Liver Segmentation of 3D CT Scan images using Parallel Processing

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ABSTRACT: This study describes a new 3-D liver segmentation method for purpose of transplantation surgery as a treatment for liver tumors. Liver segmentation is not only the key process for volume computation but also fundamental for further processing to get more anatomy information for individual patient. Due to the low contrast, blurred edges, large variability in shape and complex context with clutter features surrounding the liver that characterize the liver CT images, it is a convoluted problem and still a challenge task to robustly and accurately segment the liver. In this paper, we overcome these difficulties with a novel variational model based on the idea of intensity probability distribution propagation and region appearance propagation with which we can focus on the target liver regardless of how complex the uninterested background is. This 3-D segmentation is based on combining a modified k-means segmentation method with a special localized contouring algorithm. De noiseing of the image is done in order to obtain good results for the technique. Histograms are plotted so as have a graphical view of the difference between noisy and de noised image. In the segmentation process in order to divide the image, five separate regions are identified on the computerized tomography image frames. The merit of the proposed method lays in its potential to provide fast and accurate liver segmentation and 3-D rendering as well as in delineating tumor region(s), all with minimal user interaction.

Keywords: image segmentation, liver segmentation, MATLAB, k-means algorithm

1. INTRODUCTION

Living donor liver transplantation takes advantage of the fact that:
1) The liver is able to regenerate after partial resection. In the light of the lack of deceased donor organs as well as religious and cultural obstacles, parts of the liver are taken from healthy donors to be transplanted to the diseased donees. Donor’s liver will regenerate up to almost 100% of its original size within a few months. Surgery planning for both donor and done must meet the criteria which is minimize risk for the donor by preserving a maximum remnant liver volume 2) For the calculation of expected intra operative weight and volume of a living donor’s liver. Liver segmentation is the first significant process for liver diagnosis of the Computed Tomography (CT scan images). The process of image segmentation consists of transforming an image into different phases (a cartoon version), while keeping track of important properties of each phase.

Segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. The simplest method of image segmentation is called the threshold holding method. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image. The K-means algorithm is an iterative technique that is used to partition an image into K clusters. In this case, distance is the squared or absolute difference between a pixel and a cluster center. The difference is typically based on pixel color, intensity, texture, and location, or a weighted combination of these factors. K can be selected manually, randomly, or by a heuristic.

MATLAB provides effective different alternatives to address computationally intensive tasks based on issues of parallelism and high-performance computing (HPC). Krishnamurthy et al. presented an exhaustive description of all the HPC techniques offered by MATLAB [14]. The most popular techniques are MATLAB-MPI [15], [16], MATLAB [17], Star-P [18], [19], the MATLAB Distributed Computing Toolbox (DCT) [20], This computational process is structured in a way that its deployment can extend to clusters and grids [23], [24], if the need arises.

2. RESEARCH AIM

The research aim is to design a new algorithm for accurate and fast liver volume calculation using little as possible user intervention and yet maintaining the accuracy of the obtained results. This algorithm semi automatically segments the liver region from 3-D CT scans. The algorithm extracts the liver region and renders the segmented liver for 3-D viewing. The algorithm is also structured as a parallel-aware process so that a computationally taxing task can be distributed over various computing nodes.

3. METHODOLOGY

Liver segmentation based on CT images is a challenging task due to the presence of similar intensity objects in the abdomen with no clear delineation between these objects and the liver. These objects include the spleen, stomach, wall of the abdomen, and kidneys. A new method for liver has, thus, been
developed based on a combination of a modified k-means clustering process and the active contours algorithm. Although reduced manual interaction is desired, the variations in the liver datasets seen in patients having tumor along with the need to obtain accurate volume determination for the SIRT treatment justify the use of the proposed semiautomatic method. The proposed method used to select the slices requiring human interaction is based on tracking the changes observed in the liver region across the slices. The image obtained via any transmission media may contain noise. Hence it is essential that before applying any technique, the image should be error free.

Image noise is random variation of brightness or color information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is an undesirable by-product of image capture that adds spurious and extraneous information. The original meaning of "noise" was and remains "unwanted signal"; unwanted electrical fluctuations in signals received by AM radios caused audible acoustic noise ("static"). By analogy unwanted electrical fluctuations themselves came to be known as "noise". Image noise is, of course, inaudible. The magnitude of image noise can range from almost imperceptible specks on a digital photograph taken in good light, to optical and radio astronomical images that are almost entirely noise, from which a small amount of information can be derived by sophisticated processing.

Various noises can affect an image. Hence average and median filter is used as to recover the original image. Once the original image is obtained segmentation technique can be done. Comparison is done between images by using histogram so as to view the between original and denoised imagr.

Fig.1. Five reference regions, M1 through M5, needed to apply the k-means based segmentation method on a liver CT dataset.

A. Design Structure of the Algorithm

The algorithm as designed requires the user to manually pick five points of varied intensity in the scan for the k-means segmentation as well as a rough outline of the liver in widely spaced slices throughout the given CT dataset. From this initialization process, the following automated steps are then considered.

1) k means algorithm: K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed a priori. The main idea is to define k centroids, one for each cluster. These centroids should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest centroid. When no point is pending, the first step is completed and an early groupage is done. At this point we need to re-calculate k new centroids as barycenters of the clusters resulting from the previous step. After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new centroid. A loop has been generated. As a result of this loop we may notice that the k centroids change their location step by step until no more changes are done. In other words centroids do not move any more.[25], [26].

Finally, this algorithm aims at minimizing an objective function, in this case a squared error function. The objective function
\[ J = \sum_{j=1}^{k} \sum_{x^{(j)} \in C_j} \left\| x^{(j)} - c_j \right\|^2, \]
where \( \left\| x^{(j)} - c_j \right\|^2 \) is a chosen distance measure between a data point \( x^{(j)} \) and the cluster centre \( c_j \), is an indicator of the distance of the n data points from their respective cluster centres.
For the modified $k$-means approach adopted in the procedure segments the different regions of the CT slice around the user selected points. The user selected points act as the seeds for each of the five masks. The selection of the seeds, rather than a random selection or uniform selection of points in the range, yielded much better segmentation results. To obtain results free of misclassifications, a logical intersection of three independent segmentation runs are employed. Also the “online update mode” that calculates the sum of the distances with the movement of every pixel is used to obtain higher accuracies at the cost of processing time.

The segmentation results using the $k$-means yield five masks namely $M_1$ through $M_5$ corresponding to the aforementioned five regions are depicted in Fig. 2. The masks liver ($M_1$) and surrounding organs ($M_2$) are logically ORed together to obtain the final mask ($M_{final}$). Based on empirical results, it was determined that the optimal mask would require a combination of the first two identified regions since in some cases the entire liver is not seen in mask $M_1$ due to the inhomogeneous intensity.

2) Histogram: An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value. By looking at the histogram for a specific image a viewer will be able to judge the entire tonal distribution at a glance. Image histograms are present on many modern digital cameras. Photographers can use them as an aid to show the distribution of tones captured, and whether image detail has been lost to blown-out highlights or blacked-out shadows. The horizontal axis of the graph represents the tonal variations, while the vertical axis represents the number of pixels in that particular tone. The left side of the horizontal axis represents the black and dark areas, the middle represents medium grey and the right hand side represents light and pure white areas. The vertical axis represents the size of the area that is captured in each one of these zones. Thus, the histogram for a very dark image will have the majority of its data points on the left side and center of the graph. Conversely, the histogram for a very bright image with few dark areas and/or shadows will have most of its data points on the right side and center of the graph distribution across the entire liver region in the CT scans.

IV. RESULTS

Figure (3) shows original and denoised image. The difference between the images is shown by plotting histogram for both. Figure (4) shows the difference between images and histograms obtained by filtering the image by average and median filter. Figure (5) shows the five sets of image obtained by applying $k$-means algorithm, Figure (6) shows the image obtained after adding the required images to obtain complete size of liver.
V. Conclusion

Thus image was denoised and histograms were plotted so as to view the difference between original and denoised image. Results shows that median filter proves to be best as compare to average filter. Different masks were obtained by means of k-means algorithm. Final image showing size of

VI. REFERENCES


