

Medical Image Analysis and new image registration technique using mutual information and optimization technique

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Abstract: *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. Accurate assessment of lymph node status is of crucial importance for appropriate treatment planning and determining prognosis in patients with gastric cancer. The aim of this study was to systematically review the current role of imaging in assessing lymph node (LN) status in gastric cancer. The Virtual Navigator is an advanced system allows the real time visualization of ultrasound images with other reference images. Here we are using gastric cancer MRI, gastric cancer CT and gastric cancer PET scanning techniques as a reference image and we are comparing all the three fusion imaging modalities. The objective of this research is to registering and fusing the different brain scanning imaging modalities by keeping Ultrasound (US) as base image and Positron Emission Tomography, Computed Tomography and Magnetic Resonance Imaging as a reference image, the efficiency and accuracy of these three fused imaging modalities are compared after fusion. Fused image will give better image quality, higher resolution, helps in image guided surgery and also increases the clinical diagnostic information.*

Keywords: Image registration, Virtual Navigator, Image fusion. Gastric cancer.

I. INTRODUCTION

Gastric cancer is the fourth most common cancer and the second leading cause of cancer-related death world wide .In 2002, about 934 000 people were diagnosed with gastric cancer, and approximately 700 000 died of the disease [1]. Image fusion is the combination of two different imaging modalities with regard to one and the same anatomic area. The intent is to combine anatomic and functional image information. Specific examples of systems where image registration is a significant component include matching a target with a real-time image of a scene for target recognition, monitoring global land usage using satellite images, matching stereo images to recover shape for autonomous navigation, and aligning images from different medical modalities for diagnosis The development of multimodality methodology based on nuclear medicine (NM),positron emission tomography (PET) imaging, magnetic resonance imaging (MRI), and optical imaging is the single biggest focus in many imaging and cancer centers worldwide and is bringing together researchers and

engineers from the far ranging fields of molecular pharmacology to nanotechnology engineering. This paper presents a new technique for registration of multimodal images (CT and MRI) using mutual information. The Virtual Navigator is an advanced system allows the real time visualization of ultrasound images with other reference images. Here we are using gastric cancer MRI, gastric cancer CT and gastric cancer PET scanning techniques as a reference image and we are comparing all the three fusion imaging modalities. The combination has, as the final result, the real time data fusion which allows increasing the accuracy and confidence of ultrasound scanning, by overlaying the different images or visualizing them side by side. The superimposition of US to the previously acquired MRI, CT and PET volume consisted of two procedures depending on the operator skill and experience. One is external marker registration and another is internal marker registration. In external marker registration we are using a point based rigid registration. The internal marker registration is obtained by scanning from any available ultrasound window. The common registration used is External Fiducial Marking acquired with the two modalities was improved using facial anatomical landmarks. By fusing the images, it will give better performance, high resolution picture, and reduces the randomness, redundancy in order to increase the clinical diagnosis information.

II. LITERATURE SURVEY

As imaging technology continues to evolve [9], the purpose of this study was to systematically review the current role of imaging in assessing LN status in gastric cancer. This study reviews the role of imaging in discriminating node-negative from node-positive patients rather than its role in assessing nodal stage according to the TNM or Japanese Gastric Cancer Association (JGCA) classifications. Image registration is the process of transforming different sets of data into one coordinate system [1], [2], [3], [4]. Data may be multiple photographs, data from different sensors, times, depths, or viewpoints. This Registration is used in medical imaging, computer vision, in military, comparing images, analyzing satellites images. In image registration two images are involved- the reference image and test image. The reference image is denoted by $f_1(x)$ and test image is denoted by $f_2(x)$, where x is the coordinates of images. If T is a transformation of

coordinates then $f_2(T(x))$ is associated to reference image $f_1(x)$. We need to find the transformation T such that it gives maximum similarities between reference image and test image with the help of an optimization method.

$$T = \text{ArgmaxMetric} [f_1(x), f_2(T(x))].$$

The organization of the paper is as follows. Section I presents a general outline to the image registration process. A comprehensive literature survey on image registration methods applied in the medical image analysis is given in Section II. The Virtual Navigator algorithm is presented in Section III. Section IV deals with medical image registration methods. Results explained in section v. Finally, the work is concluded in Section VI.

III. IMAGE REGISTRATION

Frame work of medical image registration is shown in figure.1, and the components involved are presented in the following subsection.

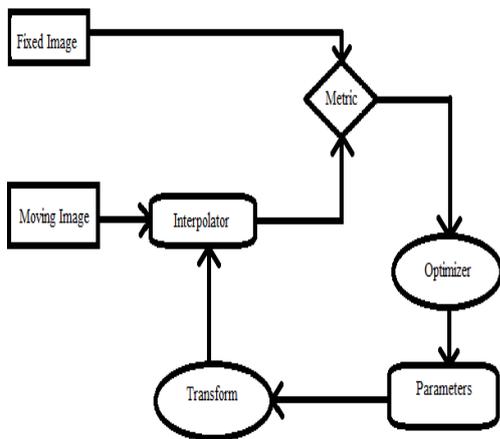


Fig. 1 Process of Image Registration

Image registration involves aligning two or more images before they can be meaningful overlaid or compared. Medical image registration is applied to three major areas:

1. Multimodality Fusion (overlying) of images that provide complementary information (typically structural and functional).
2. Serial comparison to quantify disease progression or regression especially in response to treatment.
3. Intersubjective registration which is aimed at creating a normalized atlas representative of a patient population.

IV. METHODOLOGY

Virtual Navigator is the fusion technology which uses Intra operative Ultrasound (US) as base image and Preoperative PET (study analysis purpose)/CT/MRI as reference images. First we give US and PET, US and CT, US and MRI as input images then these brain scanning imaging modalities are registered using point based rigid registration and manual registration (by selecting control points), the registered images are fused using Rigid

Transformation and Spatial Transformation. We compare the accuracy and efficiency after the fusion of these three imaging modalities Image Fusion of Ultrasound with different Imaging Modalities using Virtual Navigator with ultrasound. These fused images will give better image quality, higher resolution and it decreases the randomness, redundancy and helps in image guided surgery, increases the clinical diagnostic information.

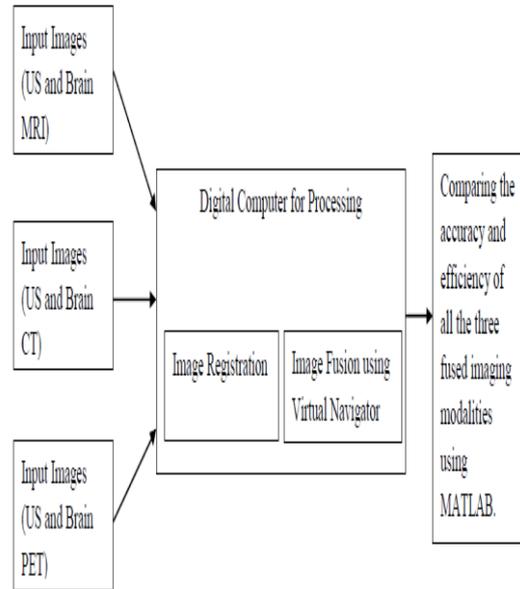


Fig 2:B.D of Comparing the accuracy and efficiency of all the three fused imaging modalities.

V. MEDICAL IMAGE REGISTRATION METHODS

A. RIGID REGISTRATION

Rigid image registration models assume that the transformation that maps the moving image to the fixed image consists only of translations and rotations, while deformable models allow localized stretching of images. Rigid models are sufficient in certain circumstances. Point-based rigid registration is commonly used for image-guided systems. One set of point is to be registered to another set of corresponding points by means of a rigid transformation of the first set. Surgical guidance systems based on preoperative images, such as CT or MRI; typically employ a tracking system to map points from image to the physical space of the operating room. For neurosurgery and ear surgery, because of the rigidity of the skull, the point mapping is typically a rigid transformation. The transformation is usually based on fiducial markers that are attached to the head before imaging and remain attached until the procedure begins. A fiducial point set is obtained by localizing each fiducial marker both in the image and in the operating room. Then, a least-squares problem is solved to register the image points to their corresponding physical points, and the result is the rigid transformation. Fiducial localization error (FLE) causes registration error, and the least-squares approach is used to obtain the transformation that minimizes this error in fiducial alignment.

B. DEFORMABLE REGISTRATION

There are many existing approaches to deformable registration: Splines-based transformation models are among the most common and important transformation models used in non-rigid registration problems. Splines-based registration algorithms use control points in the fixed and moving images and a splines function to define transformations away from these points. The two main spline models used in image registration problems are thin-plate splines and B-splines. Thin-plate splines have the property that each control point has a global influence on the transformation. That is, if the position of one control point is perturbed, then all other points in the image are perturbed as well. In contrast, B-splines are defined locally in the neighborhood of each control point. As a result, B-spline-based registration techniques are more computationally efficient than thin-plate splines, especially for a large number of control points.

C. LAND MARK REGISTRATION (MANUAL REGISTRATION)

Landmark-based registration techniques use the correspondence of a set of features, or landmarks, in the images to determine the transformation that maps the moving image to the fixed image. Although landmark-based techniques are computationally easy to implement, the identification of corresponding features in the images to be registered is a difficult and time-consuming task, and the accuracy of such techniques is dependent on precise correspondence between landmarks. Landmark-based registration algorithms use the (manual or automatic) identification of corresponding anatomical structures (or other features) in the images to be registered. Landmark based registration algorithm use the (manual or automatic) identification of corresponding anatomical structures in the images to be registered. Landmark-based registration techniques are computationally simple and efficient, but the main drawback of such techniques is that they rely on precise correspondence of features in the images to be registered. Although there has been recent research on automatic identification of landmarks in practice landmarks are typically identified manually. Precise identification of corresponding landmarks is time consuming and tedious, even for a medical expert. In addition, there are numerous known examples of cases in which the result of the landmark registration process is a transformation which correctly matches the user-supplied landmarks but is not physically meaningful.

D. IMAGE FUSION

Image fusion is a technology which can combine two or more images into a larger image. There are many image matching methods with promising matching results. Image mosaic techniques can be mainly divided into two categories:

- 1) Based on image mutual information and,
- 2) Based on image feature.

Usually former Image fusion algorithms requires high overlap ratio of two images and due to that high mismatch rate exist. Mismatch can be reduced among image pairs by improving Feature correspondence between image pairs are available and utilize these correspondences which register the image pairs. Feature is defined as an "interesting" part of an image, and features are used as a starting point for many computer vision algorithms, the desirable property for a feature detector is repeatability: whether or not the same feature will be detected in two or more different images of the same scene When feature detection is computationally expensive and there are time constraints, a higher level algorithm may be used to guide the feature detection stage, so that only certain parts of the image are searched for features. Many computer vision algorithms use feature detection as the initial step, so as a result, a very large number of feature detectors have been developed. At an overview level, these feature detectors can be divided into the following groups: Edges, Corners/interest points, Blobs/regions of interest or interest points, Ridges.

V. RESULTS

Based on rigid registration and rigid transformation

A. PET AND ULTRASOUND (US)



Fig 3: Positron Emission Tomography and Ultrasound Image for registration.

This image is related to the Image registration and Image Fusion of Ultrasound which is having problem in Circle of Willis, this image is taken as a base imaging modality and Positron Emission Tomography gastric cancer, this image is taken as a reference imaging modality.

B.US AND PET REGISTRATION

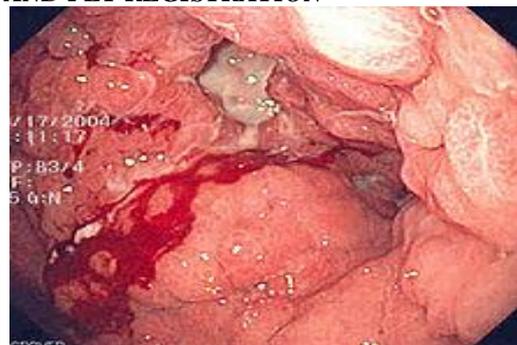


Fig: 4. Ultrasound and Positron Emission Tomography registration.

This image is the registration image of Ultrasound and positron emission Tomography. By registering the image Error and alignment problem will reduce. Time taken to register the image is 0.2223 sec.

C.US AND PET FUSION WITH OPTIMIZER AND METRIC PARAMETERS



Fig: 5 fusion of Ultrasound and Positron Emission Tomography

It fuses with 100 iterations with epsilon $1.5e-4$, hence the iteration decreases time also decreases, but here efficiency and accuracy will increase compare to other images. It takes 0.2087 sec.

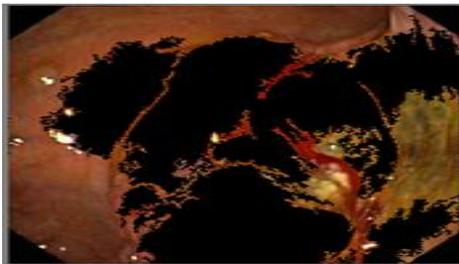


Fig 6. Fusion of Ultrasound and Positron Emission Tomography with 80 iterations

It is the fused image with 80 iterations, and initial radius 0.001, time taken is 0.2000 sec.

D. CT AND ULTRASOUND (US)

This image is related to the Image registration and Image Fusion of Ultrasound which is having problem in Circle of Willis, this is taken as a base imaging modality and Computed Tomography image of gastric cancer..

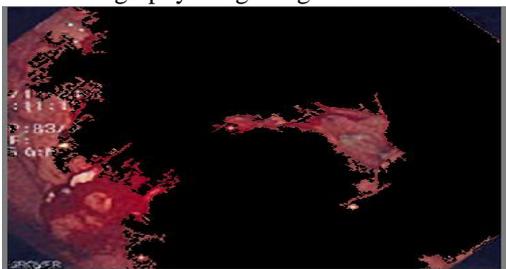


Fig: 7. Computed Tomography and Ultrasound image for registration.

E. US AND CT REGISTRATION

By registering the image Error and alignment problem will reduce. Time taken to register the image is 0.2267 sec.

us and ct fusion with optimizer and metric parameters:

After fusing the images we will take Optimizer and Metric parameters to measure the efficiency, accuracy of fused imaging modalities. Time taken to fuse the image is 2.4661 sec.

F. MAGNETIC RESONANCE IMAGING (MRI) AND ULTRASOUND (US)

This image is related to the Image registration and Image Fusion of Ultrasound which is having problem in circle of Willis part, this is taken as a base imaging modality and magnetic Resonance Imaging of epilepsy, this image is taken as a reference imaging modality.

G. US AND MRI REGISTRATION

By registering the image Error and alignment problem will reduce, especially these two imaging modalities will overcome the orientation problem. Time taken to register the image is 0.3225 sec.

H. US AND CT FUSION WITH OPTIMIZER AND METRIC PARAMETERS

This image is the fusion of Ultrasound and Positron Emission Tomography. After fusing the images we will take Optimizer and Metric parameters to measure the efficiency, accuracy of fused imaging modalities. Time taken to fuse the image is 1.9661 sec

I. US AND MRI REGISTRATION

By registering the image Error and alignment problem will reduce, especially these two imaging modalities will overcome the orientation problem. Time taken to register the image is 0.2565 sec.

J. US AND MRI FUSION WITH OPTIMIZER AND METRIC PARAMETERS

After fusing the images we will take Optimizer and Metric parameters to measure the efficiency, accuracy of fused imaging modalities. Time taken to fuse the image is 1.9636 sec.

VI. CONCLUSION

The proposed registration method is based on external fiducial marker or facial landmarks, then on internal structures, demonstrated good applicability and precision. Therefore the fusion of different imaging modalities will decrease the randomness, redundancy and also improve the quality of image; so that it will increase the clinical applicability of medical images for diagnosis and it is used in the image guided systems. By seeing the results we can conclude that the fusion of US and MRI gives the more accurate results, better quality picture compared to US/CT and US/PET.

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