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Survey of Segmentation Techniques of Cancer Images Emphasizing on MRI Images

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ABSTRACT

Research remains the most important process as far as cancer diagnosis and treatments are concerned. The outcome of such research should lead to decrease the number of deaths due to cancer. The main objective of cancer research is to identify cancer and to suggest the best possible treatment. Digital image processing has been used as a domain for such research to automate the process of findings in diagnosis and treatment. Image segmentation is a prerequisite in digital image processing for understanding the content of the organ scanned through different modalities in medical study. Magnetic resonance imaging (MRI) is one of the modalities in medical imaging procedure that uses strong magnetic fields and radio waves in order to create the images of organs in horizontal cross sections and to display the internal structures in the body. Segmentation techniques are part of digital image processing and it is one of the essential techniques which is required to precisely locate the organ and apply the domain knowledge for treatment. This paper focuses on the various segmentation techniques of digital image processing especially with MRI images of cancer. It analyzes the approaches being followed in different research in segmenting the organs of interest which may lead to further medical processing.

Keywords:- Segmentation, MRI, Tumour, Lesion, Threshold, Clustering, Region Growing, Edge detection

I. INTRODUCTION

Cancers that are confined to the wall of the organ (usually in stage 1) are often curable with surgery whereas the cancer that has spread outside the organ and to other neighboring parts usually is incurable or very difficult to cure. In such cases the oncologist focuses on extending the life of the patient through chemotherapy, radiation etc. As far as research in medical imaging is concerned, a lot of effort has been put to focus on tumours that may lead to cancer. The existing procedure makes the patients psychologically very stressful since frequent visits to clinics followed by pathological as well as scanning tests are to be performed along with the surgical procedures. Apart from diagnosis, the finding of stage of the cancerous tumor is much more important since the kind of treatment is dependent on the stage of the cancer. Various modalities and pathological testing are done in order to detect the stage. Irrespective of the type of cancer, to have a absolute uncovering and investigation of the problem under consideration, it is very essential to do preprocessing of the obtained medical images and use the best method to extract the organ under study. This paper throws some inputs on the various segmentation techniques on MRI images that are being compared as well as being used to find the best possible outcome. The study is focused mainly on MRI images of different types of cancer with special attention to rectum cancer. The anatomical structure of the region of interest (ROI) needs to be delineated and extracted from which better diagnosis can be done. This study is the outcome of the analysis done on earlier research works pertaining to this area. The study is important because of the high need to have proper segmentation techniques while deploying image processing. Figure 1 shows the role of segmentation and its importance in the field of digital image processing. Segmentation is considered to be one of the most critical functions of image

processing since all the trailing processes such as image representation and description, image feature measurement, image classification are dependent on the proper segmentation of the object under study.

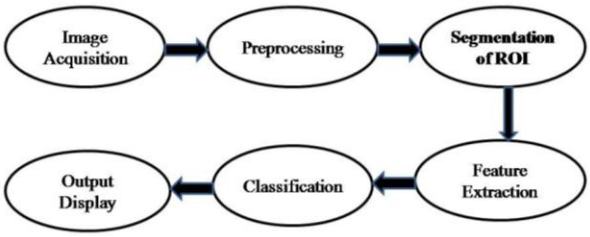

Figure 1. State of Segmentation in Image Processing.

This paper attempts to bring the various researches on segmentation under one roof. Its focus is to bring out the consensus of various research papers based on segmentation of cancer related images. Apart from the section 1 on Introduction, this paper is further divided into following four sections. The second section introduces with the concepts of segmentation in image processing entitled segmentation in medical images, which is followed by rationale for MRI in section 3. In section 4, the emphasis is on Survey and observations from researches. Section 5 gives the conclusion and section 6 the "references" of the literature survey.

II. SEGMENTATION IN MEDICAL IMAGES

Segmentation refers to divide a given image into sub segments based of similar characteristics or location as neighborhood pixels. The objective of segmenting the image is to separate out the region of interest from the whole image according to its functional components. The main properties on which the segmentation is dependent are similarity or discontinuity of intensity values of the object. Thus it partitions the input image into its sub components or sub regions. Segmentation in general can be applied to any digital image. When this technique is applied in medical images such as CT scan, MRI etc., it involves the knowledge of biology along with computer science so that the required result can be achieved automatically. The image captured through medical modalities contains the object (organ) under study along with the neighboring objects. Identifying the concerned object is an important and complicated task. Segmentation of digital image processing thus helps in achieving that. The methods of image segmentation can be broadly divided into four types as in figure 2.

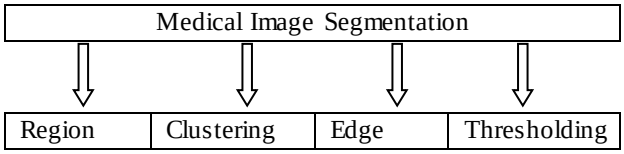

Figure 2. Types of Segmentation

Under these broad classifications there are many knowledge based approaches which are dealt in brief viz.,Clustering methods, and methods based on Intensity, Discontinuity, Similarity, Graph, Pixon, and Hybrid methods.

Clustering Methods:

Similar pixels in the images are grouped together to form a cluster. This may represent a portion of the image. So on comparing the pixel values - similar clusters will be grouped to form different clusters. This method is effective when we are in need of separating different organs of a human body. But when we are required to segment within an organ, clustering may not give a clear dissimilarity among pixels.

Threshold Based Techniques:

These techniques classify the image into two classes, namely those pixels above a threshold value (high intensity) and those pixels below a threshold value (low intensity). In other words it can be called as light and dark regions. The main disadvantage of this method is one cannot guarantee for object coherency. There are possibilities that the image may have holes or extra pixels.

Discontinuity based Method:

Rajiv Kumar et al. [33] discusses about the discontinuity based method in which the partitions or sub-division of an image is based on some abrupt changes in the intensity level of images. The distorted points are identified as the same object.

Similarity based Method:

Pixels of same intensity and similarity in the texture are chosen for grouping as segments.

Graph based Method:

The Graph based method on the other hand converts the image into a graph where in pixels are represented as vertices and there are edges formed between these

vertices. This method tries to identify the different objects present in the image.

Pixon based Method:

Another popular method is the pixon based method which works with creation of new pixons and combining Markov Random Field(MRF) model under Baysean network.

Hybrid Method:

Hybrid method can be combination of one or more of the above mentioned methods which may give a better segmentation thus providing the advantages of all methods. The advancement in medical imaging field in the process of diagnosis and other findings is rapidly increasing. Accurate segmentation of the region of interest is very important in processes like contouring, projecting etc. Many researches show that segmentation is a crucial step in the process of detecting or testing a disease and therefore each further research paves a way for advanced segmentation techniques.

III. RATIONALE FOR MRI

Initially the primary role of magnetic resonance imaging (MRI) has been in the investigation of neurological diseases and was effectively used for diagnosis of musculoskeletal abnormalities. With the advent of technology and innovations in MRI systems, the role of MRI has rapidly grown to a large extent expanding itself to diagnosis of any disease concerned with the damage or internal organs of human body. Several applications and researches have given different dimension to the use of medical instrumentation like X Ray, MRI, CT scan, PET scan etc. This new dimension is nothing but application of digital image processing especially with diagnosis of critical diseases like cancer. MRI has its own pros and cons. Though MRI gives a grayscale image and not a coloured image, it still plays a major role in diagnosing medical problems especially for detecting cancer. The reason behind this is the clarity of the image. MRI has inherently superior quality of the soft tissues of the object which enhances the contrast. This helps in improving localization of tumour as well as staging the cancer. Many researchers have discovered that MRI is the best available radiologic modality in investigating the local staging of cancer especially the rectum cancer. While focus of the radiologic expert is primarily on axial view of the image, equally the coronal and sagittal images are important which are well captured in MRI. MRI gives cross section pictures of the internal organs from different angles if required and the clarity of the image is also good.

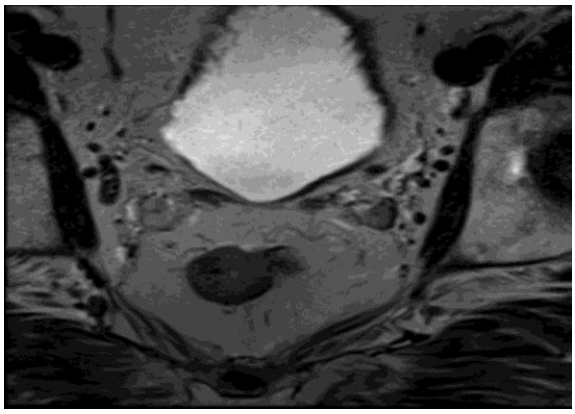

Figure 3. An MRI Image of rectum cancer along with neighboring nodes

Figure 3 shows the axial T2 weighted MRI image of rectum cancer where it has captured not only rectum but also the nearby lumph nodes and bladder. In order to process the rectum portion alone for finding the lesion's spread level, one need to extract only the rectum part from this image. The above figure illustrates the MRI image taken from a GE scanner of the rectum area in axial T2 orientation. This picture is a clear example of the need for segmentation since it includes the other lymph nodes and neighboring organs as well. The GE instrument might have correctly focused on the rectum area but the capturing mechanism might not have the shape and the location of the organ. So segmentation plays an important role in further processing of this MRI image.

IV. SURVEY AND OBSERVATIONS FROM RESEARCHES

The research on segmentation techniques for medical images and especially for cancer images is never ending. Future research will strive for improving the accuracy, processing speed and precision of segmentation techniques. Even today, since the detection of cancer is related with the life of human, atlas based methods are adopted which gives more assurance in the findings. Medical Image Computing (MIC) being an interdisciplinary field tries to solve problems using computational and mathematical

modeling. The following sections discusses on the various research papers which has focused on medical images segmentation and how it helps in further improving the system on the whole. Patil and Deore [1] in their paper have dealt with an overview as well as a review on various research methodologies which are used in image segmentation. In that it has been observed that threshold, region growing, clustering and edge detection are compared to find the best suiting algorithm and the performance of each in medical images. This paper also indicates that there are no universally accepted methods for image segmentation as image segmentation is affected by lots of factors like homogeneity, spatial characteristics texture and so on. So we can't conclude with a single method which can be considered good either for all type of images or all methods equally good for a particular type of image. Withey and Koles [2], on the other hand discuss the first and second generation methods which require manual correction to be done by the experts. Thus it brings out a point that atlas selection, registration and manual segmentation is always preferred over automatic segmentation. But in [3], the focus of the paper is on brain MRI images wherein the author proposes an algorithm for automatic segmentation of Corpus callosum from the mid sagittal brain image. According to the study, once the corpus callosum is segmented from the surrounding tissues, it will be easier to detect other brain structures keeping the segmented callosum as the landmark. Further the study says that classification of the images is also possible based on the size and shape using image mining framework. But post processing is not included in this since it requires further minor level removals and divisions of the image. A different kind of segmentation technique is tried out in this research called NCuts. Several shots of the scene or the image is captured using graphical partitioning and upon that NCuts is used to find the optimal scene segmentation. In order to retrieve more useful information from the scenes, this research also focused on both parallel and serial scenes. The output of this research has been tested in several movies and TV series and the NCuts gave a promising result on segmentation. But whether it will be useful for medical images is still under study. With existing and newer segmentation methods the future research would concentrate in improving the accuracy, precision and also the processing speed It would also reduce the manual interaction or interference in implementing such methods. It has been found in some research that suing neural networks has given better results for segmentation. Lauren O'Daniel states in [6] that they have presented a user steered segmentation algorithm which is based on livewire paradigm. But how far it is really helping in further processing with the segmented images in reality is yet to be analyzed. Felicia Jones [6] deals with colour images especially that of CT images and how to have 3D visualization from the segmented regions. The paper itself says that future work needs to be carried out by providing with semantic meaning to the images. In [7] we can again see clearly that there is no single method available which can be considered for all type of images. But in [8], the authors focus on the study of soft computing techniques especially for edge detection based image segmentation methods. They have tried using fuzzy algorithms, genetic algorithms and neural networks on real life natural scene images and have obtained efficiency in the image segmentation. Tian et.al [9] focus on segmenting brain lesion in diffusion weighted MRI (DWI) using automated region growing approach. To get lesion region, region splitting and region merging were used. Region growing involves threshold value. Inorder to obtain seeds selection automatically, the TH value is calculated by means of histogram thresholding. The results have shown better results with fully automated region growing compared to semi automatic region growing segmentation. A new method has been proposed [9] for successful segmentation of HRCT lung images. The author says that in order to have effective segmentation based on feature and texture characteristics based on local variance of the DCT coefficients seems to work better. The difficulty is the appearance of patterns which is purely dependent on pathological conditions of the imagery object. Basically the paper focuses on classification using K-means and finally the with unsupervised segmentation. But the paper does not give a clear picture of the output. Survey has also been done on graphical approaches for image segmentation using discrete mathematics. The application of graph theory in images in enormous. The need of active participation of experts from both the fields, (Mathematics and Computer Science) along with the domain expert in radiology is at the peak of the hour to develop a proper tool for medical image processing

and to face the challenges of the problems faced in image segmentation. There is one paper which discusses on the use of topological gradient approach along with watershed transformation to solve the segmentation problem. The paper lists the various advantages of the above approach like cost, unwanted contour reduction, better output, edge based segmentation method which is easy to understand. In [13], the emphasis is given for accuracy, complexity, efficiency, interactivity of segmentation methods and review of various methods are studies. It has considered the principle ideas, application field, advantages and disadvantages of those methods to find the best among them. As mentioned earlier, each method is useful for certain kind of images. A paper on Segmentation of Lumen from endoscopic images has introduced the differential region growing algorithm and thus has done adaptive segmentation. It provides a good estimation of the optimum threshold for obtaining the seed for DRG that segments the lumen. Another study on Lumen uses adaptive progressive thresholding which enhances the boundary of the region of interest. The research has proposed a new algorithm for boundary extraction in segmentation method which is based on a heuristic search and the experimental results validated the effectiveness of the newer method on various images. S. Kumar et al. in their research [14], discuss about a newer method especially for endoscopic images which is framed as a newer algorithm. The new method has been compared with the traditional gradient based region growing technique. The method which works on a dual step has provided a easy, simple and a fast output and accuracy is moderate. It has been tested with several endoscopic images and the paper suggests for a future enhancement of increasing the accuracy in segmenting lumen region. The most commonly used segmentation techniques such as region growing, edge detection and thresholding techniques have been used alternatively in various medical images for further processing. A paper on Digitized Mammograms [15] focuses on the detection of clusters of micro calcifications. The paper further says that the system was evaluated by two radiologists and the results showed that there was an improvement in breast cancer detection. In [10], proposes fully automatic segmentation techniques which have been tested for brain lesions where in the images obtained were DWI MRI. After preprocessing, the method uses region splitting and growing algorithms and statistical features such as misclassified are, false negative rate, false positive rate etc are calculated for comparison with earlier methods. The outcome of this research is successful segmentation of brain lesions which can be further used for classification. A comparative study on the image segmentation methods done and published in IJSCE [16], describes that the segmentation process can be divided into various categories based on the parameter selected for segmentation. The parameters include pixel intensity, homogeneity, discontinuity, cluster data, topology etc. This paper also brings out the same view that single approach to segment all variety of images is practically unachievable. The prior knowledge on the image can give better results and gives the user the choice to decide a proper segmentation method to be chosen. Some of the research works focused on getting a three dimensional representation of anatomical structure of human body generated through computers. In addition to that more clarity of the organs was visible when analyzing the segmentation of the Visible Human body. In this paper, the authors have presented a new automatic region growing algorithm called the Medical Image Segmentation Technique (MIST) which is used to reconstruct 3D structures by segmenting 2D contours thus improving its performance. It is their first attempt to address the issue of segmenting organs, tissue and other structures from color anatomical images. There are several advantages in seeded region growing algorithm than the traditional segmentation algorithm. When the region is found using region growing method, there is continuity in the image segment and has one pixel thick boundary when compared to gradient and Laplacean based edge detection methods. MIST addresses the adjacency problem by defining the parameters correctly, thus eradicating too many adjacent tissues in the segmented region. Singh & Singh [35] have compared and analyzed the existing segmentation algorithms for different types of images especially for grayscale images and also taken efforts to extract text from the images in their research. Niran Joshi et.al in [36], have used a non-parametric mixture model for dividing the tumour portions and the neighbourhood lymph nodes of the rectum in to small segments. The non-parametric model is used for describing the intensity values of edges and ridges which are further used for segmentation. The method is actually used for

circumferential resection margin (CRM) to find the shortest distance so that the region of interest is focused. In [37], the focus is on the information retrieval of image combining colour, texture and shape features. Based on "Most Similar Highest Priority" method a combinatorial integrated matching method is created in order to do pattern matching in the image. Invariant moments are used to record the shape features. Segmentation and image retrieval become easier using this integrated method. The experimental results have shown efficiency in image retrieval. Several researches have shown considerable improvement by using the mean-shift segmentation and hybrid segmentation algorithms. They can create realistic segmentations with a wide variety of parameters, at the same time the ability of the hybrid algorithms has slightly been improved.

Sample output of most predominantly used segmentation techniques are shown below:

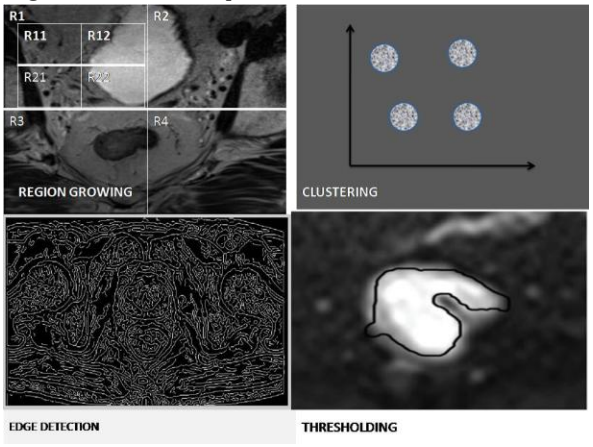

Figure 4. Sample outputs of the 4 segmentation methods

From the referred research works in section 6, some papers were randomly picked to find the statistical usage of major four segmentation techniques such as region growing (RG), edge detection (ED), thresholding (TH), clustering (CT) and other hybrid methods (OTHERS). The year of publications were taken right from 1993 till 2015 as being referred and the analysis is depicted in the graph as below where it is seen that thresh-holding method is used extensively especially for MRI images of various cancers.

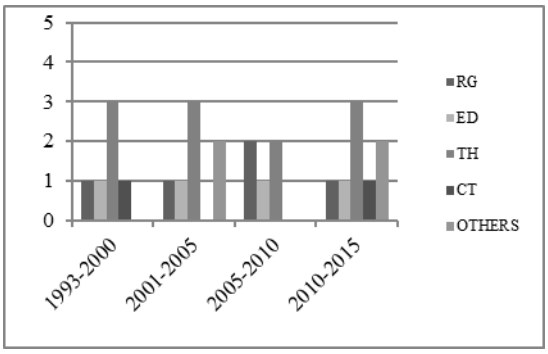

Figure 5. Graph displaying the usage of segmentation methods

V. CONCLUSION

In some papers it is shown that semi-automatic segmentation algorithm can produce accurate and reproducible tumor volume measurements when in finding the four types of lesions. There are advantages and disadvantages in every method. When we use dynamic contour based image segmentation, then wavelet based edge detection method is much suitable to other methods which have shown promising results. Fuzzy imaging techniques can be used to generate a general framework for producing accurate results in both qualitative and quantitative ways. A novel segmentation method proposed in one of the papers on region growing and level set found to be appropriate method for setting up initial seed and other parameters in case of MRI images. Some papers discussed about merging multiple techniques in classification of image segments and to produce separate feature sets. On comparison of the several methods and techniques, the most relevant method is described in the thesis submitted by Joseph Gaber Elias Awad in [38]. Though it describes about a fully automatic segmentation of the region of interest, some amount of manual intervention is required from the expert to point out the area to be inspected. Since it is very difficult at this stage to find the exact location by the system itself which needs to be introspected, the manual intervention of specifying the points to be considered through an user interface seems to be the better method in classifying the findings. Yet there is no single method for all types of modalities and all types of cancers. When there is a vast difference in approach from one cancer to another as well as in modalities, then the level of analysis and techniques

required for other types of diseases is enormous. Still this area is niche and has scope for further findings.

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