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# Segmentation of Liver from CT Abdomen using K-Means and Morphological Operations

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***Abstract*—** Liver plays a vital role in human body. In the present scenario, Liver related diseases affect large number of peoples in India. Segmentation of liver image from computed tomography helps in disease diagnosis and making pre-planning decisions for hepatic surgery. This paper presents a segmentation method with the combination of K-means clustering, thresholding and morphological operations. The proposed segmentation scheme is applied on a 2-dimentional computed tomography abdominal image and the experimental result is evaluated using Dice similarity co-efficient and the measure is 94.46% against gold standard image.

***Keywords*—**CT Liver, K-means, Liver Segmentation, Morphology.

## I. Introduction

With the advent of technological revolution the medicine field is on the stride of medical imaging. By replacing human tissue excise with medical imaging, facilitates patients with non invasive diagnosis, and physicians with treatment planning of disease since medical imaging detects diseases at the tissue level. Wide ranges of imaging modalities are available for imaging human body. They are X-Rays, Ultrasound, Computed tomography (CT), Magnetic Resonance imaging, functional Magnetic Resonance Imaging (fMRI), etc. According to the nature of the disease and the requirement the specific modality is used. Liver is the largest gland in human body, reddish brown in color; wedge shaped and weighs approximately 1500 grams located below the diaphragm in upper right quadrant of the abdomen region protected by ribs [1]. Liver has varied functions such as detoxification, producing bile that aids in digestion. Liver diseases are one of the dreadful diseases worldwide and also in India [2]. So far no other artificial techniques have been devised to substitute its functions in case of liver failure. A Computer Aided Diagnostic system for segmentation of liver from Computed Tomography of abdomen helps physician and radiologist better understand the image and make interpretation faster. CT is a non invasive imaging technique. CT image can be acquired either with Intravenous/Oral contrast or without using contrast. “CT offers the best spatial resolution and the ability to study the entire liver in a single breath-hold. CT serves as an ideal screening examination for the entire abdomen” [3]. Due to this imaging fact we preferred CT images for our experimental research. Segmentation refers to delineate the structures from image. Abdomen is the largest cavity in human body. Segmenting liver region from abdomen image is a complex task due to variability in shape, size, and pathology and also majorly due to organs such as spleen, stomach, right kidney which are of similar intensity to liver. Before devising a liver segmentation method prior knowledge about the abdomen anatomy is required.

In this study, previous works related to our research are given in Section II. The proposed segmentation method is described in Section III. Empirical results are shown in Section IV with validation. Conclusion is stated in Section V.

## II. Related Work

In recent years, many techniques have been proposed for segmenting liver from abdomen. Very few are given here. Belgherbi A et.al, [4] developed a semi automatic method, which uses morphological reconstruction for extracting liver and watershed transform devoted to detect hepatic lesions. Wu W et.al, [5] has proposed a method for delineating liver on CT volume images using graph cuts automatically. Xiao Song et.al [6] developed a extraction scheme based on an adaptive fast marching method. Paola Campadelli et.al, [7] developed a gray-level based technique which cope with high inter- and intra patient gray level and shape variability. Ciecholewski M, [8] presented a segmentation method using approximate contour model.

## III. Proposed Method

Computed Tomography of abdomen with Intravenous contrast agent is used in our experiment. The contrast materials are used to enhance the image visualization and differentiate the liver tissues since stomach, right kidney; spleen and liver all are of same intensity range. The sequence of operations in our proposed method is given in Figure.1.

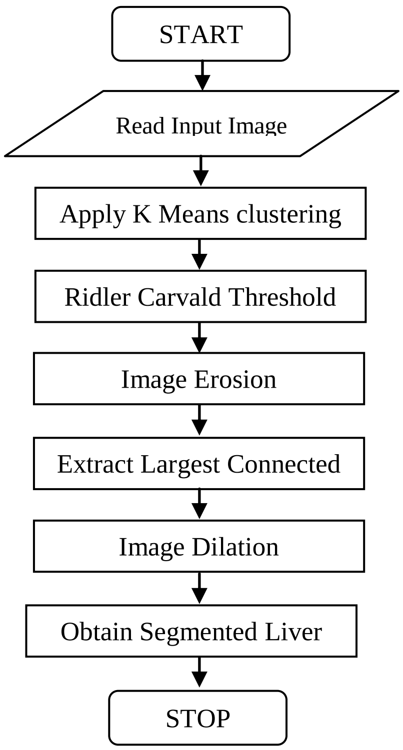


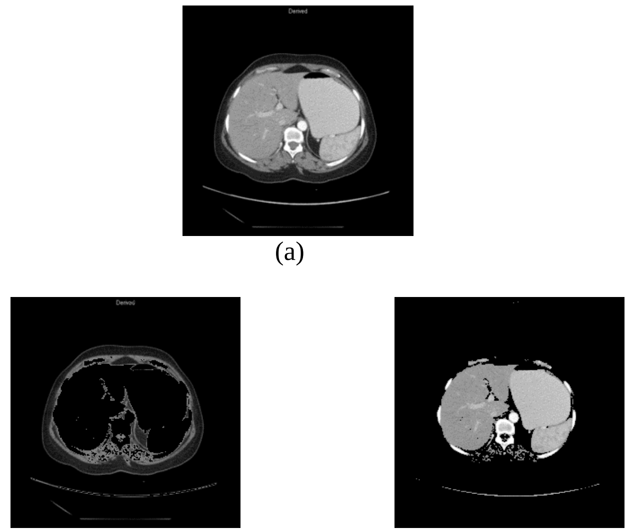

**Figure.1:** *Flowchart of the proposed method*

### *A. K Means Clustering*

K means [9] is one of popular and simplest clustering algorithm. It partitions each data points into k number of clusters. Each cluster will be defined with a cluster centroid (k number of centroids). Each pixel (n) in the image is taken and by finding the Euclidean distance between the centroid points and it is assigned to the nearest cluster. This step is repeated when no pixel point is pending. By calculating the mean of each cluster the new centroid is allotted. This step is repeated until no more changes in centroid is encountered. K means clustering step is given in equation (1).

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \| x_i^j - c_j \|^2 \qquad (1)$$

Where, $\| x_i^j - C_j \|^2$ is the euclidean distance between value of data points and c clusters. We use K means clustering with 2 centroids. (i) Segments region outside the ribcage of CT abdomen and (ii) Segments region inside the ribcage. The result of k means is shown in Figure.2



(a) (b) (c)

**Figure.2 :** *(a) Original Image,(b) K means centroid 1,(c) K means centroid 2.*

### *B. Ridler-Carvald Thresholding*

The result of K means clustering is taken as input for finding the intensity threshold. We use Ridler-Calvard [10] method for finding the Threshold value (T). Ridler-Carvald is an iterative threshold finding method. Using the threshold value, the image $I_K$ is converted into binary image ($I_T$). The obtained binary image is calculated using equation (2).

$$I_T = \begin{cases} 1 & \text{if}(I_K) > T \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

### *C. Image Erosion*

Mathematical Morphology [11] is used in image processing to reshape the images with the basics of set theory. A kernel or structuring element is designed with odd number of structuring matrix that is 3x3, 5x5, 7x7, 9x9, 11x11 and so on. The matrix can be in any of the shapes square, rectangle, diamond, Octagon, line, disk, and ball according to the requirement. There are two main operations, erosion and dilation, which is the base for all other morphological operations. We use both the operations here.

The result obtained from the process of threshold is taken as the input image for erosion. Image erosion is the minimum of all pixels in its neighborhood. The structuring element (D) is superimposed on the input image. A structuring element of disk shape with radius 2 is used is shown in Figure.3

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | **1** | 1 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 |

**Figure.3:** *Disk shaped structuring element*

The kernel is allowed to run over the original image. $I_{IE}$ is the eroded image which separates liver from other surrounding organs and tissues given in equation (3).

$$I_E=I_{RD}\ \Theta\ D \qquad (3)$$

### D. Largest Connected Pixels

In the eroded image, we can find many groups of isolated pixels. The knowledge about abdomen anatomy helps in removing smaller group of pixels with only liver remains as largest connected region ($I_{LCP}$).

### E. Image Dilation

The image $I_{LCP}$ is then dilated with the same structuring element (D). The lost pixels of liver region are regained. Image Dilation takes the maximum of all pixels in its neighborhood. Dilation operation is given in equation (4).

$$I_D=I_{LCP} \oplus D \qquad (4)$$

## IV. Results and Discussion

The CT abdomen image used is an IntraVenous (IV) contrast image from the GE lightspeed VCT scanner. The test image volumes are obtained from Medall Diagnostics, Trichy. The proposed method is experimented with two normal volumes of CT abdomen. Each volume consists of approximately 18 to 20 two dimensional slices which has liver region in the image which is of 5mmx5mm thickness. We have implemented our method in MATLAB 2013a environment. We evaluate the results of our segmentation method in terms of accuracy. Dice similarity co-efficient [12] is used to evaluate the percentage of accuracy between the results of our proposed method and manual segmentation done by radiological expert. The Dice metric is calculated as in equation (5).

$$Dice = \frac{2|A \cap B|}{2|A \cup B|} * 100 \qquad (5)$$

Where, A is the proposed segmentation method and B is the manual segmentation from expert radiologist. By comparing our results with manual segmentation the average Dice measures is 94.46%. Our methods lack behind when the liver region is too small. Figure.4 is the original CT abdomen slices taken for our experiment and the results of our proposed method is given in Figure. 5.

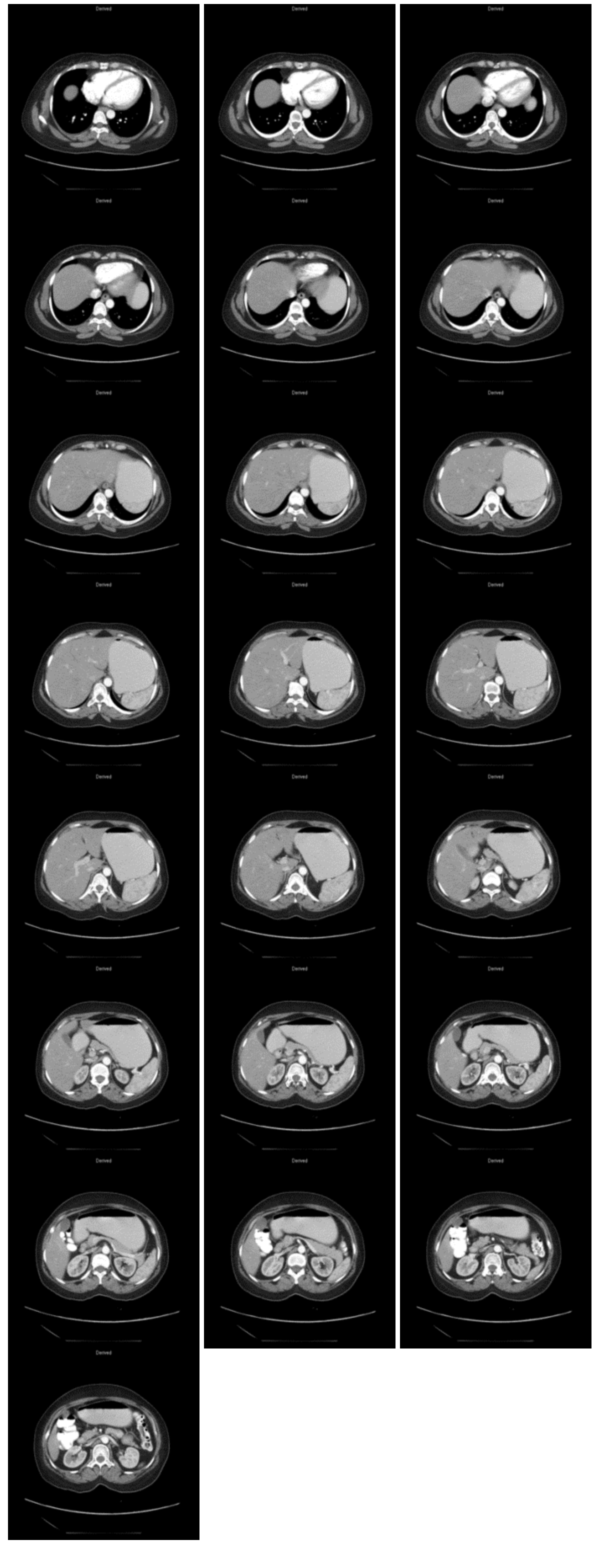


**Figure.4:** *Original volume of CT abdomen images*

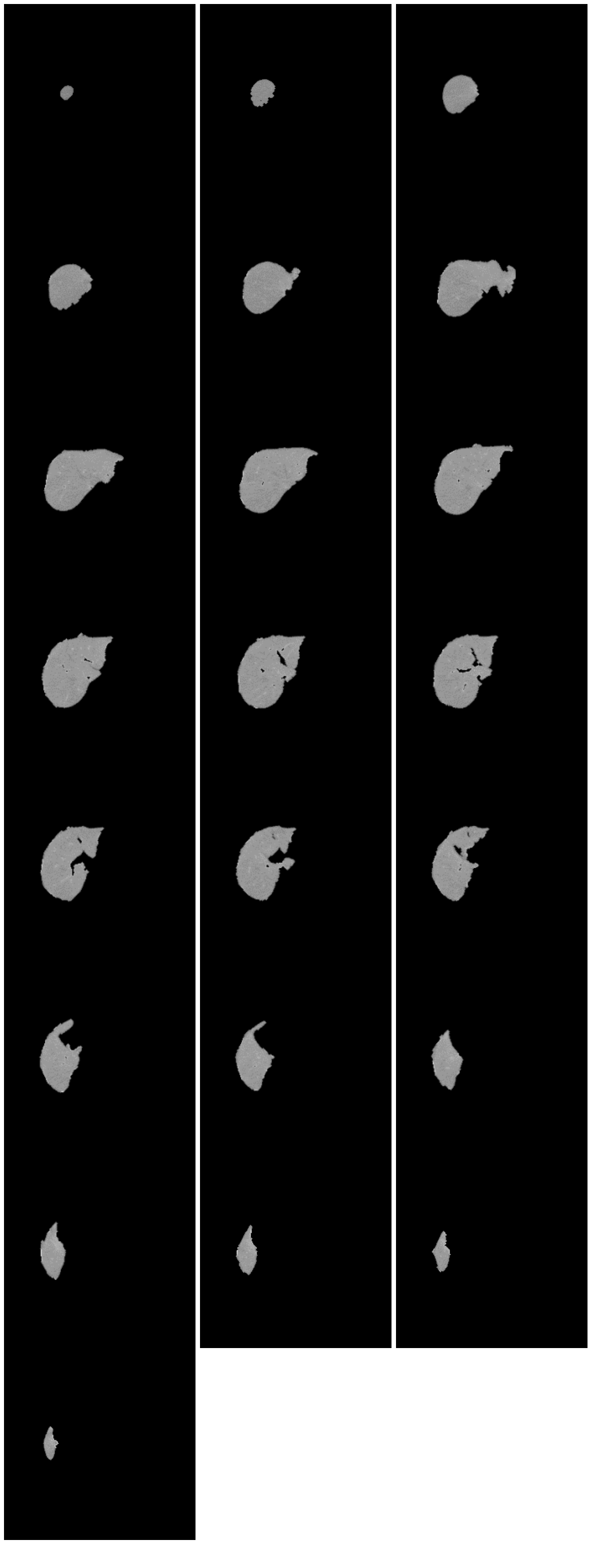


**Figure. 5:** *Liver region segmented from the Original Images*

## V. Conclusion

The presented segmentation method uses K means clustering for separating CT abdomen into region inside ribs and region outside ribs. Thresholding is used for converting gray scale image into a binary image. Morphological operations are for disconnecting adjacent pixels which does not belong to liver, and regaining the removed pixels after segmentation. Largest connected component is for extracting liver from abdomen. This segmentation method is simple and works efficiently in most of the images. However there is a drawback in our method, that when the liver portion is very small it results in under segmentation.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