

Adaptive Thresholding in Ultrasonograph Images

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Abstract— The development of segmentation using foetal ultrasound images is explained. The current paper work explains the development of enhancement and segmentation algorithms as the ultrasound diagnosis highly depends on the quality of the data. Developed algorithms segment the foetus and helps in analyzing the anatomical structure. This makes an easy diagnostic tool for the obstetricians to analyze and the data can be stored in the database for further analysis.

Median filtering is used to remove speckle noise in the ultrasound image for better visualization. Removing the noise will also help in segmenting the image. Adaptive thresholding and Prewitt's edge detection are used to segment the foetus, which helps in analyzing the foetal anatomical parts like the head, neck, limbs etc in the mother's womb

Index Terms— Edge Detection, Foetal Ultrasound, Image segmentation, Median Filter, Morphological Operation, Speckle Noise, Thresholding..

1 INTRODUCTION

PRENATAL ultrasound (also called foetal ultrasound or foetal sonography) has become an almost automatic part of the childbirth process which is a safe and a non-invasive procedure compared to X-ray, MRI and CT scan for visualizing child birth process. Ultrasound produces detailed imaging of the foetus and its condition in the mother's womb along with a detailed visualization of the underlying anatomy of the foetus in real time. It can also image dynamically varying structures of the foetal body [1]. Another important application of the ultrasound is to determine or distinguish between the normal and abnormal foetus by the motion of the foetus in the mothers uterus. Analysis of motion of the foetus mainly rests on the visual inspection or manual measurement by experienced obstetricians which requires real time monitoring. Although ultrasound has reached the highest level of technical sophistication, speckle noise is the contamination factor which has addressed in interpreting the ultrasound images and is the property of the ultrasound image itself [1][2]. It arises from random variations in the strength of the backscattered waves from objects [3]. It is caused due to diffuse scattering [5], which occurs when an ultrasound pulse randomly interferes with the small particles or objects on a scale comparable to the sound wavelength and gives a granular appearance. Speckle reduces image contrast and detail resolution that in turn reduces the ability of segmentation, and makes it difficult to identify abnormal tissue patterns (or texture) that may indicate disease. Hence, reducing noise i.e. enhancement and filtering, should improve effective diagnosis and segmentation [5]. Thresholding technique and edge detection technique is used for segmentation which improves speed and accuracy [5, 6]. An extensive research is being carried in the field of ultrasound enhancement to check the techniques available to remove speckle noise to enable image post processing such as segmentation.

K. Thangavel [4] used different spatial enhancement approaches which were analyzed and finally concluded that image enhancement is difficult to measure and that there is no common algorithm for the enhancement of the image i.e. the enhancement techniques/algorithm is image specific. Jago [5] used adaptive filtering technique to remove speckle noise as the adaptive nature of the algorithm allows it to smoothen the regions of speckle or noise while preserving resolution and tissue texture, and enhance tissue interfaces without boosting noise. Their results showed that the adaptive algorithm played a significant role in improving contrast resolution (mainly through speckle reduction), improving border definition and continuity, and in reducing noise and clutter for better visualization. Derek [6] focused on adaptively thresholding images from a live video stream in order to maintain the real time performance. Here the input sequences are segmented dynamically. They concluded that the technique used is basically a simple and fast and an important tool. Chedsada Chinrungrueng [7] in 2001 developed an edge preserving noise reduction filter called as Savitzky-Golay filter. The paper described a novel filter which is two dimensional (2-D). It is based on the least squares fitting of a polynomial function to image intensities. The performance of Savitzky Golay filter has been compared with that of the commonly used median filter in reducing speckle noise on ultrasound thyroid image. Experimental results indicate that on these particular examples, the new filter can achieve at least the same level of noise reduction and edge preservation as that of the median filter, but with far less computation time.

2 PROBLEM DEFINITION

The Region of interest (ROI) is the foetus and the mother's womb. Initially, the image is enhanced to improve the quality of the ultrasound data for segmentation using a few enhancement techniques. Then segmentation of the womb and the foetus is done from the results obtained from the previous step.

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3 METHODOLOGY

Ultrasound Image enhancement and filtering techniques were reviewed to carry out segmentation of foetal ultrasound images. Based on literature and understanding, functional block diagram figure 1 for foetal segmentation was designed. Algorithms for ultrasound foetal segmentation is developed and implemented in MATLAB.

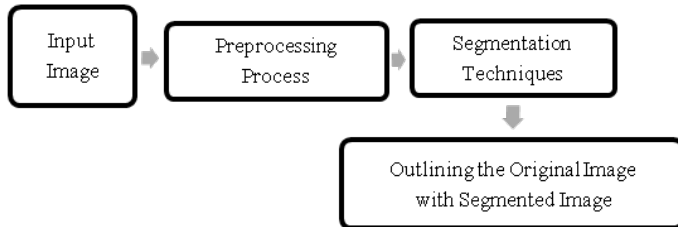


Figure 1. Functional Block Diagram

In the current study different enhancement techniques are followed to remove *speckle noise* and *salt and pepper noise* for better image post processing (segmentation).

3.1 Foetal Ultrasound Image Enhancement

Ultrasonograph image in RGB form is converted to gray scale and the further enhancement techniques are carried out for the segmentation of image.

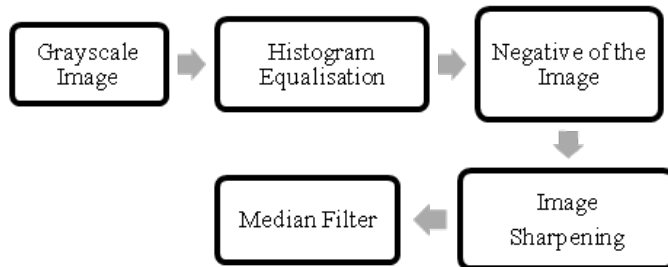


Figure 2. Schema for Foetal Ultrasound Enhancement

Histogram equalization is on the gray scale image to distribute the pixel values over the entire range of the image making the pixel values almost equal in the image increasing the contrast resolution. By taking negative of an image the idea is to reverse the order from black to white so that the intensity of the output image decreases as the intensity of the input image increases enhancing the image from its background. Image sharpening is to highlight fine details in an image or to enhance the edge that has been blurred. Median filtering technique is used to remove salt and pepper noise preserving the edges and increasing the image quality.

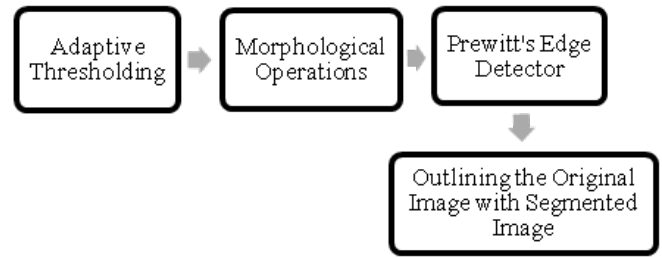


Figure 3. Schema for Foetal Ultrasound Segmentation

3.2 Foetal Ultrasound Image Segmentation

To be effective, especially for ultrasound, adaptive algorithm is used as it is able to recognize the difference between real targets and artifacts, and to modify its processing accordingly - it adapts automatically to the nature of the target, ideally both locally (i.e. within an individual image) and temporally (over time from image to image), reducing artifacts while preserving diagnostic information. This helps to reduce the noise caused by the local analysis of textured light or dark area and can process images dynamically. The Prewitt edge detector is an edge detection technique which is an appropriate way to estimate the magnitude and orientation of an edge. Dilate (or dilation) adds extra pixels to the boundary of objects in the image and causes objects to dilate or grow in size Dilation technique is used in the study since the contour traced in the edge detected image is too thin. Performing morphological operation like erosion will make the edges invisible because of which dilation operation is performed to enhance the segmented edges. The accuracy of the enhanced edges results in the correct estimation of motion along the contour. The dilation operation has been implemented using the MATLAB.

4 RESULTS AND DISCUSSION

The results obtained by the application of enhancement and segmentation techniques for foetal ultrasound image is discussed below

4.1 Results of Enhancement Technique

From the histogram plot obtained in figure 5, it can be observed that histogram equalization is applied so that the image uses the full intensity range to display the maximum contrast (i.e. the intensities are stretched to the full range making the pixel values almost equal) which thereby increases the image contrast to a maximum shown in figure 6. The negative of the image is used to enhance the ROI (foetus and the mother's womb) from its background as shown in figure 7. From the figure 8, it can be seen that the edges are enhanced in the image through image sharpening. As ultrasound image contains speckle noise and salt and pepper noise median filter is applied as shown in figure 9. Speckle noise is suppressed through image enhancement techniques improving the foetal ultrasound image quality making the image suitable for segmentation.



Figure 4. Gray Scale Image



Figure 7. Negative of the Image

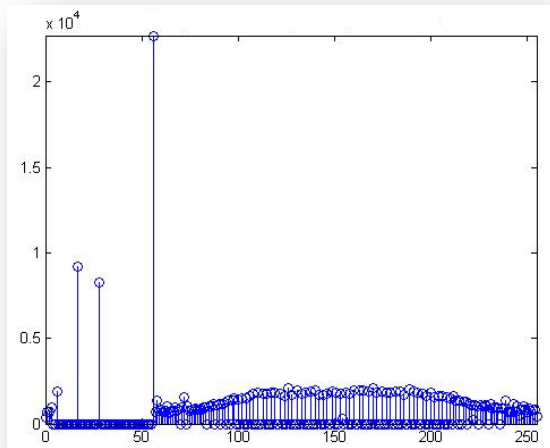


Figure 5. Histogram Equalization



Figure 8. Sharpened Image



Figure 6. Result of Histogram Equalization



Figure 9. Median Filtering

4.2 Results of Segmentation Technique

The Adaptive thresholding technique is used to correctly separate the foetus from the abdomen and the womb shown in figure 10. The result of edge detection to trace the contour/edges of the ROI is as shown in the figure 11. The accuracy of the detected edges results in the correct estimation of motion along the contour. The edges along the foetus and the mother's womb are detected to analyze the foetal anatomical structure to perfection. From the results obtained through edge detection in figure 11, it can be observed that edges are very thin. Outlining the image with the results obtained through edge detection will give poor results where the edges will not be seen making it difficult to segment the ROI to perfection. Hence, the segmented or the edge detected image is enhanced using morphological dilation operation. Then the thick border got is outlined to original image by adding both border image and original image and then displayed as final output as shown in the figure 12.



Figure 12. Outlined Image



Figure 10. Adaptive Thresholding

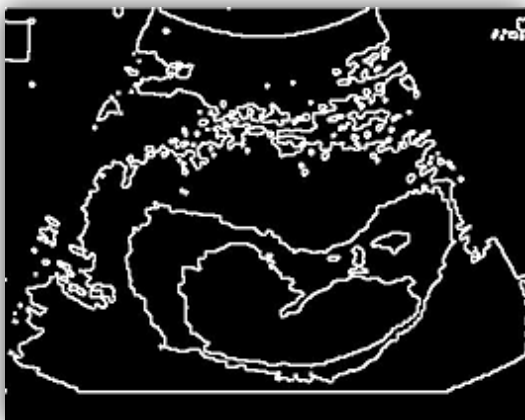


Figure 11. Prewitt's Edge Detection

5 CONCLUSION

Segmentation foetal ultrasound image was conducted with an objective of providing a better analysis of foetal anatomical structure.

- The enhancement technique implemented show an increase in contrast of the image suppressing the speckle noise in ultrasound image sequence improving the quality of the ultrasound data for segmentation.
- The segmentation algorithm is implemented using Adaptive thresholding technique which is easy to implement and computationally fast. The adaptive algorithm is very useful for segmentation as the technique is automatic where the images are processed dynamically enhancing the target and suppressing the artifacts.
- Detecting the edges after thresholding enables identifying and analyzing the foetal anatomical structure.

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