Accurate Image Registration using SURF Algorithm by Increasing the Matching Points of Images

Megha M Pandya[1], Nehal G Chitaliya[2], Sandip R Panchal[3]
[1]ME Scholar, Department of Electronics & Communication Engineering
[2]Research Scholar, Department of Electronics & Communication Engineering
[3]Research Scholar, Department of Electronics & Communication Engineering
[1, 2] Sardar Vallabhbhai Patel Institute of Technology, Vasad (Gujrat), India
[3]Charotar University of Science and Technology, Changa (Gujrat), India
[1]meghapandya27@yahoo.in, [2]nehal_chitaliya@yahoo.co.in,
[3]er_sandip79@yahoo.com

***Abstract* – Feature extraction and feature matching are the basic steps of image registration and accuracy of the panoramic image is mostly depending upon the feature matching. To reduce the time for feature detecting, SURF is mostly used algorithm as it is the fastest descriptor. This paper shows that by increasing the matching points, image registration can be accurately done. To increase the quality of the image, the process applied on the images are filtering and edge detection, for which different operators can be used. In this paper, SURF is used for feature extraction, RANSAC is for outlier elimination, and at end affine transformation is used as transformation model. Based on experiments SURF is the fastest algorithm, so panorama image for large image can be obtained in less time period.**

***Keywords* – Affine transform, edge detection, panoramic image, SURF, RANSAC.**

I. Introduction

IMAGE processing is the improved technique of pictorial information having the different working areas like object recognition, morphology operation, motion detection, face recognition and image registration. But now-a-days, image registration is the most interested area as it can be used for Computer vision, Remote sensing, Medical imaging, Pattern recognition, Image retrieval, Target recognition, Monitoring global land usage using satellite images, Matching stereo images to recover shape for autonomous navigation and aligning images from different medical modalities for diagnosis[1]. It can be defined as the overlapping two or more images from the same scene and combined them to make the panoramic image. This can be shown in the Figure 1. So panoramic image is nothing but the alignment of the images taken from same scene matches the points and by stitching, make one image containing the whole scene [2]. The process contains four [4] steps but feature detection and points matching performs the important task for making panoramic image so it is the main concentration of this paper. For the purpose of feature detection, three detectors can be used: (1) Harris corner detector [5], (2) Scale Invariant Feature Transform (SIFT) detector [4] and (3) Speeded Up Robust Feature (SURF) detector [6].

IMAGE 1 IMAGE 2

PANORAMIC IMAGE

Fig.1. two images are combined and making panoramic image

By using Harries corner detector, the calculation can be done easily and also corners can be detected very accurately in the images. But it cannot adapt to the changes for scale which largely affects its application. SIFT algorithm, is a good robustness of the scale invariant feature description method. But because of some disadvantages, such as highly time complexity it is not applicable to the real-time problems. To overcome such limitations, many improved versions of SIFT were proposed which reduce the computation time, such as PCA-SIFT [7]. PCA-SIFT can improve the performance in case of scaling and rotation but still it cannot recover the time required. So for most of the real time applications, SURF is used as feature detector. Also the integral images and box filters are used to improve the speed of detection in SURF [7].

Then again to decrease the computation time through the homography estimation, RANSAC is used. It eliminates the outliers from the extracted points. RANSAC is the robust estimation procedure that uses a minimum set of randomly sampled correspondence to estimate image transformation parameters. After this elimination process, only matching inlier points are remaining. According to these points, transformation model can be estimated, which is affine transform. It is sufficient to match two images of a scene taken from the same viewing angle but from different position.

By using the above mentioned algorithms, panoramic image can be obtained. But for obtaining accurate panoramic image having good quality, the maximum numbers must be matched from the original extracted points. And for that, different processes are performed on the images like filtering and edge detection by using different operators. After getting the number of matching points, the images can be stitched. So the stitching can be done very accurately and good panoramic (registered) image can be obtained.

In this paper, the main intension is to increase the matching points and then stitch the images so accuracy can be improved in making of panoramic image. Section 2 shows the basic flow of panoramic image. Section 3 gives the deep information of the algorithms used for image stitching in this paper. In section 4, the experimental results have been shown. At last it gives the total contribution of this paper.

II. Basic Flow to Make Panoramic Image

Panoramic image is the combination of two or more images from the same scene but taken at different time, different cameras and different viewpoints. First of all, two or more images are captured by the camera at different time or viewpoints but from the same scene. Then by using the SURF descriptor, feature points are extracted. But among all these points, only matching points from the both the images are considered. After that, unwanted outlier points are eliminated using RANSAC. So, only matching inliers are remaining. Then affine transform is used as geometric transformation model. Then stitch the images and make panoramic image. In this paper, two images are taken. The process flow diagram of making panoramic image is shown in Fig. 2.

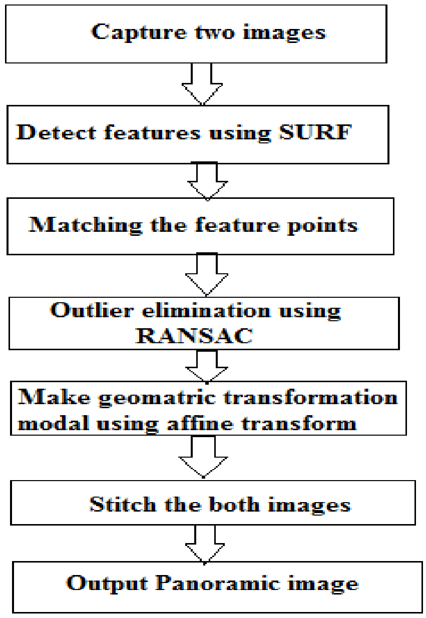


Fig. 2. Process flow for Making of panoramic image

III. Introduction to Algorithms Used for Images Stitching

A. Speeded Up Robust Feature Detector(SURF):

In feature detection, SURF is faster than SIFT which is the main requirement of the today's real time application. It is the robust image detector and descriptor. SURF detector is mainly based on the approximated Hessian Matrix [2]. On the other hand, the descriptor gives a distribution of Haar-wavelat responses within the interest points neighborhood [2]. Both the detector and descriptor are used to reduce the computation time because descriptor has low dimensionality. So that SURF is better than previously used schemes with respect to repeatability, distinctiveness, robustness and speed.

SURF creates a "stack" without 2:1 down sampling for higher levels in the pyramid resulting in images of the same resolution. Due to the use of integral images, SURF filters the stack using a box filter approximation of second-order Gaussian partial derivatives [7], since integral images allow the computation of rectangular box filters in near constant time. In keypoint matching step, the nearest neighbour is defined as the keypoint with minimum Euclidean distance for the invariant descriptor vector. The Gaussian second order partial derivative box filters of D_{yy} and D_{xy} are show in Fig. 3.

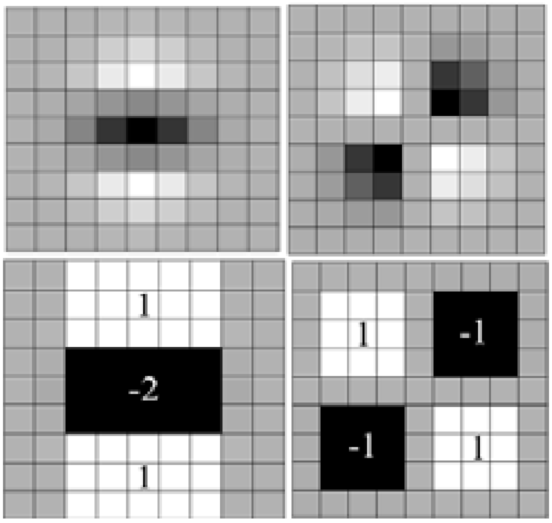


Fig. 3. The Gaussian Second order partial derivative box filters in in y-(Dyy) and xy-direction (Dxy) [6]

Fast Hessian Detector

Surf detector is based on the Hessian metrics which causes good performance and also good accuracy. Suppose in the image I, X = (x , y) is the given point, then the Hessian metrics H(x , σ)[2] for the X having the Scale σ, is defined as given in equation(1)

$$H(x, \sigma) = \begin{bmatrix} Lxx(x,\sigma) & Lxy(x,\sigma) \\ Lyx(x,\sigma) & Lyy(x,\sigma) \end{bmatrix} .. \quad (1)$$

Where Lxx(x, σ) is the convolution of the Gaussian second order derivative $\frac{\partial^2}{\partial x^2}$ g(σ) with the image I in x and same for Lxy(x, σ), Lyx(x, σ) and Lyy(x, σ).

In approximated Hessian detector, an approximated Hessian matrix using box filter is used instead of only Hessian matrix as shown in Fig. 3. Here, 9×9 box filter is used having σ = 1.2[2]. Normally, the filter response is normalized with respect to the mask size.

SURF Descriptor

In the first step of the SURF descriptor, to extract the feature points, fix a reproducible orientation based on information from a circular region around the interest point. After, it built a square region aligned to the selected orientation. To become the invariant to rotation, it calculates the Haar- Wavelet which responses in x and y direction as shown in Fig. 4.

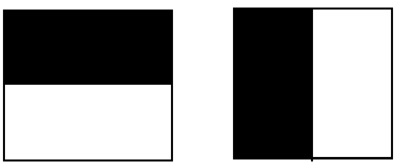


Fig. 4. Haar-wavelet response in x and y direction

It can be processed in a circular neighborhood of radius 6s around the interest points, where s is the scale at which the interest points are detected. By calculating the sum of all responses within a sliding orientation window which covering a 60 degree [2], the dominant orientation is estimated. Then the horizontal and vertical responses within the window are summed and the resulting is called a new vector. The longest such vector lends its orientation to the interest point.

The size of the window is 20s [2]. The whole region is split up regularly into 4×4 square sub region. A few simple features are computed at 5×5 spaced sample points. Here, dx is the Haar wavelet response in horizontal direction and dy is the Haar wavelet response in vertical direction. So, this descriptor having the low dimensionality that reduces the computation time.

B. Random Sample Consensus (RANSAC):

RANSAC (RANdom SAmple Consensus) algorithm is used to estimate parameters of a mathematical model from a set of observed data. These data contains outliers [4]. After searching initial homonymy point-pairs from BBF method, this algorithm can be used to eliminate mismatches. The steps for this algorithm can be given as:

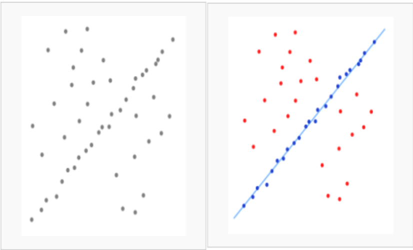
1. A model is fitted to the hypothetical inliers, i.e. all free parameters of the model are reconstructed from the inliers.
2. All other data are then tested against the fitted model and, if a point fits well to the estimated model, then considered as a hypothetical inliers.
3. If many points are obtained from the hypothetical inliers, the model is re-estimated very accurately.
4. Finally, the model is evaluated by estimating the error of the inliers relative to the model.

This procedure is repeated a fixed number of times, each time producing either a model which is rejected because few points are classified as inliers or a refined model together with a corresponding error measure. RANSAC can produce a model which is only computed from the inliers, provided that the probability of choosing only inliers in the selection of data is sufficiently high. The output of the RANSAC algorithm can be shown as given below in Fig.5.

Here, both the images (a) and (b) shows the information about,

(a)A data set with many outliers from which a line has to be fitted

(b) line using RANSAC, outlier has no influence on result



(a) (b)

Fig. 5 Outlier elimination using RANSAC

C. Affine Transformation:

The most commonly used registration transformation is the affine transformation which issufficient to match two images of a scene taken from the same viewing angle but from differentposition. It is composed of scaling, translation, and rotation. It is global transformation which isrigid. Affine transformations are more general than rigid. The equation for P'can be given as,

P' = Ap + t …………….. (2)

The general 2D affine transformation can be given as,

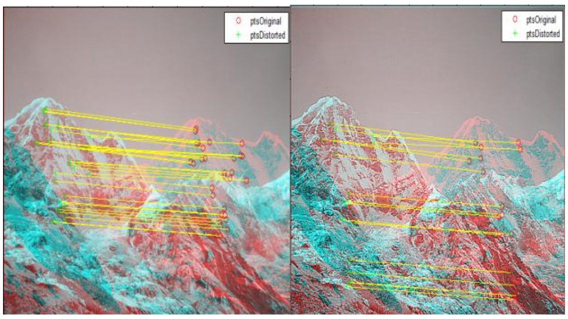
$$\begin{bmatrix}x'\\y'\end{bmatrix} = \begin{bmatrix}tx\\ty\end{bmatrix} + \begin{bmatrix}a11 & a12\\a21 & a22\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} \quad ....(3)$$

Angles and lengths are not preserved. Parallel lines remain parallel.

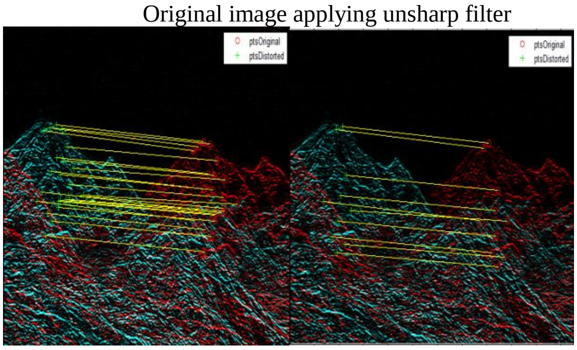
IV. Experimental Results

To increase the quality of the panoramic image, the number of matching points must be increased. So for increasing the matching points, the quality of both the images should be good. When images are captured by the camera, noise is also introduced with the main image. So because of this reason, images may be distorted and decrease the quality. To remove this noise, filtering can be done which filters the noise from the images. In this experiment, different operators are used like Sobel, Prewitt, Robert, Average, Logarithmic, unsharp etc.

The whole process is implemented on the MATLAB software. The size of the original captured image is 418×577 uint8. Here, different filter operators are applied to the original image and then found the number of matching points. The time taken for executing the whole program is also calculated. Then analyzed the results and get increased matching points using Sobel, Prewitt, unsharp and combination of Sobel and Prewitt. These results are shown in Fig.6 as given below.



(a) Matching points of **(b)** Matching points after
Original image applying unsharp filter

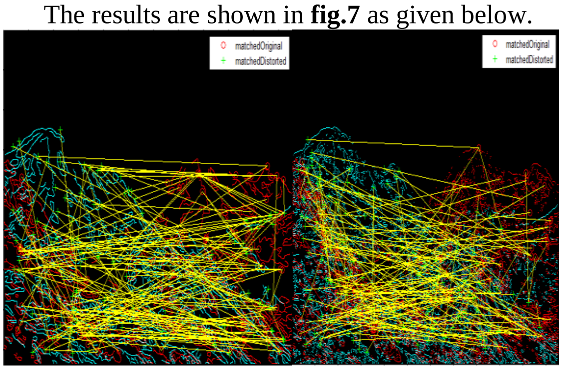


(c) Matching points **(d)** Matching points after
after applying Sobel filter applying Prewitt filter

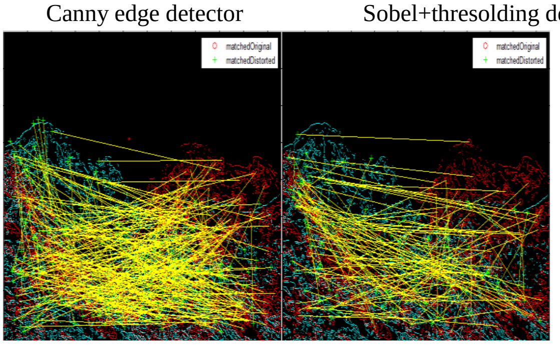
Fig. 6. How increase the matching points after filtering

The matching points can be also increasing by the process of Edge detection. Here, in this experiment different detectors are used for detecting edges. In edge detection, the edges in the images are enhanced so that less points are eliminate in outlier elimination. Then appling thresolding which make the edges more clear. So the numbers of matching inliers are incresed which is the aim of experiment. For edge detection, the detectors like Canny edge detector,

The results are shown in **fig.7** as given below.

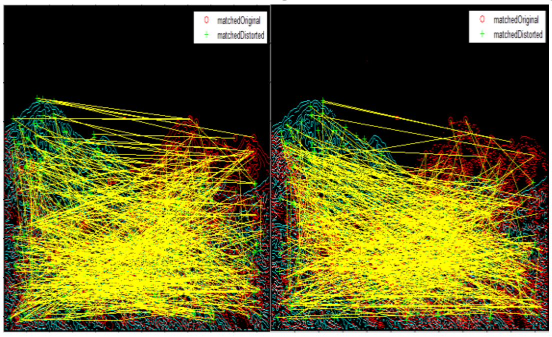


(a) Matching points using **(b)** Matching points using
Canny edge detector Sobel+thresolding detector



(c) Matching points using **(d)** Matching points using

Roberts+thresolding Prewitt+thresolding



(e) Matching points using Log detector **(f)** Matching points using Sobel filter+Zerocrossedge detector

Fig. 7. The results of matching points by applying Edge Detection using different operators

In the above figures, yellow lines show the matching lines.According to above results, the experimental table which shows the number of matching points and the time taken in seconds.

TABLE 1

RESULTS OF FILTERING AND EDGE DETECTION

Operation performed on the images	*Number of matching points*	*Time seconds*
Original image	135	3.2016
Filtering using Unsharp filter	157	3.9457
Filtering using Sobel filter	663	4.8653
Filtering using prewitt filter	426	4.1057
Filtering using Sobel+prewitt filter	541	4.7842
Edge detection using canny edge detector	167	4.6824
Use Sobel+thresolding detector	165	6.0805
Use Roberts+thresolding detector	324	5.2379
Use Prewitt+thresolding detector	148	4.6960
Use Log detector	543	5.4127
Use Sobel filter+zerocross edge detector	696	6.8667

TABLE 1 contains the results of both filtering and edge detection. By referring this, the reader can decide which one is best.

From the above TABLE 1, the maximum no of matching points can be obtained by combining both filtering and edge detection. By the results of filtering, Sobel filter gives maximum matching points. So in above case, for filtering Sobel filter is used and Zero cross detector is used for edge detecting. But it can be also shown that as number of matching points increase, it takes more execution time. So, after filter the image and detecting the edges, stitch the both images. So accurate panoramic image can be obtained as shown in Fig.8.

Fig.8. Accurate Panoramic image obtained by applying Sobel filter+Zerocross edge detector

V. Conclusion

From the whole experiment, this can be concluded that by increasing the matching points, stitching can be done accurately. So that the quality of the panoramic image can be improved. By using Sobel filter, maximum matching points can be obtained. Further increasing the matching points, edges are also detected in the images. But the time of executing process is increasing as filtering process becomes complex.

Acknowledgment

The authors would like to thank the anonymous reviewers whose suggestions significantly improved the focus, quality, clarity, and readability of this paper. And also Heartly thankful to the college, by which the stage for this kind of research has been provided.

References

[1] Somaraju Boda, “feature-based image registration”, Department of Electronics & Communication Engineering National Institute of Technology Rourkela, 2009.

[2] Meng You, Jong Seok Lim, Wook Hyun Kim, “ Panoramic image stitching using SURF”, Yeungam univercity.

[3] Barbara, Zitova, J., Flusser, “Image Registration methods: a survey”, Image and Vision Computing, Vol. 21, No. 11, pp. 977-1000, 2003.

[4] ViniVidyadharan, SubuSurendran, “Automatic Image Registration using SIFT-NCC”, Special Issue of International Journal of Computer Applications (0975 – 8887) on Advanced Computing and Communication Technologies for HPC Applications - ACCTHPCA, June 2012.

[5] Hernani Gonzalves, Jose Alberto Gonzalves, and Luis Corte- Real, “HAIRIS: A Method for Automatic Image Registration through Histogram Based Image

Segmentation", IEEE transactions on image processing, vol. 20, no. 3, march 2011.

[6] Shiqiang Li, Tianding Chen, Changhong Yu, Lin An, "SURF-based Video Mosaic and Its Key Technologies", Journal of Computational Information Systems 6:10 (2010) 3267-3275.

[7] Luo Juan, Oubong Gwun, "A comparision of SIFT, PCA-SIFT and SURF", International Journal of Image Processing (IJIP) Volume (3), Issue (4).