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RESEARCH ARTICLE

Segmentation of Fetal Brain to Extract Limbic System Region from Raw Prenatal MRI

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Abstract- Brain is the major part of the human body. Brain disorder that affects certain behaviours of a person like communication, relationship with outers and response to environment, etc. such disorders are called as Autism. Some people show behaviours like relatively high functioning, with speech, intelligence intact as part of signs of autism. For some people, it may lead to put them off or locked to repetitive behaviours and change in pattern on thinking. All patients of autism do not have specific symptoms. This is caused due to improper functioning of brain cells and structures. Scientists and researchers are designing many techniques for finding more about normal and abnormal development of the brain. If this is discovered in the prenatal stage, then early diagnosing is possible before social impact on the patient is corrupted. Though there are many methods to find changes in brain structures of prenatal pregnancy stage, this paper concentrates on exploring a new one.

Keywords— Autism, Fetal Brain, Segmentation, Limbic System

I. Introduction

Throughout pregnancy, brain of the fetus will be developed. Brain starts developing with few cells, and these cells divide and grow into billions of cells, which are specialized for specific functions. These cells are called as Neurons. Brain is a complex organ as shown in fig 1. It has distinct regions and sub-regions. Each region is associated with precise functions and responsibilities as given below-

- The hippocampus: this region helps to recall recent experiences and new information.
- The amygdala: this region directs emotional responses.
- The frontal lobes of the cerebrum: this allows us to solve problems, planning, understanding the behaviour of other and restrain impulses.
- The parietal areas: this region helps to control abilities to hear, speak and use of language.[1]
- The cerebellum: this is responsible for body balancing, movements, coordination, and the muscles while speaking.
- The corpus callosum: this helps to transfer information from one side of the brain to the other.

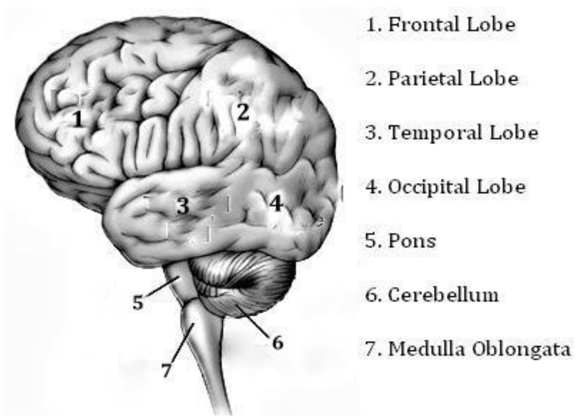


Fig. 1. Human Brain

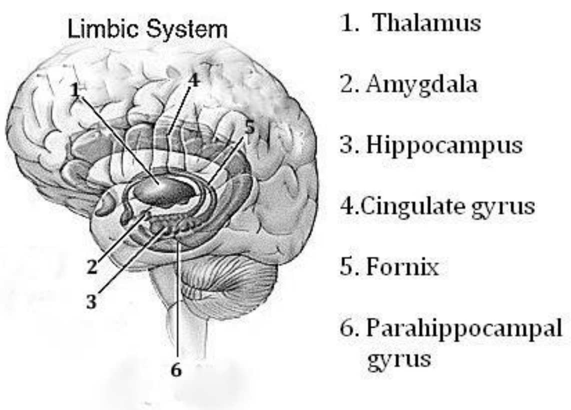


Fig. 2. Limbic System in Human Brain

Deep brain consists of Limbic system as shown in fig 2. This contains many parts, including amygdala and hippocampus. This region of a brain is mainly responsible for learning, memory and emotions. Furthermore, this part of the brain is affected by drugs like alcohol and nicotine. Abnormalities in this area, especially with amygdala lead to affecting social and emotional behavior of a person. So, researchers are looking for an efficient method to find abnormalities in this area during prenatal stage. It is proven in a study that imparity is found in an amygdala region of a child with high-functioning autism. [4]

A. *Signs of Autism in Fetus*

Brain will be developed by second trimester of pregnancy. If imparities are found in a limbic region during early trimester helps in preliminary detection of autism. Irrespective of reasons, if normal development is affected during this stage will lead to problems in sensory, language, social and mental functioning of child. The autistic brain contains patches of neurons, which are abnormal. These irregularities should be tracked. If these patches are found in frontal and temporal lobes of cortex, it will impair social, emotional, communication and language functions. That autism, whose reason can be tracked and diagnosed, is called as Autism Secondary Disorder. Factors responsible for Autism:

1) Genetic factor: Some genes of a child are inherited from parents can lead to Secondary Autism. Currently, there is no research, which has proven a specific gene linked to autism.

2) Environmental factor: Some of the researchers have argued environmental factor, and triggers are also responsible for autism. For example, pre mature babies, and if the child is exposed to alcohol or medicines that contain sodium valproate (used to treat epilepsy) during pregnancy. Again, no evidence to prove pollution and maternal infections are responsible for autism.

3) Psychological factor: Children without autism have full understanding of theory of mind by age of four. Children with autism will be limited in understanding the theory of mind. Symptoms are like. They need order or routine-based and getting lost in detail.

4) Neurological factor: Study carried out, and medical theories suggest that connection between parts of the brain is called the cerebral cortex. Amygdala and limbic system may be over connected in autism patients. This paper concentrates on method to check imparities due to this. One of the symptoms is patient will get an extreme sentimental response during. They see at trivial object or event, hence people with autism are fond of routines. Their emotional response is provoked, and also they suddenly become very upset and broke down. These children may be interested in topics, which are boring to others. They exhibit exaggerated responses to tastes, sounds, noises and smell.

Hence, this paper concentrates on early detection of autism by finding irregularities in the fetal brain. It uses image processing techniques to find irregularities in limbic system whose malfunction is one of the factors for autism.

II. EXISTING METHOD

[Semiautomatic Segmentation of Brain Subcortical Structures from High-Field MRI]

First author et al presented an active surface model for segmentation using sub cortical structure such as basal Ganglia or thalamus. This paper uses ultrafield MRI. The edge indicator function exploits SNR and SNR of SWI at highfield MRI. This generates features for combining two edge maps. These maps are obtained from Laplacia n of Single MR modal images. Algorithm should be extended to segment structures on clinical MRI (1.5 or 3T) based on statistical shape and pose relationships between multiple adjacent structures ultra-high fields. [2]

[A Survey of MRI-Based Brain Tumor Segmentation Methods]

First author et al provided an overview on state of art MRI-based brain tumour segmentation methods. Most of the existing system are noninvasive and uses classification and clustering methods by using di fferent features. Also consider spatial information in local neighborhood. These methods provide preliminary ju dgment on diagnosis, tumor monitoring and therapy planning for a physician. [4]

[Normal Development of the Fetal Brain by MRI]

This paper describes how a fetal brain can be imaged in vivo with fetal MRI. It describes embryologic aspects of brain development and their correlative appearance on MRI. [7]

[Fetal Brain MRI: Segmentation and Biometric Analysis of the Posterior Fossa]

First author et al proposed algorithm for segmenting posterior fossa and its content. Performance of segmentatio n was found to be good. It requires several preset threshold values. These values remain constant for all images. However, algorithms had limitations when it is dealing with acquisition artifacts and when vascular structures hi de edges. Segmenting aqueduct, colliculi and vermis are very difficult. [10]

[Self-Organizing Maps as a Model of Brain Mechanisms Potentially Linked to Autism]

First author et al proposes a novel SOMbased model of brain mechanism, which is potentially related to autism. Dimensions of SOMbased network are manipulated by modeling abnormal growth. There was no significant eff ect on performance. Attention functions were used to analyze sensory issues. These issues were used to model h ypersensitivities and hyposensitivity [12].

III.PROPOSED METHOD

It is found that irregularities in the limbic system can be found by applying image processing steps on brain MRI image.

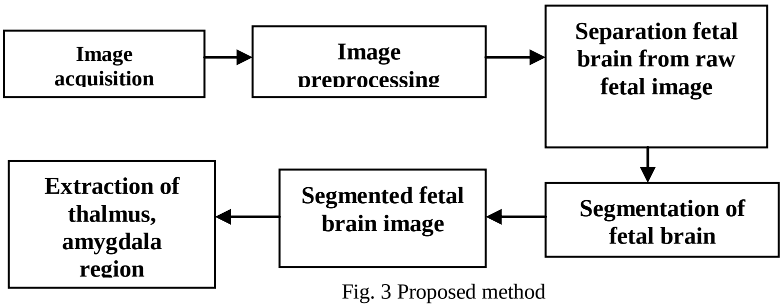


Fig. 3 Proposed method

Proposed method as shows in fig3 involves developing an algorithm with following objectives:

1) Fetal MRI image acquisition: This involves patient preparation and acquisition of MRI image using Magnetic Resonance scanning devices. Images are acquired during prenatal second trimester stage of pregnancy. Image quality depends of fetal motion since MRI is performed with sedating mother or fetus. So, fetal MRI is performed using Single-shot rapid acquisition with refocused echoes. This is one of the ultra-fast MRI techniques. Single T2-weightier image is acquired within one second. Images are obtained in axial, sagittal and coronal planes. Images are acquired when mother is free breathing. Anyhow, image can be acquired using fetal diffusion-weighted imaging.

2) De-noising the image: This involves removal of artifacts, noises, which are induced due to scanning devices. Most likely, noises are contrast reduction, noises induced from movement of a patient while scanning,

noises induced due to voltage fluctuations in devices. Biological noises like blood, lymph, etc. are to be removed.

3) Segmentation: Segmentation involves partitioning image into homogeneous regions. These regions are composed of pixels with the same characteristics. These characteristics are selected as per pre-defined criteria. This includes two major features-

- Separation of the fetus brain from a background: This involves separating part of image, which contains the only fetus. This excludes rest of the maternal body parts. This is similar to background elimination. This also involves object recognition in an image. Whereas this paper concentrates on segmentation of the fetal brain itself, part of a fetal brain will be manually cropped and given as input to the algorithm and making it automatic can be considered as future enhancement of proposed method.

- Segmentation of the fetal brain: This paper concentrates on implementing the suitable method as shown in fig 4 to segment fetal brain MRI image.

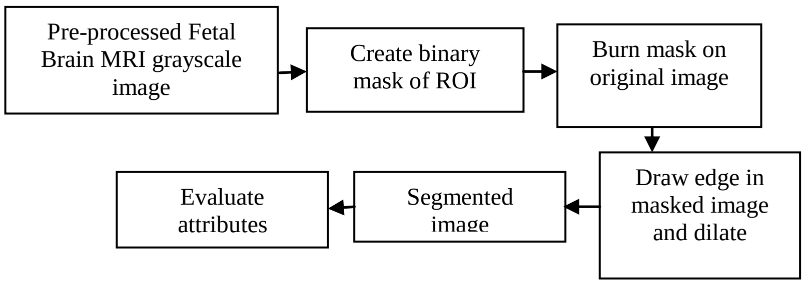


Fig 4. Segmentation of the fetal brain.

An algorithm involves accepting MRI images as grayscale image, and then creates a binary mask of the region of interest objects. Label the mask. Get co-ordinates of the region of interest. Burn the mask into an original image. This is done two ways, fetch an image within the mask and outside the mask. Inside region of image mapped within the mask is blackened. Draw an edge within the blackened image then apply dilation using structuring element. It will result in the segmented image. Attributes of ROI like mean, center, centroid, area is found out.

IV. RESULTS AND DISCUSSION

Performance of segmentation were found to be around 80%. Table I show original image and segmented image. These images contain other parts of the brain along with limbic system. Different parameters like mean value of area, number of pixels, Area, perimeter, centroid, center in a segmented image is calculated as shown in Table II. These parameters are further used to extract and analyses the features specific to the limbic system. Fig 5 shows plot of different parameters for each sample image considered. Algorithm was tested for around 700 to 800 fetal brain MRI images. Area was well distinguished and many variations in the value of perimeter from image to image. Fig 6 shows standard deviation of these individual parameters. Table III gives standard deviation for separate parameters considered. Fig. 6 depicts a graph of standard deviation of separate parameters. For high standard deviation for pixels and area shows that values are spread out into a wide range and can be used for further analysis. Mean and perimeter had comparatively low standard deviation tends to be very close to mean values of their set.

TABLE I
ORIGINAL AND SEGMENTED IMAGE

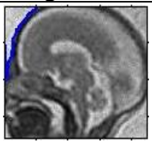
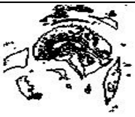
Images	**Image 1**	**Image 2**	**Image 3**	**Image 4**	**Image 5**
Original Image					
Segmented Image					

TABLE II.
DIFFERENT PARAMETERS

Image	**Mean value of area (in pixels)**	**Pixels (in number)**	**Area (in pixels)**	**Perimeter (in pixels)**	**Centroid (x,y)**	**Center (x,y)**
Image 1	172.607	14425	14553.63	1340.32	177.7,143.1	178.3,133.3
Image2	180.104	20558	21124.13	5.62	2.0,116.7	2.0,116.7
Image3	172.609	14425	14553.63	1340.32	177.7,143.1	178.3,133.0
Image4	163.794	14741	14906.75	273.74	14.0,31.4	13.6,31.2
Image5	138.872	5735	5827.13	1.96	1.0,104.5	1.0,104.5

TABLE III
STANDARD DEVIATION OF DIFFERENT PARAMETERS

Mean value	**Pixels**	**Area**	**Perimeter**
16.01747	5296.82	5449.722	691.6001

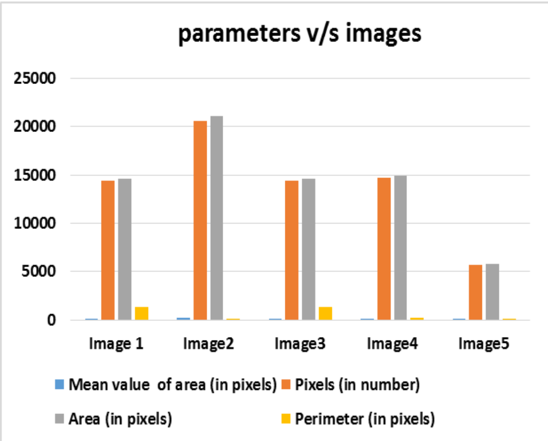


Fig 5. Graph parameters v/s images

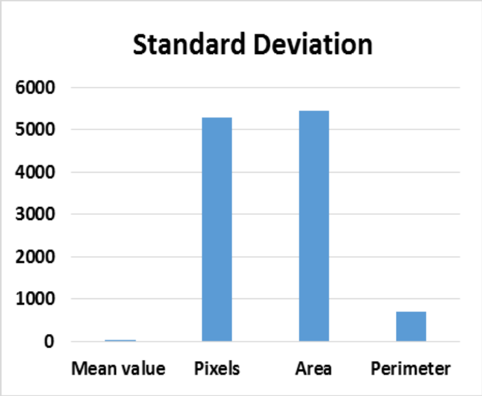


Fig 6. Plot of Standard deviation

But a brain has to be cropped manually from raw fetal image. This involves manual separation of maternal information from fetal information in the image. This has to be done automatic. Extracting features from segmented image and decision about normal and existence of imparities from these features is viewed as future work.

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