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Ultrasound Image Segmentation Techniques for Renal Calculi - A Review

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Abstract: The structural defects related to size and position of kidneys' such as presence of cysts and stones can be estimated with the help of Kidney ultrasound visual presentation. However, Speckle sound in ultrasound icon acts as a barrier in performing segmentation methods for kidney metaphors. Here we detect the stones present in kidney, fragment the kidney regions and evaluate the part of the renal which is occupied by kidney stones. Recognition of stone is fundamentally an essential preliminary phase to solve the segmentation problem profitably. Thus, the client ultimately comes to identify that it is hard to detect the boundary of the kidney in the ultrasound image; even though it is done by expert sonographers. Individual errors may occur during the interpretation of ultrasound image by an inexperienced sonographer, especially while taking dimensions. Thus, for the purpose of sinking the dependability to the sonographers' expertise, some icon processing can be done which can automatically detect the centroid of human kidney and its calculi. On top, on boundary edges may be omitted or not properly visible and usually incomplete at various spaces. With the assist of exceeding authenticity, the four premeditated methods have been urbanized for renal calculi segmentation.

Keywords: Ultrasound Image; Sonographer; Radiation; Image Segmentation; Image analysis; Kidney

I. INTRODUCTION

Patients are provided with proper health care assessment to treat the diseased condition with the aid of medical images. Although the use of ultrasound was a vital tool for break urinary calculi, visualization posed a problem, which required either radiograph or computer tomography. Low cost and minimal discomfort are the main advantages of ultrasound imaging, rather images are relatively poorer in quality [1]. So the image analysis in general is a perplexing task due to data composition described along with speckle noises. These speckles are apt to mask the presence of low contrast lesion and reduce the ability of a clinician to read the actual information in the image. Image measurement, image display and feature extraction appear as errors in image analysis. So that in case of medical image segmentation proper image segmentation is difficult because of size of the head, torso, leg, brain parts, type of disease etc., are different. Hence for the segmentation of medical images we need different algorithms and procedures to segment and classify images [2]. However, depending on the experience of a radiologist, he/she may consume time for studying medical images which depends on visual interpretation. Computer-aided systems should be used to overcome these limitations.

The clinical history, nature of imaging findings, radiologist experience and the quality of examination are some of the factors on which exact diagnosis of renal calculi is dependent. The main objective of this work is to support the clinicians in successful detection of the renal calculi in ultrasound urinary calculi images.

Despite the undisputed usefulness of automatic stone segmentation, this is not yet a common clinical practice; therefore automatic kidney stone segmentation is still a widely studied research topic.

The heterogeneous nature of renal calculi in terms of shape, color, texture and position and their deforming capability into other nearby anatomical structures, acts as main difficulties in automatic stone-area segmentation. Normally the renal diseases are classified as hereditary, congenital or acquired [3]. The detection of calcifications inside the body is a large field of study including several forceful areas of research, which is mostly useful for diagnosing the renal stone diseases. The actual kidney stones may be rough and non-spherical in form, but the dominant effects that are used to find the fracture in actual renal stones, are based on the reverberation time across the length of the stone [4]. Due to dominant speckle noise and weakened artifacts in abdominal ultrasound images, the segmentation of stones from these images is very complex and challenging. So, this job is performed by the use of much prior information such as texture, shape, spatial location of organs etc. A number of

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automatic and semiautomatic methods have been proposed by various authors.

I.1 Proposed Methodologies

1) Inner Outer Regions based new Enhanced-Watershed Segmentation method (IOREWS) effectively segments and detects the calculi using enhanced watershed transformation along with ANFIS approach. An effort has been taken to make the finding accuracy of renal calculi area high in terms of relative error which the previously proposed techniques suffer. Hence, to overcome these drawbacks, 2) Region Indicator with Contour Segmentation (RICS) method was proposed [2]. 3) KSST (Kidney stones and its Symmetric analysis using Texture Properties based on logical operators was proposed later in which algorithm using logical operator method to classify the image using its texture properties is developed. Different regions of an image are identified based on texture properties [3]. This technique is usually applied for medical images to enhance the quality of representation and better understanding of hidden information for proper objective diagnosis. 4) Squared Euclidean Distance Method (CSED). In this method Squared Euclidean Distance (SED) is determined between the training image centroid values and the selected regions centroid values. The usage of ANFIS in supervised learning has made the technique more efficient than the previous techniques. Thus the obtained error is minimized when compared to the existing algorithm that leads to high efficiency [4].

II. RELATED WORK

Image segmentation is the initial step and also one of the most difficult tasks of image analysis, whose objective is to extract information that is represented in the form of data from image via image segmentation, feature measurement and object representation [4]. The result of segmentation of image considerably depends on the accuracy of feature measurement. Segmentation of image is computer-aided so that the computerization of medical image segmentation plays an important role in medical imaging applications [5]. Image segmentation is a process that subdivides an image into its constituent parts and extracts those parts of interest or objects. The medical image segmentation technique is well understood by figure 1 for medical sciences field [6].

In case of medical science, medical image segmentation technique understood by figure 1.

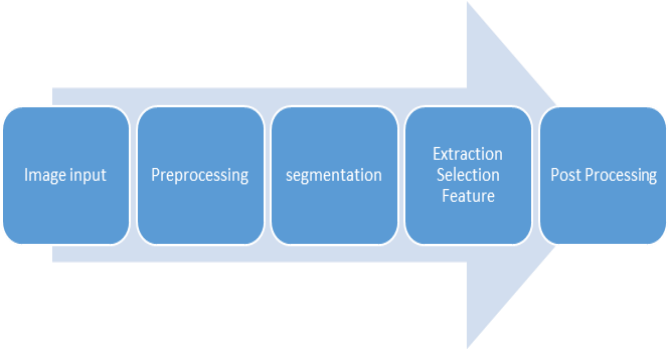


Figure 1. Automatic Medical Image Segmentation Method

Automatic medical image segmentation by intelligent method requires five steps such as pre-processing, segmentation of input image, extraction and selection feature of the image, recognition and post-processing, out of which the combination of second and third step is nothing but the process of image analysis [7].
Based on image segmentation evaluation, the techniques are categorized into two types [8]:

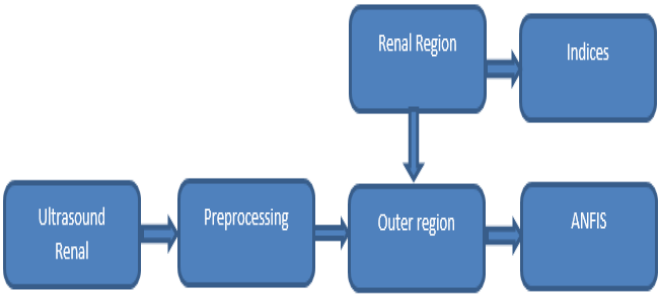
- Characterization
- Comparison.

Characterization as an intra-technique process while comparison technique as an inter-technique one.

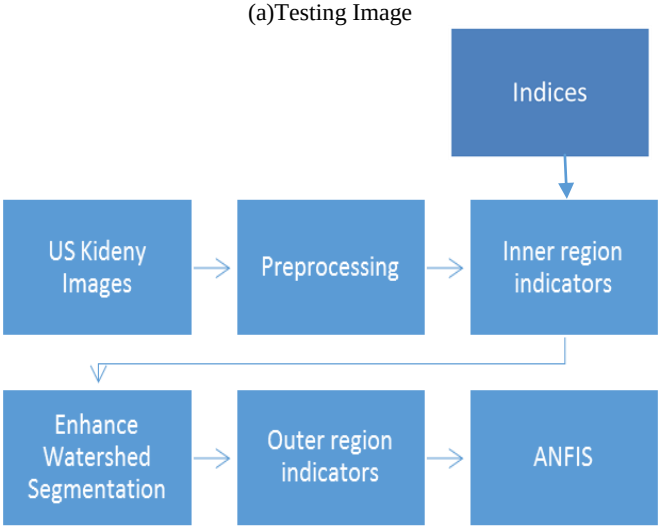
Benoit et al. [9] have proposed a region growing algorithm for segmentation of renal calculi on ureteroscopic images. Using real video images, the ground truth was computed and segmentation compared with reference segmentation. Sridhar et al. [10] have constructed a framework for the identification of renal calculi. Performance analysis has been performed to a set of five known algorithms by using some parameters likely, success rate in calculi detection, border error metrics and time. Then the best algorithm was chosen from this performance analysis and framework constructed by using this algorithm. Moreover, a procedure was given for validation of detected calculi using the shadows that appear in ultrasound images. The algorithm has been tested by using the ultrasound images of 37 patients.
Region Growing (SRG) algorithm, originally proposed by, is a fast, robust, parameter-free method for segmenting intensity images in given initial seed locations for each region. In SRG, individual pixels that satisfy some neighborhood constraints are merged, if their attributes, such as intensity or texture, are similar [11].
Region-based methods focus attention on an important aspect of the segmentation process missed with point-based techniques. If we use a feature image for segmentation process instead of the original image, the representation of features will not be constrained to a single pixel, but, a small neighborhood, depending on the mask size used by operator [12]. At the edges of the objects however, where the mask includes pixels from the object and the background, several features that could be useful cannot be calculated. The correct procedure would be however to limit the mask size at the edge points of either the object or its background [13].

III. THE IOREWS SEGMENTATION

The proposed method performs four major processes, namely, (i) Preprocessing, (ii) Determining outer region indicators (iii) Determining inner region indicators and (iv) Enhanced watershed segmentation. The block diagram of IOREWS stone segmentation method is shown in Figure 2.



(a)Testing Image



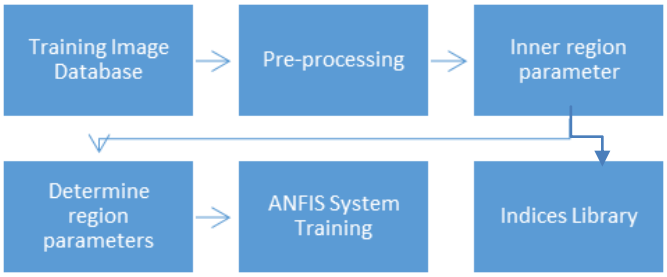
(b) Training Image

Figure 2: IOREWS Segmentation Method

In this IOREWS method, the images are resized to 256 x 256 pixels. These resized images are given as an input to the system. In Figure 2 (a), the noises in the input image are removed and the noise free image is given to the outer region indicators. The result of the outer region indicators is nothing else the pixel values; which are then given to the ANFIS (Adaptive Neuro Fuzzy Inference System) to perform the training process. In Figure 2 (b), by preprocessing, the noises in the testing images are removed and using inner region indicators, the renal centroid coordinates values are found. The enhanced watershed algorithm is used to segment the regions and the outer region pixel values are found through the outer region indicator's procedure. The indicator pixel values results are then used to perform testing process through the ANFIS system.

IV. THE RICS METHOD

In the calculi IOREWS segmentation procedure, the urinary calculi were shown to be segmented from the medical ultrasound urinary calculi images using region indicators and modified watershed segmentation. But, the accuracy of stone detection in IOREWS method does not give a satisfactory result. Moreover, the high complexity of the method has given only less utility to the medical environment. Hence, to overcome these problems, a new Region Indicator with Contour Segmentation (RICS) method was proposed [2]. In this segmentation method, five major steps are followed to select the exact calculi region in the renal calculi images. Figure 3 shows the algorithm of RICS segmentation method.



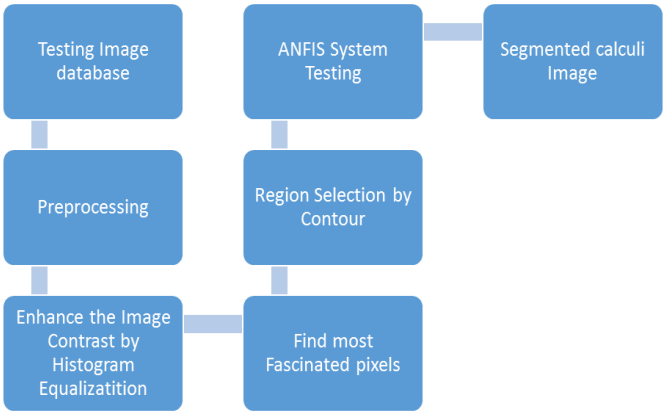


Figure 3: KSST Segmentation Method

In RICS method, five major steps are followed to select the precise calculi region from the renal calculi images. In the first and next stages, the library of region indices and renal calculi region parameters are calculated. Then image contrast is enhanced by the Histogram Equalization and the most interesting pixel values of enhanced images are selected by the k-means clustering. Such values are then utilized to find the accurate calculi from the renal images. In the final stage, a number of regions are selected based on the contour process. Subsequently, pixel matching and sequence of thresholding processes are performed to find the calculi. In addition, the usage of ANFIS in supervised learning has made the technique more efficient than the other described techniques. Here, the utilization of contour reduces the relative error in between the segmented calculi and the expert radiologist, which are obtained from the proposed algorithm. Thus, the obtained error is minimized that leads to high efficiency. The implementation result shows the effectiveness of the proposed RICS segmentation method in segmenting the renal calculi in terms of sensitivity and specificity.

V. KIDNEY CALCULI AND ITS SYMMETRIC ANALYSIS USING TEXTURE PROPERTIES BASED ON LOGICAL OPERATORS

Kidney calculi and its Symmetric Analysis using Texture Properties based on Logical Operators is a fully automatic method and given to automatic algorithm to detect quantification of renal Stones by using symmetric analysis. This task is performed by the use of prior information such as shape, texture spatial location of organs, etc. Performance of such methods are better when the contrast-to-noise ratio is high, it however deteriorates quickly when the structures are inadequately defined and have low contrast like the neuro-anatomical structures, such as thalamus, globus pallidus, putamen, etc. This algorithm uses a logical operator method to classify an image using its texture properties. A logical operator extracts the features to classify the image[3]. This technique is usually applied on medical images for better understanding of hidden information and enhance the quality of representation to diagnose the proper objective. In this project, the texture properties are applied to the medical images to classify three different categories of Ultrasound renal images. By using this technique, it is also possible to extract some features that will be very helpful for the diagnosis of the medical images to make a relative study on

images for better decision making. This method gives a wonderful presentation on texture images and therefore can be applied to the medical ultrasound renal stone image classification and compare the performance with texture result.

Figure 4: Block Diagram of ROI Generation

To develop the scheme for creating the renal ultrasound region of interest fully automatically, an automatic defined rectangular Region of Interest will be generated and this ROI can be used as a preprocessing step for any other segmentation method as it only cuts the redundant background while keeping the renal stones. Fig. 4 shows a block diagram of the steps for ROI generation. Firstly, reduce the speckle noise by any method, for which three speckle noise reduction methods were chosen to be compared and consists of Wiener filter median filter, and Gaussian low-pass filter[6]. Then texture analysis is applied for creating texture image and morphological operation is used for removing unwanted regions by selecting a proper threshold value. Then, the left over objects will be windowed so that only one object is chosen as the seed point.

VI. CALCULI USING SQUARED EUCLIDEAN DISTANCE

The proposed urinary calculi CSED (Calculi Using Squared Euclidean Distance) segmentation method involves three major steps namely, (1) Determining the region parameters [4]. (2) Region selection using contour method. Boundary of objects can be find by Contour method in images. (3) Finding distinction between centroids by utilizing Squared Euclidean Distance (SED) [4]. The region parameters determined for each region are (i) Area (ii) Centroid (iii) Orientation and (iv) Bounding Box. The proposed urinary calculi CSED segmentation training and testing method is shown in Figure 5.

The proposed procedure was executed and set of renal calculi images were utilized to evaluate the proposed segmentation procedure [9]. The procedure has accurately detected the calculi and formed a high segmentation accuracy result when compared to the existing segmentation method. The CSED method produced less relative errors than the existing methods.

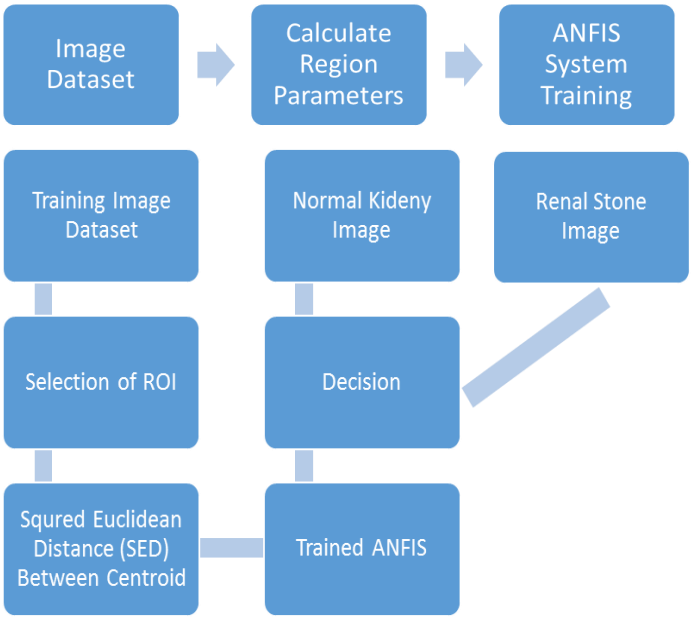


Figure 5: Proposed CSED segmentation training and testing procedure

VII. CONCLUSION

The overview of various segmentation methodologies applied for medical Ultrasound digital image processing is explained briefly in this review. The research on various research methodologies applied for medical image segmentation and numerous research disputes in this field of study, has been also included in this study review. These approaches are most significant for detection of pattern and recognition of renal calculi by means of edges, images or points. Image segmentation provides a promising and challenging future as the universal segmentation algorithm and has become the center of existing research. Not a single method which can be considered good for all type of images is available, nor all methods equally can be considered perfect by for a particular type of image. Due to all above factors, image segmentation remains a perplexing problem in image processing and computer vision and is still an unresolved problem in the modern world. However Ultrasound medical image segmentation gives more methodologies applied to diverse fields, ever till date.

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