Fetal Weight Estimationusing Canny Segmented Ultrasound Images

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Abstract: - Estimation of fetal weight is significant in the assessment of high risk pregnancies. Sonographer estimates fetal weight with combination of various fetal biometric measurements. The precision and accuracy of fetal biometric measurements is highly dependent on the skill and experience of the sonographer or even the quality of medical ultrasound images. Thus, in this paper, a method for enhancing the ultrasound images is suggested to make the estimation of fetal weight less subjective. For that, various edge detection techniques have been performed to extract the edges by detecting the sharp changes of fetal ultrasound images brightness along the boundaries of interest region. The results were compared based on the quality performance of detected edges. Measurements for three parameters, femur length, biparietal diameter and, abdominal circumference,have been computed from the segmented images. Then, fetal weight is calculated based on the measured parameters obtained through (a) original fetal ultrasound images and (b) segmented fetal ultrasound images, then both methods have been compared and the difference is 40grams.

Key-Words: -Fetal weight,Segmentation,Fetal biometry, Edge detection,Binary segmentation.

1 Introduction

Evaluating the fetal growth is important as it is associated withan increased neonatal morbidity and mortality[1]. One indicator for the fetal growth is the fetal weight. Estimating the fetal weight enables the early planning of the delivery. The accuracy of the estimated value is vital to make the resulting clinical advice reliable. Fetal biometric measurements that are obtained in obstetric sonographic assessment for the purpose of predicting fetal weight has been integrated into the mainstream of obstetric practice during the past quarter century[2].

The assessment of fetal size and growth has essentially been based on predictive formulae derived from two-dimensional (2D) ultrasound measurements[1].Michael G. Pinette[3] stated that there were several equations having been developed for estimating the fetal weight in the late second and third trimester. The equations were based on fetal parameters such as femur length (FL), Biparietal diameter (BPD) and, Abdominal Circumference (AC).Manual estimationbased onultrasound images is highly dependent on the skill and experience of the sonographer [2].So, the poor quality of ultrasound imagesresulted in a low accuracy of fetal weight estimation[4]. Moreover, the outcome of the pregnancy's high risk assessment will be unreliable if the estimated fetal weight is determined based on subjective measurements. This isa challenge in obstetric care services. As proposed in[5], image processing has been applied to enhance the quality of the medical ultrasound images.To prevent any subjective data, the measurements of the needed fetal parameters were done based on the enhanced images. In this study, image segmentation technique has been proposed to enhance the quality of medical images by edge-detection. The difference between the estimated fetal weight of the segmented fetal ultrasound images and the original fetal ultrasound images was determined.

2 Methodology

2.1Overall Work Flow

For implementing the part of image processing, Matlab was used. Edge detection algorithms have been used to process the fetal ultrasound images and ensure the more clarity imagesare produced. The

measurements for each parameter were computed after the images have been processed. Then, fetal weight for both methods wascalculated based on the parameters obtained through original fetal ultrasound images and segmented fetal ultrasound images.

2.2Data Collection

Toshiba Aplio-MX Ultrasound is used in this study to collect the two-dimensional (2-D) images. A convextransducerwith a frequency of 3.5MHz was used.

The subject is a woman in the 23th week of gestation. The transabdominal ultrasound scanning was done by a sonographer to ensure the correct images are taken.One image for each of the three parameters was collected.

Parametermeasurements were performed based on the standardized obstetric practice. FL was measured with a linear array which includes only ossified diaphysis. BPDwas measured from the outer edge of the proximal parietal bone to the inner edge of the distal parietal bone. AC was measured from the outer diameter to outer diameter at the level of portal sinus and stomach.

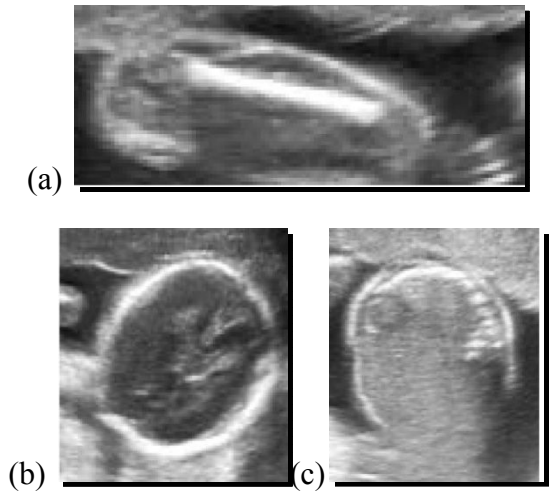

Figure 1 Ultrasound images
(a) FL, (b) BPD, (c) AC.

Fig.1 shows the 2-D medical ultrasound images forFL,BPD andAC. Manual measurement of the previous three parameters used for fetal weight estimation is subjective. The result highly depends on the experience of the sonographer. Using image processing analysis, the estimation of the fetal weight could be more accurate and feasible. So, it can be applied by a technician.

2.3 Segmentation

Segmentation is typically used to locate boundaries in an object of interest[6]. In[7], asegmentation technique is described to isolate biological structures of interest. Segmenting the imagemakes the analysis easier.

In[8], there are two classes ofsegmentation techniques:(1) edge-based approaches and (2) region-based approaches.The concept of edge-based approaches is to detect the bounderies of an object using an edge-detector[6]. In order to avoid any subjective behavior during the measurement of fetal biometric, the edges of the interest object must be performed clearly.

In this study,the edge-based approach has been applied to enhance the quality of ultrasound images for segmenting the boundaries of objects of interest. Since there is alarge number of edge detection operators available, but only six commonly used operators were applied in this study. These are Laplacian, Sobel, Prewitt, Roberts, Zerocross and Canny. Each edge detector was designed to be sensitive to certain types of edges. In order to study the effect of edge detection methods on fetal ultrasound images, a comparison were made based on the quality of the detected edges.

Edge detection processed the image by identifying the abrupt changes or discontinuity in pixel intensity which characterizes boundaries of objects. The purpose of detecting sharp changes in image brightness is to capture important features and changes in properties[9]. By applying edgedetection algorithms, the noise or irrelevant information of the image would significantly be reduced and the desired part on the image will be preserved. If the edge detection is successful,it will be easier to further process the image and compute the measurement for each parameter.

2.4Computation of Parameters

Parameters measurement for FL and BPD were computed using Matlab. In order to measure the FL and BPD of the edge-detected images, the images were displayed using image tool. Image tool provides a distance tool which allows the FL and BPD to be measured. This tool measures the distance between two pixels. However, the computed measurements in unit pixels were converted to millimetres.Computation of AC is different from FL and BPD. Before the AC is determined, the edge-detected image needs to be

ISBN: 978-1-61804-122-7

further processed by using binary segmentation. First, an ellipse was used and put into the overlay of the image to determine the abdominal region. A binary mask was formed from the determined region. “imellipse” uses rasterization to calculate the position of the indices and that the “createMask” function formed the pixel 1 for the enclosed region along the perimeter of the ellipse by rounding the fractions of pixels. The mean pixels for the binary mask region were computed. By assuming the binary mask is ofcircular shape, a formula to calculate the circumference of a circle was applied to compute the AC. Moreover, the AC in pixels was converted to millimetres.

2.5Fetal Weight Estimation

Akinola, R.A[2] describes that fetal weight can be estimated using fetal biometric measurements. Using multiple parameters gives the most accurate prediction of fetal weight, especially when using AC, BPD and, FL[2].In this study, the fetal weight was calculated based on the parameters measurement of FL, BPD and AC. The formula shown in (1) is used[10]. BPD, AC and FL are to be given in cm and the resulting Estimated Fetal Weight is in g.

The difference between the estimated fetal weights for both methods was determined.

$$EFW = (1.07 \times BPD^3) + (0.3 \times AC^2 \times FL) \quad (1)$$

Where: BPD is Biparietal diameter
AC is abdominal circumference
FL is femur length

3 Results and Discussion

Various edge detection methods have been used for segmenting the collected fetal ultrasound images. The results for each image were shown below.

Fig.3, 4 and 5 show the results of the six edge detection methods for image of FL, BPD and AC. By visual comparison, Canny edge detection shows the most effective method in detecting the edges of the region of interest. Since this method is hardly affected by noise, this method segments most of the edges with low noise appearing in the result.

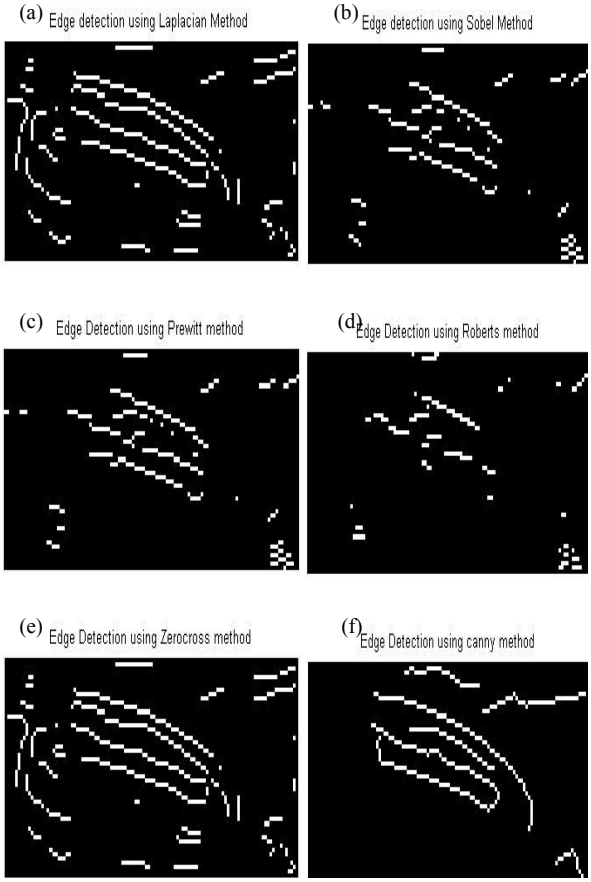

Figure 2 Edge-detectionresults for image of FL using (a)Laplacian(b)Sobel(c)Prewitt (d)Roberts (e)Zerocross (f) Canny

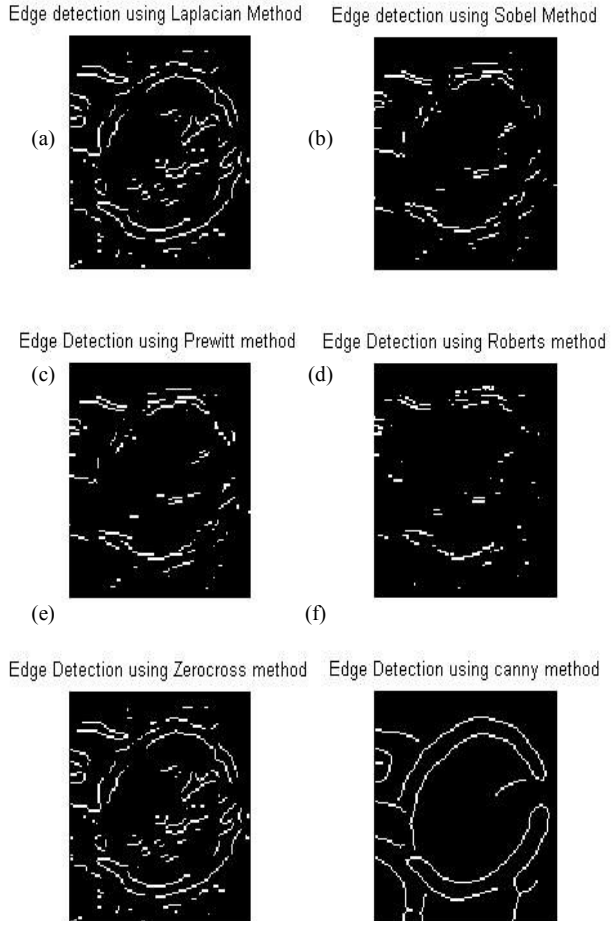

Figure 4 Edge-detection results for image of BPD using (a) Laplacian (b) Sobel (c) Prewitt (d) Roberts (e) Zerocross (f) Canny

Although Laplacian and Zerocross techniques show clear detected edges, those methods were sensitive to noise. However, the results performed by methods of Sobel, Prewitt and Roberts were not acceptable as the edges of the region of interest were not clearly detected and information about the needed edges were lacking.

Based on the concept of Canny edge detection, Ehsan Nadernejad[11] defines that edges occur at points where the gradient is at a maximum. In Fig. 1 (a)-(c), the images show a high pixel intensity along the boundaries of each parameter compared to the surrounding pixels. Thus, this characteristic enables the Canny Edge detector performing well in fetal ultrasound images.

The results indicate that the Canny edge detector is sensitive in segmenting and detecting the edges of fetal ultrasound images compared to others.

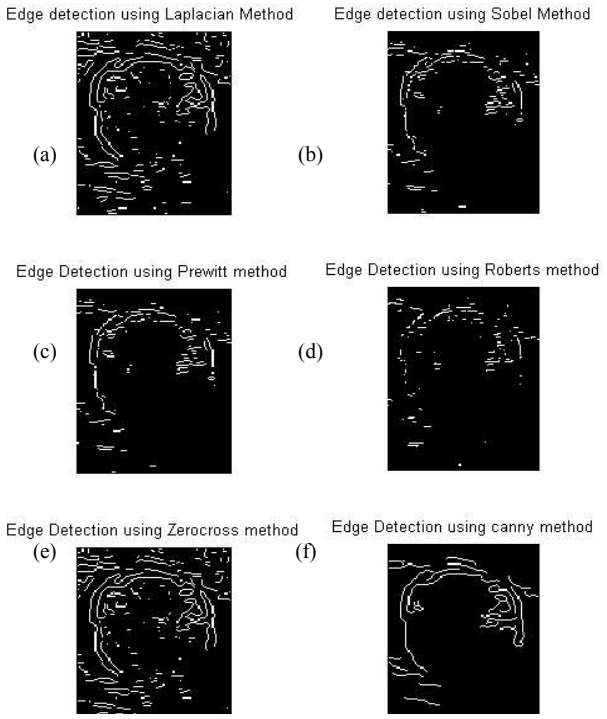

Figure 5 Edge-detection results for image of AC using (a) Laplacian (b) Sobel (c) Prewitt (d) Roberts (e) Zerocross (f) Canny

3.1Computation of Fetal Parameters

The best edge-detected fetal ultrasound images produced by using the Canny edge detector were further processed to compute the measurements of FL, BPD and, AC.

Figure 6 Measurement of FL image after Canny edge detection

Fig.6 shows how the Matlab distance tool was used to measure FL. The computed measurement for FL is 39.7mm.

ISBN: 978-1-61804-122-7

Figure 7 Measurement of BPD image after Canny edge detection

As shown in Fig.7, the same measurement tool was used to measure the BPD. Themeasured value for BPD is 51.3mm.

Fig.8 shows how the ellipse tool was used to select the region of interest and how the binary image was formed. The white pixels of the binary image show the region enclosed along the perimeter of the ellipse. The computed mean pixels for the binary mask region was further computed to determine the AC. The measurement of AC was converted from pixel to mm and the result is 183.0mm.

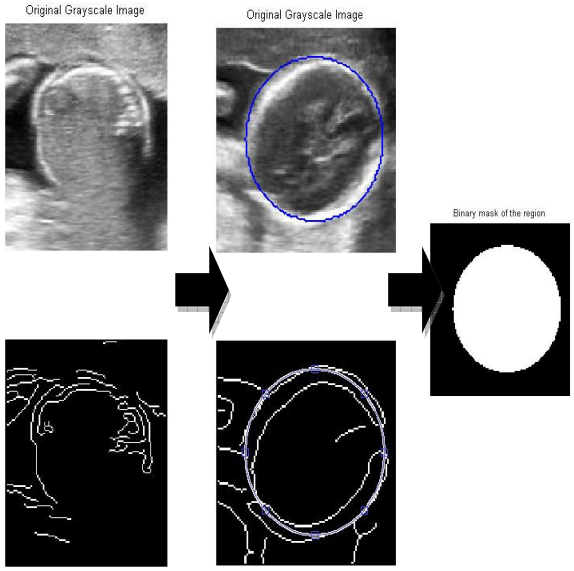

Figure 8 The segmented binary image using eclipse.

3.2Fetal Weight Estimation

By inserting the measured parameters, FL=3.83cm, BPD=5.12cm and, AC=17.62cm,taken by the sonographer from the original fetal ultrasound images into the equation (5), the estimated fetal weight is 500.0grams.

However, the estimated fetal weight is 543.3grams when inserting themeasured parameters done with the enhanced imagesinto the same equation. Those parameters are FL=3.97cm, BPD=5.13cm and AC=18.3cmwhich obtained from segmented fetal ultrasound images.

InTable 1, it is obvious that the fetal weight calculated from the segmented ultrasound image is differenttothe value based on the original ultrasound images. The difference is about 40grams.

	Measurement (cm)			
	FL	*BPD*	*AC*	Estimated Fetal Weight
Original Images	3.83	5.12	17.62	500.3grams
Segmented Images	3.97	5.13	18.30	543.3grams

Table 1 Measured parameters and the estimated fetal weight.

4 Conclusion

From the various edge detection techniques, the results indicate that the Canny edge detector is most sensitive in segmenting and detecting the edges of fetal ultrasound images compared to others. The results for fetal weight calculated based on the measured parameters obtained through (a) original fetal ultrasound images and (b) segmented fetal ultrasound images show a difference of 40 grams. In conclusion, the difference of the estimated fetal weight shows that the accuracy of fetal weight estimation is affected by the quality of the medical ultrasound images but the accuracy of method (b) cannot be proved from this study due to limited data.In future study, more data are needed to improve the reliability of the result. Moreover, investigation on the accuracy for both methods in estimating the fetal weight is recommended.

ACKNOWLEDGEMENTS

The author would like to thank Dr.Yin Mont Mint and Pn. Maria for their guidance in accomplishing this paper. The help of sonographer Mr. Heamn in collecting the data is really appreciated. In addition,

a special thanks to the subject involved. A sincere thanks to my colleagues for their helpful comments and suggestions in paper writing.

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