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Diagnosis of Abnormality in Ultrasound Kidney Images using Spectral Components

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ABSTRACT

Ultrasound image diagnosis has become wide spread because it is a low cost, reliability and noninvasive procedure. The image is first removed of speckle noise using contour let transform after which based on the algorithm designed, the objective diagnosis is made. Spectral analysis of images is done to extract the content descriptive information that defines the characteristic of the image. In this research, three classes of ultrasound kidney images such as normal, medical renal diseases and cortical cysts are collected from medical centre. Then the spectral component namely *mean power* P_m and total power P_t, are evaluated for possible objective diagnosis and classification. Feature extraction is done on images, which are preprocessed. Circles are formed on the spectrum of the image to determine the P_m and P_t. A threshold value is determined from this component using which the classifications of kidney images are done. The algorithm will compare the input kidney image with the standard reference image. This will result in the objective classification of kidney as normal or abnormal.

KEY WORDS: Ultrasound image, Spectrum, Denoising, Wavelet, and Contour let transform

1. INTRODUCTION

Ultrasound images are widely used in the clinics as it is portable, affordable and a non-invasive technique with no ionizing radiation involved. This method also called as Sono graphy uses high frequency sound waves to obtain the images of internal organs. The high frequency reflected sound waves echoes are recorded and displayed as visual image. The main shortcoming of ultrasound imaging is the presence of speckle patterns. This speckle noise is removed using contourlet transform.

Figure.1. Ultrasound Kidney Image

When the ultrasound transducer is pressed against the skin, it directs a stream of inaudible, high-frequency sound waves into the body. The sensitive microphone in the transducer records the strength and character of the reflected waves and mapped as an image. This image is used for the purpose of objective diagnosis. This classification is done on the basis of extracted features of the spectral components.

This research work concentrates on image classification task through the use of image spectral components. The spectral components within the image for each class used for categorization. Categorization carried out based on their spectral relationship with the standard reference values. The organization of paper is as follows: section 2 discusses the literature survey, section 3 provides the spectral analysis of the image, section 4 provides the experimental results and section 5 provides the conclusions.

2. MATERIALS AND METHODS

Ultrasound images are mainly affected by Speckle noise, which can be effectively removed by wavelet, and contourlet transform. The sample ultrasound kidney image is first denoised with wavelets and contourlets using MATLAB software and comparative results are tabulated. After denoising the kidney images are classified into three types based on spectral component analysis.

Related Terminologies:

Power Spectrum: Power spectrum defined as the modulus square of Fourier transform of the image. The power components obtained from the spectrum analyzed for the objective study. Various power features extracted and studied. Mean power (P_m) and Total power (P_t) are the two important features in our consideration.

Spectral Components: The characteristics of an image explained well using its spectral components. In medical field, most of the diagnostic works after scanning done using this technique. By applying the spectral function to the image, the pixel values changes to power values. The spectral components necessary for this research: Mean power and Total power.

Spectrum Analysis of Ultrasound Images: The pre-processed ultrasound image is converted to spectral image for analysis. The power spectrum of each image found and then the image is divided into sections. This is performed using the method called circling. Our approach mainly concentrates on sectoring the image into concentric circles.

Image Classification using Spectrum Analysis: One important application of Power spectral analysis is to classify digital (binary) images. Due to the high variability of medical image data it is important to use appropriate method for the classification process. One can perform a range of operations including simple extraction of regions of interest, subtraction of background. These operations need to be performed very carefully to minimize their effect on measurements made in the power spectra.

3. EXPERIMENTAL RESULTS

An ultrasound image is denoised using wavelets and contourlets, The SNR of wavelets Vs contourlets for different Noise Densities of Ultrasound Image is shown in Table 1. It is found that denoising using contourlet provides better results

Table.1. Comparison of noise density for noisy image and image denoised using Wavelets and Contourlets

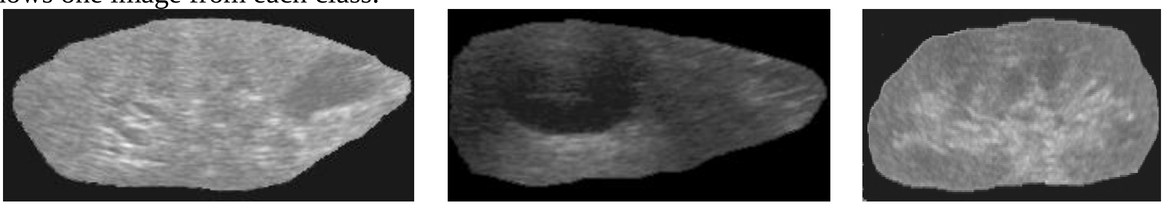
Noise Density (dbm/Hz)	Noisy image	Wavelets	Contourlets
	SNR(dB)	SNR(dB)	SNR(dB)
0.040	6.17	6.31	8.33
0.045	5.61	5.77	7.79
0.050	5.13	5.36	7.18
0.055	4.89	5.14	6.92
0.060	4.38	4.65	6.25
0.065	3.84	4.13	5.53
0.070	3.79	4.08	5.48

Table 2 below gives the various values of Sigma and the corresponding Signal to noise ratio of Noisy Image, Denoised image using Wavelets and Contourlets.

Table.2. SNR comparison for denoising using Wavelets and Contourlets

Sigma	Noisy image S/N (db)	Wavelets S/N (db)	Contourlets S/N (db)
0.01	12.2	12.68	12.82
0.02	10.46	11.1	11.53
0.03	9.31	9.92	10.45
0.04	8.36	8.95	9.51
0.05	7.57	8.11	8.64
0.06	6.97	7.47	8
0.07	6.92	7.42	7.93
0.08	6.37	6.82	7.3
0.09	5.9	6.29	6.77
0.1	5.43	5.82	6.25
0.12	4.65	4.99	5.38
0.14	4.05	4.35	4.67
0.16	3.48	3.74	4.04
0.18	2.99	3.24	3.51
0.2	2.54	2.76	3.01

After denoising the ultrasound image, the next step is to classify the three classes of kidney images. They are Normal Kidney, Medical Renal Disease (MRD) and Cortical Cyst image. Ten images of each class are collected and made an image data bank. Each image differs in size, so all are adjusted to a standard size before applying spectral function. All the thirty images are analyzed in terms of the total power and the mean power. Figure 2 given below shows one image from each class.



Medical Renal Disease **Cortical Cyst** **Normal**

Figure.2.Different classes of image

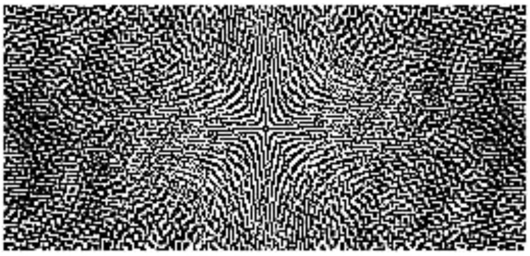


Figure.3.Shifted Fourier Transform of the image

Preprocessed ultrasound images are taken by class as the input to our algorithm. First step is to take the Fourier transform of this image. Now to get the perfect distribution of frequency over the image, shifting of Fourier transform is carried out. The spectrum image is shown in Figure 3.

Next step is to sector this image into circles with increasing radius from the centre. For carrying out perfect sectoring, padding of the image is necessary which is shown in Figure 4. Then some specified numbers of concentric circles are drawn on the image. These circles have same step in radius. From this, we concentrate more on the 4th and 5th circles with angular frequencies: $\omega_4 = \pi / 30$ and $\omega_5 = \pi / 37$, where the maximum difference in power values are noticed. Thus the total and mean powers inside these circles are determined and plotted which shows a perfect distinction between the three classes.

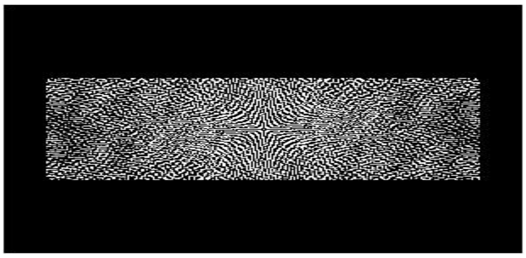


Figure.4. Spectral image after padding

Analyzed all the images in spectral domain and the result indicate that maximum variation is present in 4th and 5th circles. For this work there are two results based on the $\boldsymbol{P_m}$ *and* $\boldsymbol{P_t}$ values. The values obtained is shown in Table 3

Table.3. Values obtained for kidney classes

Class	P_m		P_t	
	ω=π/30	ω=π /37	ω=π/30	ω=π/37
NORMAL	175059.6	185951.7	1750596	1859517
MRD	162238.4	173553.1	1622384	1735531
CYST	167280.6	179350.8	1672806	1793508

P_{mean} is the mean of the power values inside the circle with angular frequency specified for the all ten images in each class. This gives a range with perfect boundary, i.e. without overlapping of values. P_{tot} is the sum of the power values inside the circle with angular frequency specified for the all ten images in each class. From these values two graphs are plotted and presented in Figure 5 and 6.

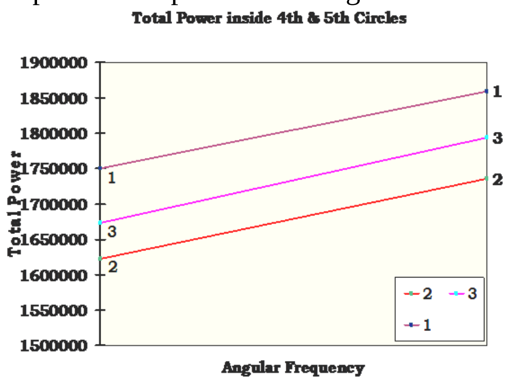


Figure.5. Total power values in ω = π / 30 and ω= π / 37

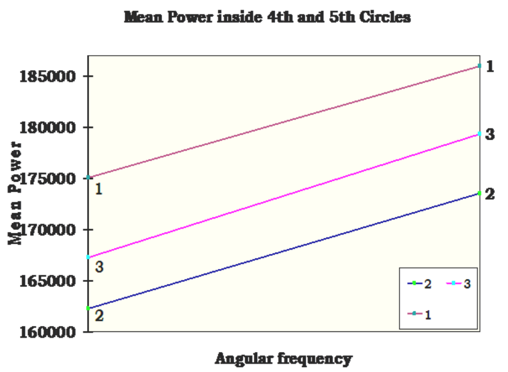


Figure.6. Mean power values in ω = π / 30 and ω= π / 37

Line numbers 1, 2 and 3 represent Normal, MRD and Cortical Cyst classes of kidney respectively. These plots points to the objective classification of Ultrasound Kidney Images.

4. CONCLUSION

The ultrasound kidney image was denoised using contour let transform and then classified using spectral components. From the results obtained, it can be concluded that the proposed algorithm can classify ultrasound image with high degree of accuracy. From the values given in the table above, we can fix a threshold value for classification. The threshold limit we obtain as the result of this spectral analysis gives a relative function of kidney and its abnormality. This threshold value can be used in future as a reference value which helps for diagnosis of kidney deficiencies. The pixel values inside the circle with one particular frequency are added up to attain the threshold value. The amount of step size, given to the algorithm determines the accuracy of classification of image. The proposed algorithm can classify the ultrasound kidney images into MRD, CYST and NORMAL more accurately.

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