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# Development of Automated system for Measurement and Analysis of Gestational age for monitoring fetal Growth

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***Abstract*—** Gestation is defined as a interval of time between thought and start. Estimation of gestational age is necessary in order to foretell the early date of delivery and screen the development of fetus during the three trimester of pregnancy. Comparison of gestational age is centered on size of quite a lot of fetal biometric parameters like gestational sac, bi-parietal diameter, femur size, belly circumference, head circumference for the period of the gestation period. In medical photo processing, ultrasound technique performs a major position for imaging organs for an obstetrician and gynecologist. Monitoring of those parameters is finished with human interplay. These methods are liable for a couple of subjective decisions which increase the inter-observer error. The foremost function of this work is to measure fetal biometric parameter for correct estimation of gestational age. An automated computer headquartered algorithm has been used to apply morphological operation in order to admire the desired parameter contour in the ultrasound picture, refine its shape and catch up on targeted irregularities, then properly measure its size, achieving premiere accuracy and reproducibility of measurements. Automation algorithm makes use of morphological operation, Hough transform and tracing ways. It has been found that, the proposed scheme, is competent to estimate the gestational age of the fetus with a prediction accuracy of ±2 days.

***Keywords*-***Hough transform analysis, morphological operation, Gestational Sac, Bi-parietal diameter, Head Circumference, Femur length, Filtration*

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## I. Introduction

The obstetric care has been enhanced with the development within the area of computer technology in the recent prior. Correct estimation of gestational age is desirable for monitoring and accessing the fetal progress. It additionally confirms health of the pregnancy particularly in patient with the historical past of bleeding/pain, principally in high danger pregnancies [1]. These estimations have also been anticipated to furnish useful understanding to take decisions in three trimesters of pregnancy. Fetal growth assessment by ultrasound analysis depends on correct estimation of Yolk Sac (YS), Gestational SAC (GS), Crown Rump size (CRL), Femur length (FL), Head Circumference (HC), abdominal Circumference (AC) and Biparietal Diameter (BPD). In first trimester evaluation of Gestational sac, Yolk sac, Crown rump size performs an major position in predicting the gestational age [1]. In second and 0.33 trimester extraction of Femur size, stomach Circumference, Biparietal diameter, Head circumference of fetus is finished to predict the gestation interval effectively. In implemented scheme extracted parameters incorporate GS, FL, BPD which can be used for the development of automated medical decision help approach (ACDSS) in obstetrics and gynecology.

Comparison of gestational age is established on sufferer historic information and the bodily examination, maternal sensation of fetal action [5]. With the appearance of ultrasound, obstetrics examination has been made less complicated and accordingly noninvasive process has been used for extraction of fetal biometric parameter. For assessment of quite a lot of parameters, gynecologist first freeze the ultrasound picture of favored biometric parameter, consequently, opting for two elements on the boundaries of parameter by using utilising pleasure sticks or mild pens to measure its length. Accordingly output in phrases of length of parameter is displayed. This process involves more than one subjective decisions increasing the inter-observer error. Considering of tedious and time drinking nature of handbook measurement an automatic system is crucial which objectives to locate the contour segment of favored parameter thoroughly.

Ultrasound pictures are the outcomes of reflection, refraction and deflection of ultrasound beams from quite a lot of forms of tissue with distinct acoustic impendence. Therefore these photos are characterized by using a couple of forms of perturbations: elimination of real structural echoes, displacement and distortion of echoes [8]. In addition, echography includes powerful presence of speckle and additive noise. It additionally include presence of different highly echogenic adjacent to the pinnacle contour and non-uniform bone texture. In addition, the acoustic beam deflections on the bone surface explanations a transformation within the wave propagation direction, for this reason weak echoes are detected through transducer on the assumed attitude of reflection. These entire reasons make the analysis of ultrasound images more complex. Consequently computerized segmentation of those photographs is crucial.

METHOD AND MATERIAL

The system float chart implemented to extract desired parameter for comparison of gestational age is detailed in figure 1. In the implemented scheme, distinction of an image is superior to modify the depth values of pixels. The fetal images are processed by using an expanded Gaussian filter followed by means of wiener filter to put off additive and speckle noise present in ultrasound photograph and the desired parameter are segmented utilizing world threes protecting system. Results obtained have proven that this segmentation scheme is able of segmenting the aspects with no trouble and locate and retain the sides for additional processing as a consequence, as a result of high depth, snapshot having colossal number of gaps is shaped. Morphological reconstruction is used to lessen the false region. Preferred parameter boundary is detected with morphological operation in case of BPD and GS, whilst detection of femur size is finished headquartered on Hough transform. Extraction of desired fetal biometric parameter estimates the gestation age with top-rated accuracy.

*A. Preprocessing*

As ultrasound photograph is outcomes of reflection, refraction and deflection of ultrasound beam from tissue interface of human body, the contrast of ultrasound image is more often than not low. For this reason in preprocessing stage, contrast enhancement manner is used. Enhancement is the system of manipulating an photo in order that the outcomes is more suitable than the original for specific utility [9]. Distinction of an image is enhanced to give a boost to the interpretability and to switch attributes of an picture.

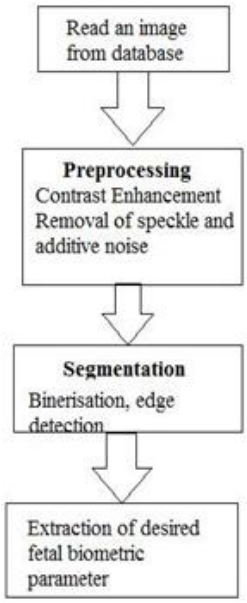



Figure 1: Process Flow Chart for Gestational Age Estimation

The distinction can also be limited as a way to hinder amplifying noise gift in the snapshot. The distinction enhanced picture is extra filtered to suppress the speckle noise. An elevated Gaussian filter reported through the authors of their prior work has been used [4]. This despeckling eliminates the speckle and preserves the details at the edges. Further wiener filter is applied to get rid of the additive noise from the image. Mixture of Gaussian filter followed by using Wiener filter gives extra uniform results in further steps. The despeckled photos are segmented making use of international thresholding approach, awarded in [3].

*B. Segmentation*

The worldwide thresholding system mentioned in the literature, segments the facets that lie just about each and every other established on intensity histogram of an picture. This procedure is applicable over the entire range when depth and history pixels are sufficiently particular. The target of thresholding is to minimize the natural error incurred in assigning pixels to 2 or extra classes. The threshold giving the great separation in the lessons in phrases of their intensity values viewed as a most reliable threshold. The method is finest within the sense that it maximizes between class-variance, a good identified measure utilized in statistical discriminant evaluation.

Binary photograph bought after thresholding suggests favored fetal biometric parameter and also significant number of false regions. Morphological operation is aimed toward finding the contour phase of parameter area whilst discarding the opposite foreground buildings. It is described as a instrument for extracting picture add-ons that are priceless in the illustration and outline of neighborhood shape such as boundaries, skeleton and the convex hull [3]. The boundary of set A, denoted by B(A) can also be obtained by means of first eroding A with the aid of B and then performing the set difference between A and its erosion, the place, B is structuring element, set A is long-established photograph.

*C. Extraction of Gestational Sac and Biparietal Diameter*

Number of false edges is placed in segmented image. Removal of false edges is based on expertise founded filtering [7][11]. Gestational sac and biparietal diameter are round in form. Probably ultrasound image is freezed when above mentioned parameter is at valuable phase. For that reason false edges that lies close the boundary of an photograph and which aren't round are must be removed [6].

Circularity of an object is located through utilizing eccentricity of an object. Eccentricity of round or elliptical

object lies within the range of 0 to 1. Gestational sac and biparietal diameter are virtually round in shape, nevertheless, eccentricity price of these object is practically 1. Accordingly algorithm is developed to generate the eccentricity price of each and every object present in snapshot. Object whose eccentric worth found out beneath zero.7 are eradicated. In this method GS and BPD boundaries estimated competently.

### *D. Extraction of fetal femur length using Hough Transform*

Segmented image of femur length consist of large number of false edges. Hence knowledge based filtering is done to locate the boundaries or edges of desired parameter. Prior knowledge based filtering proves invalid in case of femur length. Hence in this case Hough transform is used. In Hough transform all pixels are candidate for linking and thus have to be accepted or eliminated based on predefined global properties. An approach has been developed based on whether set of pixels lie on curves of predefined shape. Once detected these curves form the edges or region boundaries of interest.The linear Hough transform algorithm uses a two-dimensional array, called as an accumulator, to detect the existence of a line described by.

The dimension of the accumulator equals the number of unknown parameters, i.E., two, considering that quantized values of r and θ in the pair (r, θ). For each pixel at (x, y) and its nearby, the Hough become algorithm determines if there's sufficient evidence of a straight line at that pixel. If that is so, it will calculate the parameters (r, θ) of that line, after which look for the accumulator's bin that the parameters fall into, and increment the value of that bin.[10] by discovering the containers with the highest values, most of the time by using looking for nearby maxima within the accumulator area, the without doubt traces may also be extracted. The easiest approach of discovering these peaks is by using applying some type of threshold, but different techniques may yield better results in unique instances; picking out which traces are located as well as how many. Considering the strains lower back do not include any length expertise, it's on the whole imperative, in the next move, to find which parts of the photo suit up with which lines. Additionally, due to imperfection blunders within the part detection step, there will more commonly be blunders in the accumulator house, which may make it non-trivial to search out the appropriate peaks, and for that reason the proper lines.

The effect of the linear Hough change into is a two-dimensional array (matrix) just like the accumulator one dimension of this matrix is the quantized attitude θ and the other dimension is the quantized distance r. Each and every detail of the matrix has a value equal to the quantity of facets or pixels which are put on the road represented via quantized parameters (r, θ). So the detail with the best price shows the straight line that is most represented within the enter photograph.

Extraction of femur length is situated on the suggestion of strongest line in the emerged snapshot. Hough develop into matrix suggests the 2 or extra Hough-peaks considering the fact that of noise reward in scientific ultrasound photo. These hough-peaks represent the end facets of certainly straight traces which regarded in output image. Norm of each line is calculated with a view to detect the perimeters of femur length. Line whose norm is calculated as a optimistic integer worth is considered to be the strongest line.

## III. EXPERIMENTAL RESULT

### *A. Data Acquisition*

The test snap shots are obtained from scanning procedure, particularly THI Siemens computing device with curvilinear probe with transducer frequency of 3-5 MHz. The fetal snap shots are got from 5 weeks of gestation. Quintessential care has been given to hold the form, dimension and grey degree distribution as it impact the sonography content of information. Handbook examination of fetal parameters involves using joystick or pen for its measurement. Care should be taken to position the joysticks as any variant within the preliminary placement of joystick will purpose the error in choice making and could result in false prediction. It is in general elaborate to position the joysticks at the right role due to the inferior nature of clinical ultrasound.

In the automatic gestational age estimation procedure implemented on this paper, the medical ultrasound portraits to be analyzed are preprocessed to develop the brightness of an photo making use of an adaptive histogram equalization manner. Additional the speckling artifacts are removed making use of an multiplied Gaussian filter; extra wiener filter is applied to suppress the additive noise reward in an image. These comprise the evaluation of gestational sac within the first trimester and Femur size, head circumference, biparietal diameter in the later trimesters. Determine 3 shows normal image of favored fetal biometric parameters to be extracted. Determine four indicates distinction more desirable photograph through software of adaptive histogram equalization algorithm. Determine 5 suggests output photos of GS, BPD, and FL after utility of wiener filter.

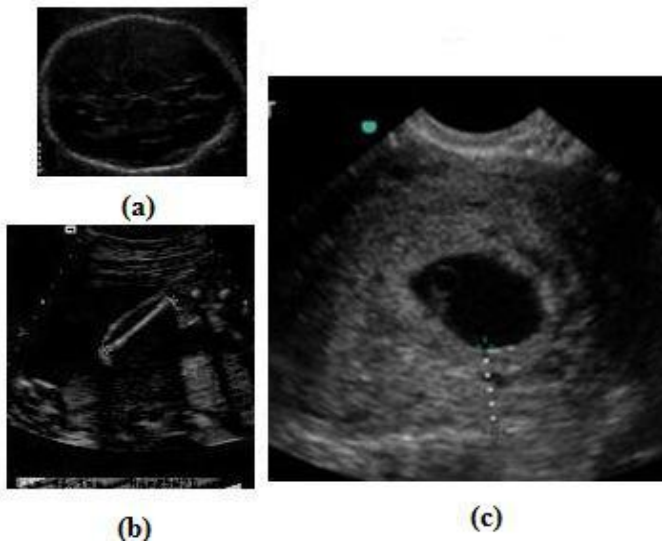
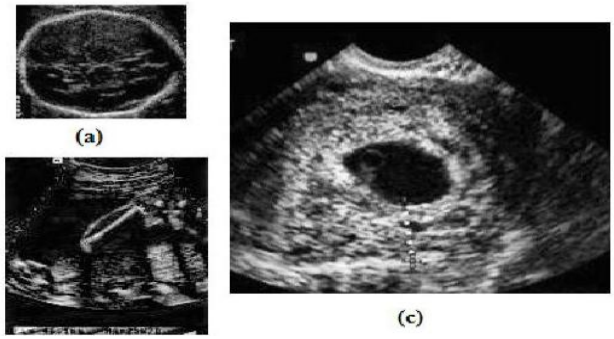



Figure 2: (a) Original Image of Biparietal diameter (b) Original Image of Femur length (c) Original Image of Gestational sac




(B)

Figure 3: (a) Contrast enhancement of BPD (b) Contrast enhancement of FL(c) Contrast enhancement of GS

Desired features are segmented using global thresholding technique. Morphological approach is used for boundary detection and false edge removal of GS, BPD. Figure 5 and figure 6 shows binarised image, edge detection and extraction of GS and BPD respectively.

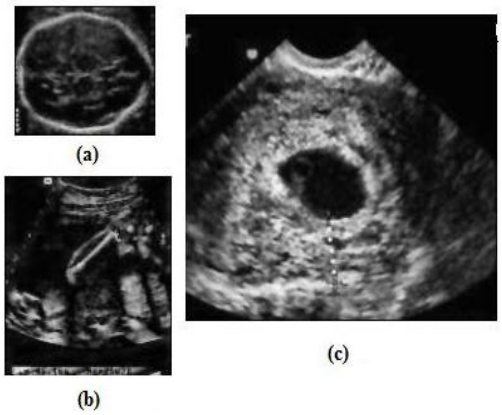



Figure 4: (a) Wiener filtered image of BPD (b) Wiener filtered image of FL(c) Wiener filtered image of GS

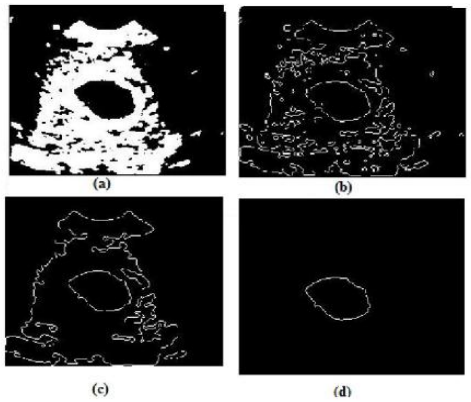



Figure 5: (a) Binarised image obtained after thresholding (b) Edge detection using morphological operation (c) Image obtained after false edge removal (d) Extraction of gestational sac

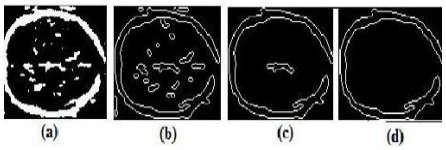



Figure 6: (a) Binarised image obtained after thresholding (b) Edge detection using morphological operation (c) Image obtained after false edge removal (d) Extraction of biparietal diameter

Hough transform is used to notice the femur length with most beneficial accuracy and extraction of femur size is centered on proposal of strongest straight line whose finish co-ordinate pixel price is maximum. Straight line whose norm is observed to be constructive integer price is viewed to be the strongest line and represented within the red colour. Figure 7 shows facet detection of femur length by way of morphological strategy, Hough become matrix to become aware of the straight line gift in the image.

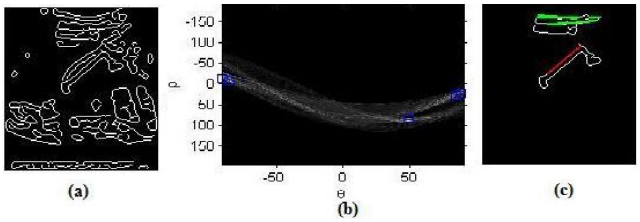



Figure 7:(a) Edge detection using morphological operation (b) Hough transform matrix of Femur Length (c) Extraction of Femur Length

Favored fetal biometric parameters i.E. GS, BPD, FL dimension measured on ultrasound desktop with the aid of radiologist is considered and when put next with outcome acquired from automated approach.

In case of GS, biggest diameter is discovered because sac is just not certain circle. This greatest diameter is found out through finding the highest distance between two elements on

the boundary. This boundary is expressed as array of (x, y) coordinates of features on boundary. For this, one point on boundary and its distance with all different facets is viewed. Maximum distance between any two points is lower back.

Out of 7 pictures, in 6 pix gestational sac is appropriately detected. Desk 1 shows assessment of automated and guide procedure of gestational sac at quite a lot of level of trimester and gestational age is expected. Error size of size will also be found out through following equation

$$error\% = 100 \mid S_{man} - S_{auto} / S_{man} \mid \quad (2)$$

Where, Sman - size obtained by manual method
Sauto - size obtained by automated method

Figure 7:(a) Edge detection using morphological operation (b) Hough transform matrix of Femur Length (c) Extraction of Femur Length

Preferred fetal biometric parameters i.E. GS, BPD, FL measurement measured on ultrasound computer through radiologist is viewed and compared with results acquired from automated approach.

In case of GS, greatest diameter is discovered given that sac is not unique circle. This largest diameter is found out by using discovering the highest distance between two features on the boundary. This boundary is expressed as array of (x, y) coordinates of elements on boundary. For this, one factor on boundary and its distance with all other features is considered. Highest distance between any two points is lower back.

Out of 7 pix, in 6 snap shots gestational sac is competently detected. Desk 1 suggests assessment of automated and manual process of gestational sac at more than a few level of trimester and gestational age is anticipated. Error measurement of dimension can also be learned by way of following equation

$$error\% = 100 \mid S_{man} - S_{auto} / S_{man} \mid \quad (2)$$

Where, Sman - size obtained by manual method
Sauto - size obtained by automated method

TABLE 1: COMPARISON OF AUTOMATED AND MANUALGESTATIONAL SAC PARAMETER INFIRST TRIMESTER

| No | Images | Automated Measurement in cm | Manual measurement in cm | Error in percentage | Gestational Age in weeks |
|---|---|---|---|---|---|
| 1 | GS1.jpg | 1.53 | 1.51 | 1.32 | 6 wk 1day |
| 2 | GS2.jpg | 1.47 | 1.48 | 0.675 | 6 wk |
| 3 | GS3.jpg | 1.59 | 1.61 | 1.24 | 6 wk 2 day |
| 4 | GS4.jpg | 2.50 | 2.52 | 0.79 | 7 wk 5 day |
| 5 | GS5.jpg | 1.57 | 1.53 | 2.6 | 6 wk 3 day |
| 6 | GS6.jpg | 3.12 | 3.13 | 0.319 | 8 wk 2 day |
| 7 | GS7.jpg | 4.1 | 4.3 | 4.65 | 9 wk 5 day |

Fetal progress estimation within the later trimesters requires the estimation of bi-parietal diameter, femur length. In computerized process, the BPD is measured on a transverse axial component of the fetal head. The BPD is measured from the outer fringe of the nearer parietal bone to the inside fringe of the more distant parietal bone. In evaluation of femur length, Euclidian distance between the top (x, y) coordinate is measured. Then this distance is changed to cm. Out of seven graphics, in 6 pictures biparietal diameter is appropriately detected. Set of 5 pictures is received for femur length measurement. Evaluation of estimated and handbook measurements of BPD and FL is certain in desk 2 and 3. Error measurement may also be calculated utilizing eq 2.

TABLE 2: COMPARISON OF AUTOMATED AND BIPARIETAL PARAMETER AT VARIOUS LEVEL OF GESTATION

| No | Images | Automated Measurement In cm | Manual Measurement In cm | Error In Percentage | Gestational age in weeks |
|---|---|---|---|---|---|
| 1 | A1.jpg | 4 | 4.72 | 1.2 | 19 weeks 5 days |
| 2 | A2.jpg | 1.82 | 1.85 | 1.62 | 11 week 6 days |
| 3 | A3.jpg | 2.89 | 3.0 | 3.66 | 14 weeks 3days |
| 4 | A4.jpg | 2.51 | 2.6 | 0.4 | 13 weeks 5days |
| 5 | A5.jpg | 3.65 | 3.68 | 0.81 | 16 weeks 3 days |
| 6 | A6.jpg | 4.9 | 4.88 | 0.409 | 20 weeks |
| 7 | A7.jpg | 5.3 | 5.25 | 0.95 | 21 weeks 5 days |

TABLE 3: COMPARISON OF AUTOMATED AND MANUAL FEMUR LENGTH PARAMETER AT VARIOUS LEVEL OF GESTATION

| No | Images | Automated Measurement In cm | Manual Measurement In cm | Error In Percentage | Gestational age in weeks |
|---|---|---|---|---|---|
| 1 | fl.jpg | 1.01 | 1.13 | 1.2 | 13weeks 1 days |
| 2 | fl2.jpg | 1.71 | 2.11 | 1.62 | 17 weeks |
| 3 | fl4.jpg | 1.21 | 1.41 | 3.66 | 13 weeks 3 days |
| 4 | fl5.jpg | 2.11 | 2.41 | 0.4 | 16 weeks 2 days |
| 5 | fl6.jpg | 1.13 | 1.12 | 0.81 | 13 weeks 6 days |

The BPD measures 1,82 cm on the end of 11th week. It grows approximately via 2 mm per day and reaches 5.Three cm on the finish of 21 weeks whereas the femur bone which has been measured at 1.0cm on the start of thirteenth week reaches 1.Seventy one cm on the end of 17th weeks. The experimental outcome received had been compared with the extremely sound examination record of a field with clear menstrual history index, bought from Dr Mahajan polyclinic. Parameters estimated utilizing the automatic segmentation algorithm provide an total accuracy of 87%

## IV. CONCLUSION

This paper has offered an extended preprocessing and segmentation scheme for fetal biometric aspects segmentation from ultrasound pics. The morphological operation headquartered segmentation scheme has produced stable and reproducible results of GS and BPD with improved edges. Hough transform discover the femur length with highest accuracy. The accuracy of the gestational age prediction largely depends upon the estimated values and it has been shown that the gestational age can also be expected with an accuracy of ±2 days which is way much less compared to different ways. Therefore this proposed work is anticipated to help wellbeing care gurus in making choices without difficulty and provide more advantageous wellbeing care.

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