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MEAN-MULTI THRESHOLDING BASED LIVER LESION DETECTION FROM CT SCAN IMAGES

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Abstract

The objective of this research is the liver lesion regions detection and extraction for diagnostics. It involves four stages in this work such as pre-processing, extraction of liver, detection of liver, segmentation of liver and estimation of lesion regions. The outputs of lesion regions are analyzed from segmented livers. Lesion regions detection stage is used with mean-multi thresholding method and implemented with Matlab Programming language. Hundred data sets of CT abnormal liver images (256 × 256 pixel, 2D liver slices) are tested and lesion regions are calculated from the criteria that the number of gray pixels which are greater than mean value of that block is greater than one-third time of total pixels. The comparative results in this research can be shown with mean value of lesion regions of benign liver CT images is in the range 149-167 and malignant liver CT images is in the range 125-135.

Keywords: CT-liver, lesion regions, detection, extraction.

Introduction

Image processing procedures are very useful appliance in medical diagnosis and surgical operation. Image processing is a quite time-consuming phase. There are various imaging modalities such as Computed tomography (CT) scan, Ultrasound, X-Ray, and Magnetic Resonance Imaging (MRI) can be used to diagnose. The liver is the biggest gland in the body as it can weigh up to 1.5kg in an adult human. It has a central role in the body's metabolism as it secretes bile, a secret that metabolizes many of the essential nutrients for survival (Stewart B, 2014). The novelty of this work is using difference of intensity and texture features between lesion and surrounding area from normal liver tissue to classify liver lesion into benign or malignant. The CT scan is often preferred for diagnosing liver diseases, especially as being considered of high accurate imaging and cheaper than MRI. They have greatly improved the possibility for the human body to examine without using invasive methods. Computed tomography (CT) is an imaging procedure that uses special x-rays equipment to create a series of detailed pictures, or scans, of areas inside the body. X-rays tomography is a technology that uses computer-processed X-rays to produce tomographic images of specific areas of a scanned object, allowing the users to see inside the object without cutting. Digital geometry processing is used to generate a three-dimensional image of the inside of the object from a large series of two-dimensional radiographic images taken around a single axis of rotation.

Related Work

Images of multiple phases are required to detect and diagnose the liver lesions but most publicly available CT datasets contain only the portal phase with pre-pixel segmentation labeling. Automatic liver lesion detection is a fundamental requirement in medical diagnosis. Liver lesion detections were presented in many research works which were tested with computed tomography (CT) images with different models. Kalpana M.K (2011) and his colleagues studied liver noise

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detection techniques to determine the upper limit of noise for detection of small low-contrast lesions in a liver phantom. Bi L (2018) and his colleagues presented Deep Residual Networks for Segmentation that liver lesions are segmented automatically. They solved the problem of the training degradation of training accuracy in very deep networks and used additional layers for learning more discriminative features. Lee S-G (2018) and his colleagues proposed the Single Multibox Detector (SSD) based real-world clinical lesion detection which is a deep learning-based object detection model. The strength of this model can leverage richer information of the multi-phase CT data. Their experimental results are tested CT dataset of 64 subjects by five-fold cross validation.

Material and Methods

Experimental procedure

The 100 datasets from 80 patients were acquired from No.2, 500 bedded Military Hospital in Yangon and these liver CT images are 256 by 256 pixel (2D liver slices). These results are obtained using MATLAB R 2018a. The proposed framework is emphasized to early stage detection of liver lesion regions which has four stages, pre-processing, detection of liver, segmentation of liver and detection of lesion regions.

Medical image Filtering

Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges while removing noise. The morphological operators are based on set theoretic approach and are suitable for extracting shape information with the help of a structuring element. Morphological operations are dilation, erosion and opening. Erode and dilate are the fundamental operators of mathematical morphology, a theory for the analysis of spatial structure (Senthilraja. S, March- 2014). Opening operators are generally used as filters that remove dots characteristic of pepper noise and to smooth the surface of shapes in images. It can be generally applied in succession and the number of times they are depends on the structural element size and image structure (Kalpana M. K, 2011). Filling is used to fill the gaps, holes present in the binary image. One of the fundamental morphological operators erosion is a process used to shrink the area of an object in the image. Dilation, expand the images is the complementary process to erosion.

Segmentation of Liver Region

Segmentation is the essential process for detection of the image. This process is separated the liver and other abdominal organs such as stomach, spleen and pancreas etc. Generally, liver segmentation methods are divided into two main classes, semi-automatic and fully automatic methods, under each of these two categories, several methods, approaches, related issues and problems will be defined and explained (Alagdar M.A, 2015; Lagdar .M.A.A,2015). The aim of segmentation is to represent an image to be more meaningful and easier to analyze. And then, segmentation could be used to diagnose and study of anatomical structures or localization of pathologies such as cancer tumors but it is a still challenging problem in medical image. The detection of liver region is the most important for early diagnosis and treatment of liver diseases. Medical image detection can be used to estimate of the boundary of an object, classification of tissue abnormalities, shape analysis, contour detection (Nader H. Abdel-massieh, 2010).

Nevertheless, the model generation is time consuming and could not respond sensitively among different patients. The grayscale image and dilated binary image are masked out in this step.

Detection of Lesion Regions

The detection of liver Lesion regions is the essential step for early diagnosis and treatment of liver diseases. Segmented liver images are blocked 8X8 that mean value, maximum value and minimum value are calculated in each block. The block has no lesion if all pixels of each block is normally distributed of grayscale value. Otherwise most of intensity gray values are fluctuated in each block, that block may have lesion.

Results and Discussion

Pre-processing is the first step of our proposed framework which has grayscale conversion, binarilization, text noise removing and morphological opening processes. The better preprocessed images gives more precise liver from other organs. Input image is converted to grayscale image and then binarilized. The tested images are satisfied with threshold value 0.4256. The patient information of text are removed with filters and morphological opening processes. Morphological dilation processes and some filtering processes are help to process in the liver detection mask. Figure 1-5 are the output liver images of pre-processing step and detected liver region is shown in figure 6 .It is the second step of proposed framework.

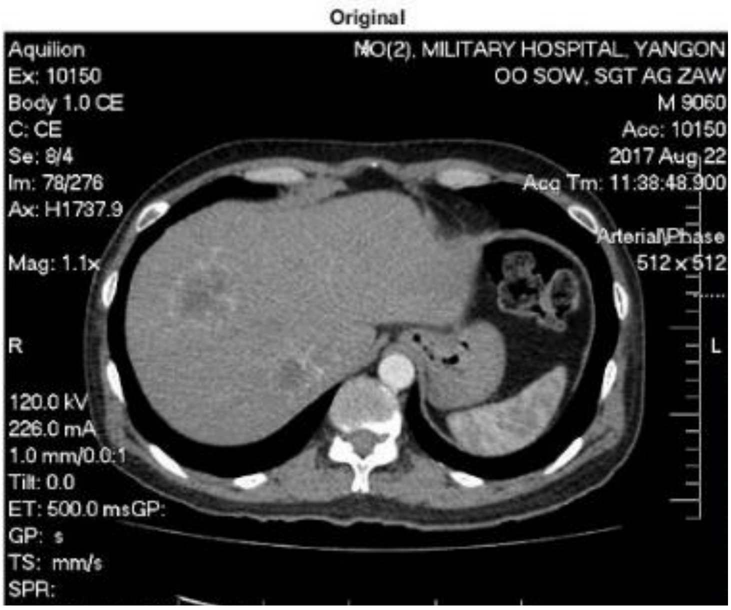

Figure 1 Original Liver Image

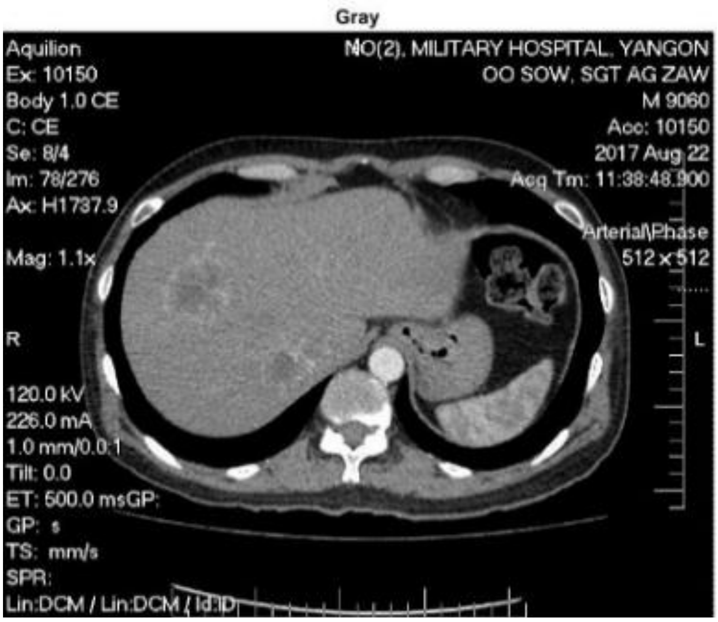

Figure 2 Grayscale Liver Image

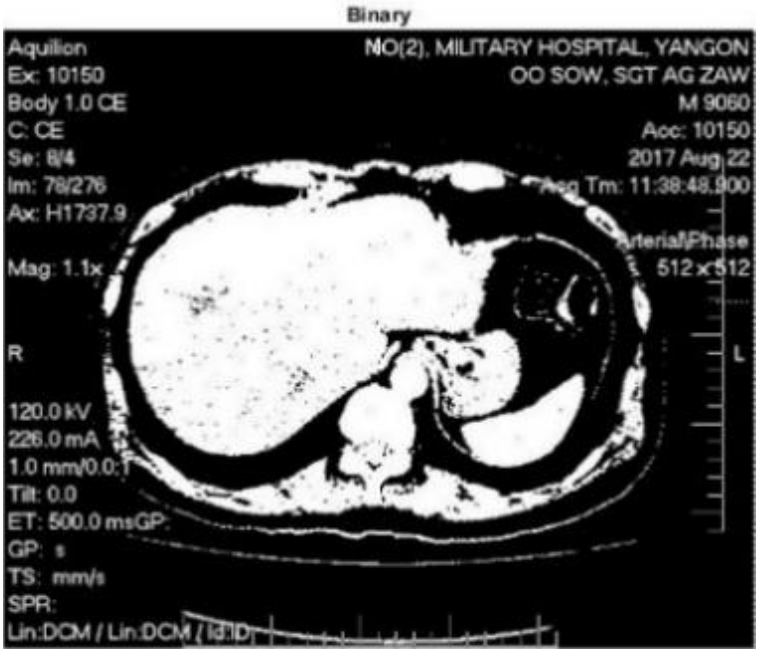

Figure 3 Binary Liver Image

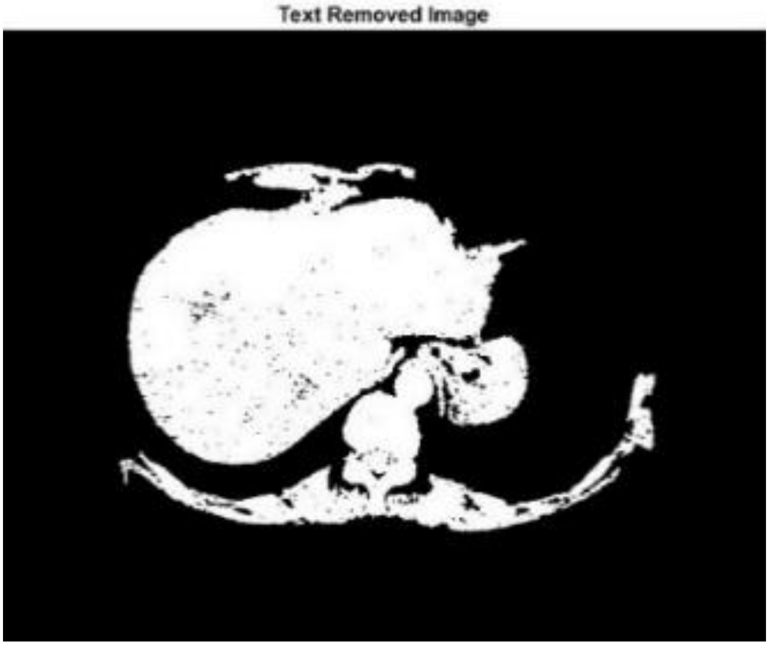

Figure 4 Text Noise Removed Liver Image

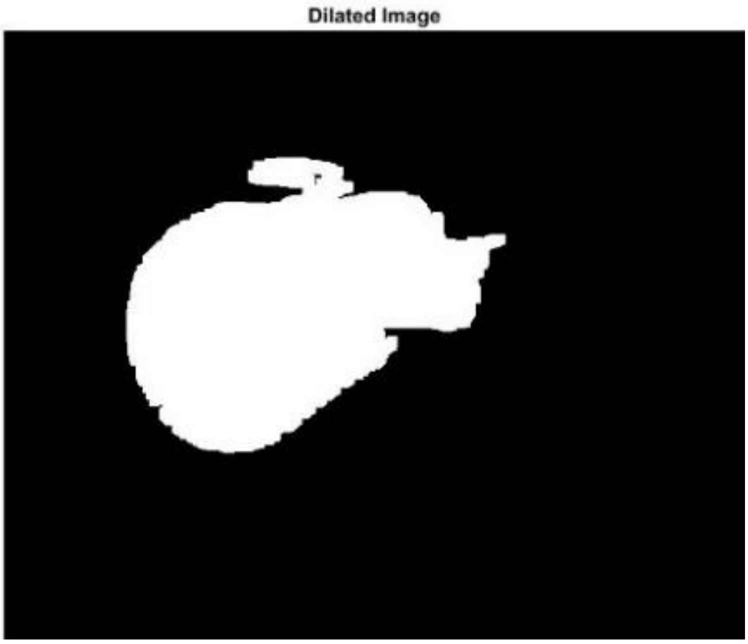

Figure 5 Dilated Liver Image

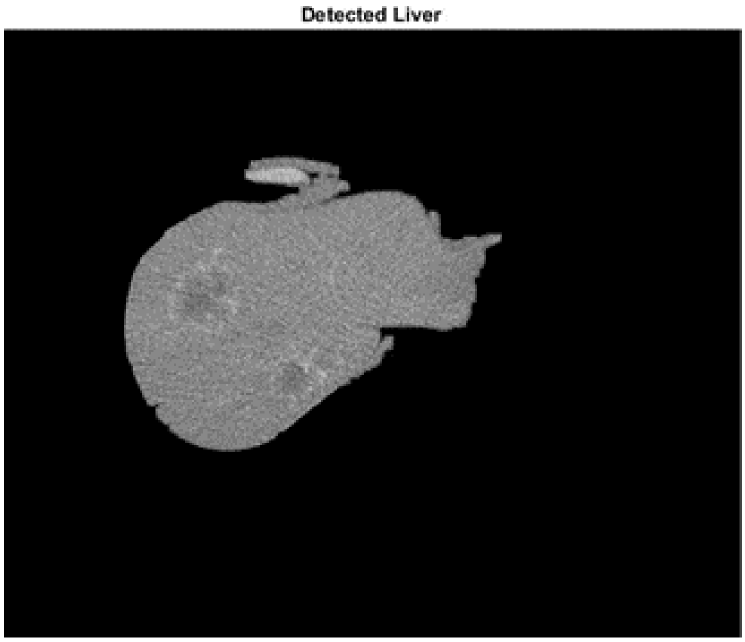

Figure 6 Detected Liver Image

The grayscale image and dilated binary image are masked out in this step. In the third step, the histogram value of detected liver image are calculated and finding the points A, B, C and D which points are the left top point of detected liver, right top point, left bottom point and right bottom point respectively shown in Figure 7. By using these points, the segmented liver are automatically as shown in figure 8.

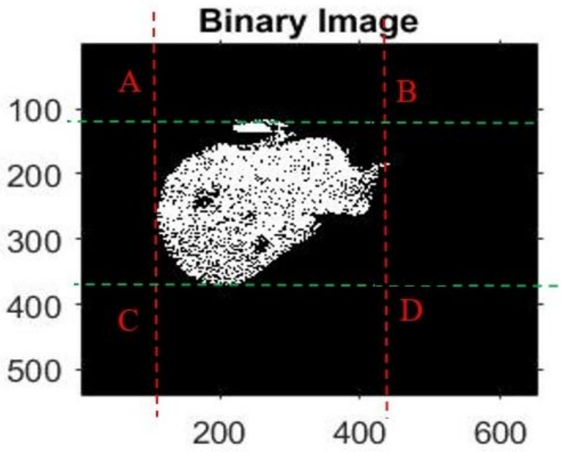

Figure 7 Finding liver edge

D

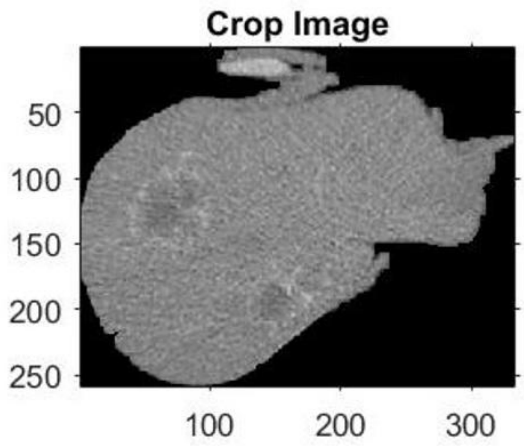

Figure 8 Segmented Liver Image

In this research work, detection constant $\varphi\ is \frac{1}{3}$. Samples of lesion regions by performing with grayscale intensity matrix are shown in Figure 9 and 10. Mean value can be calculated from equation (1) and (2) count the number of pixels which intensity value is greater than mean value of respective block. The CT scan images are tested and lesion regions are calculated from the criteria that the number of gray pixels which are greater than mean value of that block is greater than one-third time of total pixels.

$$\mu = \frac{\sum_{i=1}^{N} X_i}{N} \quad (1)$$

$$C(B_k) = \begin{cases} 1 & X_i > \mu \\ 0 & otherwise \end{cases} \quad (2)$$

Where μ= mean value of each block

N= Number of pixels of each block

C (B_k) = Count of pixels which are greater than mean value

If Lesion Region satisfies the following condition:

C (B_k) > $M_k \times \varphi$ then B_k is Lesion Region.

M_k = Number of pixels in B_k

φ = Detection Constant

111	104	108	121	118	104	103	113
119	109	107	120	113	105	100	111
134	124	118	121	117	111	100	110
123	124	126	127	118	111	106	110
118	122	131	136	131	102	95	87
114	109	112	121	124	123	116	107
123	114	108	110	112	112	111	115
121	123	118	113	105	105	104	115

$\mu = 114.109, min = 87, max = 136,$
$C(B_k)$ =29,$M_k = 64, \varphi = \frac{1}{3}$

Figure 9 Sample of Liver Lesion Region

139	148	136	119	112	114	124	133
133	146	140	127	121	124	136	141
117	130	130	128	128	131	137	136
110	118	121	131	133	129	129	128
115	119	122	122	123	113	114	123
119	113	109	109	105	108	122	132
122	118	121	121	119	121	126	128
116	123	135	136	136	134	127	118

$\mu = 124.969, min = 105, max = 148,$
$C(B_k) = 30, M_k = 64, \varphi = \frac{1}{3}$

Figure 10 Sample of Liver Lesion Region

Morphological dilation is used to refine the segmentation results. Segmented liver images are blocked 8X8 that mean value, maximum value and minimum value are calculated in each block are shown in table 1 and 2. The block has no lesion if all pixels of each block is normally distributed of grayscale value. Mean value of lesion regions which benign liver CT images is in the range 149-167. Mean value of lesion regions which malignant liver CT images is in the range125-135.

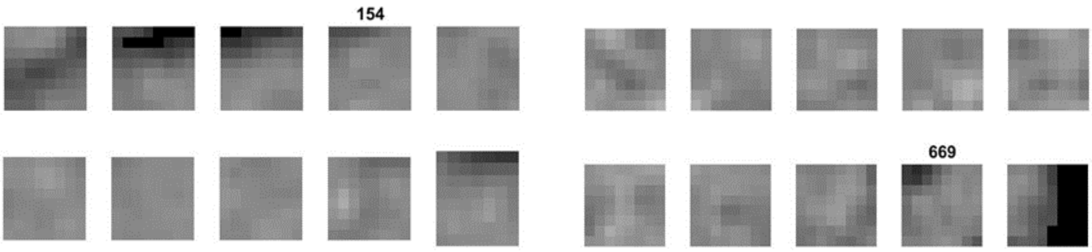

Figure 11 Block 154 and 669 are Lesion Regions

Table 1 Some Experimental results of benign liver region

Input CT image	Mean	Maximum	Minimum
B_1	167.0012	180.0033	162.0051
B_2	164.0002	166.0012	1640031
B_3	180.0000	181.0005	171.0011
B_4	163.0101	181.0001	158.0521
B_5	161.0112	150.1205	148.0001
B_6	156.1006	179.0044	170.0054
B_7	152.3621	150.8731	150.7764
B_8	138.9218	145.9425	142.0000
B_9	145.9924	144.0987	137.0041
B_10	149.8754	150.01115	149.7691
B_11	152.0019	145.1409	138.5241

Table 2 Some Experimental Results of malignant liver region

Input CT Image	Mean	Maximum	Minimum
M _1	135.2811	136.5659	134.0151
M _2	122.0147	121.9938	133.7781
M _3	126.4311	128.8140	126.4082
M _4	125.5576	122.6940	121.1616
M _5	128.3201	133.9364	133.6906
M _6	135.4928	140.1780	138.8933
M _7	115.7018	126.9384	128.1335
M _8	150.2997	148.1046	147.6892
M _9	128.0763	126.7986	123.5444
M _10	129.0208	129.6627	128.7222
M _11	157.6499	150.0308	160.8747

Conclusion

A grayscale image is a data matrix whose values represent intensities within some range. MATLAB stores a greyscale image as an individual matrix, with each element of the matrix corresponding to one image pixel. In this study, the step of the algorithm adaptive morphological operations are performed including largest connected component selection, hole filling and morphological opening. In order to check the accuracy of automated segmented from all liver region images is segmented manually by the radiologist and oncologist. After tested hundred segmented liver images and are obtained 70% of lesion regions are detected with detection constant one third in this experimental results. The block size in this research is 8×8 and therefore the comparison of mean value of the regions will be performed by using different block sizes and various detection constants. It is expected to identify liver tumor and liver diseases in our future work.

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