IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol-6, Special Issue-4, May 2018 E-ISSN: 2347-2693

A Review on Fetal Brain Structure Extraction Techniques from Human MRI Images

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Available online at: www.ijcseonline.org

***Abstract*—**Fetal brain magnetic resonance imaging (MRI) is an essential and trivial task to analyze and detect the growth of baby brain abnormalities and possibilities of diseases related to the brain. This Paper starts with different perception and view of different elder's analysis and techniques such as morphological, voxel classification, Richardson LucyDeconvolution Method, diffusion-weighted and fast furious transform with Fetal Brain MRI. Finally, concluded with the development trend of automated image segmentationtechniques of fetal brain MRI imagesand their comparison.

Keywords*—Image Segmentation, fetal brain MRI, Morphological, Voxel Classification,Richardson Lucy Deconvolution Method, Diffusion-Weighted, Fast Furious Transform*

I. Introduction

The Brain is the crucial organ which can handle and control the intact parts of the human body. The disfiguration in the head/brain can lead to various diseases like, appearance of tumor, shrinking of brain, neurological disorder, brain injury, trauma, autism, seizures, stroke,dementia [1], Alzheimer Diseases [2], Parkinsons Syndrome and so on.

This paper primarily focuses on the fetal brain MRI images segmentation. The ultimateaim is to prevent or reduce the impact of the diseases for the baby using the analysis on the images.

The fetal brain structure segmentation also helpful in monitoring the fetal growth. The fetal brain segmentation from MRI iamges helps the physicians in accessing the fetal development disorders.

There are many imaging modalities available in the market today, the most democratictools are, Magnetic Resonance Imaging (MRI)for extracting images from the human organs. The MRI images are used largely to deal with brain which has high resolution and contrast comparing with the all existing modalities. Since it was complex and requires more sensitive analysis.

Magnetic Resonance Imagingimages are produced in three different views such as axial, coronal and sagittal produces T1 and T2 weighted images. The MRI images helps to study the diversity of data from the human brain for instance volume estimation, automatic tumor detection [6], image registration, segmentationand so on.

The article is channelizedas follows:

In Section II challenges in handling the image segmentation, Section III describes the fetal brain extraction methods, Section IV elaborates the literature review on various existing techniques, Section IV presents the comparison of various existing algorithms and Section Vconclude the presentation.

II. Challenges

The fetal brain MRI will slice the brain in the milli-meter scale. As the images are of higher number in count; it is hard for a physician to segregate manually and it is time consuming and subjective. Since, the segmentation is performedon number of patients, n where $n = \infty$, this manual method of segmentation fails to satisfy the needs and even expensive. So, it is necessary to proceed to the automatic segmentation of the fetal brain MRI with various strategies and methods.

In this day and age, automatic segmentation [7][8] of fetal brain MRI is a highly challenging task to investigate comparatively with the fetal brain MRI. The brain abnormalities cannot be easily identified due to various factors, small head size, less signal to noise ratio and higher partial volume effects.

Perinatal period (From 22 weeks completed to 7 completed days after thedate of birth)is suitable time duration to work with quantitative neuroimaging studies. During the segmentation process, two methods are used together diffusion weighted imaging (DWI) and functional magnetic resonanace imaging (fMRI). There are two important parameters which can measure the quantitative measurements i.e., volume and cortical surface [11].

III. SEGMENTATION TECHNIQUES

The process of dividing the digital image into various boundaries based on their functions and characteristics is termed as segmentation, finally region of interest (ROI) is extraced.Image segmentation algorithms containstwo important facts which is discontinuity and similarity principle. Intensity, texture and color properties are extracted from the image is termed as discontinuity principle. On the other hand, focusing to group and combine pixels based on common nomenclature is called similarity principle.

A. Morphology Based Technique

A long-familiar morphological approach [13]is followed to segment the images using watershed algorithm [14] [15], it is commonly implemented to the gradients of the target image.

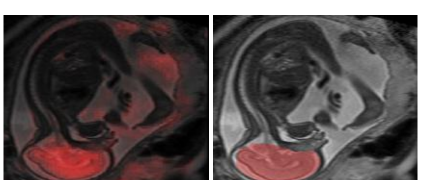
Predominately images are examined with watershed preprocessing and post processing approach. Watershed preprocessing, initially reads the image and performs gaussian filtering technique, then it determines the gradient image followed by applying gradient thresholding by producing the watershed labeled image.After thethresholding process, it converts allpixel'sintensities into the range from 38 to 255.This technique gets rid of dark and bright regions, filters noisein the image background.

In the watershed post processing, constructing the morphological region similarity function by merging and updating the region of interest, here they used the popular region merging techniques [14] [15].

B. Voxel Classification Method

Non-localmedian denoising is performed with normalization on the training image which in turn translate the image in to feature space and vectors. The classifier is used to identify the brain performs the first level of segmentation and then leads to 2D refinement.

State-of-the-art Classification Forest ensemblelearning techniqueis used for trainingSGD imagefeatureson decision trees to compromiseefficiencyand classification performance.



(a) (b)

Fig.3.3.1 (a) IntialUnsegmented Image (b)FianlSegmented Image

C. Richardson Lucy(RL) Deconvolution Method

The RL deconvolutionalgorithm is used to get blurred image from the point spread function which is obtained by applying the Gaussian Filter. The iterative RL deconvolution algorithm results in desired result.An intensity threshold is figured out for the deconvolutedimageby employing Otsu method [21]. Binary image is obtained from the deconvoluted grey scale image. Stronglyu connected areas in the brain portion is focused and remaining regoins are eliminated.Dilation process is used to recover the lost pixels. Finally, Hole fillingalgorithm is used to extract the fetal brain

D. Diffusion-Weighted Imaging Cues

Initially, Diffusion Tensor Images(DTI)arereconstructedand Fractional Anisotropy(FA) was computed using DTI Fit.On the average of the diffusion-weighted images, rough-cut outer mask of the brain is computed using morphological opening and closing operation to identify the boundaries along the surface of the extracted image. In the next step, external force was computed from the gradient magnitude and internal force was evaluated based on contour mean curvature.

Internal and external push is applied to the normal vector of the contour, creates inner cortical mask after more than 1000 iterations. In the final step, outer cortical surface is generate from the combination of FA image and inner cortical mask. Collision detection algorithm is used to avoid self-intersections among the evolved mesh.

E. Fast Fourier Transform

Fast Fourier Transform (FFT) method [24] converts the image from the spatial to frequency domain. Initially, real and imaginary components identified which is called frequency domain. The inversetransform (IFT) converts the frequency domain image into spatial domain.

Low and high frequency components are identified to find the boundaries of the target image. High frequency components are retained to obtain the edges alone. High Pass Filter(HPF) is convoluted with Fourier Transform(FT) imagewhich helps in appearing the high frequency domain in one frequency domain.

IV. LITERATURE SURVEY

Wooi Haw Tan, et al.,[13] discussed regarding morphological watershed algorithm and experimentally determined the merge-controlling factor(c) up to 25. The mainadvantages of their proposed pre-processing technique produced an average of 647 regions, whileHernandez's technique produced,1452 regions.Results were coimpared withHaris [8] and Tan [13] region merging techniques.Haris's method helps in combining the tiny portions, avoiding the heavy regions unmerged and Tan's method,thresholding parameters are handled in such a way that it is channelizedgradually.They have concluded their work with enhanced segmentaion output than the existing techniques.

Bernhard Kainz, et al., [16] focused on T2 images, evaluated the novel classification method which locate the brain and classified with above 97% of accuracy. They also implemented their own version retlated to Nvidia CUDA[18]. In addition, they have used Cross-validation to determine the preferable voxel set treated by a descriptor and finally they have obtained the results with descriptor size between 3-4 millimeter.

K Somasundaram, et al., [19], have analyzed 60 Slices per volume with 256 x 256 pixel. obtainedJaccardandDice similarity indicesas 0.9092 and 0.9531 respectively. The result produced are better than the existing methods in the market. The method has few drawbacks with selected shape and size.

Rosita Shishegar, et al., [22] segmented cortical interface of a 90-dga sheepbrain. The Dice ratio was calculated to validate the accuracy of the segmentation results.The Dice values for the inner and outer corticalsurfaces between 0.87 and 0.92 respectively, showinghigh consistency with manual segmentation results. The proposed methodoutperforms the semiautomatic method.MRtrix software package [23] is used to extract the streamlines. They end up with the demonstration of fetal sheep brain by comparing with the results of semi-automatic segmentation and automatic segmentation.

Jose Dolz, et al., [24] adopted hyper-density connected 3D convolutional neutal network(CNN) exploits the dense connections in a multi modal image scenario. HyperDenseNet process the T1 and T2 images separately and then inter connected ina a dense manner. The dice value obtained in cerebro spinal fluid, grey matter, white matter are 0.957, 0.920 and 0.901 respectively.

V. COMPARISON TABLE

In the below table [Table 4.1], the techniques and the algorithms used by the authors in their work are tabulated with the number of images handled by the authors. Thus, all the authors who have examined with brain images most likely to use the T2 images.

Table: 4.1 Comparison table of different technique with their dataset

S.No	Author	Technique and Algorithms	Dataset Handled
1	Md. Shakowat, et al.,	**Morphological Based Technique** • Watershed Algorithm • Region Similarity Function	40 - T2 weighted images
2	Bernhard Kainz, et al.,	**Voxel Classification Method** • Normalization • Non-local Median Denoising Filter • State-of-the-art Classification Forest ensemble learning method	50 prenatal - T2 weighted images
3	K Somasundaram, et al.,	**Richardson Lucy Deconvolution Method** • Gaussian Filter • Richard-Lucy(RL) Deconvolution Algorithm • Point Spread Function(PSF) • Otsu 's method	12 from Internet Brain Segmentation Repository (IBSR)
4	Rosita Shishegar, et al.,	**Diffusion-Weighted Imaging cues** • Diffusion Tensor Images Fit (DTIFIT) • Tractography • Collision Detection Algorithm	4 fetal sheep brains of 90 days gestational age (dga),
5	Jose Dolz, et al.,	**Fast Fourier Transform** • hyper-density connected 3D convolutional neutal network	55 Slices from Whole Brain Atlas(WBA)

However,it is identified that automatic segmentation detection of fetal brain MRI has wide open opportunities in this area and we would like to start towards the path to identify brain abnormalities in the earlier stage to prevent or aware about problems in earlier.

VI. CONCLUSIONAND FUTURE SCOPE

Each of these techniques has merits and demerits, which makes it unacceptable to favour one over the other and decide on the most beneficial technique. After the study, related to the fetal brain MRI segmentation with various techniques of different authors. Automatic segmentation is the significant method to work with brain images which is more efficient even though it is complex to work with MRI images due to low light and intensity. The filter algorithms like Gaussian filter is more efficient result in better output. In order to reduce fetal motion artifact, it is possible to use thicker cuts for more eminent image quality [12].

Finally, we present remaining challenges and disputes of possible future directions in this field. There are still remaining obstructions in method development mainly due to deficiency of data. Abnormalities in the fetal brain will allow the elaborated characterization of pathological cases and can likely to use automatic segmentation in clinical practice effectively.

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