Ultrasound Image Analysis of Kidney Stone using Wavelet Transform

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Abstract

A wavelet-based method is introduced in this paper for efficient speckle suppression and detection of calculi in sonographic images of the kidney. Wavelets are developed in applied mathematics for the analysis of multiscale image structures. The aim of this project is to analyse and to provide most significant content descriptive parameters to identify and classify the kidney stones with ultrasound scan. Speckle filtering is a critical preprocessing step. Daubechies - DWT provides an appropriate basis for separating the speckle noise from an image. Fuzzy c means clustering is used for unsupervised image segmentation. The statistical features are extracted by decomposing the kidney stone images into different frequency sub-bands using wavelet transform. The ability of these features in classifying kidney stone is done using Backpropagation Neural Network (BPNN) and it saves the radiologist time, increases accuracy and yield of diagnosis of kidney stone.

Keywords: BPNN, Daubechies Wavelet, Fuzzy C Mean, Kidney Stone, Ultrasound Image.

I. INTRODUCTION

Ultrasonography is often preferred over other medical imaging modalities because it is noninvasive, portable, and versatile, it does not use ionizing radiations, and it is relatively low-cost. However, the main disadvantage of medical ultrasonography is the poor quality of images, which are affected by multiplicative speckle noise[3]. Speckle occurs especially in images of the kidney whose underlying structures are too small to be resolved by large wavelength ultrasound.
A kidney stone, also known as a renal calculus (from the Latin "kidney" and calculus, "pebble") is a solid concretion or crystal aggregation formed in the kidneys from dietary minerals in the urine. Urinary stones are typically classified by their location in the kidney (nephrolithiasis), ureter (ureterolithiasis), or bladder (cystolithiasis), or by their chemical composition (calcium-containing, struvite, uric acid, or other compounds).

The presence of speckle is undesirable since it degrades image quality and it affects the tasks of human interpretation and diagnosis. As a result, speckle filtering is a critical pre-processing step for feature extraction, analysis, and recognition from medical imagery measurements [1]. For 2-dimensional B-mode ultrasound images, we use an image enhancement algorithm based on filtering and noise reducing procedures from the coarse to fine resolution images that are obtained from the wavelet-transformed data. A wavelet-based method is introduced in this paper for efficient speckle suppression in sonographic images of the kidney. The region of interest is obtained from the image [4]. Fuzzy c mean clustering plays an important role in solving problems in the areas of pattern recognition and kidney stone identification.

Texture extraction is the process of quantifying the texture patterns within a specified neighbourhood of size M by N pixels around a pixel of interest [2]. The features extracted give the property of the texture, and are stored in knowledge base the extracted features are compared with the features of unknown sample image for classification [10]. Texture features are used to distinguish between normal and abnormal images.

**Wavelets**

A wavelet is a mathematical function that is used to represent a continuous time signal into different scale components. A wavelet transform is representation of a function by wavelets. Wavelet decompositions are fast to compute and yield a small number of coefficients [1]. As a result, wavelets are exceptionally suited for applications such as data compression, noise reduction, and singularity detection. The image is divided into 4 sub bands by applying DWT as shown in fig.1 (a). These subbands are labeled LH1, HL1, and HH1 represents finest scale wavelet coefficients while LL1 corresponds to coarse level coefficient.
II. PROPOSED METHOD

To overcome the drawbacks of ultrasound medical images image enhancement algorithm has been proposed. Ultrasound medical images are produced in large number because of their availability in all hospitals. The application of wavelets to medical image enhancement has been extensively studied and starts recently to be applied. The conventional methodology for the detection of kidney stone is a multiple step process that includes: speckle noise removal, application of fuzzy c mean clustering for segmentation, statistical feature extraction and classification in neural network. Figure 2 shows the overall process of the proposed system.
A. Preprocessing

Daubechies wavelets are compactly supported orthogonal wavelets which are energy or norm preserving. It is useful in compression and noise removal in image processing. Speckle filtering is a critical pre-processing step for feature extraction, analysis, and recognition from medical imagery measurements. Speckle reduction techniques are classified into three groups: (1) filtering techniques, (2) wavelet domain techniques, and (3) compounding approaches [1].
The discrete wavelet transform (DWT) translates the image into an approximation sub-band consisting of the scale coefficients and a set of detail sub-bands at different orientations and resolution scales composed of the wavelet coefficients. In this method we use ‘db1’-discrete wavelet transform. DWT provides an appropriate basis for separating the noise from an image[6]. These properties make DWT attractive for denoising. From the structural computation point of view, wavelet denoising involves three stages: calculate the discrete wavelet transform; remove noise by changing the wavelet coefficients; and apply the inverse wavelet transform (IDWT) to construct the despeckled image [1]. Thus using dwt speckle noise is removed from the image.

B. Segmentation

Fuzzy C Mean algorithm is one of the well known unsupervised clustering techniques used for segmentation [8]. Clustering of data is a method by which image large sets of data are grouped into clusters of smaller sets of similar data. Fuzzy c means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. It is frequently used in pattern recognition. The process of detection of edge stone in particular image appears very dark on the image which is very confusing. To overcome this problem, fuzzy c mean clustering techniques was performed. The output image will have all gray values in equal proportion. It is used to detect the kidney stone in ultrasound scan image [2].

C. Region of interest

To identify the kidney stone kidney region is focused. We use the area criteria to select the label that represents the stone region and to eliminate the unlikely labels (tape artifacts and high intensity labels). Finally, to obtain the effective kidney stone region, the result of this step was multiplied with the original image. Thus kidney stone is detected [9].The result of renal calculi images are used for the future analysis. From the renal calculi image, the calculi regions are extracted.

D. Texture Feature extraction

The ultrasound medical images based on texture feature consist of several steps. The purpose of feature extraction is to reduce the original data set by measuring certain properties, or features,
that distinguish one input pattern from another. The extracted features provide the characteristics of the input type to the classifier by considering the description of the relevant properties of the image. Statistic features such as mean, variance, standard deviation and entropy are extracted from the detected kidney stone image [8].

E. Artificial Neural Network

Neural networks have achieved a greater in the field of medical image analysis. The concept of neural network is combined with wavelets to develop a CAD system for kidney stone feature detection. The denoised and quality enhanced image obtained after wavelet processing is given as an input to the neural classifier. The difficult task in CAD system development is the feature extraction in images. Kidney stone detection includes four features namely mean, standard deviation, variance and entropy.

The back-propagation algorithm is used to identify the kidney stone [9]. Neural network takes the above said four features as input and classifies whether the detected feature is kidney stone or not. A suit of MLP is used with the classic Back-Propagation learning algorithm.

III. EXPERIMENTAL RESULTS

The method is implemented in Matlab 7.9 to obtain results. We have been used several methods for the detection of kidney stone. Figure 1 shows experimental results for a 5 MHz kidney image captured from a convex probe. Transducers in the range of 6 - 10 MHz are able to detect renal calculi as small as 3 mm. The protection of the renal calculus is based on the presence a of highly echogenic focus with posterior acoustic shadowing of the stone.
Figure 3. Conventional ultrasonography shows a poorly defined low echoic multiple kidney stone (renal calculi). Renal ultrasound demonstrates echogenic focus with an associated acoustical shadow. Such a small stones is easy to be hampered and overlooked by artifacts and speckles.

Figure 4. Despeckling noise by DWT
Figure 4 shows that despeckling noise from the kidney image also the wavelet transform performs like a feature detector, retaining the features that are clearly distinguishable in the speckled data but cutting out anything which is assumed to be constituted by noise.

![Segmented kidney image](image1)

**Fig 5., Segmented kidney image**

Figure 5 shows the segmented kidney stone from the original image. Fuzzy clustering plays an important role in solving problems in the areas of pattern recognition and kidney stone identification. A variety of fuzzy clustering methods have been proposed for automatic detection of stone.

![Detected Kidney Stone](image2)

**Fig 6., Detected Kidney Stone**
Figure 6 shows the detected kidney stone from the ultrasound image. Experimental results showed that the proposed method performed better in detecting stone. The numerical values of these quantitative parameters indicated the good feature preservation performance of the algorithm, as desired for better diagnosis in medical image processing. The visual evaluation is made. The experts suggested that the results produced by the wavelet method and the Weiner filter are approximately same from clinical point of view. But from the speckle removal capability point of view, the wavelet method performs better than other methods.

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Table 1: Features Extracted

IV. CONCLUSION

As diagnosing tool, the conventional ultrasound is a simple method bringing useful information but largely dependent on the examiner. We present an ultrasound image enhancement algorithm based on the wavelet transform. In ultrasound images, the speckle energy is comparable to the signal energy in a wide range of frequency bands. So it is not easy to discriminate speckle from the signal only using magnitude statistics of wavelet coefficients in the decomposed image. In the proposed algorithm, to discriminate speckle from the signal, we obtain the structural information from the wavelet decomposed image. Fuzzy clustering plays an
important role in solving problems in the areas of pattern recognition and kidney stone identification.

The features extracted give the property of the texture, and are stored in knowledge base the extracted features are compared with the features of unknown sample image for classification. The experimental results show that the proposed algorithm considerably improves the subjective image quality without generating any noticeable artifact, and provides better performance compared with the existing enhancement schemes. Our algorithm was tested and found to be effective for an exact matching of the signal and noise distributions at different scales and orientations. Computerized analysis of the US data objectifies the examination and makes easier and more accurate the early diagnosis of certain diseases which usually provide similar US images.

REFERENCES


