A Review on Image Registration

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***Abstract*— Abstract— Image registration is the process of overlaying images (two or more) of the same scene taken at different times, from different viewpoints, and/or by different sensors. The image registration geometrically aligns two images (the reference and sensed images). The goal of registration is to produce as output a geometrical transformation that aligns corresponding points in two images. It is a fundamental task in image processing that is used to match two or more pictures taken. In face recognition for better recognition rate the image must be registered before implementing any recognition algorithm .This paper intends to give an overview of image registration, steps involved in image registration and different problems with the emphasis on Fourier Mellin Transform Method.**

***Keywords*— Fourier Mellin Transform, geometric transformations, MI.**

I. INTRODUCTION

Registration is a fundamental task in image processing used to match two or more pictures taken, for example, at different times, from different sensors or from different viewpoints. Over the years, a broad range of techniques have been developed for the various types of data and problems. These techniques have been independently studied for several different applications resulting in a large body of research. In case of face recognition this is an important step because when we capture the image at different instant of time this might be possible that the image is translated, rotated or scaled with respect to the images present in the database. Thus for better recognition rate the image must be registered before implementing any recognition algorithm. Most image registration problems are formulated in an asymmetric fashion. Given a pair of images, one is implicitly or explicitly regarded as a template, and warped onto the other to match as well as possible. The same is implemented for the face which comes for the recognition and also all images in database are registered prior to classification step.

Registration algorithms attempt to align a pattern image over a reference image so that pixels present in both images are in the same location. This process is useful in the alignment of an acquired image over a template, a time series of images of the same scene, or the separate bands of a composite image.

For typical image registration problems, the sources of differences between two images fall into four categories:

1. Differences of alignment between images are caused by a spatial mapping from one image to the other. Typical mappings involve translation, rotation, warping, and scaling. For infinite continuous domain images, these differences are a result of a spatial mapping from one image to the other. Changing the orientation or parameters of the imaging sensor can cause differences of alignment.
2. Differences from occlusion occur when part of a finite image moves out of the image frame or new data enters the image frame of a finite image due to an alignment difference, when sensor errors produce identifiably invalid data in an image, or when an obstruction comes between the imaging sensor and the object being imaged. For example, in satellite images, clouds frequently occlude the earth.
3. Differences from noise occur from sampling error and background noise in the sensor, and from undeniably invalid data introduced by sensor error.
4. Differences due to change are actual differences between the objects or scenes being imaged. In satellite images, lighting, erosion, construction, and deforestation are examples of differences due to change. It may be impossible to distinguish between change and noise.

II. DIFFERENT METHODS OF IMAGE REGISTRATION

A. Mutual information-based methods

Mutual information-based registration begins with the estimation of the joint probability of the intensities of corresponding voxels in the two images. The use of information-theoretic measures such as mutual information has obviously benefited voxel-based registration. The present papers have demonstrated that mutual information can be used to parameterize and solve the correspondence problem in feature-based registration. They have appeared recently and represent the leading technique in multimodal registration. Registration of multimodal images is the difficult task, but often necessary to solve, especially in medical imaging. The comparison of anatomical and functional images of the patient’s body can lead to a diagnosis, which would be impossible to gain otherwise. Remote sensing often makes use of the exploitation of more sensor types, too.P. Viola and W.M. Wells [2] have maximized Mutual Information using gradient descent optimization method. Jiarui et al [3] described the effects of rescaling intensity values of an image on MI method, and then compare the registration results and computation time of the same image pairs with different grey levels. They implemented series rigid registration of CT and MR image, in each registration, the intensity values of CT and MR images are linearly rescaled to the same range. They adopt 5 different levels in our experiments, i.e. 256, 128, 64, 32 and 16 grey levels to exploit the affection of grey levels on MI based registration method. They also count the time cost on the calculation of single MI value and the whole registration procedure. Finally they reach to the conclusion that the results become worse with the reduction of grey levels of the image, and rescaling the intensity values of the original images into [0, 63] is an excellent tradeoff in brain registration by mutual information.

B. Coincident Bit Counting

Chiang and Sullivan [4] proposed a new similarity measure based on the number of coincident bits in multi channel images is presented. The similarity criterion incorporated in the image registration algorithm uses a coincident bit counting (CBC) method to obtain the number of matching bits between the frames of interest. The CBC method not only performs favorably compared with traditional techniques, but also renders simpler implementation in conventional computing machines. An image registration algorithm which incorporates the CBC criterion is proposed to determine the translational motion among sequences of images. The analysis of the errors caused by noise, miss registration, and a combination of these two is also included. Some experimental studies using low contrast coronary images from a digital angiographic sequence have been performed. The results compare favorably with those obtained by using other nonparametric methods.

C. The Geometric Transformation

Conventionally, the geometric transformation consists of the translation, rotation, and uniform scale transformation, therefore, also called rotation-scale-translation (RST) transformation. Consider for registration two functions denoted by f and g, representing a gray-level image defined over a compact set of R2, which are related by a four-parameter geometric transformation that maps each point (x_g, y_g) in g to a corresponding point (x_f, y_f) in f according to the matrix equation

$$\begin{bmatrix} x_f \\ y_f \\ 1 \end{bmatrix} = \begin{bmatrix} \alpha\cos\beta & \alpha\sin\beta & -\Delta x \\ -\alpha\sin\beta & \alpha\cos\beta & -\Delta y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_g \\ y_g \\ 1 \end{bmatrix} \quad (1)$$

Equivalently, for any pixel (x, y) it is true that

$$g(x, y) = f(\alpha(x\cos\beta + y\sin\beta) - \Delta x, \alpha(-x\sin\beta + y\cos\beta) - \Delta y) \quad (2)$$

where Δx and Δy are translations, α is the uniform scale factor, and β is the rotation angle. According to the translation, reciprocal scaling and rotation properties, it may be readily shown that the magnitudes of the Fourier transform of these images are invariant to translation but retain the effects of rotation and scaling, as follows

$$|G(u, v)| = \frac{1}{\alpha^2}\left|F\left(\frac{u\cos\beta + v\sin\beta}{\alpha}, \frac{-u\sin\beta + v\cos\beta}{\alpha}\right)\right| \quad (3)$$

where F(u, v) and G(u, v) are the Fourier transforms of f(x, y) and g(x, y), respectively.

D. Phase Correlation Technique

Phase correlation technique actually tries to detect the horizontal and vertical translation between two images in frequency domain. The concept is to transform both images using Fourier Transform and then compute cross spectrum of two as in equation (6) and by computing inverse Fourier Transform the peak of the signal will give both translation parameter.

Let f_s and f_r denote two images that differ only by a displacement (x_o, y_o), where f_r is a reference image and f_s is an input one to be registered, i.e.

$$f_s(x, y) = f_r(x - x_o, y - y_o) \quad (4)$$

F_s, F_r are the corresponding Fourier Transforms with the Fourier shift theorem

$$F_s(u, v) = e^{-j2\Pi(ux_o + vy_o)} F_r(u, v) \quad (5)$$

The cross-spectrum of F_s and F_r is defined as

$$R = \frac{F_s(u, v)F_r^*(u, v)}{|F_s(u, v)F_r(u, v)|} = e^{j2(ux_o + vy_o)} \quad (6)$$

Where F* is the complex conjugate of F. By taking the inverse Fourier Transform of R, an impulse function will be obtained

$$F^{-1}(R) = \delta(x - x_o, y - y_o) \quad (7)$$

E. Fourier Mellin Transform

The Fourier-Mellin transform [5-6] is a useful mathematical tool for image recognition because its resulting spectrum is invariant in rotation, translation and scale. The Fourier Transform itself (FT) is translation invariant and its conversion to log-polar coordinates converts the scale and rotation differences to vertical and horizontal offsets that can be measured. A second FFT, called the Mellin transform (MT) gives a transform-space image that is invariant to translation, rotation and scale. The working flow chart of the image registration algorithm based on the Fourier–Mellin transform is illustrated.

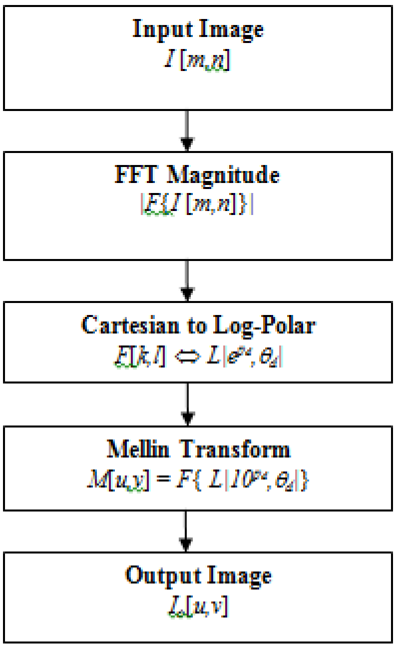

Figure 1. Block Diagram of the Fourier-Mellin Transform

If f_s is a replica of f_r with scale k, rotation θ_o, and translation (x_o,y_o), then

$$f_s(x, y) = f_r[k(x\cos\theta_o - y\sin\theta_o) - x_o, k(x\sin\theta_o + y\cos\theta_o) - y_o] \quad (8)$$

The Fourier transforms F_s and F_r are related as

$$F_s(u,v) = \frac{1}{k^2} e^{-j2\pi((ux_0/k)+(vy_0/k))} * F_r\left(\frac{u\cos\theta_o - v\sin\theta_o}{k}, \frac{u\sin\theta_o + v\cos\theta_o}{k}\right) \quad (9)$$

$$\left|F_s(u,v)\right| = \frac{1}{k^2}\left|F_r\left(\frac{u\cos\theta_o - v\sin\theta_o}{k}, \frac{u\sin\theta_o + v\cos\theta_o}{k}\right)\right| \quad (10)$$

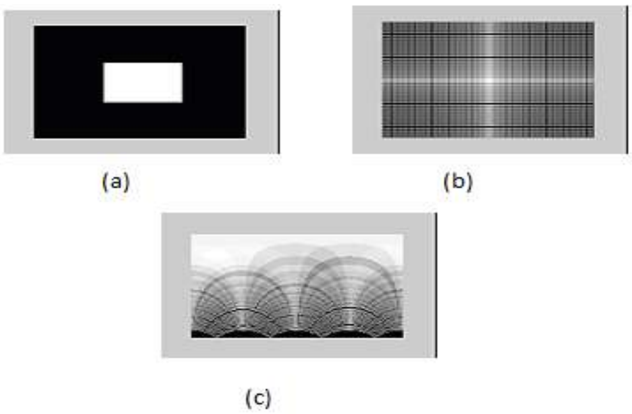

Figure 2. (a) Original image, (b) FFT in Cartesian and (c) Log-polar coordinates

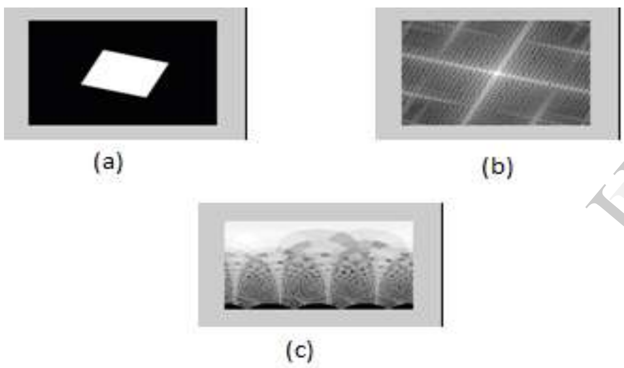

Figure 3. (a) Rotated image, (b) FFT in Cartesian and (c) Log-polar coordinates.

Let G_s and G_r denote the magnitude spectra

$$G_s(u,v) = \frac{1}{k^2} G_r\left(\frac{u\cos\theta_o - v\sin\theta_o}{k}, \frac{u\sin\theta_o + v\cos\theta_o}{k}\right) \quad (11)$$

Let H_s and H_r denote the transforms of G_s and G_r converted from Cartesian coordinates to polar coordinates,

$$\rho = (u^2 + v^2)^{1/2} \quad (12)$$

$$\theta = \tan^{-1}(u/v) \quad (13)$$

$$H_s(\rho,\theta) = \frac{1}{k^2} H_r(\rho/k, \theta + \theta_o) \quad (14)$$

After introducing a log transform for r in the polar coordinates, which is derived from the Mellin transform, the scale factor k can be resolved by the phase correlation technique in the log-polar coordinate.

$$r = \log\rho; \varphi = \theta \quad (15)$$

Let Q_s and Q_r denote the corresponding transform of H_s and H_r in the log polar coordinate,

$$Q_s(r,\varphi) = Q_r(r - \log k, \varphi + \theta_o) \quad (16)$$

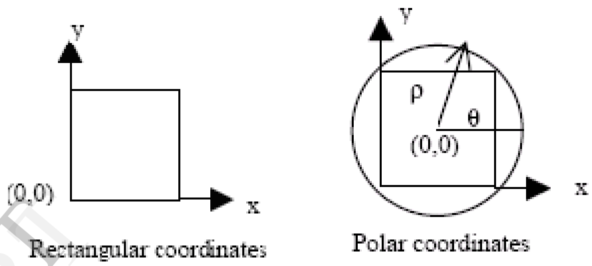

Figure 4. Transformation from rectangular to polar coordinates

Then log k and u_0 can be obtained by using the phase correlation technique. Taking the Fourier transform of a log-polar map is equivalent to the computing of the Fourier–Mellin transform.

$$F_M(k_1,k_2) = \int_{-\infty}^{+\infty}\int_{0}^{2\pi} f(e^r\cos\varphi, e^r\sin\varphi) e^{j(k_1 r + k_2 r)}\, dr\, d\varphi \quad (17)$$

The modulus of the Fourier–Mellin transform is rotation and scale invariant. After obtaining rotation θ0 and scale k, a new replica f3 can be created which is affined from f1 according to these two factors. The new image f3 is the same as f2 except for translation. Then, by using a phase correlation technique again, translation (x0, y0) can be obtained, which means all parameters of R, S, T have been obtained and a 2-D image registration has been performed.

III. RESULT AND DISCUSSION

An image registration approach based on the Fourier–Mellin transform is used; as the overall information of the image is used it works well. Even when there are variations in captured image, the registration result is also correct as long as the percentage of variation is not very high, which means that it

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is insensitive to the varying light direction and the performance of registration is robust to some extent.

Figure 5. Reference Image and its rotated and scaled version

Figure 6. Registered image

However, because of the complexity of the Fourier– Mellin transform, the algorithm cannot be performed in real time on a computer. The period of time for registration on images with resolution 256X256 is about 2 seconds on our workstation. The whole database is registered by using this algorithm as this registration is done offline so the time taken by this hardly matters. As the accuracy of this system is very well so all the images in database get registered to an extent and the task of classification is implemented on this registered database.

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IV. CONCLUSION

Registration is defined as the determination of a geometrical transformation that aligns points in one view of an object with corresponding points in another view of that object or another object.there are different methods used for image registration viz. phase correlations ,point based and surface based techniques. Fourier Mellin Transform is a new method of image registration and works well when the two images differ by rotation and scaling. This is a reliable and fast method of registration and is invariant to rotation and scaling..

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