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Detection and Classification of Fetal Abnormalities by Anfis in First Trimester

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Abstract: ***Detection studies of fetal abnormalities are essential particularly in the first trimester. These are important for physicious and patients as abnormality can be corrected in the early stage of growth of fetus. Ultrasound techniques give us good opportunity to known about abnormal his such as Anencephaly, Renal anomalies, Cystic Lymphangioma, Cystic Hygroma, Gastroschisis and Fetal megacystis. Firstly the fetal data has to be processed by proper methods such as those used in digital image processing to generate classification of abnormalities.Secondly comparisons with equivalent methods are to be made. After preprocessing using median filter to remove noise, segmentation is done to give qualitative and quantization analysis. This is followed by feature extraction and feature selection using Particle Swarm optimization .Ultimately classification is done by Adaptive Neural Fuzzy Inference System .Comparison of this method with others is carried out to vindicate the efficacy of the proposed technique. The results show that the classification done by the proposed method scores over that of Naive-byes Supports Vector Machine, Linear Discernment Analysis and K-nearest neighbor methods. The proposed method has advantages in detection and classification of the seven abnormalities taken up.***

Key words: Fetal, Abnormalities, PSO,ANFIS

I. INTRODUCTION

Bio medical instrumentation offers a number of imaging techniques such as X-rays, MRI, NMR, CT-Scan and ultrasound. Of these, the US (Ultra sound) techniques are found to be more suitable for fetal studies because of non-invasive nature, safety of radiation, cheaper cost. In this imaging, α beam of waves operating above the sound-range are sent through transducer into the human body and the received echoes are used to create image formation which has to take care of problems of attenuation, missing boundaries, presence of artifacts or speckles [1]. Fetal abnormalities are detected by study of fetal biometric parameters and thickness of nuchal translucency. For detecting abnormalities biometric parameters include bi parietal diameter (BPD) , gestational sac(G.Sac) head circumference (HC), abdominal circumference (AC), femur length (FL).These parameters measure the gestational age of the features and detect growth patterns and abnormalities [1].Fetal abnormalities increases rate of mortality, still birth and morbidity during early life. Diagnosis of abnormalities during fetal growth gives wide option for doctors and patients. An efficient method has been proposed in this paper figure 1 to have improved segmentation and classification to detect the abnormalities.

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The state of abnormalities is classified by ANFIS after feature selection using PSO preceded by segmentation by Adaptive K means clustering. Median filter is used for preprocessing the fetal image set.

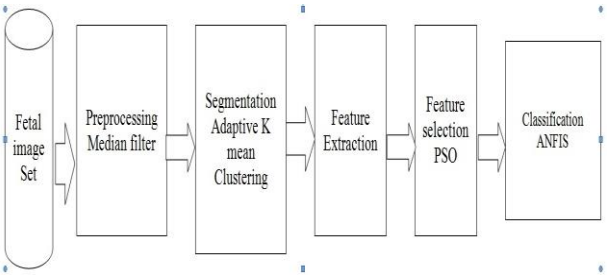

Fig.1 Classification using ANFIS

II. OBJECTIVES

The chief objective of this research is to identify fetal abnormalities in the first trimester of pregnancy by using Ultrasound technique and processing the fetal data by median filter, Adaptive K mean clustering, feature extraction, PSO followed by ANFIS classification.To compare the results with equivalent techniques for confirming that the selected method is effective.

II. III.PROPOSED METHODOLOGY

1. Extensive study of literature is carried out based on fetal abnormalities and the corresponding detection methods including Ultrasound CT scan, MRI and X-rays.
2. The fetal data set was obtained by US methods.
3. Preprocessing of the available data was done by Median filter [2].
4. Segmentation was carried out by Adaptive K means clustering [3].
5. After feature extraction [4], the selection of features was done by Particle Swarm optimization [5].
6. Classification was achieved by ANFIS [6].
7. Various parameters such as accuracy, specificity, sensitivity were used to compare the ANFIS classification with other methods such as Naïve-Bayes, Support Vector Machine, Linear Discriminate Analysis, K-Nearest neighbor in table 5.

III. IV. DESCRIPTION

The first task of the endeavor is to identify salient fetal abnormalities. Anencephaly is a serious birth defect in which a baby is born without parts of brain and skull. Renal anomaliesare related to fetal kidney tract defect.

Cystic_Lymphangiomais scarcely seen tumor of the lymphatic nature in which small than channels similar to blood vessels do not carry blood; instead these collect and carry tissue fluid.Cystic Hygromaare abnormal growths which appear on neck of fetus Gastroschisis is a congenital defect which occurs when an opening forms in the baby's abdominal wall.Fetal megacystisis related to presence of large bladder (>7 mm). Omphaloceleindicates a hole in the fetal abdomen.

5.1 *Ultrasonic imaginguses Doppler Effect* (above 20 KHz). The amount of frequency shift can be expressed as [7]

$$\Delta f = \frac{2V}{\lambda}$$

Where f = shift in frequency of the reflected wave

V = velocity of the interface

λ = wave length of the transmitted ultrasound

Modes of transmission are a) Pulse ultrasound (1 to 12 KHz) b) continuous Doppler c) Pulsed Doppler (Three cycles of 3MHz are transmitted per pulse at rate of 4 to 12 KHz)

a) Range gated Doppler:

The types of scan are: - a)A scan b)M scan c)B scan

In A scan, each transmitted pulse triggers the sweep of oscilloscope (EEG). In M scan the received pulses are used to trace rather than control the vertical reflection. In B scan 2-D image is obtained for a stationary organ on body structure. Evidently, A scan is the choice of EEG, M-Scan is preferred by ECG and B-Scan is suitable for fetal studies.

To study the set of fetal images, it is essential to have preprocessing by Median filter. In segmentation, which follows preprocessing, qualitative and quantitative analysis? The weak edges and false edges present in ultrasound images create substantial confusion. Feature extraction table 2 follows the step of segmentation by adaptive K-mean clustering which is preferred because of the intrinsic nature of fetal data. Feature selection is done by PSO followed by classification by ANFIS.

Table 1 Feature Extractions

Statistical method	i. Mean ii. Std. Deviation iii. Variance
Texture	i. Contrast ii. Energy iii. Homogeneity
Shape	i. Centroid ii. Equivalent diameter iii. Area iv. Eccentricity

In segmentation by adaptive K-mean, clustering is done by K points in the neighborhood space. Iterations are done so that values of centroid of clusters are updated one by one until the best clustering results are obtained. Due to need of determining the K clusters, certain complexity may arise in computation. This problem is sorted by trial and error method. Feature extraction offer reduction of types of dimensionality so that necessary parts of image are obtained as an input feature vector.

Feature selection is based on Particle Swarm Optimization in which objective function involves identification of image object which are space-wise contiguous pixels of similar texture, color and tone. Consideration of shape, size of texture as well as spectral context can be done by this method [8]. PSO takes population of specific solution termed as particles which emulate Swarming of particles by the assumption that there is movement in search space according to governing equation covering position and velocity.

The movement of particles is influenced by the local best known position as well as guided towards the best known position in the search space which can be altered on updated. The aim is to move the swarm to optimum p solution. Introduced by Eberhart and Kennedy [9] this method is a nature inspired heuristic method simulating animal population, collection of fish, birds, bees on insects in search for food. Each of the individual, in the swarm is represented by the position with vector X_{in} and a suitable velocity of movement represented by velocity vector (v_{in}). Iterative computations are used in updating the velocity vector. The governing equations are:

$$V(t+1) = V(t) + c_1.\text{rand}().(P_{best} - P_t) + c_2.\text{rand}().(G_{best} - P_t) \quad (1)$$

$$X(t+1) = X(t) + V(t+1) \quad (2)$$

The main advantages of PSO are less memory, computing time and high speed of process. Concept of minimal distance is used to determine the decisions as shown in the algorithm.

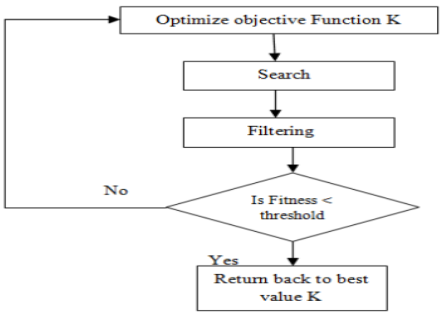

Fig. 2 Particle Swarm Optimization Process [10]

Algorithm

Basic Algorithm for PSO
For each Input object (fetal image) Particle
Initiate Input object Particle with feasible random number
End
Do
For each Input object Particle
Determine the fitness value
If fitness value is better than best fitness (Particle$_{Best}$)
Set current value as new Particle$_{Best}$
Otherwise update the particle value
End

[10].

In PSO, the evaluation of fitness function is carried out after each step. To get updating of best values of fitness iteration are carried out. Evaluation of fitness of individual particles constituent so that velocity can be modified by p best and g best

Final classification is achieved by ANFIS [11] which combines in figure 3 the learning ability of neural networks and uncertainly dealing ability of fuzzy based inference system.

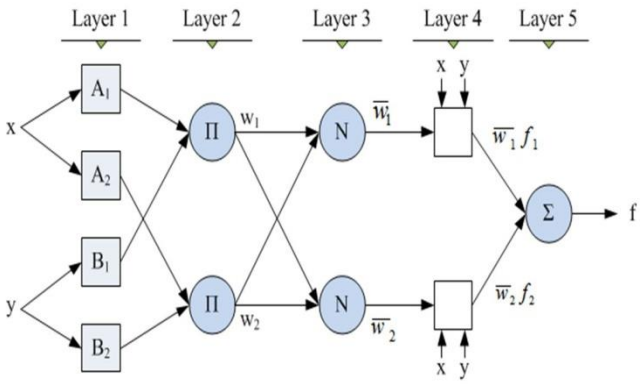

Fig. 3. Structure of ANFIS [12]

After classification, comparison is done using the sensitivity – specificity equations. Fuzzy logic does not require exact values for analysis of the image. By suitable membership function of IF-THEN rules it is possible to take care of classification. Sensitivity and specificity are two main factors for comparison table 2.

Sensitivity is given as True Positive Rate TPR = $\frac{TP}{TP+FN}$

Specificity on True Negative Rate TNR = $\frac{TN}{FP+TN}$

Accuracy is calculated as $\frac{TP+TN}{P+N}$ .Sensitivity of test is defined by proportion o people with disease having positive results specificity is the proportion of people without disease having negative results in table 4 and in table 5.

Table 2 Testing And Conditions

	Condition positive	Condition Negative
Test outcome positive	TP	FP
Test outcome negative	FN	TN

V. RESULTS AND DISCUSSION

1. The first trimester fetal image is represented further processing into 256 × 256 pixels for further processing figure 4.

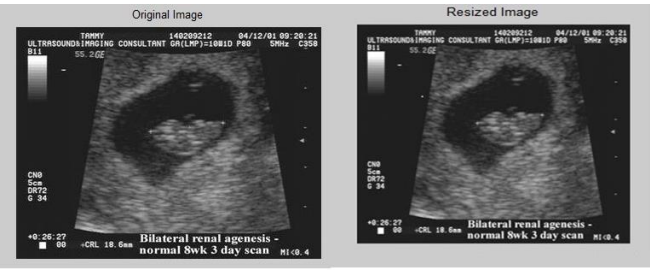

Fig. 4 Bilateral renal agenesis of fetal image

2. The speckle noise is removed by Median filter (figure 5) which replaces the value of pixel by the median of the intensity values in the neighborhood of that pixel with original value of the pixel being included in the computation of the median. Median filters are particularly effective in presence of impulse noise or salt and pepper noise like speckle noise. White and black dots are superimposed on the image.

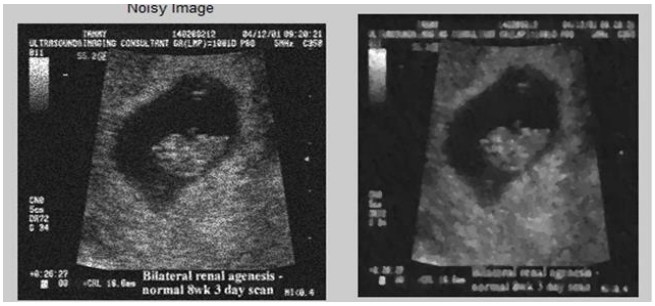

Fig. 5 Noise image removed through median filter

3. Before segmenting, the cropping operation is done to improve clarity (figure 6).

Fig. 6 cropping operation is done to improve clarity

4. Segmentation process involves detection of point lines and edges. Edge pixels are pixels at which the intensity of an image function changes abruptly. The output of this stage is shown in figure 7.

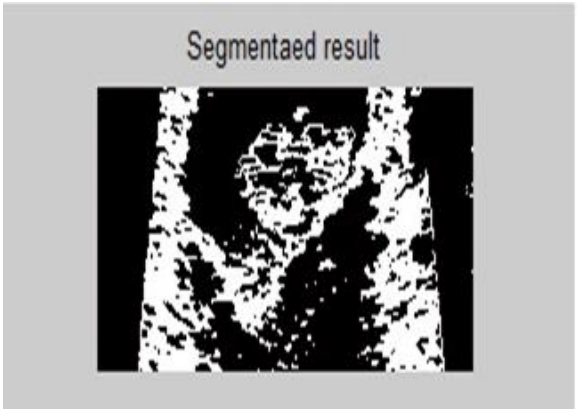

Fig.7 Bilateral renal agenesis Segmentation process

5. The results of feature extraction in table 3
6. Feature selection is done by PSO which are given to the ANFIS for classification the output of the classifier is shown in figure

Fig. 8 outputs of ANFIS

7. Finally after classification by ANFIS the picture is shown in figure 8 as the indicator of items such as renal agenesis.

Table 3 Parameters and performance and analysis

Features / Abnormalities	Variance	Entropy	Mean	Eccentricity	Std. Deviation	Energy	Kurtosis	Skewness	Homogeneity	Auto correlation
Anencephaly	0.0055	1.0357	0.2564	8.7799	0.1321	4.5804	46.9672	3.4121	8.2272	1.2135
Renal Agenesis	0.0070	1.0905	0.3194	8.7799	0.1713	4.1341	99.7924	1.2840	8.3806	1.6675
Cystic Lymphangioma	0.0010	1.0629	0.6455	8.7799	0.0358	4.1638	5.0635	0.0022	8.6884	3.8150
Cystic Hygroma	8.5225	8.8855	2.3790	8.7799	1.7916	5.3373	1.4964	1.4573	8.9716	1.3105
Gastrochisis	8.7494	1.1169	4.9138	8.7799	1.8549	3.7213	1.5043	5.9865	8.6813	2.8305
Megacystis	0.0079	7.5737	0.2113	8.7799	0.1757	6.0009	10.0611	0.6439	9.3750	1.2577
Omphalocele	0.0089	1.0692	0.4652	8.7799	0.1720	3.9219	18.2535	1.2826	8.8962	2.7219
Normal	4.7592	1.0448	2.7924	8.7799	1.0478	4.4713	2.2897	2.6737	8.3822	1.4041

Table 4 Observations And Comparison Of Different Techniques

Serial no.	Techniques	Features Used	Accuracy In %	Specificity In %	Sensitivity In %
1	NB	statistical feature	76	63	82
2	SVM	statistical feature	76	58	92
3	LDA	statistical feature	70	54	77
4	KNN	statistical feature	72	54	87
5	ANFIS	statistical feature	81	70	87

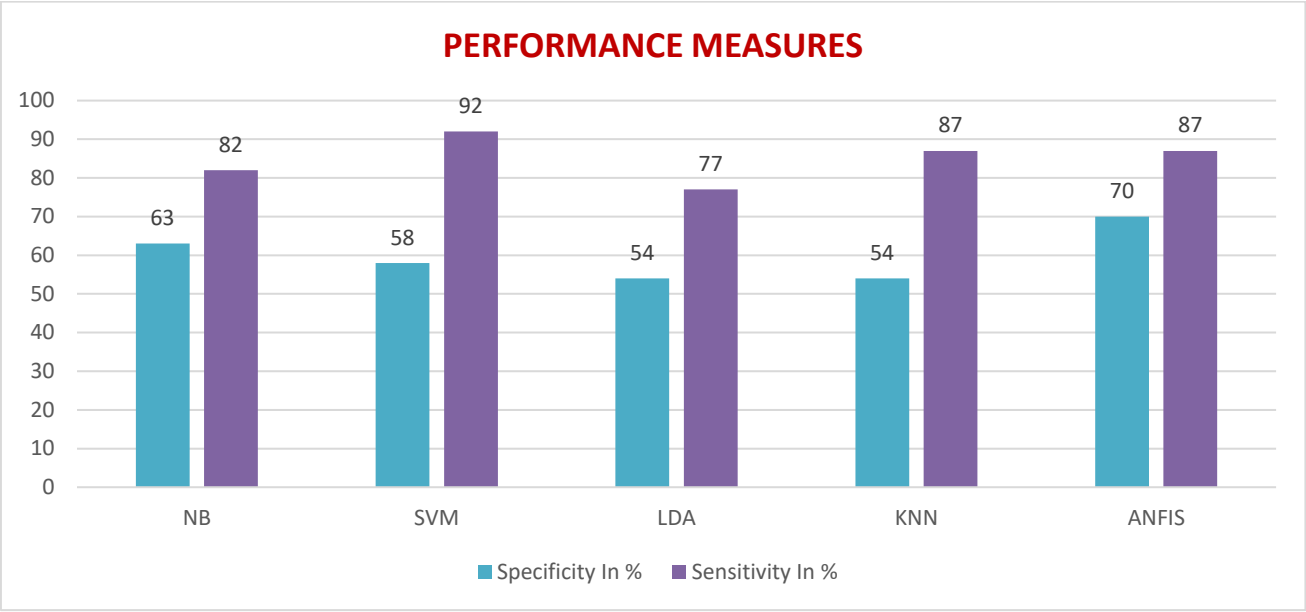

Fig. 9: Performance Measures - Specificity and Sensitivity

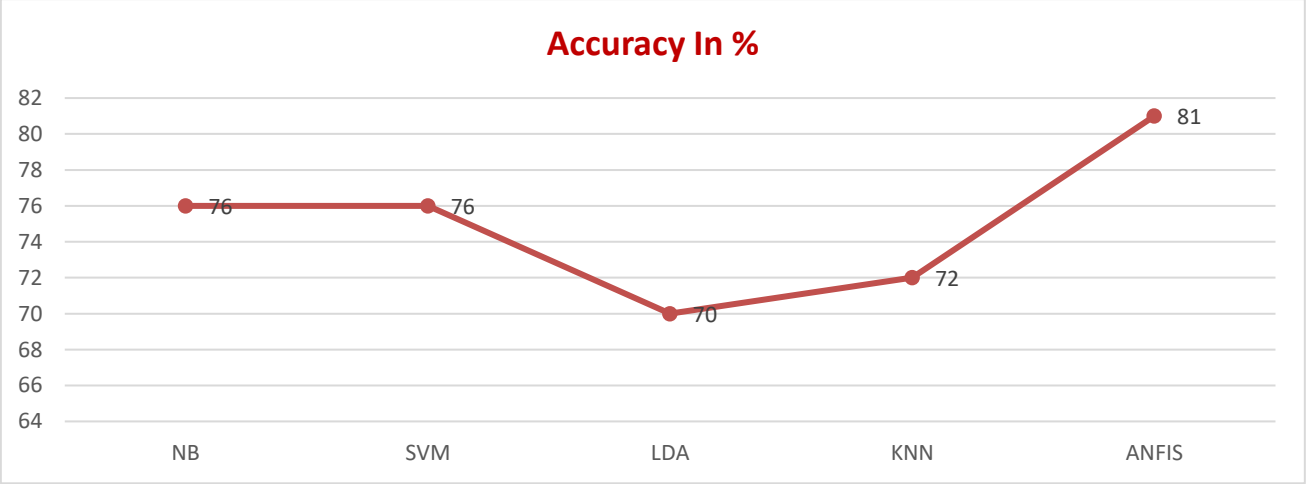

Fig. 9: Performance Measures - Accuracy

VI. CONCLUSION

The techniques of Naïve-Bayes (NB), Support Vector Machine (SVM), Linear Discriminate Analysis (LDA), and K-Nearest Neighbor (KNN) are compared with ANFIS used in this work. 1 It may be seem that ANFIS achieves the highest accuracy of 81%, specificity of 70% and sensitivity of 87%. SVMs come above ANFIS in sensitivity only. So considering the all the features, ANFIS is the most suited for the analysis. Further improvement can be obtained by utilization of DNN.

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