A Novel Abnormality Detection using OBF-PSO for US Fetal Images

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Abstract: **This paper deals with ultrasound fetal image for finding the abnormalities of fetal in first trimester period of pregnancy. Finding aberration in first trimester period is essential in order to overcome the abnormalities by suitable medical treatments. A way to identify the abnormalities this research work proposes an object-based feature selection and an optimization module. OBF uses Structural information extracted from an object to address the curse of dimensionality. Multi resolution segmentation and object based feature extraction are performed for fetal image and particle swarm optimization is used to evaluate and sharpen the accuracy of the detection methodology. Experimental results depict hybrid object based optimization model produces remarkable results.**

Keywords - **Trimester, Particle Swarm optimization, Object based feature (OBF)**

I. INTRODUCTION

A simple ultrasound instrument produces high-frequency sound waves that reach and reflect back from a different layer of body tissue. The reflected echo signals are converted into an electrical signal with the help of suitable transducers. The instrument calculates the distance from the probe to tissue using the speed of sound in tissue and time of each echo's returns. Then it displays the distance and intensities of echoes on the screen forming a 3D image. Ovulation, conceptus, Embryonic and fetal are the four stages of first trimester period. A transabdominal or transvaginal approach is used to observe the fetal abnormalities in first trimester period. Monitoring the fetal growth in first trimester period is significantly used in past three decades. Extraction of information from image based on the fetal features present in US machine for classification and analysis to obtain best results. In general the classification algorithm is divided into pixel-based classification (PBC) and object-based classification (OBC). PBC works only with information from single pixels of the fetal image. OBC method divides the image into small objects which made of groups of pixels.

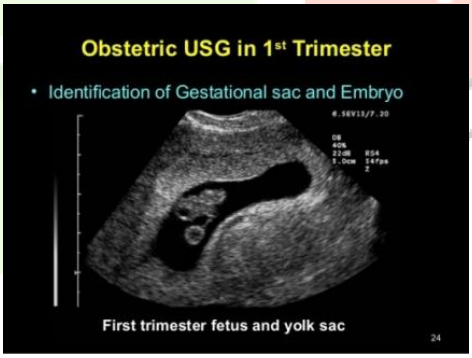


Figure 1 Clinical Suspicion of Early pregnancy failure

This method minimizes complexity and redundancy in the spatial detail of images. Figure 1 depicts the clinical suspicion of early pregnancy failure for the first trimester period fetus. In the abnormality detection process this ultrasound image measures the gestational sac and embryo for obtaining the status of the fetus as normal or abnormal. Charts are given in figure 2 and 3 for various values of sac and embryo. These values are predefined by the medical association from all over the world and the values are standard in all regions, the fetus and yolk sac in given in the ultrasound image. The main advantage of OBC is producing hundreds of different features for each image object (IO). This large number of feature information leads two drawbacks. First one is this huge data will increase computational burden of classification procedure. The second one is the accuracy of classification is degraded because of the curse-of-dimensionality issue. Selection of optimum feature for image processing is important for explanatory problems because of computational complexity and irritation of dimensionality issue.

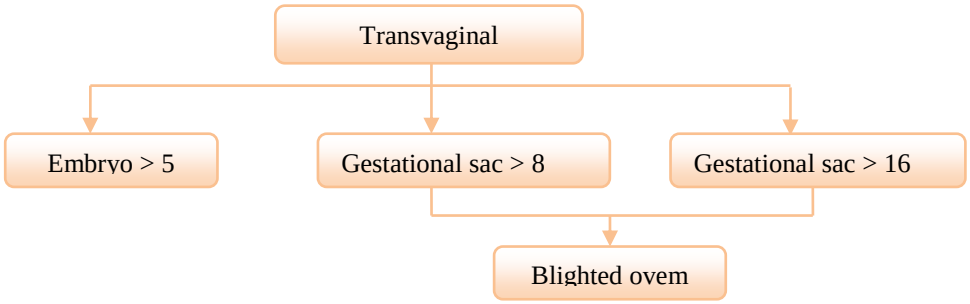


Figure 2 Chart and sizes for Transvaginal ultrasound

Transabdominal ultrasound size ratios are given in figure 3 and it is similar to transvaginal with small variations in its sizes such 9mm in embryo and 20 mm and 25 mm in gestational sac.

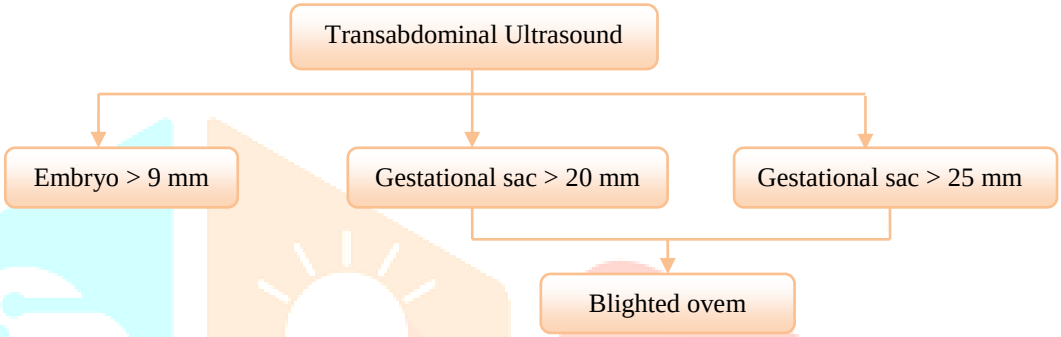


Figure 3 Chart and sizes for Transabdominal Ultrasound

Feature selection can be implemented to manage the major issues of OBC i.e., the type of features and its number. The function of feature selection is broadly divided into two types: wrapper and filter algorithms. In filter algorithms, Redundant and least important features are removed from the feature set by using statistical attributes. In wrapper methods, based on the monitoring of both learning algorithm and the training data, this method uses an iterative procedure to select the best subset of the feature. Concurrent selection of features with learning process gives better output than Filter methods. This paper proposes an innovative two-step framework. The first step of processing segmented the image into IOs and OBFs. Spectral, textural, and structural features were extracted for each IO. Figure 4 gives the general illustration of image classification.

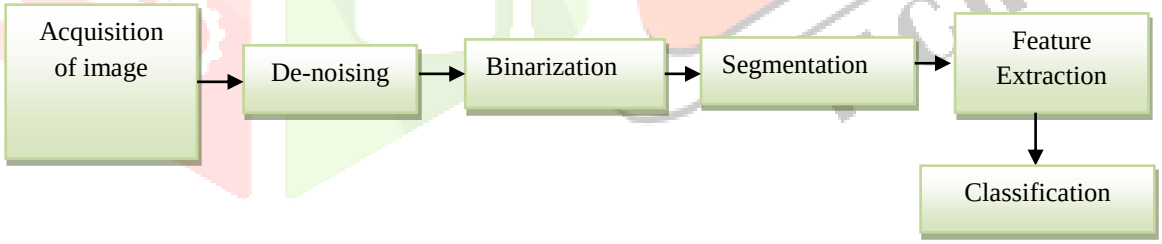


Figure 4 General Illustration of Image classification

To improve the objective function of input fetal image that can be optimized using particle swarm optimization technique. PSO is used to find an approximate solution for extremely difficult problems. Research paper organized as introduction as first section, a deep and crispy literature survey about optimization models as second section, third section proposes a PSO based optimization model in fetal image abnormality detection and the last section discusses about the experimental setup and results.

II. RELATED WORKS

This extensive literature review shows the features of ultrasound for detection of malformation in first trimester period of pregnancy. Literature [1] focused on congenital rubella syndrome (CRS) infection during the early stage of pregnancy. Rubella virus infection causes cardiac septal defects, pulmonary artery stenosis, microcephaly, cataract, microphtalmia, and hepatosplenomegaly to fetus. Literature [3] explores the characteristics of different pregnancy and identifies the structural anomalies. Literature [2] reported huge range of fetal abnormalities during 11 -13th week of pregnancy. The measurement of crown-rump-length in 11-14 week explored gestational age. [4] [5] Nuchal translucency (NT) measurement in an early stage, assessing the risk of aneuploidy. Major anomalies detected in first trimester are higher in fetuses with increased Nuchal translucency.

Literature [6] described the detection of fetal limb anomalies. It incorporates with other malformation in context of different syndromes. Author presented two cases of isolated fetal limb anomalies that associated with distal part of upper limb. The ultrasound fetal examination identifies the phalangeal aplasia namely fetal hand. Literature [7] [8] reveals the structural abnormalities in twin pregnancies. Detection of structural malformation in twins was large for cranial vault, midline brain and abdominal wall defects. Discrepancy in crown–rump length and nuchal translucency increase the abnormalities of fetal structure. Chromosomal aberrations and structural anomalies of fetal were identified by sonographic findings. The important finding in [9] shows anti-epileptic drugs (AEDs) in earlier stage of pregnancy and specific congenital anomalies of the fetus. Another finding from the Literature [11] describes the Trisomy syndrome is a rare chromosomal anomaly associated with multisystem dysmorphism and central nervous system (CNS) malformations. The literature [12] describes more about the most common Dandy-Walker malformation (DWM). It indicates the spectrum of abnormalities of the posterior fossa that are categorized using CT scans, such as classic DWM. Dandy-Walker variant is one of the variable hypoplasia[10] [13] occurs in the cerebellar vermis, with or without enlargement of the posterior fossa. Megacisterna magna is an enlarged cistern magna, which is unaffected cerebellar vermis and fourth ventricle. The clinical and sonographic findings that have been describe the CNS abnormalities, facial abnormalities, cranial abnormalities, congenital heart defects, skeletal defects, urogenital malformations, and intrauterine growth restriction. The article provides the prenatal ultrasound findings in a second-trimester diagnosis of a nonmosaic trisomy fetus with increased nuchal translucency in the first trimester.

In Literature [14] author proposed the genetic algorithm as a function for developing an optimized model using machine learning approach. Genetic algorithm is used to obtain the optimization results for the images sets. Literature [15] proposed an optimization based on object feature selection method. This research work has automation for fetal scene detection its enhanced quality reduces the complexities with minimum processing time. Literature [16] describes about the SIFT technique uses in image processing from a line scanning ophthalmoscope and the computed results are compared with other works and shows that SIFT computes twice as fast as conventional methods. The study of PSO in many benchmark optimization problems used by researchers to analysis novel optimization techniques [17]–[19].In Literature [20] the given fetal image (control variables were continuous) was classified as one of mixed integer nonlinear optimization. It demonstrated the complex optimization problem by enriching the output accuracy and reducing computational time. An adaptive uniform mutation [21] was used to improve the performance of object based feature selection. Self learning ability of each particle in an object improves its overall result. This [22] author's research was based on differential learning to exhibit the image with sparse solutions in search space. First method for selecting base vector Xbest was done from big crowding distance. In second method two random solutions Xn1 and Xn2, are set as differential vectors. Literature [23] explicit four major types of PSO worked in boundary constraints: absorbing, reflecting, damping and invisible. [26] Proposed a new image annotation Method which was based on PSO and a new class of kernels. The kernels get better values when both share the same Pixel value and the same object value. In other experiments based on feature selection optimization, authors in [24] proposed a method from a set of choices in a objects. In object image searching. The most important factor was execution time and resources that are consumed for find a set of parameters from input fetal image. Optimization of deep learning algorithms where demonstrated for PSO over traditional object image searching [25]. Image object searching is inefficient and could provide poor selection(s) because the set originally has been built with poor choices. From the revision of various research articles, PSO model has better optimization results in general image classification based research works. Still utilization of PSO in fetus image classification is not yet available, this shows a view of implementing PSO in fetus classification for producing an optimized results.

III. PROPOSED WORK

Particle Swarm Optimization (PSO) is motivated by movements and communications of insects, fish schooling or bird flocking. Inspired from the nature, PSO is designed for solving optimization problems without wide knowledge in this domain. It uses simple operators for performing mathematical operations. So it requires less memory and computationally inexpensive and it provides high speed for processing.

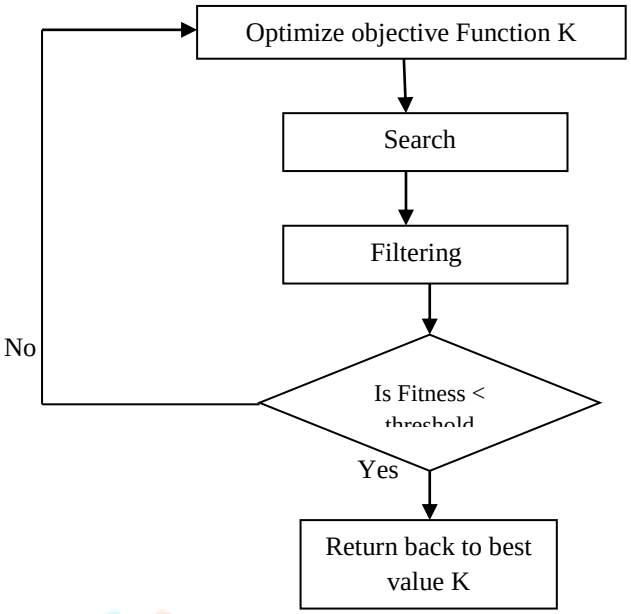


Figure 4 Particle Swarm Optimization

The group of object solution to the optimization problem is referred by the term swarm of "particles". The optimization function determines position, velocity and a fitness value of each particle. The direction and distance of fly is measured by particle velocity. Based on personal extreme of particle, system updates its velocity and position. Initialization of PSO is performed with set of random particles. Particles take its position from one place to another place through solution space. And particles evaluated for few fitness criterion. They were under gone iteration process for updating Particles by two best values iteration. The major issue of object based classification is curse of dimensionality. To overcome this problem we proposed wrapper feature selection (FS) approach. Input fetal image were segmented to image objects (IO) and then feature related objectives to each IO were extracted. Following this PSO fused with minimum distance for choosing the optimum features. In protection of choosing of minimum distance as a object based classifier. In this proposed method were processed fully with object based feature (OBF). This OBF contains spectral, textural and structural features of each image object. The optimal spectral–textural–structural feature values were selected for PSO algorithm.

a. Fetal Image Segmentation and Feature Selection

The important part of OBC is generating fetal image under the basis of fetal image segmentation. This was done through multi-resolution fetal image segmentation technique. To perform high level of segmentation it uses three basic functions namely scaling, shaping and compactness. Trial and error method is handled to implement these functions. Following this process was validated visually, the functions of scale, shape, and compactness were set to some random value first and second image. The three categories of OBFs, namely, spectral, structural, and textural features, were extracted for each IO in both images after segmentation process.

b. Particle Swarm Optimization for Object-Based Feature Selection (PSO-OBFS)

Binary version of optimization technique was proposed namely BPSO. BPSO is stochastic optimization technique based on population. In this optimization technique input fetal image particle is denoted as binary bit string, in which each bit have either 0 or 1. Movement of each image particle according to its velocity, it is calculated as

$$V_{(x+1)} = v(x) + a_1 v_1[P_{best}(x) - x_{id}(x)] + a_2 v_2[g_{best}(x) - x_{id}(x)] \quad (1)$$

Where $V_{(x+1)}$ is the velocity of particle i at time x the best fitness positions of image particle P_{best} (personal best) and g_{best} (Global Best) were identified by particle I and entire swarm up to x^{th} iteration. The random variables v_1 and v_2 are in the range [0, 1]. v is an inertia weight scaling the previous time step velocity, a_1 and a_2 are two acceleration coefficients. Find out the threshold value from velocity by using sigmoid function. Finally, the binary position of each fetal image particle can be obtained by:

$$x_{id}(x) = \begin{matrix} 1, if\ \delta_{id} < s(v_{id}) \\ 0,\ otherwise \end{matrix} \quad (2)$$

Where δ_{id} is a random number with uniform distribution in the range [0, 1]

Major two important component of PSO is introduction of fetal image object particle and objective function of fetal IO particle evaluation. To show the performance of each component, the fetal IO particle explores the features selected for every level. The maximum number of features equalized to particle length. Each particle of fetal image is initiated with binary value.

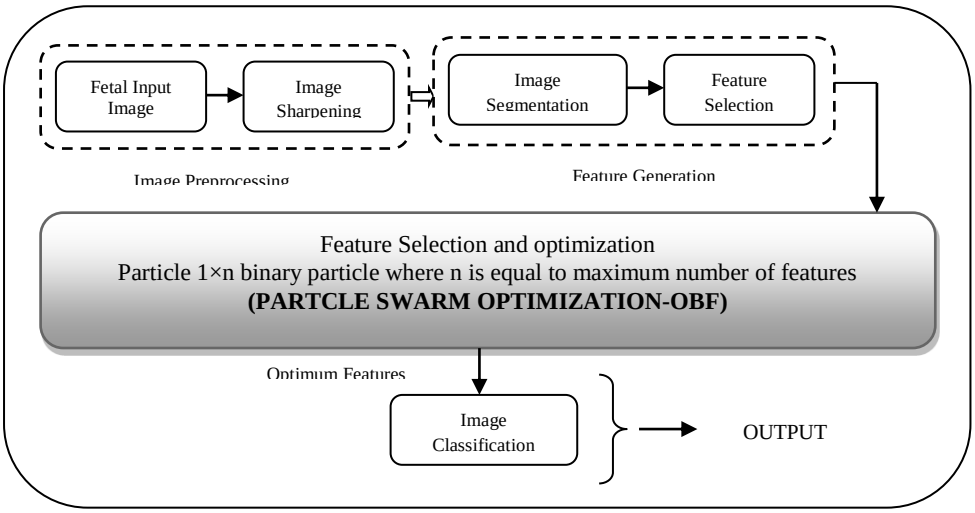


Figure 5 Proposed OBF-Particle Swarm Optimization model in fetal image classification

In figure 5 the proposed optimization is depicted and the process starts from fetal input image to classification and based on the segmented values the features are selected and then it is given to the optimization module. To find the optimum solution for the following PSO model algorithm is used in the proposed model.

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

IV. RESULT AND DISCUSSION

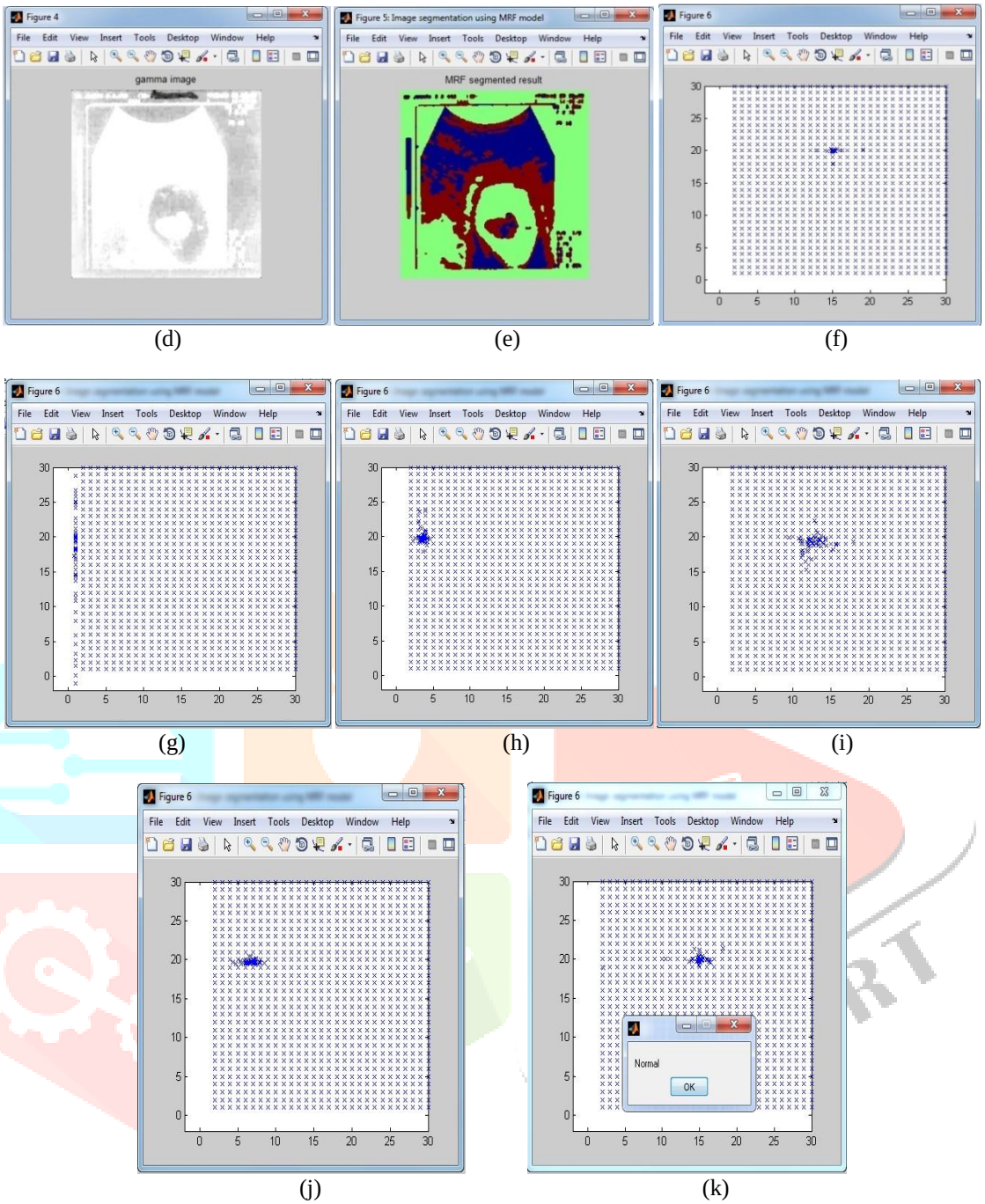
The experimental results are obtained by simulating proposed model in matlab14 in Intel i5 operating system with clock frequency of 2.10 GHz. The data set is divided into training data sets and test data sets and a training classifier is used for classification. Feature selection and extraction are obtained for data set and the evaluation process provides a solution for finding the abnormality in fetus. Test data is comprised of feature selection data and it does not included in the evaluation process. The total portion of the input image is sub divided into real image which and validation image and test sets.

Table 1 parameters used in OBF-particle swarm optimization

classifier	Number of features	Classification accuracy (%)	Training time (s)
SVM	10	93.00	134.8
OBF-PSO	10	97.15	83.54

These three sets of data make the system to work with less computational time with satisfied speed using particle swarm optimization model. Table 1 depicts the parameters considered in optimization process. PSO is compared with the SVM classifier model and the features are selected less in the PSO model and it produces classification accuracy higher than the SVM model.

(a) (b) (c)



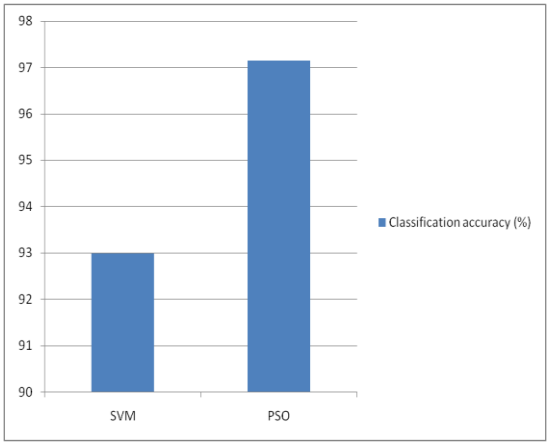
(d) (e) (f)

(g) (h) (i)

(j) (k)

Figure 6 Experimental Results. (a) Input Fetal Image of 7.5 weeks (b) De-noising using median filter (c) Logarithmic Image (d) Gamma Image (e)MRF segmented Image (f - k)particle swarm optimization.

Figure 7 depicts the comparison of classification accuracy and training time with proposed OBF PSO model and SVM model. In both figure the proposed model has better results as high classification accuracy and minimum computing time for train the data for data set.



(a)

(b)

Figure 7 comparison of proposed model with SVM. (a) Accuracy Comparison (b) Training time comparison

The proposed work has implementation results using particle swarm optimization to obtain the best results in fetal abnormality detection using OBF. PSO is used for obtaining the optimum solutions and the results are computed based on the parameters. Results depicts the proposed model produces more accurate results for input fetal image using OBF method. Best spectral and textural combinations are obtained using OBF and this allows the model to work with minimum computation time.

REFERENCES

[1] Alexandre Yazigi, Aurelia Eldin De Pecoulas, Christelle Vauloup- Fellous, Liliane Grangeot-Keros, Jean-Marc Ayoubi, Olivier Picone,2016, "Fetal and neonatal abnormalities due to congenital rubella syndrome: a review of literature" , Journal of Maternal-Fetal & Neonatal Medicine, Taylor & Francis.

[2] Yen-Ni Chen, Chih-Ping Chen, Chen-Ju Lin,Shin-Wen Chen,2016,"Prenatal Ultrasound Findings of Pregnancy Associated with Zika Virus Infection", Journal of Medical Ultrasound Vol.24, pp.89-92.

[3] Tashima E. Lambert, MD, Jeffrey Kuller, MD, Maria Small, MD Eleanor Rhee, MD, Piers Barker, MD,2016. "Abnormalities of Fetal Situs:An Overview and Literature Review" Obstetrical and Gynecological Survey , Wolters Kluwer Health, Vol.71(1).

[4] Debbie Jarvis, Cara Mooney,Judith Cohen, Diana Papaioannou, Mike Bradburn, Anthea Sutton, Paul D. Griffiths,2016, "A systematic review and meta-analysis to determine the contribution of MR imaging to the diagnosis of foetal brain abnormalities In Utero" ,Springer.

[5] Fabio Azevedo Caparroza, Luciano Lobato Gregorioa, Giuliano Bongiovannia,Suemy Cioffi Izua, Eduardo Macoto Kosugib, 2016, "Rhinitis and pregnancy: literature review, Brazilian Journal of Otorhinolaryngology, Elsevier.

[6] Claudiu Marginean, Claudiu Molnar-Varlam, Lorena Elena Melit, Maria Oana Marginean, Vladuţ Ştefan Bogdan Sasaran, Daniel Muresan,2016, "Isolated Anomalies Of The Fetal Hand – Two Case Reports and A Review of The Literature" Romanian Journal of Morphology & Embryology,Vol.57(4), pp. 1415–1419.

[7] Francesco D Antonio, Alessandra Familiari, Basky Thilaganathan, Aris T. Papageorghiou, Lamberto Manzoli, Asma Khalil& Amar Bhide, 2016, "Sensitivity of first trimester ultrasound in the detection of congenital anomalies in twin pregnancies: population study and systematic review" journal of medical science London, fetal medical.

[8] Shang Liu, Qingqing Wu, Zhaojuan Chen,2017, "Fetal anomalies detection in China by screening with ultrasound" Journal of Biomedical Research, Vol. 28(11), pp.4891-4896.

[9] Josta de Jong, Ester Garne, Lolkje T. W. de Jong-van den Berg, Hao Wang,2016, "The Risk of Specific Congenital Anomalies in Relation toNewer Antiepileptic Drugs: A Literature Review" Journal of Drugs - Real World Outcomes Vol.3, pp.131–143.

[10] Claudia Mehedintu, Elvira Bratila, Costin Berceanu, Silviu-Mirel Pituru,2016, "Body-Stalk Anomaly. A Case Report and Review of The Literature" Romanian Society of Ultrasonography in Obstetrics and Gynecology, Vol.12, pp. 8-11.

[11] Panchaud A, Stojanov M, Ammerdorffer A, et al,2016, "Emerging role of Zika virus in adverse fetal and neonatal outcomes" Clin Microbiol Rev, Vol.29, pp. 659-94.

[12] Culjat M, Darling SE, Nerurkar VR, et al, 2016, "Clinical and imaging findings in an infant with Zika embryopathy", Clin Infect Dis, Vol.63(6), pp.805-811.

[13]Shuang Liu1, Qingqing Wu1, Zhaojuan Chen, 2017, "Fetal anomalies detection in China by screening with ultrasound", Biomedical Research,vol.11(28),pp. 4891-4896.

[14] J. Echanobe, I. del Campo, Victoria Martínez, 2017, "Genetic Algorithm-based Optimization of ELM for On-line Hyperspectral Image Classification", 978-1-5090-6182-2/17, IEEE.

[15] E.Tamimi , H. Ebadi b, A. Kiani,2017, "Hybrid optimization of object-based classification in high-resolution images using continous ant colony algorithm with emphasis on building detection", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol.7(10), pp.271-279.

[16] Yi He, Guohua Deng, Yuanyuan Wang, Ling Wei, Jinsheng Yang, Xiqi Li , Yudong Zhang,2018, "Optimization of SIFT algorithm for fast-image feature extraction in line-scanning ", Optik 152, Vol.152,pp.21-28.

[17] B. Du,W. Xiong, J.Wu, L. Zhang, L. Zhang, D. Tao,2017, "Stacked convolutional denoising auto-encoders for feature representation," IEEE transactions on cybernetics, vol. 47(4), pp. 1017–1027.
[18] B. Baker, O. Gupta, N. Naik, R. Raskar, 2017, "Designing neural network architectures using reinforcement learning," International Conference on Learning Representations.
[19] E. Real, S. Moore, A. Selle, S. Saxena, Y. L. Suematsu, Q. Le, and A. Kurakin,2017, "Large-scale evolution of image classifiers," arXiv preprint arXiv:1703.01041.
[20] L. Ma, L. Cheng, M. Li, Y. Liu, X. Ma,2015, "Training set size, scale, and features in Geographic Object-Based Image Analysis of very high resolution unmanned aerial vehicle imagery," ISPRS J. Photogramm. Remote Sens., vol. 102, pp. 14–27.
[21] J. Senthilnath, S. Kulkarni, J. A. Benediktsson, X.-S. Yang,2016, "A novel approach for multispectral satellite image classification based on the bat algorithm," IEEE Geosci. Remote Sens. Lett., vol. 13(4), pp. 599–603.
[22] M. Ghaemi and M.-R. Feizi-Derakhshi,2016, "Feature selection using Forest Optimization Algorithm," Pattern Recognit., vol. 60, pp. 121–129.
[23] X. Zhao et al.,2014, "Feature selection based on improved ant colony optimization for online detection of foreign fiber in cotton," Appl. Soft Comput., vol. 24, pp. 585–596.
[24] R. Kakar & A. Singh,2015, "Image Segmentation using hybrid PSO-FCM," International Journal of Innovative Science, Engineering & Technology, vol. 2(7).
[25] D. Mishra, I. Bose, U. C. De & B. Pradhan,2014, "A multilevel Image Thresholding Using Particle Swarm Optimization," International Journal of Engineering and Technology, vol. 6(6).
[26] A. Tandan, R. Raja , Y. Chouhan, 2014,"Image Segmentation based on Particle Swarm Optimization Technique," International Journal of Science, Engineering and Technology Research (IJSETR), Volume 3(2).