

# Diagnosis of Liver Tumors Using Image Processing

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**Abstract**—In this paper, a computer-aided diagnostic (CAD) system for the diagnosis of benign and malignant liver tumors from computed tomography (CT) images is presented. The research aims to develop an automated way to extract suspicious regions of liver area in the scanner image to the abdominal area, this research uses a new method for extracting the liver area of the scanned image for abdominal area automatically, depending on the use of connected compounds numbering algorithm CCL, in addition to the use of data collection algorithm FCM to extract suspicious regions of the extracted area of the liver.

**Keywords**—liver; Image processing; Tumors; regions.

## I. INTRODUCTION

The liver has vital importance to human beings, so liver diseases are considered seriously. The liver is made up of various cell types, so several distinct types of tumors can develop in it. These tumors can be benign or malignant (cancerous). The benign tumors of the liver seen most frequently include cavernous hemangioma, liver cell adenomas and focal nodular hyperplasia (FNH). The malignant tumors of the liver seen most frequently are hepatocellular carcinoma, intrahepatic cholangiocarcinoma, bile duct cystadenocarcinoma, and hepatoblastoma [1].

Computers are used widely in medical research, where there is a vital need for better microelectronic sensors for data acquisition. Imaging modalities like Ultrasound, MRI (Magnetic Resonance Imaging), CT (Computed Tomography) and PET (Positron Emission Tomography) are widely used techniques for liver cancer tumor diagnosis [2].

Liver cancer tumor is sixth dangerous diseases in the world. Because of the liver's vital importance to human beings, Liver diseases are considered seriously. There are two classes of liver tumors: benign and malignant [3].

Computer-assisted liver tumor classification which is based on the image analysis techniques provides more useful information. The conventional methods for the liver tissue classification consist of three-step process. The first step involves the segmentation of liver and tumor from CT abdominal image. The second step is the feature extraction and the third step is classification using a classifier. The Characterization of liver images based on texture analysis techniques have been developed over the years [4]-[7].

## II. DEVELOPED METHOD

The research aims to develop an automated way to extract suspicious regions of liver area in the scanner image to the

abdominal area, this research uses a new method for extracting the liver area of the scanned image for abdominal area automatically, depending on the use of connected compounds numbering algorithm CCL, in addition to the use of data collection algorithm FCM to extract suspicious regions of the extracted area of the liver.

This method is characterized as follows:

1. Based on fractionation through two phases:
  - Extracting the liver area of the abdominal area scanned image.
  - Extraction of suspicious areas of the liver area.
2. Use of one cross-sectional image to the abdomen to give a two-dimensional representation of the suspicious blocks.
3. Depends on a particular situation of scanned images to the abdominal area, where Liver area details are fully clear.
4. Automated method at all stages and does not require any user intervention.

The developed method consists of two phases:

### • First Phase :

Input Image: Scanned Image of the abdomen area as following:

1. Giving image thresholds values of 90 & 200.
2. CCL Algorithm applying to number connected areas which form the image.
3. Specification and extraction the largest region which contains Liver.
4. Getting rid of other organs areas which appear along with the Liver area.
5. Retrieval of the original values of the elements of Liver area.

### • Second Phase:

Getting Output Image (Suspicious Regions image in the Liver area) after:

1. Applying FCM Algorithm to group elements of Liver image into three sets.
2. Retrieval of original values of the elements of three sets.

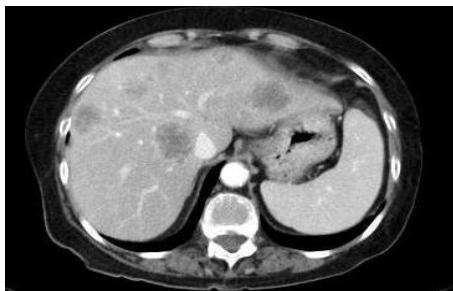
3. Specification of image which represents the suspicious regions in the Liver area.
4. Getting rid of regions of small area comparing with the suspicious regions areas.
5. Retrieval of original values of the suspicious regions elements.



(A)



(B)



(C)



(D)

Fig. 1. Images for examples of the basic cases for medical used: (A) Liver Tumor, (B) cyst in liver, (C) secondary Liver Tumor, (D) liver healthy.

*First Phase (Extracting the liver region of the computerized scanned image to the liver area):*

In this paragraph, first stage steps of the developed method are explained in details, and applied to one of the images used

in the search. Figure 2 shows one of the images used in the research, medical diagnostics has indicated to the presence of two suspicious regions in left and right lobes, these suspicious regions are indistinguishable by eye due to the difference in grey levels between cells of these regions and normal liver cells.

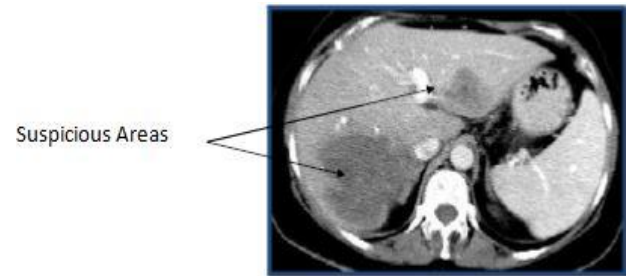


Fig. 2. Computerized Scanned Image of Abdomen Area

First Phase consists of five steps as follow:

#### 1 First Step:

In this step, each image element that belongs to the range of (90-200) is given the value of zero, so it will appear in black. On the other hand each image element that doesn't belong to the range will be given the value of one, which will appear it in white.

$$f(i,j) = \begin{cases} 0, & 90 \leq f(i,j) \leq 200 \\ 1, & \text{otherwise} \end{cases} \quad (1)$$

These values ( 90 & 200 ) have been chosen as the threshold values because of that the used medical image grey analysis has shown that most of the Liver image elements belong to the range in between these two thresholds ( Grey levels ) 90 & 200.

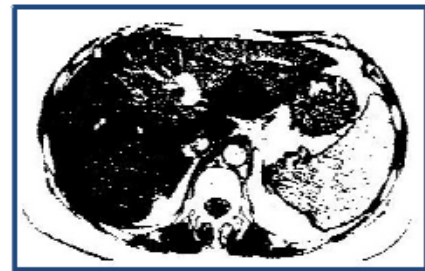


Fig. 3. Resulted Image of giving elements thresholds values ( 90 & 200 ).

#### 2 Second Step:

In this step, algorithm numbering of related compounds CCL has been used, to number areas or related compounds in image, so that each set of connected elements form a region. Because of the resulted image from the previous step is a binary image, so numbering of related compounds has been performed on the levels of 1 & 0.

As a result of CCL algorithm application, a set of connected regions will appear. Applying of this algorithm has resulted into 339 connected regions figure 3.

#### 3 Third Step:

By this step, an approximate specification of the area of liver is being performed, based on: The anatomical description, which refers to it as the region of the

largest space in the computerized scanned image of the abdominal area, and related compounds which have been numbered in the previous step.

Thus Liver area has been specified. Reviewing of the areas of connected regions in the image has shown that the largest area has the 51071 elements. Elements of all the other regions have been given a value of zero, thus the elements of the largest area have remained as shown in Figure 4.

It could be noticed that this image contains the region of liver, as well as many parts of other organs, and the reason for this is that the values of the gray levels of these parts are close to the values of gray levels of the liver area components.

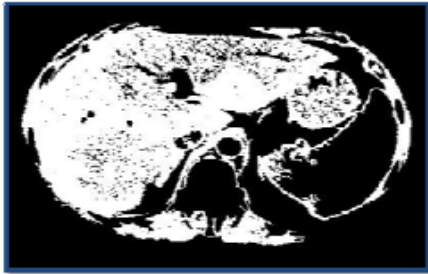


Fig. 4. Elements of the Largest Area in the Image.

#### 4 Fourth Step:

A series of Morphological Operations are being applied through this step, exactly the Closing and Opening operations to obtain the Liver Area, and to get rid of parts of other organs.

Opening function has the duty of smoothing borders of the body, also it cuts small barriers between connected parts as well as delete simple outcrops with small thicknesses. While Closing function tends to smoothen the borders of body, but this process (as the opposite of the first one) integrates and merges the narrow intersections, gets rid of the holes, and fills in the blanks located within the borders of the body. An appropriate configuration element which will be used in both functions should be chosen [8].

Initially, Closing function is performed to fill in the small blanks in the body of the liver using a configuration element has the shape of disk and a diameter of 3 elements.



Fig. 5. Resulted Image of applying Closing function to fill in small blanks in the Liver.

After filling small blanks in the area of Liver, both Opening and Closing functions are being applied respectively to separate the regions of different organs by using a

configuration element has the shape of disk and a diameter of 13 elements.



Fig. 6. Resulted Image of applying Opening function to separate the regions of different organs.



Fig. 7. Resulted Image of applying Closing function on the image resulted from Fig. 6.

It could be noticed that more than one region has formed (the region of Liver in addition to another small region). To get rid of all additional regions, one additional opening function is being performed, but this time by using a configuration element a diameter of 25 elements (Which is an estimated value to the areas of non-desired regions, those could appear along with the area of Liver).



Fig. 8. Resulted Image of applying Opening function to get rid of non-desired regions

#### 5 Fifth Step:

Original values of the components of the liver area (derived from the original image) are being retraced, according to the equation (2):

$$f^*(i, j) = \begin{cases} f_0(i, j) & \text{if } f_B(i, j) > 0 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

Where:

$f^*(i, j)$ : Derived image of the area of Liver,  $f_0(i, j)$ : Original image,  $f_B(i, j)$ : Image of Fig 8.

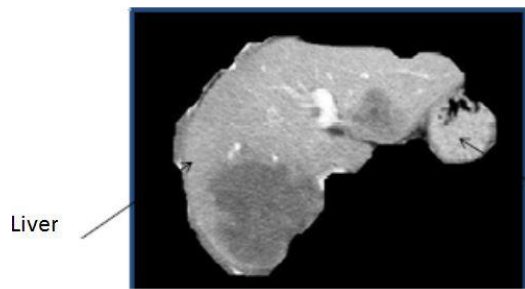


Fig. 9. Extracted Liver area of the computerized scanned image of the abdomen area.

### II.I.II Second Phase (Extraction of Suspicious Regions of Liver Area):

The Image of Liver extracted of the Abdomen Image includes the suspicious regions which should be extracted. This is considered a hard process due to the nature of these suspicious regions in terms of shape, census and distribution. Therefore, it is necessary to find a flexible algorithms, capable to deal with this diversity in various pathological conditions.

Considering Image items as a group of data, classified into minor groups, each has items of the same properties ( such as grey levels ), algorithms can be used to collect data for the compilation of picture elements within groups, so that elements of one set are similar with each other, and differ with elements of the other groups.

FCM algorithm is one of the most important data collection algorithms that are used in the field of medical image processing. It doesn't rely on fixed values of the level of gray, but deal with cases on the basis of one by one, which gives good results, although there is a difference in values of gray levels in medical images result of many factors, such as the parameters of the imaging process and physical specifications for the patient. To apply the FCM algorithm on the image of the liver area, fcm function has been used of library of image processing tools in Matlab [9].

```
[center,U,obj_fcn] = fcm(data,cluster_n)
[center,U,obj_fcn] =
fcm(data,cluster_n,options)
```

Where:

- Data is the Matrix Data, which is a data group should be divided into groups so that each line of this matrix confirms one data point (in our case, an element of the image).
- Cluster n: Number of groups (>1).
- Center: Matrix of the final groups centers, so that each line represents the coordinates of the center of a group of them.
- U: Matrix of random distribution.
- Obj\_fcn: Matrix of function values by repeating the algorithm.
- Options: Matrix of options by which the parameters of the control and are as follows:
  - The first option: Fuzziness Degree. The default value : 2.

- The second option: The maximum number of iterations of the steps allowed. The default value: 100.
- The third option: Minimal value of the improvement of the outcome allowed for the continued implementation of the repetition of steps and, of course, within the limits of the maximum number of iterations. The default value: 0.00001
- The fourth option: Showing values and cost improvement through the process implementation. The default value : 1.

The second phase consists of five steps as follows:

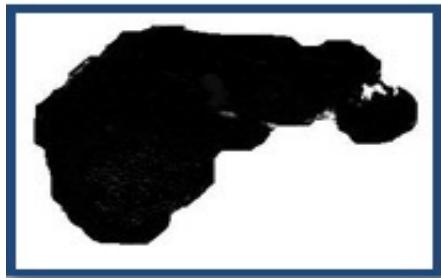
#### 1. The first step:

In this step, we continued to apply the fcm function on the image of the liver derived by using the default options matrix and determine the number of groups within 3 groups, so that one of these groups includes the elements of the image that lies in the background of the image, while the second group includes picture elements in suspicious regions, and therefore the last group includes picture elements in natural areas. Table 1 shows the results of FCM application on the liver image extracted in figure 9.

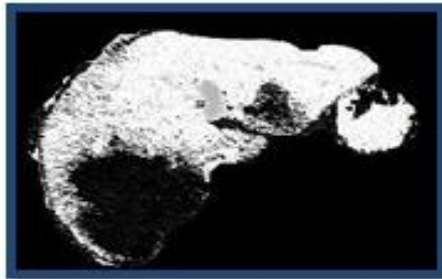
Table 1: Shows that the value of improvement at iteration 25 has recorded a value less than the allowable minimum value, therefore the function will stop at this iteration.

Iteration Count	Cost Function(obj_fcn)	Improvement Value ( _ )
1	14323.457117	
2	11094.385136	3229.071981
3	11093.741025	0.6441111
4	11083.445149	10.295876
5	10921.407518	162.037631
6	8910.165077	2011.242441
7	2928.070674	5982.094403
8	1615.482088	1314.588586
9	1282.112222	333.369866
10	718.559898	561.552324
11	563.817394	156.742504
12	531.893084	31.92431
13	522.099320	7.793764
14	521.991893	2.107427
15	521.389860	0.602033
16	521.212805	0.177055
17	521.159923	0.052882
18	521.143996	0.015927
19	521.139177	0.004819
20	521.137716	0.001461
21	521.137272	0.000444
22	521.137137	0.000135
23	521.137096	0.000041
24	521.137084	0.000012
25	521.137080	0.000004

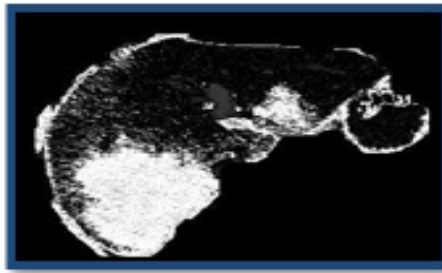
Resulting from the application of the fcm function three sets of elements, the re-formation of the elements of each group separately to form a specific part of the original image, Figure 10 shows the images resulting from the formation of the elements of each of the resulting three groups:



(A)



(B)



(C)

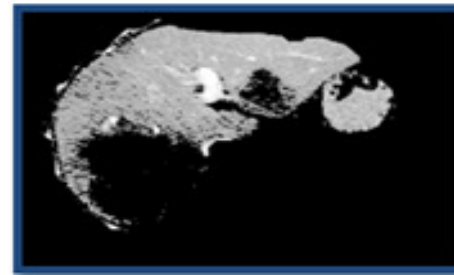
Fig. 10. Images resulting from the formation of the elements of the three groups: (A) Elements of the background image and includes a very small number of elements that do not belong to the background, (B) Image of healthy elements in the liver, (C) Image of suspicious areas in the liver.

## 2 The Second Step:

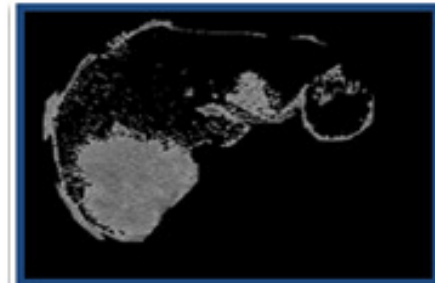
For each one of the pictures from the previous step, the corresponding elements in the image area of the liver in Figure 9 should be retrieved, where the boycott of each image elements with the image of the liver form three partial images, if been collected together, the result would be the original image which represents the entire liver area that was drawn in the first phase.



(A)



(B)



(C)

Fig. 11. Photos of the three groups after retrieving elements of the image area of the liver resulting from the first phase: (A) Image of elements of the background and includes very few elements that do not belong to the background, (B) Image of healthy elements in the liver, (C) Image of suspicious areas in the liver.

## 3 The Third Step:

In this step, three groups resulting from the previous step are examined and the group that represents the cells of suspicious areas is selected, this is because the fcm function does not give images of the three groups in the same order each time it is executed (Even when using the same data for income). So it is not correct to always assume that the first group will represent the normal cells in the liver, and that the second group will represent suspicious cells regions in the liver area, and the third group will represent cells that belong to the background.

Screening process has executed and the group has been identified, depending on the maximum value of gray levels in each group because:

$$g_L > g_S > g_B \quad (3)$$

Where :

$g_L$ : The maximum value of grey levels in the group of healthy cells in the liver area.

$g_S$ : The maximum value of grey levels in the group of suspicious regions cells in the liver area.

$g_B$ : The maximum value of grey levels in the group of image background elements.

Therefore, the maximum value of the grey levels is calculated in each image of the three images resulted from the previous step, and the previous terms being applied to select the image that represents suspicious areas in the region of the liver.

4 The Fourth Step:

In this step, regions of very small areas is being neglected and deleted, comparing to the areas of suspicious areas which required to be extracted.

This happens as a result of bwareopen function application, which is one of the available morphological operations at MATLAB image processing library, so that all connected regions with the number of elements less than or equal to a specified number are deleted. (100 elements, which is estimated value of these small areas).

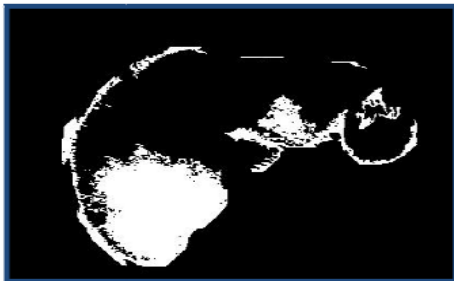


Fig. 12. Deleting connected regions which have very small areas comparing to the areas of suspicious regions.

5 The Fifth Step:

The original values is being retrieved of the suspicious region elements of the image of Liver by using the equation (4):

$$f^*(i, j) = \begin{cases} f_0(i, j) & \text{if } f_B(i, j) > 0 \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

Where:

$f^*(i, j)$ : Images of suspicious regions extracted of Liver area.

$f_0(i, j)$ : Images of Liver resulted from the first phase (Liver Area Extraction)

$f_B(i, j)$ : Combined Image, fig 12.

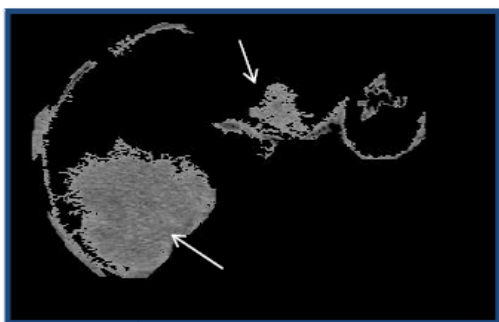


Fig. 13. Suspicious Regions extracted of Liver Area.

It is noticed from the figure 13 the existence of undesired regions in addition to the suspicious regions due to the rapprochement in the values of their grey levels and levels of grey of the suspicious regions. Getting rid of these parts

depends on comparison of their properties (Shape, Area, proximity to the periphery,) with the standard values of these properties of Tumor Blocks.

III. RESULTS AND DISCUSSION

Table2: Results of applying developed method on images presented as percentages

Studied Case	Qty	Extraction Accuracy %	Remarks
Primary hepatocellular tumors	6	95	Most of Tumors regions have been extracted
Transitional secondary hepatic tumors.	2	80	Most of Secondary Tumors regions have been extracted
Healthy Liver	1	100	No wrong regions have been extracted
Cyst in the Liver Area	1	100	Cyst region has been extracted completely.
Suspicious regions in the Liver Area	2	100	Suspicious Regions have been extracted completely.

Accuracy of extraction has been determined through a rough calculation of the ratio of suspicious areas derived from the liver to suspicious areas determined by medical diagnosis.

Almost all the entire areas of suspicious regions in the used images of the liver were extracted, no additional regions have been extracted as negative or wrong results (with the exception of parts of borders of the liver, which could be disposed of during the subsequent treatment).

A small portion of the suspicious region in one of the used images has not been extracted, this is due to the section of the liver area that contains this part has not been extracted in the first stage because of the high cell gray level of this section, which led to delete them during the threshold step. Principally this problem could be overcome through the application of appropriate pretreatment for used images [10].

Almost secondary tumors areas have been extracted when the developed method has been applied on secondary tumor images, the detection and extraction of these tumors require an additional special treatment due to its nature in terms of proliferation and space.

Correct results have been obtained when the developed method has been applied on healthy cases, where cells of liver area have been collected in one group except some parts of liver because the liver is free of any suspicious region. These results show the proper performance of the developed method in both healthy and diseased cases.

Values of gray levels of the liver border cells are close to the values of gray levels of suspicious regions when imaging the liver by using colored media. This has led to show parts of liver borders in most of the resulted images when the developed method has been applied. However, this doesn't affect the clarity of extracted suspicious regions.

IV. CONCLUSION

Show that the use of CCL algorithm in the process of extracting the liver area helps to develop an automated

method, because it is not affected by many variable factors, such as differing imaging conditions and space of the liver.

This algorithm is useful in extracting suspicious areas of the liver area, due to its reliability and non-affecting by conditions changes of the imaging process, accurate results been obtained by this method as shown in Table 2.

The success of developed method in the research on optimized extraction for the liver area, this is due to the extraction of suspicious areas in the second phase of the developed method, so the suspicious areas in area of the liver has to be extracted within the area of the liver in the first stage of the fully developed method. The more clarity and separate of the liver area, the better extraction of the liver area, the best extraction for suspicious areas could be obtained when the discrepancy between values of the gray levels of normal liver cells and values of the gray levels of cells of suspicious areas.

Developed method can be applied to a larger number of images obtained for different cases of liver lesions and patients in order to conduct a clinical trial on the performance of the method. In addition to the adjustment of its steps, such as the optimal select of the volume and shape of used composition elements of morphological operations used in this way.

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