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Survey on Various 3D Brain Image Reconstruction Methods based on MRI

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ABSTRACT: Brain image registration, formation, reconstruction, assessment and investigation permits significant measurable examination of variety of modalities like CT, MRI, PET etc. Registration of Brain image is essential to integrate the brain information that is obtained from various kinds of sensors to discover the anatomical variations in images. Those images are taken under various conditions, at different period of times and to interpret the information about the brain from images. It aids as powerful tool in correction of motion, fusion of image, locating disease and detecting tumors etc. The brain image reconstruction is an enormous field in dealing with various modality images. The brain MRI images have unique characteristics, i.e. very complex changes of the gray-scales and highly irregular boundaries. The reconstruction helps to analyze the images of brain in precise manner to examine the problems and diseases related to brain and diagnose them effectively. In this proposed work literature survey is done to study different 3D reconstruction techniques, which helps the doctor to diagnose the brain diseases.

KEYWORDS*:* *MRI image, Registration, 3D Reconstruction, Brain MRI*

I. INTRODUCTION

Brain is one of the important human body parts. It consists of several kinds of encephalic tissues. The edge of these encephalic tissues makes the brain that is extremely irregular. The traditional approach of 3D reconstruction using brain MRI images does not give the reconstructed result accurately. In biomedical imaging applications, 3D image reconstruction is an attractive outlet in digital signal processing.

The 3D reconstruction research provides security that is necessary in the medical imaging technology development. 3D reconstruction mechanism also provides important technical support and broad application prospect in the field applications of medical image. Soon after development years, from auxiliary diagnosis, 3D medical image reconstruction became on prominent means of supplementary therapy. Using 3D reconstruction technology in medical image processing, the structure of 3D model, the information of the extracted relevant organs, and the three dimensional model from display of different direction projects, can make quantitative explanation of the space position, and size, sharp of the doctor interested organs. Overview of the 3D demonstration of 2D brain MRI image is presented in Figure 1.

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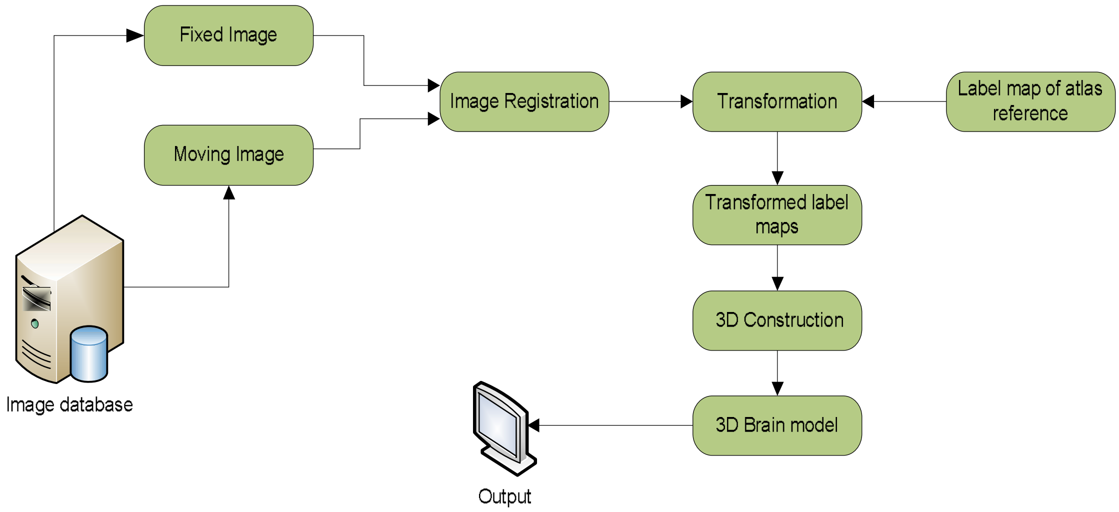

Figure 1: Overview of 3D reconstruction of 2D Brain MRI Image

Medical Image Registration refers to the procedure of identification and alignment of interrelated structures of two medical images. Correlation and a transformation of two images that are to be registered must be found to map location in one image to a new location in the second image. This mapping must be optimal. The optimality criteria depend on the actual structures or objects in the images that are used to match. The various types of medical images are discussed below [2]:

a) CT SCAN

The image information from various angles using special X-ray tools around the body is obtained using CT (Computer Tomography). The cross section of organs can be viewed by processing this data in the computer. As we get clear and good clarity in various type of tissues and gives detailed view of cross-sectional areas of tissues, radiologists are able to diagnose various diseases and disorder easily. Studying of chest and abdomen has become easy from the CT scan image characteristics. Mineral density in the bone to identify osteoporosis can be also measured from this. This also helps in identification of injuries in the liver, kidneys, spleen and many other internal organs.

b) *MRI* SCAN

The detailed view of the inside the body is acquired by MRI (Magnetic Resonance Imaging) which uses magnetic and radio waves. It is free from the radiations that form damaging (X-rays). The nuclei in the atom of the human are enforced to shift different positions from the rays of MRI equipment. These nuclei when moves back to places they emit the radio waves of themselves to the scanner that image in the computer. These images depend on the potency and location of signal which is incoming to the scanner. MRI scan is created by using the hydrogen atom nuclei as our body mainly consists of water. Water includes atoms of hydrogen. The part which has least hydrogen atoms will appear darker while the tissue that contains more number of hydrogen atoms will appear brighter. Thus MRI images are suitable to discover the tumor exist in the brain and to inspect the spinal cord. Two kinds of images fall MRI scan: T1 and T2. T1 weighted images present admirable detailed anatomic but contrast between ordinary normal tissues and the abnormal tissues are not shown good, while T2 weighted images even though has anatomical detail less but shows contrast between tissues of abnormal and normal excellently.

The following are general steps for registration if the image [1]:

- Detection of features: Discriminative and the salient objects (like contours, corners, edges, closed-boundary regions, line intersections, etc) from sensed image and reference image are detected.

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- Matching the features: The correspondence among features is established in the sensed image and reference image.
- Estimation of transform model: Estimation of various types and parameters of aligning or mapping functions of sensed image to the reference image.
- Re sampling and transformation: using mapping functions the sensed image is transformed. Figure 2 represents the basic steps involved in the image registration.

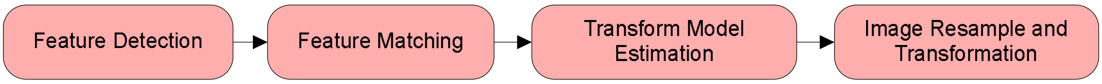

Figure 2: Steps involved in Image Registration

The rest of the paper is formed as follow: Section II explain the different techniques that have been studied as a part of the literature survey. Lastly, we conclude our survey paper in Section III followed by the reference.

II. LITERATURE REVIEW

This section presents literature survey on different 3D reconstruction methods based on brain MRI image and image registration methods.

- **Image Registration**

Medical Image Registration is the method of recognition and alignment of interrelated structure of two medical images. Image registration is a significant step in all image study tasks in which the ultimate information is extracted from the various data sources combination. Various data sources are like in image fusion, detection of changes and multichannel image restoration. Survey is conducted on image registration mechanisms are explained below.

Terrence Chen et.al [03] presented a novel coarse to fine registration technique, which distinguishes fine and coarse images using objects at various scales instead of using the different resolutions of the images. As traditional 3D brain MRI registration techniques will avoid local minimum and uses multi-resolution coarse-to-fine algorithm to improve the process of registration efficiently. But it is not enough to avoid local minimum traps. To overcome this drawback, authors in [3] propose a new viewpoint on coarse-to-fine registration. A new framework for image registration is developed based on this new viewpoint, which combines the novel multi-scale technique with method of multi-resolution to achieve robustness and higher accuracy on 3D brain MR images. This is called multi-scale and multi-resolution coarse-to fine (MMCTF) optimization technique which is used combination with any interpolation method, transformation method, and also with metric of similarity in order to attain results of registration accurately and consistently. The initial step of this technique is to obtaining contour for reference and floating images. Second step is to use coarse to fine technique for registration of both contour images. At the beginning of lowest resolution registration, rotation, translation and parameters of global scaling are applied to speed up the search. Then Powell's local optimization technique is applied to discover the maximum similarity measurement in all the levels. The final parameters are used for registration of floating as well as reference image which is followed by the contour image registration [3].

The appearance of identical structures in the images varies from the images acquired by different imaging device like MR or CT. Registration algorithms usually deforms one image as floating image in such way that it matches with the referenced images, by increasing the resemblance score between the images. Daewon Lee et.al [04] presented a learning of similarity quantify in a discriminative way that high similarity score is received between references and properly distorted floating images instead of universal. In this referred work, the method employs the structural information that is present in neighborhoods around a voxel of interest. Applying a changed version of the method max margin structured output learning techniques to the problem, the above effects are achieved. The statistics between and within the modalities of the images that are to be registered from the use of feature space demonstration in the infinite dimensional are captured in the efficient way by utilizing joint kernels for input space and output space.

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Sylvain Prima et.al [05] presented a multimodal non rigid registration technique. The registration of intra-subject (rigid-body) multimodal 3D image is done through the approximate mutual symmetry of brain to respective inter-hemispheric fissure. An estimated symmetry plane of the two images is defined and computed in order to register and as well as to use these planes in the problem of registration as constraints. This difficulty of 6-parameters is turned into problem of three successive parameters. Hoping that these three sub problems are made easier and faster in solving than the previous, the algorithms are implemented, with frame work of common intensity using similarity measure which is the mutual information [5].

Brian B. Avants et.al [06] presented a brain image registration technique. In this referred method, twofold cross-validation is used to contrast the performance on manually labeled, openly available, T1-weighted 40 MRI brain image data subjects. The ANTs open source software library contains a suite for the registration of state-of-the-art image, segmentation and pattern construction tools for the analysis of quantitative morphometry. The ANTs is used for the first time to estimate the pattern-based normalization learning of similarity metric impact on the deformable and affine components. The performance of similarity metrics is compared by the utilization of twofold cross-validation on T1-weighted MRI brain image data which is openly available and manually labeled.

The common categorization schema is provided by following components for registration methods:

- The transformation model, which contains the regularization kernels.
- The similarity measures, and
- The optimization strategy.

Generally, the optimal transformation is computed by image normalization that maps each x of image I(x) to the location in image J which is finished using by minimizing a cost function, C that describes the similarity between I and J.

Registration process is challenging task when performing fusion of different sensor images with different resolutions. In image registration ridges are helpful geometrical features. Ayush Dogra et.al [18] presented an Image registration system of MRI and CT images for medical applications. In this referred method, initially to sharpen the images butterwort high pass filters and Gaussian filters are used. Then ridges in the CT and MRI brain images are detected using scale space primal sketch. Finally 3D volume of the both CT and MRI images are cross correlated for registration. At cutoff frequency 100MHz, filters shows improved quality in visual comparison and also fourth order of Butterworth filter yields very sharper images than Gaussian filter. Visual results of this registration can be used in certain ENT surgical and neurosurgical planning. Table 1 shows the survey on different medical image registration techniques.

Table 1: Survey on Medical Image Registration Techniques

Title	Year	Algorithm	Advantage	Improvement
Image Registration Improves Human Knee Cartilage T1 Mapping with Delayed Gadolinium-Enhanced MRI of Cartilage (dGEMRIC) [17].	2013	Rigid Transformation model	Improves the T1 maps and reduces the uncertainty	Improvement in the quality of T1 maps
Unsupervised Deep Feature Learning for Deformable Registration of MR Brain Images [21].	2013	Deformable image registration.	Promising registration results	Improvement in quality of image registration
CT and MRI Brain Images Registration for Clinical Applications [18].	2014	Based on Geometrical features	Method is fully automatic	Also used for T1 and T2 MRI Registration

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Nonrigid Registration of Ultrasound and MRI Using Contextual Conditioned Mutual Information [19].	2014	Contextual Conditional Mutual Information based non rigid registration technique	Best results in Ultrasound and Magnetic resonance Registration	Registration can be extend between T1 and T2 MRI of Brain
MR to CT Registration of Brains using Image Synthesis [22].	2014	Contrast synthesis technique	Showing 25% improvement	Can be implement in MRI-MRI image registration

- **3D Reconstruction**

3D reconstruction is the method of producing a computer model of the 3D visualization of an object using a set of two dimensional images. It is very common in medicine and computer vision using, for instance serial sections produced by magnetic resonance imaging or computed tomography (CT). Now a day's 3D reconstruction is gaining more importance and it is very significant for doctors to diagnose diseases. The survey of the 3D reconstruction techniques associated with brain MRI is presented below.

Kanglin Chen et.al [08] presented an approach of obtaining 3D reconstruction and mapping the depth from various 2-D images is introduced. The approach of self calibration to simple essential matrix is exploited. 3-D depth extraction is obtained by image registration, segmentation and mapping of the pixels in retinal images and human faces. A 3-D array from the MRI slices is obtained and iso-surface is extracted to get complete 3-D reconstructed skull. Here the method is based on L 2 – and L 1 –norm.

Mrs. Megha Sunil Borse et.al [07] presented a paper on 3D reconstruction from 2D MRI images. It is found that two classes support vector machines are successful for the problems of pattern identification because it has more ability to solve problems related to nonlinearity, it is used in the reconstruction of 3D. Based on the intensity values of the brain tissues, they can be segmented. In MRI image segmentation, region growing technique is used for segmentation as it will segment more than a single type of brain tissue and also gives accurate results. And these images use SSSVM which is more flexible by optimizing the parameters by the use of Immune Algorithm.

Sayali Lopes et.al [09] presented an approach for brain tumor detection and 3D construction. It involves various implementation steps for detection of tumor and tumor extraction from the 2D MRI slices using seeded region growing method with automatic selection of seed. New software also designed for 3D image reconstruction from 2D tumor images. In semantic image segmentation seeded region growing technique is very important method. Seeded region growing contains high knowledge level in components of image during seed selection process. Including 3D reconstruction tumor volume also estimated based on image computation.

M. Fathima Zahira et.al [10] presented a MRI brain image analysis and 3D reconstruction. This referred system contains six steps namely: pre-processing, segmentation, feature extraction, feature selection, classification and 3D reconstruction. Initially in this approach preprocessing of brain MRI is performed using modified spatial median filter and processed image is segmented with the help of region growing segmentation technique. To take out the features from segmented image WV-GLCM method is used and the feature selection process is performed based on ANFIS technique. The next process is classification which is done by Type 2 fuzzy logic system and finally 3D reconstruction process is presented that is based on ImageJ tool.

Megha P. Arakeri et.al [11] presented an approach of 3D Reconstruction and Brain Tumour Quantification on MRI Images is presented. To achieve enhanced quality in acquired images pre-processing is performed. After pre-processing, modified fuzzy c means (MFCM) clustering method is used for segmentation of abnormal brain slice to identify the tumour region and normal slices are removed from the slice set. To offer smooth surface, the gab in the slices is filled using referred system developed interpolation mechanism. Finally 3D construction is performed using marching cub technique and also tumour volume is computed using tumour slices.

A. Sakthi Bharathi et.al [12] presented a 3D construction of brain tumour MRI using triangulation technique. In this referred paper implementation of 3D reconstruction are done using two different reconstruction techniques namely: stacking algorithm and Delaunay triangulation based on patches. In those two techniques Delaunay triangulation

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technique presented best quality and tumour volume ratio. Table 2 shows the survey on various 3D reconstruction techniques.

Table 2: Survey on 3D Reconstruction Techniques

Title	Year	Algorithm	Performance
3D Reconstruction of Brain Tumour from 2D MRI's using FCM and Marching Cubes [20]	2014	Marching cubes technique	Improvement in execution speed
A Useful Approach towards 3D Representation of Brain Abnormality from Its 2D MRI Slides with a Volumetric Exclamation [13].	2015	Stack Implementation technique	Accurate 3D model in less amount of time
Smart Algorithm for 3D Reconstruction and Segmentation of Brain Tumour from MRIs using Slice Selection Mechanism [16].	2015	Slicer 4.3.0. 3D modelling tool	Accuracy = 96.6%
An Efficient Classification of MRI Brain Images and 3D Reconstruction Using Depth Map Estimation [14].	2017	Depth Map Estimation	Less computation intricacy
Trilinear Interpolation Algorithm for Reconstruction of 3D MRI Brain Image [15].	2017	Trilinear Interpolation technique	Enhance 3D model with Multi view

III. CONCLUSION

This proposed paper presents short depiction and examination of the techniques and methods implemented for processing brain imaging in the prospect of registration and reconstruction in previous works. Registration strategies can be modified to meet various requirements by optimizing tradeoffs between speed and accuracy. Brain image reconstruction is important for disease diagnosis. We have presented different registration and 3D reconstruction techniques. This 3D construction helps doctor to identify and diagnose brain disease. This explains that there is lot of work is conducted in this area but still there is a need to formulate medical sector more effective in 3D construction of MRI.

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