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Multimodal Image Registration using Contourlet Transform

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Abstract: Registration is 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. Image Registration deals with the matching of two images. Relationship between type of distortion and the type of image registration is the most important task. Image registration is becoming a crucial step in most image processing tasks. It is a key technology in computer vision, remote sensing, image processing, medical image analysis and other fields. The main objective is to match two or multiple images got at different times by different sensors or different angle. This is the fundamental task in image processing which can be used to match two or more pictures taken at different time or from different sensors or from different viewpoints. Various transforms can be used for the purpose. Medical imaging is the technique and process used to create images of the human body for clinical purposes seeking to reveal, diagnose medical science. It is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. Medical image registration is to find a spatial transformation to match all the anatomical points and diagnostic points on the image. This paper presents a new technique for registration of multi modal images using mutual information.

Keywords: Image Registration; Feature detection; Contourlet transform (CT); Mutual Information

I. INTRODUCTION

The process of registration is to achieve the global optimum of similarity measure between two or more images when one image is transformed to overlap another. Image registration is the process of overlaying images (two or more named reference and sensed images) captured from the same scene but at different times and view points, or even by using different sensors. Typically, image registration is required in remote sensing applications such as change detection, multispectral classification, environmental monitoring, weather forecasting, super resolution images, and integrating information into Geographic Information Systems (GIS). Image registration plays a fundamental and crucial role in medical decision in disease diagnosis, treatment planning, radiation therapy, and treatment assessment. Its goal is to determine a geometrical transform that aligns corresponding points representing the same underlying structure in two or more images. Multi-modality registration methods are often used in medical imaging as images of a subject are frequently obtained from different scanners. Examples include registration of brain Computer Tomography (CT)/Magnetic Resonance Imaging (MRI) images or whole body Positron Emission Tomography (PET)/CT images. For tumor localization, for segmentation of specific parts of the anatomy, and registration of ultrasound and CT images for prostate localization in radiotherapy multimodal Image registration is used.

Image Registration is explained efficiently by Lisa Gottesfeld Brown and Image Registration deals with the matching of two images. Registration is 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. [1, 2, 5]

Jignesh N Sarvaiya, Dr. Suprava Patnaik & Salman Bombaywala illustrates efficient use of Normalized cross correlation for image registration. Template matching is done using NCC. In this paper, correspondence between main image and template image is established which gives the degree of similarity between them. Then, the minimum distortion, or maximum correlation, position is taken to locate the template into the examined main image [16]. Luigi Di Stefano, Stefano Mattoccia & Martino Mola also used cross correlation as a method for feature matching. This method is based on the rotation and scale invariant normalized cross-correlation. Both the size and the orientation of the correlation windows are determined according to the characteristic scale and the dominant direction of the interest points [4].

There are various methods of Image Registration. Some are efficiently explained by Lisa Gottesfeld Brown and Barbara Zitova, Jan Flusser [1, 5]. Methods are Correlation, Fourier Method, Point mapping etc. Correlation Can be used effectively. Point mapping method is less sensitive to local distortions as they use control points and local similarity, they use information from special relationship between control points and they are able to consider possible matches based only on supporting evidence. It can be efficient to use method point mapping for image registration. J. Flusser used moment based approach to correct affine distortion, he has also done degraded image analysis to locate invariants in images[10,11]. P. Ramprasad, H.C. Nagaraj and M.K. Parasuram presented a new wavelet based algorithm for registering noisy and poor contrast dental x-rays. Proposed algorithm has two stages, first stage is preprocessing stage, which removes the noise from x-ray images, Gaussian Filter has been used. Second stage is a geometric transformation stage [12]. Sangit Mitra and B.S. Manjunath explained various contour based approaches for multispectral image registration in their different papers [13].

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Sh. Mahmoudi-Barmas and Sh. Kasaei have explained the edge extraction for Image Registration using Contourlet Transform. Control points are used to detect edges [14]. For multimodal images registration is explained by P.Pradeepa and Dr. Ila Vennila .Proposed method said that for two images which are multimodal registration can be done with the mutual information between two images [15]. Also Yonggang Shi have explained about multimodal image registration. Proposed method said that Mean and variance of Joint Intensity Distribution can be efficiently used for the multimodal images [16]. Nemir Ahmed Al-Azzawi with Harsa Amylia and Wan Ahmed K. Abdullah have explained about the monomodal image restration. Nonsubsampled Contourlet Transform with the help of Mutual information can be effectively used for monomodal image registration [17]. S. Anand and R.Aynesh Vijaya Rathna have clearly explained abour contourlet tansform and its use for image registration [22].

II. CONTOURLET TRANSFORM

For Many signal processing tasks such as compression, denoising, feature extraction and enhancement image can be efficiently represented by Contourlet Transform (CT), which is one of several transforms aimed at improving the representation sparsity of images over the Wavelet Transform (WT). The major drawback for wavelets in two-dimensions is their limited ability in capturing directional information. To overcome this deficiency, researchers have recently considered multiscale and directional representations that can capture the intrinsic geometrical structures such as smooth contours in natural images. There are two main properties that the CT possess: 1) the *directionality* property, i.e. having basis functions at many directions, as opposed to only 3 directions of wavelets 2) the *anisotropy* property, meaning that the basis functions appear at various aspect ratios (depending on the scale), whereas wavelets are separable functions and thus their aspect ratio equals to 1. The main advantage of the CT over other geometrically representations, is its relatively simple and efficient wavelet-like implementation using iterative filter banks. Due to its structural resemblance with the wavelet transform, many image processing tasks applied on wavelets can be easily adapted to contourlets.

The contourlet transform was proposed as a directional multiresolution image representation that can efficiently capture and represent singularities along smooth object boundaries in natural images. Its efficient filter bank construction as well as low redundancy makes it an attractive computational framework for various image processing applications. The contourlet transform was proposed as a directional multiresolution image representation that can efficiently capture and represent singularities along smooth object boundaries in natural images. Its efficient filter bank construction as well as low redundancy makes it an attractive computational framework for various image processing applications. The contourlet transform is implemented via a two dimensional filter bank that decomposes an image into several directional subbands at multiple scales. This is accomplished by combining the Laplacian pyramid with a directional filter bank at each scale. Due to this cascade structure, multiscale and directional decomposition stages in the contourlet transform are independent of each other. One can decompose each scale into any arbitrary power of two's number of directions, and different scales can be decomposed into different numbers of directions. This feature makes contourlets a unique transform that can achieve a high level of flexibility in decomposition while being close to critically sampled. Figure below shows an example frequency partition of the contourlet transform where the four scales are divided into four, four, eight, and eight directional subbands from coarse to fine scales, respectively.

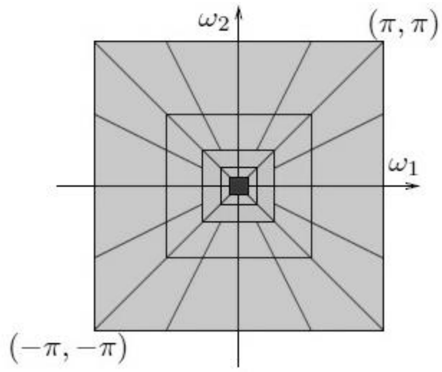

Figure 1: Frequency Decompositions by the Contourlet Transform

Figure 1 shows examples of possible frequency decompositions by the contourlet transform. In particular, by altering the depth of the DFB decomposition tree at different scales (and even at different orientations in a contourlet packets transform), we obtain a rich set of contourlets with variety of support sizes and aspect ratios. This flexibility allows the contourlet transform to fit smooth contours of various curvatures well.

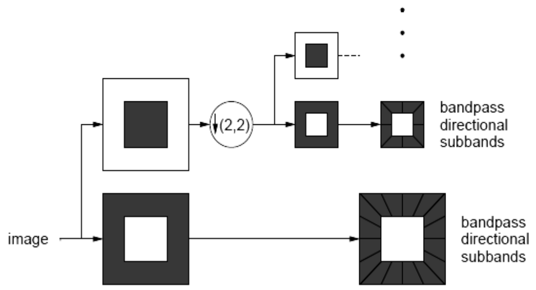

Figure 2: Contourlet Transform

Consider a 2-D function $f(t)$. We decompose it by discrete contourlet transform of scale J with $j\,l$ directions.

$$a_J[\vec{n}] = \langle f, \phi_{J,n} \rangle = \int_{\vec{t}} f(\vec{t})\, 2^{-J} \phi(2^{-J}\vec{t} - \vec{n})\, d\vec{t}$$

$$c_{j,k}^{(l_j)}[\vec{n}] = \langle f, \lambda_{j,k,n}^{(l_j)} \rangle = \int_{\vec{t}} f(\vec{t})\, \lambda_{j,k,n}^{(l_j)}(\vec{t})\, d\vec{t} \qquad (1)$$

$$\lambda_{j,k,n}^{(l)}(\vec{t}) = \lambda_{j,k}^{(l)}(\vec{t} - 2^{j-1} S_k^{(l)}(\vec{n}))$$

$$= \sum_{\vec{x} \in Z^2} d_k^{(l)}(\vec{x})\, \mu_{j,x}(\vec{t} - 2^{j-1} S_k^{(l)}(\vec{n})) \ ; \vec{n} \in Z^2 \qquad (2)$$

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$$\mu_{j,2n+k_i}(\vec{t}) = 2^{-j}\psi^{(i)}(2^{-j}\vec{t}-\vec{n})$$

$$S_k^{(l)} = \begin{cases} diag(2^{l-1},2) & for\ 0 \le k < 2^{l-1} \\ diag(2,2^{l-1}) & for\ 2^{l-1} \le k < 2^{l} \end{cases} \quad (3)$$

where $0 \le i \le 3$, $0 \le k \le 2l-1$, $j = 1,2,..., J$, and i k is a downsampling rate with ratio 2 for each dimension.

$$k_0 = (0,0)^T \quad k_1 = (1,0)^T \quad k_2 = (0,1)^T \quad k_3 = (1,1)^T$$

Therefore, we rewrite Equation (2) as

$$\lambda^{(l)}_{j,k,n}(\vec{t}) = \sum_{i=0}^{3}\sum_{\vec{x}\in Z^2} d_k(\vec{x})2^{-j}\psi^{(i)}(2^{-j}\vec{t} - 2^{-1}S_k\vec{n} - 2^{-1}\vec{x} + 2^{-1}k_i) \quad (4)$$

In these equations, $a_J[\vec{n}]$ is the approximation of the image and $C^{(l)}_{j,k}[\vec{n}]$ are detail coefficients. Also, $\{\lambda^{(l)}_{j,k,n}(\vec{t})\}_{\vec{n}\in Z^2}$ is a tight frame for the directional subspace $W^{(l)}_{j,k}$. Contourlet function $\lambda^{(l)}_{j,k,n}(\vec{t})$ has compact support with width of $c2$ j and length of $c2$ $j+l-2$ in the scale j. Also, it has L-order directional anishing moment (DVM). We can explain it the other way. For a contourlet function $\lambda^{(l)}_{j,k,n}(\vec{t})$ constructed from an iterated filter bank as in Equation (5), it has an L-order DVM along direction u□ if the discrete-time Fourier transform $W^{(l)}_k(e^{j\omega_1}, e^{j\omega_2})$ the associated filter $w^{(l)}_k[\vec{n}]$ also has L-order zeros along the line $u1w1 + u2w2 = 0$.

$$\lambda^{(l)}_{j,k}(\vec{t}) = \sum_{\vec{m}\in Z^2} w^{(l)}_k[\vec{m}]\phi_{j-1,m}(\vec{t}) \quad \text{……….. (5)}$$

where $w^{(l)}_k$ is the impulse response of the filter and $\phi_{j-1,\vec{m}}$ is a scaling function.

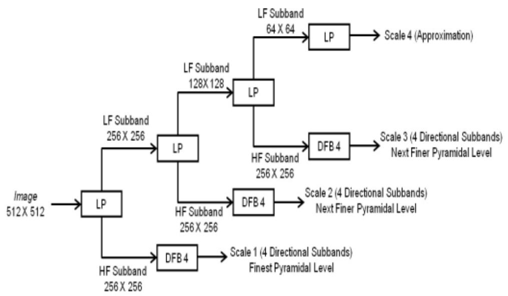

Figure 2.1: Flowchart of Contourlrt Transform for a 512 X 512 image.

Contourlet Transformgives a multiresolution, local and directional expansion of image using Pyramidal Directional Filter Bank (PDFB). The PDFB combines Laplacian Pyramid (LP) which captures the point discontinuities, with a DFB which links these discontinuities into linear structures. Figure 3.6, shows the fiowchart of Contourlet Transform for a 512X512 image. As shown in Figure 2.1, first stage of Contourlet Transform is LP decomposition and DFB is the second stage.

The Contourlet Transform is a multiscale, multi resolution filter that comprised of Pyramidal filter and Directional filter. The Proposed algorithm used Laplacian Pyramidal filter as Pyramidal filter and Steerable filter as directional filter. The Contourlet Transform enhances the image with its property of decomposition and reconstruction. The Laplacian Filter highlights regions of rapid intensity changes. The Laplacian Filters smooth the input image using a Gaussian smoothing filter in order to reduce its sensitivity to noise. Laplacian pyramid filter is used to capture the edge point. Directional Filter Bank is used to link the discontinuities point in linear structures. The Laplacian Filter decomposes the images into information at multiple scales. This filter extracts features of interest and to attenuate noise that present in the image. The applications of this filter can be image enhancement, restoration and image analysis. The input image is applied to a LP filter H and then down sampled to derive a coarse approximation a (Lowpass Subband). Then the image is up sampled. The resultant highpass subbands are derived from subtracting the output of the synthesis filter with the input image. The output of Laplacian filter is follwed by Directional Pyramidal Filters leads us to the contourlet transform. Here Steerable Pyramidal filter is used as Directional Pyramidal Filter.

III. MUTUAL INFORMATION

Although the information content of the images being registered is constant, the information content of the portion of each image that overlaps with other image will change with each change estimated registration transformation. Therefore a suitable technique for measuring joint entropy is to measure with respect to marginal entropy. This measure is known as MUTUAL INFORMATION I(A,B) .It can be independently and simultaneously proposed for multimodal medical image registration.

I (A,B) =H(A) + H(B) - H(A,B) ……….. (6)

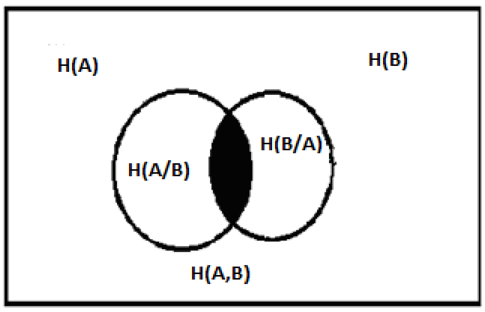

Figure 3: Mutual Information

Mutual information is a direct measure of the amount of information common between the two images as shown in fig 2. During image registration, however, different transformation estimates are evaluated, and these transformation estimates will result in varying degree of overlap between images, though it is better than joint entropy. The problem has been addressed by proposing various normalized form of mutual information that are more overlap independent.

$$I(A,B) = \frac{H(A)+H(B)}{H(A,B)} \quad \text{…………. (7)}$$

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Mutual information can be consider as a measure of how well one image explains the other; it is maximized at the optimal alignment.

IV. PROPOSED METHOD

In proposed method we use conturlet transform to detect the features from images followed by application of mutual information for similarity measurement.

The image is read and is given to the Contourlet Transform (comprised of Laplacian Pyramidal Filter and Steerable Filter) to enhance it. To enhance the image with more orientation the Steerable filter is applied at different angles as a directional filter in the Contourlet transform.

Algorithm

- Read Reference main image and Image to be registered.
- Obtain contourlet transformed imaged for both.
- Calculate values for joint histogram of two images.
- Determine Mutual information and the maximum of it.
- Calculate the angle of rotation and scale.
- Rotate the image with calculated angle of rotation and scale image accordingly.

V. EXPERIMENTAL RESULTS

Proposed algorithm is applied on various images, monomodal as well as multimodal and results are obtained for the same.

a. Mutual Information for Monomodal Image Registration

Two monomodal images are registerd using Mutual Information. Mutual information is used here as a similarity measure between two images.

Dataset 1:

(a)

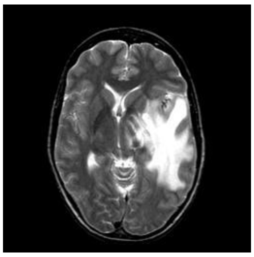
(b)

(c)

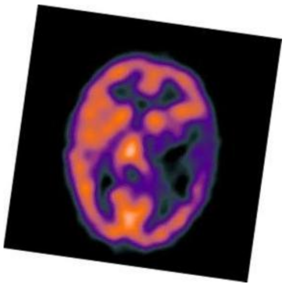
Figure 4: (a) Reference Input Image (210x210) (b) Image 2: Rotated Image (234x234) (c) Registered Image (210x210)

b. Mutual Information for Multimodal Image Registration

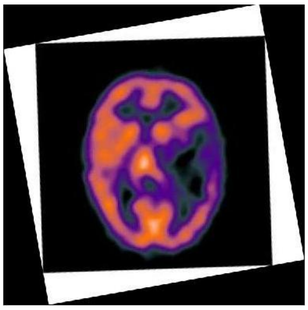
Mutual Information can be used as similarity measure for monomodal as well as multimodal images. Multimodal here refers to images taken by different source. Two images of same brain are used for the experiment. One is MRI of brain and other one is PET image of same brain.Mutual information is calculated for them and roteted and scales image is registered. Initialy experiment is done for roteted image later followed by roteted and scaled image.



(a)



(b)



(c)

Figure 5: (a) Reference Input Image (210x210) (b) Image 2: Rotated Image (234x234, Rotation 8 degree) (c) Registered image (304x303)

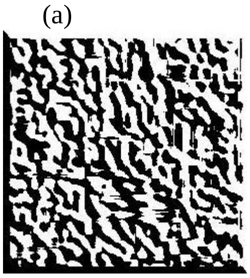
c. Contourlet Transform based Image Registration

For multimodal images mutual information can be effectively used as similarity measue and registration can be done. This registration can become more correct n effective if we use feature of images. Here features are extracted and then it is followed by mutual information as mapping function leads to increase in accuracy.

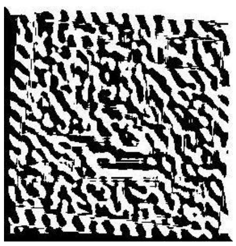
Dataset 1: Monomodal Images

(a)

(b)



(c)



(d)

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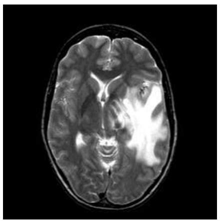
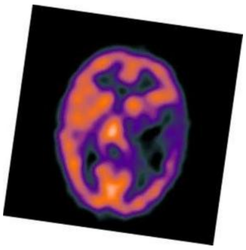
(e)

Figure 6: (a) Reference Input Image (210x210) (b) Image 2: Rotated Image (234x234) (c) Transformed Reference Input Image (210x210) (d) Transformed Image 2: Rotated Image (234x234) (e) Registered image (210x210)

Dataset 2: Multimodal Images



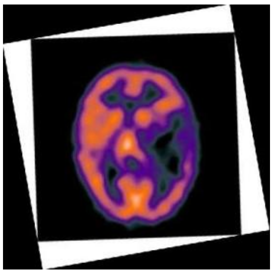
(a)



(b)

(c)

(d)



(e)

Figure 7: (a) Reference Input Image (210x210) (b) Image 2: Rotated Image (500x500, Rotation 8degree, scaled by 2) (c) Transformed Reference Input Image (256X256) (d) Transformed Image 2: Rotated Image (500X500) (e) Registered image (210X210)

VI. CONCLUSION AND FUTURE SCOPE

In multimodal registration, MI technique has become a standard reference, mainly in medical imaging. Some authors combined the MI with other, preferably feature-based, methods to gain higher robustness and reliability. This method can effectively register image but little lagging in accuracy. To increase accuracy, features of image can be extracted followed by Mutual Information as similarity measure. Contourlet Transform can be efficiently used for image registration. For a computational image representation to be efficient, it should based on a local, directional and multiresolution expansion. The need for image registration is to capture fine curves in image with multiresolution, which can be efficiently done with Contourlet Transform. With this method scale is corrected and angle of rotation is corrected with the difference of 1 degree. The future development on this field could pay more attention to the feature-based methods, where appropriate invariant features can provide good platform for the registration.

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