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Infants Brain Tissue Segmentation using Gaussian Mixture Model in MR Images

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ABSTRACT:
Infant's image segmentation is at a primitive phase of its use in medical diagnosis tools and also, the detailed segmentation of infant's brain MRI images is vital for these tools to properly diagnose. MRI brain segmentation of infants is very challenging task compare with adult brain: Due to low signal to noise ratio, in-homogeneity, overlapping tissue. In this paper we propose Gaussian Mixture Model based segmentation algorithms for infant's soft tissue segmentation. Initially BM3D image denoising method use for preprocessing thenGMMalgorithms is used to segment white matter, gray matter and Cerebrospinal fluid soft tissue of infants MRI brain. To certify the anticipated algorithm, the results are matched with the ground truth of the iseg 2017 infant's images dataset. Upon assessment, it is concluded that the suggested algorithm segments the soft tissue with great accuracy than the present algorithms.

I. INTRODUCTION

Magnetic Resonance Imaging (MRI) is a significant imaging modality used to observe several medicinal conditions of the human body. It offers high quality decent information of tissue [1]. In comparison to conventional X-rays and CT scan, Ionizing radiation is not used in the MRI for image production. MRI is used most widely for neuroimaging thus, it is safe and non-invasivemethod. In the case of neonates, the significance of MRI imaging increases in several respects. Prospective applications embrace the investigation of regular development patterns and examine of the infants at high risk for developing neurodevelopmental disorders. Therefore, to segment appropriate soft tissue from infant's brain MRI is acute. Neonate tissue segmentation is very difficult task when compared with the segmentation of brain MRI of adults. This is due to various factors: low signal to noise ratio, tissue intensity inhomogeneity (bias field) and the inhomogeneity of the myelinated and non-myelinated white matter. Automatic segmentation approaches for adult brain MRI usually not applicable to correctly segment infants brain MRI [1, 2].

1.1 Challenges inNeonatal and infants MRI

The majority of MRI analyses in newborns and children are currently using 1.5 or 3T Scanners.In maximum MRI centers, fit infants cannot be sedated for analysis purposes. This is challenging, meanwhile images are very vulnerable to motion.

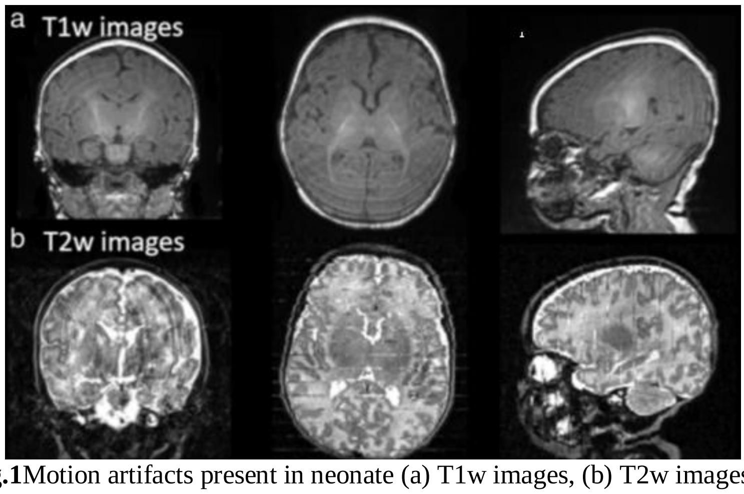


Fig.1 Motion artifacts present in neonate (a) T1w images, (b) T2w images

Partial volume effect are introduced at time acquiring image it can be minimize by increasing image spatial resolution this has happen due to small size of brain structures. For the accurate categorisation of brain structure, the spatial resolution of T1w and T2w images is also a big issue, Figure 1 clearly shows typical motion artifacts on newborn T1W and T2w images [3].

In contrast with adults, pathological MRI weighted by T1 or T2 relaxation times must face the challenge of diverse water and saturated fat in the neonatal brain, causing in diverse signal strengths in newborns and infants. Infantile pattern (below 6 months), presenting T1-weighted image lower white matter intensity than grey matter intensity; T2w: higher white matter intensity than grey matter intensity [3, 4].

1.2 Related work

Infant's brain tissue segmentation is more difficultrelated to adult brain due to low Contrast-to-Noise Ratio (CNR), low Signal-to-Noise Ratio (SNR), the myelination development and lesser brain size. Various segmentation approaches for infant's tissue segmentation are employed in past decade. Detail Neonate and infant's tissue segmentation and more detail structure description and illustrated in figure 2.

Beare et al.MANTiS [5]introduced hybrid method for neonate tissue segmentation, initially pre-processing achieved using topological filtering and template utilization via morphological segmentation tools. For experimental purpose they used NeoBrainS12 dataset data set and achieved overall dice coefficient above 0.7.

M. Jorge Cardoso et al. [6]proposedadaptive preterm segmentation algorithm for neonatal brain MRI tissue Segmentation using a maximum a priori expectation maximisation algorithm.

Ivana Despotovicet al. [7]present an extension of the Fuzzy C-Means algorithm as spatially constrained FCM (SCFCM) clustering algorithm in which they combine the information of T1w and T2 w image.

In section 2 illustrated data set and BM3D denoising and segmentation method. Section 3 Simulation results are presented and in section 4 converse the conclusion

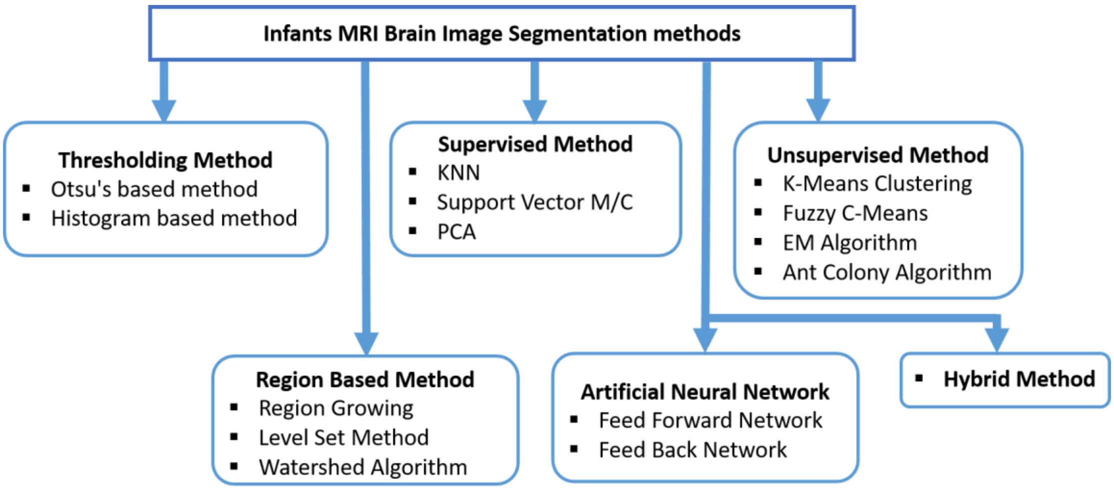


Fig.2 Neonate and infants Brain MRI Segmentation Methods

II. METHODOLOGY

Manual segmentation is very tedious process and also time consuming process. Resolves the constraints of manual segmentation we proposed accurate automatic segmentation method for neonate MRI images.

2.1 Input Data and Noise Removal

In this work we used infants (iseg 2017) data set available on http://iseg2017.web.unc.edu/ consist of T1 and T2 image. Only T1 weighted image used for segmentation. Recently, BM3D Filtering provided great result. Edge preservation and Motion artifacts correction is important task before accurate segmentation [8, 9]. We have used the Block matching BM3D filtering for prepossessing the infants MRI images. It is being recognized in following steps

1. Discovering and grouping image patches linked to a given image patch in a 3D block.
2. Linear 3D transformation of a 3D block
3. Shrinkage of the transform coefficients followed by inverse 3D transformation.

2.2 Segmentation

Standard Gaussian mixture model (GMM) has been widely used in model-based approaches

[10-15] because it's very straightforward, and with the expectation maximisation (EM) algorithm, the involved parameters can be effectively calculated.An image is a matrix in which each component is a pixel. The pixel value is a number that represents the image's intensity or hue.The proposed GMM based system for segmentation as shown in Figure 3.

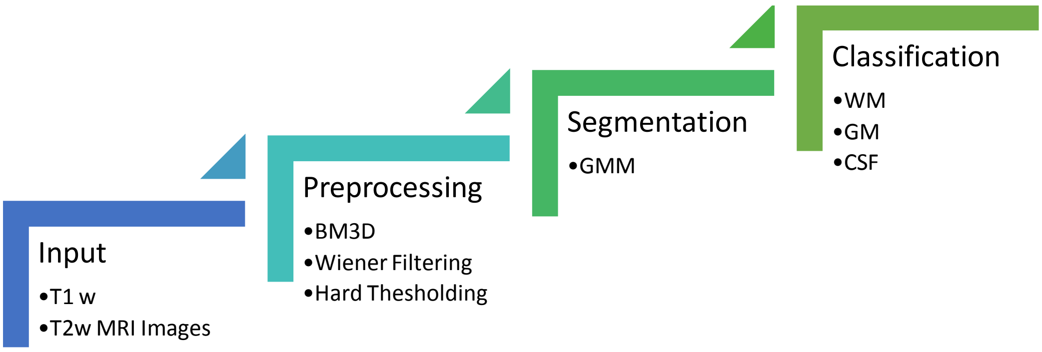


Fig.3 Proposed segmentation method

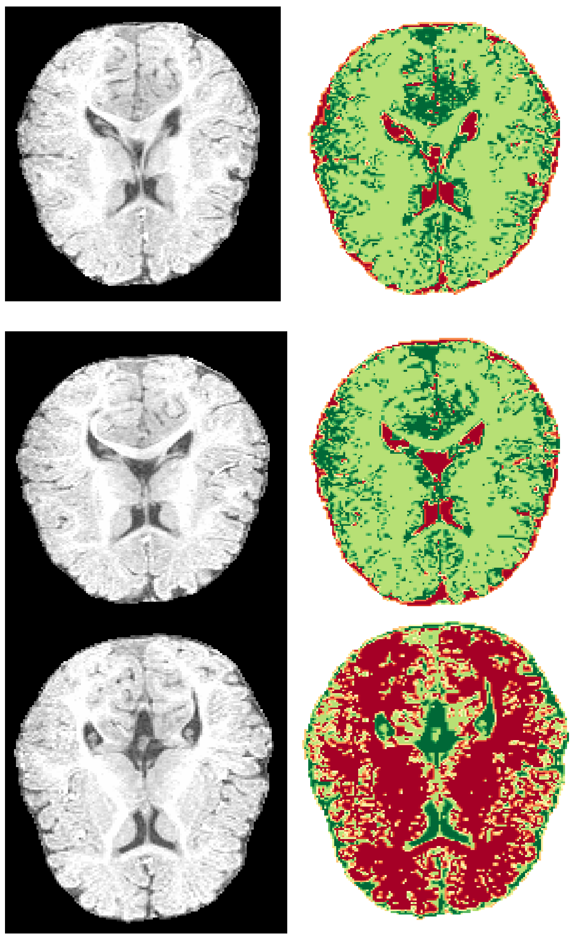
III. SIMULATION RESULTS:

Subject Input Image Segmented Image

Subject 1

Subject 2

Subject 3



Subject 4

Subject 5

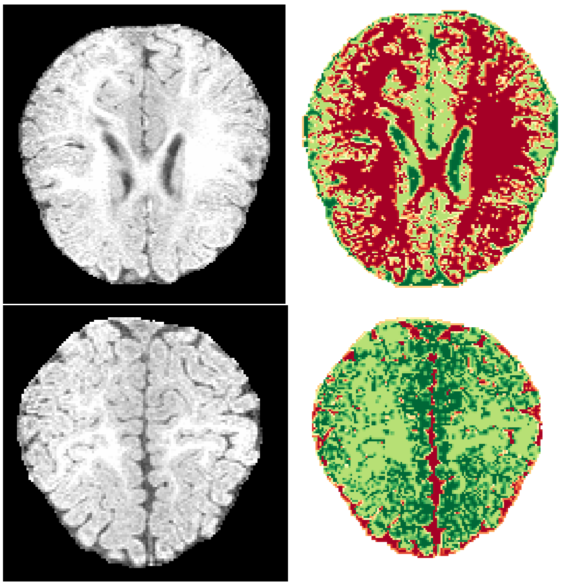


Fig.3 Experimental result

Experimental results of proposed method is illustrated in figure 3 The DSC and accuracy metrics are being used for measuring each segmentation approach by evaluating results with manual segmentation. The Dice Similarity coefficient indicates to become the most important overlap, measure used in infants brain MRI and is represented by the expression following

$$DSC = \frac{2\,|X \cap Y|}{|X| + |Y|}$$

Table 1. Performance Evaluation Metrics

Image	DSC	Accuracy (%)
1	0.90	90.56
2	0.89	89.47
3	0.91	90.87
4	0.90	90.48
5	0.91	90.78

IV. CONCLUSION:

One of the key new approaches for providing a better learning of neurodevelopmental growth as well as establishing lifelong connections among brain lesions and neurological implications is the MRI analysis of developing brain. Brain research during the emergence and especially during the perinatal period, through complex tool analysis and information acquisition challenges, continue to be challenging with specialized methodological instruments for the handling of adult MRIs. Another more prominent factor prior comprehensive brain analyses are the segmentation of the neural tissue class. The detection of fetal brain diagnostic imaging tissues is extremely difficult considering its usually reversed comparison of T1/T2 tissue with adults. The proposed infant brain MRI pre-processing and segmentation framework outperforms as compared to other existing methods.

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