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Effective Liver Image Segmentation from Abdomen Computed Tomography Images Using K-Mean Technique

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Abstract:-

Liver segmentation from CT abdomen image plays an important role in computer aided diagnosis. Computer aided diagnosis helps in treatment planing, liver transplantation and trageted drug delivery for a patient. As a result, an auutomatic liver image segmentation technique for abdomen CT Image is developed using K-mean clustering followed with morphological operation. The test result are evaluated using Co-efficient similarity and spatial overlap measuring technique,testing is done on different patient image sets, which shows better performance and minimum orientation effect on the segmented image. The developed algorithm is effective enough to the segement liver accurately.

I. Introduction

Liver is a most important internal organ of human body, which is responsible for hormonal balance, producing immune factors, regulating blood clotting, producing Bile and plays a vital role in digestion and detoxifying the substance that are harmful for the body. During exercise, the liver plays an important role in quickly breaking down the stored glycogen into glucose, which is realized into the blood stream to be used by muscles as a source of energy. Without functioning of the liver one cannot survive. So early liver functioning test is needed to recognize liver disease and another factor is that, liver disease symptoms do notappear until the critical stage of most liver condition, which result into serious or permanent damage. Liver tumour is the most common occurring disease [1, 2]. A tumour is an abnormal growth of the tissue due to uncontrolled multiplication of cells and serving no physiological function. Liver tumour can be either cancerous or non-cancerous [2, 7].

In the worldwide, it has reported liver cancer is second most death causing in men and seventh most in women. Liver cancer is classified into Primary liver cancer and secondary liver cancer [1]. Primary liver cancer is the sixth most commonly occurring cancer in world-wide and most common cause for cancer is the due to hepatitis B or C viruses. Secondary liver cancer is also known as metastasis cancers that have spread from another primary cancer source in the body like breast cancer, colon, prostate, lung, pancreas, stomach, oesophagus, adrenal glands, or skin cancer [3,6]. Early detection of liver cancer helps to improve life span of the patient. Physician and radiologist are in need to know about tumour status during treatment stages. Computed tomography imaging, Magnetic resonance imaging, Ultrasound imaging or Positron Emission tomography imaging these imaging diagnostic tools is used in medical field to determine tumour and its status [5, 8].

The radiologists prefer Computed Tomography imagingfor its rapid acquisition nature with clear and specific information about liver tumours. Radiologist performs Manual segmentation of the image using mental correlation of the pre-procedure and intra-procedure images to estimate tumour location, tumour boundariesand its adjacent anatomy, which is a time consuming task [4, 12]. Biomedical Image segmentation play a key role in obtaining region of interest, whereascomputed tomography image is to be segmented to obtain the region of interest. Liver image Segmentation from abdominal CT is being considered as the most difficult task, because of its complexity, shape versatility and proximity of other organ. Over the years, several approaches are followed to obtain liver segmentation. This paper is structured as follows: Section II Gives details the recent work; Section III Describes Method and Methodology followed in this work, In Section IV, We present Results and Discussion related to the obtained experimental results. Finally, Section V gives conclusion related to the work.

II. Related Work

The image segmentation is the fundamental problem over the years.In recent years several liver segmentation techniques were developed and utilized for biomedical images. Ahmed M. Mharibet al. [9] presented a study on various segmentation method used for CT images, the review work is classified into automatic and semi-automatic segmentation technique. Laszlo Rusko et al. [10] Proposed automatic liver image segmentation using region growing technique for multi and single phase contrast enhanced CT image andS. S. Kumar et al. [11] also suggested a region growing based automatic liver segmentation method. Miao Liao et al. [12] proposed CT liver image segmentation utilizing graph cut and bottle Neck detection technique. Pan.S. et al. [13] suggested level set based automatic liver segmentation from abdominal CT image. Ina Shing et al. [14] developed a comparative study of clustering based technique for liver segmentation form Abdominal CT image. Jue Lu et al. [15] utilized an Ant colony optimization and K-mean clustering algorithm to obtain good accuracy and computational speed of the algorithm.

III. Method and Methodology:-

Segmentation:-

Image segmentation is a process of partitioning image into groups of pixels which are homogeneous with respect to some criterion. Different group must not intersect with each other and adjacent group must be heterogeneous. Hence segmentation is concerned about dividing an image into meaningful region. Digital image Segmentation can be classified as thresholding based segmentation, edge based segmentation, clustering based segmentation and region based segmentation [16, 17]. The Liver image segmentation is an extremely important task for computer aided diagnosis (CAD). To obtain liver image segmentation from abdominal CTimage is a difficult and challenging task due to poor resolution, contrast, noise, artefacts and instrumental limitation.

Thresholding Techniques: Image thresholding produce segments having pixel with similar intensity. Image Thresholding helps in obtaining boundaries in an image that contains solid objects resulting on a contrasting background [16]. Whereas global thresholding technique is utilized to obtain region of interest, Mathematical representation is done using expression (1)

$$f(m,n) = \begin{cases} 1 & if\ f(m,n) \geq T \\ 0 & else \end{cases} \quad \ldots\ldots\ldots\ldots (1)$$

Where T: is an intensity value of the thresholding image.

K-mean clustering: k-mean clustering technique is among the simplest unsupervised learning algorithms. This algorithm divides image into K segments depending on mean value of the data point.Then it tries to reduce the total distance between data points to the allotted clusters and re-computes the cluster center until no more re-assigning occurs. K-mean algorithm is simplest one

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works well on the images when clustering is not well separated from each other [14, 15, 16].

Algorithm steps of K-Mean clustering is given below

1. Select initially desired number of clusters K.
2. Initial cluster centre predicted using mean value.
3. Assign each data point to the cluster whose center is nearby.
4. Re-compute the cluster center
5. Go to step 3 until no more re-assigning occur or the maximum number of iteration reached.

Labelling of the pixel is done based on clustering pixel,which separates object from the image.The specific cluster is selected depending on the region of interest, which is used for further process.

Morphological operation:

Mathematical morphology is a collection of nonlinear processes which can be applied on an image, to remove details smaller thana certain reference shape. Morphological operation is utilized to extract edges of an image, filter an image or fill the region of an image. Two morphological operations are discussed as follows a) opening and b) region filling.

Opening: Opening is based on morphological operation Erosion and dilation, it soothes insidethe object contour, breaks narrow strips and eliminates thin portion of the image. Opening operation is performed by applying erosion followed by dilation operation on an image with a suitable structuring element [16]. The mathematical representation is shown as in equation (2).

$$X \odot B = (X \ominus B) \oplus B \quad \ldots\ldots\ldots (2)$$

Where X: is an input image.

B: is a structuring element.

Region filling: Region filling is the process of filling in a definite image area using the bounding pixel that outlines the object [17]. The mathematical representation is shown in equation (3).

$$X_k = (X_{k-1} \oplus B) \cap A^c \quad \ldots\ldots\ldots\ldots (3)$$

Where k:denotes number of iteration

B: denotes the structuring element

A: denotes a set containing a subset whose elements area of the connected boundaries

Image enhancement technique:

Wavelet filter: Wavelet de-nosing attempts to remove the noise present in the image mean while preserving image characteristicsregardless of its frequency content. Wavelet methods mainly depend on thresholding the discrete wavelet transform coefficients. Thresholding is performed using either hard or soft thresholding and selection of threshold value is a challenging concept. Wavelet de-nosing includes three steps, namely, image decomposition, followed by thresholding the coefficients and image reconstruction. [16, 17]

Proposed novel technique for liver region extraction:-

1) The abdomen CT image is loaded.
2) Pre-processing is done using Wavelet filter to enhance the image quality.
3) The thresholding technique is utilized to Converting gray to binary.
4) Morphological operations are applied to remove broken edges and filling the region in the binary image.
5) The bone and outer muscles are removed bymultiplying binary mask with original image.
6) Extracted image is segmented with K-mean algorithm and eachclusteris labelled.(consider maximum number of clusters N=4)
7) Labelled Cluster 3 is used as liver image.
8) Area of the extracted liver is calculated.

Liver Area calculation:-

Total liver area= Tpixels

Where, Tpixels: stands for total number of liver pixel.

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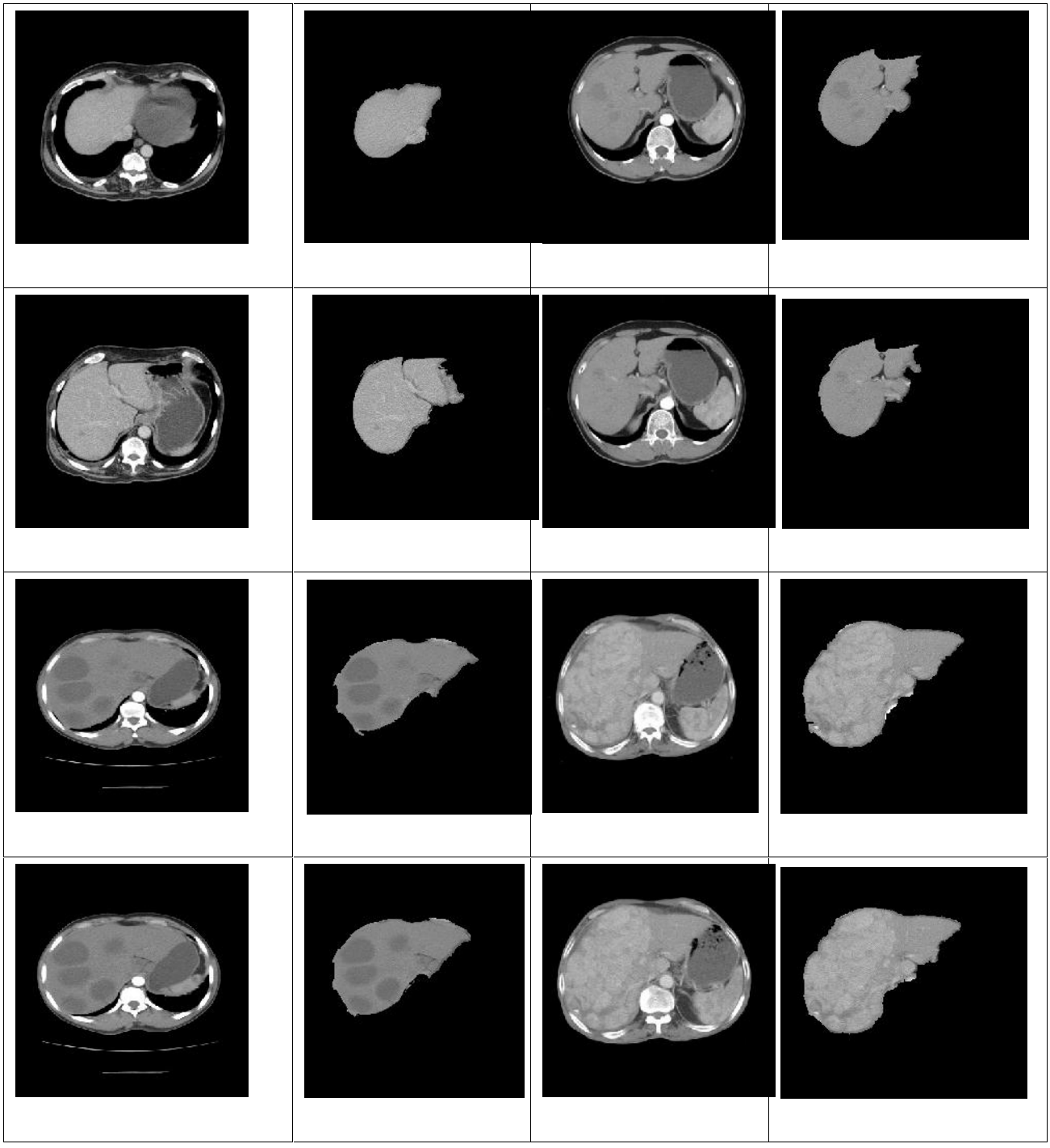

Fig. 1:- Liver Segmentation results of Abdomen CT image. First and third column shows Abdomen CT image, second and fourth show liver segmented image corresponding to first and third column.

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Table 1: Calculated features for 32 different randomly selected images used for test analysis

Image number	Automatic segmentation (pixels)	Manual segmentation (pixels)	Co-efficient of Similarity (∈)	Spatial Overlap (η)
1	19776	21592	0.915895	0.956101
2	35751	35886	0.996238	0.998115
3	40119	40623	0.987593	0.993758
4	40501	41723	0.970712	0.985138
5	43378	43658	0.993587	0.996783
6	18933	19209	0.985632	0.992764
7	23987	26478	0.905922	0.950639
8	29558	30516	0.968607	0.984053
9	37139	41574	0.893323	0.943656
10	19776	21592	0.915895	0.956101
11	39239	40779	0.962235	0.980754
12	40369	43824	0.921162	0.958963
13	40725	41535	0.980498	0.990153
14	42167	42254	0.997941	0.998969
15	35103	36368	0.965217	0.982301
16	33199	34867	0.952161	0.975494
17	29335	31063	0.944371	0.97139
18	29228	29967	0.97534	0.987516
19	55258	57561	0.95999	0.979587
20	54795	55917	0.979935	0.989866
21	53843	54528	0.987438	0.993679
22	43761	44359	0.986519	0.993214
23	41189	44001	0.936092	0.966991
24	34788	35268	0.98639	0.993148
25	23660	24985	0.946968	0.972762
26	24018	25435	0.944289	0.971347
27	24019	24950	0.962685	0.980988
28	24019	24244	0.990719	0.995338
29	16044	16616	0.965575	0.982486
30	17177	17980	0.955339	0.97716
31	17303	19283	0.897319	0.945881
32	19148	20269	0.944694	0.97156

Result and discussion:-

The proposed method is fulfils the need of CT abdomen image segmentation. The CT imaging is a non-invasive technique, which uses X-ray to produce image from different angle around human body. In this experimental study, we developed a database containing abdomen CT Images from different patients with a spatial resolution of 512 X 512 (M = 512 and N = 512) pixels and slices thickness of 5mm. The proposed novel Liver image segmentation technique is implemented on MATLAB (2014) environment, with a computer having windows 7 operating system on Intel core i3 Processor.

The manual segmentation results into a difficult task in each abdomen CT image, the similar intensity tissues that adhered to liver such as, spleen, stomach and right kidney, which result into over or under segmentation. The manual segmentation of liver from abdomen CT image is done with help of expert radiologist andThe proposed algorithm has an ability to exclude adjacent tissues such as, right kidney, spleen, stomach rib and spinal cord. In which, liver boundaries were described accurately and have no noticeable difference in comparison with the ground truth.

The validation of segmented result is done using quantitative analysis like co-efficient of similarity, spatial overlap.

Co-efficient of Similarity

$$\in = 1 - \frac{|L_m - L_{a1}|}{L_m} \quad \text{..... (4)}$$

Spatial Overlap

$$\eta = \frac{2*[L_m \cap L_{a1}]}{L_m + L_{a1}} \quad \text{..... (5)}$$

Where L_m and L_{a1} are liver segmented pixel value using manual and automatic technique respectively. The tabulated result in table shows segmentation performance compared with manual segmentation, for 32 data set of different patient, which can extend to more data irrespective of number. Figure gives detail of extracted liver region from the image. The visual quality of the resultant image and statistical values are considered as evidence to uphold the developed algorithm and thisalgorithm help, for further analysis of liver transplantation and tumor detection.

Conclusion:-

In our discussion, the proposed liver segmentation technique has ability to extract the liver region from the abdomen CT image. The K-mean clustering technique is utilized in segmenting liver, Pre-processing is utilized to enhance the image quality and in post processing morphological operation is followed to eliminate the small non liver tissues retained in the segmented image. The developed technique has over comes major drawback of manual segmentation.This algorithm has applied to the different patient image sets, which shows highperformance and minimum orientation effect on the segmented an image with tumor and without tumor. The result shows the benefit of patient oriented approach which affects minimally, where we have overcome the challenges effectively.

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