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Detection of Renal Calculi Using Semi Automatic Segmentation Approach

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***Abstract*— The semi automatic and automatic segmentation methods of Ultrasound images can help the physician by providing accurate location of abnormal regions. This framework describes a semi automatic technique for segmentation of kidney from ultrasound images by using seeded region growing technique. This is a best method for segmentation of ultrasound images because it is not affected by speckle noise and also preserves spatial information. Segmentation of kidney region in ultrasound kidney images has been developed and presented. The performance of the proposed method is measured and compared with marker-based watershed segmentation and morphological segmentation methods. The proposed semi automatic region growing algorithm provides best results.**

***Index Terms*—Ultrasound Kidney Images – Semiautomatic –Segmentation-Calculi Detection.**

I. INTRODUCTION

Ultrasonography is a method which helps the physician to visualize the structures of internal organs of human body. In some cases it is not easy to identify the boundaries of abnormal regions in the image. Hence segmentation is necessary. Segmentation is the usage of image processing tools to find a distinction between objects and background. Segmentation technique basically divides the spatial domain, on which the image is defined, into 'meaningful' parts or regions. The region is a group of connected pixels with similar properties. These regions are important in interpreting an image because they may correspond to objects in a scene. This meaningful region may be complete object or part of it. It is very difficult to interpret the ultrasound image. More experience and training is required to interpret the ultrasound images. Even human experts differ in the interpretation of ultrasound images. The available segmentation algorithms are general techniques and fail to detect the kidney from ultrasound image for stone detection. The manual methods of segmentation needs high attention of sonographer and also suffer from poor accuracy and time consuming. A semiautomatic algorithm is proposed based on the region-growing framework. The proposed model is used for segmenting the kidney contour from the ultrasound image for detection of kidney stones.

II. RELATED WORKS

Medical image segmentation, a critic step for most subsequent image analysis tasks, is to delimit the image areas representing different anatomies. Segmentation of the abdomen, in particular, is often a challenging task due to the considerable overlap of soft tissues by [1]. Since intensity-based methods have met with limited success for abdominal segmentation, texture segmentation, which makes use of statistical textures analysis to label regions based on their different textures, has attracted our attention. In this approach, low-level features based on texture information, that is expected to be homogenous and consistent across multiple slices for the same organ, are mostly used to perform automatic image analysis in the medical imaging field investigated by [2].Among various image segmentation methods, the Seeded Region Growing (SRG) algorithm, originally proposed by [3], is a fast, robust, parameter-free method for segmenting intensity images given initial seed locations for each region. In SRG, individual pixels that satisfy some neighborhood constraint are merged if their attributes, such as intensity or texture, are similar enough. The seed location, an optimal threshold value and a similarity measure need to be determined either manually or automatically.

Region-based methods focus attention on an important aspect of the segmentation process missed with point-based techniques. There a pixel is classified as an object pixel judging solely on its gray value independently of the context. This meant that isolated points or small areas could be classified as object pixels, disregarding the fact that an important characteristic of an object is its connectivity. If we use not the original image but a feature image for the segmentation process, the features represent not a single pixel but a small neighborhood, depending on the mask sizes of the operators used. At the edges of the objects, however, where the mask includes pixels from the

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object and the background, any feature that could be useful cannot be computed. The correct procedure would be to limit the mask size at the edge to points of either the object or the background [4].

For kidney tumor segmentation, the region-growing method was applied from the center of the selected seed region as the starting point. Generally, the region-growing method performed the homogeneous test from the start pixel to the neighbor pixel using gray-level, texture, and color as acceptance criteria, and included or excluded the neighbor pixel according to the homogeneous test result until termination condition was satisfied [5].

Computer-Aided Diagnosis (CAD) for classification of focal liver tumors in sonography requires segmentation as a preprocessing step for successive texture analyses of the tumors [6]. However, effective segmentation is a difficult task for noisy images such as B-scan ultrasound images, because the boundaries of the tumors of interest can be fuzzy and has low contrast. A study of quantitative evaluation of (semi)-automated segmentation of US images and showed that even manual segmentation of noisy US images is not straight forward. On the other hand, reliable semi-automatic segmentation methods offer the potential advantage of making the measurement process more consistent [7].The term "watershed" is a geographical one. In geography, a watershed line is defined as the line separating two catchments basins. Thus, they represent valleys; while edges represent peaks (edges have high gradient values). [8] Proposed the immersion simulation algorithm for watershed lines calculation. Initially, the image gradient is calculated using the Sobel operator [9]. In the immersion simulation algorithm, the image is viewed as a surface and the gradient local minimum of each region as a hole from which the water will rise up. The local minimum for each overlapped 3x3 block within the gradient image is calculated.

III. PROPOSED SEMI AUTOMATIC SEGMENTATION ALGORITHM

Initially the system extracts texture features for each pixel in the Region of Interest. The proposed system uses the gabor texture features, i.e. texture features are computed for pixels in each slice of kidney ultrasound image. This semiautomatic region growing algorithm, takes a set of seeds as input along with the image. The kidney region to be segmented is marked by the seeds. By comparing all unallocated neighboring pixels to the regions iteratively grows the regions. The similarity measures used in this model are the difference between a pixel's intensity value, region's texture and local threshold. This technique is presented as, first preparation of lookup table of local statistics of all pixels to be used for initial region growing procedure, second grouping of pixels satisfying a specify homogeneity criteria and produce the homogeneous region, and finally merging the neighboring regions, which have similar intensity values with the tolerance level. The pixel with the minimum difference measured this way is allocated to the respective region. This process is repeated until all pixels are allocated to a region. The additional input to the seeded region growing process is it requires seeds. The segmentation process results are dependent on the choice of seeds. Noise in the image can cause the seeds to be poorly placed.

A. Seed Point Selection

The proposed framework uses heterogeneous feature minimization approach for seed point determination. This method takes a set of seeds as input along with the image. The seeds mark each of the objects to be segmented.Comparing all unallocated neighboring pixels to the regions iteratively grows the regions. The difference between a pixel's intensity value and the region's mean is used as a measure of similarity. The pixel with the smallest difference measured this way is allocated to the respective region. This process continues until all pixels are allocated to a region. Seeded region growing requires seeds as additional input. The segmentation results are dependent on the choice of seeds. Noise in the image can cause the seeds to be poorly placed. The local variance, and mean ratio of the granularity in the fully developed ultrasound speckle kidney image and the gradient values are used as the measured parameter for seed point selection. The local variance and mean ratio is defined as

$$\text{LVMR} = \frac{\sigma^2}{\mu}$$

The gradient value is calculated as

$$|\nabla I(s)| = |I(x+1,y) - I(x-1,y)| + |I(x,Y+1) - I(x,y-1)|$$

According to this parameter, it is possible to decide whether the processed pixel is within the homogeneous region or not. The gradient value specifies wither the selected seeds gray value is within the range (231-258). Based on the histogram it is observed. Normally, if the local variance to mean ratio is larger than that of speckle, then the corresponding pixel can be considered as a resolvable object.

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B. Seeded Region Growing

Given a seed point the region growing method searches neighbors of the seed point to determine whether they belong to the same region. If they are belongs to the same region, their neighbors are searched. The process is executed repeatedly until no more new neighbors can be added to the region. The requirement to determine whether a neighbor pixel belongs to the same region is when the distance is lower than a threshold value means the neighbor point is added. So it is very important to determine the distance measure, linkage strategy, connectivity strategy and a threshold value. Region growing techniques are better than the edge-based techniques in noisy images where edges are difficult to detect. Region growing similarity among pixels to find different regions Region growing is a method that groups pixels or sub regions into larger regions. The process starts with a set of "seed" points and from these grows regions by appending to each seed points those neighboring pixels that have similar properties by using various measure like distance measure, linkage strategy, connectivity strategy and a threshold value. Region growing based techniques are better than the edge-based techniques in noisy images where edges are difficult to detect. The regions are indicated in Table 1.

Table 1 Regions of Image

<table>
<tr><td>R_{11}</td><td>R_{12}</td><td rowspan="2">R_2</td></tr>
<tr><td>R_{13}</td><td>R_{14}</td></tr>
<tr><td colspan="2">R_3</td><td>R_4</td></tr>
</table>

Distance measure is calculated by using the euclidean distance in the feature space. With the semi-automatic texture feature, the distance between two pixels is the Euclidean distance of their feature vectors.

Euclidean distance is calculated as follows

If $x=(x_1, x_2)$ and $y=(y_1,y_2)$ are two points in Euclidean, then the distance from x to y, or from y to x is given by

$$d(p,q) = \sqrt{(x1 - y1)^2 + (x2 - y2)^2}$$

Single linkage strategy and centroid linkage strategy are used as the linkage strategy. In Single linkage the pairs of neighboring pixels are compared for merging, it is one of the simplest approaches. While in centroid linkage, a pixel's value is compared with the mean of an already existing region. But region is not necessarily completed region. In this approach we have chosen the single linkage strategy because it is faster and memory efficient by calculating the texture features and recursively running the seeded region growing.

C. Optimization of Threshold Value

Initially the threshold value is assigned manually. By choosing correct thresholding leads to better segmentation. It is very complex to identify threshold value from ultrasound images by using histogram analysis. After assigning the threshold initially, next stage the threshold is selected by iterative threshold method. Iterative threshold method successively refines an approximate threshold to get a new value which partitions the image better.The region growing process is stopped by using an optimal threshold value and the obtained region is optimal. It is desirable that the optimal threshold value is sufficient to extract the whole region; however if the value of the threshold is higher than the optimal one, the extracted region may grow over the actual region boundary and grow to a much larger region. This process is called explosion. Our aim is to find the maximum threshold value just before this explosion. So the algorithm starts from a small threshold value and increases by one. With each threshold value Seeded Region Growing algorithm is performed and the results are evaluated. This process is the first pass. When the threshold value causing explosion, we retrieve the last value not causing explosion, and from that value to the explosion value, by a step of 0.05 retrieve the value just before explosion, perform another pass. That value is our optimal threshold value. If we compare the threshold value versus number of pixels in the region, the explosion value must have a big slope the reason is the threshold value always increases by the same amount whereas the number of pixels in the region has increased considerably. Thus this slope value is calculated by (number of pixels in the region/ threshold value change) is used to check explosion. If the slope value is very larger i.e. a big value, explosion has occurred. The algorithm stops the process if an explosion occurs. In this case, the resulting region is smaller than the actual region and this is called under-segmentation.

To avoid stopping region growing too early, the algorithm does not stop instantly when it finds an explosion. It checks all the explosions and does not stop until their number of pixel are more than the total number of pixels in the Region of Interest. Then we pick the last explosion with the large amount of pixels as the actual explosion. To

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avoid over segmentation, two stop checking procedures are added to the algorithm. One is the number of pixels in the resulting region cannot exceed the number of pixels in the Region of Interest. Second is the leftmost, rightmost, uppermost and lowermost pixels in the resulting region should not exceed the spatial location of these four pixels of Region of Interest by some level. We allow them to exceed 30 pixels, but this is flexible and case dependent. The procedure for selecting the threshold is as follows. First, we search the maximum intensity I_{max} and the minimum intensity I_{min} in the kidney ultrasound image. The initial threshold is obtained by using the following equation. Second, estimate the mean intensities of the foreground and background and on the basis of threshold T_{old}, with the following equations.

$T_{old} = (KI_{max} + KI_{min}) / 2$

$KI_{bm} = \sum KI(x, y) / \sum N(x, y)$ where $KI(x,y) < T_{old}$

$KI_{fm} = \sum KI(x,y) / \sum N(x,y)$ where $KI(x,y) >= T_{old}$

$T_{new} = (KI_{bm} + KI_{fm}) / 2$

Where, KI_{bm} is the mean intensity of the background, KI_{fm} is the mean intensity of the foreground, KI(x, y) is intensity of pixel and N(x, y) is the number of pixels. The new threshold is T_{new}.
If T_{new} is equal to T_{old}, then T_{new} is the proper threshold value. The range of image segmentation process is based on region growing criteria. Region growing algorithms take one or more pixels, called seeds and grow the regions based upon a certain homogeneity criteria. If the adjoining pixels are similar to the seed, they are merged with them within a single region. The process continues until all the pixels in the image are assigned to one or more regions. The proposed framework has to do two-pass scans and for every threshold value SRG has to be performed and on texture feature space the process of texture feature extraction and distance calculation is much more complex than simple intensity features. However, the process saves time calculation when threshold value increases, the resulting regions are always the super set of the previous resulting region.

D. Region Merging

In the region merging neighbors are merged starting from a uniform seed region. Here each region is labeled with a unique number. Neighboring region information for every seed region is stored. The merging process continues until no more neighboring regions satisfy the uniformity criterion. The region is extracted from the image, and the next seed is used to merge another region. The regions obtained from the region growing procedure with similar intensity values are merged together.

$P(R_i \cup R_j) = FALSE$ for any adjacent region Ri and Rj and $i \neq j$.

In this procedure every identical regions are identified and labeled by unique number. Labeling of the regions is implemented by using the 8-connectivity region labeling technique.

IV. RESULTS AND DISCUSSION ON US KIDNEY IMAGE SEGMENTATION

In the semi automatic seeded region growing segmentation algorithm, incrementing threshold values from a starting value gives the minimum value of the distances between the seed point and its neighbors. Apply SRG on every incremental threshold value and when it reaches a point of homogeneous value, the region of interest is detected across the kidney portion. Then execute the algorithms on kidneys of US images and obtained segmentation result for semi-automatic SRG respectively The necessity of identification of the region-of interest lies in the fact that two problems being pointed out are still unsolved. First of all, due to the anatomy related ambiguity, part of the left and right kidneys are connected cross sectional. Such ambiguity can not be differentiated solely by the intensity. Secondly, sometimes the local noise may become so remarkable that large non uniformly can occur in the kidney object or background region. The consequence may be a large area attached to or hollow space inside the left kidney even after the initial morphological operations. Existing schemes dealing with such problem all introduced human interferences one way or another, either outlining the valves by a human operator, or applying additional constraints interactively to the location where the ambiguity is present. In order to reduce potential errors and eliminate operator biases associated with human interferences, knowledge based intelligent approach is adopted. This is motivated by the success of shape modeling the kidney by super quadrics with tapering and bending deformations in the US volumetric shape analysis of the kidney images. The proposed SRG is implemented with matlab for US kidney images and sample screens are shown in below figure 1a & 1b. Here 1a is the given original image and 1b is renal calculi image after the detection of renal portion. The performance of the segmentation method is analyzed by various statistical measures as well as by comparing segmented stone area against the conventional segmentation algorithms. The statistical performance measures, which are obtained for four different US images, of our proposed segmentation method are shown in Table 2.

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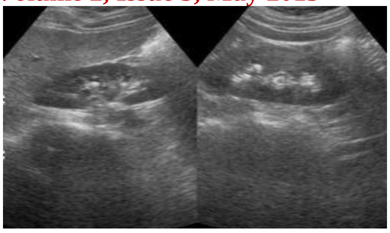

Fig 1 a Original Image

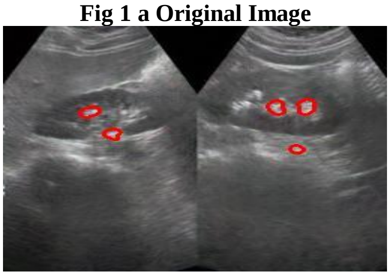

Fig 1 b Renal Calculi Detected Image

Table 2: Statistical performance measures for different US images with renal calculi

Data Set	Sensitivity	Accuracy	Specificity
	99.9	100	99
2	98.9	98	98
3	99.5	100	100
4	99.2	99	74
5	90.1	99	93

A relative error is calculated between the stone area marked by the proposed method and the expert radiologist. The errors are compared against the relative errors that are obtained from the conventional renal calculi segmentation algorithms. The stone area, which is determined by the proposed algorithm and the expert radiologist, and its relative error are given in Table 3.

Table 3: Relative Error Performance

Expert radiologist (mm^2)	Stone area (mm^2)	Relative error of SRG method
293	104	1.817
126	97	0.298
87	115	0.243
316	225	0.404
205	144	0.423
153	117	0.307
103	87	0.183

V. CONCLUSION

In this paper an efficient segmentation process is performed to detect calculi from the renal calculi images. By performing the calculi detection using SRG it is obvious that the proposed renal calculi segmentation method correctly finds the calculi area in the kidney stone images and it gives high classification, calculi detection accuracy. The segmentation accuracy of renal calculi achieved by the proposed method is adequate for using in various medical fields. The performance of the proposed method is evaluated by comparing the result of the expert's detection process. The comparison result confirms that the proposed renal calculi segmentation technique is highly effective and efficient in finding the calculi area.

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