Distinguishing Staghorn and Struvite kidney stones using GLCM and Pixel Intensity Matrix Parameters

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ABSTRACT

Kidney stone disease is one of the common health problems throughout the world and majority of people with kidney stone formation do not notice the disease at initial stage as it damages the organ slowly. According to the survey conducted in 2013, 49 million people were affected by kidney stone diseases and nearly 15,000 deaths occurred due to kidney stone. The currently used low cost imaging techniques for the diagnosis of kidney disease is X-ray imaging and US(Ultrasound) imaging. Image analysis and image processing techniques are used for the kidney stone identification and kidney stone disease management. Here two sets of staghorn and struvite kidney stone images (three in each set) are considered. This paper analyses the Gray Level Co-occurrence Matrix (GLCM) parameters and pixel intensity matrix parameters for the categorization of struvite and staghorn kidney stone images.

Keywords– **Categorization- staghorn, struvite, GLCM, MATLAB, pixel intensity matrix**

I. INTRODUCTION

Kidney stone disease is one of the most common health problems throughout the world. Since it does not show any particular symptoms in its initial stage, majority of people with this disease do not realize the problem in early stage and it can be noticed only when the disease starts damaging the organ. X-ray is used to detect the size and position of kidney, and stones. The diagnosis of kidney diseases and any abnormalities using ultrasound produces the ultrasound images with speckle noise which makes analysis of X-ray images more complex. Therefore image processing technique is chosen in order to enhance the image and remove this speckle noise. According to the survey conducted in 2013, 49 million people were affected by kidney stone diseases and nearly 15,000 deaths occurred due to kidney stone. The kidney stones are formed due to the super saturation of crystals of dietary minerals. Severe pain in the side and back, below the ribs and lower abdomen are the major symptoms. When the pain is severe, nausea, vomiting, frequent urination, foul smelling urine and pain on urination can be felt. Fever and chills can be found if any infection is present.

Farid.G.Mitri et.al [1] proposed a method known as vibroacoustography technique for imaging and then detecting the stones within the kidney and to show the anatomical features while differentiating stones from surrounding tissue. K.Viswanath et.al [2] proposed a method of level set segmentation and ANN classification for the detection of kidney stone from Ultrasound images. P.R.Tamiselvi et.al [3] developed an algorithm on semiautomatic region growth to detect calculi from renal calculi images from Ultrasound images. For an computerized analysis and classification of ultrasound kidney images, K.Dhanalakshmi et.al [4] developed and implemented a computer aided decision support system .K.Bommanna Raja et.al[5] proposed a neural system for the classification efficiency and to identify the categories of kidney stones. K. Krishna et.al[6] presented a computer aided automatic exposure of abnormality in kidney on IOT enabled convenient ultrasound systems.

II. METHODOLOGY

In the proposed method, the acquired images undergo a pre-processing stage which is of two steps namely:

1) Image enhancement for blur removal,
2) Filtering the noise by low pass filter Region of interest is then selected.

The region of interest is then selected whichis an RGB image converted into gray image. For this, two sets of staghorn and struvite kidney stone images (that is 3images for each set) are taken for comparison. The images are analyzed using GLCM parameters and pixel intensity matrix.

The GLCM parameters of the gray image are found. Also the pixel intensity matrix of the gray image is then found and from which the features namely covariance, standard deviation, mean and mode are extracted. The features are found using the formulae:

GLCM parameters:-

Contrast: ∑_(i,j)=⟦[i-j]2 p(i,j)⟧

Where p=image, (i,j)= coordinates p(i,j)= intensity value at i,j

Correlation: ∑_(i,j)=⟦p(i,j)[((i-μ)(i-μ))/√((σ2σ2))]⟧

Energy: $p(i, j)^2$

Where $p(i,j)$= (i,j)th entry in a gray-tone spatial dependence matrix.

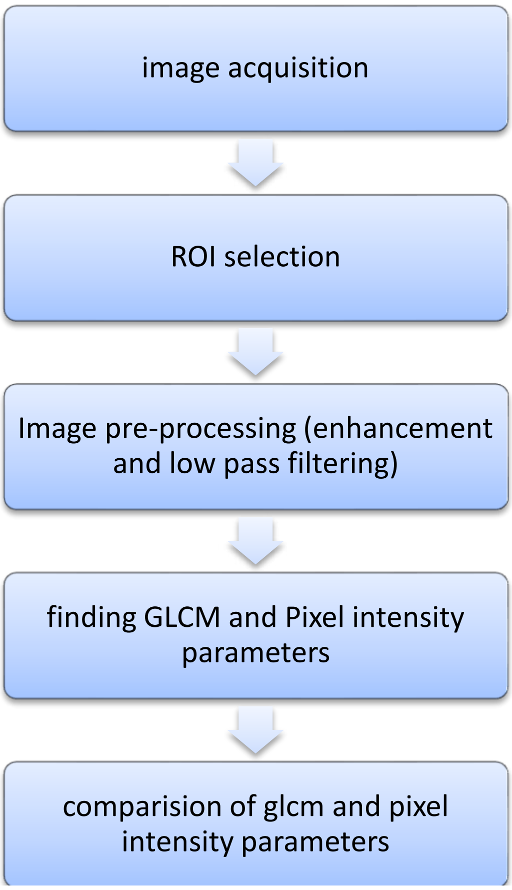

Fig (1) Block diagram

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Homogeneity: $\sum_{i,j} \frac{p(i,j)}{1+[i-j]}$

Where$p(i,j)$= (i,j)th entry in a gray-tone spatial dependence matrix.

Pixel intensity Matrix parameters:-

Covariance: C(x, y) =E [{x−E [x]} − {y−E [y]}],

Where x = row intensity value;
y = column intensity value;
E = mathematical expectation;

Standard deviation: $\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x-\bar{x})\,2}$

Where n= total number of pixels in selected region
$\bar{x}$= mean

Mean: $x^n = \frac{\sum_{i=1}^{n} x_i}{n}$

Mode= maximum pixel intensity value

Decision rule:

After finding all the parameters value, the average of each parameter is found by using the formula below:

Average=$\frac{sum\ of\ all\ the\ values}{total\ number\ of\ values}$

Reference value=$\frac{sum\ of\ average\ values\ of\ both\ stones}{2}$

Later, the reference value is calculated by finding the mean of the averaged values. This reference value is considered to distinguish staghorn and struvite kidney stones.

III. RESULT

Figure 1 shows a set of staghorn kidney stone images (three images in each set) and figure 2 shows a set of struvite kidney stone images (three in each).

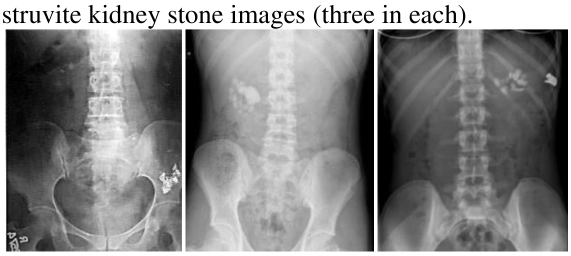

fig 1: X-ray images of staghorn-1, staghorn-2, staghorn-3

fig 2: X-ray images of struvite-1, struvite-2, struvite-3

Similarly table 1 and table 2 shows the glcm parameters for staghorn and struvite kidney stone parameters respectively.Also table 3 and table 4 shows the pixelintensity parameters for staghorn and struvite kidney stone respectively.

Table 1: GLCM parameter values for staghorn kidney stone:-

Images	Contrast	Correlation	Energy	Homogeneity
staghorn-1	0.0452	0.8546	0.6518	0.9774
staghorn-2	0.0547	0.9346	0.5233	0.9726
staghorn-3	0.0367	0.9497	0.5237	0.9816
Average	0.0455	0.9130	0.5662	0.9772

Table 2: GLCM parameters values for Struvite kidney stone:-

Images	Contrast	Correlation	Energy	Homogeneity
struvite-1	1.2708	0.5124	0.0850	0.6744
struvite-2	0.1006	0.8829	0.3935	0.9497
struvite-3	0.0920	0.9186	0.3116	0.9540
Average	0.4878	0.7713	0.2635	0.8593

Table 3: Pixel Intensity Matrix parameter values for staghorn kidney stone

	Covariance	Standard deviation	Mean	Mode
staghorn-1	68.7261	8.2901	228.2618	238
staghorn-2	655.3792	25.6004	172.0081	192
staghorn-3	337.6460	18.3751	166.8763	180
Average	353.9171	17.421	189.049	203.34

Table 4:Pixel Intensity Matrix parameter values struvite kidney stone

Images	Covariance	Standard deviation	Mean	Mode
Struvite-1	1709.2	41.343	190.391	201
Struvite-2	348.67	18.673	194.885	211
Struvite-3	590.073	24.292	128.933	112
Average	885.98	28.102	171.403	174.67

Table 5: Reference Values

Parameters	Reference Values	
	GLCM	Pixel Intensity Matrix
Contrast	0.2665	-
Co-relation	0.8422	-
Energy	0.4149	-
Homogeneity	0.9183	-
Covariance	-	619.95
Standard Deviation	-	22.7615
Mean	-	180.226
Mode	-	189.005

Table 6: Accuracies of both the methods used

Parameters	Accuracy values(in percentage)	
	Staghorn	Struvite
Contrast	100	33.334
Co-relation	100	33.334
Energy	100	100
Homogeneity	100	33.334
Covariance	66.667	33.334
Standard Deviation	33.334	66.667
Mean	66.667	33.334
Mode	66.667	33.334

Calculation:

Reference value= $\frac{sum\ of\ average\ values\ of\ both\ stones}{2}$

$=\frac{0.0455+0.4878}{2} = 0.2665$

The above calculations is for finding the reference value of contrast.

Discussion:

A set of staghorn kidney stone and struvite kidney stone images (three in each set) are taken for analysis.These staghorn and struvite images are preprocessed and the ROI is selected.the average value of glcm parameters-contrast, correlation, energy and homogeneity and the pixel intensity parameters covariance, standard deviation, mean and mode are found and then tabulated.

The tabulated glcm parameters values show that struvite has high contrast and low correlation, energy and homogeneity when compared to staghorn. Also the pixel intensity matrix parameters values are compared which shows that struvite have high covariance and standard deviation whereas the mean and mode values are low.

After analyzing 3 images each, the average values are calculated and from which a reference value is fixed. Based on the reference value categorization of the staghorn and struvite kidney stone can be done.

Considering the glcm parameters, it seems that the contrast values below 0.2665 can be considered as staghorn kidney stone and higher are struvite kidney stone. Similarly the stones with the correlation, energy and homogeneity values above 0.8422, 0.4149 and 0.9183 respectively can be considered as staghorn and those below the above mentioned values are struvite.
Now, considering the pixel intensity matrix parameters, it shows that the covariance and standard deviation values less than 619.95 and 22.7615 respectively can be considered as staghorn kidney stone and higher are struvite kidney stone. Similarly the stones with the mean and mode values above 180.226 and 189.005 respectively can be considered as staghorn and those below the above mentioned values are struvite stones.the stones. However, more kidney stone images are to be tested to know about the accuracy of the proposed method

Conclusion:

A set of staghorn kidney stone and struvite kidney stone images (three in each set) are taken for analysis.The results obtained show that the GLCM performs better in distinguishing the staghorn kidney stone and struvite kidney stones compared to pixel intensity matrix.The reference values obtained by comparing these two stones using GLCM and pixel intensity matrix parameters are tabulated. For the confirmation of the result, analysis has to be performed on more number of images and empirical analysis has to be carried out on multiple images.

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