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A Survey: Different Techniques of Multi-view Image Registration

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***Abstract*-This paper aims to present review of different techniques used for multi-view image registration. Multi-view image registration is used in the field of video conferencing, 3D image reconstruction, generating large field of view and satellite imaging. It can also be used for mosaicing based localization, shape recovery and motion detection and tracking. The key steps of multi-view image registration are feature detection and feature matching. A lot of researchers have worked in the area of multi-view image registration. Based on their nature different reviewed approach is classified as area-based methods and feature-basedmethods. The advantages and disadvantages of different approaches are mentioned in this paper. The main goal of the paper is to provide a detailed reference source for the researchers involved in multi-view image registration.**

***Keywords*-**Image registration, feature detection, feature matching, mapping function, Harris, SIFT, RANSAC.

I. INTRODUCTION

Image registration refers to the process of overlaying two or more images of same scene which are multi-view, multi-temporal or multi-modal. It geometrically aligns two images called reference image and sensed image. Different image registration methods are widely used in remote sensing, computer vision and medical imaging [1]. Based on the manner of the image acquisition process for different applications image registration process is categorized in following four categories [2].

Multi-view image registration: Images of same scene are taken from different view-points for registration. The main objective behind this is to gain a complete and multi-dimensional scanned scene.

Multi-temporal image registration: Images of same scene are taken at different times possibly under different conditions for registration. The main objective behind this is to find and evaluate changes in the scene which appeared between the consecutive images.

Multi-modal image registration: Images of same scene are taken using different sensors. The main objective behind this is to integrate the information obtained from different sensor, to obtain more complex and detailed scene representation.

This type of image registration is widely used in medical imaging.

Model based image registration: A model (computer representation or another scene with similar content) of the scene and images of the scene are registered. This type of registration is different from other types, because here we take one image and another model or map of that imageinstead of two images. The main objective behind this is to localize the acquired images in the model and compare them [8].

Steps of image registration technique:

Feature based image registration involves the following four basic steps:

1) Detection of Feature: Here, any salient and distinctive objects or features like closed boundary regions, edges, contours, line intersections or corners are detected.

2) Matching of Feature: In this step, the correspondence between the features detected in the sensed image and those detected in the reference image are established.

3) Estimate Transform model: The type and parameters of the mapping functions (Geometric transformation function) are estimated, to aligning the sensed image with the referenced image.

4) Image resampling and transformation: In this step, the sensed image is transformed by means of the mapping functions. The appropriate technique is used to compute the image values in non-integer coordinates.

II. AREA-BASED METHODS

Area-based method combines the feature detection step with the feature matching step. These methods process directly with the images without detecting the image features [1]. Area-based methods are used when the images have notspecific details and the distinctive information. Most often used area based approaches of multi-view image registration are Normalized cross-correlation and Phase correlation method.

Normalized Cross-Correlation

The normalized CC is classical representative of the area-based method [19].Normalized CC combines the

feature matching step and feature detection step of the multi-view image registration. This method establishes correspondence between images by calculating cross-correlation. There are two images called sensed image and reference image used cross correlation to calculate the maximum similarity between them [1]. This measure of correspondence is computed for window pairs from the sensed and reference images and its maximum is searched. The window pairs for which the supreme value is achieved are set as the corresponding ones. CC based multi-view image registration can precisely align mutually translated image, and it can also be effectively applied when slight rotation and translation are present. Two main drawbacks of the correlation-like methods are the flatness of the similarity measure maxima and high computational complexity.

Phase Correlation

Phase correlation method is based on the Fourier Shift Theorem. If the acceleration of the computation speed is needed or if the images were acquired under varying conditions or they are corrupted by frequency dependent noise, then Fourier methods are preferred rather than correlation-like methods [11]. Phase correlation method operates in frequency domain for finding the translation and rotation parameters and used them for multi-view image registration. It calculates the cross-power spectrum of the sensed and referenced images and looks for the location of the maximum peak in its inverse.

Vinod G.R and Mrs. Anita R [3], proposed an approach for Automatic Image Mosaicing based on Fast Fourier Transform (FFT).This paper proposed FPGA implementation technique to generate a panoramic image by combining partially overlapped images. They used weighted average blending method, to remove the seam if appear in image mosaicing which improve the quality of output image. From experimental result they found that the proposed approach is very efficient in mosaicing multiple images with large overlaps.

II. FEATURE –BASED METHODS

The feature-based methods are mostly used when images contain enough distinctive and effectively detectable objects. It is based on the extraction of any salient structures or features in the images. The comparability of detected features in the reference and sensed images is assumed by the invariance and accuracy of the feature detector and by the overlap criteria [22].Using the image features detected from corresponding images taken from different viewpoints, multi-view image registration is achieved. Any salient and distinctive objects or features like closed boundary regions, edges, contours, line intersections or corners are detected as feature. Different methods often used to detect edges are Robert operator, Sobel operator [18], Prewitt operator, and Canny operator and Krish operator. Compare to other features corners are invariance of imaging geometry and they are well perceived by a human observer. They are widely used as control points. Chris Harris, Mike Stephens [23] proposed a combined edge and corner detection method. Hemlata Joshi,Mr. KhomLal Sinha proposed combined Harris and sift feature detection algorithm [16]**.** Feature based methodsdetect distinctive features from each images and matches these features to establish a global correspondence.

Harris Corner Detector

Harris corner detector is a well-known corner detector algorithm due to its invariance to rotation, illuminations variation and image noise which has been proposed in 1988 [22]. It is based on intensity in which corner point is detected with variation of gray value in small window size. Harris promotes a formula that can be calculated out the variation of gray value in any direction [4].

$Z_{(p,q)}(x,y) = \sum w(x,y)[I(x+p,y+q) - I(x,y)]^2 \ldots (1)$

For each pixel (x, y) in the given image find the autocorrelation matrix M

$$M = \sum_{x,y} w(x,y) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \ldots\ldots\ldots\ldots\ldots (2)$$

Where $I_{x\ and}\ I_y$ is image differences in x and y direction calculated using Gaussian function

C.Harris and M.J.Stephen given corner response function for practical situation:

$$R = Det\ M - k(traceM)^2 \ldots\ldots\ldots\ldots\ldots (3)$$

Where, $DetM = \lambda_1 \lambda_2$ and $traceM = \lambda_1 + \lambda_2$ and k is constant.

If variation of gray value at a given point is greater than the threshold than that point are considered as the corner point. The Disadvantage of this method is it is not invariant to large scale changes [7].

SUSAN Corner Detector

Smith and Brady proposed robust Smallest Universal Segment Assimilating Nucleus (SUSAN) corner detection method [25].This method was based on the concept of USAN. The USAN is defined by scanning the whole image by placing a circular mask at each pixel in the image. Then compare the Brightness of each pixel within the mask with the brightness of center point, if the brightness difference is less than the given threshold. All the pixels sustaining the condition constitute a region called USAN. Then setting area threshold and comparing it with USAN's area to get corner response function. This method is robust to noise and less affected by rotation [13].

SIFT Feature Detector

Scale Invariant Feature transform (SIFT) was proposed as a method to extract and describe feature point

[7]. The registration performed using SIFT is capable of handling the difference in spectral content, rotation, scale, translation and change in illumination [16]. SIFT consist of following four main steps.

1) Scale-space Extrema Detection, in which search over scale space using a Difference of Gaussian (DoG) function to identify potential interest points that are invariant to scale and orientation.

2)Feature Point Localization ,in this the location and the scale of each detected point are determined and reject the feature point that have low contrast or are poorly localized along an edge.

3) Assign one or more orientation to each feature point location based on local image gradient directions.

4)Feature Point Description, in which a feature descriptor is created by first computing the gradient and orientation at each image sample point in region around the feature point location.

This method is very suitable for object detection in images with high resolution, but the running time of a SIFT algorithm is large as it takes more time to compare two images [12].N. NagaRaju, T. Satya savitri and Ch. A. Swamy [6], proposed a new Automatic Image Registration (AIR) approach based on SIFT. They applied the combination of image segmentation, SIFT and principle component analysis (PCA), which is followed by a robust procedure of outlier removal. The proposed method is widely applicable in remote sensing.

FAST Corner Detector

FAST is a corner detector algorithm proposed by Tranjkovic and Hedley in 1998. In this method, the detection of corner was prioritized over edges as corners were found to be the good features to be matched because it shows a two dimensional intensity change, and thus well distinguished from the neighboring points. FAST corner detector uses a corner response function (CRF) that gives a numerical value for the corner strength based on the image intensities in the local neighborhood. A multi-grid technique is used to increase the computation speed of algorithm and for the suppression of false corner being detected. FAST is an accurate and fast algorithm that produces good localization and high point reliability, but its performance is poor in presence of noise [23].

SURF Feature Detector

Speeded up Robust Feature (SURF) is a scale-invariant feature detector based on second order Hessian matrix. Three main steps of the SURF are Blob detection, Description and Matching. It speeded-up the detection process by keeping in view the quality of detected points and gives more focus on speeding-up the matching step [23]. SURF is extensively used in computer vision field. SURF has proven its efficiency and robustness in the invariant feature detection [27].

Vrushank H. Gandhi and Sandip R. Panchal [2] have given review of various techniques used for feature based multi-view image registration.To detect the various features like point, line, edge, corner, surface from the image different methods like, Basic sharpening filters ,LoG filters , Harris corner detector , DoG , SURF, SIFT, Canny edge detector and Wavelet based feature detection methods are discussed. The registration accuracy of feature-based techniques is high, but their structures are more complex compare to area-based technique. The main advantages of feature-based technique are their low computational complexity,fast calculation, insensitive to illumination changes and invariant to image rotation and scale.

RANSAC Algorithm

Random Sample Consensus (RANSAC) is a robust iterative method originally proposed by Fishcler and Boller in 1981.It is used to compute the homography from a set of observed data which contain outliers. A basic assumption is that the data may consist of "inliers", which may be subjected to noise, and "outliers". Inliers are the data whose distribution can be explained by some set of model parameter and outlier are data that do not fit the model. RANSAC algorithm starts by randomly selecting the sets of corresponding points in reference and sensed image. For each possible set of four key points at the referenced image and their respective matches at the sensed image calculate the transformation matrix [20]. Using the transformation matrix, the symmetric transfer error is calculated for every matching point, and the inlier that are less than the threshold are counted. Then the same procedure is repeated for rest of keypoints. This procedure allows establishing the number of keypoint pairs that fits the model within certain tolerance [13]. The model that supports maximum number of keypoint pairs within a transform model is considered as optimal model. Then the model will transform the sensed image to the reference image, so that corresponding point in both images are spatially close to each other.

Fuli wu and Xiongo Fang [5] have presented the improved RANSAC algorithm to found homography based on the modified media flow filter, to detect wrong matches. This paper present new feature based image mosaicing algorithm. SIFT method was used for features localization and features are matched with priority search in k-d tree structure. After that, the improved RANSAC homography algorithm based on the modified median flow filter is applied. Then image composition and final mosaic can be generated. From experimental result they compare the normal RANSAC homography algorithm with the improved RANSAC homography algorithm and shown that there is no ghosting in the rectangular areas when used improved.

IV. ESTIMATION TRANSFORM MODEL

After the feature detection and feature matching has been established, next step is construction of mapping function also called the transformation function. Select

the type of mapping function and then find the parameter of mapping function. Similarity transforms (rigid transform),affine transform, perspective projection and elastic transform are different mapping functions. The selection of the transformation function is depends on the geometric deformation of the sensed image [24]. Model of the transformation function can be divided into two broad categories according to the amount of image data they use. Global models use all control points for calculating one set of mapping function parameters valid for the entire image. Similarity transform is the simplest global transform model, which consist of translation, rotation and scaling. This model preserves angles and curvatures and is explicitly determined by two control points. Global models cannot properly handle images deformed locally. The local models treat the image as a composition of patches and the function parameters depends on the location of their support in the image [1].

V. CONCLUSION

In this paper different methods of multi-view image registration are discussed. For each technique a detailed explanation of techniques can be given which are used for detection of feature, matching of feature and transform model estimation. Area-based methods are used when the images have not specific details and the distinctive information. The feature-based methods are mostly used when images contain enough distinctive and effectively detectable objects. From this survey, a number of advantages and limitation were highlighted in each and every technique. It is experimental that area-based methods cannot applied when more complex transformation are present in images. The analysis proved that the feature-based methods will produce the accurate result and increase the speed of multi-view image registration compare to area-based methods.

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