Comparison of Various Feature Detectors and Outliers Removal

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Abstract
Image registration is the process in which two or more images of the same scene taken at different times are overlayed. For registering two images, preliminary steps are feature detection, matching and control point detection. For feature detection and matching there are many point detectors. The common among them are Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF).The control points are detected using SIFT, SURF, Correlation based matching and then the results are compared using the number of keypoints and matches and the results are considered for further process. Then the outliers are removed by using RANSAC algorithm.

Keywords
Image Registration, SIFT, SURF, RANSAC

I. Introduction

Image registration is the process of matching two images so that corresponding coordinate points in the two images correspond to the same physical region of the scene being imaged [1]. These two images may be referred to as reference image (which is fixed) and sensed image or target image (which has to be fixed).These images may be of single modality or multimodality. Image registration techniques can be mainly classified as intensity based and feature based image registration [2]. In Intensity based image registration [3] the intensity pattern in the two images are compared. This can be obtained by the maximization of mutual information [3], correlation and template and pixel intensities. Feature based [4] approaches are used to find the distinct features of two images. These features are points, curves or a surface model. Feature based image registration [4] can handle complex data such as image distortion and will be faster because they will not match every single voxel in the image but rely on relatively small number of features. This paper focus on feature based image registration. The majority of the registration methods consist of following four steps [5]:

A. Feature Detection

Salient and distinctive objects (closed boundary regions, edges, contours, line intersections [6], corners etc) are manually or automatically detected.

B. Feature Matching

Correspondence between features are detected in this step [7-8]. Various feature descriptors and similarity measures along with spatial relationship among the features are used for that purpose.

C. Transform Model Estimation

In this parameters are find out which can otherwise called as mapping functions, aligning the sensed image with the reference image are estimated.

D. Image Resampling and Transformation

The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates [8] are computed by the appropriate interpolation technique. Steps in image registration can be shown in fig. 1.

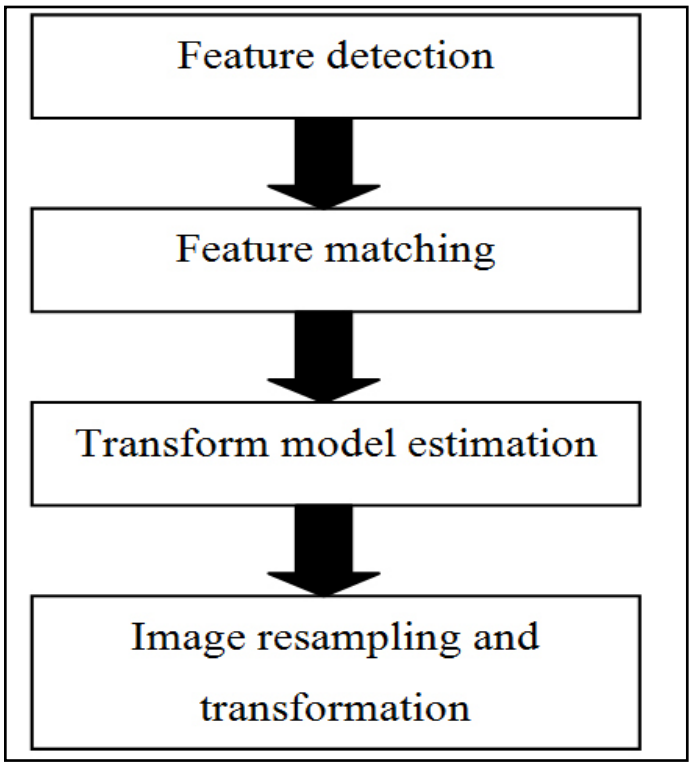


Fig. 1: Steps in Image Registration

Feature detection and matching are the initial steps in image registration. The reason for going feature detection is that it is useful for finding whether a feature that may be either an edge, corners/interest points, blobs exist in a particular point or not. Thus the points which have features will be subsets of image domain. The features obtained can be reffered to as interest points of an image and is considered as the starting points of many algorithms, so the overall algorithm will depend upon the feature detectors. Feature detection is performed as the first operation on an image and is considered as the low-level image processing operation. Different types of feature detectors are available SIFT and SURF are the commonly used feature detectors. Feature matching is the process in which the features obtained in the reference and sensed image are matched.
In this paper, one of the two images in a set of two will be referred to as the reference image and the second image will be referred to as the sensed image. The reference image is the image which is kept unchanged and the sensed image is the one has to be changed.

II. Approach

A. Flow of Computation

The flow of computation of the proposed method is shown in fig. 2. Image preprocessing is done for both the images. Image

preprocessing involves removal of low frequency background noise, normalizing the intensity of the individual particles This is a technique of enhancing the image quality for further analysis. In this paper image sharpening and edge detection is done. Image sharpening is a technique that highlights edges and fine details in an image. Edge detection is the fundamental task in image processing, useful in feature detection and extraction.

Image pyramid represent a mutiresolution analysis which is a collection of decreasing resolution images arranged in the shape of pyramid. The image at the bottom of pyramid represents high resolution and the image at the top will represent the low resolution image.

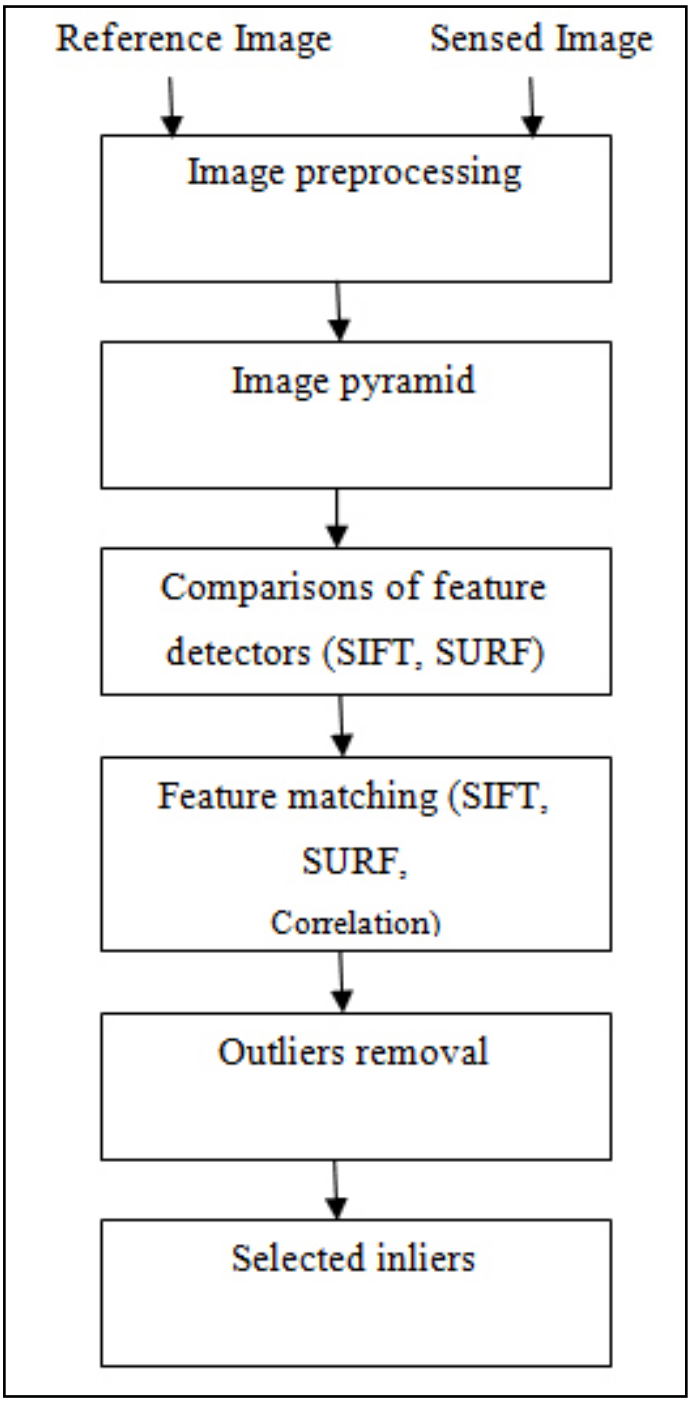


Fig. 2: Flow of Computation

Wide variety of feature detectors are available [9]. Among them Scale Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) are used for the comparison. Feature matching is then performed by SIFT, SURF and correlation based matching and the results are compared. Then RANSAC algorithm is used to remove the outliers which are not suitable for the operation.

III. Overview

A. Scale Invariant Feature Transform

Scale Invariant Feature Transform (SIFT) of Lowe [10] is an algorithm to detect and describe local features [11] in an image. These have a wide application in object recognition, robotic mapping and image stitching. SIFT detector [10], finds the keypoints in an image and finding matching features based on the Euclidean distance [17] of their feature vector obtained from the two images are used to select the required points. SIFT [10], consists of four main stages: Scale-space extrema detection, keypoint localization, Orientation assignment and keypoint descriptor. Difference Of Gaussian (DoG) is used to identify the potential interest points [12] in the scale-space extrema detection. DoG image $D(x,y,\sigma)$ is given by

$$L(x,y,\sigma)=G(x,y,\sigma)*I(x,y) \quad (1)$$

B. Speeded-Up Robust Features

SIFT and SURF [13], differs small in ways of detecting features. SURF creates a stack instead of pyramids in SIFT without 2:1 downsampling for higher levels. SURF make use of integral images [14], SURF follows the same steps in SIFT. In keypoint matching step the nearest neighbor is defined as the keypoint with minimum Euclidean distance for the invariant descriptor vector. SURF is based on sums of 2D Haar wavelet responses and makes an efficient use of integral images.

C. Correlation Feature selection

Correlation feature selection makes use of Harris corner detector to find out the feature points. The Correlation Feature Selection (CFS) measure evaluates the subsets of feature obtained from Harris corner detector on the basis of "Good feature subsets contain features highly correlated with the classification yet uncorrelated to each other" [15].

D. RANSAC

RANdom Sample Consensus (RANSAC) [16], algorithm is an iterative method to estimate the outliers from set of data which contain both inliers and outliers. This produces a reasonable result as a probability and is increased when the number of iteration is increased. The outliers are the data that donot fit the model this can be noise or maybe incorrect construal of data. A set of observed data values is the input to the RANSAC [16,19] algorithm then the model can be set which contain some parameters.RANSAC [16] will select a random number of points from the original data. These selected random data is considered as the hypothetical inliers. The algorithm is as follows [16]

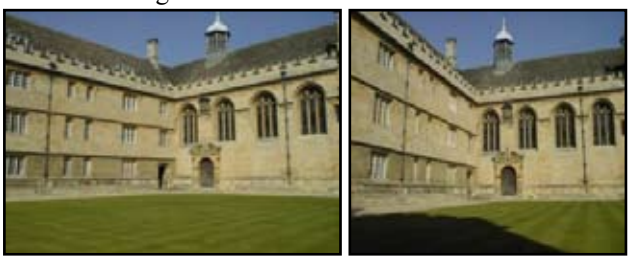
1. Hypothetical inliers are fitted by using a model.
2. Other data other than the hypothetical inliers are tested to the fitted model.
3. The model can be selected if it have large amount of inliers.
4. The model is reestimated until it get best inliers.
5. Then the model checked with error.

The procedure is repeated for a fixed number of times, and then selects a model which gives maximum inliers.

IV. Results and Discussions

A. Data sets

To evaluate the performance of the feature detectors and the outliers removal the results of two images are reported and discussed. The images shown in fig. 3 are the reference and sensed image respectively and are of size 1024x768 represents two views of Wadham college.



(a) (b)

Fig. 3: Images used to Evaluate the Performance of Feature Detectors. (a) Reference Image, (b) Sensed Image

B. Image Pyramids

An Image pyramid is created for both the reference image and the sensed image. Images at the bottom of the pyramid represents the high resolution images and images at the top will represent the low resolution images, and images at the middle represent the mid resolution images. Images are reduced by a scale factor of 2. Fig. 4 and 5 represents the image pyramid for the reference and sensed image.



(a) (b) (c)

Fig. 4: Image Pyramid for the Reference Image. (a) High Resolution Image (b). Mid Resolution Image, (c). Lowest Resolution Image



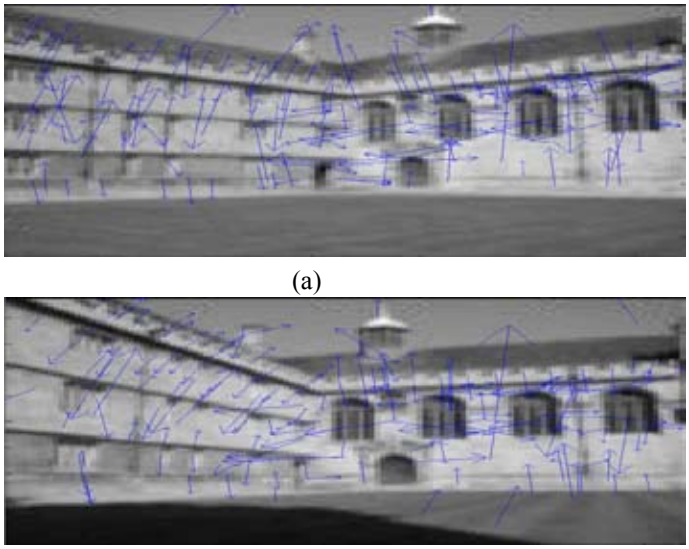
(a) (b) (c)

Fig. 5: Image Pyramid for the Sensed Image. (a). High Resolution Image, (b). Mid Resolution Image, (c). Lowest Resolution Image

C. Feature Detectors

1. SIFT

SIFT is used to find the keypoints from the images. The keypoints are represented by arrows. Each keypoints gives location, scale and orientation. The main advantage of SIFT [10] is that it is invariant to scale and rotation and also gives better positional accuracy. Lowest resolution image is used to find the keypoints and is shown in fig. 6.



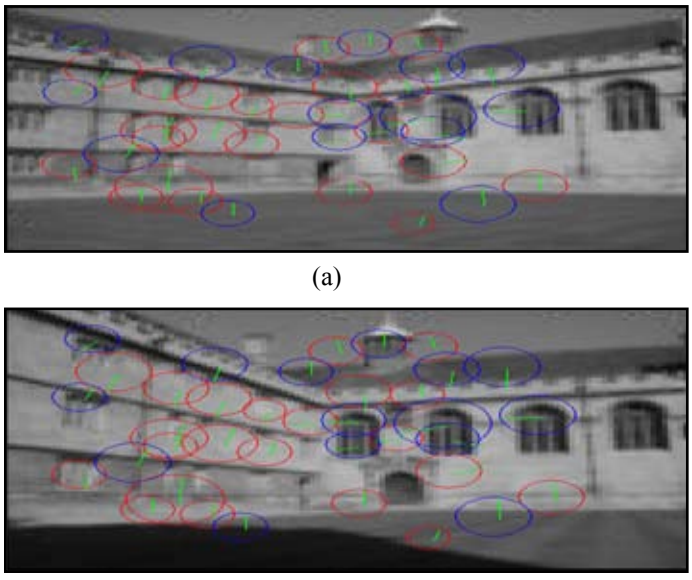
(a)

(b)

Fig. 6: Feature Detection using SIFT. (a) Keypoints in Reference Image. (b) Keypoints in Sensed Image

2. SURF

SURF uses fast Hessian blob detector to detect the keypoints from an image. In this green lines represent the orientation. Keypoints using SURF can be shown in fig. 7.



(a)

(b)

Fig. 7: Feature Detection Using SURF. (a) Keypoints in Reference Image. (b) Keypoints in Sensed Image

3. HARRIS Corner Detector

HARRIS corner detector is useful for finding the features likes edges and corners. The features detected by HARRIS is given in fig. 8.



(a)



(b)

Fig. 8: Feature Detection Using Harris Corner Detector. (a) Keypoints in Reference Image, (b) Keypoints in Sensed Image.

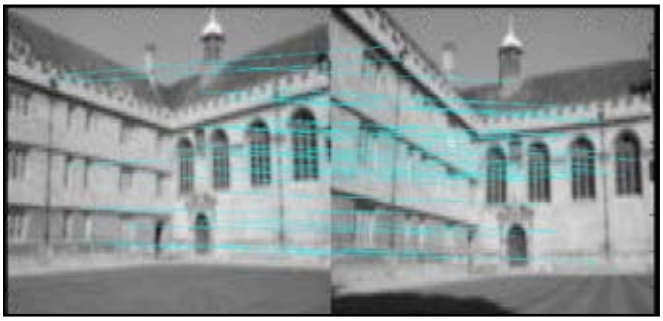
Table 1: Comparison Between SIFT and SURF

Images	Number of keypoints	
	SIFT	SURF
Reference image	169	32
Sensed image	171	37

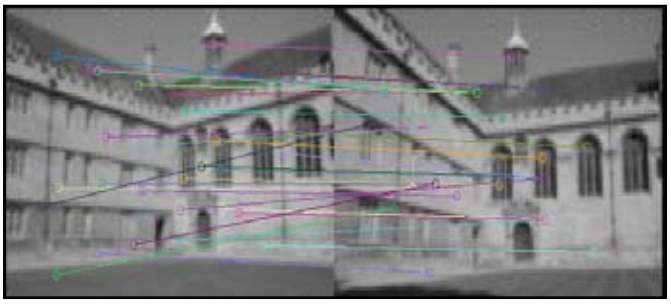
Table 1 gives the comparison between SIFT and SURF interms of number of keypoints. SIFT detects 169 keypoints in the reference image, but SURF detects 32 keypoints. In sensed image SIFT detect 171 SURF detect 37.

D. Feature Matching

Feature matching is used to find out the correspondence between two images. This will matches the matching points in both the images by a straight line. Feature matching using SIFT, SURF and correlation based is shown in fig. 9(a)-(c)



(a)



(b)



Fig. 9: Feature Matching,(a) Feature Matching Using SIFT, (b) Feature Matching Using SURF, (c) Correlation Based Putative Matching.

Table 2: Comparison Interms of Matches

Methods	Number of matches
SIFT	36
SURF	30
CORRELATION BASED	21

Table 2, gives the comparison interms of number of matches. SIFT gives good matches.SURF gives 30 matches while correlation gives 21 matches.

E. Outliers Removal

Outliers removal can be done by using RANSAC algorithm. RANSAC takes random number of samples, and fit a model to it. It finds the best model by doing an iterative method depends on inliers. The inliers are represented by green points and outliers are represented by red points shown in fig. 10.

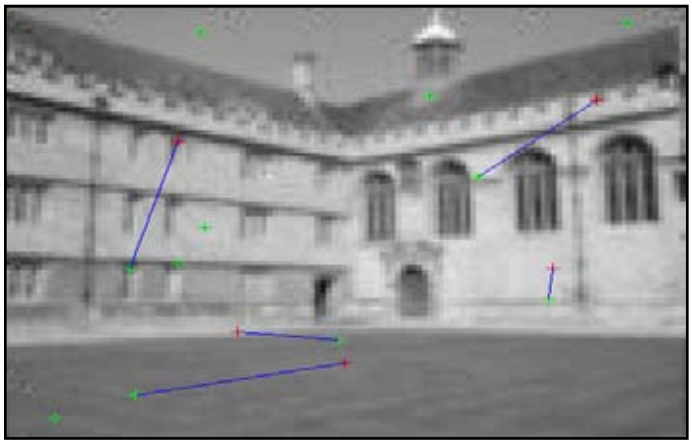


Fig. 10: Outliers Removal

V. Conclusion

For performing image registration, it is necessary to find out the features of two images, reference image and the sensed image and then to match that features. In this paper a comparison is done based on the number of keypoints and number of matches. SIFT performs well in feature detection and matching but SURF performs faster compared to SIFT. So depending upon the application the feature detectors are choosen .RANSAC is an effective algorithm for detecting the inliers and outliers.In our results RANSAC found out 57% of inliers from the data set.

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