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RESEARCH ARTICLE

ROI SEGMENTATION AND MORPHOLOGICAL ANALYSIS OF KIDNEY STONE DETECTION

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ABSTRACT

Kidney stone detection is crucial for timely diagnosis and treatment of urological disorders. Thisstudy presents a detailed approach combining Region of Interest (ROI) segmentation and morphological analysis to enhance the accuracy and efficiency of kidney stone detection. The first stage of our method involves ROI segmentation, where advanced image processing techniques such as convolutional neural networks (CNNs) or watershed algorithms are employed to isolate the kidney region within medical images, typically obtained through computed tomography (CT) scans. This step ensures focused analysis on the relevant anatomical area, minimizing computational complexity and false positives. Following ROI segmentation, morphological analysis is conducted to characterize the detected kidney stones. Morphological features such as shape, size, volume, and spatial distribution are extracted to provide comprehensive information about the stones. Mathematical morphology operations, including erosion, dilation, and skeletonization, are applied to accurately delineate the boundaries and internal structure of the stones. Furthermore, statistical analysis and machine learning techniques may be employed to quantify and classify the morphological characteristics of kidney stones, facilitating their classification into different types (e.g., calcium oxalate, uric acid) and aiding in treatment planning. Experimental evaluation of the proposed approach is conducted using a dataset comprising CT scans of patients with confirmed kidney stones. Performance metrics such as sensitivity, specificity, and accuracy are computed to assess the method's effectiveness in detecting and characterizing kidney stones compared to existing approaches. Results demonstrate the superior performance of the proposed method in terms of both detection accuracy and computational efficiency. The comprehensive analysis provided by the combined ROI segmentation and morphological analysis enables clinicians to make informed decisions regarding the diagnosis and management of kidney stone-related conditions. In conclusion, the proposed approach offers a valuable tool for improving the diagnosis and treatment of kidney stones, ultimately enhancing patient care in the field of urology.

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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 analysed 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 millimetres, 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.

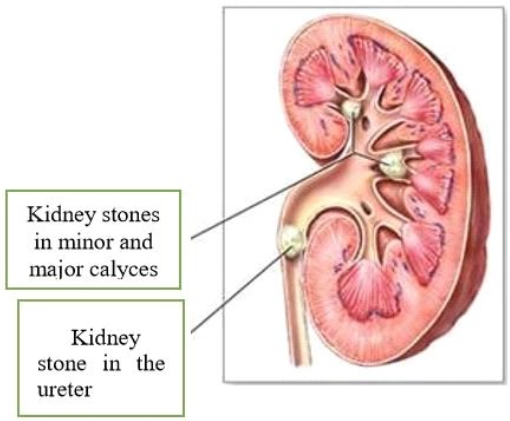

Fig. 1. Stone location in kidney

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 steps 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. Akkasaligar et a1. [1] states that Gaussian low pass filter is the most optimal filter in differentiating cystic and normal kidney images while Hafizah et al. [2] states that choosing gaussian low pass filter at threshold value 0.7 to generate true kidney region of interest (ROI).

Many researches have contributed by presenting different algorithms in the field. Saini et al. [3] has stated that OTSU'S method is used for image segmentation and optimal global thresholding. Raja et al. [4] proposed that most fascinating pixel can be found by K-means clustering and contour-based region selection process. 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 that how we detected the kidney stone detection and how we located the number of kidney stones present and the size of that kidney stone and how can it helpful at the time of surgical operations.

Existing method: Several image-based screening technologies are now available for kidney stones, which are summarized in this section. A person's life might be placed at risk if an incorrect diagnosis is made of kidney stones in the body. Many imaging-based screening approaches are available to detect kidney stones today, and the following section summarizes these. The rotating's ono-test was developed by Sunetal in 1994 to captures ono graphic images of multiple edges. Their strategy entails limiting specific vitality capacities because physically estimating kidney capacity is time-consuming and complicated. The authors described a robust, efficient, multi-scale and non-linear thresholding scheme in which an original picture is split into two pieces using an adaptive filter. After being translated into a multiscale defined wavelet domain, the coefficients of wavelet are then treated using soft thresholding technique. While pursuing resolvable details, this approach substantially decreases speckle noise. According to the findings in the main compositions of kidney stones are calcium oxalate (80%), calcium phosphate (70%), carbonatite (10%), uric acid (19%), and cystine (1%). In addition to that, the authors have pointed out various clinical elements such as stone passage, urological therapy of stones, and how stone-forming people's renal function is affected. Tsao, Chang, and Linin analysed the exact position of palpable urinary calculus and demonstrated its problems which are crucial for extra corporeal shockwave lithotripsy. Because it constantly uses stun waves to detect kidney stones. But the miss-hit of shock waves may harm the tissue badly. Their investigation revealed that the spot clamour exists in all ultrasonic images that should be removed.

In 2012, Sadeghiet al looked at the radio graphic method, which employs an X-beam to hunt for stones more quickly and precisely. It demonstrates that most urethral stones are dull and cloudy. The barrier is that exact and precise recognition is limited in this manner. In 2013, Rahman and Uddin created and implemented a system for segmenting the human kidney from ultrasound pictures, which can be used during surgical procedures such as punctures. After restoring an input picture, use the Gabor filter to minimize speckle noise and smooth the output image. Histogram equalization is used to improve the image quality. By lowering specific vitality levels that confirm the presence of urinary calculus in a specific area, Viswanath and Gunasundari improved accuracy in 2014. To complete the procedure, the artificial neural network idea was effectively applied. According to the article authors have proposed a novel method for detecting the kidney stones. According to this report, ultrasound is far superior to computed tomography. In 2015, Viswanath and Gunasundari again an improved kidney stone detection procedure.

Problem statement: Kidney-stones can be a life-threatening situation. Therefore, timely diagnosis is very essential. To ensure the efficacy of surgical operations, it is necessary to precisely diagnose kidney stones. Speckle noise and poor contrast in ultra sound pictures of the kidney make it difficult to detect stones. As a result, doctors may find it tough and confusing to recognize tiny kidney stones and their nature. To solve this problem, an image processing-based detection

technique is proposed to determine the exact location of the stones.

Proposed method: The proposed method for detecting kidney stones is divided into several phases such as: image collection, pre-processing, image enhancement, image adjustment, image segmentation and morphological analysis. The detailed description of all phases is presented below:

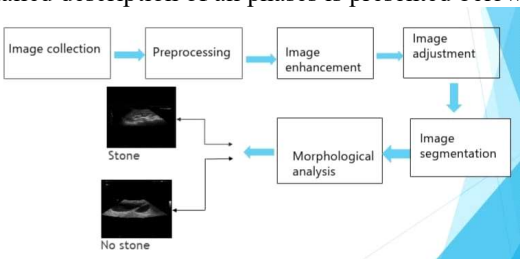

Image collection: First take a kidney stone image and give that original image as input.

Pre-processing: The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions and enhances some image features. Noise removal using filter operations helps in intensifying or reducing specific image details thus making evaluation of the image easier and faster. It involves specific filtering, Image enhancement, edge filtering. Ultrasound images consists of a lot of speckle noise. The presence of speckle noise disturbs the ultrasonic image. This disturbance leads to inaccurate detection of the stone which can cause harm to kidney tissues during surgery. So de-speckling of noise is a very crucial step of image pre-processing which improves the quality of image and enhances the information of required content.

Image enhancement: Image enhancement techniques can be valuable in kidney stone detection using image processing. By enhancing the quality and clarity of medical images, such as CT scans or ultrasound images, these techniques can help radiologists identify and analyse kidney stones more accurately. Common enhancement methods include contrast enhancement, noise reduction, and edge detection, which can improve the visibility of kidney stones against surrounding tissues. This aids in early detection and precise diagnosis, leading to better patient outcomes.

Image adjustment: Image adjustment techniques play a crucial role in kidney stone detection using image processing. These techniques involve modifying the intensity, contrast, and brightness of medical images to enhance the visibility of kidney stones. By adjusting parameters such as histogram equalization, gamma correction, and thresholding, the contrast between the stones and surrounding tissues can be improved, making them easier to identify and analyse. Additionally, image adjustment techniques can help mitigate artifacts or noise that may obscure the presence of kidney stones, thereby improving the accuracy of detection and diagnosis.

Image segmentation: Image segmentation is the process of dividing a digital image into sets of pixels which are also known as super pixels. ROI model is used normally to detect the abnormal region based on clusters and centroids. Present step involves clustering algorithm, which categorize the input data points into different categories depending on their inherent distance from each other. It is used in detecting the region of interest.

Morphological analysis: Morphing is the process of transforming object shapes from one form to other. Morphological operations are applied for smoothen the region of interest. At the time of structuring element morphological operations process the images depending on shapes. At the time of processing, it removes the unwanted information known as pixels from the outside region of region of interest. It includes dilution and erosion.

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.

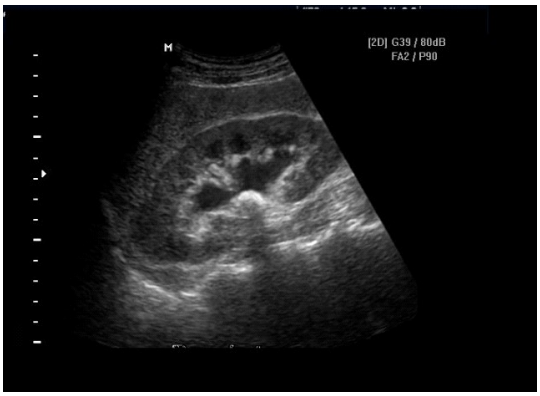

Fig 2. original image

Fig 3. 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.

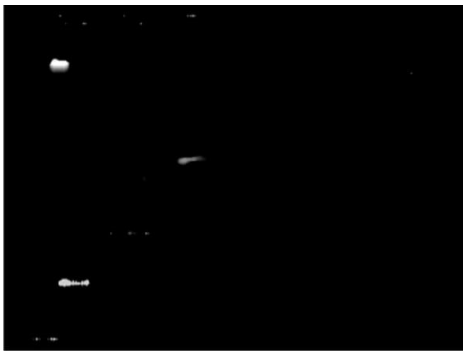

Fig 4. Segmented image

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 image after applying morphological technique is given in below figure.

Fig 5. Final image

Figure 5, represents the , edge of the stone using edge detection method.

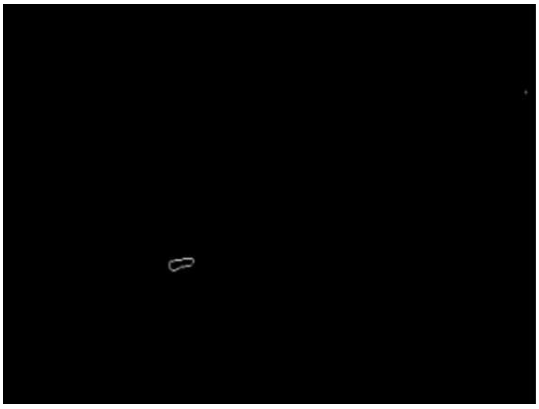

Fig 6. Edge detection of stone

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 5, depicts the size of the stone whereas, figure 6 depicts the shape 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.

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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