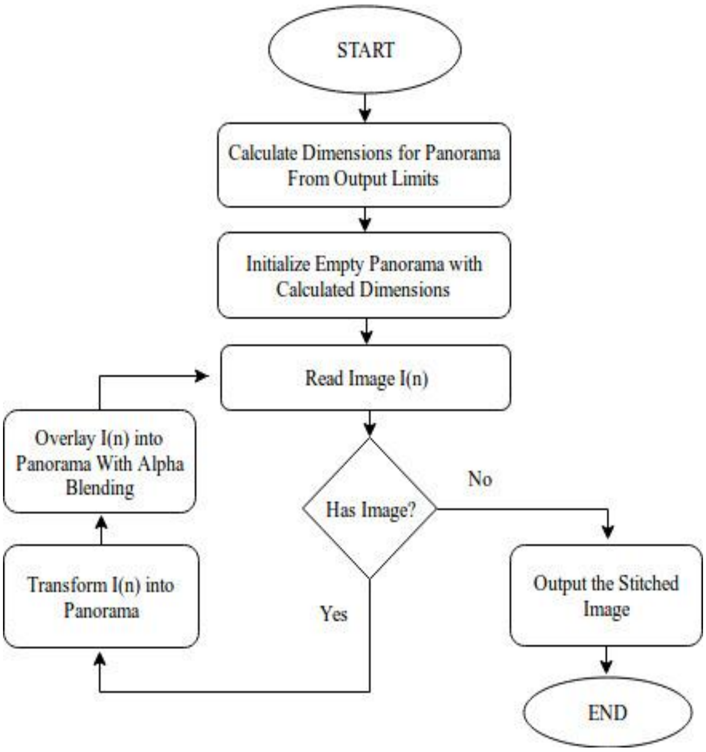


Fig. 6: Flowchart of creating panorama with Alpha blending

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The proposed method has been implemented for various types of input images. Here two images are used for analysis the effects of image enhancement for feature detection. Image set is shown in the **Fig. 8.** Adaptive histogram equalization technique has been applied for image enhancement shown in **Fig. 9.**

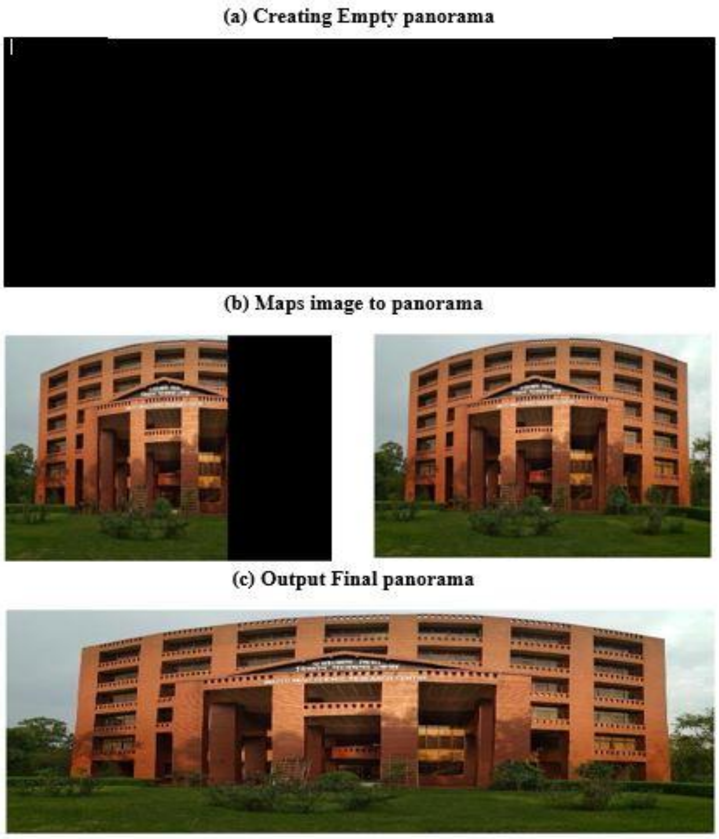


Fig. 7: Simulation of creating Panorama with Alpha blending

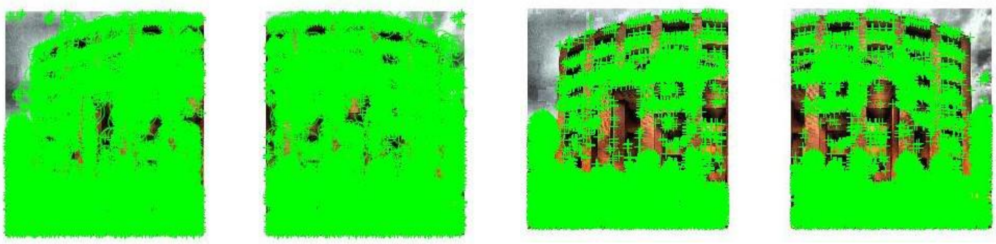
Fig. 8: Original input images

Fig. 9: Input Images after image enhancement

A. Responses of the Feature Extraction Detectors

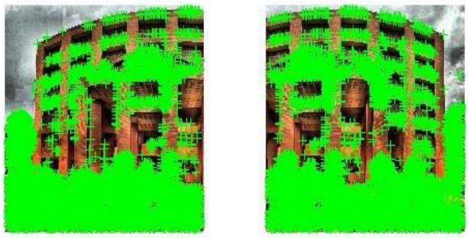
Fig. 10 and **Fig. 11** show the extracted feature points using SURF, FAST, Harris, and MSER feature descriptors before and after image enhancement respectively.

Fig. 10: Feature points before image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

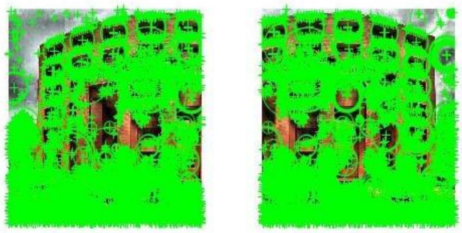


(a) Using SURF feature detector

(b) Using FAST feature detector



(c) Using Harris feature detector

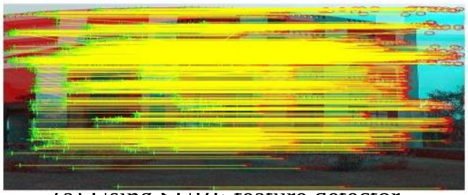


(d) Using MSER feature detector

Fig. 11: Feature points after image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

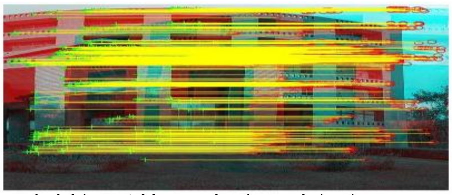
B. Responses of Matching Features using Modified RANSAC

Fig. 12 and **Fig. 13** show the matching feature points using SURF, FAST, Harris, and MSER feature detectors before and after applying adaptive histogram equalization respectively. **Table-1** shows that more feature objects are detected after image enhancement and in the case of feature matching, the number of matching points among the outputs increased rapidly after contrast enhancement of image.

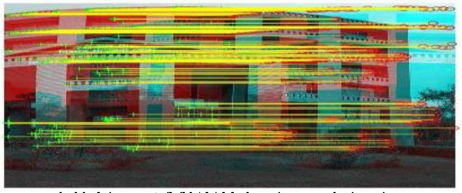


(a) Using SURF feature detector

(b) Using FAST feature detector

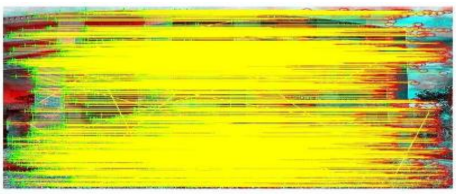


(c) Using Harris feature detector

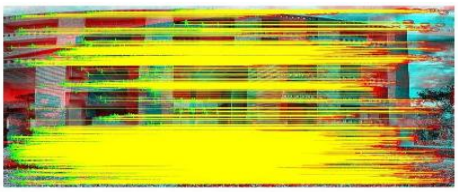


(d) Using MSER feature detector

Fig. 12: Before image enhancement, the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

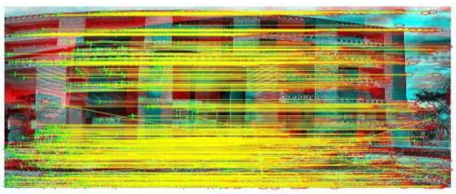


(a) Using SURF feature detector



(b) Using FAST feature detector

(c) Using Harris feature detector



(d) Using MSER feature detector

Fig. 13: After image enhancement, the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

Table 1: Comparison results of the responses before and after image enhancement

Methods	Feature Points		Matching Points	
	Before	**After**	**Before**	**After**
SURF	**1229**	**11946**	**239**	**1622**
FAST	**1170**	**19215**	**104**	**988**
Harris	**1028**	**8986**	**123**	**338**
MSER	**1366**	**8934**	**56**	**245**

C. Input Image Set for Stitching

The experiment employed the image set of **Fig. 15** as input images. This set of images is stitched to recover the original image of **Fig. 14.** The final stitched images are shown in **Fig. 16** using SURF, FAST, Harris, and MSER feature detector.

Fig. 14: Original image to be recovered

(a)

(b)

(c)

(d)

Fig. 15: Set of images (input images) used for stitching to recover the original image of **Fig. 14.**

(a) Using SURF

(b) Using FAST

(c) Using Harris

(d) Using MSER

Fig. 16: Stitched images for image set of **Fig. 15** using (a) SURF, (b) FAST (c) Harris and (d) MSER feature detector.

V. PERFORMANCE EVALUATION

Fig. 17 shows that after image enhancement more feature points and matching points could be extracted.

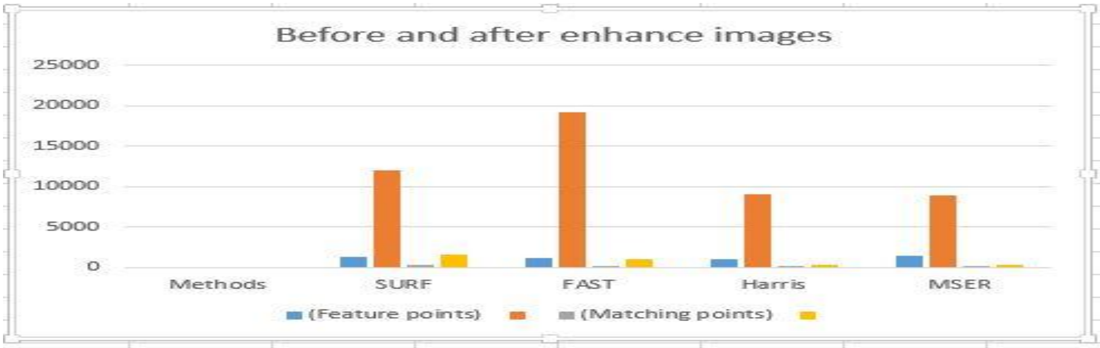


Fig. 17: Comparison of results of the responses before and after image enhancement

Table 2: Comparison of accuracy of image stitching before and after image enhancement.

State	SURF	FAST	Harris	MSER
Before Enhancement	**89.83%**	**Failed**	**Failed**	**Failed**
After Enhancement	**94.65%**	**92.10%**	**92.08%**	**92.10%**

Table 3: Accuracy rate of various feature based methods comparing output stitched images with the original image.

Input Images	SURF	FAST	Harris	MSER
Input Set	**92.27%**	**92.10%**	**92.08%**	**92.17%**

VI. CONCLUSION

The experiment has been implemented in the Computer Vision Laboratory at Department of Computer Science and Engineering in Jahangirnagar University, Bangladesh. It takes some images as input and then produces a stitched image. Comparing the performance and accuracy rate of various feature based methods, it is confirmed that the SURF based method is better for image stitching. In this experiment shiny images are used. For noisy and blurred images it is very challenging. Developing a method for stitching videos for dynamic panoramas is our future challenge.

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