

# Thickness based Characterization of Ultrasound Placenta Images using Regression Analysis

G. Malathi

Affiliated to Anna University  
Velammal Engineering College  
Chennai 66, India

Dr. V. Shanthi

Affiliated to Anna University  
St. Joseph Engineering College  
Chennai 96, India

## ABSTRACT

In the medical domain, one of the major challenges faced by the medical experts is the extraction of critical information for medical diagnosis. Specialized tools are necessary to assist the experts in diagnosing the diseases. Information retrieval is difficult in the case of ultrasound medical images due to its low resolution making diagnosis difficult. Gestational diabetes is a form of diabetes, which affects pregnant women. It is believed that the hormones produced during pregnancy reduce a woman's receptivity to insulin, leading to high blood sugar levels. The duration of departures from normoglycemia in maternal diabetes is the critical factor. The earlier detection of GDM occurs, the lesser the influence on placental development, which indirectly accounts for fetal growth and metabolism. This pilot study involves the feasibility for classifying the ultrasound images of placenta with complicating diabetes based on placenta thickness using statistical textural features

## Keywords:

Placenta, Image Pre processing, Regression Analysis, Textural Features, Classification, neural networks, Gestational Diabetes Mellitus, thickness equation

## 1. INTRODUCTION

Diabetes is still poorly controlled in India owing to delays in early detection and proper treatment, says a study conducted by the International Diabetes Management Practices Study (IDMPS). IDMPS is a five-year survey involving 1755 Indian participants. With an estimated figure of 40.9 million diabetics, India is the diabetes capital of the world, followed by China and the United States. The World Health Organization (WHO) estimates the number of diabetics to exceed 350 million by 2030. Governments and other healthcare providers around the world are investing in health education, diagnosis and treatments for this chronic, debilitating but controllable disease [1]. Maternal diabetes mellitus complicates pregnancy with combinations of growth-promoting and growth-restricting forces which may alter the normal growth trajectories of both the fetus and placenta. The human placenta is a focal, disk-like thickening of the membranous sac that is achieved by splitting the membranes into two separate sheets, the chorionic plate and the basal plate. Maternal diabetes is a condition that can be associated with large placentas. Large placentas, however, should raise the suspicion for a maternal diabetic state[2]. The study in [3], demonstrates that there

is change in shape in one placenta from diabetic group. Weight central thickness and diameter were significantly greater in diabetic group as compared to normal and hypertensive group. Placenta is an essential organ for exchange of nutrients and metabolites between mother and fetus [4]. Placentas less than 2.5cm thick are associated with intrauterine growth retardation of the fetus.[5] Placentas more than 4cm thick have an association with maternal diabetes mellitus, fetal hydrops and intrauterine fetal infections [6].

The task of classifying ultrasonic images of the placenta according with the gradation proposed by Grannum is attempted in [7]. The ability of a decision tree classifier to discriminate different textures with three sets of textural features was tested. The performance of the classifier using textural features corresponding to co-occurrence matrices, Law's operators and neighborhood gray-tone difference matrices (NGDTM) was firstly assessed. In [8], the feasibility for detecting anomalies in placental growth due to the implications of gestational diabetics by considering the stereo image mapping based on wavelet analysis for 2D reconstruction was studied. With the image matching strategy the corresponding points between left image and right image in stereo image pair can be obtained and matched. The shape of the placenta was reconstructed using the Back Propagation Neural Network. The research used wavelet-based methods to extract features from the ultrasonic images of placenta. The Euclidean Distance Classifier was used to classify the ultrasonic images of placenta as normal placenta and abnormal placenta with the implications of gestational diabetes mellitus.

In [9], the classification of scans of the placenta according with Grannum grading is attempted and used feature selection for determining the relevant textural features that were extracted from the scans. Three different sets of textural features, namely co-occurrence matrices, Laws masks and neighborhood gray-tone difference matrices (NGTDM) were used. The strategy used for classification was the k-Nearest Neighbor algorithm using leave-one-out crossvalidation. In [10], the region-growing algorithm was to extract features from the ultrasonic images of placenta and employed K nearest neighbor technique for classification of ultrasonic images of placenta using region growing segmentation method. The cases were classified into four groups namely

- **Group1:** These groups consisted of 121 normal placentas not affected by any disease.
- **Group2:** This group consisted of 10 placentas affected by hypertension.
- **Group3:** This group consisted of 10 placentas affected by placenta previa.
- **Group4:** These groups consisted of 10 placentas affected by gestational diabetes mellitus.

The geometrical features which include shape, perimeter, area of the placentas were included in this study.

Tools for the statistical analysis of placenta shapes using a random sample of placenta images was presented in [11], by noting the key features of the shape like the position of the Umbilical Cord Insertion Point relative to the outer and inner perimeters, the thickness of the inter perimeter region, shape of the perimeter boundaries like convexity, roundness to predict features of the new born with presence of some disease or abnormality. The relation between Foetal Placental Ratio and placenta shape by building a regression model explaining FPR as a function of shape and estimating the posterior distribution of FPR given shape using Kernel based methods.

In [16], the authors have made an attempt to classify the placenta based on the intensity level of histogram of the ultrasound images of placenta. The image histogram is used to classify the ultrasound images of placenta into normal and abnormal placenta using k nearest neighbor classifier. It is further used to analyze the complications of gestational diabetes mellitus on the growth of placenta. The statistical moments obtained above were broadly classified into two groups as normal placenta and abnormal placenta. The abnormal placenta images were further classified into specific conditions of placenta during the gestational period. The training set includes the data for classification for each specific category of ultrasound placenta images. For every new input, the textural features for mean, contrast, correlation and entropy are obtained. The new input is placed in the class that contains the most items which is close to the specific class of image. Technique identifies the implications of diabetes mellitus on the growth of the placenta.

## 2. IMAGE PRE-PROCESSING

The ultrasound images of placenta obtained is subjected to histogram equalization to enhance the contrast of the input image. The ultrasound placenta images is then reduced to 64X64 pixels and stored. The reduced image is used in measuring the placenta thickness, area and perimeter using the crown – rump length and biparietal diameter.

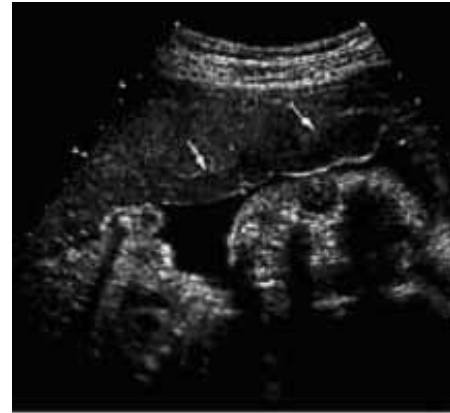


Fig. I: Grayscale sonogram revealing a subchorionic hematoma

## 3. MEASURING PLACENTA THICKNESS

Ultrasonographic placental diameter and thickness measurements appears to be of prognostic value in identifying the subsequent occurrence of fetal growth retardation. The study aimed at assessing placental diameter, placental thickness measured by ultrasound scan and estimated placental volume [12] and classify the ultrasound placenta images as normal and abnormal placenta complicated with gestational diabetes mellitus. The study included the following criteria 1.Known last menstrual period (LMP) 2.Viable singleton cyesis 3.Nil history of diabetes mellitus or other metabolic diseases 4.Nil history of previous adverse fetal outcome 5.Nil history of intrauterine growth retardation 6.Nil co-existing uterine or adenexal mass 7.Nil placental mass or anomaly 8.Nil fetal mass or anomaly 9.Placenta can be distinguished from the myometrium 10.Nil history of immune or non-immune hydrops 11.Nil hydroamnios 12. Nil pregnancy induced hypertension (PIH) The foetus was observed for gross anatomical defects and the gestational age estimated using crown – rump length (CRL) and biparietal diameter (BPD) in the first trimester, (BPD) and femur length (FL) in the second trimester and BPD, FL and abdominal circumference (AC) in the third trimester. The placenta was localized in longitudinal section and its anteroposterior thickness measured at the level of insertion of the umbilical cord. Correlation and regression analysis was used to establish the relationship between placental thickness and gestational age. Regression analysis yielded the following linear equations of relationship between gestational age (y) in weeks and placental thickness (PT) in mm: [13].

$$\begin{aligned} &\text{In the first trimester} \\ &y = 0.374 (PT) + 5.568 \quad (r = 0.729) \quad (\text{Eq 1}) \end{aligned}$$

$$\begin{aligned} &\text{In the second trimester} \\ &y = 0.4323 (PT) + 9.2742 \quad (r = 0.671) \quad (\text{Eq 2}) \end{aligned}$$

In the third trimester  
 $y = 0.3106 (PT) + 21.832 (r = 0.557)$  (Eq 3)

In the combined trimester  
 $y = 0.7347 (PT) + 3.8881 (r = 0.872)$  (Eq 4)

**Table I.: Regression coefficient in the logistic model for predicting low birthweight from placental parameters at 36 weeks of gestation.**

Regression Coefficient						
Variables	$\beta$	S-E ( $\beta$ )	Wald stat	O.R.	95% CI	Ref
Constant	-8.8845	3.44	6.66			[12]
Placental diameter	0.3994	0.1976	4.08	1.49	1.01-2-20	[12]
Placental thickness	1.2482	0.4641	7.23	3.48	1.40-8.65	[12]

Overall prediction rate=88.6%.

**Table II: Distribution of placental thickness according to gestational age**

Gestational Age (wks)	Number of cases	Placental thickness mm	Reference
7	7	9.6 + 1.9	[13]
8	3	9.0 + 1.0	[13]
9	17	10.9 + 1.7	[13]
10	9	10.0 + 1.2	[13]
11	6	11.0 + 0.9	[13]
12	13	15.3 + 3.1	[13]
13	9	18.0 + 3.0	[13]

Mean placental thickness = 12.5 + 3.7

**Table III: Pearson's correlation values between placental thickness and gestational age**

	Trimesters				Ref
	First	Second	Third	Combi- ned	
Pearsons Correlation Coefficient (r)	r = 0.729	r = 0.671	r = 0.557	r = 0.872	[13]
P - values	p < 0.01	p < 0.01	p < 0.01	p < 0.01	[13]
Number of measurement (n)	n = 64	n = 237	n = 429	n = 730	[13]

Placental thickness of less than 2.5 cm is associated with intrauterine growth retardation (Kunlmann and Warsof, 1996) while thick placentas are associated with maternal diabetes mellitus, foetal hydrops and intrauterine foetal infections.[14]

**Table IV. Correlation between placental thickness and the growth parameters; biparietal diameter (BPD) and abdominal circumference (AC).**

Pregnancy	BPD	AC	Reference
Second trimester	r = 0.626	r = 0.626	[14]
(n = 244)	p = 0.000	p = 0.000	[14]
Third trimester	r = 0.522	r = 0.523	[14]

The placental thickness data were analyzed for mean, standard deviation, 95% confidence interval, and 2.5<sup>th</sup>, 5<sup>th</sup>, 50<sup>th</sup>, 95<sup>th</sup>, and 97.5<sup>th</sup> percentile for each week of gestational age. The best-fit mathematical model was derived by regression analysis. Regression analysis yielded the following linear equation of the relationship: [15]

$$PT = GA \times 1.4-5.6 (r = 0.82). \quad - \quad (\text{Eq } 5)$$

Where,

PT=placenta Thickness (in mm)  
GA=Gestational Age( in weeks)

#### 4. TEXTURAL FEATURES

Texture based features: area, perimeter and thickness of the placenta. The crown rump length (CRL) and biparietal diameter (BPD) are obtained from the ultrasound image of the placenta. The shape features were found to correlate with a subjective assesment of the texture. Regarding the size (weight, diameter, central thickness) a highly significant increase in weight (22%), diameter (33%) and ventral thickness (85%) [3] was found in placenta of diabetic mothers when compared with normal placenta.

- A. **Shape of Placenta:** The placenta were roughly oval or rounded in shape in all groups except the placenta complicated by gestational diabetes mellitus
- B. **Diameter of placenta:** Mean diameter of placenta significantly increase in ultrasound placenta image complicated by diabetes
- C. **Central Thickness:**Mean central thickness was found to increase significantly in placenta complicated by gestational diabetes mellitus.

#### 5. CLASSIFICATION

The ultrasound placenta images are then classified into normal placenta and placenta complicated by gestational diabetes. Initially the ultrasound placenta images are marked as normal or placenta complicated by GDM by the experts in the medical field. This is used to confirm the classification accuracy. The above tabulated values shows that there is a significant increase in thickness, area and biparietal diameter in the case of placenta complicated by diabetes and also in case of intra uterine growth retardation which can be suspected as a cause of GDM.

#### 6. CONCLUSION

The earlier screening for Diabetes Mellitus in pregnancy influence on placental development, which indirectly accounts for fetal growth and metabolism. This study attempted to find the feasibility for classifying the ultrasound images of placenta with complicating diabetes by measuring the placenta thickness , area and biparietal diameter from the ultrasound placenta images. It is found that the thickness of placenta plays a major role in the classifying the ultrasound placenta images.

#### 7. FUTURE ENHANCEMENTS

The future work focusses on the classification of placenta based on the principal component analysis.

#### 8. ACKNOWLEDGEMENTS

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#### **FIRST AUTHOR**

Mrs. G. Malathi, MCA., M.Phil., is working as a senior lecturer in the Department of Computer Applications in Velammal Engineering College. She is currently doing her PhD as part time in Mother Teresa Women’s University, Kodaikanal. She has presented in 2 International and 4 National Conferences. Two Research paper has been published in an reputed International Journal.

#### **SECOND AUTHOR**

Dr. V. Shanthi, M.Sc., M.Phil., PhD is working as a Professor in the Department of Computer Applications in St. Joseph’s Engineering College, Chennai affiliated to Anna University. She has published one book and published 7 research papers in National Journals and 8 in International Journals and 14 conferences .