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Segmentation and Detection of White Matter Damage from Cranial Ultrasound using Hybrid Neural Networks

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Abstract:
WMD (White matter damage) is a particular type of brain neurological disease. It is the main cause of neonatal death and nervous system dysfunctions and may cause sequel such as mental impairment and cerebral palsy. Cranial ultrasound is a widely used monitoring method for premature baby who is associated with high risk of WMD. In the cranial sonography, radiologists scan the baby's brain to determine whether there are scarring or gliosis in the white matter. Accurate ROI segmentation can help radiologists to analyze the margin, shape of white matter. The normal and disorder images are trained together to help the system recognize the WMD. Ultrasound images are segmented using a series of steps like contour f, canny edge detection and Metric score estimated using the maximally stable external regions (MSER) feature extraction technique is applied to neural network. With the help of time series neural networks and non linear auto regression (NARX) model the detection and performance of white matter damage is analyzed.

Keywords: WMD, Ultrasound images, ROI, NARX, MSER.

I. INTRODUCTION:

Every year, an estimated 15 million babies are born preterm. Preterm birth complications are the leading cause of death among children under 5 years of age. Severe disabilities were present in 23% of babies born at 22-25 weeks such as Cerebral palsy, a disorder of movement, muscle tone or posture that are caused by White matter damage (WMD). It also includes impaired learning and vision problems.WMD may appear on an MRI scan, however it is not possible for a preterm newborn to undergo the process of MRI which involves the baby to be still. Even though there is a option of sedating a baby for a MRI which still includes low blood pressure, dehydration and constant irritability. The typical MRI scanner generates 110 decibels of noise which is about the same noise level as a steel mill. Therefore here we rule out the option of MRI and opt for ultrasound scans that are safe and can be done till 1.5 years of age. Ultrasound images are segmented for WMD using image processing techniques and detected by using neural networks where the images are trained all on their own.

II.WHITE MATTER DAMAGE

White matter are the fibrous tracts of the brain that make up a large part of the whole brain. It refers to areas of the central nervous system (CNS) that are mainly made up of my elinated axons, also called tracts. Long thought to be passive tissue, white matter affects learning and brain functions, modulating the distribution of action potentials, acting as a relay and coordinating communication between different brain regions. White matter damage is damage to the so-called white matter of the brain. The impact and complications of WMD varies depending on the site and extent of the damage. White matter damage is caused by a lack of oxygen to the brain's cortex, and can also be caused by per ventricular leucomalacia (PVL). The condition involves the death of small areas of brain tissue around fluid-filled areas called ventricles. The damage creates "holes" in the brain. "Leuko" refers to the brain's white matter. "Periventricular" refers to the area around the ventricles.

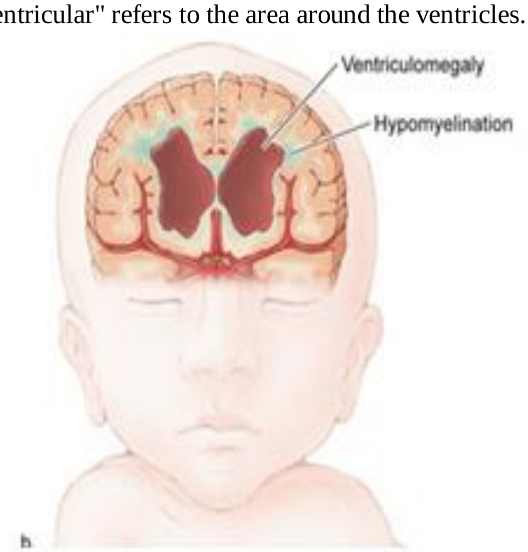


Figure.1.WMD in premature infant

III. IMPLEMENTATION

1.Software Used: MATLAB 2017a

Matrix laboratory briefly known as MATLAB is high performance language for technical computing. MATLAB is an multi- model environment and programming language that allows to do matrix manipulations, implementation of algorithms plotting of functions and data, creation of user interface, numerical computing etc. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems ,especially those with matrix and vector formulations, in fraction of the time it would take to write a program in scalar non interactive language such as C or FORTRAN.MATLAB provides various solutions in fields of Data Analytics, Wireless Communications, Deep Learning, Computer Vision , Quantitative Finance and Risk Management, Robotics, Control Systems.

2. PREPROCESSING:

The main goal of preprocessing is to enrich the visual look of the images. Preprocessing mainly aims to remove the clamor, stabilizing the intensity of the images and clear the artifacts. Image preprocessing is the technique of enhancing the image data prior to computational processing.

The steps involved in preprocessing are:

Multi-thresholding, histogram equalization and label to RGB conversion.

A.MULTI-THRESHOLDING:

Multilevel thresholding is a process that segments a gray-level image into several distinct regions. This technique determines more than one threshold for the given image and segments the image into certain brightness regions, which correspond to one background and several objects.

B.HISTOGRAM EQUALISATION:

Histogram Equalization is a computer image processing technique used to improve contrast in images. It accomplishes this by effectively spreading out the most frequent intensity values, i.e. stretching out the intensity range of the image. This method usually increases the global contrast of images when its usable data is represented by close contrast values. This allows for areas of lower local contrast to gain a higher contrast.

C. LABEL TO RGB CONVERSION:

The label2rgb(L) converts a label image, L into an RGB color image for the purpose of visualizing the labeled regions. The label2rgb function determines the color to assign to each object based on the number of objects in the label matrix. The label2rgb function picks colors from the entire range of the color map. The above mentioned three steps are initially done to the ultrasound images. As, ultrasound images are highly distorted due to the presence of noise it is essential to perform these processes.

3. CORE PROCESSING:

The core processing involves the canny edge detection and binary conversion of the image. By doing these steps the clear view of the region of interest can be obtained.

A.CANNY EDGE DETECTION:

Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts – a jump in intensity from one pixel to the next. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. Canny edge detection algorithm is also known as the optimal edge detector.

Figure.2. Canny edge image

B.BINARY CONVERSION:

Binary images are images whose pixels have only two possible intensity values. They are normally displayed as black and white. Numerically, the two values are often 0 for black, and either 1 or 255 for white. Binary image are often produced by thresholding a grayscale or color image, in order to separate an object in the image from the background. The color of the object is referred to as the foreground color which is usually white. The rest is referred to as the background color which is usually black. Depending on the image which is to be thresholded, this polarity might be inverted in which case the object is displayed with 0 and the background with non-zero values. In MATLAB, BW = im 2 bw (I, level) converts the grayscale image I to binary image BW, by replacing all pixels in the input image with luminance greater than level with the value 1 (white) and replacing all other pixels with the value 0 (black).This range is relative to the signal levels possible for the image's class. Therefore, a level value of 0.5 corresponds to an intensity value halfway between the minimum and maximum value of the class.

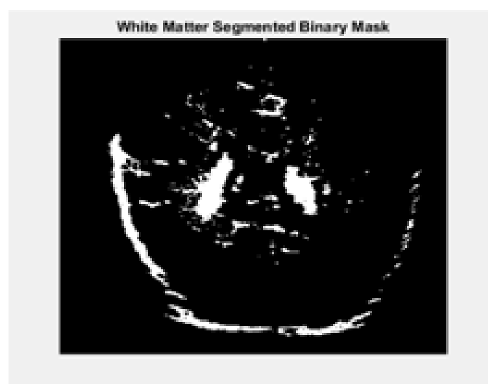


Figure.3.Binary mask imaging.

IV. CONTOUR FSEGMENATION:

Contour can be explained as joining all the continuous points, having same color or intensity. The MATLAB provides various contouring such as contour 3, contour f, f contour, contour slice. However for ultrasound contour f segmentation provides a better extraction of ROI. Contour f segmentation is used for the conversion of 3-D images into 2-D format. The effect of contour f is here is that it fills the space between the lines thus making it 2-dimensional.When we consider contour f(z),where z has the height values on x-y plane, this creates a filled plot containing the isolines of matrix z. We can also label the contour lines based on their intensity levels, thus creating a precisely valued plot to obtain the region of interest.

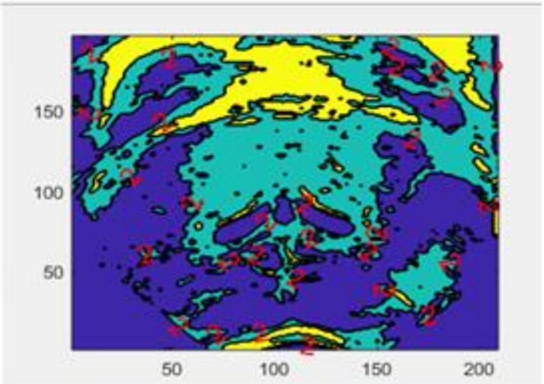


Figure.4. Contour f segmented output.

V. MSER FEATURE EXTRACTION:

MSER(Maximally Stable Extremal Regions) is based on the idea of taking regions which stay nearly the same through a wide range of thresholds. All the pixels below a given threshold are white and all those above or equal are black. If we are shown a sequence of thresholded images it with frame t corresponding to threshold t, we would see first a black image, then white spots corresponding to local intensity minima will appear then grow larger. These white spots will eventually merge, until the whole image is white. The set of all connected components in the sequence is the set of all extremal regions. Optionally, elliptical frames are attached to the MSERs by fitting ellipses to the regions. Those regions descriptors are kept as features.

Figure.5.Feature extracted output.

VI. POST PROCESSING:

ANALYSIS MODULE:

A.TIME SERIES NEURAL NETWORK:

Prediction is a kind of dynamic filtering, in which past values of one or more time series are used to predict future values. Dynamic neural networks, which include tapped delay lines are used for nonlinear filtering and prediction .There are many applications for prediction. These dynamic models are important for analysis, simulation, monitoring and control of a variety of systems, including manufacturing systems, chemical processes, robotics and aerospace systems. This tool has there types of system out of which we are using Non linear Auto Regressive NARX Model. The prediction filtering is used to predict the amount of white matter damage caused in the subjected infant and to determine its affected rate.

B.NON LINEAR AUTOREGRESSIVE MODULE:

The nonlinear autoregressive network with inputs (NARX) is a recurrent dynamic network, with feedback connections enclosing several layers of the network. The next value of the dependent output signal y(t) is regressed on previous values of the output signal and previous values of an independent (exogenous) input signal.

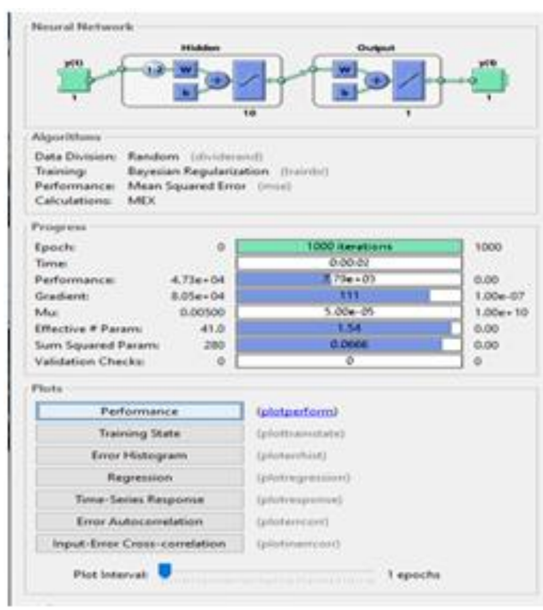
C.BAYSEIN REGULARISATION BACK PROPAGATION:

Bayesian regularized artificial neural networks (BRANNs) is generally used for training dataset. In the training process the back propagation algorithm learns associations between a specified set of input-output pairs. The back propagation training algorithm acts as follows: first, it propagates the input values forward to a hidden layer, and then, it propagates the sensitivities back in order to make the error smaller; at the end of the process, it updates the weights. We can customize our BRANN by adding needed feedback delays, hidden layers to this neural networks. In this project we have used feedback delays 1:2 and 10 hidden layers has been added to this network.

D. K MEANS CLUSTERING:

K means algorithm is an iterative algorithm that tries to partition the data set into K pre-defined distinct non-overlapping subgroups where each data point belongs to only one group. It assigns data points to a cluster such that the sum of the squared distance between the data points and the cluster's centroid (arithmetic mean of all the data points that belong to that cluster) is at the minimum. Iteratively, the values of centroid of clusters are updated one by one until the best clustering results are obtained. The K-means algorithm takes Euclidean distance as the similarity measure, which is to find the optimal classification of an initial cluster center vector.

VI. RESULT



VII. FUTURE SCOPE:

The project can be upgraded by refining the ultrasound images to provide good resolution and quality to the images. The performance can be further increased by using accurate image processing techniques. The project can be enhanced to find the white matter damage, when the baby is still present in the mother's womb. Nutrients can be given during the trimester stages to ensure healthy babies to be born.

VII.CONCLUSION:

This damage can be diagnosed using ultrasound and MRI but in some cases opting ultrasound is a better option. In this project we have collected both diseased and the normal dataset and each dataset has trained individually and analyzed. In general from an ultrasound image we can identify only the major affected areas which makes impossible to detect the damage. So in an attempt for the better mapping of the defected points have proposed the project As explained before from our project we could able to perceive WMD with good prediction and accuracy than existing system.

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