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Segmentation of Ultrasound Abdominal Images to extract Region of Interest

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***Abstract:** Ultrasound imaging is one of the safest techniques for disease diagnosis which can be used in any part of the body. One of the major reason for using ultrasound images is the cost when compared with MRI, PET etc. Further, it is free from any radiation exposure and is an efficient technique for initial diagnosis. This paper concentrates on segmentation of kidney from abdominal ultrasound images. There are many common ailments affecting kidney and hence conducting study on this segmented image becomes easy with an efficient segmentation technique. Various algorithms to pull out kidney regions from abdominal ultrasound images which are discussed by many researchers are also investigated in this paper. One of the major drawback of ultrasound image is that due to the complicated internal organs of the abdominal region, extraction of only kidney region is very challenging. This paper proposes a new technique where the collected abdominal ultrasound image is cleaned, to remove unwanted noise produced due to various interferences. After applying the filtering technique, kidney region is segmented. This extracted kidney image is subjected to Region indicator contour segmentation method to extract the renal calculi which is the region of interest in this study. The method is experimented with a reasonable number of dataset and applied the statistical performance test to check for the accuracy.*

***Keywords**: Ultrasound Images, Kidney, Renal Calculi, Segmentation, Noise Removal.*

I. INTRODUCTION

Image segmentation is an indispensable step in almost all image analysis system [1].It is the process of subdividing the image into various regions and thus extracting the required ROI from it. Many Segmentation techniques were evolved which were mainly based on similarity or dissimilarity principle. It is a crucial part in image analysis and object recognition. There are different segmentation algorithms available in literature. Some of the basic methods are thresholding, region growing, region splitting and merging etc. A quad tree representation of split and merge is shown in Figure 1.

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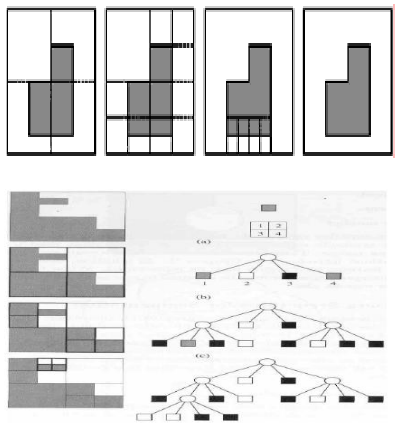

Figure 1 Region Splitting and Merging

The segmentation of medical images is very complicated due to the interference of artifacts and great care should be given for edges [2]. The occurrence of artifacts can affect the results of intensity based image processing methods.

II. DIFFERENT METHODS OF SEGMENTATION OF KIDNEY REGION FROM ULTRASOUND IMAGES

Segmentation of medical images has always been an active area of research. Accuracy of segmentation with powerful edge detection is the major motive of any segmentation algorithms. A lot of research work has happened in segmentation of kidney from other complicated organs of the abdomen.

Jun Xie, Yifeng Jiang and Hung-tat Tsui presented a novel texture and shape based method for kidney segmentation in ultrasound (US) images. A variety of Gabor filters were used to test images through two-sided convolution strategy. Using expectation-maximization method, a texture model is developed by approximating the parameters, utilizing half-planed Gaussians. With the help of this model, similar texture areas around the segmenting locality is measured. The intention of partitioning the test image is achieved using this energy function. The outcome of this work is segregation of two regions-the inside one with high texture similarity and low texture variance, and the outside one with high texture variance [3].

Another method suggested for segmentation of kidney regions is by using seeded region growing method. In this method, not only the kidney regions are extracted, but also the variation of the size of the kidney images with kidney stones were also discussed by the authors.

Tamilselvi and Thangaraj has classified images into three categories like kidney image with stone, image with small stone formation and image without stone by using intensity threshold difference method to ease the identification and classification of multiple classes[4].

Watershed transform is also used as a technique to identify kidney regions. Chun-yan Yu ,Ying Li worked on a new method to avoid the over segmentation problem of this method by using total variation model to enhance the contrast and thereby attain smoothing. This nonlinear filter solved the over segmentation problem by exposing kidney regions more precisely[5]

Luying Gui and Xiaoping Yang worked on a segmentation technique to extract lesions from ultra sound images. A detection framework to identify the difference between normal kidney and kidneys with lesions is designed. To segment, three major features like image intensity, local binary pattern and edge indicator is used. This ROI (Region of Interest) of lesions from ultrasound images is a common and popular method for preliminary diagnosis. In this paper, Luying Gui et al. developed an automatic segmentation algorithm for various types of lesions in ultrasound images. This proposed method is stated to discover and extract lesions automatically with very good accurate segmentation results for lesion regions. The average precision and dice coefficient of this method is claimed to be 95.33% and 90.16%[6]. Torres *et al.* has conducted a survey on the various techniques of kidney segmentation in MR images and CT images [7].

Shi Yin et al has applied a distance regression neural network approach for kidney segmentation from ultrasound images of abdomen. Natural images to acquire features of kidney is pre trained and then these features are used to learn kidney boundary distance using boundary distance regression networks to predict the classification of kidney pixels and non kidney pixels. Authors suggest that the automatic kidney segmentation is more accurate than deep learning based pixel classification networks[8].

III. SEGMENTATION OF RENAL CALCULI FROM ULTRASOUND KIDNEY IMAGES

The segmentation of Medical images is very complicated due to the interference of artifacts and great care should be given for edges. The presence of artifacts can affect the results of intensity based image processing methods. These are removed using a combinational approach of noise removing [CANR] before sending it for further processing [9]. Many techniques of global segmentation have been evolved over the years. In this work Ultrasound images of kidney region are segmented using Region Indicator with Contour Segmentation Method[10] to extract the region of interest, that is the renal stones which is explained in detail in the section A. The calculi/Artifact region has to be segmented and this segmentation procedure is illustrated in the following section.

A. CANR in Coalition of Region Indicator with Contour Segmentation Method

Segmentation is one of the critical and complicated steps in medical imaging. In this paper, a new approach of segmentation has been introduced using a combined approach of CANR and Contour method. CANR is combined with RICS (Region Indicator with Contour segmentation) to get a better view of the probable renal stone. The ROI can be extracted using a prior knowledge about the location and contour of the Ultrasound image. The main aim of contour model is to divide an image into fixed number of semantically important regions. Active contour which is otherwise called as snakes is immune to noise, boundaries and gaps. It aims at locating the object boundaries using curves which are flexible. It can fit large number of assorted shapes and works with the concept of computations of minimal energy path. There are various contour models discussed in literature. The contour is moved by forces of energy function and by controlling energy, the curvature can be controlled. It starts with a small curve and then minimizes the total energy to optimum value.

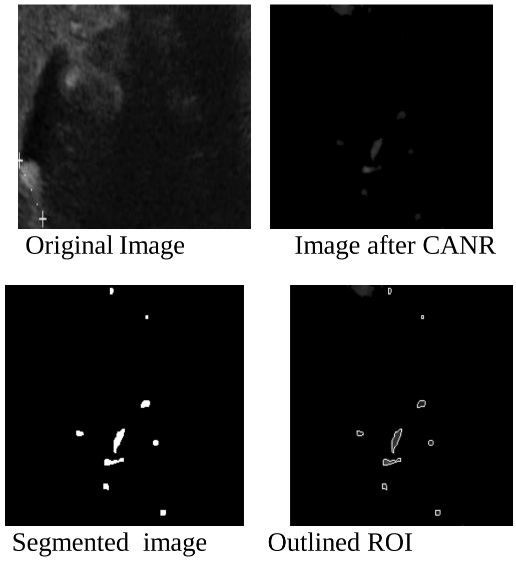

Figure 2 .-Segmented Calculi and Artifacts

The ROI, in this case RCs(Renal Calculi)/Artifacts has to be segmented to proceed with further analysis. A sample extracted Region is shown in Figure 2 and the extracted probable renal calculi is shown in Figure 3.

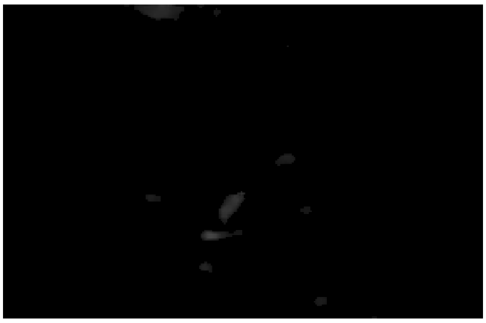

Figure 3 -Extracted Probable Calculi

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B. Performance Analysis of CANR-RICS

This performance analysis utilizes statistical measures to compute the accuracy of RC/Artifact segmentation done by the CANR-RICS method. The statistical performance measures are detailed in the following Table 1.

Table 1-Statistical Performance Index.

Sensitivity	$TPR = TP/P = TP/(TP+FN)$
Specificity	$SPC = TN/N = TN/(TN+FP)$
False Positive Rate	$FPR = FP/N = FP/(FP+TN) = 1 - SPC$
Efficiency	$ACC = (TP+TN)/(P+N)$
Positive Predictive Value	$PPV = TP/(TP+FP)$
Negative Predictive Value	$NPV = TN/(TN+FN)$
False Discovery Rate	$FDR = FP/(TP+FP) = 1 - PPV$
Matthews Correlation Coefficient (MCC)	$\frac{TP \times TN - FP \times FN}{\sqrt{(TP+FP)(TP+FN)(TN+FP)(TN+FN)}}$

The contingency Table is illustrated in Table 2

Table 2.-Contigency Table for CANR-RICS

	DETECTED BY ALGORITHM	MISSED BY CANR-RICS
ROI PRESENT	42(TP)	0(FP)
ROI ABSENT	(FN)2	14(TN)

The ROI which is segmented lies in any of the above categories. That is TP, FP, FN or TN. These are the assessment standards to gauge the performance of an algorithm. These terms are defined as follows.

TP - Number of renal calculi/Artifact ROIs properly detected

FP - Number of non-renal calculi/Artifact ROI detected wrongly as renal calculi or artifact ROI

FN - Number of renal calculi/Artifact ROIs that are not detected

TN - Number of non-renal calculi/Artifact ROI which are correctly recognized as non-renal calculi/Artifact ROIs

Every ROI of CANR_RICS therefore belongs to one of the following classes: True Positive (TP), True Negative (TN), False Positive (FP) or False Negative (FN).The precise classifications of renal calculi/Artifact are True Positive and True Negative. A False Positive occurs when there is an incorrect detection of the presence of calculi/Artifact when it is really absent. On the other hand, a False Negative is formed when the algorithm fails to detect the presence of calculi/Artifact portraying that it is not present when it is actually present. The performance analysis is shown in Table 3 below.

Table 3. Performance Analysis Table for CANR-RICS

SENSITIVITY (TPR)	SPECIFICITY(TNR)	FPR	EFFICIENCY/ ACC	PPV	NPV	FDR	MCC
93.33	87.5	17.64	91.80	93.33	87.50	6.666	91.391

Sensitivity measures the proportion of True Positive that classifies the precise presence of renal calculi/Artifact. The use of sensitivity measure is to identify the calculi/Artifact correctly. Specificity measures the proportion of True Negative that produces negative results in the absence of the calculi/Artifact. Specificity measure stipulates whether non renal calculi/Artifact in the US kidney images are not marked as renal calculi/Artifact . The predictive values are used to detect the percentage of the positive results that are True Positive and the percentage of the negative results that are True Negative. The Positive Predictive Value is the probability that the renal calculi are present in a positive test result. The Negative Predictive Value is the probability that the renal calculi is absent in a negative test result. False Discovery Rate (FDR) control is a statistical method used to monitor and correct multiple comparisons in multiple hypotheses testing. The FDR detects the expected proportion of False Positives among all significant hypotheses. If FDR value is high, artefact regions are wrongly recognized as calculi region. While performing multiple comparisons in a statistical analysis, the False Positive Rate acts as the probability of falsely rejecting null hypothesis of a particular test. The rate of occurrence of false positive test results in normal region is indicated by FPR.Matthews Correlation Coefficient (MCC) is a method used to measure the quality of binary (two-class) classifications. It takes the report of TP, FP, TN and FN and is generally regarded as a balanced measure that can be used even if the classes are of different sizes.MCC decides the quality of the renal calculi/Artifact detection process. The accuracy or success is the ability of the test to give a positive result on positives and a negative result on negatives. A good performance is measured based on the above eight measures. Among these eight measures, SV, SC, PPV, NPV, MCC and ACC should be improved and FPR and FDR values must be reduced. The equations for these performance measures are given in Table1.

IV. CONCLUSION

Though there are different image segmentation techniques, extraction of regions for disease diagnosis has to be very accurate. Even a single cell should not be missed out which is still an active area of research. This algorithm is a step towards analysis of an effective organ segmentation from abdominal ultrasound images . From these segmented organs an attempt is also made to extract renal calculi region from segmented kidney area.

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