Carotid Plaque Characterization using GLCM Transform

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***Abstract*—: To analyze the cardiac health, the classification of carotid plaque into symptomatic or asymptomatic is essential. Computer Aided Diagnosis (CAD) is very popular in these days. Here introducing a new method for analyzing the ultrasound scanned image of carotid plaque using gray level co-occurrence matrix(GLCM) transform. GLCM is used for matrix simplification and feature extraction. Also an advanced classifier called neuro-fuzzy is used for the classification of the extracted features. It is very accurate method and also applicable to real images from hospital. This paper also includes a comparison between NF and NN classifiers on the basis of their decision accuracy.**

Keywords— ***atherosclerosis, GLCMclassifier, neurofuzzy classifier, carotid ultrasound*.**

I. INTRODUCTION

Atherosclerosis is the leading cause of stroke. Stroke causes disruption of blood flow, resulting in the blockage of oxygen supply to brain cells, and these cells will begin to die. This disturbance to the blood flow is due to ischemia, caused by a blockage or leakage of blood. The main objective of this study was to develop a computer- aided system using multifeature analysis, neuro-fuzzy classifiers for the automated characterization of carotid plaques recorded from ultrasound images [1].

Here a new method is using for the plaque characterization. Mainly 3 steps are there. 1) Resize the image into desired size and image enhancement. 2) Applying GLCM for image matrix simplification and feature extraction 3) classification using an advanced classifier neuro fuzzy. Input to the classification system will be the gray scale image from ultrasound scan. Carotid ultrasound is a painless and harmless test. In this test high-frequency sound waves to create pictures of the insides of your carotid arteries[2]. Resize means converting the ultrasound scanned image to a desired size as we needed. Here carotid artery is taken for this study.

II. MATERIALS AND METHODS

Fig. 1 shows the block diagram of the proposed system. The ultrasound images of carotid plaque are preprocessed and subjected to feature extraction using GLCM technique. Selected features are then fed to the neuro-fuzzy classifier for classification. These techniques are briefly described in this section.

A. Input Biomedical Image

Our database had 55 asymptomatic and 45 symptomatic (a total of 100) carotid plaque ultrasound images that were used in this work [3]. Carotid ultrasound shows whether a waxy substance called plaque has built up in your carotid arteries. The buildup of plaque in the carotid arteries is called carotid artery disease. Over time, plaque can harden. Hardened plaque narrows the carotid arteries and reduces the flow of oxygen-rich blood to the brain [4].

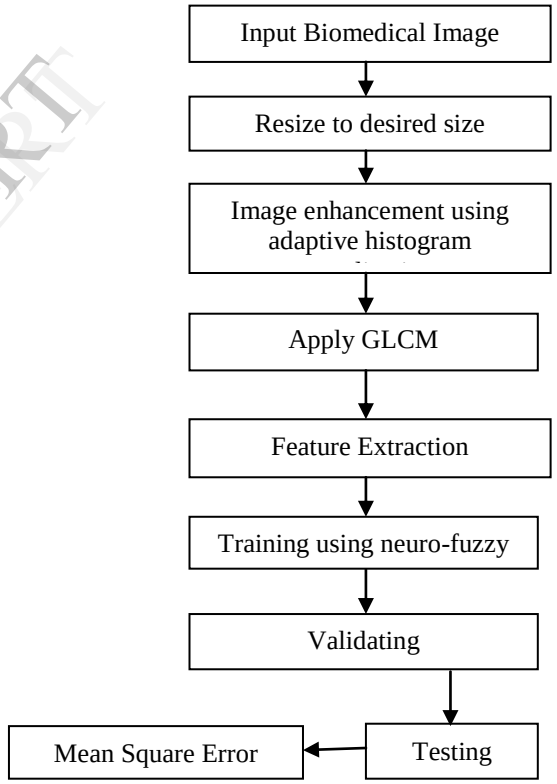

Fig.1 flow chart of the classification system. carotid ultrasound shows the structure of your carotid arteries. Your carotid ultrasound test might include a Doppler ultrasound [5]. Doppler ultrasound is a special test that shows the movement of blood[6].The plaques from patients having retinal or hemispheric symptoms, such as stroke, transient ischemic attack (TIA), and amaurosis fugax (AF), were grouped as symptomatic Plaquesand. Asymptomatic plaques were from patients who had no symptoms in the past [7],[8].

In preprocessing stage, resizing and the region of interest (ROI) Selection are the main steps. The nature of the disease is focused on the vessel wall and causes changes in the morphology of the lumen–intima interface from slow lipid formation and changing into hard plaque. Typical symptomatic and asymptomatic carotid images are shown in Fig. 2(a)

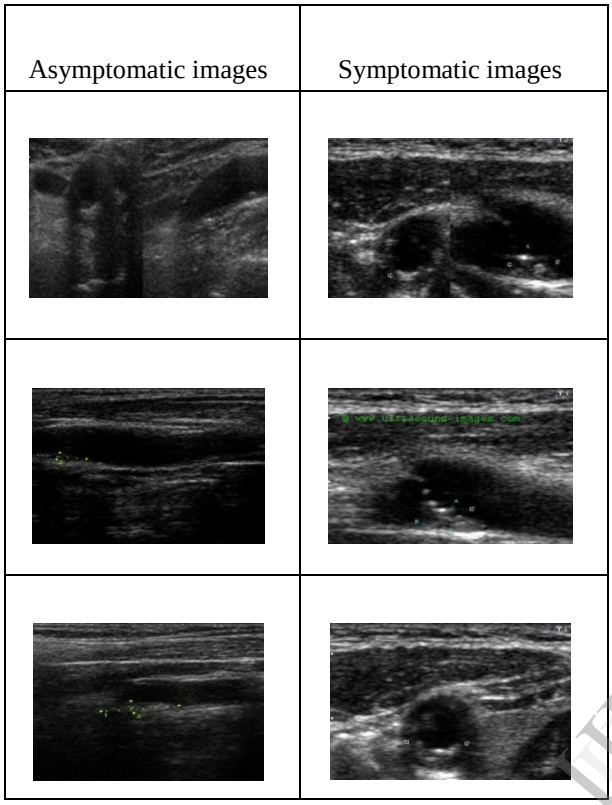

Fig.2 (a) Symptomatic and Asymptomatic images

B. Image Enhancement

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. In other words the process of improving the quality of a digitally stored image by manipulating the image with software. It is quite easy, for example, to make an image lighter or darker, or to increase or decrease contrast. The output of the image processing stage is given in Fig. 2(b). In real-time image sequences, their original form may not have good viewing quality due to lack of proper lighting or inherent noise. For example, in ultrasound scan, low-level exposure is administered until the region of interest is identified. In this case, it is desired to improve the image quality in real-time.

One of the popular method of interest, which extensively is used for enhancement of still images, is Contrast Limited Adaptive Histogram Equalization (CLAHE). So in this paper CLAHE is used for image enhancement.

C. Gray Level Co-Occurence Matrix

The definition of gray level co-occurrence matrix, is a co-occurrence distribution, is defined over an image to be the distribution of co-occurring values at a given offset or Represents the distance and angular spatial relationship over an image sub-region of specific size[9].

The identification of specific features in an image is achieved by modeling texture as atwo-dimensional gray level variation[10]. This two dimensional array is called as Gray Level Co-occurance Matrix (GLCM). A GLCM is a matrix where the number of rows and columns is equal to the number of gray levels, G, in the image. The matrix element P (i, j | Δx, Δy) is the relative frequency with which two pixels, separated by a pixel distance (Δx, Δy), occur within a given neighborhood, one with intensity 'i' and the other with intensity 'j'. The matrix element contains the second order statistical probability values for changes between gray levels 'i' and 'j' at a particular displacement distance d and at a particular angle (ɵ). So the number of gray levels is often reduced. Gray Level Co-Occurrence Matrix (GLCM) proved that it is a popular method of extracting feature from images.

D. Feature Extraction Using GLCM

In this paper four important features, contrast, Correlation, Energy, and the Homogeneity are selected for plaque characterization[11]. The mathematical expressions used for this features is given below.

$$\text{Contrast} = \sum_{i,j} |i-j|^2 \, p(i,j) \quad (1)$$

$$\text{Correlation} = \sum_{i,j} \frac{(i-\mu i)(j-\mu j)\,p(i,j)}{\sigma_i \sigma_j} \quad (2)$$

$$\text{Energy} = \sum_{i,j} p(i,j)^2 \quad (3)$$

$$\text{Homogeneity} = \sum_{i,j} \frac{p(i,j)}{1+|i-j|} \quad (4)$$

Graycoprops is the properties of the gray image. It normalizes the gray-level co-occurrence matrix (GLCM) so that the sum of its elements is equal to unity[12]. Each element in the normalized GLCM is the joint probability occurrence of pixel pairs with a defined spatial relationship having gray level values in the image. graycoprops uses the normalized GLCM to calculate properties.

E. Neurofuzzy Classifier

Neuro-fuzzy systems are fuzzy systems which use neural networks theory in order to determine their properties[13] (fuzzy sets and fuzzy rules) by processing data samples. Neuro-fuzzy systems harness the power of the two paradigms: fuzzy logic and neural networks, by utilizing the mathematical properties of neural networks[14]. The decision-based and approximation-based strategies are combined to provide a suitable amount of training for each training pattern. NEFCAR can easily provide the confidence measure of each classification decision[15],[16].

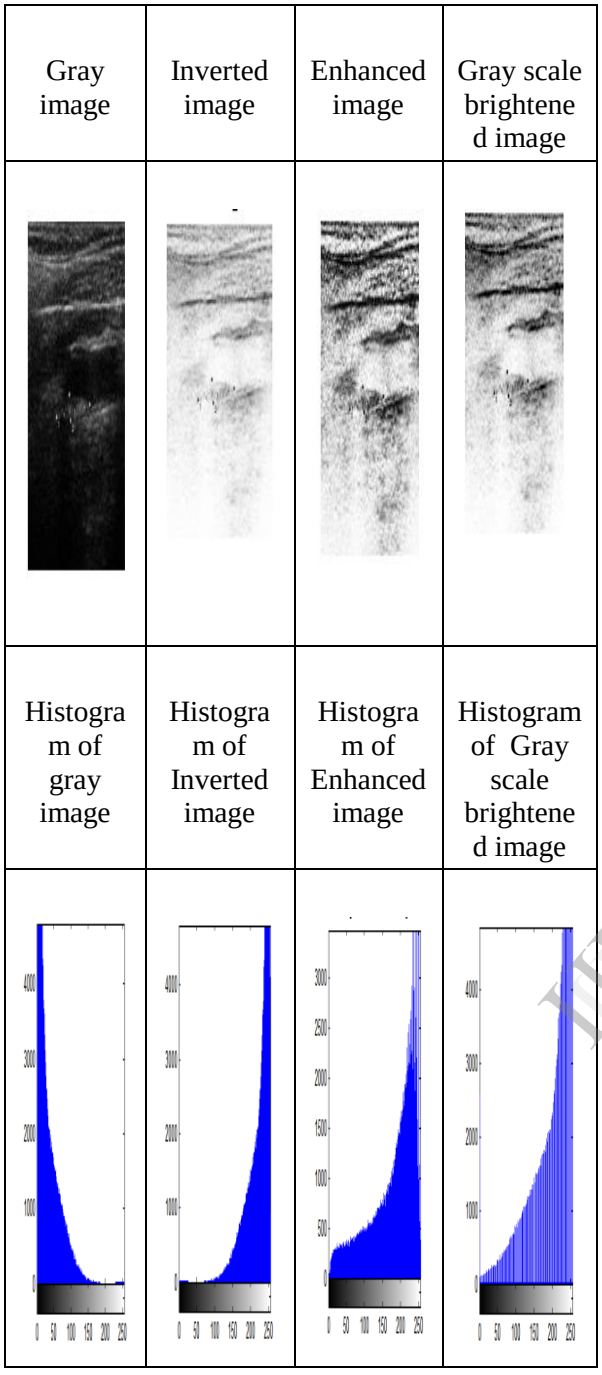

Fig.2 (b) output of preprocessing stage

F. Neural Network Classifier

Classification is one of the most active research and application areas of neural networks. Neural Network is also a powerful tool used in modern intelligent systems. Many applications that involve pattern recognition, feature mapping, clustering, classification and etc. use Neural Networks as an essential component. Many types of neural networks have been developed[17]. A neural network consists of units (neurons), arranged in layers, which convert an input vector into some output. Each unit takes an input, applies a (often nonlinear) function to it and then passes the output on to the next layer. Generally the networks are defined to be feed-forward: a unit feeds its output to all the units on the next layer, but there is no feedback to the previous layer. Weightings are applied to the signals passing from one unit to another, and it is these weightings which are tuned in the training phase to adapt a neural network to the particular problem at hand [18]. This is the learning phase.

III. COMPARISON BETWEEN NEURO-FUZZY AND NEURAL NETWORK

Neural network classifier is a powerful classifier which uses neural network theory. In neural network it uses layers of neurons for input data processing and converts to a particular output. But in the neuro-fuzzy classifier it uses both the neural network theory and fuzzy logic[19]. So we can say that neuro-fuzzy is an advanced form of the neural network classifier system. Also from our experiment we found that neuro- fuzzy classifier is more accurate than neural network classifier[20]. That is when the number of input samples increases, the neural network classifier accuracy decreases. But the neuro-fuzzy classifier is more accurate than the other even if the number of input samples increased.

IV. CONCLUSION

Carotid plaque characterization is essential for the analyzing of heart health. So in this paper introduced a new method of classification of the carotid plaque in to normal or abnormal. For this purpose first the ultrasound scanned image of the carotid artery is converted in to a gray level image. Next step is the processing the image and classification. Then the image is converted in to gray-level co-occurrence matrix and GLCM transform is used for the feature extraction of the image. Here two classification systems are used for the plaque classification. They are neuro-fuzzy classifier and neural network classifier. And we proved that neuro-fuzzy is more accurate than neural network classifier even if the number of the input images is increased. Also the processing time of the neuro-fuzzy classifier is much less than that of the neural network. So this paper proposes a new, accurate, fast method of plaque classification system.

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