An Improved Image Registration Technique for Shape Reconstruction

A thesis submitted for the degree of

Bachelor of Science in Computer Science & Engineering

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DECLARATION

We, hereby declare that the thesis "An Improved Image Registration Technique for Shape Reconstruction" is based on the results found by ourselves under the supervision of Professor Dr. Md. Haider Ali and co supervision of Mr. Moin Mostakim. It is carried out for the degree of Bachelor of Science in Computer Science. Materials of work used here found by other researchers are acknowledged by reference. This Thesis, neither in whole or in part, has been previously submitted for any degree.

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Professor Dr. Md. Haider Ali	**Mr. Moin Mostakim**

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Biprojit Roy	**Geetanjali Oishe**

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ABSTRACT

Image registration is a very useful technique in the field of Image processing. It has many potential applications for shape and angle estimation. Image registration is a basically aligning two or more images into one common co-ordinate system in order to monitor subtle changes between them. The image registration algorithms rotate or translate the source images and determine the relative transformation with the corresponding target image. In this research we are going to reconstruct the shape of a scene/object from different images. The viewpoint of the images will be arbitrary and independent of any available data set. From set of source images we are going to combine the images using image registration techniques to find the estimated shape. We believe this research will be useful regarding the studies of shape reconstruction.

Chapter 1

INTRODUCTION

1. Introduction

Recognizing objects by their outline shape and angle is a very powerful feature in image processing. Back in 2008 Yang Mingqiang and Kpalma Kidiuo discussed the essential properties of shape to be a feature that includes rotation, translation, scaling, noise resistance and reliability [1]. Image registration [2] is a very significant step in the process of analyzing an image during which essential information is originated by combining information from different data source. Generally image registration is used in remote sensing (for monitoring environment, weather forecasting), in medical image processing (combining CT, monitoring tumor growth etc.) and in computer vision. Image registration can be categorized into four different classes according to the image application [3, 4]. Also there are classifications based on essentials which are Intensity Based Methods and Feature Based Methods. Due to diversity of image to be registered and a mixture of degradation in images it is unfeasible to label a universal method for image registration. For this reason we have presented a comparative approach on applying different algorithms in the process of shape reconstruction of an image.

1.1 Motivation

Images are the illustration of the situations of our surrounding. But the different image of the same situation taken from different sensors can illustrate different view. So, extracting information from those images becomes complex. Despite of being very high functioned; human eyes may also face difficulties to perform these tasks. Here we can introduce image registration techniques to find the matches and combine the information as a whole. Over the years image registration has become very useful in the field of medical imaging, computer vision, remote sensing etc. There are sets of methodology which can perform image registration based on situations provided. But, getting an accurate result is still a challenge. The complexity of registering images with rotation and scale invariant is significant and etc. These incentives gave us a purpose to conduct a research to have the comparative study of different approaches in order to find a better image registration methodology.

1.2 Aims and Objectives

The primary aim our research work is to find the matches of different images and combine them According to their matched parts. There has been some works done in the field of image registration. Each one of them is unique in the methodologies which have been used in the respective works. For example, the algorithm of the image registration can be classified into two major classes called Intensity Based image Registration where intensity of the images are matched using co-relation matrix [5]. On the other hand, feature based technique focuses on features such as points, lines, edges, contours etc. Moreover, for different criteria SIFT, SURF, Harris Corner Detection, BRISK etc. matching algorithms can be used.

This research work focuses on the comparative study of different approaches to obtain a better set of methods to achieve better registration. The step by step process is summarized below.

- Firstly, it will take more than one images as input set.
- Secondly, it will resize the images making sure all of them are equal in size.
- Thirdly, it will determine the features
- Then, it will extract the features and match them.
- Then, it will calculate the geometric transformation and perform transformation.
- Finally, it will give the registered image as output.

1.3 Thesis Outline

- Chapter 1: This chapter is about the introduction of our thesis work
- Chapter 2: This chapter shows the literature review which includes current knowledge, related works and all the theoretical descriptions of methodologies.
- Chapter 3: This chapter demonstrates the detailed proposed model. It also includes the workflow of our proposed model.
- Chapter 4: This chapter shows the acquired result and cross methodology analysis of our work.
- Chapter 5: This chapter concludes our work with conclusion, limitations and future plan.

Chapter 2

Background Study & Analysis

2. Background Study and Analysis

Image registration is widely used in various applications. Image registration is combining partially overlapping images into one co-ordinate system. Based on the type of input images image registration can be categorized [6]. For Example,

- Multi-view image registration: Images of the same scene taken from different viewpoint. It's basically the images from different angles.
- Multi temporal image registration: Images of the same scene taken at different time. They are usually taken frequently in various conditions.
- Multimodal image registration: Images of same scene taken by different sensors. Those can be taken at the same time or in different times in different conditions.
- Scene to model registration: This type of image registration is slightly different from the above mentioned types. Here an image is registered with a model or map of an object.

There are two basic approaches for image registration [7]. One is Intensity based image registration and another is Feature Based Image registration.

2.1 Intensity Based Image Registration

Intensity based image registration [8] takes into account a pair of images along with a metric, an optimizer and also requires a transform type. The process involves the specified transformation type and an internally determined transformation matrix. It is an iterative process.

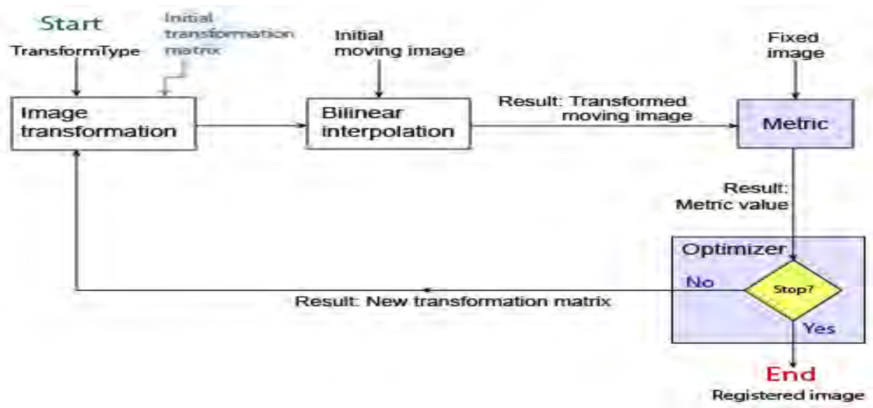


Figure 2.1: intensity based image registration [8]

2.2 Feature Based Image Registration

Feature based image registration focuses on the various features of input images. A feature can be edge, line, point, contour etc. Feature based image registration can be categorized in two parts.

2.2.1 Area Based Image Registration

This methodology gives more emphasis on feature matching rather than feature detection [3]. Generally, in this method no feature is detected. So, it directly goes to the feature matching step. As a result, there is no feature detection step in this methodology. But the processes regarding feature detection are done in other steps.

2.2.2 Feature Based Image Registration

Feature based image registration gives more emphasis on salient features. The example of salient feature can be significant shapes (mountain, river, field), lines (the boundary of shapes), edges, corners, points. The features are expected to be distinctive and easily found. The main difference between feature based and area based image registration is the area based methods works with the intensity of the images and the feature based image registration works with the feature which represents high level information. That is why feature based is more suitable for multi view, multi modal image registration. There are four basic step of feature based image registration [3].

2.2.2.1 Feature Detection and Extraction:

As described before, the common feature of the reference images and sensed images are corners, edges, points, lines etc. Each feature has its own set of algorithm to be detected.

1) Edge Detection

a) Sobel edge detection:

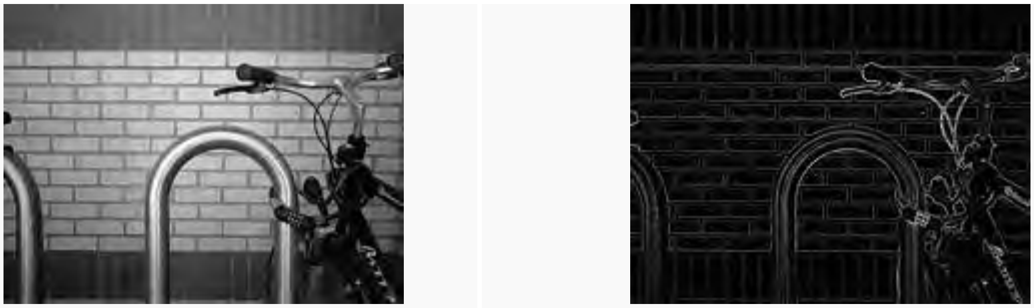
Sobel operator [9] is used in image processing and computer vision with the image detection algorithm to extract the edges from the source images. The basic idea of Sobel edge detection is a feature is an edge where the intensity of the neighbor point is sharply different from the current point. The operator uses two 3*3 kernel which are convolved with the original image to find the approximation of derivatives one horizontally, one vertically.

Here, $G_x = \begin{pmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{pmatrix} * A$ $G_y = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{pmatrix} * A$

We define **A** as the source image, and $\mathbf{G}_x$ and $\mathbf{G}_y$ are two images which at each point contain the horizontal and vertical derivative approximations respectively.

$$G=\sqrt{\mathbf{G}x^{2} + \mathbf{G}y^{2}}$$

$$\text{Ø}=\text{atan}\left(\frac{\mathbf{G}x}{\mathbf{G}y}\right)$$



Gray scale test image of brick wall and bike rack

Normalized gradient magnitude from Sobel–Feldman operator

Figure 2.2: Edge detection using Sobel edge detection techniques [10]

b) Canny edge detection:

Sobel edge detection was simpler. Canny [11] edge detection techniques were created to get better result. Canny edge detection can detect thin and light edges which was unable by Sobel edge detection techniques. Canny edge detection techniques use a two-step algorithm. Where first one is like Sobel edge detection and second one is non-maxima suppression which is to get thin lines.

Figure 2.3: Canny applied to skyline scene [12]

c) Fuzzy Canny Hybrid

In March 2013 a group of Indian authors of SVM Institute of Technology, Gujrat, India came up with a very new yet effective way of edge detection named "Fuzzy Canny Hybrid approach" [13], which is very useful in detecting more detailed edges. The approach suggests a couple of phases for detecting edges. In the first phase the image is processed under fuzzy rules and second concerns about canny.

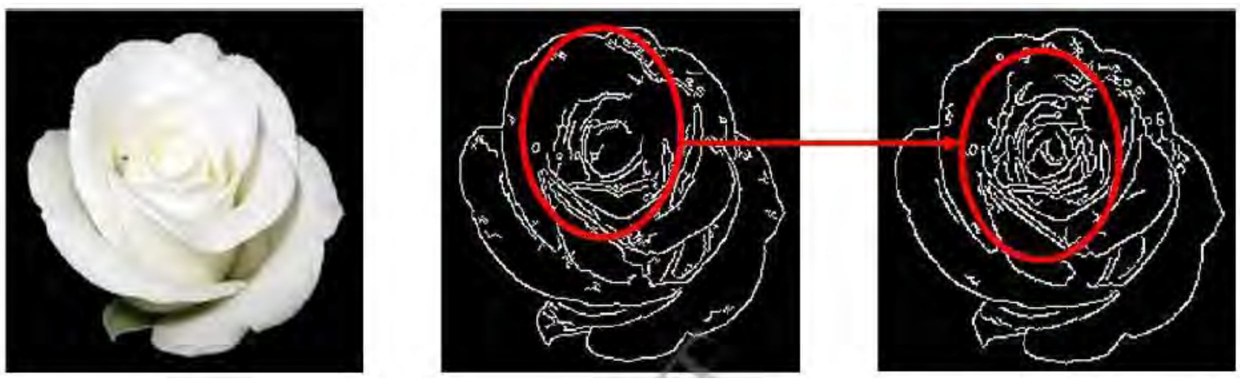


Figure 2.4: a) input image b) after canny method c) after Hybrid method [13]

We found this method extraordinary in terms of detecting edges but as it is too accurate it gives scattered result in image registration.

2) Harris Corner Detection

Back in 1988 Harris and Stephen [14] developed improved corner detection techniques considering autocorrelation score. Which is calculated based on the differential of corner score with respect to direction.

If a gray scale image I is taken with the image patch over the region (u, v) and shifted by (x, y) then the pixel intensity can be calculated:

$$E(u,v) = \sum_{x,y} W(x,y)[I(x+u+y+v) - I(x+y)]^2$$

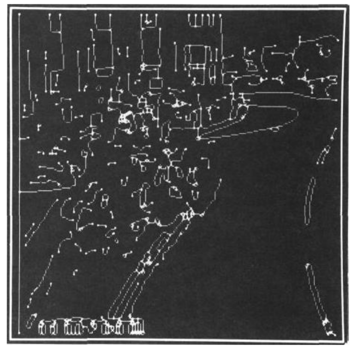
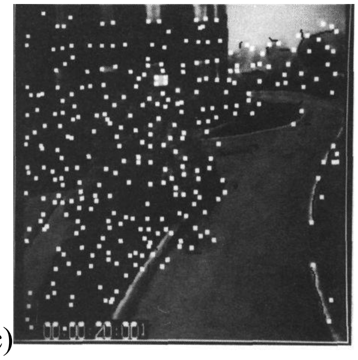
(a)  (b)  (c) 

Figure 2.5: (a) input image, (b) linked canny edges, (c) corner and edge [white=corner, black=edge] by Harris [14]

3) SURF Feature Detector

Speeded up Robust Features is a feature detector and descriptor. It was inspired by SIFT. The computational time for SURF is faster than SIFT. According to studies SURF works more robustly in different situation. SURF is widely used in image registration.

The algorithm of SURF is based on SIFT but in every step it is different. SURF uses square shaped filter as a Gaussian approximation. It works robustly if integral image is used [10].

SURF uses a Hessian matrix to detect the interest points. Several floors or stairs with various measures of the masks are calculated. Then non-maximal suppression and interpolation is performed to get the blob like features.

4) BRISK Feature Detection

BRISK is also a feature detection algorithms that works with interest points. A BRISK method detects features by scale space interest point detection. A key point at any octave is defined analyzing the eight neighboring octaves and as well as in the corresponding score-patches in the immediately neighboring octaves [15].

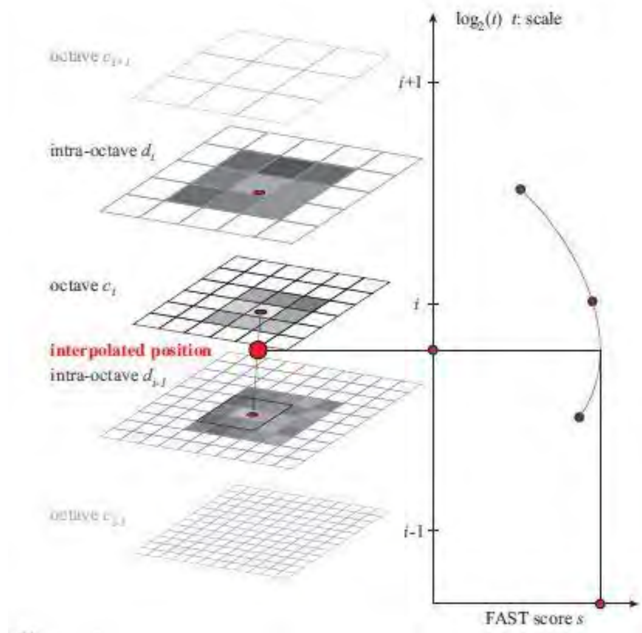


Figure 2.6: Scale space interest point detection [15]

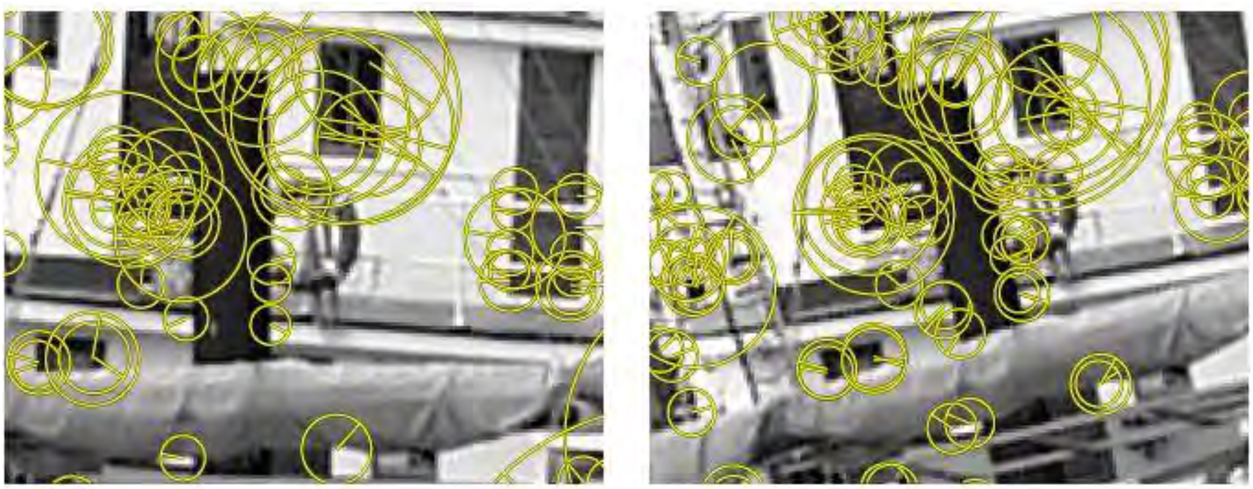


Figure 2.7: Feature detection in two images using BRISK [15]

5) MSER feature detection:

Maximally Stable Extremal Regions (MSER) is a feature detector; Like the SIFT feature detector, the MSER algorithm extracts from an image I a number of co-variant regions, called MSERs. An MSER is a stable connected component of some level sets of the image I. Optionally; elliptical frames are attached to the MSERs by fitting ellipses to the regions.

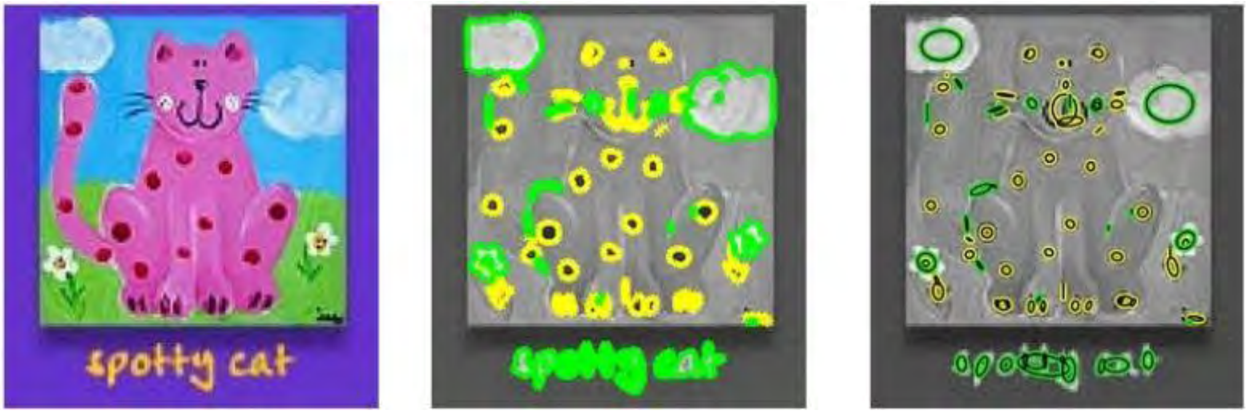


Figure 2.8: (left) original image (middle) MSER regions (Right) MSER ellipses

2.2.2.2 Feature Matching

Feature matching is finding the matching features from two similar kinds of datasets of features. We have a variety of feature matching techniques based on the types of features we have. Again there are two main categories of feature matching.

- Area based feature matching

  In area based feature matching the feature detection part is combined. The matching is done without detecting the features. Predefined windows and sometimes the whole image are used for estimation. The main limitation with this type of feature matching is the rectangular window works fine with simple transformation. But if the images are of more complex transformation this type of feature matching doesn't work robustly.

- Feature Based Matching

  Generally feature based matching is used in the 2^{nd} step of image registration for better matching. There are a few feature based matching techniques.

- SURF feature matching

For fast indexing during the matching stage, the sign of the Laplacian (i.e. the trace of the Hessian matrix) for the underlying interest point is included. Typically, the interest points are found at blob-type structures. The sign of the Laplacian distinguishes bright blobs on dark backgrounds from the reverse situation. This feature is available at no extra computational cost as it was already computed during the detection phase. In the matching stage, we only compare features if they have the same type of contrast. [10]

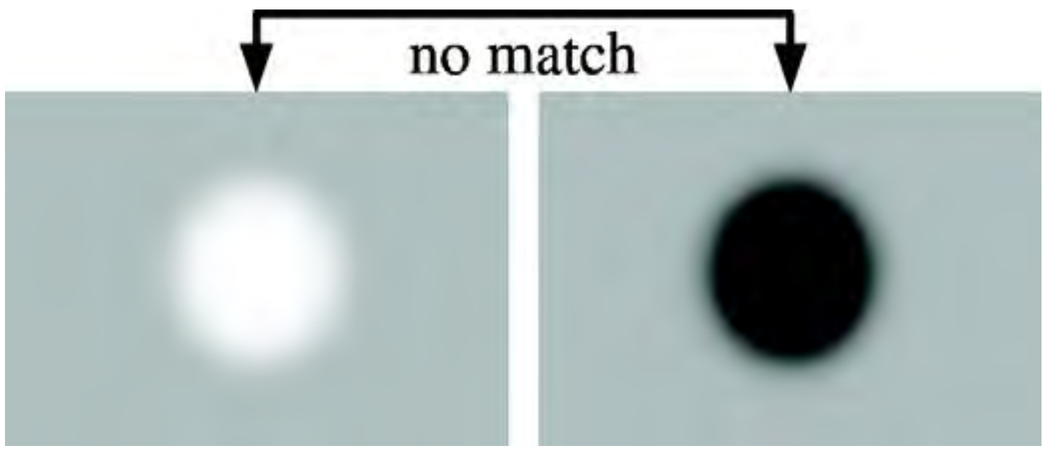


Figure 2.9: Different contrast are not considered as match [10]

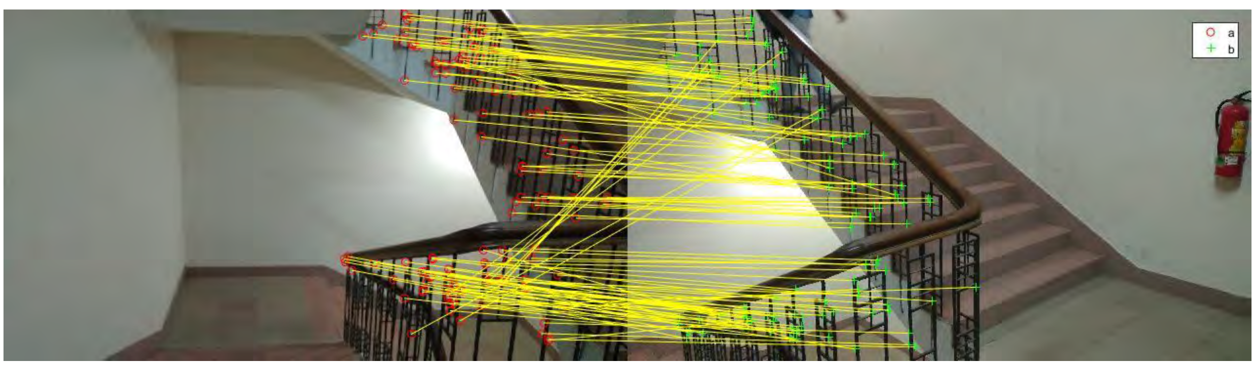


Figure 2.10: Feature matching using SURF algorithm

o BRISK feature matching:

BRIEF [17] matches two descriptors by computing their Hamming distance, so does BRIEF. Here the number of the difference of bits between the two descriptors is considered as the variation between them. Here the operations are reduced to a bitwise XOR and then a bit count.

Figure 2.11: Feature matching using BRISK

o MSER Feature matching

The computation of MSER regions are done on the intensity image (MSER+) and on the inverted image (MSER-). Measurement regions can be selected at multiple scales: the size of the actual region, 1.5c, 2x and 3x. The matching is performed robustly, so the increased distinctiveness of large regions is necessary.

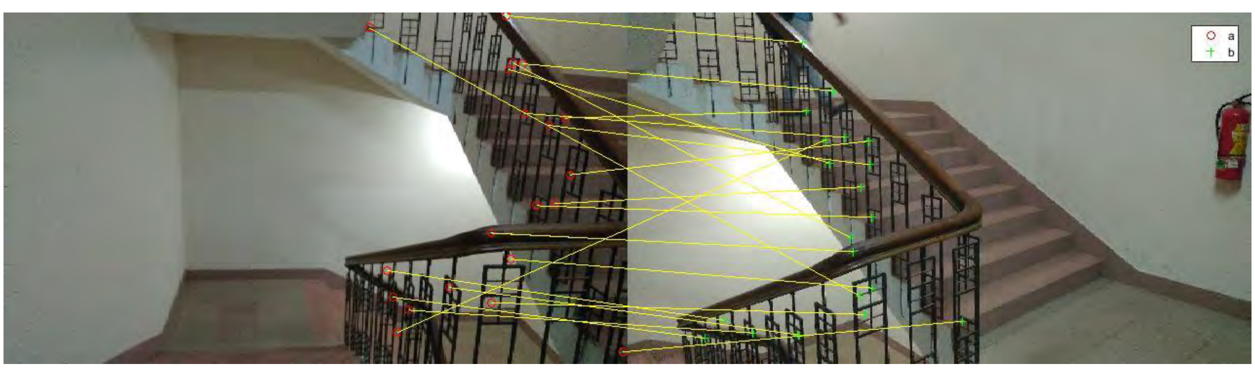


Figure 2.12: Feature matching using MSER

2.2.2.3 Transform model estimation:

After the feature correspondents are established the mapping function is constructed. The mapping function overlay the sensed image to the reference image. The correspondence of the sensed image and referenced images together on the fact that the CPs have to be as close as possible. The job is done by selecting the mapping techniques and its parameter estimation.

2.2.2.4 Geometric Transformation

Third step of image registration is mapping geometric transformation. Geometric transformation, we modify with geometric transformation, we modify the positions of pixels in an image.

Let (u, v) represent the image coordinate in an original image, and (x, y) in a deformed (or warped) image. We use a function pair to relate corresponding pixels in the use a function pair to relate corresponding pixels in the two images [16]:

Forward mapping: $\begin{cases} x = x(u,v) \\ y = y(u,v) \end{cases}$ $or\ X = x(u)$

Inverse mapping: $\begin{cases} u = u(x,y) \\ v = v(x,y) \end{cases}$ $or\ U = U(x)$

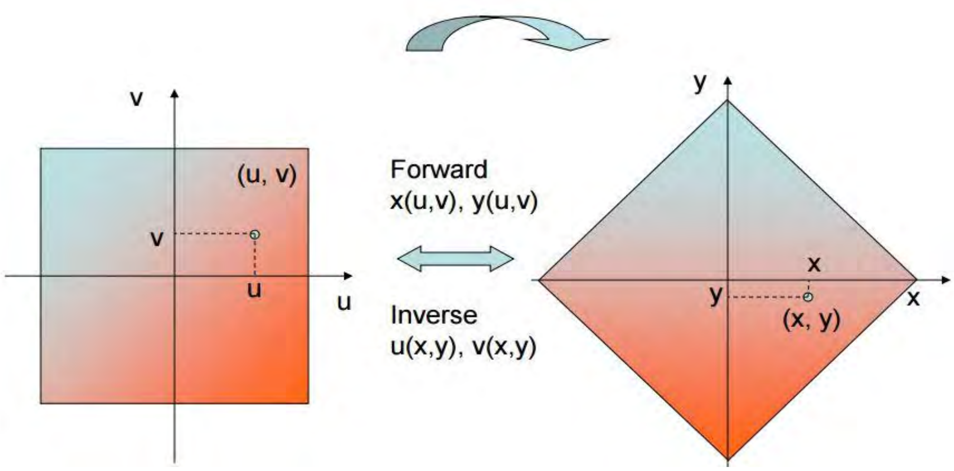


Figure 2.13: forward and inverse mapping

A geometric transformation refers to a of combination of translation, scaling, and rotation

Chapter 3

Proposed Model

3 Proposed Model

In our proposed model, firstly we have taken some input images. Then we resized the images based on the reference images as it gets easier to register images with the same height and width. Then we applied gray scale conversion to the images as the algorithms supports binary images. After that feature detection and feature extraction algorithms will be applied. Then we will get the transformation estimation. Based on the transformation algorithms registration will be applied to the sensed images to combine the images.

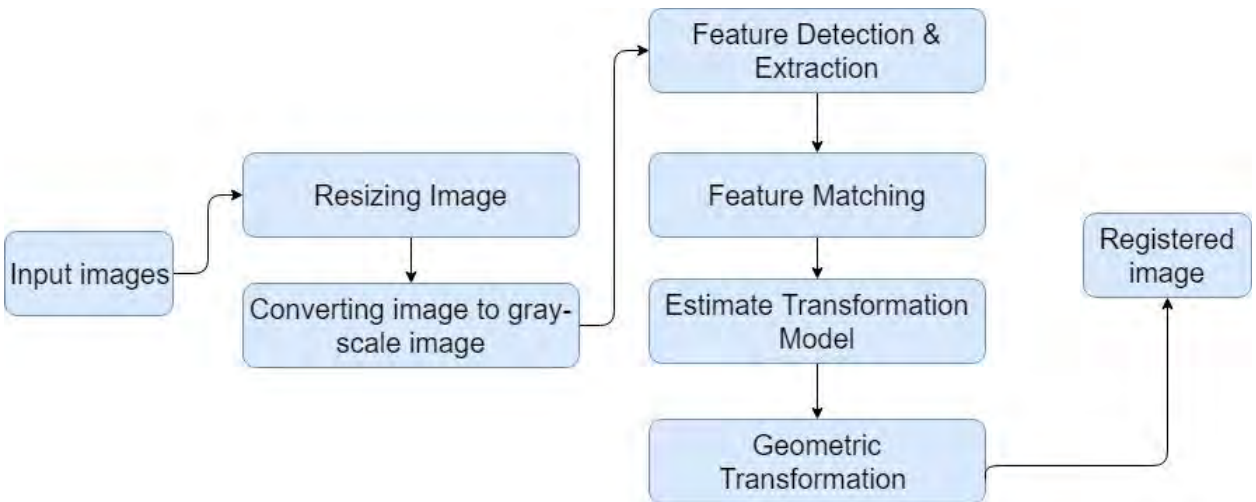
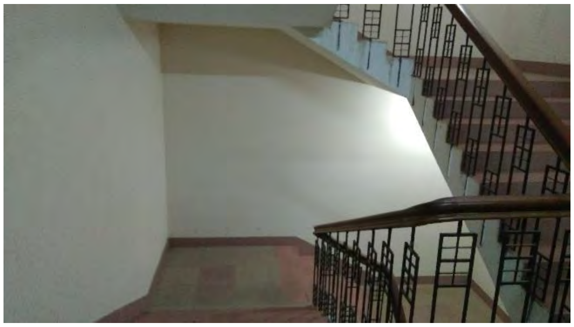
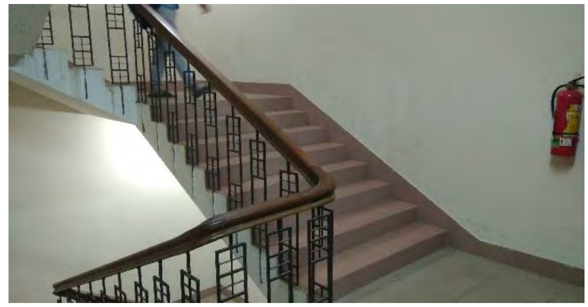


Figure 3.1: Proposed work flow of the model

3.1 Resizing Image

First we need to check all the images are of same size or not. If they are of different sizes then we need to resize them else resizing is not required. Resizing the images is an important phase in our work. As, the SURF algorithm we have used works with the images of same size. The resizing is done based on the size of the reference image.

a)  b) 

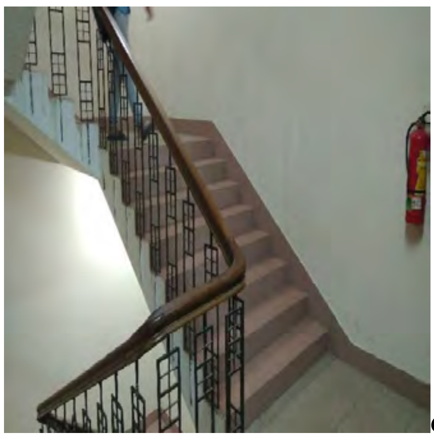
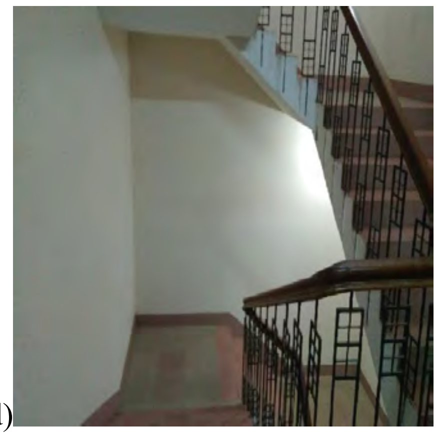
c)  d) 

Figure 3.2: a) image size of 2160px*11520px b) image size of 1985px*11493px

c) & d) after resizing both image size is 2160px*6480px

3.2 Gray scale Conversion

Feature Detection and extraction techniques only support two dimensional images. But in most of the cases the sensed images will be color images which are multi-dimensional. In that case, all the inputs need to be converted to gray scale image which is a two-dimensional image. The gray scale conversion is done by eliminating the hue and saturation. It returns an intensity based image.

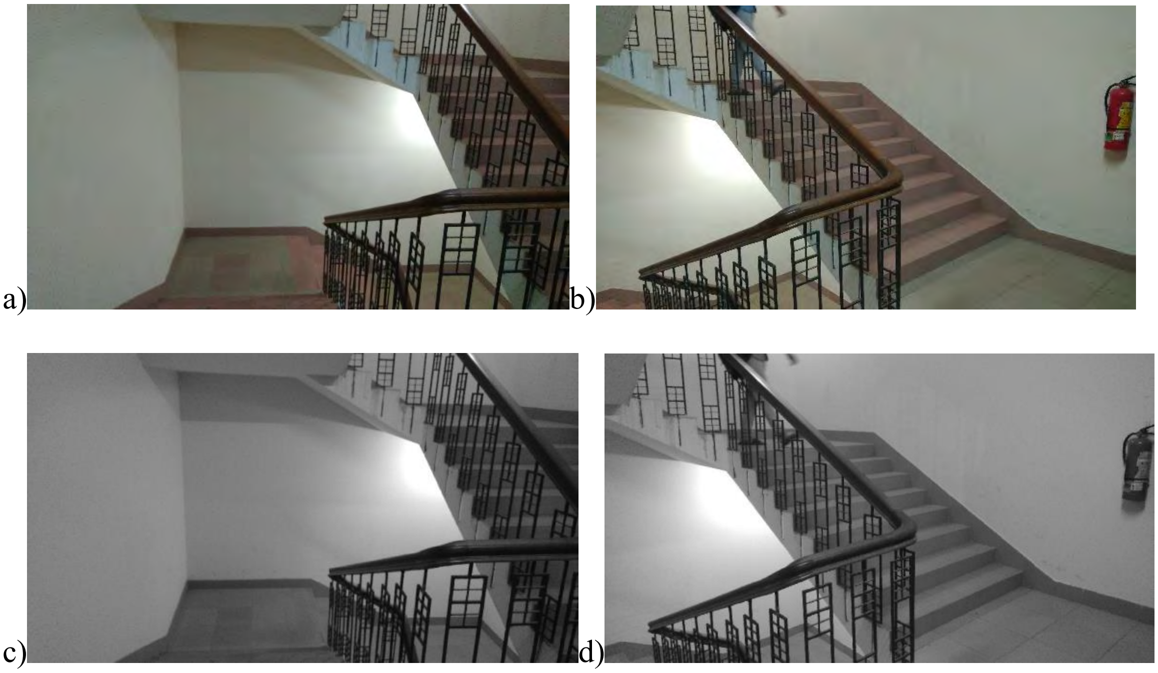


Figure 3.3: a) input image 1 b) input image 2 c) gray scale image 1 d) gray scale image 2

3.3 Feature Detection

In the whole image registration process the feature detection is the first basic step. Feature detection is basically detecting the features. Previously we have discussed about some strong feature and their detection using various algorithms. In our research work we have used BLOB as the feature and SURF as the feature detection technique.

3.3.1 Feature

Blob is the region of the image where properties of the image are constant or nearly constant. Based on the interest points and their position the methods of detecting blob feature can be classified into two main classes. They are differential methods which are based on the derivatives of the function with respect to position and another is local extrema which works upon finding minima and maxima. Hessian matrix is used to detect blob. One of the main reasons of using blob is it can represent some extra information which cannot be obtained from edges or corners. Hessian matrix [10] is used to detect the blob features in SURF for better accuracy.

3.3.2 Feature Detection Using SURF

As described before, SURF is used to detect feature. The main advantage of SURF [10] is the speed. The Hessian approximation also works greatly in terms of finding interest points. The main steps of SURF [10] detection is described below.

- SURF uses integral images. It helps to speed up the process. Integral images are the immediate representation of the image. Integral image also contains the table of sums of gray scale pixel values of the image. SURF uses a square shape filter on the integral image as Gaussian approximation.

  $$S(x,y) = \sum_{i=0}^{x} \sum_{j=0}^{y} I(i,j)$$

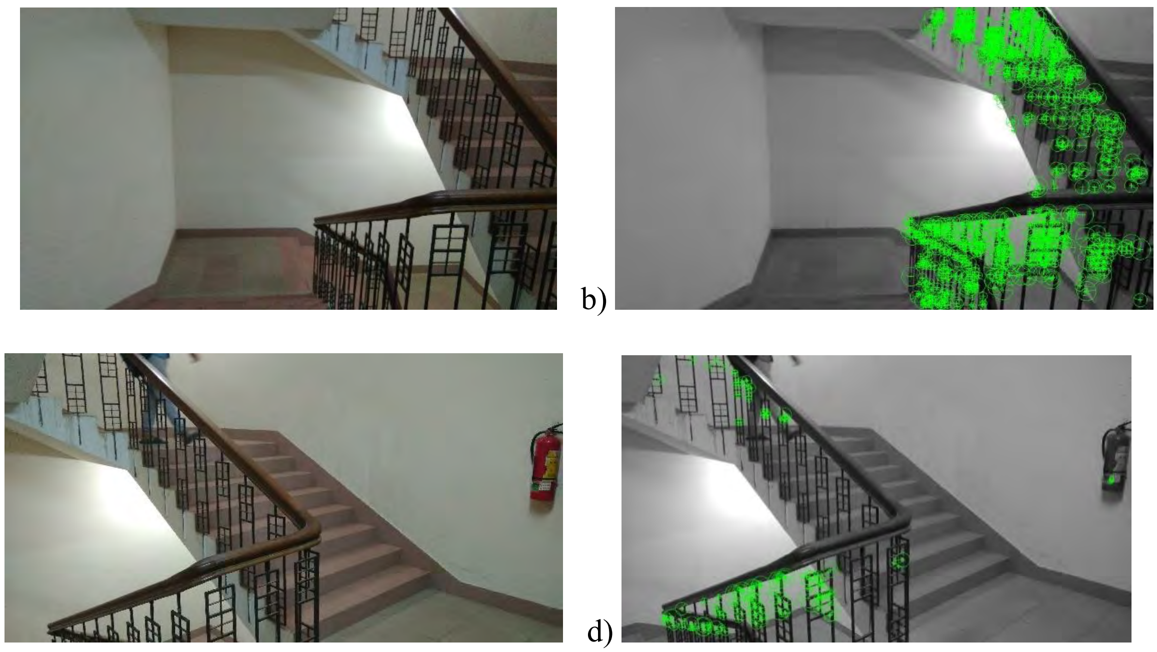
- To find the points of interest SURF uses the blob based detector on Hessian matrix. The determinant of the matrix is used as a measure of change around the point where the determinant is maximal.

  $$H(\text{Ƥ},\sigma) = \begin{pmatrix} L_{xx}(\text{Ƥ},\sigma) & L_{xy}(\text{Ƥ},\sigma) \\ L_{yx}(\text{Ƥ},\sigma) & L_{yy}(\text{Ƥ},\sigma) \end{pmatrix}$$

  Here $L_{xx}(\text{Ƥ},\sigma)$ are the second order Gaussian derivatives convolution of the image I(x,y) at point x.

- Scale spaces are like image pyramids. The Gaussian filters are reportedly applied to smoothen the image to get the higher level image of the pyramid. Firstly a 9*9 mask filter is considered as initial. Then bigger filters are applied. Then result filter size is 15*15, 21*21, 27*27 and so on.

- Non-maximum suppression is applied in the image and over the scale. The maxima of the determinant of the Hessian matrix are interpolated in the image and scales of the image. As, the difference between each octave is relatively larger the interpolation is very important.



a) b) c) d)

Figure 3.4: a) input image scene 1 b) all detected features using SURF

c) Input image scene 2 d) 150 strong detected features using SURF

As seen in the figures both the options of detecting all the features and detecting a number of strong features are available. They can be chosen based on the quality of the image.

3.4 Extracting Point and Corner Features

The motto of feature extraction [18] is to efficiently represent the interesting parts of an image and that too as a compact feature vector [19]. A feature vector is an $nx1$ array that is responsible for encoding the n features/measurements of an image. The array contents can be symbolic (a string containing the name of the predominant color in the image), numerical (an integer expressing the area of an object, in pixels) or both. Mathematically, a numerical feature vector x is given by

$$x = (x_1, x_2, \ldots, x_n)^T$$

Where,

n = the total number of features

T = the transpose operation.

As the images are not identical so the extracted feature will be helpful to reduce the amount of resources required to describe the large set of data and use only the ones that are useful for the task. Here, the detected points/corners are taken as input and the result is extracted feature vectors, which are also known as descriptors, and their corresponding locations.

Figure 3.5: Point feature (SURF) and Corner feature (Harris Corner Detector)

3.5 Feature Matching using SURF and BRISK Method

Feature matching [20] means identifying corresponding features between two similar images/datasets. Below two are the most commonly used feature matching techniques:

- Unique intensity/color configuration of region

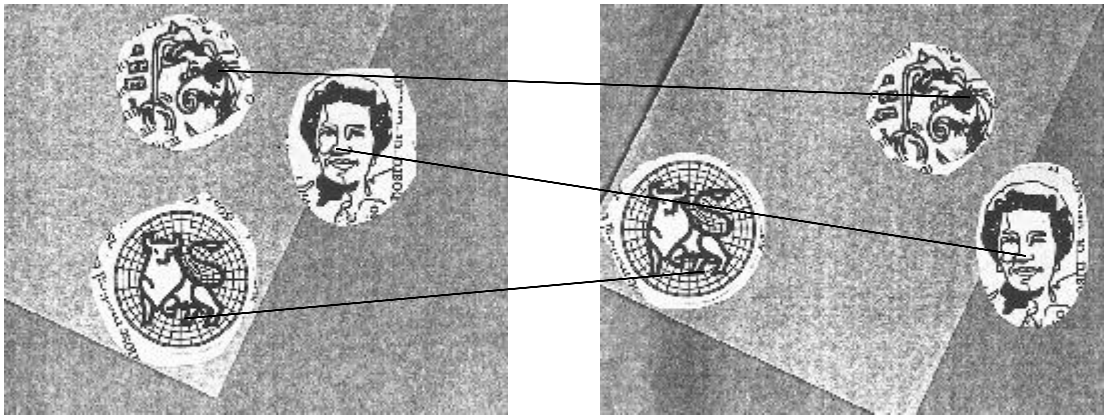


Figure 3.6: Feature matching using intensity/color [21]

➢ Geometry or topology of region

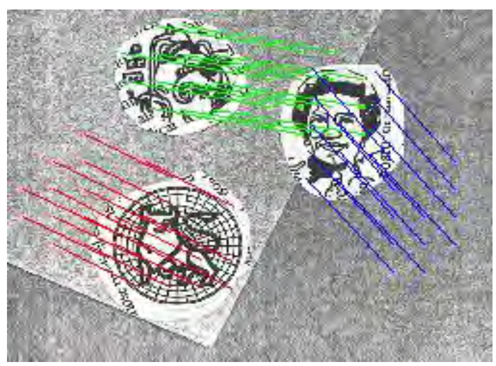


Figure 3.7: Feature matching by topology of region (similar vectors are colored the same) [21]

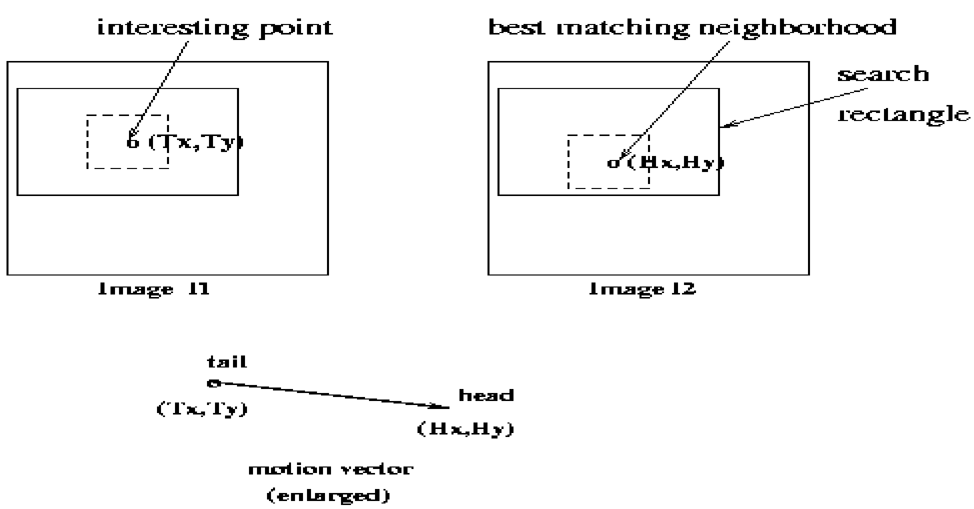


Figure 3.8: Searching best matching neighborhood for features [21]

In our work the images have some similarity but are not perfectly same due to the inconsistency of data. The images may be taken by different sensors so the quality may be different or taken from different perspective so the data are not very much alike. The results of the matching of a pair of images using SURF and BRISK methods are shown below.

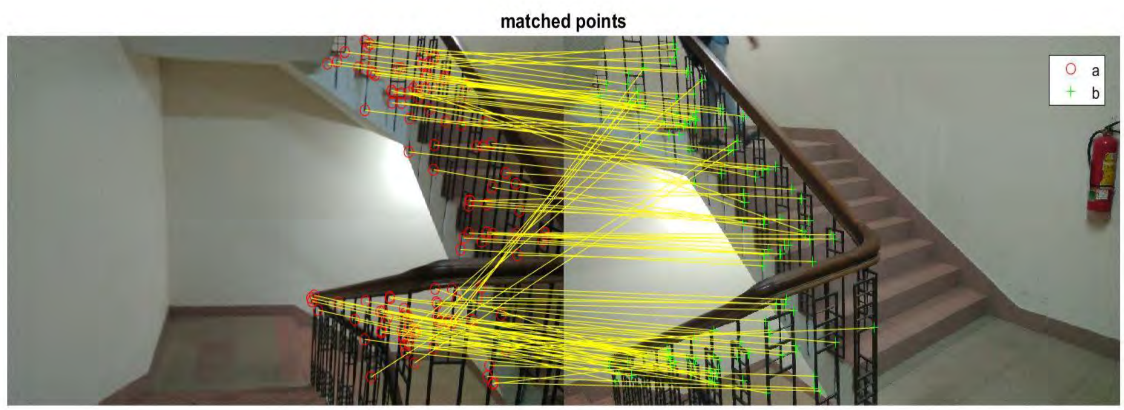


Figure 3.9: Matched features using SURF algorithm

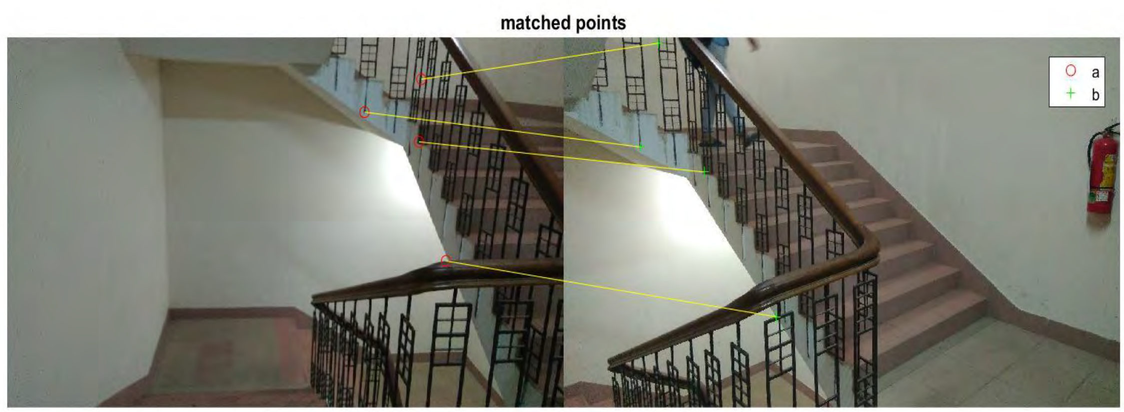


Figure 3.10: Matched features using BRISK algorithm

3.6 Transform Model

After finding the matching features it is necessary to Estimate geometric transform from the matching point pairs. The result will be a geometric transform object that maps the inliers in the first image to the inliers in the second image.

The process uses the M-estimator Sample Consensus (MSAC) algorithm and excludes the outliers. This MSAC is a variant of the Random Sample Consensus (RANSAC) algorithm,

Moreover MSAC algorithm is arbitrary in nature so results may not be alike on every run [22] [23]

w = number of inliers/points in a particular data

Most of the time w is not well-known before, but a rough value can be assumed. So, assuming n points are needed for estimating a model, w^2 can be the probability of all n points being inliers and $(1-w^2)$ is where at least one of the n points is an outlier. And the probability to the power of k is the probability that the algorithm may never select a set of n points which all are inliers which is the same as *1-p.*

$$1 - p = (1 - w^n)^k$$

This, after taking the logarithm of both sides, leads to:

$$K = \frac{\log(1-p)}{\log(1-w^n)}$$

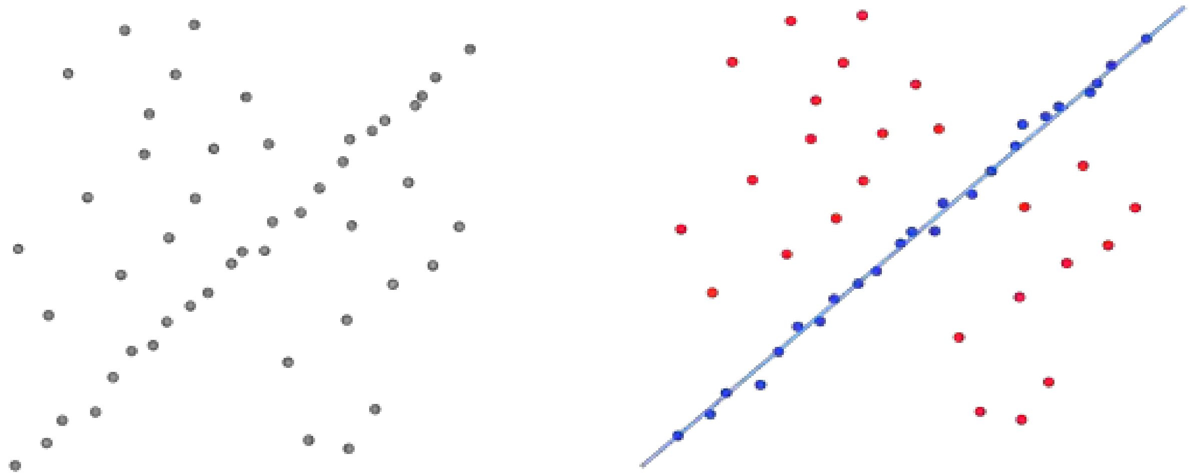


Figure 3.11: Data with many outliers vs. data Fitted line with RANSAC [24]

3.6.1 Transform Type:

The more number of point pairs are matched, the more accurate will be the estimated transformation. There are three types of transformation ‘similarity’, ‘affine’ and ‘projective’. For the respective types a minimum number of 2, 3 and 4 pairs of matched points are required.

Projective Transformation: Projective transformation preserve co-linearity which means all the lying points of a line will still be there after the transformation happens and it also preserves incidence. But it does not preserve length, angle and parallelism. [25]

Affine Transformation: On the other hand affine as it is a special case of projective transformation, in addition to having the same properties of projective it also preserves parallelism. [26]

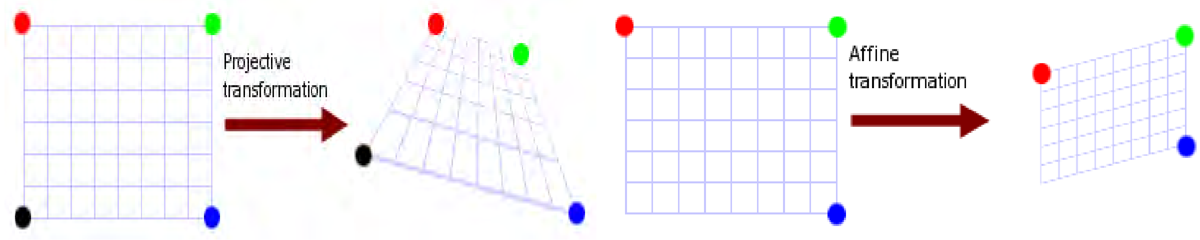


Figure 3.12: Projective transform vs. Affine transform [25]

For most of the cases we have used the projective transform as we tested on multiple situations and the projective works better than affine. However, in some cases where the camera is placed far from the captured image, affine transformation works better. Our result shows the transformation of the images:

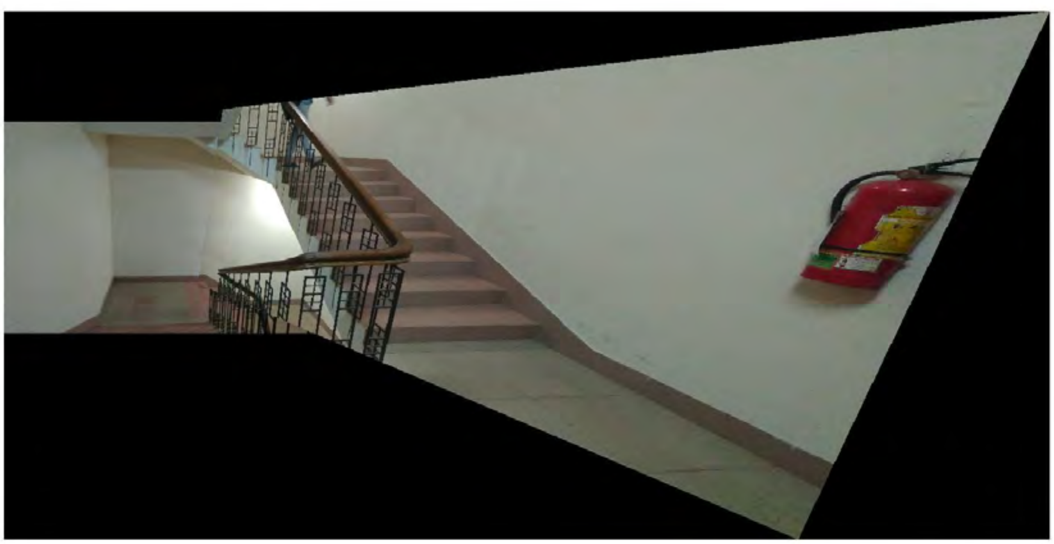


Figure 3.13: Geometric Transformation (Projective)

Chapter 4

Result and analysis

4.1 Results

We have applied three edge detection algorithms SURF, BRISK and MSER where SURF detects features as blob, BRISK as corners and MSER by region with uniform intensity. We also have applied affine and projective both on each to see which gives better result. For understanding how universal the process is we have applied each type of edge detection and geometric transformation process on images considering six different situations and recorded the time and accuracy of the result.

The situations under consideration are:

1) Images taken from different viewpoints
2) Images taken under different lighting
3) Images of different qualities (Distorted image)
4) Image pair of different perspectives (Short and long distance from the camera)
5) Rotated image
6) Multiple images

Here are the tables defining each of the situations:

SURF	**Matched Points**	**AFFINE**		**PROJECTIVE**	
		Time (s)	**Accuracy**	**Time (s)**	**Accuracy**
Different Viewpoint	6	6.968581	92%	8.658825	95%
Different Light	68	7.668549	63%	11.521172	91%
Different Quality	11	6.523592	87%	8.338492	96%
Different Perspective	52	7.241154	68%	8.596473	90%
Rotation	28	4.351330	100%	4.835939	100%
Multiple images	85	17.370232	67%	23.565562	90%

Table 4.1: Table of SURF edge detector

BRISK	**Matched Points**	**AFFINE**		**PROJECTIVE**	
		Time (s)	**Accuracy**	**Time (s)**	**Accuracy**
Different Viewpoint	Not enough points	--	--	--	--
Different Light	1	--	--	--	--
Different Quality	1	--	--	--	--
Different Perspective	Not enough points	--	--	--	--
Rotation	4	3.718211	100%	--	--
Multiple images	4	12.861460	62%	--	--

Table 4.2: Table of BRISK edge detection

MSER	Matched Points	AFFINE		PROJECTIVE	
		Time (s)	Accuracy	Time (s)	Accuracy
Different Viewpoint	3	7.682802	62%	--	--
Different Light	2	--	--	--	--
Different Quality	8	7.642032	94%	9.462759	30%
Different Perspective	1	--	--	--	--
Rotation	12	4.620744	100%	5.105966	100%
Multiple images	49	19.464507	53%	25.910655	98%

Table 4.3: Table of MSER edge detector

ALGORITHM	FEATURE TYPE	TRANSFORMATION	AVERAGE MATCHED POINTS	AVERAGE TIME(S)	AVERAGE ACCURACY
SURF	Blob	Affine	98	8.880017	79.5%
		Perspective		10.91763	93.66%
BRISK	Corner	Affine	1.67	2.8333	27%
		Perspective		--	--
MSER	Region with uniform intensity	Affine	47.33	6.56	51.5%
		Perspective		6.74%	38%

Table 4.4: Comparison among algorithms

4.2 Analysis

From the above comparison it can be stated that almost every algorithm works 100% fine with rotation of images. But others vary from situation to situation. In every situation SURF feature detection with projective transformation gives a very good registration as it detects a decent number of feature regardless the light, angle, quality, perspective or number of input images. Though it takes more time to generate output but the registrations are more universal to be precise. On the other hand, MSER gives surprisingly accurate result (Up to 98%) while applied on multiple images. The outputs of BRISK corner detection algorithm are quite unsatisfactory in most of the cases. The below charts show the outputs in a simpler manner.

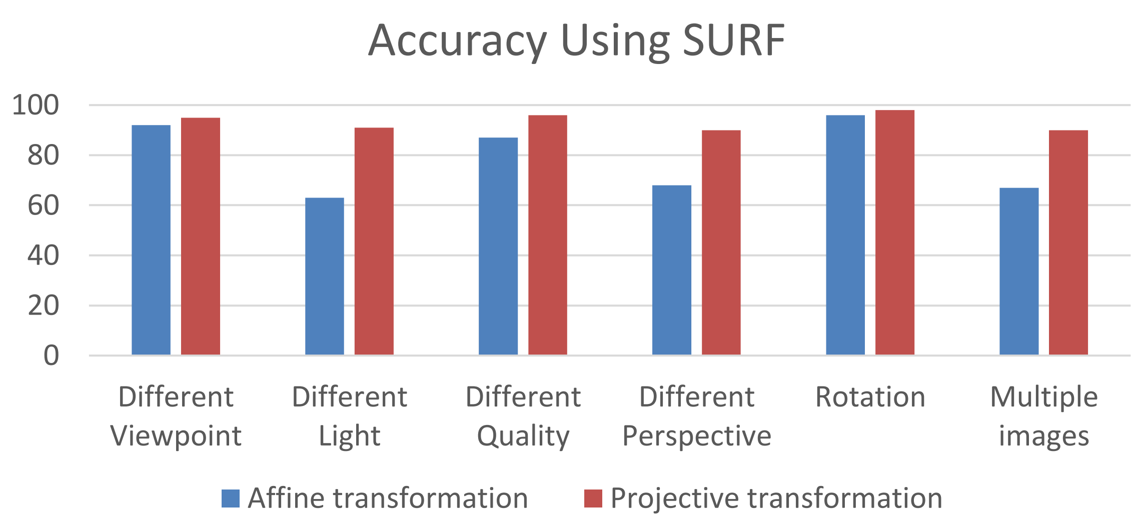


Figure 4.1: Bar graph showing the accuracy of SURF

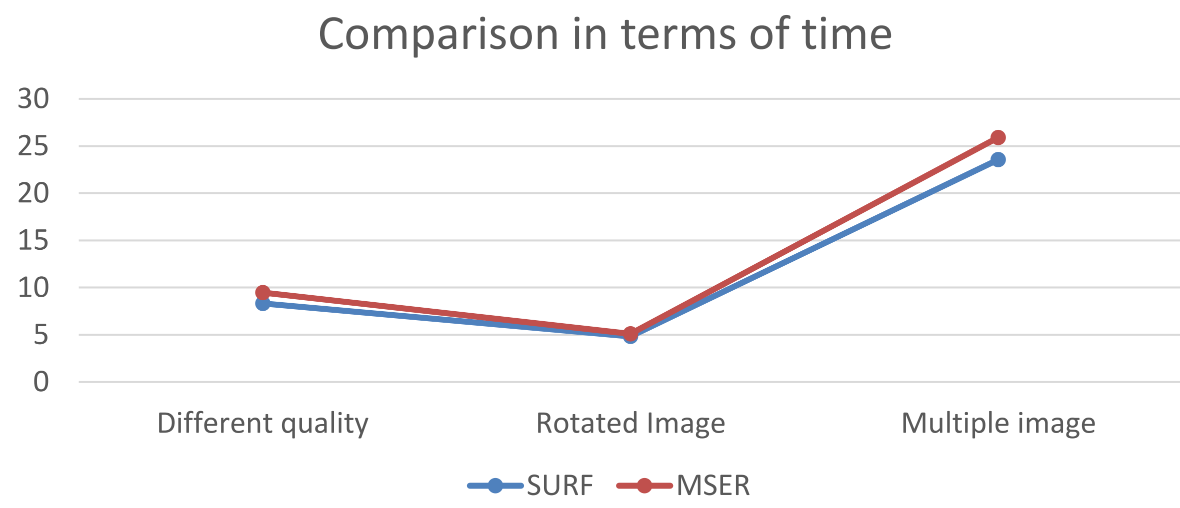


Figure 4.2: SURF vs. MSER in terms of time

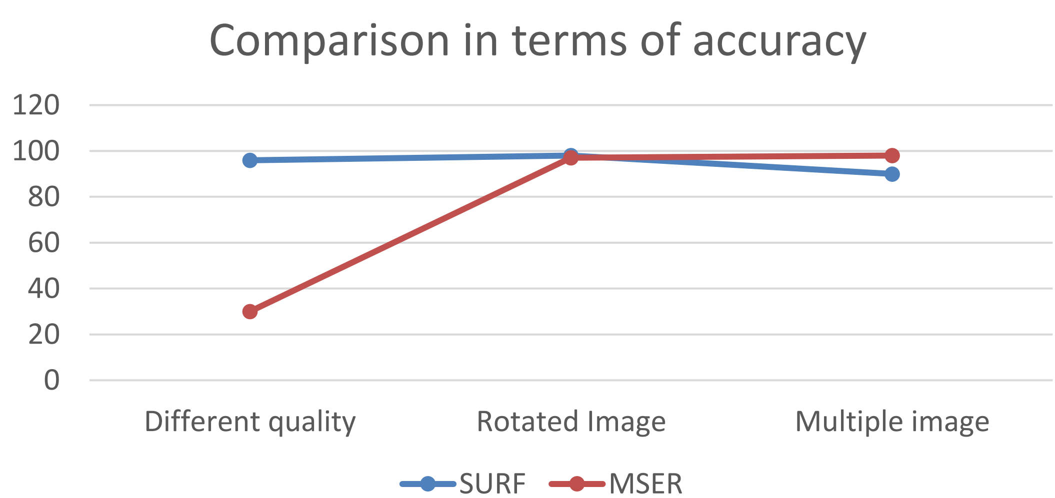


Figure 4.3: SURF vs. MSER in terms of accuracy

4.3 Outputs of SURF feature detection using projective transformation:

- **Different viewpoint**

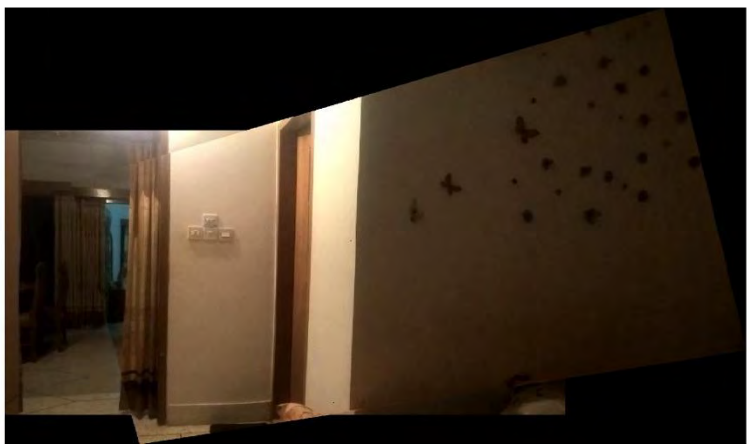


Figure 4.4: input images from different viewpoint (up), registered scene (down)

- **Different image quality**

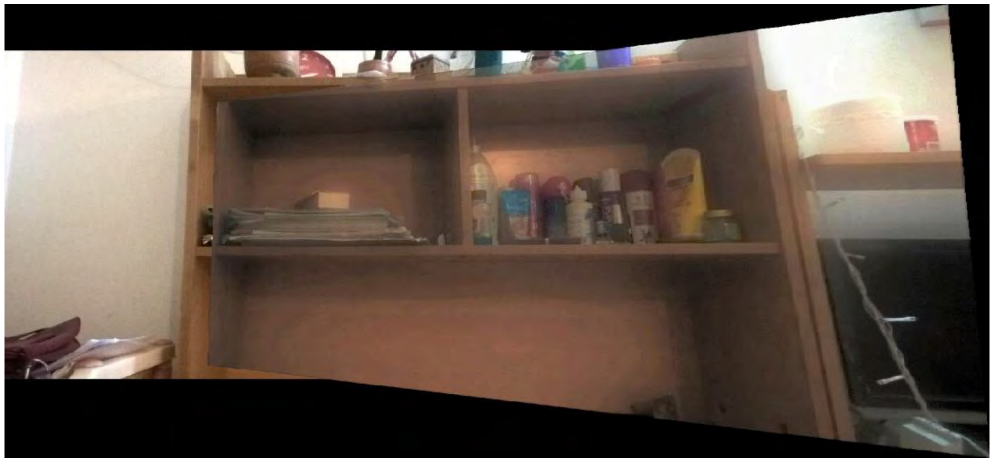


Figure 4.5: input images of different quality (up), registered scene (down)

- **Different perspective**

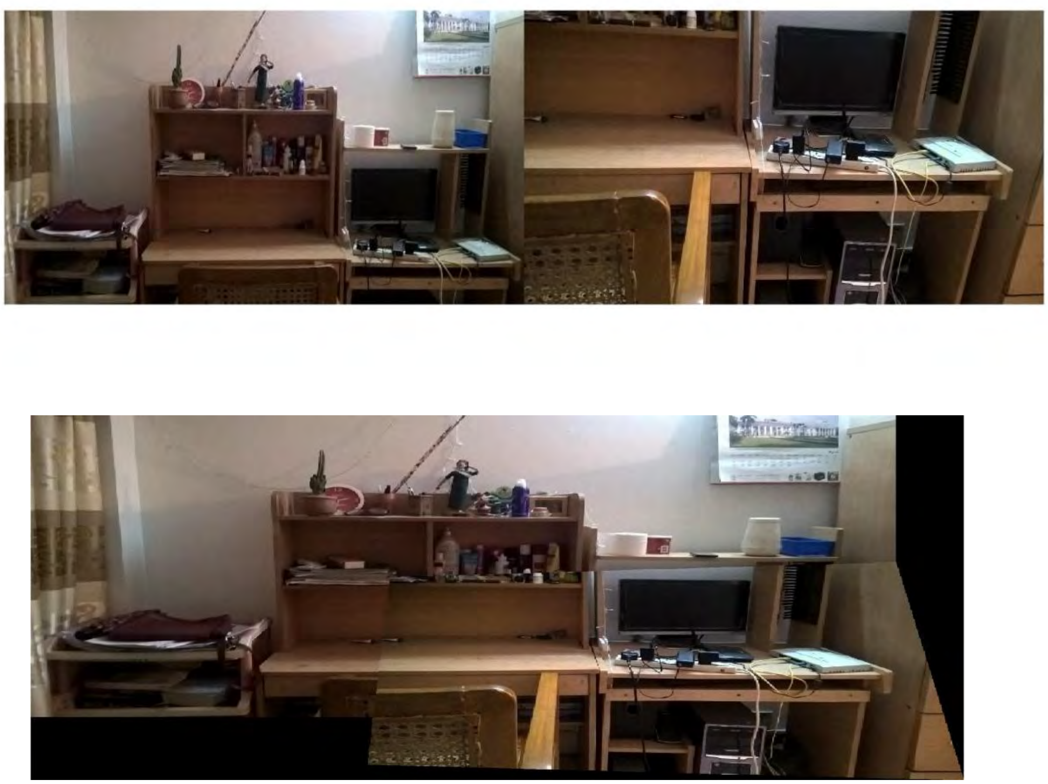


Figure 4.6: input images from different perspective (up), registered scene (down)

- **Light difference**

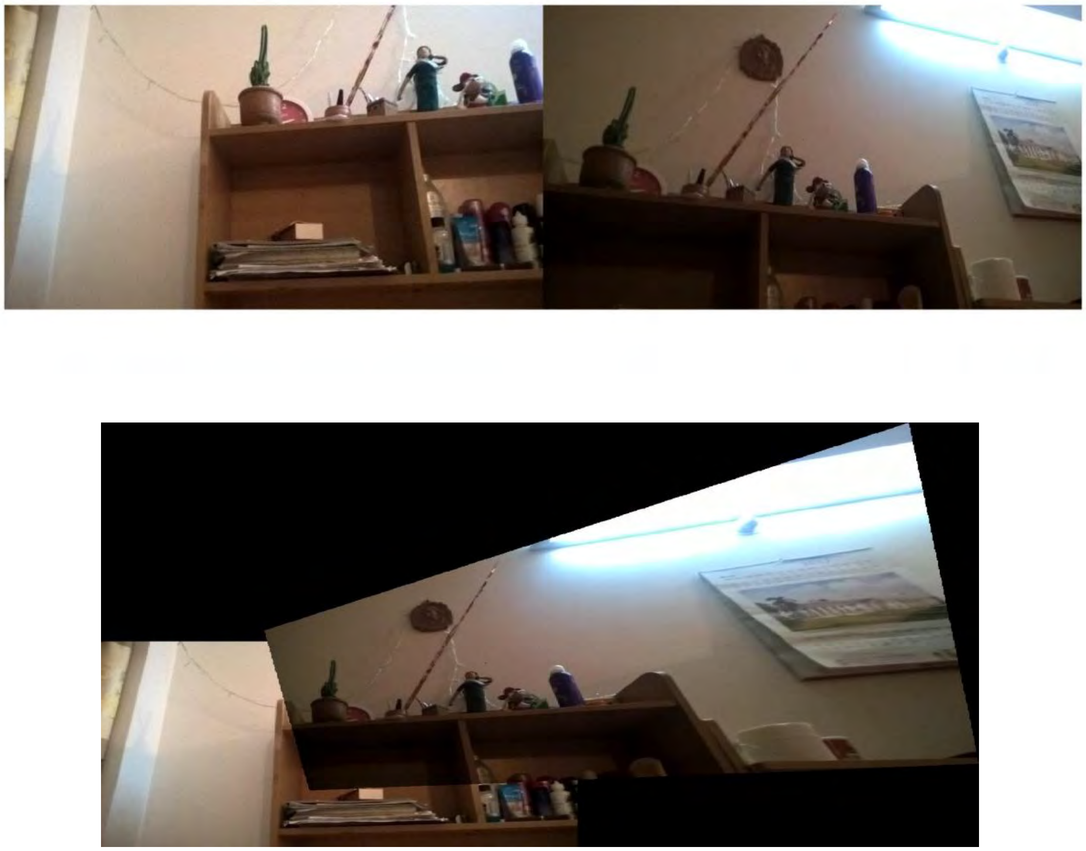


Figure 4.7: input images in different light (up), registered scene (down)

- **Rotated image**

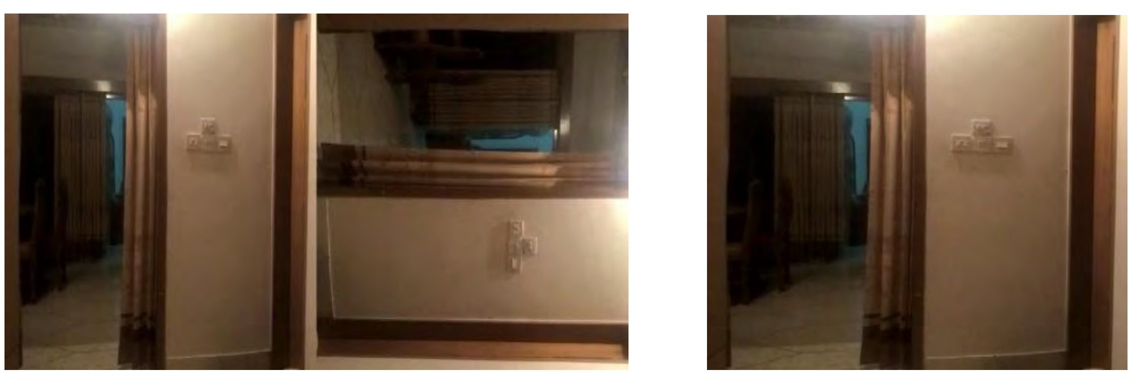


Figure 4.8: input images rotated (left), registered scene (right)

- **Multiple images**

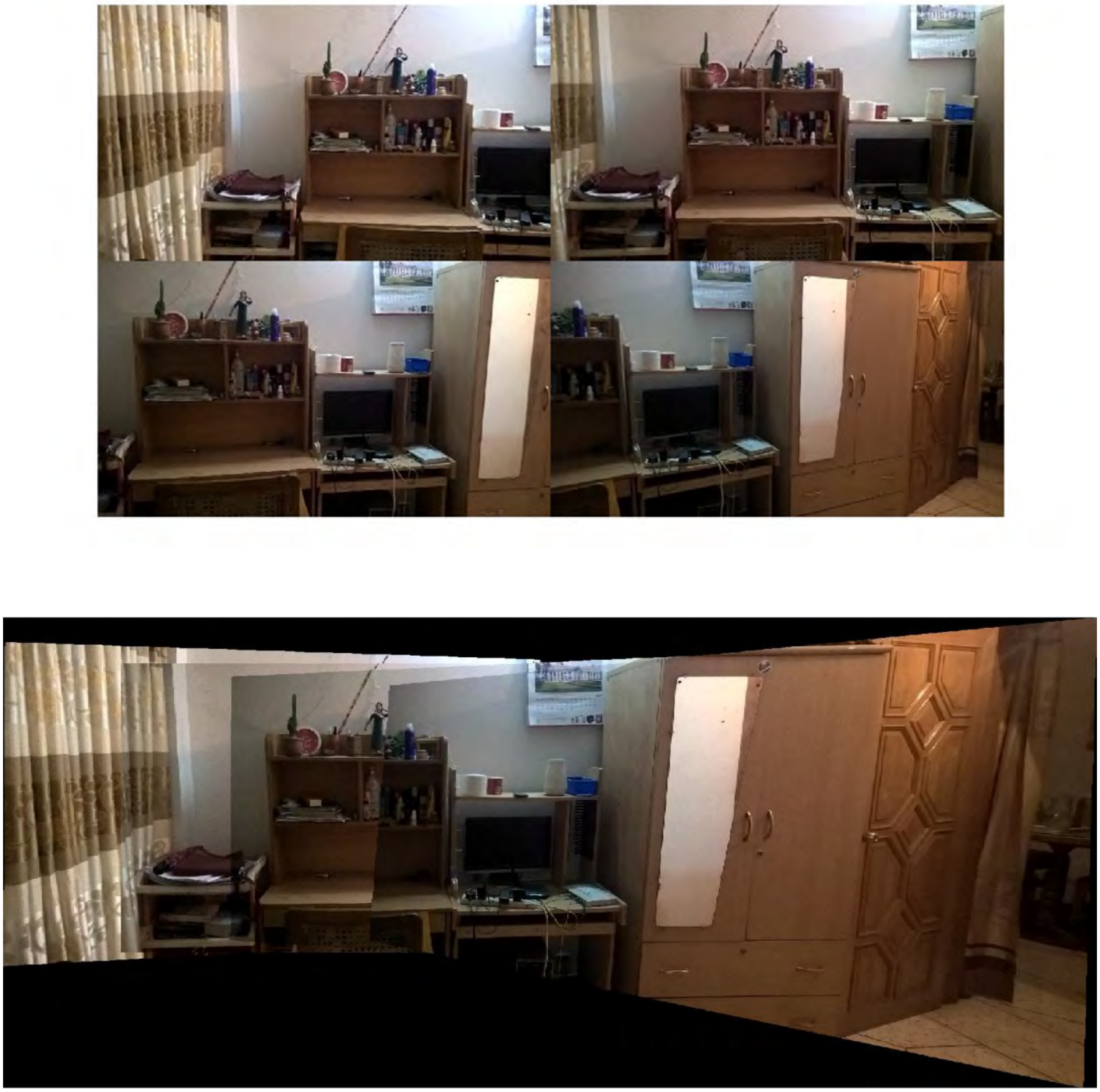


Figure 4.9: input images in different light (up), registered scene (down)

Chapter 5

Conclusion &
Future Development

5.1 Conclusion

In this research, we have proposed a 2D shape reconstruction technique by performing image registration. For that, we have used SURF algorithm as it can detect more features and works comparatively faster. We have used affine and projective transformation based on the focus of the scene. In almost 90% cases this model can register scenes. Cross examination of different algorithms were performed to bring more accuracy in the outputs. But a few things are needed to be solved for more diversity. Our proposed model doesn’t work robustly when one of the input images is flipped. As, descriptions of our proposed model it is clear that our input goes through various processing so image degradation is not unavoidable specially when the input images are of different sizes. Then, as the color contrast of input images are not the same, the color contrast of the registered scene is not totally smooth. Same thing happens when input images are of different qualities. As our concentration was fully upon image registration we did not focus upon image enhancement.

5.2 Future Development:

As described before, our proposed image registration technique does not work robustly when a scene completely opposite of another scene. In future, we tend to fix this issue. Moreover, we would like to fix the color of the registered image as it cannot fix the colors robustly. Then the image quality issues can be fixed by performing image enhancement.

Finally the major part that we want to include in the model is 3D registration. Our model generates the feature and transforms the images by overlapping the images based on the transformation calculated. So, it creates a 2D shape of the whole scene. But detecting the points and applying advanced geometric transformation 3D shape of the scene can be created.

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