

# Abnormality Detection in Kidney Ultrasound Imaging

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**Abstract:** *This paper proposes a technique for segmentation and identification of kidney stone from the ultrasound image of kidney. Initially ultrasound kidney image is pre-processed using two types of filters namely median filter and wavelet filter. Pre-processed image is taken as input for segmentation process; seed region growing algorithm is used to segment the renal calculi from ultrasound image of kidney, further region parameters are extracted from the segmented region. Finally area of each renal calculi and time taken for the entire process is calculated.*

**Keywords:** Ultrasound images of kidney, renal calculi, seed region growing.

## 1. Introduction

In human beings, kidney is the most silent organ. There are pair of bean shaped organ called kidney and are situated at the rear side of abdominal cavity in the retroperitoneal space. Kidney does two important functions like removing harmful substances from the blood and it keeps the useful components in a proper balance. Kidney makes two important hormones namely- erythropoetin and renin. Few of the abnormalities that we can usually find in kidney are congenital kidney disease, kidney infection, diabetic nephropathy, polycystic kidney disease, tract infection and kidney stone.

Imaging has become most essential component in the biomedical and clinical research. Medical imaging is technique that allows physician to create a visual representation of interior organs. They are later used for the clinical analysis and medical intervention. The wide varieties of medical imaging modalities are available to treat and diagnose the disease. For our study we have considered the ultrasound imaging. The ultrasound imaging can be used to measure the size of the renal stone (calculi), appearance of the stone, detect the anomalies, to find out swelling and blockage of urine flow. The drawback of the ultrasound imaging is its poor quality. Presence of speckle noise and disturbance will degrade the quality of images. Diagnosis of the renal calculi depends on many factors like human expertise (radiologist) and quality of the image. Ultrasound images are of low quality which is an important performance limiting factor in visual perception of US imaging that makes calculi complex to identify. When a physician is yet to decide about imaging modality, he must concentrate on potential benefits and risk, so that potential benefits must be greater. However the quality of the US images can be improved by using pre-processing and enhancement techniques.

The most common abnormality that occur in human urinary system is kidney stone or renal calculi. It is a pebble like structure formed by the solid concretion or

crystal aggregation by the dietary mineral components in the kidney. We can also classify the kidney stones based on their location as well as the chemical composition. Based on their chemical composition they are classified as calcium oxalate, uric acid, sturvite and cystine stones. Based on their location kidney stones are classified as kidney (nephrolithiasis), ureter (ureterolithiasis) and bladder (cystolithiasis).

In [1], the authors have proposed detection of renal calculi using semi automatic segmentation approach. They have described the semi automatic method for segmentation of kidney from ultrasound images by using seeded region growing. Seeded region growing is one of the good techniques for identification and classification of renal calculi because this method does not affected by speckle noise. This seeded region growing preserve the spatial information. In [2], the authors have proposed fully automatic and given to automatic algorithm to detect quantification of kidney stones by using symmetric analysis. Initially region of interest has been generated. Their method involves mainly 3 steps: detection of renal stones, segmenting the renal area and calculates the area surrounded by stone. The performance of segmentation method is analyzed and it has produced less relative error. This segmentation method also tests the accuracy. In [3], the authors have proposed Contour Based Squared Euclidian Distance (CSED) segmentation method. In this method initially pre-processing is applied to reduce noise, Squared Euclidian Distances is determined between the training image centroid value and selected region centroid value. Usage of ANFIS supervised learning has made technique little efficient. In [4], the authors have introduced many enhancement techniques and are applied to ultrasound images to see which technique is most suitable. They have concluded that morphological and median filtering provides better results for ultrasound images of kidney. In [5], the authors have proposed, automatic region of interest generation in kidney ultrasound images. The methods consist

of the speckle noise reduction using Gaussian low-pass filter, texture analysis is done by finding the local entropy of the image, threshold selection, morphological operations, object windowing, determination of seed point and last but not least the ROI generation. In [6], the authors have proposed region indicator with contour segmentation (RICS) method. Initially the region indices are checked to see whether they are inside kidney region or not, if inside then those pixels are included in region indices set. It is a supervised method and multiple thresholding made method little complex but provides the expected accuracy. In [7], the authors have proposed computer aided system for stone detection and early detection of kidney stones. Depending on the stone size the classification is done as early stone or stone or normal. In [8], the authors have proposed new technique towards operator independent kidney ultrasound scanning. The presence of speckle noise makes the process difficult to identify the boundary and to find the accurate centroid. Authors work provides the automate detection of centroid for the kidney and their by making further segmentation technique easier. In [9], the authors have proposed analysis of renal calculi in ultrasound image using MATLAB. It also provides a method for obtaining clear images from ultrasound scanning machine by applying different types of filtering techniques. In our proposed work we are only concentrating on only one abnormality renal calculi or kidney stone.

The paper is organized into four sections. Section 2 gives the proposed methodology. Section 3 describes about experimental results. Finally conclusion of the work is described.

## 2. Methodology

In this paper, we have proposed a method for identifying the presence of renal calculi (kidney stone) in the renal ultrasound images. The proposed method also helps in measuring the size and area of the kidney stones as well as the time required for this segmentation process can be calculated. Our methodology consists of pre-processing, segmentation, and region parameter extraction as shown in Fig 1.

### 2.1 Preprocessing

Image pre-processing is used to reduce the noise. Usually ultrasound images are affected by the many artifacts like speckle noise, reflection etc hence it is necessary to pre-process the image. There are so many image preprocessing techniques are available to remove the noise and to enhance the image. For our study, we have used median filtering and wavelet filtering.

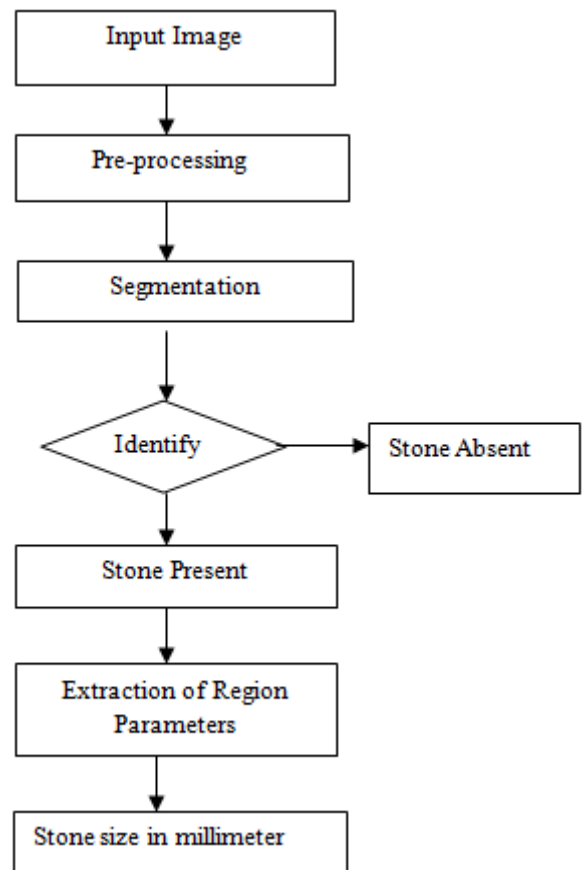


Fig 1 Block diagram of proposed work.

#### i. Median filter

It is a well known and most commonly used non linear filter. It is also known as rank filter. It replaces the original gray image pixel value by its median value in its specific neighbourhood. It helps in reducing the speckle noise, redundant noise present in an ultrasound image.

#### ii. Wavelet filter

It is used to analyze the multi scale image structure. In wavelet we use thresholding to de-noise the image. We can perform hard or soft thresholding on an image. Hard thresholding is simplest than that of soft. Hard thresholding is a process, where the elements whose values are lower than given threshold are set to zero.

### 2.2 Segmentation

Image segmentation is a process of dividing an input digital image into multiple parts or regions. It does the separation of boundaries from an interested organ. Goal of segmentation is to make an image simpler to analyze by representing only a required object or a region. Region growing is the simple segmentation technique. There must be region criterion on what basis the region needs to grow like intensity, gray image etc. It is one of the region based segmentation technique. In our work we find the seed point automatically. Segmentation process starts from the seed point, it checks the neighbouring pixel to decide whether it belongs to seed point region or not. If it belongs to the seed region then is added to the set called seed. If the seed max is reached then new mean is calculated from that point. Same process as above is followed. The similarity is measured as a difference between pixel intensity value and region mean.

**Identification:** Identification process depends on the segmentation results. If the seed region growing algorithms results with regions, it indicates the presence of stone/s otherwise stone is absent. If stones are present in the kidney then size of kidney varies by 2cm than its original size.

**Algorithm:** Region growing segmentation.

**Input:** Ultrasound images of kidney.

**Output:** Segmented regions of kidney representing calculi.

**Start**

**Step1:** Read the pre-processed ultrasound image.

**Step2:** Calculate the mean.

**Step3:** Check if neighbour is inside or outside the image.

**Step4:** Add neighbour if inside.

**Step5:** Add pixels with intensity that is nearer to the mean of a region.

**Step6:** Calculate new mean.

**Step7:** Continue, until all pixels belong to some regions

**End**

### 2.3 Region parameter extraction

Here in our proposed work we are considering both normal and ultrasound renal calculi images of kidney. If the segmentation results with regions representing the renal calculi, region parameters are extracted for that renal calculi US image. Region parameters used are centroid, area, bounding box, pixel id list etc. Segmentation doesn't provide any region; it indicates the absence of the calculi so further region properties are not extracted for such normal images.

i. Centroid: It represents the centre of mass of the kidney. Kidney centroid is detected.

ii. Area: Area is a scalar quantity and it provides the number of pixels present in a particular area. If the segmentation results with the regions, for each region the area is calculated. Later the area is converted to find the size (mm) of each stone.

iii. Bounding box: It is used to represent the region with smallest rectangular box. Bounding box has its own properties like colour, width etc. If not we set the values explicitly it will take the default value. Segmentation results with regions representing the renal calculi, for each calculi region (stone) bounding box is applied (Fig.4(b)).

iv. PixelIdlist: It provides the linear indices of the pixels. It display the each stone area in an array form, later are used to calculate the individual stone value.

## 3. Experimental results

The proposed method is implemented in MATLAB image processing platform version R2012a. The performance is evaluated for 40 ultrasound images of kidney. The images are collected from certain sources like hospital and websites. The image dataset consists of 20 normal renal images, 7 renal calculus (kidney stone) images and 13 renal calculi (kidney stones) images.



Fig 2 Ultrasound images of renal calculus and calculi respectively.

The Fig 2 shows sample US image renal calculus and US renal calculi image. The input images are initially pre processed using median and wavelet filters to denoise or despeckle the ultrasound image. Pre processing is done to enhance the image for easier analysis and accurate segmentation. Fig 3 shows the pre-processed and filtered renal calculi image.

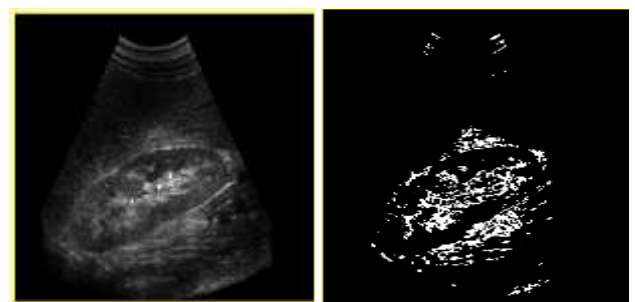


Fig 3 Pre processed and filtered image of renal calculi.

The region growing algorithm is used for the segmentation process; selection of seed point is the critical step and is made automate in our proposed method. Pre-processed renal calculi images are taken as input to region growing technique. It results with the segmented calculi regions. For segmented calculi regions the region parameters - area, bounding box, pixel id list etc are calculated. Proposed method also provides the size of renal calculus in millimetre, finally the time taken for the segmentation process is calculated for each renal calculi image.

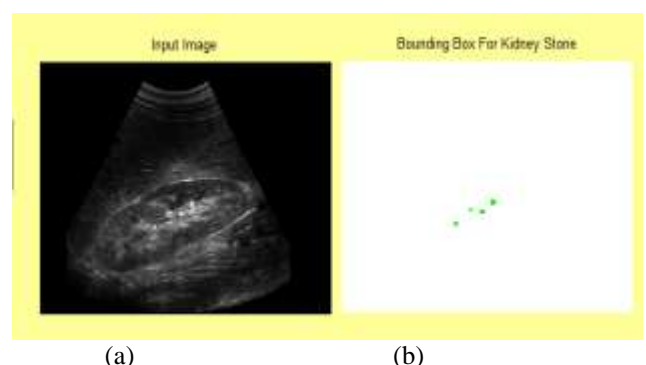


Fig 4 It shows the segmented regions representing calculi with bounding box applied to stone.

In Fig 4 (a) renal calculi ultrasound image of kidney is taken as input and is passed through pre-processing step to despeckle the image. The segmentation is applied to the pre processed image to extract the calculi regions from renal ultrasound image. The presence of stones is indicated with the bounding box (Fig 4 (b)).

Table.1 The area of renal calculi and time taken (sec) in our proposed work for the single image.

Sample image	Number of stone	Total Area(pixel)	Time taken(Sec)
Normal	Nil	Nil	1.02
Calculus	1	8	1.011
Calculi	4	72 (16,4,24,28)	1.003

Table.1 contains the information regarding number of kidney stones, area for each stone and time taken for the process to identify the presence and absence of stone. In above table, we have considered one sample calculus image, it has stone area of 8 pixels and stone size is 3.02mm. Sample calculi images has 4 stones and total area of 72 pixels, each stone is of 16, 4, 24, 28pixels and size of each stone are 4.2mm, 1.05mm, 6.3mm and 7.4 mm respectively.

The performance of the proposed method is evaluated based on the following four cases:

Case1: True Positive (TP) – the input image containing kidney stone and is identified as stone present.

Case2: False Positive (FP) - the input image is normal kidney image and is identified as stone present.

Case3: True Negative (TN) - the input image is normal kidney image and is identified as kidney stone not present.

Case4: False Negative (FN)-the input image is kidney stone and is identified as kidney stone not present

Table.2 Performance evaluation of proposed method.

	TP	FP	TN	FN
Normal and renal calculi image	18/20 = 90%	2/20 = 0.1%	19/20 =95%	1/20 0.05%

Table.2 depicts the accuracy achieved by our proposed method ‘abnormality detection in kidney ultrasound imaging’ for normal ultrasound image is 95% and for renal calculi ultrasound image is 90%.

## Conclusion

In this paper, a method for segmentation and identification of renal calculi is proposed. Pre-processing involves the two types of filters namely median and wiener filters to despeckle the ultrasound images of kidney. The segmentation results with regions then region properties are extracted for those regions. Time required for entire process is calculated for each kidney images. The average accuracy of the proposed method for both normal and calculi images are as 95% and 90%. Our segmentation method is easier and the time taken

to process the image is comparatively low than other methods described in literature.

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