Identifying Renal Calculi using different Techniques

Ranjitha. M
Department of Information Technology
CMR Institute of Management Studies
Bangalore

G.M Nasira
Department of Computer Science,
Government Arts College, Tirupur

ABSTRACT
Identifying Renal Calculi is a major challenge in medical field. Many researchers have worked on different methods to identify the renal calculi from scanned images like Ultra sound, CT, MRI etc. The objective of this paper is to analyze different approaches suggested to detect renal calculi using various techniques. Existing literatures that have discussed the various approaches of detecting renal calculi from scanned images, categorizing them according to the methodology were reviewed. Algorithms for identifying renal calculi from Shadow, Seeded Growing Methods, Watershed Methods, Spatial gray level dependence Method and a Combinational Approach (CANR) with their advantages and limitations is discussed. CANR is compared with other methods and its performance is analyzed.

Keywords
Intensity threshold, Seeded Region Growing, Preprocessing, Classification, Co-occurrence matrices, Watershed Method, Noise Removing, Smoothing

1. INTRODUCTION
The two kidneys are located deep behind the abdominal organs, below the ribs and towards the middle of the back. The kidneys are accountable for removing wastes from the body, maintaining electrolyte balance and blood pressure, and triggers red blood cell production. It filters out fluids and waste from the body, there by producing urine [1] [2]. Kidney stones are hard, solid particles that form in kidney and in urinary tract. In many cases, the calculi are very small and can pass out of the body without any problems. Sometimes these stones get stuck in urinary tract, (even a small one) blocks the flow of urine thereby excruciating pain may result, and prompt medical treatment is needed. The existence of renal calculi was known from many years, and lithotomy for the removal of stones is one of the earliest known surgical procedures. New techniques in lithotomy began to emerge from 1520, but the operation remained risky [3] [4] [5] [6]. When Henry Jacob Bigelow popularized the technique of litholapaxy in 1878, the mortality rate reduced from about 24% down to 2.4%. Still, other treatment techniques were also developed that continued to produce high level of mortality, among inexperienced urologists. In 1980, Dornier MedTech familiarized extracorporeal shock wave lithotripsy to break up stones via acoustical pulses, and since then this technique has become very popular [7]. With the advancement in technology, different scanning methods like Ultrasound scan, CT scan and MRI scan became popular and the next trend was to identify calculi from these scanned images.

2. SEGMENTATION TECHNIQUES
There are different segmentation techniques followed by different researchers. The whole image is extracted and the homogeneity in features is identified. The second step is to identify the borders between these regions. For this, Region Extraction techniques like, Pixel based Approach, Thresholding or Region based approach is followed [16-20]. In Pixel based approach, the feature values at every pixel are mapped to a feature space and thus distinct clusters are formed. Every pixel is treated independently. In Thresholding, a feature histogram is expected to contain different peaks and valleys each of which corresponds to distinct type of regions. In region based approach a seed pixel is identified. All nearest neighbor, 4 or 8 is selected as pixels of same region, if they together satisfy the homogeneity property of a region. This process is continued recursively [8].

2.1 Region Growing Approach
Sridhar, S. has used a region growing approach for identifying the renal calculi. Using Ultrasound Scan (US) technique, images of kidney are taken. Since US images contains noise, it is removed using background removal and filtering. Bright spots are separated using various techniques. But all bright spots are not calculi. To differentiate calculi and shadow there are two phases. In first phase, image is scanned line by line. A pixel with higher intensity value is selected as seed. Neighboring pixels within the same range are added, to grow the region and a complete region of similar intensity is obtained. This method identifies all the bright spots. The second phase differentiates the calculi from these white spots and identifies the kidney stones using shadow. For this, the region below the identified bright spots is taken as a polygon. A 3X3 mask of unit weight is applied with in this ROI. If the value lies between the upper and lower limit of ROI pixels then it is considered as a shadow point. If the shadow points are connected in the neighborhood, algorithm identifies the presence of Calculi [9].

Tamilselvi and Thangaraj has applied all the three methods like Pixel based, Thresholding and Region based approach to detect the presence or absence of renal calculi. Images are analyzed using textural approach. Only with segmentation method, it is not possible to get the required results due to the presence of noise and artifacts. Hence some extra features like texture, shape etc are identified. The sizes of the segmented parts are compared with the size of the stones in the database. Based on the size of the stones, presence and absence of stones are detected [10][11].

2.2 Watershed Segmentation
In this technique, edges are detected more accurately. It gives a continuous boundary or contour around each region. The image is viewed as gray level, which is treated as two dimensional and three dimensional topographic surface A new Watershed Method for MR Renography (MRR) Segmentation was also proposed by Chun-yan Yu and Ying Li to identify the kidney regions. Watershed transform is one of the popular image segmentation methods but one of the major drawbacks is its over-segmentation. Authors have

proposed a new watershed method for MR renography image segmentation. In order to achieve smoothing and to enhance the contrast in image preprocessing, the total variation model is used as a nonlinear filter. The experimental results claims that this approach solves the over-segmentation problem effectively and it can identify the kidney regions more accurately [12].

3. TEXTURE SEGMENTATION

Texture analysis is another approach followed for renal identification [13]. Texture is evaluated based on features like coarseness, smoothness, granulation, randomness and regularity. Textural features can also be used for identification of depth and orientation. There are three major approaches followed

(i)Spectral Approach- This is based on Fourier spectrum. Image is analyzed by identifying the percentage energy in peak. Laplacian of the peak, angle of the peak, area of the peak, distance of the peak from origin and angle between two highest peaks are studied.

(ii)Statistical Approach - In this method, autocorrelation functions, texture edges, structural elements, spatial moments, spatial co-occurrence probabilities, gray level run length and autoregressive models are used

(iii)Structural Approach-This deals with the Primitives (connected set of pixels characterized by attributes) and their spatial relationships are taken into consideration to identify renal stones [14 - 17].

3.1 Statistical Approach

The Spatial Gray Level Dependence Method (SGLDM) is widely used for statistical texture description. All known visually distinct texture pairs can be discriminated using above method. The statistical features of second order can be computed in two phases. The first step delivers the co-occurrence matrices containing the element P (i, j). Each (i, j) th entry of the matrices represents the probability of going from pixel with gray level (i) to another with a gray level (j) under a predefined newly recommended angles, 0^o, 30^o, 60^o, 90^o, 120^o and 150^o. On the basis of the co-occurrence matrices, texture features are classified [18].

Another proposed approach was to extract the feature of kidney from ultrasound images based on five intensity histogram features and nineteen gray level co-occurrence matrix features. Kidney ultrasound images were divided into four different groups; normal (NR), bacterial infection (BI), cystic disease (CD) and kidney stones (KS). Kurtosis, mean, skewness, cluster shades and cluster prominence are examined to determine the various groups with different pathologies [19].

4. COMBINATIONAL APPROACH [CANR]

G M Nasira and Ranjitha M [20] have worked on a new approach of extracting probable calculi from ultrasound images. In this approach, various noise removing techniques were used to extract the probable stones. A combination of Wiener and Median (WM) is applied on US images . Figure 1 is the raw ultra sound image of kidney and Figure 2 is the same image after implementing CANR (Combinational Approach on Noise Removing and Smoothing). It is very clear from the given figures that this approach has reduced the noise and the stones are highlighted.

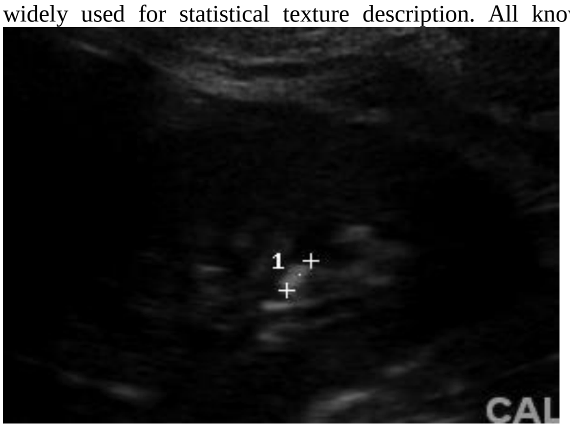

Figure 1: Original Raw US Image

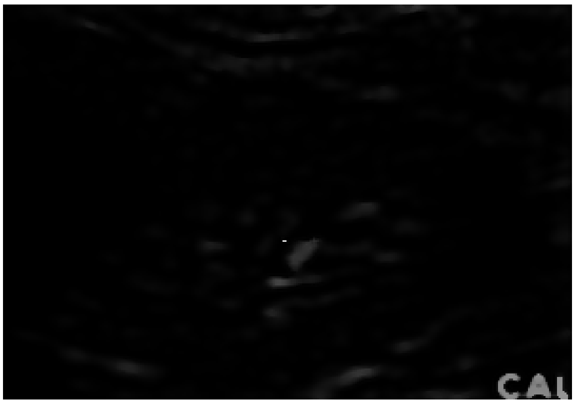

Figure 2: US Image after applying CANR technique

In general, all the approached was based on the following model.

Preprocessing

Segmentation

Feature Extraction

Formation of diagnosis rules

Object Recognition

5. PERFORMANCE ANALYSIS

Performance of CANR was compared with Median and Gaussian on Median (GM) and is analyzed using various statistical measures. The performance analysis is based on 45 US images and the sample MSSIM values of 10 images are given in Table 1.The MSSIM value should be closer to unity for optimal measure of similarity. MSSIM Values are calculated after applying Median, WM and GM filters on original raw images.

Table 1. MSSIM for Median, WM and GM

MEDIAN	WM	GM
0.08912	0.845	0.456
0.0904	0.864	0.367
0.5338	0.626	0.0752
0.1777	0.2962	0.0013
0.2345	0.8276	0.0412
0.1548	0.6450	0.0564
0.2784	0.8645	0.3471
0.3245	0.8789	0.0345
0.1467	0.7958	0.0403
0.1563	0.7863	0.0432

The Performance of CANR is meticulously investigated and the accuracy of the framework is determined. It is able to attain the efficiency of 91.80%. Accuracy (ACC) is a statistical measure which checks how exactly a test identifies and excludes a given condition. This can be measured from Sensitivity and Specificity parameters [21]. Sensitivity/True Positive Rate (SV/TPR) is the probability of correctly identifying the renal calculi from an US image. Higher the sensitivity, higher are the chances of true diagnosis. Specificity / True Negative Rate (SP/TNR) is the probability of false-positive result. That is, it measures the probability of detecting an US image without stone. Positive Predictive Value (PPV) Predicts that an US image contains Calculi and Negative Predictive value (NPV) predicts that an US image does not contain a Calculi. CANR is compared with few popular algorithms and the performance analysis is shown in Table 2 below.

Table 2. Sensitivity, Specificity Analysis

Algorithm	SV (%)	SP (%)	PPV (%)	NPV (%)	ACC (%)
Region growing algorithm with shadow detection	72.72	85.71	100.00	50.00	75.86
Automatic seed selected region	94.82	100.00	100.00	50.00	78.57
Morphology based watershed	72.72	100.00	100.00	50.00	78.57
CANR	96.00	99.68	93.3	87.50	91.80

6. CONCLUSION

All the algorithms in this review have detected the presence of Calculi. But the major difference lies in the accuracy and detection of borders. The challenge in US image lies in differentiating the artifacts or air bubbles in kidney. Moreover, an artifact can be misinterpreted as calculi in ultrasound scanned images. CANR has produced 91.80% accuracy in predicting an US image of Kidney with the presence or absence of Calculi. Extracting Kidney region from the US image is very challenging due to its complex anatomical structure. An accurate algorithm is necessary for segmenting kidney region from medically scanned images. A new approach of differentiating artifacts from calculi can solve the problem of wrong diagnosis in medical Ultra sound Kidney images. Methods vary in advantages and disadvantages, and the choice of which algorithm to use depends on the requirements posed by the application at hand.

7. REFERENCES

[1]http://www.scripps.org/articles/3169-acute-tubular-necrosis.html.

[2] Malvinder, S.P, 2004, Kidney stones. Br. Med. J., 328:1420-1424. DOI: 10.1136/bmj.328.7453.1420, 2004.

[3]http://www.healthcentral.com/ency/408/guides/000081_1.html

[4] http://www.nytimes.com/health/guides/disease/kidney-stones/background.html

[5] Neil R. Owen, Michael R. Bailey, Lawrence A. Crum and Oleg A. Sapozhnikov, 2007, Identification of Kidney Stone Fragmentation in Shock Wave Lithotripsy, In Proceedings of IEEE Ultrasonics Symposium, New York, NY, pp. 323-326, 2007.

[6] Ioannis Manousakas, Chih-Ching Lai and Wan-Yi Chang, 2010, A 3D Ultrasound Renal Calculi Fragmentation Image Analysis System for Extracorporeal Shock Wave Lithotripsy, International Symposium on Computer, Communication, Control and Automation, Vol. 1, pp.303-306, 2010.

[7] www.ospringtechnology.com/Report/Kidney%20stone.pdf

[8] Jun Xie, Yifeng Jiang and Hung-tat Tsui, 2005,Segmentation of Kidney From Ultrasound Images Based on Texture and Shape Priors, IEEE Transactions On Medical Imaging, Vol. 24, No. 1, pp. 45-56, January 2005.

[9] Sridhar, S., 2012. Segmentation of Ureteric and Bladder Calculi in Ultrasound Images, Journal of Computer Science 8 (5): 716-720, 2012.

[10] P.R.Tamilselvi, Dr.P.Thangaraj.,2011 Segmentation of Calculi from Ultrasound Kidney Images by Region Indicator with Contour Segmentation Method, Global

Journal of Computer Science and Technology Volume 11 Issue 22 Version 1.0 December 2011.

[11] Tamilselvi and Thangaraj, 2011, Computer Aided Diagnosis System for Stone Detection and Early Detection of Kidney Stones, Journal of Computer Science, Vol. 7, No. 2, pp. 250-254, 2011.

[12] Chun-yan Yu ,Ying Li , 2012, A Watershed Method for MR Renography Segmentation, IEEE Conference Publications Biomedical Engineering and Biotechnology (iCBEB), 2012

[13] Jun Xie, Yifeng Jiang and Hung-tat Tsui, 2005, Segmentation of Kidney From Ultrasound Images Based on Texture and Shape Priors, IEEE Transactions On Medical Imaging, Vol. 24, No. 1,pp. 45-56, January 2005.

[14] Digital Image Processing William K Pratt, PixelSoft, Inc.Los Altos, California- 4th Edition

[15] Digital Image Processing by John C Russ, North Carolina State University Materials Science and Engineering Department Raleigh, North Carolina - 6th Edition.

[16] Digital Image Processing and Analysis,B.Chand and Majumder-PHI Learning, 2nd Edition.

[17] R. Nevatia, K. Babu (1980) Linear feature extraction and description Computer Graphics and Image Processing,Vol. 13.

[18] Saurin R. Shah, Manhar D. Desai and Lalit Panchal, 2010, Identification of Content Descriptive Parameters for Classification of Renal Calculi, International Journal of Signal and Image Processing, Vol.1, No. 4, pp. 255-259, 2010.

[19] Hafizah, W.M.; Supriyanto, E.; Yunus, J., 2012, Feature Extraction of Kidney ultrasound images based on intensity histogram and Gray Level Co-occurrence Matrix", Modelling Symposium (AMS), 2012 Sixth Asia Publication , pp. 115 - 120 ,2012.

[20]. G.M. Nasira, Ranjitha. M, 2014, A Combinational Approach For Noise Removing And Smoothing Ultra Sound Kidney Images. International Journal Of Computer Engineering & Technology (IJCET).Volume:5, Issue:3, pp:138-147, March 2014.

[21] Devashish Sharma, U.B. Yadav, Pulak Sharma, 2009, The Concept Of Sensitivity And Specificity In Relation To Two Types Of Errors And Its Application In Medical Research, Journal of Reliability and Statistical Studies Vol. 2, Issue 2,pp: 53-58,2009