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Classification of Ultrasonic Uterine Images

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Abstract: **Uterine fibroids are most common benign tumors of the female pelvis in the world. In the field of biomedical imaging, the ultrasound imaging is a vital tool for diagnosis of various disease or abnormalities and is the preferred modality for diagnosis and monitoring of fibroid. This abnormality is predominant among woman of childbearing age where the secretion of estrogen hormone is significant. The most crucial factor is that the presence of fibroid can cause infertility and repeated miscarriage. Exactly extracting the fibroid in the uterus is a challenging task because of size, location and low contrast boundaries.**

Test procedure comprises of the wavelet packet decomposition, feature extraction and classification of ultrasonic uterine images into normal and abnormal. Based on user-defined ROI, three level wavelet packet decomposition is applied to calculate the sub bands i.e. approximate, horizontal, vertical and diagonal coefficients. Support vector Machine and Bayesian classifier are used to discriminate the normal and fibroid uterus images.

Keywords: **Fibroid, Uterus, USG, Ultrasonic Imaging, Wavelet Packet Decomposition**

1. INTRODUCTION

The uterus is the part of the female reproductive system. There are a few abnormalities present in the uterus such as tumors. These tumors can be benign or malignant in nature which is called as 'Fibroid'. Another medical term for fibroids is '*leimyoma'* or just '*myoma'*. Fibroids are muscular tumors that grow in the wall of the uterus. Fibroids are almost always benign (not cancerous). Anyhow the symptoms caused by fibroid may cause certain inconvenience in women which needs to be identified and treated.

Ultrasound imaging is a common modality used for detecting fibroids. It is widely used in the field of medicine for imaging soft tissues in organs such as liver, kidney, spleen, uterus, heart and brain. The most noticeable advantages of ultrasound scanning are safety, cost effectiveness, speed, easy handling and portability. Ultrasound is based on the principle of sound wave echoes. Sound wave travels from the probe to the object, passes through it and is continuously reflected back to the probe from multiple points inside the object. Ultrasound involves sound wave of frequency in the range of megahertz; typically this ranges between 3.5-10 MHz The reflected sound wave is converted back to electrical signals in the probe and transmitted to the processing device which displays the image on the monitor. Bright or white areas in the image represent high reflectivity or reflective surfaces/inter phases in the body. This paper deals with the feature extraction and classification of USG uterine images into normal and fibroid ultrasonic uterine images using statistical and textural features. The performance of the classifiers is evaluated in terms of classification accuracy, sensitivity and specificity.

2. PROPOSED WORK

A. Image Acquisition

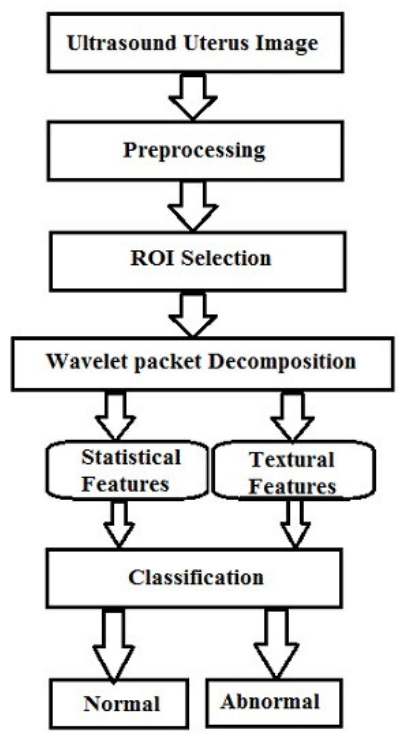

Fig.1. Flow Diagram of the Proposed Method

The uterus ultrasound image scanning is performed either longitudinally or transvaginally else both. The appropriate selection of scanner frequency, operating range forms the trade-off between the spatial resolutions of the ultrasonic image and image depth. For the experimental work, 50(25-

normal and 25 abnormal) test images are obtained from Ghundiyal Diagnostic Center, Amravati, India for evaluation purpose. These images are in JPEG format. JPEG (Joint Photographic Expert Group) images are compressed images which occupy very little space. Basic block diagram for the proposed work is shown in Figure 1.

It includes the following steps:

1. Pre-Processing
2. ROI Selection
3. Wavelet Packet Decomposition
4. Feature Extraction
5. Classification: Normal / Abnormal

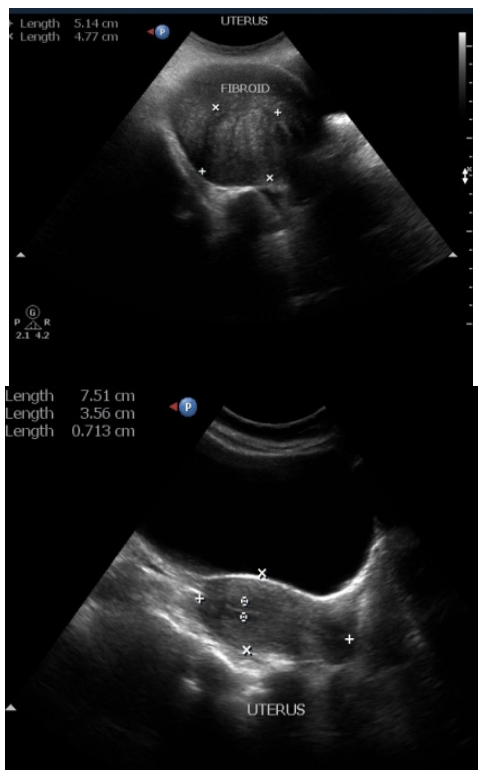

Fig. 2: Example Images (Upper fig shows a fibroid and lower fig shows a normal uterus image)

B. Preprocessing

Preprocessing of uterine images involves conversion of acquired images into 256 x 256 grey scales for effective analysis.

C. ROI Selection And Wavelet Packet Decomposition

Once the preprocessing of uterine images is done successfully, the next step is to select the region of interest and decomposing the image into its approximate, horizontal, vertical, diagonal coefficients using wavelet packet decomposition in MATLAB. ROI is user-defined as the tumor size and location is not fixed.

Wavelet packet decomposition (WPD) is a wavelet transform where the image is passed through more filters than the discrete wavelet transform. DWT is any wavelet transform for which the wavelets are discretely sampled. It captures both frequency and location information. The image is decomposed into several resolution levels. First, the original image is decomposed by two complementary half-band filters (high-pass and low-pass filters) that divide a spectrum into high-frequency (detail coefficients; D1) and low-frequency (approximation coefficients; A1) components (bands). For example, the low-pass filter will remove all half-band highest frequencies. Information from the low frequency band (A1), with a half number of points, only will be filtered in the second decomposition level. The outcome will be filtered again for further decomposition. Here when the image is passed to a filter at stage one, it is passed through a high and a low pass filter. The high and the low pass components of the image are separated and they are further introduced to another set of filters at each stage. At each stage we get the horizontal, vertical and diagonal coefficients. This whole process is called decomposition.

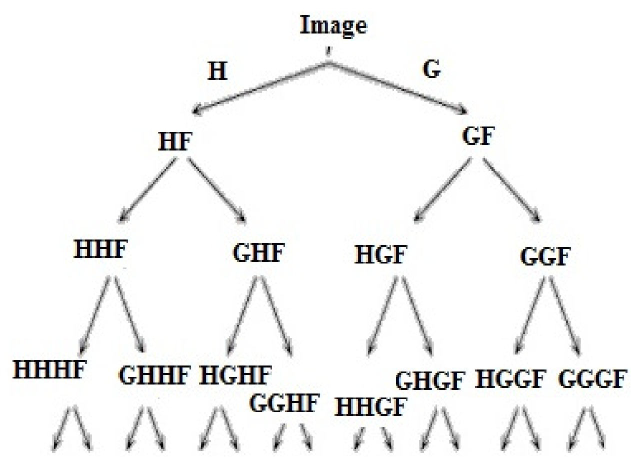

Fig 3: Three level Wavelet Packet Decomposition of an Image

Figure 3. shows the general wavelet packet decomposition level. Any object present in an image is a high frequency component. For this application, the presence of a fibroid is an object and this is a high frequency component. Therefore we considered only the high frequency components i.e. the detailed coefficients of the image. The detailed horizontal and vertical coefficients are numerical values. A Haar wavelet transform is used in the proposed work to decompose and reconstruct the image using wavelets. 2D Haar DWT decomposes a grey level image into one average and three detail sub bands. Haar wavelets real, orthogonal and symmetric. It can be used to analyze texture and detect edges of characters.

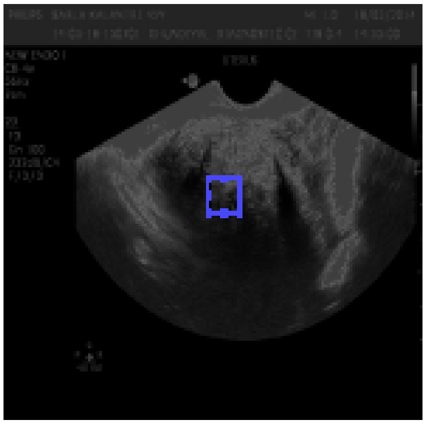

Fig 4. USG image showing Region of Interest (ROI)

D. FEATURE EXTRACTION

Feature extraction helps in providing useful measures from the segmented structure. There are so many methods available for Feature extraction like mathematical morphology and also using wavelet transform we can classify the USG uterine images. In this paper, the goal of feature extraction is to obtain representative features that can be used to distinguish abnormal from the normal patterns. Feature Extraction is performed on the wavelet packet coefficients. Following statistical and textural features are used for the classification purpose.

$$\mu_X = \frac{1}{N}\sum x_i$$

Mean : This is defined as the average or mean of the matrix elements. It is given by the formula,

Variance:This is a measure of the average distance between each of a set of data points and their mean value. It is also equal to the sum of the squares of the deviation from the mean value.

$$\sigma_X^2 = \sum (x_i - \mu_x)^2 p_i$$

Skewness: Skewness is a measure of the asymmetry of the data around the sample mean. The skewness of the normal distribution (or any perfectly symmetric distribution) is zero. An asymmetrical distribution with a long tail to the right (higher values) has a positive skew. An asymmetrical distribution with a long tail to the left (lower values) has a negative skew. The skewness is unit less. far from symmetrical. The skewness of a distribution is defined as,

Kurtosis: Kurtosis is a measure of how outlier-prone a distribution is. The kurtosis of the normal distribution is 3. The kurtosis of a distribution is defined as

$$\frac{1}{N}\sum((x_i-\mu)^3) \div \sigma^3$$

$$\frac{1}{N}\sum((x_i-\mu)^4) \div \sigma^4 - 3$$

Norm: Summation of the squares of matrix elements.

GLCM Contrast: Measures the intensity contrast between a pixel and its neighbor over whole image

GLCM Energy (Uniformity of energy): Provides the sum of squared elements in the GLCM. Also known as uniformity or the angular second moment.

GLCM Correlation: Returns a measure of how correlated a pixel is to its neighbor over the whole image.

Range = [-1 1]

GLCM Homogeneity: Returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. Range = [0 1]

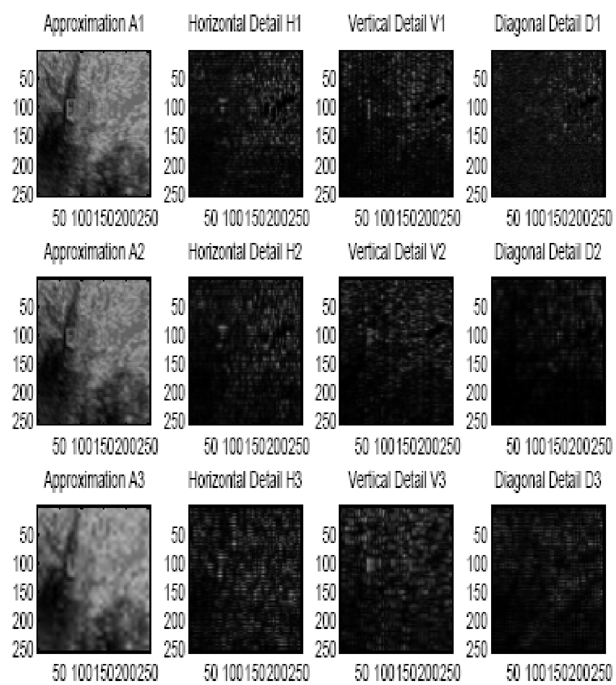

Fig 5. Sub band Decomposition of Uterus Images Up to Level-3

D. CLASSIFICATION

After processing the images, all the values and results need to be classified. When there is large amount of data present, checking if the given image is normal or abnormal individually is a tedious task. In order to make this easier classification algorithms are used. For this particular application two types of algorithms are used, namely, Naive

Bayes Classifier and SVM (Support Vector Machine). Performance evaluation of the proposed classifier is evaluated in terms of classification accuracy, sensitivity and specificity which are defined as,

$$\text{Classification Accuracy} = \frac{TP+TN}{TN+TP+FN+FP} \qquad (1)$$

$$\text{Sensitivity} = \frac{TP}{TP+FN} \qquad (2)$$

$$\text{Specificity} = \frac{TN}{TN+FP} \qquad (3)$$

(TP)True positive = correctly identified
(FP)False positive =Incorrectly identified
(TN)True negative = Correctly rejected
(FN)False negative = Incorrectly rejected

3. RESULTS

Following Tables shows the comparison of classification accuracy for different classifiers.

It can be seen from the Tables that Bayesian and SVM both performs well and Bayesian gives better accuracy for discriminating the normal and fibroid uterus patterns.

	SVM	Bayesian Classifier
Statistical Features	93.18	95.45
Textural Features	88.63	84.09

4. CONCLUSION

Thus, this paper proposes an approach to classify the uterine abnormality based on sonography images and the experimental results are confirmed by the radiologists

It is observed from the above experimentation that both the Support Vector Machine and Bayesian perform well for classification using Statistical features. The performance of the above algorithm was measured using three evaluation criterion accuracy, sensitivity and specificity. By comparing the output of proposed algorithm with the ground truths from experts gives the accuracy of 93.18% and 95.45% resp. Anyabnormality can be detected or classified by applying different classifiers like Neural network in the Future.

5. ACKNOWLEDGMENT

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