Liver Segmentation Techniques of CT Images for Clinical Diagnosis

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Abstract: Liver Segmentation has become one of the most efficient and systematic tasks in the case of medical applications. Recently, the segmentation of liver has found its part in the research areas also. It has become a common feature to hinder the accurate and the proper segmentation of the liver intensities and its neighbor organs in the human body. Different techniques of liver segmentation can be performed with CT images, MRI images and PET. Among these CT images have a wide application in the detection, identification and segmentation of the liver deficiencies. Manual segmentation of the liver seems to be more time consuming yielding less precision and robustness. Nowadays, many techniques have been developed for the segmentation of liver that are more efficient, fast with accurate as well as better results than the traditional methods.

Keywords: Liver, Segmentation, CT, MRI

I. INTRODUCTION

The Liver is an abdominal organ and is the largest digestive gland of the human body. It acts as a detoxification organ that additionally produces bile. The liver resides on the upper quadrant of the abdomen. The diaphragm surrounds the liver superiorly, laterally and anteriorly. The stomach, duodenum and the transverse colon are layered along the median of the liver, the hepatic colonic flexure are found along the inferior part; and the right kidney and the adrenal gland are found in the posterior.

In the recent years, liver diseases have become a frequent cause of death all over the world. Hence it becomes crucial to prevent and treat the liver diseases all over the world. Most of the high resolution anatomical structures of the human organs are obtained by the use of CT images. Computed Tomography (CT) imaging has delineated to be one of the vital imaging techniques for diagnosing and in the treatment of clinical liver diseases.

Liver diseases diagnosed from the CT images are essential in medicine. Liver Segmentation is a crucial analysis subject in medical imaging. Liver segmentation will facilitate to determine the contours and the lesions structures present in the liver from the other tissues; hence certain applications like the evaluation of the liver, identification of the tumor in the liver and the surgeries are found to be efficient and accurate when it comes in the case of medical treatment of the deficiencies. In some cases, the organs like the abdomen, intestine and spleen might tend to have minor variations, whereas the liver may undergo sturdy discrete variations due to external forces which causes changes in the structure and the position of the liver. Hence an efficient and accurate segmentation of the liver in a CT image tend to be one of the challenging functions worldwide.

II. RELATED WORK

Kaijian et al [1] proposed an improved DeepLab-v3 framework that includes a Pix2pix network of the adversarial model. A semantic segmentation algorithm was developed for the segmentation of the CT images. According to this proposed model, the deep feature and the multi-scale semantic feature are combined to design an improved framework segmentation. The generalization ability and the accuracy of the CT images is improved by combining the loss-function of the cross entropy in a traditional multi classification system with the generator output loss function and the discriminator output loss function. Here, the outcomes and performance of the proposed algorithm shows better results than the other segmentation models. It can improve the efficiency of segmentation of the space consistency of the CT images. The comparison of the other segmentation models are shown in Fig 1.

Fig 1. Comparison of the results of different segmentation models (a) raw CT image, (b) Ground truth, (c) Proposed, (d) DeepLab V3 (e) SegNet (f) DeconvNet

Mubashir et al [2] developed a deep belief network that is based on the automatic feature of the learning algorithm. This algorithm is based on the training of the unsupervised pre-training and supervised fine tuning which is termed as DBN-DNN model for liver segmentation. In the post-processing stage, an automatic liver contour method is applied. The results were more satisfactory upon the healthy CT images that produced a dice similarity coefficient range of 95%. The segmentation results of the DBN-DNN are shown in Fig 2.

Revised Manuscript Received on November 05, 2019.

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ZhenZhou et al [3] proposed a heuristic approach of multiple thresholds based on the slope difference distribution to segment the liver automatically. In order to delineate the liver boundary the results of the segmentation of the liver were combined together and a 3D image of the liver was created using the function of energy minimization globally. The performance of the segmentation process avail that the Ct images of the liver were robust as well as automatic. The segmentation results are shown in Fig 3.

Mohammed et al [10] proposed a Modified K-Means Algorithm for estimating the automatic liver volumes towards SIRT. According to this algorithm the human intervention will be minimized when the region contouring of the masks are initialized. Based on the proposed work, the Modified K-Means method is combined with the localized contouring algorithm. The slice of the liver can be segmented into different regions and they belong to various structures. The different regions of the liver can be segmented further by means of the localized contouring algorithm. The segmentation results produce a volumetric dice coefficient of around 0.92 and the accuracy of 97%. The results of the Modified K-Means Algorithm is shown in Fig 4.

Huiyan et al [11] proposed a GrowCut Algorithm along with the Snakes model which was used to segment the region of the liver in case of CT images. A pretreatment process of the K-Means algorithm is performed by the improved GrowCut method. The improved version of the GrowCut algorithm can be used as the contour for the Snakes model initially. The segmentation results show that the proposed algorithm has better precision and robustness and also add an overall efficiency than the other traditional algorithms.
Table 1. Advantages and Disadvantages of various Liver Segmentation algorithms

| Ref.No | Authors | Algorithm | Advantages | Disadvantages |
|--------|---------|-----------|------------|---------------|
| [1]    | Kaijian Xia | Semantic Segmentation Algorithm – DeepLab V3 Network | To improve the segmentation efficiency for abdominal CT images. | The boundaries of the liver region of the CT images seem to be blurred. |
| [2]    | Mubashir Ahmad | Automatic Feature Learning Algorithm | Saves memory and computational time | Less sensitive to tumor on the boundary of the liver |
| [3]    | Zhenzhou Wang | Slope-difference distribution based Threshold Selection Method | -Very efficient. -Accuracy is better | The optimal accuracy of the liver region cannot be achieved in case of unsupervised segmentation. |
| [4]    | Baochun He | CNN-ASM Segmentation Algorithm | More accurate with smaller standard deviation | Accuracy not as high as marginal space learning method. |
| [5]    | Yong Chang Zheng | Appearance and Context based Liver Segmentation Algorithm | Saliency of liver is improved compared to other organs | Running time takes a long image analysis |
| [6]    | Weiwei Wu | Improved Fuzzy C-Means and GraphCut Algorithms | Improved time efficiency of liver tumor segmentation while maintaining accuracy. | Relatively under segmentation and over segmentation errors occurred |
| [7]    | Xuehu Wang | Sparse A Priori Statistical Shape Model (SP-SSM) | Effectively converge to the liver boundaries obtaining more accurate segmentation results. | Average time required for liver segmentation can still be significantly improved. |
| [8]    | Weiwei Wu | Supervoxel based GraphCut Method | Reduce computational time and memory requirements. | Liver boundaries may be misclassified. |
| [10]   | Mohammed Goryawala | Modified K-Means Algorithm | Correctly segments liver region from other organs in the body. | Accurate calculation of liver volume may tend to cause precise radioactive dosage to patients |
| [11]   | Huiyan Jiang | Snakes Model and GrowCut Algorithm | Better robustness and precision and faster than traditional GrowCut Algorithm. | does not improve the accuracy |

III. LIVER SEGMENTATION TECHNIQUES

Segmentation algorithms can be classified into two main categories: fully automated segmentation and semi-automated segmentation methods. Fully automated algorithm are the threshold-based method, clustering method, region-based method, Snakes-based method. Semi-automated methods are termed to be interactive image segmentations based on graph cut, the random walker technique.

A. Thresholding

Thresholding methods are the sum of the weights of any number of probability densities with normal distribution and an approximation of the image histogram that represent a distinct approach termed as optimal thresholding or iterative threshold selection. The threshold will be set as a closest gray-level of the corresponding minimum probability between the maxima for two or more normal distributions, which results in minimum error segmentation.

B. Region Growing Segmentation

A segmented image using region growing method might contain either very few regions or more regions due to the setting of the optimal parameter. For the purpose of the enhancement and the classification of the CT images, a huge number of post processors are being evolved.

C. Active Contour Model

Active Contour Models are mainly used in the case of the segmentation of the images such as liver and the image understanding concepts. Active Contour models are mainly applicable for the 3D image data and the analysis if the image data’s. The active contour model, or snake is defined as an energy minimizing spline- the snakes energy depends on its shape and location within the image. Local minima of this energy then correspond to desired image effects. A common proficiency of the equivalent deformable image model can be analyzed using the Snakes model and also the energy minimization.
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D. GraphCut Segmentation

The GraphCut Segmentation can be identified as the automotive and an interactive method for either one or more points representing the object and one or more points representing the background- these points are called the seeds and serve as segmentation hard constraints.

E. Semantic Image Segmentation

Semantic approaches represent a significantly advanced field of image segmentation. Semantic image segmentation may comprise with different interpretation of the image regions and parts and the other image understanding ideas. Most of the semantic algorithms are based on the syntactic information of various systems. They also tend to combine the regions based on their local resources and are normally heuristic in nature.

F. Gaussian Mixture Models and Expectation Maximization

In the case of Expectation-Maximization (EM) Algorithm, the maximum value can be determined and identified locally. The obtained EM is computed more frequently and is of a good quality. During each phase of the computation the Gaussian value is estimated upon the sample which is termed as the expectation and the Gaussian parameters are refined which is termed as the Maximization.

IV. DISCUSSION

Most of the liver segmentation techniques have their own advantages and disadvantages which seems to be more effective in certain cases. Some methods improve the efficiency of the segmentation of the abdominal CT images. We can also identify that the robustness and precision of the liver segments are improved compared to the traditional algorithms. Certain methods offer inadequate accuracy during the segmentation process, which do not produce better results. In order to provide accurate results, certain algorithms can be used as a hybrid and enhanced to produce good outcomes.

V. CONCLUSION

This paper summarizes the liver segmentation techniques for the abdominal CT images. Most of the techniques are based upon the image segmentation and image understanding concepts. Some of the algorithms are compared and their performance is listed in the Table 1. It is possible to identify the problems of the earlier segmentation algorithms and make a solution to it. Here we point out that there are still multiple techniques that are available and they can be utilized together to achieve better results in future.

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