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Image Segmentation Techniques for Medical Ultrasound Images

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Abstract— Image segmentation is the foremost step in several applications of computer vision. The major goal of the segmentation process is to partition an image into multiple regions or set of pixels that are homogeneous with respect to one or more features or characteristics, such as texture, colour or intensity. The adjacent regions are significantly different with respect to the same characteristics. The segmentation is an important tool in the medical domain and it has been useful in many applications. This paper provides a overall view about various image segmentation techniques applied to ultrasound images.

***Keyword s* — Image segmentation, Ultrasound Images, Texture, Region, Watershed, Morphology and contour based models.**

I. INTRODUCTION

In medical image processing, the segmentation is important for feature extraction, analysis of dynamic behavior of anatomical structures or quantitative image measurements such as area, volume and image display. A wide variety of segmentation techniques have been proposed. However, there is no single standard segmentation technique that can produce satisfactory results for all image processing applications.

The Cyst is one of the most common lesions in kidneys and can be diagnosed exploiting the US images as explained by [1]. They have developed an automatic approach for cyst segmentation of the US images. The proposed approach is fast and less complex to suit the US exploration applications.

To reduce the complexity of the previous method, US image based renal stone detection and identification algorithm has been proposed by [2]. The contrast and the target shape are the two types of image features that have been chosen for stone detection and identification. The produced results have confirmed the practicability of the US images based computer aided detection and identification of renal stones. However, this method has produced less accuracy results in the renal stones detection.

To improve accuracy and solve the time complexity problem, [3] and [4] have proposed two different methods. [3] have proposed a utilization of stone models for the computation and evaluation of shock waves. The computation of measurement has matched satisfactorily in the time domain and discrimination between fractured and intact model stones has been possible by means of frequency analysis of detected acoustic scattering. [4] have proposed a system that performs monitoring of real time renal stones by means of the US imaging and described certain features of the image analysis module. They have proved that the improved system has more robustness compared to the original system. The damage to healthy tissues as well as the treatment time has been considerably decreased by such systems.

The problem of image segmentation has been approached from a wide variety of perspectives. The approaches available for segmentation are

1. Texture based approaches
2. Region growing techniques
3. Watershed and Morphology based approaches
4. Contour based models

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II. SEGMENTATION METHODS

A. Texture Based Segmentation

[5] have stated that the medical image segmentation which is a critical step for most subsequent image analysis tasks is to restrict the image areas representing different anatomies. This method is an exigent task due to considerable overlap of soft tissues in the abdomen. An additional texture based method has been proposed by [6] for kidney segmentation in US images. The texture features are extracted by applying a bank of Gabor filters. This method lacks its performance considering the occurrence of relative error in the segmentation process.

The performance to be improved by the intensity-based methods has been proposed. They have explained that the intensity-based methods have secured only limited success in abdominal segmentation and texture segmentation, which makes use of statistical textures analysis to label regions based on their different textures.

B. Region Growing Algorithms

Region growing is a procedure where one or more seeds are taken and grows the regions around them based on certain homogeneity criteria. The selection criteria for merging are again dependent on the nature of the problem. The merging criteria maybe gray level, color, texture, shape or semantic information. The region growing methods requires

- A definition of the connectivity measure
- Planting of a seed
- Growing the region until the criteria is no longer satisfied.

Among the various image segmentation methods, the Seeded Region Growing (SRG) algorithm, originally proposed by [7] is a fast, robust, parameter-free method for segmenting intensity images given initial seed locations for each region. The use of SRG algorithm in the renal calculi segmentation has been proposed by [8] and [9]. The renal calculi detection method proposed by [8] failed to analyze the accuracy in segmenting the calculi regions i.e relative error. [9] Their algorithm has been tested with the US images of 37 patients. In the test results, only 95% accuracy is achieved, which is not adequate in the contest of medical relevance.

To eliminate the drawbacks of the existing techniques and achieve segmentation performance, three different segmentation techniques with SRG algorithm have been proposed by [10], [11]. [10] have discussed that region-based methods focus attention on an important aspect of the segmentation process. They do not use the original image for segmentation process and only the feature image is used. The features do not represent single pixel but neighborhood pixels depending upon the size of the mask which the operator uses.

The problems with the region-oriented approaches are that they are prone for over or under segmentation. Certain post-processing steps are required to avoid too many regions or too few regions due to non-optimal parameter settings, many post-processing steps are suggested.

C. Watershed and Morphology Based Approaches

Watershed segmentation is a famous edge-based segmentation algorithm. The term "watershed" is a geographical one. In geography, a watershed line is defined as the line separating two catchment basins. The rain that falls on either side of the watershed line will flow into the same lake of water. This idea can be used in digital images. The image gradient can be viewed as an environment. The homogeneous regions in the image usually have small gradient values. Thus, they represent valleys while edges represent peak i.e. edges having high gradient values.

The watershed transformation based segmentation approach is the function based on the morphological principle [14]. The watershed transformation technique is used to reduce the over-segmentation of the watershed algorithm. The objective of the watershed transform is to search for the regions of high intensity gradients, which separate the neighboring local minima.

To obtain a clear image, [15] have proposed the watershed transform has interesting properties which make it useful for many different image segmentation applications. However, when it is applied for medical image analysis, it has got major drawbacks such as over segmentation, sensitivity to noise and poor detection of thin or

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low signal to noise ratio structures. But the segmentation result performance is inappropriate. i.e. the results have the over segmentation problem.

To remove such drawback in the previous technique, a new watershed segmentation method has been proposed by [16]. The watershed lines divide individual catchment basins. When an image is partitioned into too many regions, it also produces over segmentation. To avoid over segmentation, foreground and background markers can be used. These foreground and background markers do not work well in solving the over segmentation problem. [16] has stated that the hybrid watershed scheme increases the capture range of initial contour. It also improves the computational speed and enhances its robustness to noise. But it has over segmentation and missing boundaries due to speckle noises in the US images. Moreover the morphology based method also used in the segmentation process.

As the ultimate goal of a stone segmentation algorithm is to position and mark the exact location of stones in an US image. From the results, the proposed algorithm automatically detects the kidney stones with minimum relative error.

D. Contour Based Methods

[17] have presented a technique of combining information about curvilinear continuity, color and intensity in a region-based approach to perform image segmentation. The contour information is obtained through orientation energy. Here the major advantage of contour-based approaches is that the grouping factor of curvilinear continuity can be treated very naturally. This contour based image segmentation method does not acquire a very accurate result. In order to improve the segmentation accuracy, a fuzzy logic method is introduced with the contour based segmentation method. All these active contour based segmentation methods utilize a US images for renal calculi segmentation and detection processes. The process of contour based methods manually placed the contour in the images. The random processes of contour based method segmentation results are not precise.

III. CONCLUSION

The main focus of the detection system is to extract the minute details of the calculi present in the US images. The image analysis of the calculi provides the necessary information to the calculi detection process. These rules are then combined with the human expertise so that the resultant system will exhibit a better performance. The survey provides a study about various segmentation approaches related with medical images.

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