

Image Registration Techniques and Its Applications: A Review

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Abstract—The matter of Image Registration has become one of the most important Electronic and Digital processing applications in the last few decades. In image processing, when combining the information content of image, we are interested in the relationship between two or more images. The examination of this relationship generally becomes tractable once a correspondence is set up between the images. Image Registration is the methodology of adjusting two or more image of the same scene taken from different viewpoints, at different times, from different sensors. The result of image registration is a new registered image which is more plentiful for human being and machine discernment for further image-processing tasks like segmentation, feature taking out and objects recognition. In this paper we have discussed and analysed some popular method like Log polar technique (LPT), Wavelets technique, Mutual Information (MI) and Affine transformation and also discussed Image Registration applications.

Keywords— Image registration, Log polar, Affine, Mutual Information (MI), Wavelets

I. INTRODUCTION

In image processing, when combining the data substance of image, we are intrigued by the relationship between two or more image. The investigation of this relationship typically gets to be tractable once a correspondence is situated up between the images. Image registration is the undertaking of setting up this correspondence. Image registration is a methodology of adjusting two images procured by same/distinctive sensors, at different times or from different viewpoint. To register image, we require to focus geometric change that adjusts images to admiration to the reference image. The most well-known transform are Rigid, affine, projective and global.

Numerous image processing applications like Computer Vision (target restriction, quality control, stereo matching) Medical Imaging (consolidating CT and MRI information, tumour development checking, treatment confirmation) Remote Sensing (arrangement, ecological checking, change recognition, imagemosaic king) and so on need image registration. This paper composes this exploration by building the relationship between the varieties in the images and the kind of registration techniques which can most properly be connected.

II. STEPS IN IMAGE REGISTRATION

Image registration comprises of following steps, Fig 1 shows the procedure.

- **Feature Detection:** Notable and Different object in a image (edges, lines, shapes) are recognized physically or naturally. These feature focuses are spoken to by their descriptors.
- **Feature Matching:** In this step, the features detected in the reference image and individuals detected in sensed image has been matched. Feature descriptor and similarity measure are used for this purpose.
- **Transform Model Estimation:** The type and parameter of mapping function is established which is used to align the sensed image with reference image.
- **Image Re-sampling and Transformation:** The sensed image is transformed by establish mapping functions.

Feature Detection

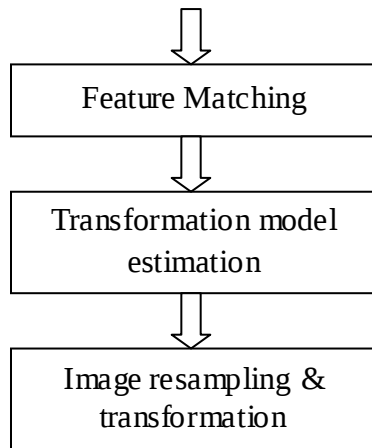


Fig 1. Steps in Image Registration

III. IMAGE REGISTRATION TECHNIQUES

A. AFFINE TRANSFORMATION

Affine transformation is widely used methods in registering two images. While only linear, it models a combination of four simple transformations: translating, rotating, scaling and shearing. In Registered image an affine transformation corrects some global distortions in the images[5].

An affine registration model assumes that the above transformation ϕ is linear.

$$\phi(x) = \phi_a(x) = \begin{bmatrix} \phi_{a1}(x) \\ \phi_{a2}(x) \end{bmatrix} = \begin{bmatrix} a1 & a2 \\ a4 & a5 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \end{bmatrix} + \begin{bmatrix} a3 \\ a6 \end{bmatrix} = Ax + b,$$

Where $A = \begin{bmatrix} a1 & a2 \\ a4 & a5 \end{bmatrix}$, $b = \begin{bmatrix} a3 \\ a6 \end{bmatrix}$ are the affine transformation matrix and the translation vector equally, for all $x \in \Omega$. Here for streamlining reason, the vector $a = (a1, a2, a3, a4, a5, a6)$ $T \in R^6$ will be used abruptly. Clearly the inverse transform is simply $x = A^{-1}(\phi a - b)$ if A is invertible.

The affine transformation parameters can be figured by directions of control points and afterward geometric change may be directed for image registration. Finally, Image registration is refined. In the process of image geometric transformation transformed coordinate is not an integer, or no mapping point exists between the sensed image and the reference image, the color values of these points can be obtained by interpolation[15].

The most usually utilized registration transformation is the affine transformation [16]. Because it is enough to match two images of a scene taken from the same point yet from different position. It is composed of scaling, translation, and rotation. Rigid transformation is global transformation. Affine transformations are more broad than rigid.

$$P' = sRp + t$$

The general 2D affine transformation

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} t_x \\ t_y \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Angles and lengths are not preserved. Parallel lines remain parallel[17].

B. MUTUAL INFORMATION TECHNIQUE

In latest years, multimodality image registration techniques are anticipated in the medical imaging field. Specifically, a CT and MR image of the head for determination and surgical planning demonstrates that doctors and specialists increase essential information from these modalities [12].

The Mutual Information (MI) systems are the last technique for the area based method in Features Matching step. Registration of multimodal image is the troublesome task, yet particularly in medical imaging. Medical imaging applications are, combination of sensors recording the anatomical body structure like MRI, ultrasound or CT with sensors checking functional and metabolic body exercises like PET, SPECT. Mutual information based registration starts with the estimation of the joint likelihood of the intensities of comparing voxels in the two images.

Mutual information between two irregular variables X and Y is given by the equation.

$$MI(X, Y) = H(Y) - H(Y/X) = H(X) + H(Y) - H(X, Y)$$

Where $H(X) = -E_x(\log P(X))$ represents “entropy of random variable” and is probability distribution of X . this method is based on maximizing MI. If $MI(X, Y) = 0$, then image X is independent of image Y . The larger $MI(X, Y)$ the higher similarity between two images.

The maximization of mutual information is an intensity-based technique that can be applied also in the case of affine transformations[10].

The application of MI by magnetic resonance images as well as for the 3D object model matching to the real scene for image registration. Mutual information is a standout amongst

the most seriously looked into similarity measures for image registration. Despite the successful results by mutual information registration, mutual information can result in mis-registration [18].

It is observed that this technique is more accurate registration than any other registration method. But this technique has its own limitations [2]. When images are of low resolution, when images contain little information or when the region of overlap is small then mutual information result in mis-registration [17][1]. New similarity metric called enhanced mutual information (EMI), which combines mutual information with a weighting function based on the absolute difference of corresponding pixel values [11].

It has one more limitation of speed when time is an important constraint one cannot use this method. It has some also limitations entropy and mutual information is best approaches for multimodal image registration.

C. WAVELETS TECHNIQUE

At the point when a sub-window was utilized to figure out the likely hopefulness of the relating window in reference image and afterward full size window is connected [2] [3]. After that a rectangular framework of windows is undertaken which cross correlation is performed for lessening the computational load.

As of late, wavelet decomposition of the images was proposed for pyramidal method. Wavelet transform allocate not only frequency domain information but also allocate spatial domain information [13]. There is numerous correlation tests have been completed to create which wavelet family has the best execution. Methods can contrast in the kind of the connected wavelet and the set of wavelet coefficients utilized for discovering the correspondence.

Most oftentimes utilized systems separate the image recursively into four sets of coefficients (LL, HL, LH, HH) by sifting the image progressively with two channels, a low-pass channel L and a high pass channel H, both working along the image row and columns.

The advantage of DWT over Fourier transformation is that it performs multiresolution analysis of signals with localization. As a result, the DWT decays a digital signal into distinctive sub groups so that the lower frequency sub groups will have better frequency resolution and coarser time resolution contrasted with the higher frequency sub groups [14]. A wavelet-based feature extraction method, standardized cross-correlation matching and relaxation based image matching procedures are utilized.

D. LOG POLAR TECHNIQUE

For image processing, the LPT is a nonlinear sampling method used to convert image from the Cartesian coordinate, $I(x, y)$, to the log-polar coordinate $LP (L, \emptyset)$ [8]. The log-polar transform is a well known tool for image processing because of its rotation and scale invariant properties [6]. The mathematical expression of the mapping is:

$$L = \log_{\text{base}} \sqrt{(x - x_c)^2 + (y - y_c)^2}$$

$$\emptyset = \tan^{-1} \frac{y - y_c}{x - x_c}$$

Where (x_c, y_c) is the center pixel of the transformation in the Cartesian coordinates (x, y) denotes the sampling pixel in the Cartesian coordinates and $(L, \emptyset)$ denotes the log-radius and the angular position in the log-polar coordinates.

The LPT is usually constructed so that a quadratic input region is sampled and transformed and the output region is also quadratic [9]. The matching mechanism will focus more on the central area while the peripheral area is given less consideration, since the number of samples at the central area of the image is larger than that of the peripheral.

The log-polar transform is very useful in image registration for its rotation and scale invariant properties. But if there is translation variant between the two images at the same time, the log-polar transform will be fail [6]. The advantage of using log-polar over the Cartesian coordinate representation is because any rotation and scale in the Cartesian coordinates is represented as shifts in the angular and log-radius directions [8].

Despite the fact that the Fourier-Mellin transform also uses the log-polar transformation to recoup rotation and scale, it is limited in use to two-fold scale factors. Also advantage of log-polar transform is easy to understand and implemented. The purpose of the log-polar registration module is to bring two images into alignment using only rotation, scale, and translation [7].

IV. APPLICATIONS

Same scenes of the images are caught from distinctive perspectives. The reason behind this to accomplish a two-dimensional image representation. It can be used in remote sensing & the mosaic king of image.

An alternate application is same scenes of the image are procured at different time relying upon distinctive conditions. The reason behind this is to discover and assess changes

happen in the scene amid distinctive time period. Sample is remote sensing and machine vision.

Same scenes of the image can be procured from different sources. The reason behind this is to dissect the data from distinctive hotspots for acquiring the more itemized data. It can also used in remote sensing and medicinal imaging.

It can also used for medical purposes like combining data from different modalities e.g. computer tomography (CT) and magnetic resonance imaging (MRI), observing tumour growth, treatment verification, and acquire more complete information about the patient.

V. CONCLUSION

Here, in this paper we have tried to cover recent development in the field of the image registration. Image registration is vital assignments when we need to coordinate and examine data from diverse sources to acquire the more precise data. This paper gives a review and characterization of image registration techniques. Advantage of log-polar transform is easy to understand and implemented. Using log-polar technique over the Cartesian coordinate representation. In multimodal registration, MI system has turned into a standard in medical imaging. On the other hand, in an area based procedure, the MI has vital Limitations. Combinational of wavelet and mutual information gives better come about. Indeed wavelet mutual information combination can be utilized as a part of multimodal image registration.

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