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A novel algorithm for earlier down syndrome detection in fetal ultrasound images

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***Abstract* - Ultrasound (US) imaging is a non-invasive technology used to monitor and analyse gestational age. Ultrasound imaging is used because it is a real time acquisition technique with patient specific and operator dependent. Autism is a neuro developmental disorder normally seen in children which reduces communication skills, social interactions. Down syndrome (DS) is similar case which becomes autism later. Thus down syndrome disease detection is important and can be detected in gestational period, several algorithms are developed. Down syndrome can be detected from US images by geometrical characteristics of femur and nasal bone. In this paper efficient and expedited algorithm is used for segmenting femur and nasal bone. The image output of US is a low quality image because it contains speckle noise and wave interferences. Disease diagnosing from US image can be made realistical by using advanced segmentation method. Image segmentation help efficiently in disease diagnosing from the US images at the earlier stage. Multilevel thresholding is used here along with morphological operations for segmentation of femur and nasal bone. This method is fast and simple when compared to sophisticated algorithms being using. LDA classifier gives better result for down syndrome detection. This algorithm is successfully tested with the database form http://ultrasound.ucsf.edu, http://www.thefetus.net,popista.com, Medical college TVM**

***Index Terms* : Ultrasound imaging, autism, down syndrome, segmentation, Classifier, fetal.**

I. INTRODUCTION

Human body contains nucleus which consists of rod-like structures called chromosomes which is responsible for inherited traits. There are 23 pairs of chromosomes present in a nucleus. Down syndrome is mainly caused due to an error in cell division occurs. Down syndrome is a condition of disease which occurs if an individual has a full or partial extra copy of chromosome 21. Each person with down syndrome possess unique characteristics. They have shortened leg, absence of nasal bone, an upward slant to eyes, low muscle tone, small stature. Thus it is important to detect this defect, which is possible when the baby is in mother's womb. From around first trimester it is possible to detect this disease. For that better method is to be selected to diagnose fetus[1].

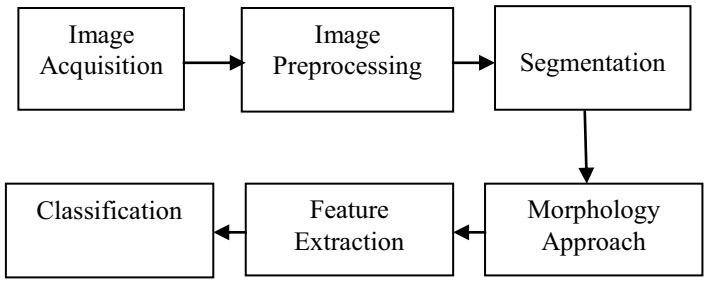
In medical science, image processing is one type of diagnosing for which real time image is used as input and the output be either an image or set of parameters related to the image [2]. Ultrasound imaging Computed tomography (CT), Medical Resonance Imaging(MRI) are some types of techniques used in medical field for imaging [3]. In which Ultrasound imaging is mainly used to get accurate imaging. Ultrasound image is the modality of choice in any application when compared to other imaging methods such as CT,MRI etc. Ultrasound imaging is a noninvasive, patient specific and operator dependent technique. Fetal monitoring is done through US imaging. US image analysis is done by the expert, thus growth and real condition of the fetus can be obtained.

2D Ultrasound imaging is done to obtain the fetal growth, size, and abnormalities. Pregnancy period is divided into 3 trimesters [4]. The first trimester is 1 weeks – 12 weeks, second trimester is 13 weeks – 28 weeks, and finally fourth trimester is 29 weeks – 40 weeks [5]. The scanning is done in all these trimester to obtain calculations. Specific result is there for all these trimesters. There is a chart which shows specific and estimated value for each size of the fetus, growth of the fetus etc. The fetus develops almost all regions such as heart brain and spine in the first trimester. Likewise all trimester has its own way of developing all regions. Periodic consultation of physician helps in diagnosing disease and treating abnormalities in the earlier stage before birth. The fetal organs are measured earlier and the following organ measurements are done for finding fetal abnormalities at the earlier stage, Bi-parietal diameter (BPD) Head circumference (HC), Abdominal circumference (AC), Femur length (FL), Humerus length (HL), Crown-rump length (CRL)

The modern fetal imaging technology needs a fast algorithm for disease diagnosing at the earlier stage[6]. Diseases can be detected from the ultrasound image without implementing sophisticated algorithm. Different types of diseases can be predicted from US image. Down syndrome is a genetic disorder which is caused by chromosome 21. Down syndrome should be predicted at the earlier stage because it causes severe other problems when it could not find properly. Congential heart disease, cognitive disability, and thyroid disorders may affect if we didn't predict down syndrome [7]. Advanced segmentation algorithm is needed for better result [8]. It is proposed to develop an efficient segmentation method to extract the region. In this paper a new concept based on multilevel thresholding along with morphological operations is used for segmenting fetal regions. LDA classifier is used to predict the fetus having down syndrome symptoms. Length of femur, presence of nasal bone, bladder size are the parameters to be measured. Two training vectors are generated. First training vector can be the parameter of fetus images which have down syndrome. Second training vector can be the parameter of fetus image which don't have the down syndrome [9].

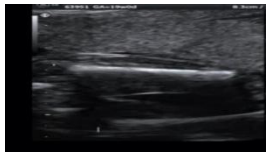
II. METHODOLOGY

The block diagram shows the methods for finding the presence of down syndrome disease.



A. Image Acquisition :

Ultrasound imaging is used to acquire the fetal images. The collected images is trained by clinicians using the machine Philips HD9 and the following protocols defined by INTER –GROWTH -21st study. The images were acquired using a transducer with frequency range 7-3MHz. All the images were in both DICOM and jpg or png format. Ultrasound imaging is radiation free when compared to MRI. It is used to acquire real time images which includes moving organs. US uses simple instrument while CT using more sophisticated instruments for diagnosing. Thus Ultrasound imaging is more simple and easy to diagnose fetus. But ultrasound images contains speckle noises which reduces the quality of the image. The images collected from Medical College hospital TVM, were also tested, but the image quality is very poor. For further analysis the images should be processed in a better way. Thus it is important to preprocess, despeckling the images.


a.Normal femur


b.Abnormal femur


c.Normal nasal bone

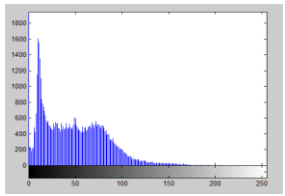
d.Abnormal nasal bone

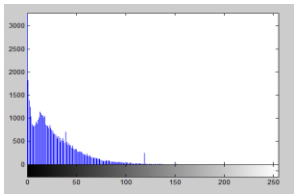
B. Preprocessing :

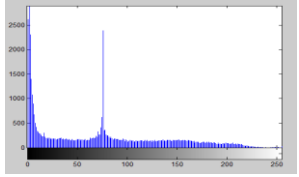
The preprocessing of the input image include image resizing, gray scale conversion, noise reduction. The input image is converted to a gray scale format which is more compatable for further processing.

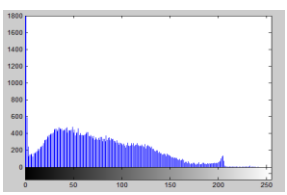
Ultrasound images contains speckle noises which is a limitation of ultrasound scanning too. Despcekling is a step to avoid speckle noises in the image. Several methods are used for despeckling. Wavelet thresholding, bilateral filtering, anisotropic methods, median filtering. In which median filtering can be used to reduce speckle noises more accurately. Median filtering is a type of digital filtering removes noises in the image. It removed noise by preserving edges of an image.

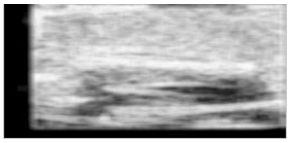
$$y[m,n] = \{x[i,j], (i,j)\epsilon\, w\} \qquad (1)$$


a.Histogram of normal femur


b.Histogram of abnormal femur


c.Histogram of normal nasal bone

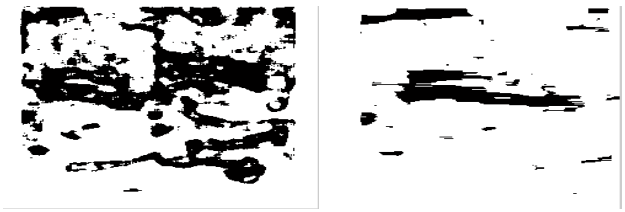

d. Histogram of abnromal nasal bone


e.Median filtering of normal femur


f. Median filtering of abnormal femur

C. Multilevel Thresholding :

Multilevel thresholding is an intermediate step in the segmentation method [10]. In multilevel thresholding multiple levels of image intensity are used according to the image. The input preprocessed image is converted to gray image and clustered to form a unique value to obtain accurate femur from the image. In linear thresholding method, single image intensity value is used to segment the image. In fetal femur segmentation multiple image intensity limit is used for better segmentation result. The femur bone should have high brightness, large size, contrasted edges. The femur is long and have sufficient width and is centered in all US image is selected as the final femur form the segmented image. These properties of the image is used to train the LDA classifier. The output thrsholded image is converted to positive and negative images to train the classifier.


Multilevel thresholded image.

D. Morphology :

Morphology based approach is used here to segment the image more accurately from the thresholded output [11]. Entropy based segmentation is done here. Morphological operation includes erosion and dialation are used. Erosion is shortening or compressing the segmented region and dialation is the enlargement or elongating the region. In this algorithm dialation is used that is elongating the region. First the image is median filtered, then multilevel thresholding is done as mentioned above. The thresholded image is a binary image. The binary image is dialated to get elongated femur bone. The femur region has the largest area.

E. Feature Extraction :

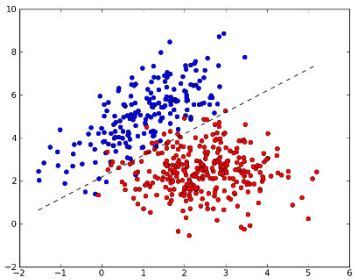
Features such as femur length or nasal bone is extracted from the image for measurement and classification. The femur bone should have high brightness, large size, contrasted edges. The femur is long and have sufficient width and is centered in all US image is selected as the final femur form the segmented image. Statistical parameters such as mean and variance can be used for detection purpose

$$\text{Mean } \bar{X} = \frac{1}{M*N}\sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij} \qquad (2)$$

$$\text{Variance } \frac{1}{(M-1)*(N-1)}\sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij} - \bar{X} \qquad (3)$$

F. Classifier :

The LDA classifier is used in this algorithm. The response of LDA classifier is a ramp. The value above a certain limit is rejected and below that limit is selected. The classifier is trained using normal and abnormal ultrasound images to get fetus image which has downsyndrom. Actually the range of length of femur is known for a normal femur. The value above or beyond this range is considered as abnormal fetus .


a. LDA classifier

III. RESULT AND DISCUSSION

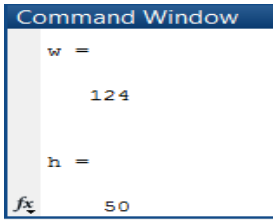
The main aim of developing this paper is to build a new segmentation algorithm through which a disease diagnosing can be effectively done. The result shows that the down syndrome can be detected by either measuring the length of the fetal femur and checking the absence of nasal bone. The input image is multilevel thresholded to get the femur as well as nasal bone. After thresholding the length of femur can be measured and the thresholded output will not contain nasal bone. The femur bone should have high brightness, large size, contrasted edges. The femur is long and have sufficient width and is centered in all US image is selected as the final femur form the segmented image. These properties of the image is used to trained using the LDA classifier.

A. Result of Normal femur.

a.Multilevel thresholded image of normal femur

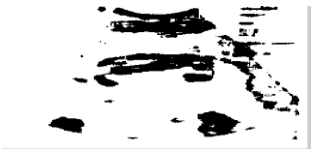
b. Dialated image

c.Femur segmentation using bounding box

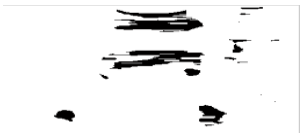


d. Measurement

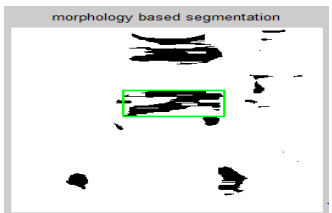
B. Result of Abnormal Femur



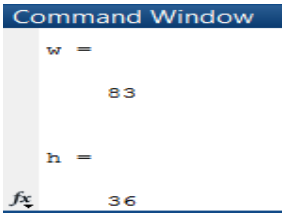
a.Multilevel Thresholded image of abnormal femur



b.Dialated image of abnormal image.



c. Femur length using bounding box



d. Measurement

The result shows that for a normal fetus (13-28 weeks) the length of femur should be in the range 110-130 and for abnormal it ranges between 50-90. This result can be used for analyzing fetus.

The next condition to finalise the disease by recognizing the absence of nasal bone. For that only multilevel thresholding is needed. The result is enough to find the presence or absence of nasal bone.

C. Result of Nasal bone

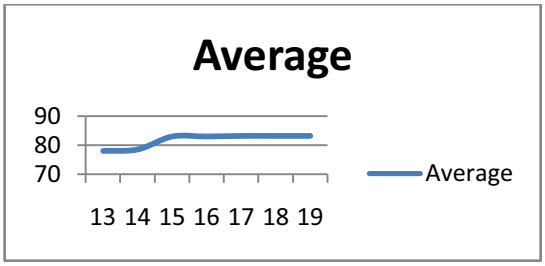
a. Multilevel thresholded image shows the Presence of nasal bone

b. Multilevel thresholded image shows the absence of nasal bone

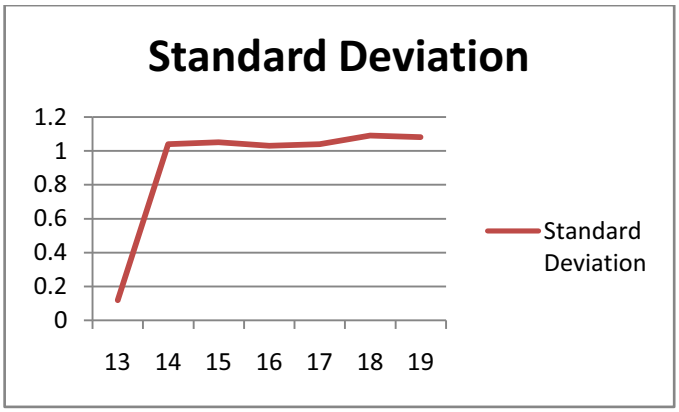
D. Abnormal femur length measurement

Gestational Age	Average	Standard Deviation
13	78	0.12
14	78.5	0.12
15	83	1.04
16	83.2	1.05
17	83.2	1.03
18	83.2	1.02
19	83.2	1.04

Table shows the measurement of abnormal femur Length



Graph plotted over Gestational age and Average



Graph plotted over Gestational age and Standard Deviation

IV. CONCLUSION

Ultrasound imaging is used for diagnosing purpose. The ultrasound image itself is used to identify the condition of a fetus. As a part of research it is found that down syndorme occurs 1/1000 live births. So down syndrome detection is essential. Segmentation is done to identify the disease. In this paper advanced method is used for segmenting femur and nasal bone. Multilevel thresholding is used here along with morphological operations. This method is fast and simple when compared to sophisticated algorithms now using. The method uses 120 images for classification. LDA classifier is used for better result. This algorithm is successfully tested with the database form Medical college hospital TVM, Laboratory TVM.

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