Kidney Stone Detection using Image Segmentation and Radial Transform

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Abstract:
While identification and detection of stone in kidney, it is imperative to use ultrasound image diagnostic methodology. However, manual analysis of ultrasound image is a tiring and cumbersome process, therefore, an automated method using radial transform is proposed that includes minimum and maximum radii in each quadrant, then area and perimeter in each quadrant gives the good estimate of the stone size. While the center of mass gives the location of the stone in image. All the measurements are taken in pixel units and can be converted to real scale by taking proper scaling factor.
Keywords: kidney stone, Ultrasound Imaging, Radial Transform, Image Thresholding, Image Segmentation.
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1. Introduction

Ultrasound imaging is the primary choice of physician because it is radiation free and economical cheaper than other techniques. Furthermore, it can be used to estimate kidney size, its position, and presence of cysts, stones and diagnosing other structural abnormalities. We cannot ignore kidney related problems as kidney malfunctioning can put life in risk. So, it is necessity to detect and locate the kidney stone in the earlier stages to perform the surgical operation to remove kidney stone successfully. It is too necessary to identify the exact and precise location of kidney stone during surgical processes. Even though, ultrasound imaging is used to detect and locate the position of the kidney stone but it is highly challenging task due to having low contrast and speckle noise.

This paper is organized into four sections. Section I represents overall introduction of concept. Literature Survey signified in Section II. Section III has discussions about automatic kidney stone recognition system and Section IV represents the conclusion of the research paper.

2. Literature Survey

K. Kumar, and B. Abhishek [1] have introduced a study which defines the comparison among three neural network algorithms namely Radial basis function, Learning vector quantization and Multilayer perception with back propagation algorithm to recognize kidney stone disease.
M. D. Sorensen et al. [2] have proposed comparison study between color Doppler twinkling artifact and B-mode ultrasonography to detect kidney stone.

T. Rahman and M. S. Uddin [3] have developed and implemented a system which could segment the kidney from ultrasound image and helps the doctor during surgical operations.

Qu. Zhong et al. [4] have appropriate methodologies were selected in order to handle a variety of real-world practical applications in the field of demand. The picture segmentation algorithms used certain characteristics, but there were always limitations to what these algorithms could do. The Otsu algorithm and the improved Otsu method were investigated in this work together with certain threshold segmentation and edge detection methods. Various images were used to analyse, research, and compare the simulation's results. The results show that the improved Otsu algorithm may greatly improve the accuracy of picture segmentation.

M. Marsousi et al. [5] introduced a three-dimensional ultrasound system for automatically detection and segmentation of kidneys in 3-D abdominal ultrasound images. The main motive of this paper was to check whether 3-D ultrasound image contains kidney or not. If the kidney was present then identified where it is located as well as segmented it.

P. T. Akkasalgar and S. S. Karakalmani [6] have developed a method to segment and identify area of kidney stone from the ultrasound image of kidney.

Soumya and Narayanan [7] have proposed a computer aided system to detect kidney disease automatically in ultrasound image. Initially, they were obtained region of interest manually by the help of physician to limit the possibilities of error.

Ranjitha [8] have developed a system for detection of kidney stone from ultrasound image. The key motive of this system was to detect the exclusive features of a ROI.

P. Vaish et al. [9] have developed an android application for B-mode ultrasound images to detect automatically abnormality of kidney. The main abnormalities were stones and cysts which were detected using Viola Jones algorithm.

M. Pathak et al. [10] have developed a semiautomatic system aimed to identify the stone region in the kidney ultrasound image. The system consists of feature extraction and classification.

3. Automatic kidney stone recognition system

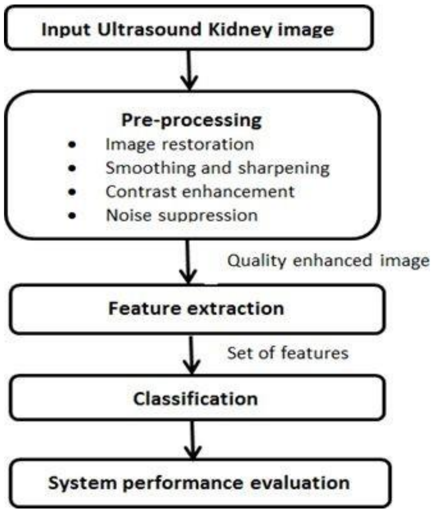

Figure -1 Block diagram of automatic kidney stone recognition system

Image Acquisition

For kidney stone detection, the very first step is to acquire kidney ultrasound (US) image using ultrasound machine. In the presented algorithm, the US images are acquired from a medical imaging centre in Gurtirath scan centre (Amloh), Preet scan centre (Khanna), UroCare hospital (Khanna), Rajindra hospital (Patiala). A large number of US image data base is maintained in the system with patient IDs and other attributes.

Image Preprocessing

After the US images are acquired, the next step is to preprocess the image in order to get binary image. The binary image is a black and white image where white is the back ground and black is the object of interest. The image preprocessing operation consists of image enhancement using histogram equalization, image thresholding using Otsu algorithm and noise removal using salt ‘n’ pepper algorithm.[12]

Image Enhancement

Histogram equalization image enhancement technique is best suited for poorly illuminated images and brings out a well brightened image. Poorly illuminated image may have a histogram either as of concave type or convex type. In each type of histogram, all pixels from gray level spectrum do not contribute and hence an image appears to be very blur. However, if good amount of pixels from each gray level intensity contribute in image formation, then the image is enhanced to a satisfactorily level. Histogram equalization is used to enhance contrast. All pixel intensities are enabled to contribute in image and thereby resulting in a flat histogram. Either the input histogram is concave or convex, after histogram equalization, the

histogram becomes in a flat shape. Histogram equalization will work the best when applied to images with much higher colour depth than palette size, like continuous data or 16-bit gray-scale images.

Image Thresholding

Otsu Algorithm is thresholding algorithm that is based on computing the minimum within class variance. It is a repetitive algorithm that starts from 0 gray level intensity and goes till the 255 gray level intensity. At each gray level intensity, the image is divided into foreground and back ground parts and variance from each class is computed followed by within class variance. The gray level intensity at which a minimum of within class variance is obtained, is taken as the gray level threshold. Using the threshold value, the image is binarized into tow colors i.e. black and white.[11]

Noise Removal

Salt and Pepper noise are removed by applying the following algorithm:

If (P0 = BLACK) & P1= P2 = P3 = P4 = P5 P6 = P7 = P8 = WHITE)

Then P0 is the Background Pixel.

If (P0 = WHITE) & P1= P2 = P3 = P4 = P5 P6 = P7 = P8 = BLACK)

Then P0 is the Object Pixel.

P8	P1	P2
P7	P0	P3
P6	P5	P4

Image Segmentation

The binary image is segmented using labeling algorithm that is accomplished using bwlabel command in matlab. bwlabel uses the general procedure given below:

- Run-length encode the input image
- Scan the runs, assigning preliminary labels and recording label equivalences in a local equivalence table.
- Resolve the equivalence classes.
- Relabel the runs based on the resolved equivalence classes.

Feature Extraction

Following statistical features are computed from the analysis of the pattern with respect to centre of gravity for categorization:

a) Normalised Maximum Radii in each Quadrant represented by R1, R2, R3, and R4. See fig. (2

b) Intercepts on each axis represented by X1, X2, Y1 and Y2 with respect to centre of gravity of object. See fig. (2).

c) Mean Radius (RM)

d) Figure Aspect i.e. length to width ratio (FA) FA = (X1 + X2) / (Y1 + Y2)

e) Normalised Perimeter (Np) Np = Total no. of pixels at the contour of object / RM

f) Normalised Standard deviation of radii taken from centre of gravity of object (NSD). SD= √[(Ri – RM)2 /Np] NSD = SD/ RM

Where RM, and Ri are the mean radius and ith radius i.e. distance of ith pixel on contour of the pattern from its centre of gravity

g) Normalised area (NA) of the pattern. = Total pixels on objects / RM2

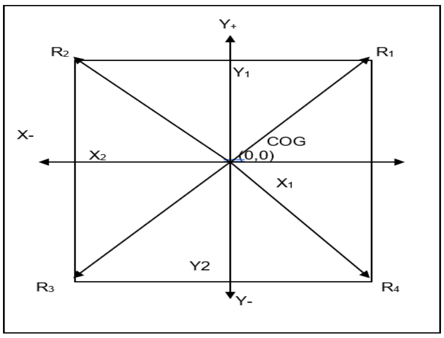

Figure -2

All features are normalized with respect to mean radius of the pattern. It makes all the statistical features independent of size of the pattern. The set of described statistical features may be termed as figures of merit to classify an object.

4. Results and Discussion

The presented algorithm has been applied on different US images and results are given in below table. The different radial features shows that the stones are identifiable with respect to their sizes. The radial features possesses good distinction in order to identify stones from their back ground.

5. Conclusion

The stone in ultrasound images of kidney are clearly identifiable with respect to their size and location using the radial transform. The center of mass gives the location of stone in ultrasound images while the radial transform including minimum and maximum radii along with area gives approximate estimate of the stone size. The features are normalized with respect to location, size and orientation for independent classification of same ultrasound image at different location, size and orientation.

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