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Ultrasound Renal Abnormalities detection using ANN and Scale Invariant feature Transform

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***Abstract*— Artificial Neural Networks are one of the most frequently used classifiers for medical diagnostic tasks to detect diseases at an earlier stage. This research work aims to diagnose ultrasound(US) kidney defects such as kidney cyst, kidney calculus, and kidney tumor. We used the Multilayer Perceptions, and obtained 98 % accuracy with 10 hidden neurons for classification between normal and abnormal. This work also seeks to provide data on the preprocessing method using median and wiener filters on how much the speckle noise was removed and how much the Fuzzy C-Means clustering was used by segmentation method. Among these methods, SIFT has been implemented for the extraction of features, and these values are given as input to the classifier. SIFT is invariant transform characteristic to obtain unique invariant characteristics. Keypoint is the location of the image where a description is computed. The local structure and the key point are summarized in the feature descriptor.**

***Index Terms*— Artificial Neural Network (ANN), Fuzzy C-Mans Clustering (FCM) Segmentation, Preprocessing Technique, Scale Invariant Feature Transform (SIFT).**

I. INTRODUCTION

In today's world, most people have had kidney disease due to different eating habits and genetic disorders. Most of the kidney disease turns to cancer. Different methods for diagnosing renal diseases such as ultrasound, MRI, CT, X-Ray are available. Ultrasound is cheaper among these methods and is commonly used [1]. Punal et al [3] used the Gray Level Co-Occurrence Matrix (GLCM) for categorization various kinds of Kidney stones features, specifically dissimilarity, co-relationship, power and homogeneity. Tamiselvi and co-authors devised a semiautomatic section that devised a technique for US kidney images to discriminate calculus from images [2]. In our work, we suggested classification using Artificial Neural Network (ANN) and we took 30 images of normal renal ultrasound, kidney cyst, and kidney calculus and kidney tumor for classification. This classifier is used for kidney stone diagnosis, thyroid diagnosis and breast cancer in the medical sector. We have obtained 98.9% precision with ANN in MATLAB using nprtool. In the pre-processing method, median and wiener filters are engaged to eliminate speckle noises in the US images and the authors noted that wiener filters remove speckle noise well compared to median filters. Segmentation is performed in order to find the ROI. The primary objective is to obtain the target objectives from different objects. The other organs near the kidney, can have an impact on the efficiency of other techniques of image processing. Scale Invariant Feature Transform (SIFT) is a detector and descriptor is a nearby attribute that takes pixel values from pixel values in the neighborhood. Clustering is nothing more than a comparable grouping of pixel values. FCM allocates pixels by affiliation to every group of the membership function.

II. METHODOLOGY

Renal ultrasound Images from www.ultrasound-images.com/kidneys.html have been acquired. The images obtained have been resized to 256x256.

a) Preprocessing

Ultrasound scanning technology plays an important role in the diagnosis of low cost diseases. Speckle noise is multiplicative in nature which reduces the contrast of the image [6, 7]. Median and wiener filters were implemented and we discovered that wiener filters work well in noise removal compared to median filters. Figure.1 illustrates the technique suggested. Quality performance analysis was carried out to determine how much noise was removed through the use of filters. For quality assessment, peak to signal noise ratio and Mean squared error were used. When the image quality is satisfactory and if the PSNR value is large the mean squared error, MSE should be small. The technique of pre-processing is shown in Figure 1.

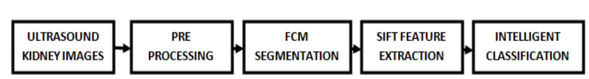

Figure 1. Proposed work flow

b) Segmentation

Image segmentation method is the component of dividing an image into distinct sections to alter the image representation for further analysis purposes. Several segmentation methods are used in the processing of images. The clustering technique of Fuzzy C-Means (FCM) has been used in our proposed method. Soft clustering technique method has been used for the segmentation [4]. Membership function is assigned to form clusters. A criterion of similarity is defined between pixels [2] and similar pixels are then grouped together to form clusters. Fuzzy C-means clustering technique, which classifies pixel values with a high degree of accuracy. Essentially, it is suitable for decision-oriented applications and can retain much more information in the segmented image. FCM assigns pixels to each other class by defining the membership function.

If = X=(x1, x2, x3 ... xn) refers to an N pixel image to be split into C clusters, FCM performs an iterative function that minimizes the following objective function as shown in equation (1)

$$j = \sum_{j=1}^{N} \sum_{i=1}^{c} uijm \ ||x_j - v_i|| \quad \ldots\ldots \quad (1)$$

Where, u_ij^m = membership function of pixel xj in ith cluster ,Vi is the centre of pixel of i^{th} cluster, m is the fuzzifier that controls the fuzziness of resulting clusters and lies between 1<m≤∞. However, there is some disadvantage in this method that noisy images do not take into account spatial information which makes them sensitive to noise and other image artifacts [4, 5].

c) Sift Feature Extraction

SIFT is both a detector and a descriptor. If we alter the value of the scale, it will change and transforms an image into an image coordinate. The primary objective is to extract unique characteristics of invariants. The name invariant in SIFT indicates the feature to invariate the scale and rotation of the image even if we alter the perspective in 3D it will not alter the feature [8]. As far as quality is concerned, many features can be generated for even small objects. Efficiency in real-time performance is good. The key point is the location of the image where a description is computed. The local structure and the key point are summarized in the feature descriptor. Various values of Gaussian sigma are given to find scale space peak selection. In our paper, together with the DoG component, we have adopted Harris Corner Detector to extract characteristics from edges. The key point localization correctly locates the function keypoints to locate peak / potential and pyramid level. Assigning orientations to the major points and describing the main point as a high-dimensional vector for orientation assignment is carried out. An image's scale space is described as the function, as given in equation (2)

L(x, y, σ) = G(x, y, σ) * I(x,y) …. (2)

Where G(x, y, σ) is the Gaussian kernel as shown in equation (3)

G(x, y, σ) = 1/(2πσ2)e^(-(x^2+y^2)/2σ^2)… (3)

I (x, y) is an input image, and * is the convolution operation. In order to detect the main points effectively, the use of extreme scale-space in the Gaussian-differentiated feature convolved with the image is shown in equation (4)

D(x, y, σ) = (G(x, y, kσ)-G(x, y, σ))* I(x, y)
= L (x, y, kσ)-L(x, y, σ) ….. (4)

Once the locations of the keypoints have been chosen, the orientation of each keypoint is developed by calculating the gradient magnitude m(x,y) and orientation θ(x,y) at each image sample point in a region around this location, where m(x,y) is given in equation (5)

m(x,y) = √((L(x+1,y)-L(x-1,y))^2+ (L(x,y+1)-L(x,y-1))^2).. (5)

d). Classification

We took 30 samples in our study, consisting of ordinary images of the kidney, kidney cyst, kidney calculi, and kidney tumor. The images are trained by the neural network, to check whether it is normal or an abnormal image. Today, the artificial neural network has become the most widely used machine learning tool for the diagnosis of diseases. One of the commonly used network structures is feed forward network where network links are only permitted between nodes in one layer and nodes in the next layer. Feed-forward neural network propagation is often used as a classifier to differentiate among both infected or non-infected individuals [9, 10]. Three inputs are given to the network in this framework and then inputs and weights are estimated using summation function. Finally, the output is either yes or no in binary form. Yes denotes that the patient is suffering from the disease and no denotes that the person is unaffected. Back propagation is a supervised training algorithm and is used primarily by Multi-Layer-Perceptrons to modify the weights associated with the hidden neuron layer(s) of the net. A computed output error is used by the back propagation neural network to alter the weight values backwards. A forward propagation phase must have been performed earlier in order to get this net error. The neurons are activated using the sigmoid activation function while propagating in the forward direction.

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III. RESULTS AND DISCUSSION

We used median and wiener filters in preprocessing technique. Figure.2 shows the sample images obtained and figure 3 shows the pre-processed image. Quality performance benchmarks were computed and we noted that the Wiener filter is better suited to eliminating speckle noise when compared to the median filter shown in Table 1.

Figure 2: Sample images of cyst, calculi, tumor and normal kidney.

Table.1 Comparison of Performance Metrics

Image	**Median Filter**		**Wiener Filter**	
	PSNR (dB)	***MSE***	***PSNR(dB)***	***MSE***
Normal	**150.52**	**0.01**	**149.78**	**0.01**
Tumor	**103.20**	**1.56**	**130.78**	**0.09**
Calculi	**62.42**	**0.99**	**63.59**	**0.98**
Cyst	**76.35**	**0.38**	**78.33**	**0.24**

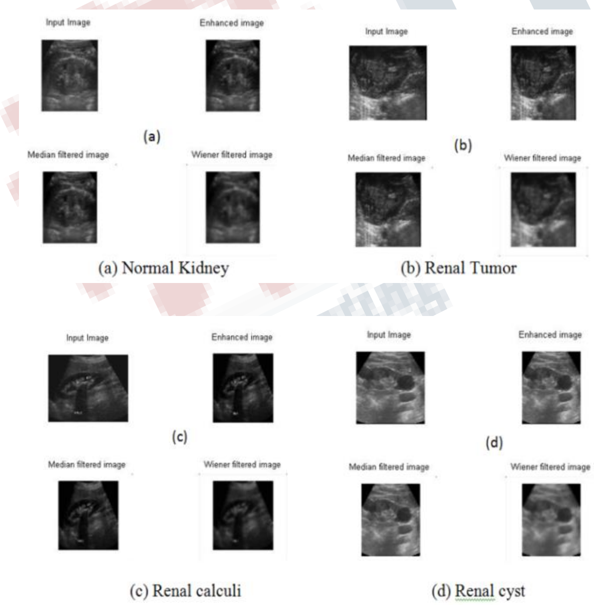


Figure 3. Filtered images (a) Normal kidney (b) tumor (c) calculi (d) cyst.

Segmented images are generated using clustering by Fuzzy C-means. Soft clustering technique is implemented in this method. In this method, a pixel may belong to a number of clusters that are not hard to cluster. In Figures 3 and 4 pixels are subdivided into groups by a partial membership function. It segments the cluster that has comparable features in the pixel.

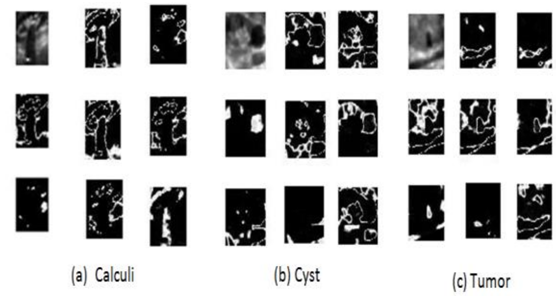
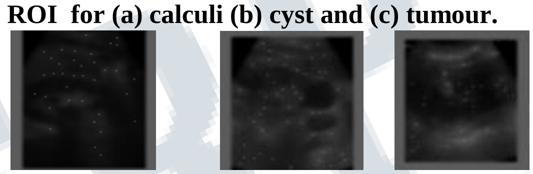


Figure 4: FCM Clustering iterations and segmented ROI for (a) calculi (b) cyst and (c) tumour.



(a) (b) (c)

Figure 5: SIFT Key points for (a) calculi (b) cyst and (c) tumour.

We obtained the feature values of 30 samples including normal kidney and abnormal such as cyst, calculus, tumor for classification results. We classified using nprtool in MATLAB by varying hidden neurons and we achieved 98 % efficiency. Accuracy is the possibility that an image test will be performed accurately.

$$\text{Accuracy} = \frac{T_P + T_n}{T_P + T_n + F_P + F_n} * 100 \quad \ldots\ldots\ldots\ldots \quad (6)$$

Table 2. Confusion Matrix Results

Parameters	Hidden neurons = 10	Hidden neurons = 5
Accuracy	98 %	76.2%
Sensitivity	96%	100%
Specificity	100%	66.6%

IV. CONCLUSION AND FUTURE SCOPE

Ultrasound images from 30 participants are obtained in this study, the normal and abnormal U.S. renal images are acquired and pre-processed using wiener and median filter to remove the speckle noise in U.S. images. Following the segmentation process of the pre-processing technique, the ROI was found in the U.S. Images and the computation complexity to extract the features was decreased. Quality measurement performance is executed to realize the image quality, the PSNR quality performance and the computation of MSE. It measures the image quality between the actual image and the reconstructed image using filter to remove the noise and to study how much the noise is recognized in the image using quality performance analysis. An attempt has been made to apply the SIFT key point extraction to normal and abnormal renal images. SIFT appears to discriminate between normal and kidney images. Some characteristics distinguish ordinary images from renal tumor, kidney calculus and kidney cyst. The future scope is to obtain the characteristics using SURF method and the main points obtained are provided as inputs to the SVM classifier.

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