Study on Ultrasound Kidney Images for Implementing Content Based Image Retrieval System using Regional Gray-Level Distribution

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***Abstract* - This work suggest a method to establish some significant feature parameters to distinguish few important kidney disorders, with ultrasound abdominal scan, to aid objective diagnosis. The proposed method depends on the spatial distribution of intensity values in the kidney region. Based on statistical method of analysis, five parameters namely M-mean, M-med, M-mod, M-max and M-min are obtained. These feature parameters are derived from ultrasound images of normal kidneys, medical renal diseases (MRD) and cortical cysts (CC) cases. The obtained parameters are verified for their potential discriminating capability. The result indicate M-med is an efficient parameter for characterizing kidney disorders, which helps in classification, objective diagnosis and designing content based image retrieval system.**

I. INTRODUCTION

The increasing reliance of modern medicine on diagnostic techniques such as computerized tomography, histopathology, magnetic resonance imaging, radiology and ultrasound imaging shows the importance of medical images. In most of the hospitals these medical images are stored to create a patient database for further reference. The prime requirement for medical imaging system is to display images corresponding to a named patient [1]. This method is based on image indexing schemes that relies on text descriptors or classification codes, supported in some cases by text retrieval packages designed or adapted specially to handle images [2,3]. But the process of locating a desired image based on (i). diseases related to particular organ or part of the body, (ii). nature of origin, (iii). depth of severity, (iv). future prediction of failure or healing is considerably difficult in large and varied image database collection. To overcome this problem, quantification and classification of images, using image processing technique is necessary. The extracted feature parameters that describe characteristics of the images are then can be efficiently used to retrieve images from huge database [1,2], similar to other available content based image retrieval (CBIR) systems. Implementation of such system (i). aid diagnosis by identifying similar past cases, (ii). helps to measure the extent of pathology associated with the diseases, (iii). facilitate to have universal reference for pathology of different nature and category and (iv). helps to avoid subjective decisions by physicians while diagnosing [3,4]. Here in this study five different parameters that are derived based on regional gray level distribution in kidney region is used for developing above mentioned system.

II. MATERIALS AND METHOD

The ultrasound images taken for analysis are obtained from medical centre, Mediscan Systems (P) Ltd., Chennai, India. The images of 50 normal, 50 MRD and 50 CC cases with a mean age of 46 (13.58*), 50.43 (24.59*) and 66.95 (13.19*) respectively (*represent standard deviation) are acquired by using scanning systems (a). ATL HDI 5000 curvilinear probe with transducer frequency 5 - 240 MHz, (b). Wipro GE LOGIQ 400 curvilinear probe with transducer frequency 3 -5 MHz. The longitudinal cross section of the kidney is taken by fixing the transducer frequency at 4 MHz.

The images are not disturbed for its shape, size, texture and intensity as it obliterate the content of information. The pre-processing procedure involved in finding the mentioned parameters is depicted in the flowchart of Fig.1. The sample scanned image for Normal subject #44 is shown in Fig.2. As this image contains unwanted information other than kidney, the image is cropped to select the region of interest (ROI). Finding the coordinate of kidney edges and by using cubic spine interpolation technique [5], contouring is made. Usually in images obtained the orientation of kidney makes an angle with respect horizontal axis (consider as zero degree) hence image is rotated in such way that maximum pixel length measured at edges lies in horizontal axis as shown in Fig.3. Sample images after rotation are shown in Fig.4, Fig.5 and Fig.6 for normal, MRD and CC respectively. Resultant image after rotation has background noise which is not suitable for calculation of feature parameters, hence background subtraction is made. Statistical parameters are then calculated from the background subtracted image.

III. Statistical Analysis

The important objective of statistical analysis is to get parameters that describe the characteristics of entire image group which facilitate comparison between the groups. Already such method has been used for detection of acute myocardial infarction in closed chest dogs [6]. The pre-processed images are gridded with grid size of 25 * 25 and statistical parameters are calculated from each gridded region.

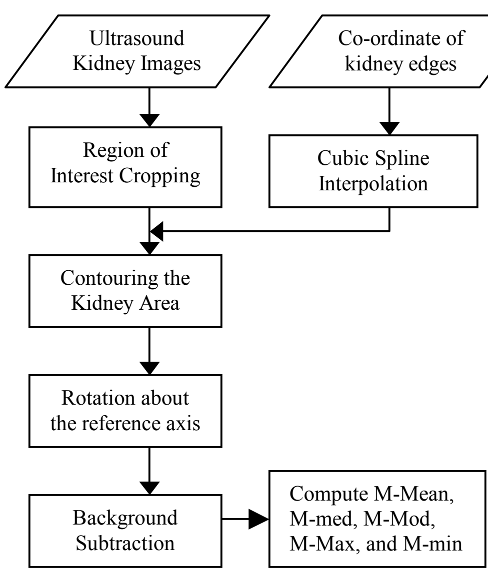

Fig. 1. The flow Chart for Image analysis

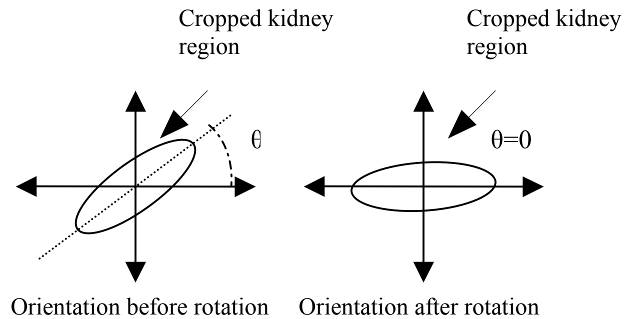

Fig.3. Kidney orientation before and after image rotation

a. M-mean

If $f(x,y)$ is the discrete image intensity [7], 'N' is number of pixel in gridded region and 'M' is number of grids, M-mean is calculated as [8]

$$M-mean=\frac{1}{M}\sum_{j=1}^{M}\left\{\left[\frac{1}{N}\sum_{i=1}^{N}f_i(x,y)\right]_j\right\} \qquad (1)$$

b. M-med

Arranging $f(x,y)$ in ascending order in each gridded region, M-med is obtained as [8]

$$G-med = f(x,y) \text{ of } \frac{N+1}{2}^{th} \text{ pixel}$$

$$M-med=\frac{1}{M}\sum_{j=1}^{M}G_j-med \qquad (2)$$

where $G-med$ is the median value in each gridded region. As grid consists of 625 pixels, $G-med$ value is estimated by finding the mean of two middle values.

c. M-mod

M-mod is obtained from finding the *histogram* $h(x_n)$ that gives the number of pixels with gray level value x_n [7], where n=0,1,2,….L-1, for each gridded region of the image.

$$G-\text{mod} = \max\{h_j(x_n)\}$$

$$M-\text{mod} = \frac{1}{M}\sum_{j=1}^{M} G_j - \text{mod} \tag{3}$$

where $G-\text{mod}$ gives the modal value [8] in each gridded region.

d. M-max and M-min

Maximum intensity value and minimum intensity value in each gridded region are obtained. From these values, M-max and M-min is calculated as

$$M-\max = \frac{1}{M}\sum_{j=1}^{M}\{\max_M[f(x,y)]\} \tag{4}$$

$$M-\min = \frac{1}{M}\sum_{j=1}^{M}\{\min_M[f(x,y)]\} \tag{5}$$

Fig. 2. Ultrasound Kidney Image obtained from medical centre for Normal Subject # 44

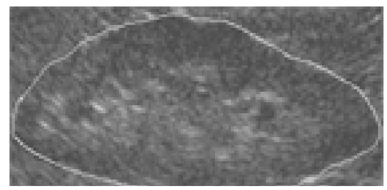

Fig. 4. Normal Kidney for Subject # 09

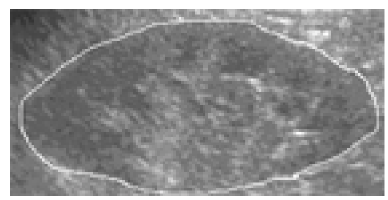

Fig. 5. MRD Kidney for Subject # 24

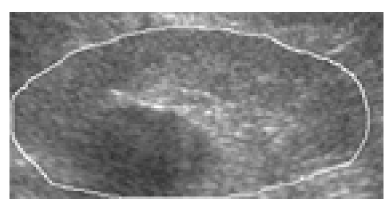

Fig. 6. CC Kidney for Subject # 36

IV. RESULTS AND DISCUSSION

The range of values obtained for the parameters are shown in the Table 1. It can be seen that there is no clear demarcation of values to distinguish kidney disorders from normal. Hence student *t*- Test is performed to measure the significance of these values in distinguishing kidney disorders. The result obtained is shown in Table 2. The Fig.7, Fig.8 and Fig.9 shows the mean intensity value calculated, after gridding, for Normal subject #21, MRD subject # 38 and CC subject #05 respectively. For normal subject the presence of renal mass at the center is represented by the high intensity value and the renal cortex region is represented as low intensity value. Because of renal mass destruction and diffusion of it in cortex region results in more echoes that is being represented by even distribution of high intensity value for MRD case. The depression in intensity values is observed in region where cysts exist in the case of CC. The student *t* - Test result shows that expect M-mod ($p < 0.025$) and M-max ($p < 0.04$) all are highly significant ($p < 0.0005$) and can be used to distinguish different kidney cases taken for analysis. The linear regression analysis indicate that for all three kidney cases M-med is less dependent on projected kidney area of the optimal image obtained during scan ($r = 0.1877$, $p < 0.4281$ for normal; $r = -0.0023$, $p < 0.9934$ for MRD; $r = 0.1137$, $p < 0.6332$ for CC). This analysis indicates that M-med is an efficient statistical parameter, appears to be independent of kidney area, which varies due to random placing of probe while scanning, and become significant in differentiating kidney disorders. This feature parameter can be efficiently used for kidney characterization.

Table 1

Range of values obtained for parameters for three different cases of kidney

S.No.	Parameter	Normal	MRD	CC
1.	M-mean	58.36 - 91.56	67.18 - 90.24	51.67- 76.75
2.	M-med	59.31 - 90.46	66.68 - 94.16	51.48 - 80.56
3.	M-mod	42.44 - 78.41	52.45 - 71.52	31.33 - 59.20
4.	M-max	93.26 - 130.71	83.48 - 124.31	72.92 - 112.38
5.	M-min	42.25 - 72.55	45.40 - 86.34	30.22 - 55.04

Table 2

Student *t*-Test results for Normal, MRD and CC

S. No	Parameter	Normal	MRD	CC	Student t-Test value for Normal / MRD	Student t-Test value for Normal / CC	Student t-Test value for MRD / CC
		Mean (SD)*	Mean (SD)*	Mean (SD)*			
1.	M-mean	71.86 (8.13)	82.02 (5.73)	59.89 (7.13)	p<0.0005	p<0.0005	p<0.0005
2.	M-med	72.68 (8.57)	85.27 (6.95)	60.53 (7.46)	p<0.0005	p<0.0005	p<0.0005
3.	M-mod	56.29 (9.83)	62.18 (5.09)	46.29 (7.54)	p<0.025	p<0.0005	p<0.0025
4.	M-max	108.25 (10.11)	109.52 (10.57)	93.46 (11.62)	p<0.40	p<0.0005	p<0.0005
5.	M-min	52.00 (8.78)	66.69 (14.77)	38.66 (7.45)	p<0.0005	p<0.0005	p<0.0005

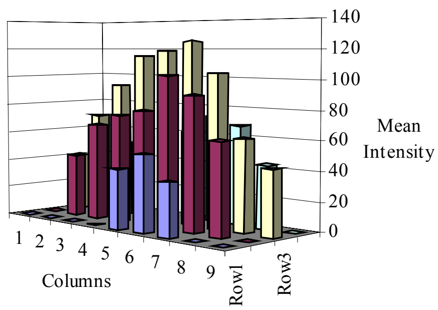

Fig.7. Mean Intensity Distribution for Normal Subject # 21

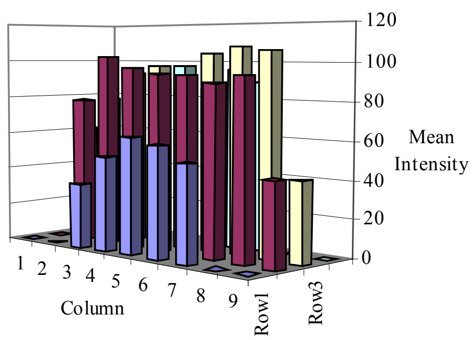

Fig.8. Mean Intensity Distribution for MRD Subject # 38

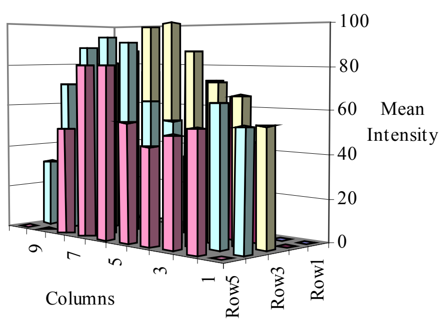

Fig.9. Mean Intensity Distribution for CC Subject # 05

V. CONCLUSION

This analysis clearly indicates that the feature parameters extracted based on statistical analysis can be used for kidney classification and objective diagnosis. It is also found from the results that the parameter M-med dominates over other parameters. This parameter can be used to create a database of ultrasound kidney images with different pathologies. It is concluded that the database with this parameter will be sufficient for comparative studies on pathologies while diagnosing.

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