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A Hybrid Segmentation Approach to Diagnose Suspicious Pixel regions in Liver CT Images

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ABSTRACT

This paper introduces computer aided liver analysis to diagnosis the suspicious pixel region (lesion) from abdominal CT images of liver and helps the radiologists in categorizing liver into typical or anomalous liver . Segmenting the liver and separating the region of interest is a difficult procedure in the field of malignant growth imaging because of the little recognizable changes between healthy tissues and unhealthy tissues. In this paper, segmentation of liver from abdominal CT image based on hybrid method is proposed. The method uses neutromatic logic with FCM thresholding, encouraged by pre processing using bilateral filter and post processing using morphological tasks for automatic segmentation of liver and finally dynamic thresholding and contour detection to extract the lesion (tumor). The effectiveness of proposed method is quantitatively evaluated by comparing automatic segmentation results with ground truth obtained from radiologists.

Keywords : Bilateral filter, Neutromatic logic, Fuzzy C means, Thresholding, morphological operation.

I. INTRODUCTION

Liver [3] is the largest and increasingly significant organ for survival. It also inclined to several types of ailments. Liver diseases have various colors. For example, blue indicate cyst, yellow color shows fatty liver , dark brown colored is fibrosis and so on. A mass of extra tissue called tumor or lesion, new formation of cells of independent growth, no useful function and has no typical termination. Liver tumor are abnormal tissue on the liver and can be benign (non- cancerous) or malignant (cancerous) tumor. Due to advances in computer technology, image-processing technology has been used to assist physicians in identifying cancer in liver. The intensity of the tumor can be lower or higher than that of the liver. The main problem of liver tumor detection is due to low contrast difference between tumor and liver intensity values.

Different imaging procedures [3] like ultrasound, Tomography Imaging, Magnetic resonance imaging, positrons emission tomography etc are accessible for determination of liver infection. Among these, CT scan is a notable non-invasive imaging method and it is suggested by pathologists since this imaging have better spatial resolution, high noise suppression, less time to examine the ROI and patient friendly protocols. It also gives the detailed information of anatomical

Data about the visualized structure. Conventional method of segmenting the liver is laborious and tedious task for radiologists. Automatic segmentation is more difficult due to more than 150 slice of liver CT image, low contrast, similar intensity of liver and tumor. Thus, there is a need for CAD system to diagnose of tumor from huge amount of medical data.

CAD [8] system guide health care radiologists to diagnose the data and identify the diseases, find extent of disease thereby providing the second opinion during diagnosis decision. CAD system also reducing inter and intra observer variability in image interpretation. The efficiency of CAD system depends on speed, automation and accuracy level. It provides second opinion about the diseases. Three key component of CAD system are segmentation, feature extraction and classification. These components are responsible for diagnosis of suspicious pixels of benign and malignant masses. Accurate liver segmentation is crucial task in CAD system. Because feature based liver classification fully rely on segmentation accuracy. Inaccurate segmentation leads to large variation in intensity texture and bad contrast. The proper choice of segmentation is very much essential.

Hybrid approaches [2] are attracting a great deal of attention at present. Pros of hybrid approaches are improved efficiency and better accuracy, thereby providing high quality of images. In this paper, Neutromatic based fully automated liver segmentation method is proposed. In medical applications, it is attractive to deal with true fact of the disease as well as false statements and the imprecise statements to know the growth of the diseases in future occurrence. It is hard for conventional fuzzy set to resolve such issues. The main difference between Neutromatic logic (NL) and fuzzy logic (FL) is that the NL extends FL by assigning a membership function ranging in degree between 0 and 1 to variables. NL introduces a new component called indeterminacy that carries more information than FL.

The framing work of this paper is sorted as below: Section 2 discusses about the existing work and Section 3 gives a details information of the proposed technique. Section 4 examines the experimental outcomes and performance analysis. Section 5 provides the conclusions and Section 6 suggests scope for future work.

II. RELATED WORK

Segmentation of liver is an open challenge for researchers. Many researchers have used various strategies and systems to separate the liver and tumor from the abdominal CT images over the ongoing years [16-20].

K.Mala et.al [10] proposed adaptive threshold decision based on intensity information for segmenting the liver and classification is based on threshold decision .The drawback is more memory space. In [3-5], authors presented automatic segmentation of liver using region growing method. SS Kumar et. al [3] presented automatic segmentation of liver and tumor using region growing method and drawback is selection of seed point. Incorrect seed point selection leads to over segmentation. In [5], presented survey of various segmentation methods for CT scan images based on morphology, thresholding and Neural network. In Raju et. al [9], developed a method on diagnosis of liver tumor. The method was more effective to minimize the risk of cutting healthy liver tissues but dataset is limited.

In [1], author proposed comparative study of liver segmentation based on SRG, label connected component and hybrid method. It overall accuracy is 83%. To segment the largest contour in abdominal image, the author [2] proposed the hybrid approach using watershed method It overall accuracy is 92%. The problems in existing methods are time consuming , high processing time by region growing, label connected component and quality comparison difficulties. The above problems are overcome by an effective hybrid algorithm which is the combination of NM logic with 3 class FCM thresholding and connected component method along with contour detection is proposed in our work for automatic liver and tumor segmentation

III. METHODS AND MATERIAL

A. Abdominal CT image

Computer Tomography [3] examination consolidates arrangements of X-ray beams taken from different angles and use computer handling process to deliver the cross sectional details of the human body. It provide the details information of the internal organs and helps radiologists to diagnosis the diseases and to confirm the presence of tumor, size and exact location of it. Liver is the largest organ in the abdomen and reddish in color, feels rubbery to touch. Liver segmentation is challenging task due to the similar intensity between liver and adjacent organs. Figure 1 shows the abdominal CT image of liver.

Figure 1. CT image

B. Preprocessing

Preprocessing [11,20] is a important step in tumor segmentation task. If the segmentation results are not accurate, that leads to improper extraction of features and irregular classification of that tumor. CT images are collected by different types of sensors and they contaminated by different types of noises. For accurate and fast liver segmentation, Pre-processing is essential. Bilateral filter is taken as pre-processing filter.

Bilateral filter [15] is a non linear, non iterative, noise reducing smoothing filter which is developed by Tomasi. This filter is obtained by the combination of weighted function two Gaussian filter: partial domain and intensity domain. The pixel intensity value is replaced by a value which is dependent on the neighbouring pixel location and difference in intensity. The idea is that the pixels which are close by will vary very little, so it is best to average the pixels in a small area.

Let Y is an image. Then Ip is value of the image Y at pixel position p. Bif (Y) is the output of bilateral filter, applied to an Image Y.

Spatial distance is calculated as

$$sp_d(p,q) = e^{-||p-q||^2}/2\sigma_{sd}^2 \quad (1)$$

Intensity difference is calculated as

$$Int_d(p,q) = e^{-|I(p)-I(q)|^2}/2\sigma_{id}^2 \quad (2)$$

σsd and σid are guassian kernel coefficient which controls spatial distance and intensity difference. σsd is directly proportional to image size. σid is directly proportional to edge amplitude. These two parameters are used for controlling the tradeoff of the weights in spatial and intensity domain.

At pixel p

$$Bif(p) = \frac{1}{C}\sum_{q\in\gamma(p)} Bif(q) sp_d\,(p,q) Int_d(p,q) \quad (3)$$

Where C is a normalization factor C=$\sum sp_d(p,q)\, Int_d(p,q)$ and shows the spatial neighbourhood of Bif(p).

Above formula is used to replace each pixel by the weighted average of values from nearby pixels

Bilateral filter Algorithm

Input: CT Image

Output: Preprocessed image

1.Use acculite software to convert DICOM image to JPEG format.

2. Convert that CT image to grey scale image.

3.Select the different attributes for the bilateral filter r w, σsd and σid

4.Do the following procedure for each pixel elements.

5.Use equation 1 to find the spatial distance.

6.Calculate the intensity difference using the equation 2.

7.Obtain the resultant pre processed image using equation 3.

C. Segmentation

Neutrosophic theory [1,21] or Neutromatic theory considers the proposition, theory, event, concept or entity and it is basis of neutrosophic logic. Neutrosophic set or Neutromatic set , a part of philosophy, deals with the origin, kind or nature, of neutralities. To handle uncertainty, fuzzy set has been used. In medical system we have to consider the truth (T), and false (F) statement as well as neutral static (possibilities of occurrence).

A Neutromatic image NI is characterized by three subsets T, I and F. The flow graph of proposed method is shown in Figure 2.The pixel P(m, n) in the image domain is transformed into Neutrosophic domain NI(m,n) ={Tr(m, n), In (m, n), Fa(m, n)},where Tr(m, n), In(m, n), Fa(m, n) are the probabilities belong to white set(object), indeterminate set(edge) and non-white set (background), respectively. Mathematically, a NI image is defined as in the following equations:

$$Tr(m,n) = \frac{\overline{g(m,n)} - \overline{g_{min}}}{\overline{g_{max}} - \overline{g_{min}}} \quad (4)$$

$$In(m,n) = 1 - \frac{\overline{Ho(m,n)} - \overline{Ho_{min}}}{\overline{Ho_{max}} - \overline{Ho_{min}}} \quad (5)$$

$$Fa(m,n) = 1 - Tr(m,n) \quad (6)$$

$$Ho(m,n) = abs(g(m,n) - \overline{g(m,n)}) \quad (7)$$

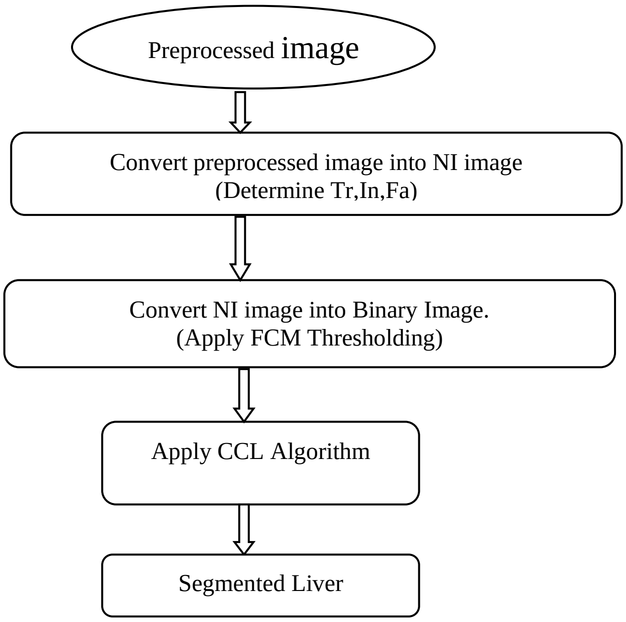
Algorithm for converting neutromatic image to binary image

Input: Preprocessed Image
Output: Binary image

1. Determine the histogram of preprocessed image.
2. Calculate local maxima of the histogram and mean of local maxima.
3. First peak of which is greater than the mean of local maxima gives us the gmin and the last peak gives us the gmax
4. Determine Tr(m,n) from local of mean window , gmin and gmax.
5. Calculate In(m,n) from the homogeneity value of Tr
6. Calculate Fa(m,n)
7. Find adaptive threshold for Tr,In,Fa using 3 class FCM thresholding.
8. Map Fuzzy Neutromatic Image into Binary Image.
9. The binary image is applied with the Connected Component algorithm.

D.Connected Component Algorithm

To find the similar regions in an image, label connected component algorithm is used. It is a graphical approach based effective segmentation algorithms used for region labeling. The algorithm works for medical images, microscopy images, binary image and thresholded image. To compute connected components [1] of an image, split the image into horizontal runs of adjacent pixels, and then label the runs uniquely. In the second pass, adjacent runs of different labels are merged. The algorithms ensure regions of similar value are labeled with one label. Two steps in label connected components are extracting of connected component and searching of largest component.



E. Morphological Operation

To separate the shape information, Morphology [3,7,16] tool is used. This method uses the structuring elements for the representation and description of region shape such as boundaries and skeleton. Dilation, erosion, opening and closing are most elementary morphological operations and defined with union and intersection operation.n the proposed method, opening is used to refine the boundaries of an image in the liver.

F. Post processing Phase

To obtain a perfect liver [7], the morphological tool for opening operation is used along with a structure element of radius 3. In this phase, the resulting image is complemented and multiplied with original image to get segmented liver. Followed by morphological operation, masking and dynamic thresholding was performed to extract the tumor.

IV. RESULTS AND DISCUSSION

A. Performance Measures

The proposed method uses several performance metrics to evaluate the performance of hybrid method. These measures are: Dice Coefficient, Jaccard coefficient, True Positive fraction and true negative fraction.

First metric is Dice Index [7] also called overlap index and it is mostly used metric in medical image segmentation. This index gives the correlation of automatic segmented output with ground truth image. And it defined as follows

$$\boldsymbol{Dice} = \frac{\mathbf{2}|A \cap M|}{|A+M|} \quad (8)$$

Jaccard coefficient between automatic and ground truth segmentation is defined by intersection divided by union and is given by

$$\boldsymbol{Jaccard} = \frac{|A \cap M|}{|A \cup M|} = \frac{|A \cap M|}{|A|+|M|-|A \cap M|} = \frac{\boldsymbol{Dice}}{\mathbf{2}-\boldsymbol{Dice}} \quad (9)$$

Third metric is True positive fraction [2]also called Sensitivity and Recall, measures the portion of positive voxels in the ground truth that are also identified as positive by the segmentation being evaluated.

$$True\ Positive\ fraction = \frac{|A \cap M|}{\boldsymbol{M}} \quad (10)$$

Fourth metrix is True negative fraction also called specificity , measures the portion of negative voxels (background) in the ground truth that are also identified as negative by the segmentation being evaluated.

$$True\ Negative\ fraction = 1 - \frac{|A-M|}{\boldsymbol{M}} \quad (11)$$

Finally , misclassification rate is defined as follows

$$Misclassification\ Rate = 1 - \frac{|A \cap M|}{\boldsymbol{M}} \quad (12)$$

Where A is Number of pixels of the automatically segmented liver regions and M is number of pixels of the manually segmented liver (ground truth) by the experts.Either Dice index or Jaccard coefficient is considered for evaluating the performance of proposed method.

B.CT dataset

The proposed method is tested on abdominal CT images. These images are acquired and collected from various sources like diagnostic scan centre and from internet along with ground truth image. Ground truth is used as bench mark for evaluation of segmentation methods. The dataset includes different cases of liver diseases with different shape and intensity. For this work, dataset contains normal, fatty, cirrhotic, overextended livers and livers with cancer are considered.

C. Results and Discussion

The proposed approach uses axial CT images of abdomen for analysis. In this work, 25 Images is taken and tested to know the abnormality in abdominal CT images. All images are in DICOM format and exported to jpeg format using acculite software. The proposed works are carried out on Pentium processor and implemented in Matlab 13.

Figure 4 shows the overall output of proposed method. Figure 4A original CT image. Preprocessed output is shown in Figure 4B. Preprocessed image is transformed into NI domain image. Results of True domain and false domain are shown in Figure 4C and 4D. Enhance image is shown in Figure 4E. Homogeneity and Indeterminate image is shown in figure 4F and 4G. Apply FCM thresholding for NL image and output is shown in Figure 4H. Region of liver is obtained after applying connected component algorithm shown in Figure 4I. Segmented liver is shown in Figure 4J.Superimposed liver and tumor images with original images are shown in Figure 4K. Extracted tumor after post processing is shown in Figure 4L. Using the proposed method, both tumor and liver can be seen together. This helps radiologist to analyze the Suspicious Pixels .

The performance of the proposed method are evaluated and compared with the result of manual segmentation done by experts. Proposed method (PM) runs for Dataset contains 25 images but the result shown for 5 test images in the Table 1 and 2. Table 1 shows liver segmentation output and Table 2 shows lesion segmentation output. The proposed method is compared with ground truth (GT) and performance measures are done in terms of Dice, TRF and MCF. For 5 set of test images, the proposed method gives an accuracy of 98% in case of liver segmentation and 95% in case of lesion segmentation.

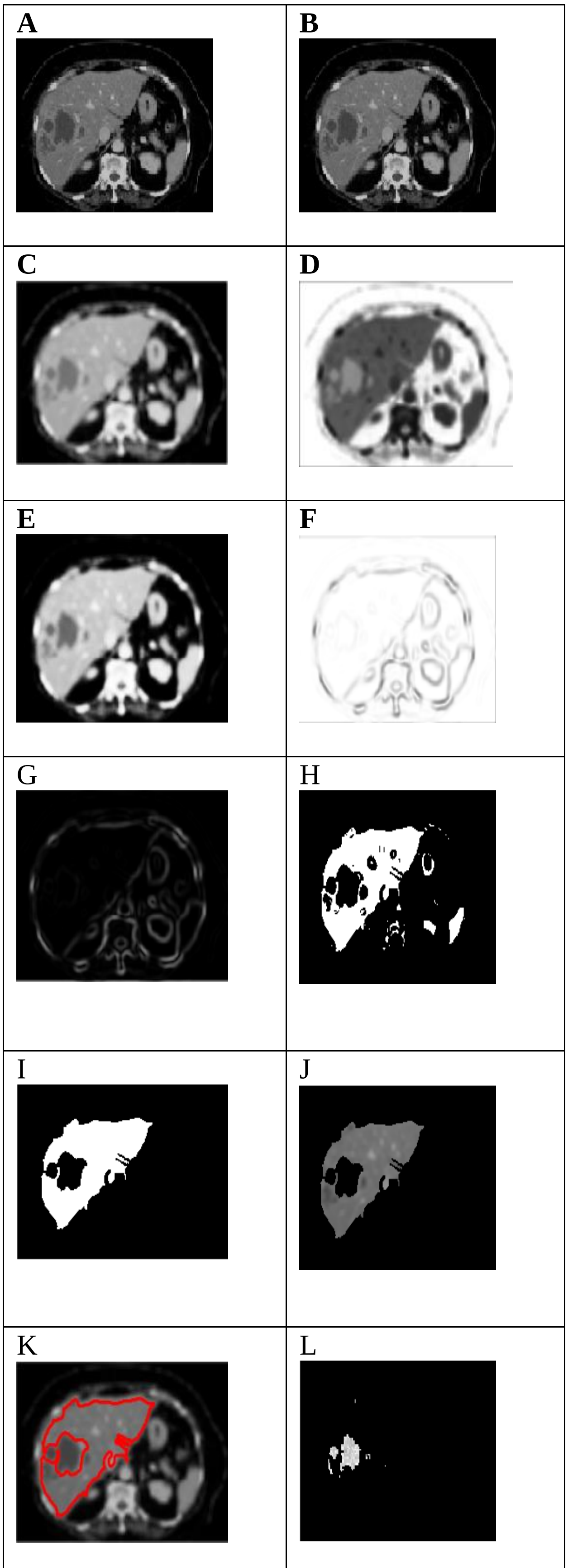


Figure 4 shows the output of proposed method

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Table 1: Liver Segmentation Results

	PM	GT	Dice	TRF	MCF
DT1	41096	42123	0.9877	0.975	0.024
DT2	2788	3103	0.9634	0.929	0.070
DT3	7102	7258	0.9891	0.978	0.022
DT4	13309	13886	0.9788	0.958	0.041
DT5	1344	1942	0.9862	0.972	0.027

Table 2: Lesion Segmentation Results

	PM	GT	Dice	TPf	MC
DT1	1734	1959	0.9391	0.8851	0.1149
DT2	476	498	0.9774	0.9558	0.0442
DT3	530	559	0.9734	0.9481	0.0519
DT4	934	969	0.9347	0.8774	0.1226
DT5	645	678	0.9452	0.8960	0.1039

In order to know the lesion area in liver portion, lesion to liver ration was calculated and tabulated in Table 3.

Table 3: Lesion/Liver Ratio

Datasets	lesion area in Pixels	liver area in pixels	Lesion/liver ratio
DT1	1734	41096	0.0421
DT2	476	2788	0.170
DT3	530	7102	0.0746
DT4	934	13309	0.07017
DT5	845	1344	0.4799

Figure 5 shows suspicious pixels in liver region. In rder to validate the esults , the results of the proposed work also compared with the result of previous work stated in the comparative study of [1]. The approaches are Histogram thresholding, seeded region growing algorithm, label connected component and NS with thresholding. The results of different segmentation techniques are stated in Table 4.

[illegible]	0	0	117	120	124	127	128	129	131	131	135	146	147	128	127	124	0	0	0	[illegible]	
0	0	138	110	126	141	142	131	121	119	119	122	128	141	135	137	127	149	0	0	0	
0	140	118	134	133	129	125	127	128	124	124	117	120	135	135	142	127	139	138	138	146	
150	127	124	122	133	137	125	114	118	132	132	144	128	132	125	135	120	128	127	127	141	137
133	121	134	139	130	118	115	127	137	129	129	114	122	122	117	135	127	131	125	125	136	140
132	119	124	130	126	134	117	128	117	128	128	125	131	131	131	134	136	134	129	129	124	121
132	128	133	128	126	129	123	130	129	136	136	135	125	120	126	140	142	127	116	116	116	122
137	130	126	131	127	118	121	116	121	116	116	116	123	111	117	138	143	129	127	127	138	125
133	130	122	125	122	109	125	118	132	123	123	128	136	128	131	141	140	127	121	121	125	129
119	131	133	131	125	110	125	116	126	116	116	121	116	126	136	139	139	136	127	127	118	129
118	127	128	136	128	119	127	123	123	118	118	124	120	129	130	122	123	136	142	142	138	127
126	125	118	127	119	125	133	145	141	0	0	0	146	143	132	118	112	117	125	125	130	129
128	131	127	134	121	128	122	132	113	124	124	130	106	107	117	129	130	123	123	123	130	134
122	124	125	132	123	124	125	116	115	122	122	122	128	132	130	124	123	130	134	134	133	138
122	124	125	132	123	124	125	116	115	122	122	122	128	132	130	124	123	130	134	134	133	138
130	141	128	139	125	123	130	129	131	132	132	125	120	123	121	114	114	122	129	129	130	131
0	0	109	142	127	123	124	119	120	125	125	121	127	122	117	120	133	144	144	144	137	140

Figure 5 shows suspicious pixels in liver region

Table 4: Comparison of proposed method with other segmentation methods based on dice coefficient.

	PM	GT	HIS	SRG	CCL	NI+CCL
DT1	2788	3103	0.67	0.78	0.83	0.9634
DT2	13309	13886	0.65	0.754	0.841	0.9788
DT3	41096	42123	0.68	0.68	0.734	0.9877
DT4	7102	7258	0.7	0748	0.815	0.9891
DT5	1344	1942	0.72	0.735	0.801	0.9862

V. CONCLUSION

The Proposed algorithm utilizes the hybrid method which is the combination of NL logic along with connected component algorithm for extraction of liver and tumor. The performance of the proposed method was compared with existing strategies. Hybrid method achieved the accuracy of 98% for liver segmentation and 93% for tumor segmentation. The proposed work is mainly used to distinguish the suspicious pixels from the liver area and helps radiologists for diagnosing liver illnesses. This method also helps specialist for pulverizing the tumor pixels or cells with high power ultrasound treatment.

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