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Medical Brain Image registration- A Survey

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Abstract: Image registration is a vital problem in medical imaging. It is a process of aligning two images into a common coordinate system thus aligning them in order to monitor subtle changes between the two. Radiologists generally use multiple views of brain images to detect and characterize suspicious regions. When radiologists discover a suspicious lesion in one view, they try to find a corresponding lesion in the other views. Registration algorithms compute transformations to set correspondence between the two images the purpose of this paper is to provide a comprehensive review of the existing literature available on Image registration methods. Most current computer aided detection (CAD) systems differ considerably from radiologists in the way they use multiple views. These systems do not combine information from available views but instead analyse each view separately. Given the positive effect of multi-view systems on radiologists' performance we expect that fusion of information from different views will improve CAD systems as well.

Keywords: Image registration, co-ordinate system, correspondence

I. INTRODUCTION

Image registration is an essential accomplishment in all image analysis tasks in which ultimate information is realized from grouping of a range of data sources like in image fusion, change detection, and multichannel image restoration. Normally, registration is required in medicine (combining CT and / or MRI data to obtain additional complete information about the patient, monitoring tumour growth, treatment verification, evaluation of the patient's data with anatomical atlases), and in computer vision (target localization, automatic quality control).

MR imaging (MRI), invented in 1970, is a popular method in medical imaging. MRI scanning is relatively safe and unlike other medical imaging modalities, can be used as often as necessary. Moreover, it can be adapted to image brain. Clinical MRI is based on the hydrogen nucleus due to their abundance in the human body and their magnetic resonance sensitivity. For image formation, a large static magnetic field is used to perturb magnetic moments of proton that exist in the hydrogen nucleus from their equilibrium and observing how perturbed moments relaxes back to their equilibrium. Naturally, the protons are oriented randomly. But in existence of a static magnetic field, they line up with the field and the net magnetization of protons tends toward the direction of the field. In existence of enough energy, it is possible to make the net magnetization zero. In the relaxation process an induced electronic signal is recorded.

Image registration finds its applications in various fields like in medicine combining data from different modalities e.g. computer tomography (CT) and magnetic resonance imaging (MRI), to obtain more complete information about the patient, monitoring tumor growth. Most of the development of Computer-Aided Detection (CAD) systems has been based on the analysis of single views. To decrease the number of missed cancer cases during brain cancer screening, CAD systems have been developed. These systems are intended to aid the radiologist by prompting suspicious regions. To decrease the number of false positives and to improve consistency, there is a lot of interest to develop CAD techniques that use multiple view of information. Radiologists in breast cancer screening are trained to use comparisons of the left half and right half of brain to identify suspicious asymmetric densities. Views from previous screening rounds are used to detect developing densities.

Image processing methods which are possibly able to visualize objects inside the human body are of special interest. Advances in computer science have led to reliable and efficient image processing methods useful in medical diagnosis, treatment planning and medical research. In clinical diagnosis using medical images, integration of useful data obtained from separate images is often desired. The images need to be geometrically aligned for better observation. This procedure of mapping points from one image to corresponding points in another image is called Image Registration.

a. The reference and the referred image could be different because were taken at different times
b. Using different devices like MRI, CT, PET, SPECT etc (multi modal).
c. From different angles in order to have 2D or 3D perspective (multi temporal).

The human body consists primarily of water and bones. Moreover, trace elements exist in different parts of human body, such as iodine in the thyroid, tellurium in the liver and iron in blood. Medical imaging techniques use different properties of these elements. The important modalities are x-ray, computed tomography (CT), positron emission tomography (PET), single-photon emission computed tomography (SPECT), ultrasound and magnetic resonance imaging (MRI). The x-ray, invented by Wilhelm in 1895, is based on the measurement of the transmission of x-ray through the body. However, a disadvantage of x-ray is the high level of radiation emitted which can cause diseases such as cancer and eye cataract. In x-ray computer assistance tomography (CT), image is reconstructed from a large number of x-rays. In PET, radio nuclides are injected into patient's body which attach to a specific organ. SPECT is a nuclear medicine tomographic imaging techniques which able to produce true 3D image. It uses gamma rays. Ultrasound measures the reflection of ultrasonic waves transmitted through the body and is the best modality for investigation of soft tissues.

Image registration is the method of superimposing images (two or more) of the similar view captured at various times, from different perspectives, and/or by different sensors. The registration geometrically aligns two images (the model and sensed images). These approaches are classified based on their nature (area based and feature-based) and have four fundamental steps: (i) feature detection, (ii) feature matching, (iii) mapping function design, and (iv) image transformation and sampling.

II. REVIEW WORKS

Functional localization is a concept which involves the application of a sequence of geometrical and statistical image processing operations in order to define the location of brain activity or to produce functional/parametric maps with respect to the brain structure or anatomy. Considering that functional brain images do not normally convey detailed structural information and, thus, do not present an anatomically specific localization of functional activity, various image registration techniques are introduced in the literature for the purpose of mapping functional activity into an anatomical image or a brain atlas. The problems addressed by these techniques differ depending on the application and the type of analysis, i.e., single-subject versus group analysis.

Many techniques of the image registration have been proposed previously. Medha V. Wyawahare et al. [1] proposed Image registration as a vital problem in medical imaging with many applications in clinical diagnosis (Diagnosis of cardiac, retinal, pelvic, renal, abdomen, liver, tissue etc disorders). Ashok Veeraraghavan et al. [2] presented an approach for comparing two chains of deforming shapes by both parametric models like the autoregressive model and autoregressive moving average model and nonparametric methods based on Dynamic Time Warping. Kendall's definition of shape is used for feature extraction. E.D. Castro and C. Morandi [3] placed steps for the new technique, based on the Fourier-Mellin transform that rapidly identify global affine transformations applied to tabular document images, and to correct those. L. G. Brown [4] stated registration as an intermediate step. J. P. Lewis [5] described image registration as cross correlation that is efficiently executed in the transform domain and its normalized form is preferred for feature matching applications. S. Zokai and G.Wolberg [6] gave an idea about registration of multi resolution and multisensory images as a challenging problem in the research area of remote sensing.

Functional to anatomical brain image registration is the core part of functional localization in most applications and is accompanied by inter subject and subject-to-atlas registration for group analysis studies. Cortical surface registration and automatic brain labelling are some of the other tools towards establishing a fully automatic functional localization procedure. While several previous survey papers have reviewed and classified general-purpose medical image registration techniques, this paper provides an overview of brain functional localization along with a survey and classification of the image registration techniques related to this problem.

They proposed a new method for automatic affine image registration based on local descriptors, called automatic image registration by local descriptors (AIRLD). V. J. Traver et al [7], H. Araujo et al [8] and H S. Stone et al [9] discussed about the log polar transform technique for image registration. D. Lowe [11] presented a technique for extracting distinctive invariant features from images that can be used to achieve reliable matching among different views of an object or scene. J. B. Antoine Maintz et al. [10, 12] presented a review of recent publications concerning medical image registration techniques. In probability theory and information theory, Mutual Information [13, 14] (sometimes known as trans-information) between two discrete random variables is termed as the amount of information shared between the two random variables. It is a dimensionless quantity with units of bits and can be the reduction in uncertainty. High Mutual Information (MI) [13, 14] indicates a large reduction in uncertainty; low MI indicates a small reduction; and zero MI between two random variables means the variables are independent.

III. PROPOSED METHOD

Image registration essentially consists of following steps as per Zitova and Flusser [3]. Figure 1 illustrates the process. Feature detection: Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc) in both reference and sensed images are detected [15].

1. Feature matching: The correspondence between the features in the reference and

sensed image established.

2. Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated.

3. Image resampling and transformation: The sensed image is transformed by means of the mapping functions.

The initial detection step results in a number of suspect image locations. Each of the detected peaks is used as seed point for region segmentation, based on dynamic programming. For each region, features are calculated that describe the position of a region in the breast for instance, the distance to the pectoral and the skin, region size, contrast, texture, compactness, and acutance measures.

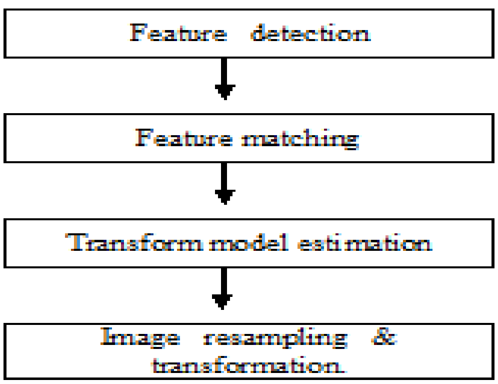

Figure 1 Step Involved in Image Registration

The registration method based on mass likelihood selects the location with the highest mass likelihood value as estimate for the mass location on the prior image. To this end we assign all locations inside the search area a mass likelihood value based on the outcome of a pixel level mass detection algorithm. This method calculates at each location inside the brain area two features for the detection of tumor area and non tumor area. Since information gained from two images acquired in the clinical track of events is usually of a complementary nature, proper integration of useful data obtained from the separate images is often desired. A first step in this integration process is to bring the modalities involved into spatial alignment, a procedure referred to as registration. After registration, a fusion step is required for the integrated display of the data involved.

For most registration algorithms [16-19], to compare two images involving the 2D geometric transformation, additional computations are essential as post processes such as image alignment; transform both images to the same coordinates prior to the comparison, and image normalization.

A registration procedure can always be decomposed into three major parts: the problem statement, the registration paradigm and the optimization procedure. The problem statement and the choice of paradigm and optimization procedure together provide a unique classification according to the nine criteria mentioned.

Image-based registration can be divided into extrinsic, i.e. based on foreign objects introduced into the imaged space, and intrinsic methods, i.e. based on the image information as generated by the patient. Extrinsic methods rely on artificial objects attached to the patient, objects which are designed to be well visible and accurately detectable in all of the pertinent modalities.

Intrinsic methods rely on patient-generated image content only. Registration can be based on a limited set of identified salient points (landmarks), on the alignment of segmented binary structures (segmentation based), most commonly object surfaces, or directly onto measures computed from the image gray values (voxel property based).

It seems paradoxical that registration of multimodal images can be non-image based, but it is possible if the imaging coordinate systems of the two scanners involved are somehow calibrated in each other. This usually necessitates the scanners to be brought into the same physical location, and the assumption that the patient remains motionless between both acquisitions.

This method based on a reduced set of feature points is established to pace the search procedure. The search is lessened from every pixel of the target image to a set of feature points only. These are got by applying Gabor transform to every pixel and selecting those pixels that generate high energy in the wavelet domain. We first estimate the line orientation at each location inside the image using directional second order Gaussian derivatives. We then denote a neighbourhood around each pixel in the image. We call this pixel the centre pixel. To estimate whether tumor is present we derive the following two features from the map of line orientations inside this neighbourhood. The first feature is a normalized measure for the fraction of pixels with a line orientation directed toward the centre pixel. The second feature calculates to what extent the pixels with a line orientation toward the centre pixel are equally distributed in all directions.

Features to detect centre point of brain we use the detection of similar pixel. Instead of determining the line orientations we now calculate the gradient orientation at each location in the image. If a mass is present pixels in a neighbourhood of the centre pixel will have a gradient orientation toward the centre. Otherwise a random gradient direction will be found. We derive the following two features from the calculated gradient orientations. The first feature is a normalized measure of the fraction of pixels with an intensity gradient pointing toward the centre pixel. The second feature calculates whether these pixels occur in all directions of the centre pixel. Figure 2 shows output of the proposed image registration approach.

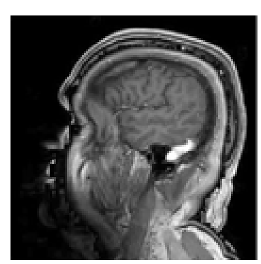

Figure 2 Registered Image obtained using Approach

Mass likelihood and mass features are used as input for a 3-layer feed-forward neural network trained on known abnormalities. Then we use the classifier output as mass likelihood. Registration methods based on gray scale correlation calculate the pixel correlation between a template Image of the current mass the current mass templatel and a candidate region on the prior image. We design different templates for the registration method based on correlation: an inner mass template, an outer mass template, and three extended templates. These templates cover different parts of the underlying mass lesion and its surrounding tissue. For all templates we first determine the contour of the current mass with a segmentation algorithm based on dynamic programming. The last registration method combines the mass likelihood with the correlation measure and a distance criterion.

IV. CONCLUSIONS

In this paper we present a method to link potentially suspicious mass regions detected by a Computer-Aided Detection scheme in mediolateral oblique and craniocaudal mammographic views of the breast. For all possible combinations of mass candidate regions, a number of features are determined. These features include the difference in the radial distance from the candidate regions to the nipple, the gray scale correlation between both regions, and the mass likelihood of the regions determined by the single view CAD scheme. It is expected the result shows encouraging.

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