Segmentation of Femur from Ultrasound Fetal Image using Shape based Approach

Mathews M, Deepa J

***Abstract*— Medical imaging is specifically used to create images of the human body for clinical purposes. Ultrasound Imaging is a gold standard modality for fetal imaging because of its non invasive nature. Also it is a challenging modality due to the properties of image formation, signal dropouts, artifacts, missing boundaries, attenuation, shadows and speckle. In medical imaging, segmentation is a necessary step and is used to obtain the location of objects of interest and its measurements. One of the main objects of interest measured in ultrasound fetal image is fetal femur. Biometric measurement such as Femur Length is estimated from the segmented object and is used for fetus growth assessment. This paper presents a fully automatic method for the measurement of standard obstetric biometric parameters for femur, after the segmentation of femur object from ultrasound fetal image. This method uses intensity based thresholds and shape based thresholds for preliminary segmentation. Support Vector Machine Classifier is used for the selection of valid femoral object from the preliminary segmented image. If more than one object classified as femur then further extraction will done to obtain valid femur object.**

***Index Terms*—femur, shape based approach, ultrasound fetal image, support vector machine.**

I. INTRODUCTION

Medical imaging provides useful information for diagnosis. X-ray, Nuclear, Ultrasound waves, Magnetic fields, Electrical currents and Infrared waves are the various energy types used for medical imaging. The different imaging modalities are based on physical interaction of different energy types with biological tissues and thus provide images of different physical properties of the tissues. X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Nuclear Imaging, Ultrasound Imaging and Infrared Imaging are the various imaging modalities. Ultrasound imaging is the modality of choice in many clinical applications due to its non-invasive nature, reduced cost and real-time acquisition compared to other imaging modalities such as CT or MRI. [1]

Due to the properties of image formation that is intrinsic to ultrasound images, they can be affected by signal dropouts, artifacts, missing boundaries, attenuation, shadows and speckle making ultrasound one of the most challenging modalities to work with. Further complications arise as the contrast between areas of interest is often low. [1]

Automated analysis of ultrasound images is hard and methods developed for other modalities do not necessarily work on ultrasound images. Also general methods for ultrasound image segmentation do not exist and the segmentation strategies are application dependent. [1] Ultrasound imaging is usually used in Echocardiography, Breast, Intravascular, Liver, Kidney, Thyroid, Prostate Ultrasound, Obstetrics and Gynecology; and the segmentation method is distinct for each application. In obstetrics, segmentation provides valuable measurements in order to assess the growth of the fetus and in diagnosis of fetal malformation. [3][4]

Various fetal biometrics are used to establish the gestational age of the fetus, estimate its size and weight, and identify growth patterns and abnormalities. Typically, fetal size is estimated by using ultrasound measurements of head, abdomen and femur at around 20 week's gestational age. These measurements and any at later gestations are then compared with population based growth charts to identify normal or abnormal growth. [1] Femur Length (FL) is one of the most important parameters used for identify growth. To create more accurate measurements, automatic methods for fetal biometric measurements have been investigated. Low level features and textures were frequently used to find the femur, because these have a brighter response. [1]

Present work includes development of segmentation technique for femur in an ultrasound fetal image. In this method, thresholds on intensity and thresholds on shape are applied at multiple levels to the ultrasound image. The results are depicted in the single binary image. Support Vector Machine classifier is used for the selection of femur object from this binary image. If the resulted image after SVM classification shows more than one object then extract the valid femur object using the shape based features of femur.

II. MATERIALS

A. *Ultrasound Fetal Measurement Standards*

Femur is the long bone in the human thigh and Femur Length is the length of the developing baby's femur.

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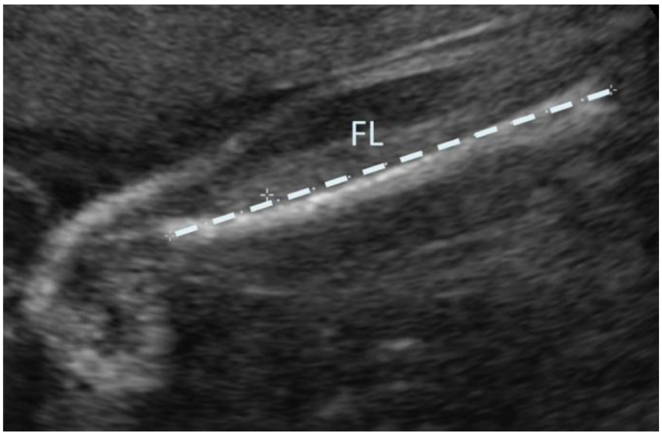

Fig 1. Femur Length (FL)

The following table shows approximate measurements of FL for various gestation weeks. [6]

TABLE I. Measurements of FL

Gestation (weeks)	Femur (mm)
+/- Standard deviations shown in (brackets). Measurements are for completed weeks.	
11	8 (2.0)
12	10 (2.5)
13	11 (2.5)
14	15 (3.0)
15	17 (3.5)
16	22 (4.0)
17	25 (4.0)
18	28 (5.0)
19	30 (5.0)
20	32 (6.0)
21	34 (6.0)
22	37 (5.0)
23	43 (5.0)
24	45 (4.0)
25	48 (5.0)
26	49 (5.0)
27	50 (5.0)
28	54 (4.0)
29	55 (5.5)
30	58 (6.0)
31	59 (5.5)
32	62 (6.0)
33	65 (4.0)
34	66 (4.0)
35	67 (6.0)
36	69 (6.0)
37	72 (5.0)
38	73 (5.5)
39	75 (6.0)
40	76 (4.0)
41	77 (5.0)

B. Support Vector Machine

The Support Vector Machine (SVM) is a widely used classifier. The basic idea of SVM is to find a hyper-plane which separates the d-dimensional data perfectly into its two classes. Optimal separating hyper-plane between the two classes is finding out by maximizing the margin between the classes closest points; and the middle of the margin is our optimal separating hyper-plane. The points lying on the boundaries are called support vectors. When we cannot find a linear separator, data points are usually projected into a higher-dimensional space where the data points effectively become linearly separable. This projection is realized via kernel techniques. Basically, SVMs can only solve binary classification problems. To allow for multi-class classification, LIBSVM uses the one-against-one technique by fitting all binary sub-classifiers and finding the correct class by a voting mechanism. LIBSVM implements the Sequential minimal optimization (SMO) algorithm for kernelized support vector machines. Here linear version of the classifier is used here finding femur object [5].

III. METHOD

'Preliminary Segmentation' section given below is used to obtain single binary image after applying intensity and shape based thresholds. 'Detection of Femur Object' section is used for finding valid femur object from the preliminary segmented image. From the segmented femur object; FL is calculated.

A. Preliminary Segmentation

The femoral bones in the fetal ultrasound images are usually much brighter than their surrounding objects. This fact implies the possibility for the segmentation of objects of interest by applying intensity threshold. [2]

As the initial step, apply high pass filtering on the original image. This make an image appear sharper and emphasize fine details in the image. The next step is to apply intensity thresholds on the original image at multiple levels. By applying N intensity thresholds to the original image I, a set of N binary images can be created. On the next step, apply shape based thresholds - thinness, elongation and size - on these binary images. Here wide ranges of shape thresholds are used to avoid any chance of losing the femur object. Thresholds on minimum thinness, maximum thinness, minimum elongation, maximum elongation, minimum size and maximum size are applied to the binary images. The objects that passed on these thresholds from every binary image were collected into the single binary image. [2]

B. Detection of the Femur Object

The binary image obtained after preliminary segmentation contains a collection of the tentative femoral objects. Support Vector Machine classifier is used for classification of femur object from this binary image. [2] Femur object can be recognized by its sufficiently large size, long length, small thickness and high brightness. These shape features of 'femur' and 'non femur' objects are given for training the SVM classifier. If the SVM classified only one object as femur then consider it as the valid femur object. If the resulted image after SVM classification contains more than one object then extract the valid femur object using the calculation based on length, thickness and area of object regions. 'Femur length' to 'thicknesses and 'femur length' to 'area' relationships are used and it is based on the idea that valid femur object will have high approximation to the already estimated measurements of femur.

IV. RESULTS

The work is implemented in MATLAB. All the ultrasound images for this study were acquired from various hospitals and the images obtained are in BMP and JPEG format. Total 90 images are used for testing and in which 45 images are in BMP and 45 images are in JPEG format.

Table given below shows the accuracy of developed method for femur segmentation. FL is calculated in millimeters.

TABLE II. Accurate Segmentation Rates

Femur Segmentation Method	Accuracy (%)
BMP	86.67
JPEG	91.11

The fig.1 and fig.2 shows the step by step output of each process in the segmentation of femur on JPEG and BMP image respectively.

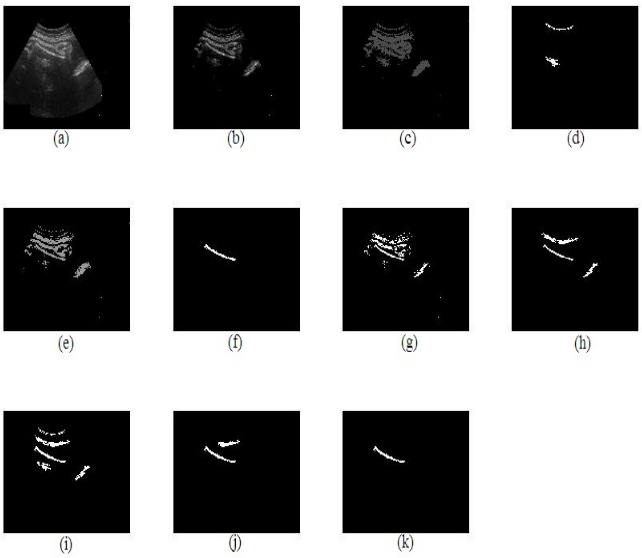

Fig. 2. Segmentation of Femur – JPEG Image. (a) Original Image. (b) Filtered Image. (c) After applying Intensity Threshold 1. (d) After applying Shape Threshold 1. (e) After applying Intensity Threshold 2. (f) After applying Shape Threshold 2. (g) After applying Intensity Threshold 3. (h) After applying Shape Threshold 3. (i) Composite Image. (j) SVM based Classification. (k) Segmented Femur.

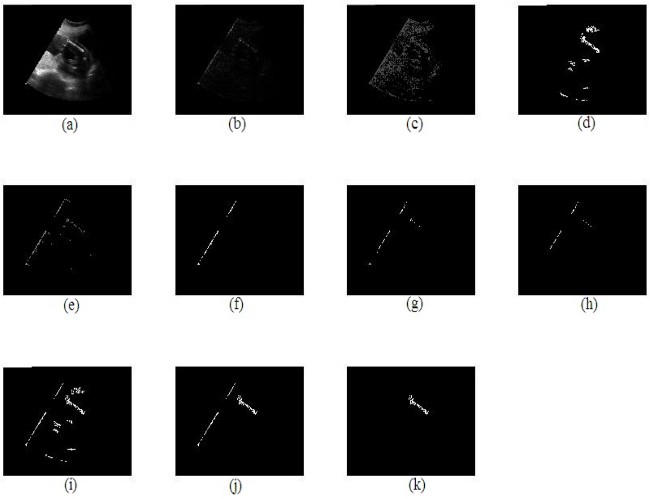

Fig 3. Segmentation of Femur - BMP Image. (a) Original Image. (b) Filtered Image. (c) After applying Intensity Threshold 1. (d) After applying Shape Threshold 1. (e) After applying Intensity Threshold 2. (f) After applying Shape Threshold 2. (g) After applying Intensity Threshold 3. (h) After applying Shape Threshold 3. (i) Composite Image. (j) SVM based Classification. (k) Segmented Femur.

V. CONCLUSION

Femur object in ultrasound fetal image is segmented and the Femur Length is estimated using the developed method. It uses thresholds on intensity, thinness, elongation and size for preliminary segmentation. Objects in the preliminary segmented image classified into 'femur' and 'non femur' object using SVM classifier. If the resulted image after SVM classification contains more than one object then extract the valid femur object using the shape based features of femur.

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