Fetal Weight and Gender Estimation using Computer based Ultrasound Images Analysis

Yudha Noor Aditya, Heamn Noori Abduljabbar, Christina Pahl, Lai Khin Wee, Eko Supriyanto

Abstract-- This paper proposes a fetal gender and weight estimation method using ultrasound images. Normally the gender and weight estimation is done by the physician through the observation only. The accuracy of the gender and weight estimation strongly dependent on the experiences of the physician as the images of ultrasound are not clear for those low cost two dimension (2D) ultrasound. In order to increase the accuracy of the gender and weight estimation during the fetal scanning process, a method has been developed by using thresholding and canny segmentation. The percentage of white level in the processed image is calculated to classify the gender of the fetus. Canny edge detection is used for segmentation, and then parameters such as femur length (FL), biparietal diameter (BPD) and abdominal circumference (AC) have been measured to estimate the fetal weight. The results shows that the percentage value equal or larger than 46% will be considered as a male fetus. While images with the percentage of white level less than 46%, the fetus will be classified as a female. Then, fetal weight is calculated based on the parameters measurement obtained through original fetal ultrasound images and segmented fetal ultrasound images, then both methods have been compared and the difference is 40 grams. The method can be further developed and applied in the low cost two dimension ultrasound machine to improve the accuracy of gender identification and reduce the human error during the scanning process.

Keywords—Fetal Gender, Fetal Weight, Thresholding, Ultrasound, Intensity, Segmentation, Edge Detection

I. Introduction

Fetal biometric and morphologic analysis on the ultrasound images is widely performed compared to other tomographic modalities such as Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) [1]. The ionizing radiation produced by CT and MRI is not safe for the fetus that the radiation might cause mutation of the fetus. The ultrasound is safe [2] where it only produce echo signal that does not produce harmful substance to investigate the condition of the fetus.

Ultrasounds in pregnancy are used to obtain the images of the fetus from early pregnancy through the end of pregnancy to monitor the development of the fetus. During fetal scanning, the sex of the fetus will be identified by the physician. Normally the gender determination is done by the physician through the observation of the genital appearance of the fetus during scanning. The accuracy of the gender identification is strongly dependent on the gestation age and experiences of the physician as the images of low cost ultrasound are not as clear where there are many gray shades shadow and fizzy noise to interfere the visibility [3].

Fetal growth is also very important to be evaluated as it is associated to the increased neonatal morbidity and mortality. Since the abnormalities of fetal growth are associated with an increased risk of adverse outcome during pregnancy period, fetal weight estimation enable the early planning on how the pregnancy and delivery will be managed. The estimation of fetal weight has been a major concern among the factors in the detection of high risk pregnancies, because the abnormal intrauterine growth is associated with increased neonatal mortality rate [4]. The accuracy of the estimation value is vital to make sure a reliable clinical advice is provided. A study done in [5] mentioned that fetal biometric measurements that 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.

Many researches of gender prediction of fetus have been done and normally the analysis is three-dimension ultrasound [1]. Three-dimension ultrasound is well equipped in most of the ultrasound machine and it can provide a three- dimension view of the fetus so the genital appearance of fetus can be identified easier. Gender prediction at the early stage of the pregnancy is a huge challenge because the appearance of the genital area cannot be finely differentiated [6][7]. But gender of the fetus can be identified more accurately during the second trimester because the genital appearance has become more apparent where there is a penis and testes for a male fetus but there are labia for female fetus [8][9]. But by using three-dimension ultrasound, the gender of the fetus can be predicted at the end of the first trimester because it provides a

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better visibility on the fetus. Fetal weight can also be estimated in the late of second and third trisemester by several developed equations [10]. The equations were based on fetal parameters such as femur length (FL), Biparietal diameter (BPD), Abdominal Circumference (AC).

For identifying the gender of the fetus from the ultrasound images, several methods can be used and all of these methods are based on the observation of the fetus genital area. Besides, the method used in indentifying the fetal gender also depends on the position of the fetus.

One of the methods for identifying fetal gender is the observation of the appearance of genital part from the bottom view where the genital part is situated between the thighs. If "three lines" is discovered during the scanning, the fetus is classified as female where the three lines indicate the female identity with the labia and clitoris, like what is shown by Fig. 1 .While a male fetus can be identified if the genital appearance shows a "turtle shape" where the turtle head is the penis and the turtle shell indicates the testes. This method might not give the correct prediction of the gender as the genital appearance of the fetus is hard to be differentiated for those with gestation age less than 20 weeks [11].

Fig. 1 "Three Lines" indicating labia and clitoris found in female fetus ultrasound image, marked by red circle

All the gender and weight estimation methods are done manually. It is highly dependent on the skill and experience of the sonographer [5]. The human errors always occur during the scanning process. The human errors are usually caused by noise and the techniques and knowledge of the sonographer to perform the ultrasound scanning. The poor quality of the ultrasound image also has been the reason for the low accuracy of fetal weight estimation [12]. Moreover, the outcome of the pregnancy's high risk assessment would be unreliable if the estimated fetal weight is determined based on subjective measurements.

In technical aspect, fetal gender and weight estimation can be done by using image processing method [13][14][15]. Hongchao Song [16] proposed of typical image enhancement algorithms including histogram equalization. Histogram equalization is revising the histogram of original image to be the gray uniformly distributed histogram by the function of gray transformation, and then revises the original image by checking the equalization of histogram. It functioned based on the probability and using gray-point operations to achieve an enhancement purpose. Besides that, this technique recovers the lost in the image by remapping the contrast of image to equalize the brightness distribution [17].

Shaohua Zhu et al. [18] used color image processing to extract the solder joint quality information. In the analysis, the color image was converted to non-uniform RGB color space to HSV space and an appropriate H domain was chosen for the image segmentation. Then, by using Otsu's method, the result showed the better object is obtained from color image segmentation which contained the information of Hue and saturation.

Laxman Sigh et al, [19] also presented with idea of image processing method on the efficient tumor segmentation technique using conventional Otsu's thresholding method aided by morphological reconstruction filtering technique. The parameters extracted were area, major and minor axis length, eccentricity, solidity, average gray level, standard deviation, and entropy. This threshold method appeared to be more effective than the existence method.

Eko Supriyanto et al. [20] proposed a series of ultrasound image processing by segmenting the abnormal tissue with the combination of morphological techniques. The thresholding process produced image with unconnected edges, so techniques of erosion and dilation were applied to reduce the noise and improve the edge preservation. The region of interest (ROI) in the image was obtained by morphological techniques of opening and closing to reduce interference and small dots in the image. The morphological techniques had successfully segment the ROI from the image.

Image of appendix in ultrasound can be segmented by using histogram thresholding method and median filtering in Eko Supriyanto et al. [2]. The thresholding method had increased the visibility of the ROI but there was much noise. So filtering, edge detection and labeling processes had successfully segmented the appendix from the image. The labeling process eliminated the undesired area in the image and displayed the ROI.

The objective of this paper is to develop a gender and weight estimation method for low cost 2-dimension ultrasound images. By thresholding, genital appearence can be seen clearly on binary image. Same threshold value can be applied in both male and female genital, because clitoris and labium in female genital differentiate from the same tissue like penis and scrotum in male genital [21], so these two genital appear with same intensity level in ultrasound images, but different in pixel amount number. Based on the shape of male genital which is "turtle shape", male genital will always have larger amount of white intensity pixel compared to "three lines" shape in female genital. Thus, male or female gender can be identified later through calculating the value of white level in genital binary image. For the fetal weight, calculations can be done by measuring Femur Length (FL), Biparietal Diameter (BPD), and Abdominal Circumference (AC) to the processed image so that the accuracy can be increased. This method can be further

improved and applied in the low-cost ultrasound to assist the sonographer in estimating the fetal weight and gender, also to increase the accuracy of the fetal gender and weight estimation. In order to achieve the main objective, an algorithm is developed to handle the ultrasound images.

II. Methodology

In this section, the procedures of the image acquisition and image processing methods are described. For the image processing, one image was selected to undergo the series of image processing to choose the best image enhancement method for this study. Lastly, all the images were processed by using the selected algorithm for image segmentation.

A. Data Acquisition

Ten images of fetus were acquired from ten pregnant women using the Aplio MX Toshiba ultrasound machine with a 3.5MHz convex transducer. There were five ultrasound images for male fetus and five images for female fetus. All of these images were captured by professional sonographer during the fetal screening at C.L.E.A.N.E.R laboratory of Department of Clinical Science and Engineering in Universiti Teknologi Malaysia. Images were captured at the transabdominal and all of them contained the images of genital part of the fetus. Before the fetal screening, the information of the fetal gender has been obtained from the pregnant women to verify the accuracy of fetal gender identification. Parameters measurements for fetal weight estimation, which are FL, BPD, and AC, also performed based on the standardized obstetric practice. FL was measured with a linear array which includes only ossified diaphysis. BPD was 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. Fig. 2 shows one of the examples ultrasound image captured during the ultrasound screening.

Fig. 2 The ultrasound image of fetus

B. Image Processing

In this study, the acquired ultrasound images were processed using a series of image processing methods. Fig. 3 shows the framework of the image processing for image enhancement and segmentation for the fetus ultrasound images.

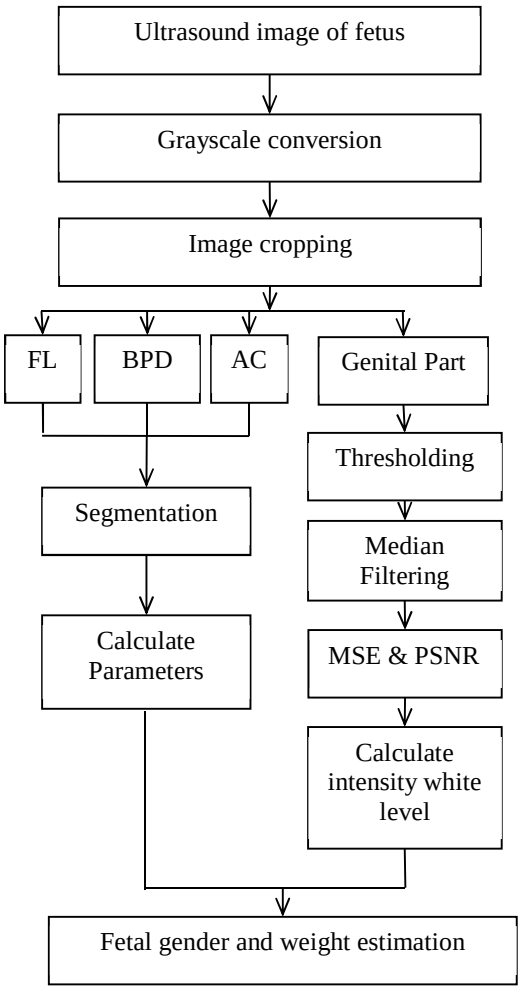


Fig. 3 Flowchart of image processing for fetus ultrasound image

i. Image Preprocessing

Firstly, the ultrasound image was read into the MATLAB software as initialization. All kind of images can be loaded into the software such as RGB images and indexed images.

Then the image was converted into grayscale image by eliminating the hue and saturation information while retaining the luminance. The ultrasound image was converted into grayscale intensity because it was in RGB colour model even though it was in gray colour. RGB image referred as colour image where it is stored as a three data array defined as red, green and blue. The colour of each pixel intensity is the combination of red, green and blue intensities. Besides that, grayscale conversion was applied on the image due to most of the build in image processing MATLAB function can only process grayscale images. Grayscale image consists of 256 intensity levels where 0 represents the pure black colour and the 255 intensity level indicates the pure white colour.

Next, the image was cropped manually to obtain the FL, BPD, AC, and genital parts of the fetus. Since the parts of the fetus only covered a very small portion of the image, so the

desired image was cropped in order to facilitate the process of image processing. The image was cropped as small as possible where it only covered the parts needed to reduce the noise in the image and increase the accuracy of analysis. The manual cropping was done by setting a coordinate and size of target image

ii. Gender Identification: Thresholding

Three thresholding methods had been used in this study to adjust the contrast of the genital part image and segment the desired element in the images. These three methods applied the thresholding techniques to improve the visibility of the images so the required element in the image can be defined clearly.

The first method was the adaptive thresholding technique which to enhance the contrast of the grayscale image by transforming the values using a threshold value where the threshold value was set automatically according to the information acquired in the images. The enhanced image was converted into binary image to standardize the result of the thresholding methods. Image binarization is a process of converting the image into binary model which is only consists of two pixel level, 0 and 1

The second method was the Otsu's thresholding method where it was a build in MATLAB function. It was a binarization process using a global threshold value and the global threshold is chosen based on Otsu's method. The chosen threshold can minimize the variance of the black and white pixels.

The third method was a manual thresholding method where it consists of the process of binirization. The binarization was done based on the threshold value that is being set manually. The threshold value was selected based on the distribution of pixels in the image done by histogram analysis, and it was between the range of 0and 1.

iii. Gender Identification: Median Filtering

After thresholding, the binary genital image underwent a process of filtering where median filtering was applied. Median filtering process reduced the small dots noise and preserved the edges in the image. It produced the output pixels by finding the median value of the matrix [m n] and it fills the edges with pixel 0 to enhance the edges of the elements in the image.

iv. Gender Identification: MSE and PSNR Measurement

Mean Square Error (MSE) and Peak Signal to Noise ratio (PSNR) are good tools in measuring the quality of image and to verify the effectiveness of the filter. MSE is a way to measure the difference or variation between the image before and after filtering. The square operation is to emphasize the differences so the errors can be more obvious. PSNR of the image is the ratio of the required information in the image to the noise to measure the content of noise in the image. The higher the value of PSNR indicates the better of the quality of image. The PSNR and MSE are in inverse relationship where the greater MSE produces lower PSNR and vice versa. The equation of MSE and PSNR are shown in (1) and (2) respectively and the *n* value used for the analysis of PSNR was 8.

$$MSE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)-\hat{x}(i,j)|^2}{MN} \quad (1)$$

$$PSNR = 20log_{10}\left[\frac{(2^n-1)}{\sqrt{MSE}}\right] \quad (2)$$

v. Gender Identification: White level Calculation

The processed image was a binary image where it only consisted of white and black colour and the desired element in the images (genital area of fetus) was shown in white colour level. In order to find the content of white pixels in the image, a histogram of the image was plotted. The histogram only consisted of two levels white is 0 and 1 and the intensity of the white level was documented. The percentage of the white level in the image was calculated based on the equation (3) below.

$$\%\, white\ level = \left(\frac{intensity\ of\ white\ level}{size\ of\ the\ image}\right) \times 100\% \quad (3)$$

This is the last step for gender identification. The last three images, which were FL, BPD, and AC, will now undergo several image processing to obtained parameters needed, so that fetal weight can be estimated.

vi. Weight Estimation: Segmentation

Three images will undergo this operation, which are FL, BPD, and AC part of the original image. As mentioned in [22], segmentation is typically used to locate boundaries in an object of interest. Study in [23] applied segmentation technique to isolate biological structures of interest. The segmented image that only performs the interest region makes the analysis work become easier.

In [24], there are two classes in segmentation technique, (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 and the edge information will be used to extract the boundaries [22]. In order to avoid any subjective behavior during the measurement of fetal biometric, the edges of the interest object must be cleary performed.

In this study, edge-based approach has been applied to enhance the quality of ultrasound images for segmenting the boundaries of object of interest. Since there are an extremely large number of edge detection operators available, but only the 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 method on fetal ultrasound images, comparison were made based on the quality of the detected edge.

Edge detection processed the image by identifying the abrupt changes or discontinuity in pixel intensity which characterizes boundaries of objects. N.Senthilkumaran et al. [25] state that the purpose of detecting sharp changes in image brightness is to capture important features and changes in properties. By applying edge detection algorithm, the noise or irrelevant information of the image would significantly reduce and the desired part on the image will be preserved. If the edge

detection is successful, it would be easier to further process the image and compute the measurement for each parameter.

vii. Weight Estimation: Parameters Calculation

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 milimeters.

Computation of AC is different from FL and BPD. Before the AC is determined, the edge-detected image needs to be further processed by using binary segmentation. First, an ellipse was used and put it into the overlay of the image to determine the region of abdominal. A binary mask region 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 region is a circle shape, formula to calculate the circle circumference was applied to compute the AC. Moreover, the AC in pixels was converted to milimeters.

By using FL, BPD, and AC, a simple formula as shown in (4) which recommended by N. Shinozuka in [26] was applied to estimate the fetal weight. The difference in estimated fetal weight for both methods was determined.

$$EFW = (1.07 \times BPD^3) + (0.3 \times AC^2 \times FL) \quad (4)$$

Fetal weight, (cm, g)

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

III. Result

This section explains the result of the digital images that had undergone a series of image processing technique. The best thresholding method was selected and used for the analysis, also for the best segmentation method. The analysis was done on 10 ultrasound images collected during fetal screening for gender identification. From ten images, one image was chosen for weight estimation and the result then was compared to the sonographer's measurements.

Fig. 4 displays the original ultrasound image for fetus loaded in the MATLAB software and this image was processed by a series of image processing methods as discussed in the previous section. This image was in RGB model, so that it was converted into grayscale image and the result is shown in Fig. 5.

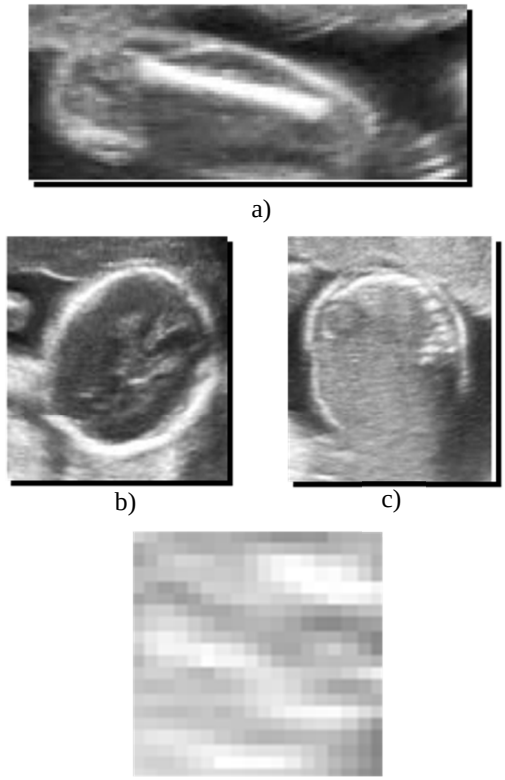
Fig. 4 The ultrasound images loaded into MATLAB

Fig. 5 The image in grayscale domain

The grayscale image was black-and-white with shades of gray varying form weakest intensity at black to the strongest intensity at white. The grayscale digital image did not show difference from the original loaded image because the ultrasound image was in gray colour with different intensity. The ultrasound image shows a bottom view of the fetus so the lower limb of the fetus was seen. While the genital area of the fetus was situated between the femurs of the fetus and it only covered a very small portion of the total ultrasound image. So the image was cropped manually and the cropped image was very small which only covered the genital area of the fetus.

For the weight estimation purpose, the images for parts FL, BPD and AC of the fetal were collected. The cropped image of FL, BPD, AC, and Genital part were enlarged for visibility purpose and it is shown in Fig. 6.

For Gender identification, the cropped image of Genital part was processed by three thresholding methods as described before. The thresholding methods enhanced the image and emphasized the desired element in the image. The emphasized elements were displayed in white colour in the black background.



a) b) c) d)

Fig. 6 Cropped image, a) FL, b) BPD, c) AC, d) Genital Area

The Fig. 7 shows the cropped image after it was enhanced by an adaptive thresholding method. The image shows that the required element (genital appearance) of the fetus cannot be shown clearly. The edges of the genital appearance cannot be seen clearly so that it cannot be differentiated from the back ground. There was many interference noise in the image and did not provide a good visibility of the image in recognize the shape of fetal genital appearance.

Fig. 7 Image after the adaptive thresholding

The Otsu's method was another thresholding method applied in this study and the image processed is shown in Fig. 8. The genital appearance of the fetus in the image cannot be seen nicely because the edges were not well preserved but they mixed up. There were noises in the image so the image was not clear and these interferences had affected the visibility of the genital appearance in the images.

Fig. 8 Image after Otsu's thresholding method

The third image enhancement technique applied in the image processing was manual thresholding method where a threshold value was determined by histogram analysis. to segment the required element from the image. From the Fig. 9, three white lines that show the genital appearance of the female fetus can be clearly seen where the edges were finely differentiated. Even though the lines indicate the labia and clitoris of the fetus can be finely defined but there were some noises in the image. This image enhancement method had successfully increased the visibility of the genital appearance of the fetus.

Fig. 9 Image after manual thresholding method

From the observation of the images produced by three thresholding methods, it can be concluded that the third thresholding method, thresholding by histogram analysis is the best image enhancement technique where it can produce a clearer image with lesser noise and the edges of the genital appearance had been preserved. So the manual thresholding had been chosen for the analysis in this study.

Fig. 10 Image after median filtering

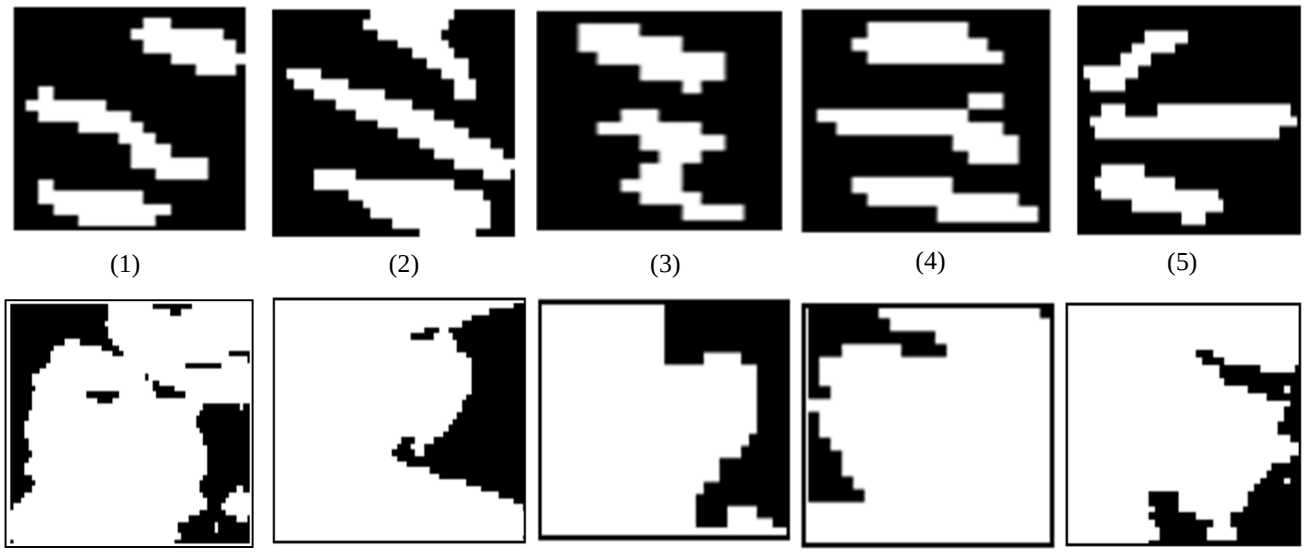


Fig. 12 10 processed images

Since there were some small white dots in the image after the manual thresholding process, a median filter had been applied to filter out the noise. The result of the median filtering is shown in Fig. 10 and it can be clearly seen that the small dots in the image had been eliminated and there were only three white lines displayed.

After the filtering process, the measurement of MSE and PSNR were done and the results recorded. The value of MSE and PSNR are displayed in (4) and (5) and these values indicate that the quality of the image has been improved where the noise in the image after the median filtering has been reduced. The median filter has successfully reduced the noise in the image and improved the quality of the image.

$$MSE = 4.1511e + 004 \quad (4)$$

$$PSNR = 1.9491 \quad (5)$$

Since the fetal genital appearance had been displayed in white colour, the level of white colour in the images can be used to classify the gender of the fetus. In order to find the intensity of white level in the image, a histogram was plotted and the intensities of the white level in the image were collected. Fig. 11 shows the histogram plotted from the image after median filtering. It shows that the white level in the image was 75 and the size of the image was 20×18. Lastly, the percentage of the white level in the image was calculated based on the equation (3).

The total ten ultrasound images for fetus had been processed by using the image preprocessing method and selected thresholding technique. The images were analyzed and all the data were recorded. Fig 12 shows the ten images after the image processing.

From Fig. 12, the images 1 to 5 were the images for female fetus and the remaining images 6 to 10 were the images for male fetus.

Fig. 11 Histogram of the processed image

Table 1 The percentage of white level in images

Image	Size	White level	Percentage of white level (%)
1	20×18	75	20.83
2	23×36	263	31.76
3	16×12	43	22.40
4	16×15	71	29.58
5	19×37	182	25.89
6	41×66	1974	72.95
7	39×59	1798	78.14
8	19×37	424	60.31
9	21×24	432	85.72
10	34×41	1144	82.07

From the observation, the intensities of the white level in the image of female fetus are much lower than the male fetus. Since the sizes of images are different so the intensity values for white level cannot be compared. In order to analyze the image, the percentage of the white level in the image was found. This percentage values can be used for comparison because they have been standardized. Table 1 shows the size, intensities of the white level and the percentage of white level

in the images. From Table 1, the percentage of the white level for the ten images was plotted as shown in Fig. 13.

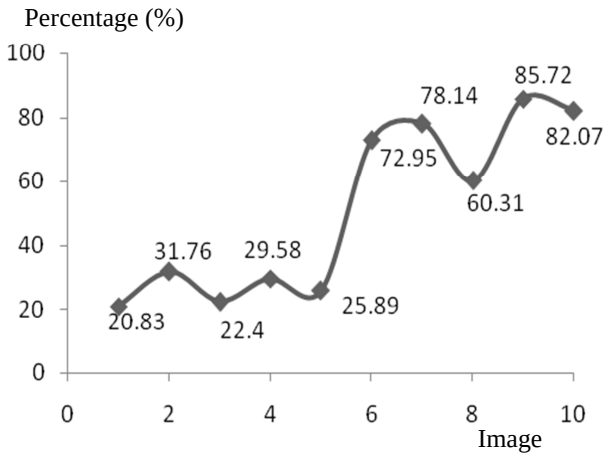


Fig. 13 Percentage of white level in the images

From the graph plotted, it shows that the percentage values of white level for images of male fetus were much higher with the minimum value of 60.31% while the white level in the images of female fetus cover less than one third of the whole image with the maximum percentage of 31.76%. From these values, the threshold value for fetal gender identification was calculated by finding the mean value for the maximum percentage value for female fetus and the minimum percentage value for male fetus as shown in (6).

$$threshold = \frac{60+32}{2} = 46\% \qquad (6)$$

So the threshold value of the percentage of white level in the image is 46% where the percentage of white level greater than or same as 46% will be classified as a male fetus while the percentage value less than 46% will be classified as a female fetus.

For the weight estimation, the three other images of FL, BPD, and AC part, were used to measure the parameters. Various edge detection methods have been used to segment the collected fetal ultrasound images. The results for each image were shown as below.

Fig. 14, 15 and 16 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 interest region. Since the process of this method is hardly affected by noise, this method segments most of the edges with less noise appear on the image. Although the methods of Laplacian and Zerocross show the clear detected edges but 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 interest region were not clearly detected and there were missed of information for the desired edges.

Based on the concept of Canny edge detection, Ehsan Nadernejad [27] defines that edges will occur at points where the gradient is at a maximum. From Fig.6 a), b), and c), the images show 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. 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.

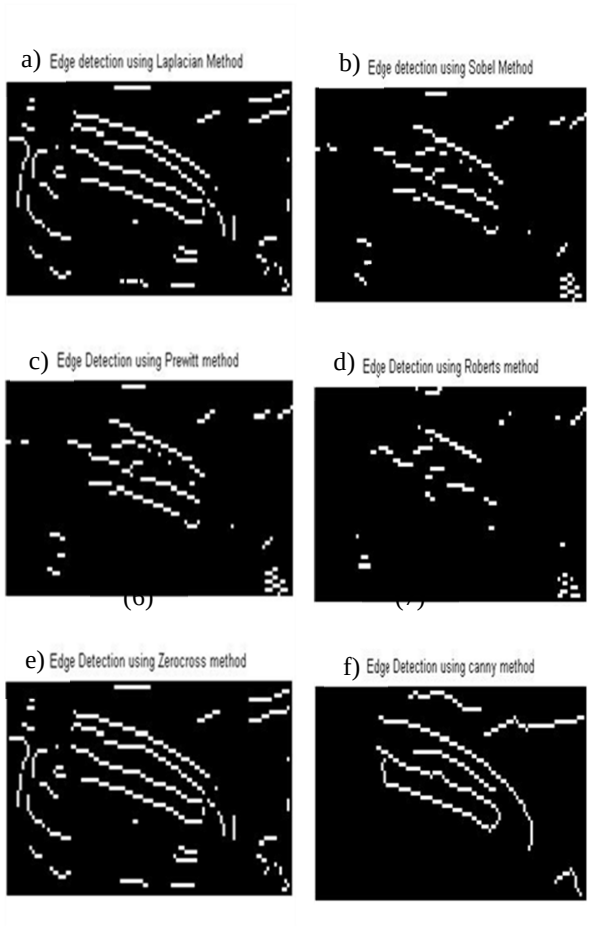


Fig.14 Edge-detection results for image of FL using (a) Laplacian, (b) Sobel, (c) Prewitt, (d) Roberts, (e) Zerocross, (f) Canny

Fig.17 shows how the Matlab distance tool was used to measure FL. The computed measurement for FL is 39.7mm.

As shown in Fig.18, the same measurement tool was used to measure the BPD. The measured value for BPD is 51.3mm.

Fig.19 shows how ellipse tool was used to select the interest region and binary image was formed. The white pixels of the binary image shows 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.

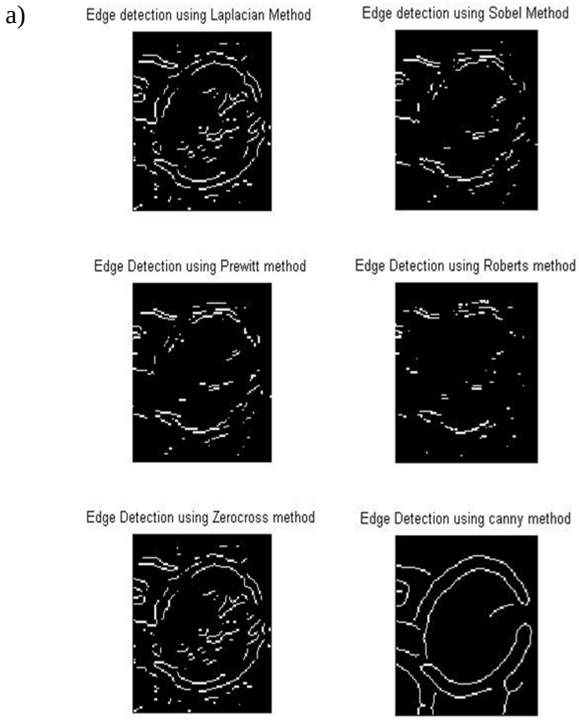


Fig. 15 Edge-detection results for image of BPD using, (a) Laplacian, (b) Sobel, (c) Prewitt, (d) Roberts, (e) Zerocross, (f) Canny

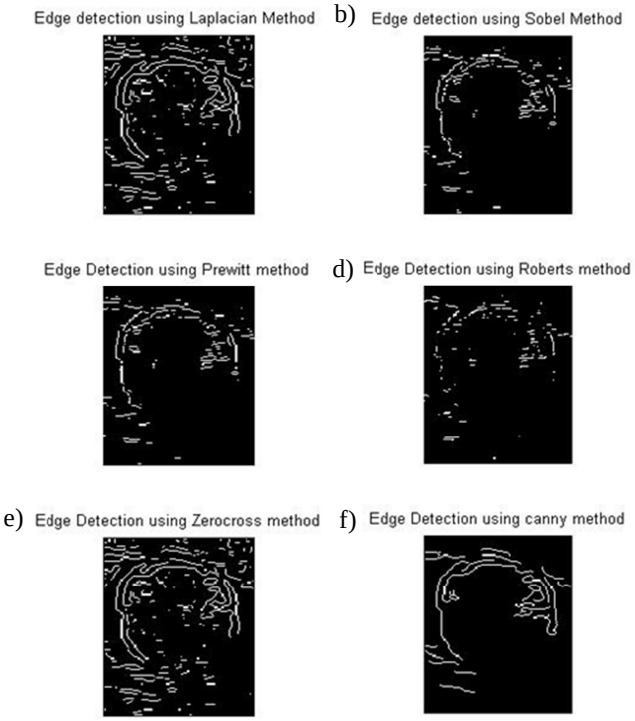


Fig. 16 Edge-detection results for image of AC using, (a) Laplacian, (b) Sobel, (c) Prewitt, (d) Roberts, (e) Zerocross, (f) Canny

Fig. 17 Measurement of FL image after Canny edge detection

Fig. 18 Measurement of BPD image after Canny edge detection

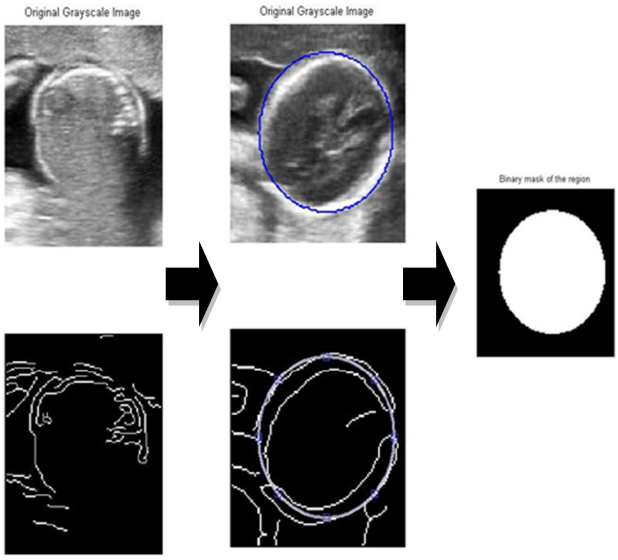


Fig. 1 The segmented binary image using eclipse.

By inserting the parameters measurement, FL=3.83cm, BPD=5.12cm and AC=17.62cm taken by sonographer from the original fetal ultrasound images into the equation (4), the estimated fetal weight is 500.0grams.

However, the estimated fetal weight is 543.3grams by inserting the parameters measurement into the same equation. Those parameters are FL=3.97cm, BPD=5.13cm and

AC=18.3cm which obtained from segmented fetal ultrasound images.

Table 2 Parameters measurement and the estimated fetal weight.

	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

From table 2 the value of fetal weight calculated using the parameters measurement which computed from the segmented fetal ultrasound image is difference from the value which calculated based on the parameters measurement which obtained manually from the original fetal ultrasound images. The difference is about 40 grams

IV. Conclusion

The image processing has successfully enhanced the ultrasound image and produced image with clear genital appearance for gender identification. The image processing requires manual image cropping and threshold value setting. This study applies the theory of percentage of white level in the image for fetal gender identification. For estimating fetal weight, Canny edge detector is sensitive in segmenting and detecting the edges of fetal ultrasound images compared to others. The threshold value for the percentage of the white level is 46. Thus, white level value equal or larger than 46% will be considered as a male fetus. While images with the percentage of white level less than 46%, the fetus will be classified as a female. Weight estimation using canny segmentation showing a difference of 40 grams between parameters obtained from original fetal ultrasound image and segmented fetal ultrasound images. The method can be further developed and applied in the low cost two dimension ultrasound machine to improve the accuracy of gender and weight estimation, and reduce the human error during the scanning process.

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