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Kidney Stone Detection Using ImageProcessing

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***Abstract*: Kidney stones are hard collection of salt and minerals often made up of calcium and uric acid. Majority of people with stones in kidney at initial stage do not notice and it damages the organs slowly. It is very important to detect the exact and accurate position of kidney stone for surgical operations. Ultrasound images normally consists of Speckle noise which cannot be removed by mankind. Hence we preferred automated techniques in detection of kidney stones in ultrasound images using Image processing.**

KEYWORDS:Kidneystones,ultrasound,imageprocessing,MATLAB,image enhancement,segmentation,accuracy,median filter.

1. Introduction

Kidney stones are on rise throughout the world and majority of people with kidney stone disease do not notice the disease as it damages the organs slowly before showing symptoms. Kidney is a bean shaped organ and present on each side of the spine. The main function of kidney is to regulate the balance of electrolytes in the blood. Formation of stones in kidneys is due to blockage of urine congenital anomalies, cysts.

Different types of kidney stones namely struvite stones, stag horn stones and renal calculi stones were analyzed. Kidney stone is a solid concretion or crystal formed in kidneys from dietary minerals in urine. In order to get rid of this painful disorder the kidney stone is diagnosed through ultrasound images and then removed through surgical processes like breaking up of stone into smaller pieces, which then pass through urinary tract. If the size of the stone grows to at least 3 millimeters, then they can block the ureter. This causes a lot of pain mostly in the back lower and it may radiate to groin. Classification of urinary stone is done based upon their location in the kidney (nephrolithiasis), ureter (ureterolithiasis), or bladder (cystolithiasis), or by their chemical composition.

The stone may be present inside minor and major calyces of the kidney or in the ureter. In medical imagining modalities, ultrasonography is used because it is versatile, portable, does not use ionizing radiations and is relatively of low cost. The major disadvantage of ultrasound image is that it consists of poor quality of images that has low contrast and multiplicative speckle noise thus making it a challenging task for detection of kidney stones. speckle noise present in the image degrades its quality which there by affects the interpretation and diagnosis.

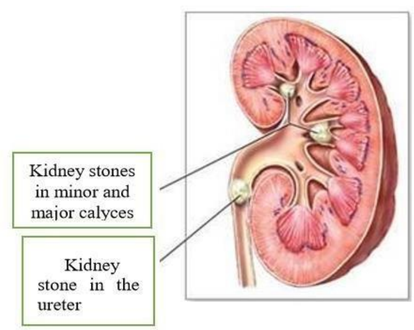

Fig. 1. Stone location in kidney

The kidney malfunctioning can be life intimidating. Hence early detection of kidney stone is essential. Precise identification of kidney stone is vital in order to ensure surgical operations success. The ultrasound images of kidney comprise speckle noise and are low contrast which makes the identification of kidney abnormalities a difficult task.

Thus to produce the efficient stone detection system, speckle filtering is one of the foremost and important step in the automated detection. This can reduce the erroneous detection which may occur due to knowledge variation of judging specialist preprocessing is then followed by segmentation and morphological analysis to detect the stone automatically.

Many researchers have contributed in the field of kidney stone detection by presenting various algorithms to detect the stone in the kidney from MRI images. Some researchers emphasize on strong and efficient segmentation. Some emphasized on strong and effective segmentation for accurate detection of stone. Once the image enhancement and noise reduction of the ultrasound image is done then the region of interest is obtained from the image.

The main contribution of this paper is that the detailed process of detecting a kidney stone using ultrasound images is given.

This paper also discusses various kidney stone detection techniques available in the existing literature with their advantages and disadvantages. Further, comparative study of various existing kidney stone detection techniques on the basis of different evaluation parameters used in the field of kidney stone detection is provided in this paper.

The rest of the paper has been organized as follows: In section 2 literature review is given which states important points made by different authors. In section 3, the steps for detection of kidney stone are given. In section 4, the parameters taken for evaluation are explained and a comparative study is made based on these parameters. In Section 5, shows result obtained after literature review and comparative study done in this paper. At last in section 6, we conclude how we improved quality of ultrasound images and how can it helpful at the time of surgical operations.

2. Literature review

This section provides a detailed overview of various existing kidney stone detection techniques using various images. Kidney stone detection in a human body is tedious task, as if wrongly detected this can lead to life threat. So in order to eliminate or reduce inaccurate detection of kidney stones many of the researchers have given their contribution by providing efficient kidney stone detection algorithms. The automation of kidney stone detection can reduce or approximately eliminate manual erroneous detection. This can help in better and accurate cure of the problem and can save human lives. Thus it has a direct impact on the society.

Moeini et al. (2021) proposed an automated system for the detection of kidney stones in ultrasound images using the Support Vector Machine (SVM) algorithm. The system consisted of four main stages: preprocessing, segmentation, feature extraction, and classification. The results showed that the proposed system achieved high accuracy in the detection of kidney stones.

Kwak et al. (2020) proposed a deep learning-based approach for the automated detection of kidney stones in ultrasound images. The system was based on a convolutional neural network (CNN) architecture and achieved high accuracy in the detection of kidney stones. The authors also compared the performance of the proposed system with other state-of-the-art methods and showed that their system outperformed .

Hamed et al. (2019) proposed an automated system for the detection and classification of kidney stones in ultrasound images using the Random Forest (RF) algorithm. The system consisted of three main stages: preprocessing, segmentation, and feature extraction. The results showed that the proposed system achieved high accuracy in the detection and classification of kidney stones.

Saritas and Alci (2020) proposed an approach for thedetection of kidney stones in ultrasound images using the Canny edge detection and Hough transform techniques. The system was based on the detection of the circular shape of the kidney stone, and the results showed that the proposed system achieved high accuracy in the detection of kidney stones.

Wong et al. (2018) proposed a texture-based approach for the detection of kidney stones in ultrasound images. The system was based on the extraction of texture features using gray-level co-occurrence matrix (GLCM) and gray-level run-length matrix (GLRLM) techniques. The authors showed that the proposed system achieved high accuracy in the detection of kidney stones

Nouri et al. (2021) proposed a dataset of kidney stoneultrasound images for the evaluation of automated systems for kidney stone detection. The dataset consisted of 101 images, and the stones were labeled based on their size and location. The authors also proposed a benchmark for the evaluation of automated systems and showed that their dataset could be used for the development and evaluation of automated systems.

We collected data set of images from various resources in which some kidney images don't have stones and some does. We preserved both the data sets to test the efficiency of the proposed system and to test it's detecting the stone accurately or not.

3. Steps for detection of kidney stone

The first step is to collect the ultrasound images and forms a dataset. After collecting the dataset, the next step follows, Image pre-processing.

SELECTING INPUT KIDNEY ULTRASOUND IMAGE

The ultrasound images of the kidney must be acquired from the databases or from the online resources and given as an input to the proposed system by clicking the button Select Input of the MATLAB application and take any of the available images from the dataset

RGB TO GRAY CONVERSION OF THE IMAGE

This step is intended to convert the input image to grayscale or if the input itself is a grayscale image this step would not lead to any difference in the image given as input and this operation is performed by clicking the button RGB to Gray of the MATLAB application.

PRE-PROCESSING THE ULTRASOUND IMAGE

The ultrasound image may have unwanted text or any other objects with it which are not required in the process of stone detection by the proposed system. So, those unwanted objects are cleared or removed by clicking the button Pre-Processing of the MATLAB application.

ADJUSTING CONTRAST OF THE ULTRASOUND IMAGE

The contrast of the given input image must be adjusted in order to process the image in a required manner and make the areas visible. This process will be initiated by clicking the button Adjust Contrast of the MATLAB application

ADJUSTING INTENSITY OF THE ULTRASOUND IMAGE

The intensity of the given input image must be adjusted in order to process the image in a required manner and make the areas visible. This process will be initiated by clicking the button Adjust Intensity of the MATLAB application.

REMOVING THE NOISE FROM ULTRASOUND IMAGE

The input will be having unwanted noise which interfere the processing of the ultrasound image. So, for the purpose of accurate results this noise must be eliminated from the image by using a filter called median filter in the MATLAB. This process is achieved by clicking the button Noise Removal of the MATLAB application.

HIGHLIGHTING THE PIXELS FOR BETTER PROCESSING

In this step, the pixel values which are greater than the value of 250 are highlighted or increased the intensity level assuming these pixels are having the kidney stone and other parts doesn't. This process is achieved by clicking the button Highlight Pixels of the MATLAB application.

SELECTING REGION OF INTEREST (ROI)

In this step, a rectangle area of interest will be selected assuming the stone is present in this area of interest and then detecting the stone from this ROI will be done. This process is achieved by clicking the button Region of Interest of the MATLAB application.

STONE DETECTION

The stone will be detected from the selected Region of Interest by clicking the button Stone Detection from the MATLAB application and the percentage of stone will be displayed. The bulb in the application is used to indicate the stone is detected or not i.e., it turns red if the stone is detected or else it will be green accordingly.

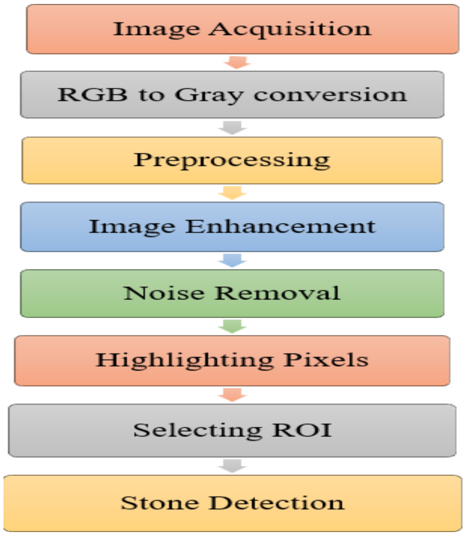

Fig. 2. Flowchart

4. Evaluation parameters

The overview of the parameters that are used for evaluating efficiency and correctness of the designed kidney stone detection algorithm.

Peak Signal to Noise Ratio (PSNR): It is the ratio of maximum possible value (power) and distortion noise power. It identifies the losses and lossy compression after reconstruction.

Signal to Noise Ratio (SNR): In multiplicative coherent images it figure out the suppression in the noise mainly in coherent imaging.

Mean Square Error (MSE): It computes the accuracy of each input in the sample recovers with the channel output. It is highly dependent on scaling intensity of the image.

Mean Absolute Error (MAE): It finds the mean of Absolute errors. The absolute error is the absolute value of the difference between the forecasted value and the actual value.

By evaluating all the above mentioned parameters we are going to find stones present in kidneys.

5. Results

The first step involves noise removal with the help of different filtering techniques such as median filter and contrast intensification of image through image pre-processing.

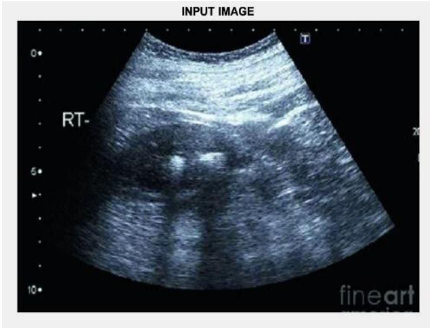

Fig. 3. Original image

Fig. 4. Image after median filter and intensity adjustment

Segmentation refers to region of interest (ROI). The region where the stone is present is detected. The image after applying segmentation is as follows.

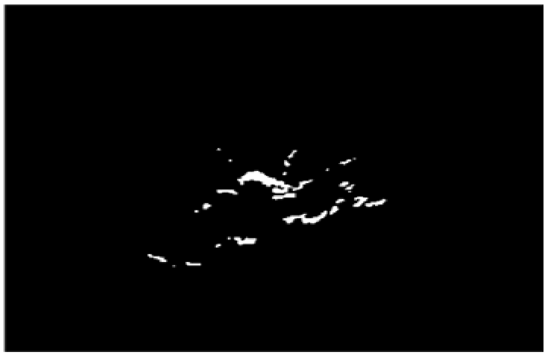

Fig. 5. Segmented Image

Morphological analysis involves the dilation/erosion of the segmented image. This step helps in differentiating the ROI from the rest of the image using different pixel values. The final image after applying morphological techniques is given in below figure.

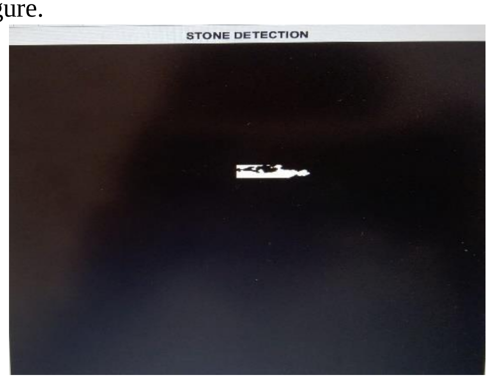

Fig. 6. Final image

On implementing the proposed algorithm there were some variations in the exact position of the stone which could be rectified by varying the intensity adjustment of each ultrasound image of the stone. The proposed algorithm leading to an accuracy in detecting stone was 92.57%.

Figure 6, depicts the size of the stone . With the help of present algorithm doctors can look forward for appropriate treatment method which can result in the removal of stone from kidneys in an efficient manner.

6. Conclusion

The proposed methodology of detecting the presence of stones formed in kidneys has been done by pre-processing the ultrasound image followed by its segmentation and finally performing morphological analysis on the resulting image. The resulting image helped in detecting the exact location of stone and further the edge detection method was used to identify the shape and structure of the stones formed. The strategic combination of these three methods proved to be an accurate method that can be used in the process of detection of kidney stone. The accuracy of proposed algorithm is 92.57% which is competent enough as compared to previous algorithms.

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