Automatic Image Stitching Using Feature Based Method

A Project report submitted to the
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ABSTRACT

Image stitching is an interesting topic in computer vision. To improve the accuracy of image stitching, image enhancement is a crucial part. In this project, we represent a method of image stitching using feature based methods. The main objective of this project is to improve the accuracy of image stitching, especially in different illumination scenarios. We use adaptive histogram equalization for contrast enhancement. Various features detectors like SURF, FAST, Harris and MSER are used to find the features. Modified RANSAC algorithm are used to estimated the geometric transformation of input images. To improve the image stitching quality, we use alpha blending method. From the experimental result, we analysis the accuracy among various features detectors.

DECLARATION

The project work entitled "**Automatic Image Stitching Using Feature Based Method**" has been carried out in the Department of Computer Science and Engineering, Jahangirnagar University is original and conforms the regulations of this University.

We understand the University's policy on plagiarism and declare that no part of this project has been copied from other sources or been previously submitted elsewhere for the award of any degree or diploma.

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Contents

Abstract i

Declaration ii

Acknowledgments iii

Table of Contents v

List of Figures vi

List of Tables vii

List of Algorithms viii

1 INTRODUCTION 1

1.1 Background 1

1.2 Motivation 1

1.3 Research Questions 2

1.4 Objectives 2

1.5 Related Work 2

1.6 Outline Of The Report 3

2 BASICS OF IMAGE STITCHING 4

2.1 Image Stitching 4

2.2 Steps of Image Stitching 4

2.2.1 Image Preprocessing 4

2.2.2 Image Registration 5

2.2.3 Image Blending 5

2.3 Applications of Image Stitching 5

3 METHODOLOGIES 6

3.1 Implementation 6

3.2 Block Diagram of Image Stitching 6

3.3 Algorithms 7

3.3.1 Image Preprocessing Procedure 7

3.3.2 Image Registration Procedure 9

3.3.3 Image Stitching and Blending Procedure 11

4 EXPERIMENTAL RESULTS AND ANALYSIS 13

4.1 Result of Image Pre-processing 13

4.2 Responses of the Extraction Detectors 13

4.3 Respones of Matching Features Using Modified RANSAC 14

4.4 Image Stitching With Alpha Blending 14
4.4.1 Original Images 14
4.4.2 Input Image Sets for Stitching 19
4.4.3 Stitched Images 19
4.5 Performance Evaluation 20

5 CONCLUSION AND FUTURE CHALLENGES 23
5.1 Conclusion 23
5.2 Future Work and Challenges 23

References 26

List of Figures

2.1 Steps of Image Stitching 4

3.1 Block Diagram of Image Stitching 7
3.2 Flow Chart of Image Preprocessing Steps 8
3.3 Simulation of Image Preprocessing Steps 8
3.4 Flow Chart of Image Registration Steps 10
3.5 Flow Chart of Image Registration Steps 10
3.6 Flow Chart of Creating Panorama with Blending 11
3.7 Simulation of Creating Panorama 12

4.1 Original Input Images 13
4.2 Input Images After enhancement 14
4.3 Feature points before image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector. 15
4.4 Feature points before image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector. 16
4.5 Before Image enhancement the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector. 17
4.6 After Image enhancement the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector. 18
4.7 Original Images 19
4.8 Input Set 1 From Image4.7a 19
4.9 Input Set 2 From Image 4.7b 20
4.10 Stitched Images for image Set 4.8using (a) SURF, (b) FAST, (c) Harris & (d) MSER feature detector. 21
4.11 Stitched Images for image Set 4.9 using (a) SURF, (b) FAST, (c) Harris & (d) MSER feature detector. 22

List of Tables

4.1 Counts of feature object points before and after enhancement for input images set 4.1 14
4.2 Counts of matching feature points before and after enhancement for input images set 4.1 14
4.3 Accuracy Rate of Different Feature Based Methods 20
4.4 Performance Evaluation from the Survey 20

List of Algorithms

3.1 Image Enhancement Procedure 7
3.2 Image Registration Procedure 9
3.3 Procedure of Creating Panorama with Alpha Blending 11

Chapter 1

INTRODUCTION

1.1 Background

Image stitching is the process of generating a high resolution panoramic image from multiple overlapping images of same field [1]. Image matching and image stitching play an important role in the various field of computer vision and image processing [2]. Image stitching has variant applications and magnificent research works [3, 4].

At the most cases of image stitching require overlaps between images. The challenge of image stitching is to produce seamless stitched image. If images have different intensities, scale and orientation, then it may produce some erroneous result [4].

Image stitching can be divided into two types: (i) Direct methods & (ii) Feature Based methods. The target of direct methods to reduce pixel to pixel mismatching. Very accurate image registration can gain by direct methods [3]. But it seems difficult in image scaling and rotation [4]. Extracting features and matching images are the main section of feature based methods. There are many robust and popular feature detectors are used in feature based method such as Speed-Up Robust Features detector (SURF) [5], Harris detector [6], Scale Invariant Feature Transform (SIFT) [3], Bage of Features (BOF) [7], Features from Accelerated Segment Test (FAST) [8], Principal Component Analysis SIFT (PCA-SIFT) [9] and Oriented FAST and Rotated BRIEF (ORB) [10].

In this project, we used feature based techniques. For this approach, there are three main process: image pre-processing, image registration and image stitching with blending process. The pre-processing step is the initial process for image stitching. The goal of this step are to re-size and enhance the contrast of images. The registration step is the core part of our method which aims to find the features point and transformations to align overlapping images. The target of blending process to produce seamless panoramic stitched image from input images.

1.2 Motivation

One day we were looking our programming contest room pictures. But we think that it will be fantastic, if we can see the room in one picture. Then we have searched about panoramic pictures techniques. There are various method of image stitching to make panoramic images. We want to develop a more accurate and understandable method for us. As we think, we are trying to design a method for image stitching with high accuracy.

1.3 Research Questions

The main research question aimed at this project objective is:

- **How can the performance and accuracy of image stitching be improved?**

From the main research question, several sub-questions are derived to conduct a more accurate study of the research topic. Some of these are :

1. What can be done if images are not in same alignment?
2. What can be done if images are duplicated?
3. Which techniques can be used to extract the features of images?
4. Which methods can be used to image registration?
5. How can the correspondences between Images be found?

1.4 Objectives

Creation of panoramas using computer vision is not a new idea. Improvement of accuracy of image stitching method is the main objective of this project. Doing image re-size, scale, rotation for better prepocessing. Applying histogram equalization for image enhancement to promote the number of detect and extract features. Using alpha blending method to produce seamless panorama.

1.5 Related Work

Image stitching is an important chapter in computer vision. There are many real life problems in computer vision related with this topics. Many researcher work for the solution of these problems. In image stitching, the main challenge is improved 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 detector methods and image blending methods to increase the quality of the stitching system. From experimental result, they chose ORG algorithm with Exposure Compensation blending method for image stitching.

L Tu et al. [2] 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. [11] 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 used for feature matching in their proposed method. Their experimental results demonstrated that the proposed method is better than existing methods on feature based image stitching.

M. Daud et al. [12] 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 remaped 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 for their proposed method.

C. Murtin et al. [13] 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 substacks. They stitched thick high-resolution laser-scanning microscopy image stacks by their developed approach.

Ma, Xiaomin, et al. [14] proposed a fast and high-quality image stitching method. They used FAST dectector 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 is used for image blending.

1.6 Outline Of The Report

The project report consists of five chapters and one reference. All the chapters describe project details and the related concepts. The framework of the report is as follows:

Chapter 1 gives the brief introduction of the work like its background , related works and motivation.

Chapter 2 briefly explains the basics concepts of image stitching, steps of image stitching and applications of image stitching.

Chapter 3 describes about the methodologies. Such as the procedure and algorithms of basics image stitching, procedure of our implementation, procedure of image pre-processing, registration and blending.

Chapter 4 explains about the experimental results and analysis. The respones of various method, final results, etc are describe in this chapter.

Chapter 5 deals with Conclusion and Future Work.

Chapter 2

BASICS OF IMAGE STITCHING

2.1 Image Stitching

Image stitching is a process of combining some overlapping image of same scenario. There is some steps of image stitching. Some of them are shown in the following figure 2.1.

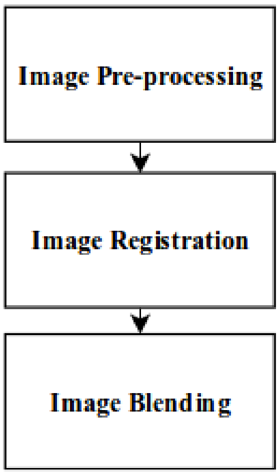


Figure 2.1: Steps of Image Stitching

2.2 Steps of Image Stitching

2.2.1 Image Preprocessing

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-size if needed. This step is necessary for various contrast levels image to equalize their contrast. Image enhancement can be done in this step. It is also an important part for removing noise from the the noisy images. There are many researcher that deal with the problem of image preprocessing and try to improve the performance and stitching quality of image stitching. For example, Tianyun Wang et al. [11] proposed an efficient preprocessing method for image stitching, Xu, Yong, et al. [15] represented image preproceesing in face recognition, Raghavan et al. [16] worked with image preprocessing for Feature Extraction from Knife-Edge Scanning Microscopy Image Stacks.

2.2.2 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 [17]. To overcome various issues like image alignment, scale and rotation, image stitching is very helpful. It is often used in medical and satellite imagery to align images from different camera sources. Digital cameras use image registration to align and connect adjacent images into a single panoramic image.

It is used in medical imaging, military automatic target recognition, computer vision, and compiling and analyzing images and data from satellites.

2.2.3 Image Blending

Image blending is necessary to produce seamless stitched image. It is the final steps of image stitching that targets to blend the overlap pixels of images to avoid seams between images. There are many approaches of image blending. Some of common blending methods [1] are given below:

- **Alpha (feathering) Blending :** It is the simplest method which takes weighted average of two images.
- **Gradient Domain Blending :** It is an alternate approach to multi-band image blending. It is performed in the gradient domain as the human visual system.
- **Laplacian Pyramid Blending :** It works in two operations: reduces image size with Gaussian and expands the Gaussian into lower level and substracts from the image at that level.
- **Exposure Compensation :** It can do better when the exposure differences become significant and can handle vignetting.

2.3 Applications of Image Stitching

There are many applications of image stitching. In medical field, there are many applications such as Diagnosis of cardiac, retinal, pelvic, renal, abdomen, liver, tissue etc disorders [18].

Image stitching is also used in digital maps and satellite photos for high resolution. It has many application virtual reality, Remote sensing and so on [19]. Video Stitching is also popular application of image stitching [20].

Chapter 3

METHODOLOGIES

3.1 Implementation

There are many researchers worked with image stitching. Everyone try to improve the quality of image stitching. Here, we also try to improve the quality of image stitching of various type of image like different illumination levels images, various scale images, rotate images and so on. Here we re-sized images if there were in various levels of dimension. We used first image's dimension for reference dimension. To gain more extract feature point we applied adaptive histogram equalization for adjusting contrast of input images. For extracting feature points, we used various available feature descriptors such as SURF, FAST, Harris, MSER. We described the results in the Chapter 4.

3.2 Block Diagram of Image Stitching

We implemented according to the following block diagram which is given in Figure 3.1. The main steps of our method are:

- **Load images :** Loading the input images for stitching.
- **Image Preprocessing:** We did image re-size, image enhancement in this steps.
- **Image Registration:** In this step, we used various methods of feature detectors to extract feature points.
- **Image stitching with blending:** It is the final steps of image stitching. Here, we used alpha blending method to blend the overlap images.

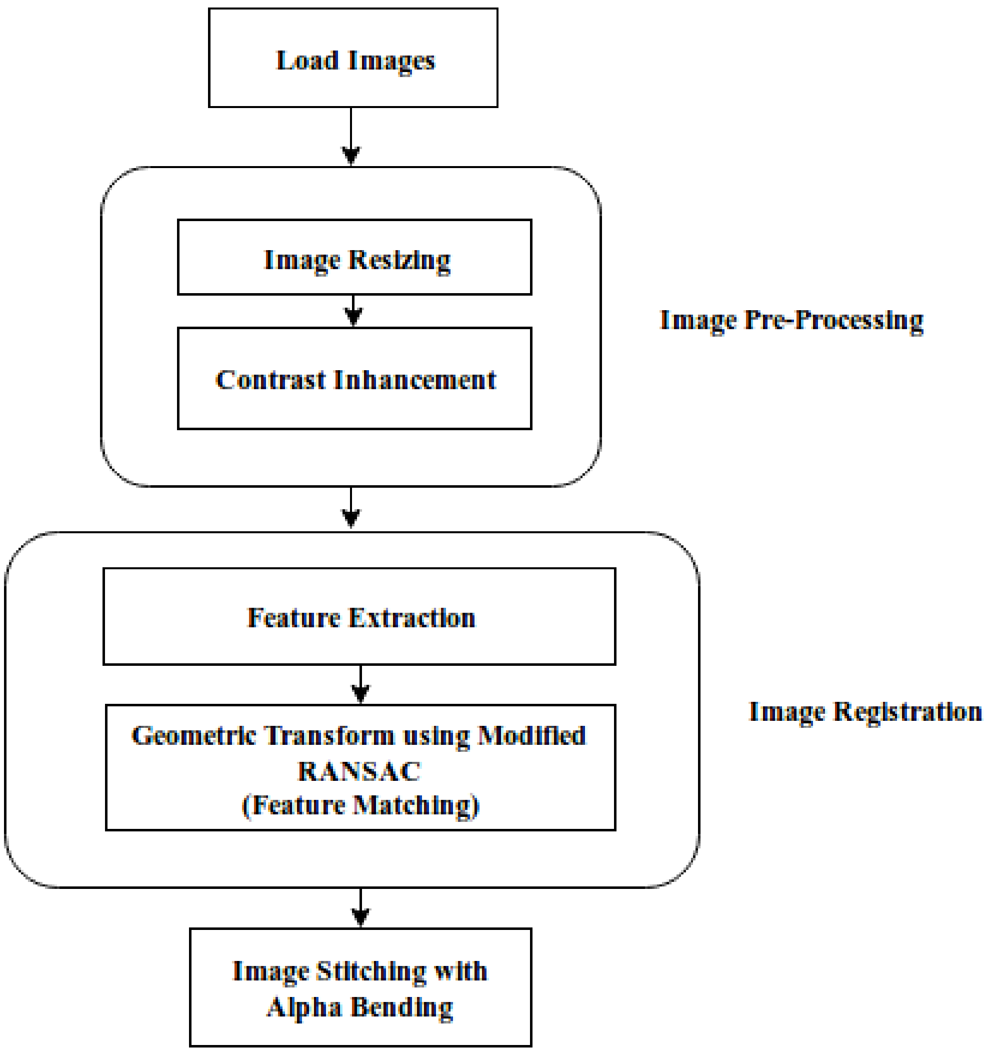


Figure 3.1: Block Diagram of Image Stitching

3.3 Algorithms

3.3.1 Image Preprocessing Procedure

Image enhancement 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 are used here for contrast enhancement. Here is the procedure of image Preprocessing in the Algorithm 3.1 and the Flow Chart in the Figure 3.2.

Algorithm 3.1 Image Enhancement Procedure

1. Read Image
2. Re-sized same as Reference Image
3. Applied Adaptive Histogram Equalization
4. Store for further used

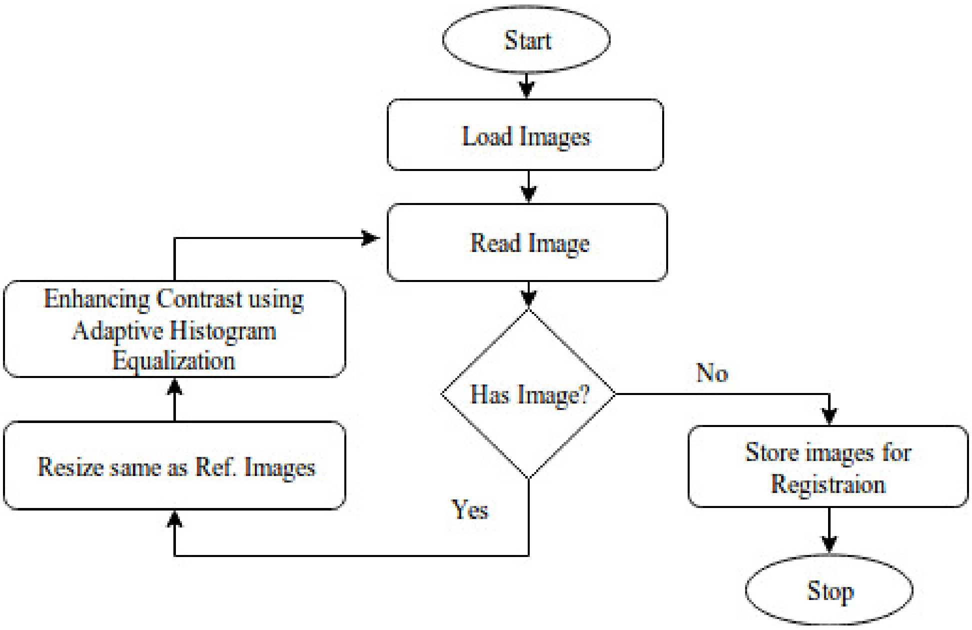


Figure 3.2: Flow Chart of Image Preprocessing Steps

Figure 3.3: Simulation of Image Preprocessing Steps

3.3.2 Image Registration Procedure

Image Registration is a major step of our method. We used feature based descriptor methods for image registration to estimate the transform of images. The steps of Image registration process is given in the Algorithm 3.2 and the Flow Chart in Figure 3.4.

Algorithm 3.2 Image Registration Procedure

1. Read First Image I(1).
2. Detect and Extract features for Image I(1).
3. Continue next steps until the last image.
   (a) Read an Image I(n).
   (b) Detect and Extract features for Image I(n).
   (c) Find Correspondences Between I(n-1) and I(n).
   (d) Estimate Geometric transform Between I(n-1) and I(n) using MSAC [21].
4. Calculate Output Limits for each transform.
5. Find Center Image using Output Limits of transfrom.
6. Apply inverse transform of Center Image to all other Images.

Here, we used M-estimator SAmple Consensus (MSAC[1]) algorithm for estimate geometric transform from matching point pairs.

We have to find Center Image to produce the most aesthetically pleasing panorama. If we use first image as starting of the panorama, then it tends to distort most of the image. A nicer panorama can be created by modifying the transformations according to the center image. This can be accomplished by applying invert transform of Center image to all other images.

[1]The MSAC algorithm is a variant of the Random Sample Consensus (RANSAC) algorithm.

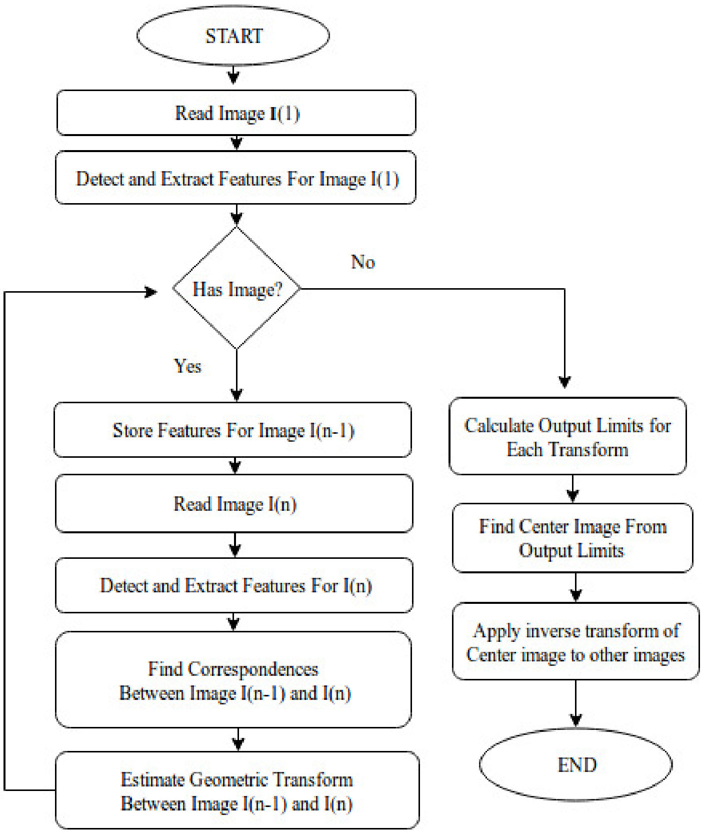


Figure 3.4: Flow Chart of Image Registration Steps

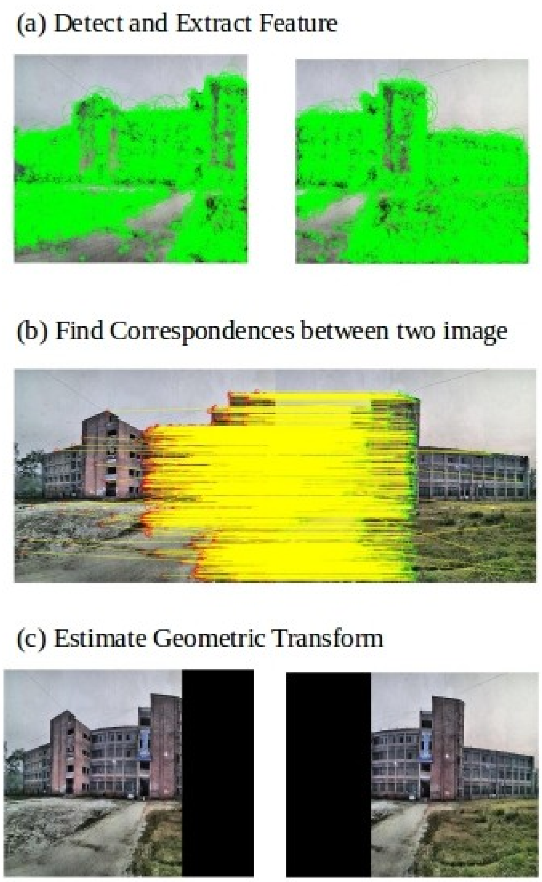


Figure 3.5: Flow Chart of Image Registration Steps

3.3.3 Image Stitching and Blending Procedure

Image blending is the final step of our method. It is important part to gain seamless panoramic images. There are some method of image blending. We used **Alpha Blending**[2] method for image blending. Here is the steps of creating panorama using image stitching with Alpha Blending. The steps are given in the Algorithm 3.3 and Flow chart of creating panorama in the Figure 3.6.

Algorithm 3.3 Procedure of Creating Panorama with Alpha Blending

1. Calculate the Dimension for Final Panorama from Output Limits.
2. Initialize empty panorama with this Dimension.
3. Next Steps Continue until Last Image
   (a) Maps images into panorama.
   (b) Overlay the images together using Alpha Blending.
4. Output Final Panorama.

Here, empty initial panorama are create for mapping all other images into this. The dimensions of initial panorama are selected from the Output Limits of transform which are calculated in image registration section 3.3.2.

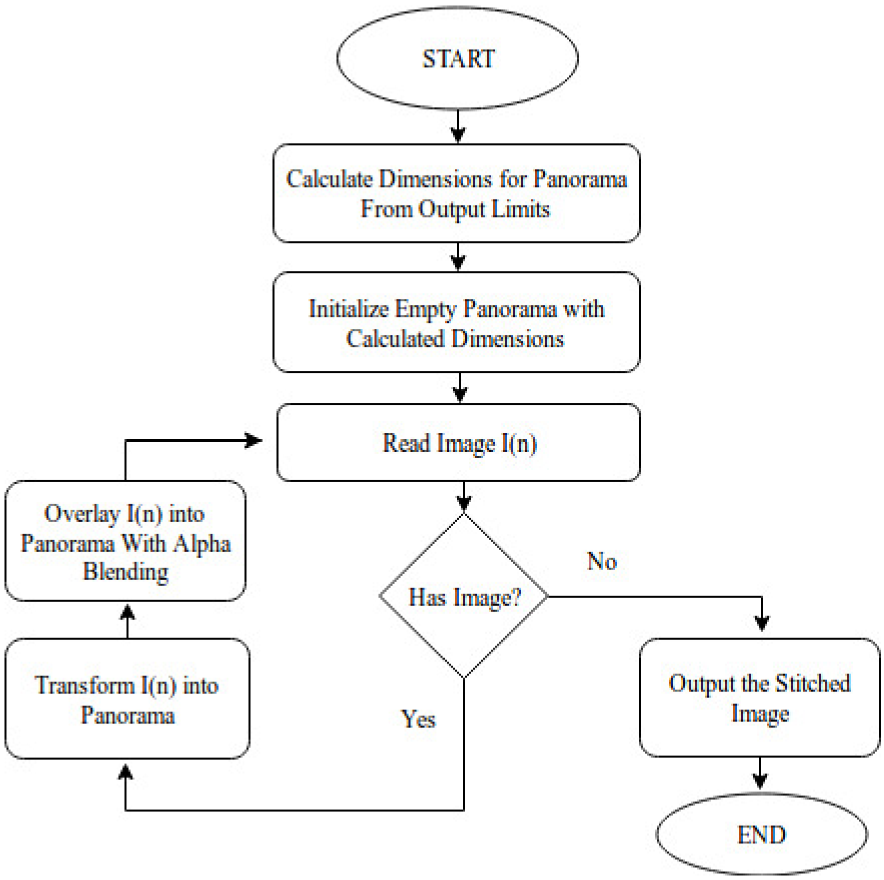


Figure 3.6: Flow Chart of Creating Panorama with Blending

[2]**Alpha Blending :** It is the process of combining a semitransparent color with a background color to produce a new blended color.

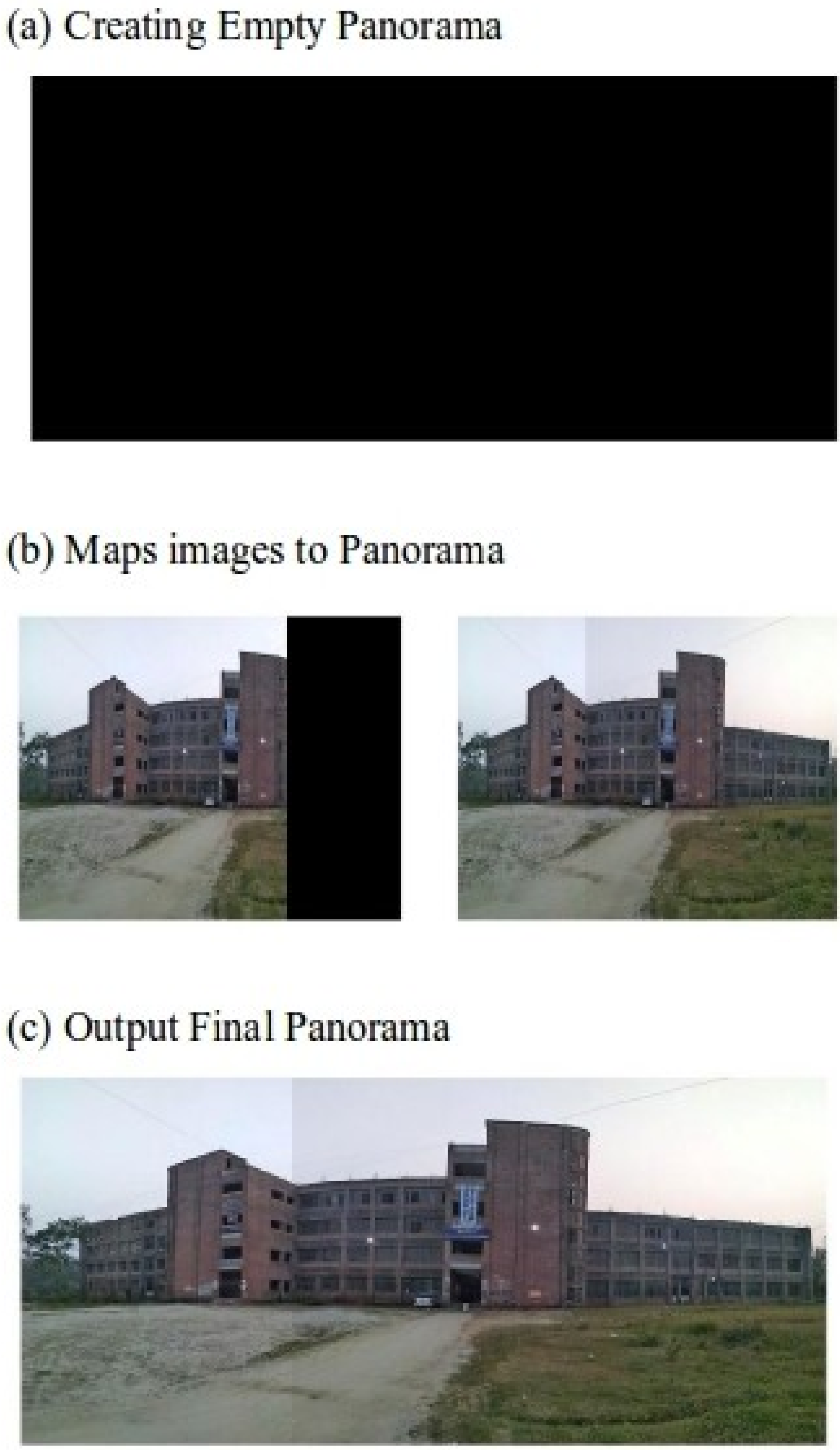


Figure 3.7: Simulation of Creating Panorama

Chapter 4

EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Result of Image Pre-processing

We are going to describe the effects after implementing our proposed method. We implemented our method for various types of input images. Here we used two images for analysis the effects of image enhancement for feature detection. Image set is given in the figure 4.1.

We implemented adaptive histogram equalization according to our proposed method for image enhancement. Here is given the original images after enhancement in the figure 4.2.

4.2 Responses of the Extraction Detectors

Before implementing image pre-processing we extracted feature objects using SURF, FAST, Harris, MSER feature descriptors. The outputs are given in the figure 4.3.

Before implementing image pre-processing we extracted feature objects using SURF, FAST, Harris, MSER feature descriptors. The outputs are given in the figure 4.4.

We have done analysis among the outputs. More feature objects are detected after

(a) First image

(b) Second Image

Figure 4.1: Original Input Images

(a) First image

(b) Second image

Figure 4.2: Input Images After enhancement

image enhancement. The statistical results are given in table 4.1.

Table 4.1: Counts of feature object points before and after enhancement for input images set 4.1

Methods	SURF	FAST	Harris	MSER
Before image enhancement	1299	1170	1028	1366
After image enhancement	11946	19215	8986	8934

4.3 Respones of Matching Features Using Modified RANSAC

Before applying adaptive histogram equalization for image enhancement, we implemented various feature detector method for feature extraction and feature matching. The output images are given in the figure 4.5.

After image enhancement the output images for feature matching between two images are given in the figure 4.6.

In the case of feature matching, we can also see that the number of matching points among the outputs increased rapidly after contrast enhancement of image. In the table 4.2, the statistical reports are shown.

Table 4.2: Counts of matching feature points before and after enhancement for input images set 4.1

Methods	SURF	FAST	Harris	MSER
Before image enhancement	239	104	123	56
After image enhancement	1622	988	338	245

4.4 Image Stitching With Alpha Blending

4.4.1 Original Images

Once, we captured some pictures of our department and Lab. One of these images is given in the figure 4.7. We have used theses images to campare with the stitched images of different feature detectors method for accuracy.

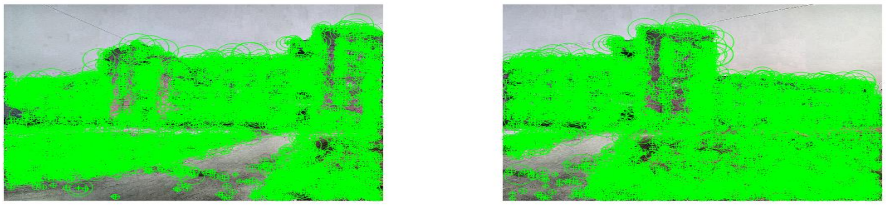
(a) Using SURF feature detector

(b) Using FAST feature detector

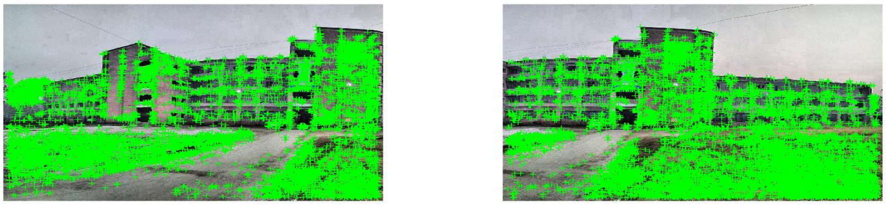
(c) Using Harris feature detector

(d) Using MSER feature detector

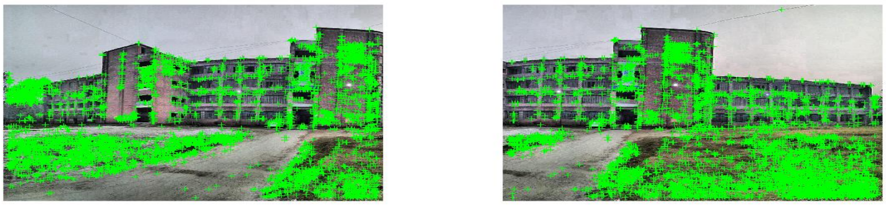
Figure 4.3: Feature points before image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.



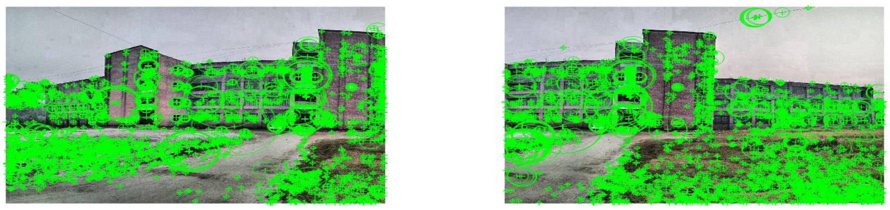
(a) Using SURF feature detector



(b) Using FAST feature detector

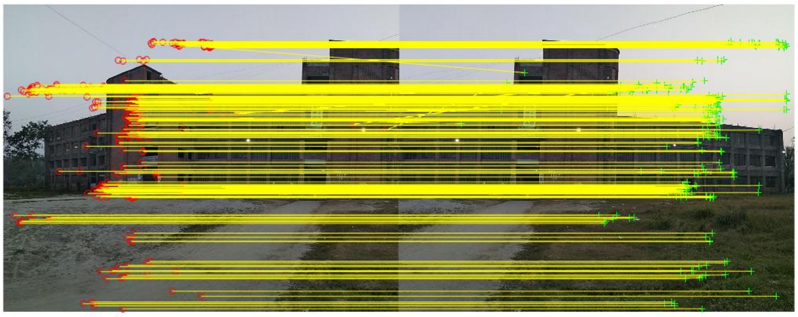


(c) Using Harris feature detector

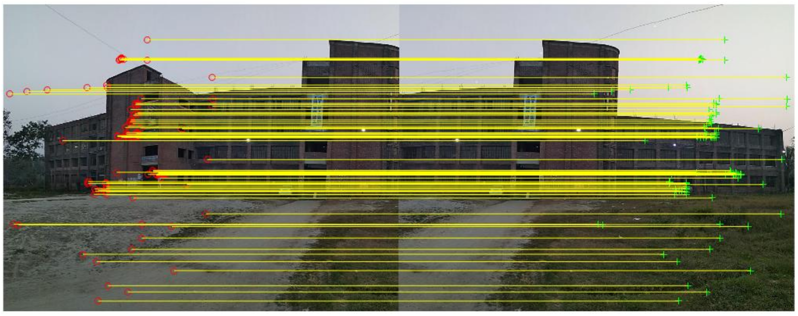


(d) Using MSER feature detector

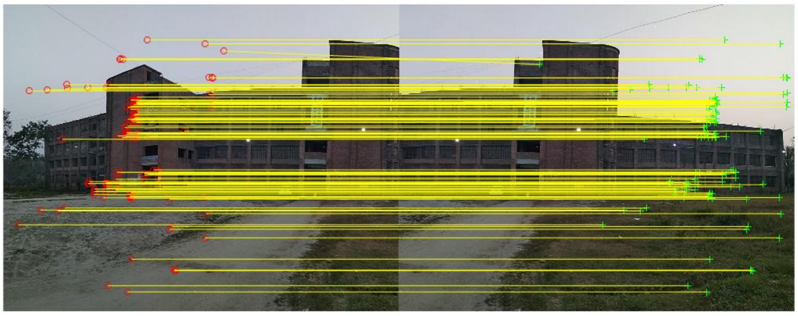
Figure 4.4: Feature points before image enhancement using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.



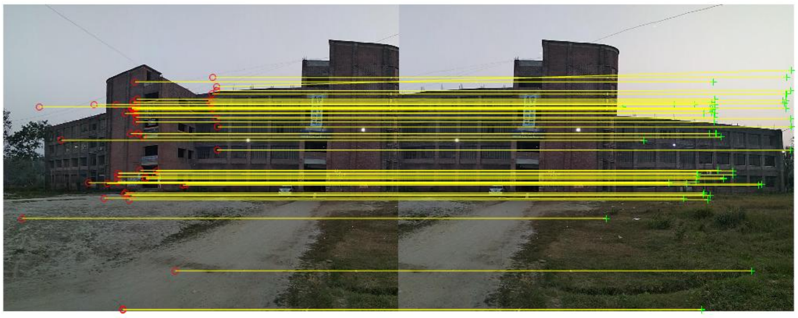
(a) Using SURF feature detector



(b) Using FAST feature detector



(c) Using Harris feature detector

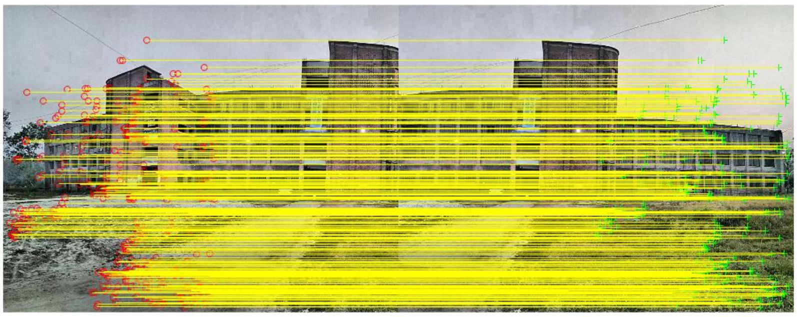


(d) Using MSER feature detector

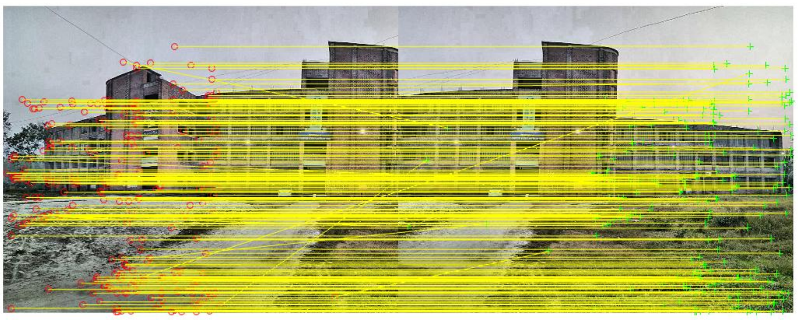
Figure 4.5: Before Image enhancement the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

(a) Using SURF feature detector

(b) Using FAST feature detector



(c) Using Harris feature detector



(d) Using MSER feature detector

Figure 4.6: After Image enhancement the matching feature points using (a) SURF (b) FAST (c) Harris and (d) MSER feature detector.

(a) For Set 1

(b) For Set 2

Figure 4.7: Original Images

Figure 4.8: Input Set 1 From Image4.7a

4.4.2 Input Image Sets for Stitching

We experimented image stitching method for two sets of input images. We have made input sets from the original images which are given in the Figure 4.7. We have made four input images for Input Set 4.8 and seven input images for Input Set 4.9. We have made these input images manually using Shotwell software in Linux System.

4.4.3 Stitched Images

The Final stitched images are in Figure 4.10 for Input Set 4.8 and Figure 4.11 for Input Set 4.9. We have used four feature based methods for image stitching.

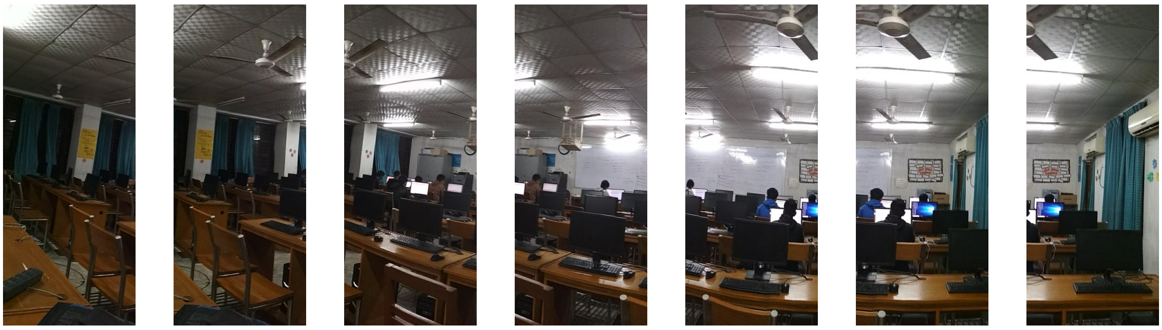


Figure 4.9: Input Set 2 From Image 4.7b

4.5 Performance Evaluation

We have done a simulation to evaluate the performance of various feature based methods. We have compared each output images with their original image. As result, we have demonstrated the accuracy of image stitching for different methods in the Table 4.3.

Table 4.3: Accuracy Rate of Different Feature Based Methods

Methods	SURF	FAST	Harris	MSER
Accuracy Rate (%) for Input Set 1	92.27%	92.10%	92.08%	92.17%
Accuracy Rate (%) for Input Set 2	94.65%	94.27%	94.60%	94.47%

We did a survey among 15 students of Janahgirnagar University who had no knowledge about image stitching. We have set up a scoring system ranging from 1 to 5. The rating score corresponding to be assigned depending upon the visual quality of an image is ranged from 1 to 5, denoting:

1. Bad
2. Poor
3. Fair
4. Good
5. Excellent

We said each students to give the rating to each stitched images for different feature based mathods. After the survey, the average scores for both input set are given in the Table 4.4.

Table 4.4: Performance Evaluation from the Survey

Methods	SURF	FAST	Harris	MSER
Average Score for Input Set 1	3.93	3.73	3.73	3.67
Average Score for Input Set 2	3.87	3.67	3.80	3.73

After implementation and analysis, we have comfirmed that image stitching based on SURF feature detector method gives the best result among the feature based methods for our implementation.

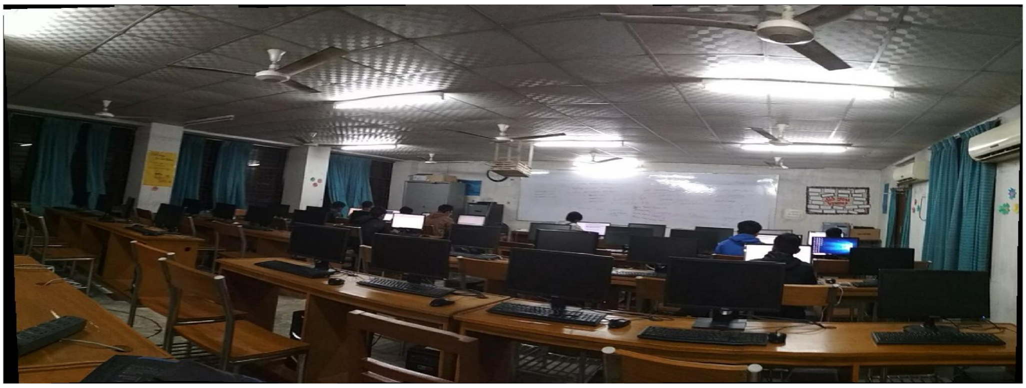
(a) Using SURF

(b) Using FAST

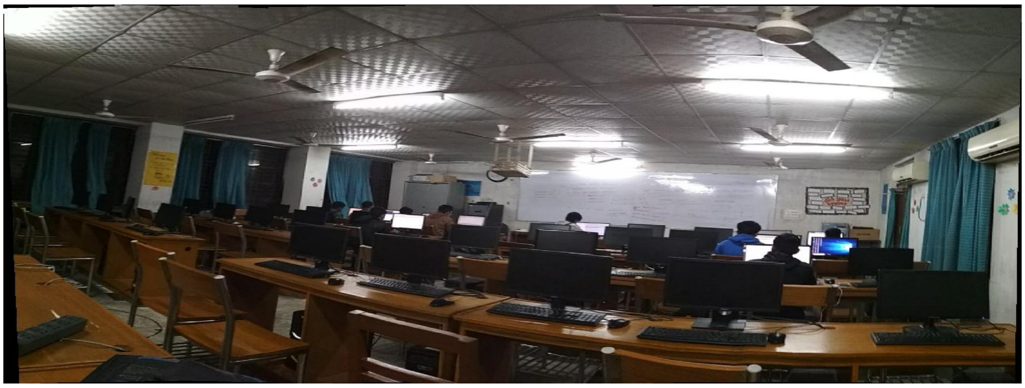
(c) Using Harris

(d) Using MSER

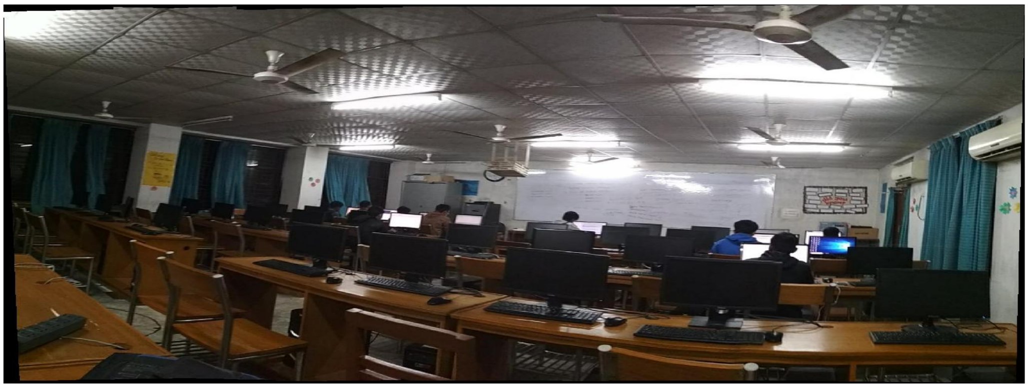
Figure 4.10: Stitched Images for image Set 4.8using (a) SURF, (b) FAST, (c) Harris & (d) MSER feature detector.



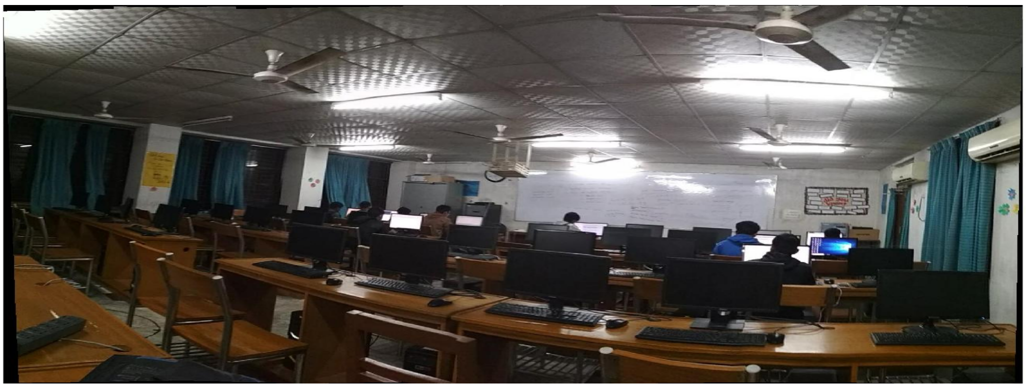
(a) Using SURF



(b) Using FAST



(c) Using Harris



(d) Using MSER

Figure 4.11: Stitched Images for image Set 4.9 using (a) SURF, (b) FAST, (c) Harris & (d) MSER feature detector.

Chapter 5

CONCLUSION AND FUTURE CHALLENGES

5.1 Conclusion

In this project, we have implemented various types of feature detectors to detect and extract features. We have also described various types image stitching techniques and analyzed their results. We have briefly described the main steps of image stitching image preprocessing, image registration and image blending. We have also analyzed the responses of image preprocessing mainly contrast enhancement. After image enhancement the number of features are promoted rapidly for all feature detectors. The maching features for two images are also increased after image pre-processing.

We have done implementation and compared those approaches based on performance and accuracy rate. Among various feature based methods, we have analyzed the results and the reports comfirmed that the SURF based method is better for image stitching.

We used two input set of images for analyzing results of different illuminations. Images of first input set are for daylight images and second input set are for dark images. From the results, we came to know that SURF based feature method is the best method among all others feature based methods.

5.2 Future Work and Challenges

In future, a method can be developed for noisy images, blur images and more changes in illumination. A method for stitching videos for dynamic panoramas can also be developed in future. There are some challenges in image stitching. In future, we want to improve and develop a hybrid method which will different methods for different types of noisy, blur, videos and so on. For producing seamless stitched images, various types of blending method can be used in a single stitching method.

Image stitching for large image may lead to more time consuming. Very large collections of images need to more time for indexing. So that it can take more time for stitching [17].

Motion panoramas often having problem from parallax errors due to tiny motions of the optical. These can be removed by doing for image translations and depths in the scene, before re-rendering from central point. There is a good representation to use may be plane at infinity plus parallax [22].

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