Liver Tumor Detection by Automated Thresholding and Image Segmentation

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Abstract

Cancer is the most prevalent disease, with higher death factor in human beings. The irregular growth of cells leads to liver cancer or hepatic cancer, where, Hepatocellular Carcinoma (HCC) is the affected liver cancer to 75% of cases. Due to risk factors, it is difficult to be diagnosing the liver cancer at the earlier stage. Since, manual segmentation of tumor from Computed Tomography (CT) image is associated with time consuming and the task requires expert radiologist. To overcome this problem we need an automatic segmentation and analysis process, to identify the prevalence of liver cancer in the early phase itself. This technique consists of various image processing techniques to detect, segment and analyse the tumor in the liver automatically. The clustering algorithm is applied on liver CT image for effective tumor detection. In order to segment the region of tumor, distance transform and watershed transform is used. Then, the intensity of the tumor can be measured by the process which involves edge detection, adaptive thresholding, hole – filling and background subtraction. This works aims to improve accurate analysis of tumor in the liver.

I. Introduction

The abnormal growth of cells in the liver is known as liver cancer or hepatic cancer. There are various image processing techniques involving Ni-LabView to detect and analyse the region affected by cancer in the liver. Here, the tumor is detected from computed tomography images. This project involves detection, segmentation and analysis of cancer in the liver. This chapter includes the objective and scope of the project, existing techniques that is being practiced and proposed techniques to improve the solution. The following chapters include the progression of the project. This method will improve the diagnosis of liver cancer leading to earlier treatment and to a better quality of life for liver cancer patients. The main objective of our project is to detect and analyse the liver tumor in the initial stage. By using various segmentation and edge detection process in computed tomography images we can easily analyse the tumor and thus the cancer can be detected and treated for the medication.

To detect the signs of liver cancer, alpha-fetoprotein levels has to be determined from blood drawn from the patient. If the level of alpha-fetoprotein seems to be high, it may indicate the presence of some form of liver disease. Additionally, to detect the presence of tumor, certain diagnosis is done through ultrasound/CT or other imaging modalities. Blood test may be performed to detect the presence of tumor markers. The blood may be tested for CEA, if the patient is subjected to colon cancer or other, in past. For the same case, modern imaging techniques like CT or MRI may be carried over to detect tumor cells in liver and the proper functioning of liver is ensured through blood test. As a result of blood test, the elevated levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are found, along with high levels of bilirubin. The severity of disease can be found through the above explained results and doctors can also diagnose for fatty liver disease, hepatitis B/C and or cirrhosis.

Generally, for pre-treatment the process like particle or edge detection or background subtraction is used. The change in pixel value belonging to the source image is detected by the differential operator to detect

contours, is done by edge detection. The differential operator is basically classified into primary and secondary differential operator. However, the picture of "dispersion staining method" in this research has very thin particles and very small particles. Therefore, it is much difficult to detect all particles, such as thin particles, in edge detection. Background subtraction is a technique which uses the background image taken beforehand. In general microscope image, a background color is constant black. Therefore, once it took a background image, it is applicable to all of the subsequent experiments. The dispersion staining method is used in this research work. In this technique, when staining is observed under microscope, immersion liquid and asbestos particles are visualised. Due to the reflection effect of light, the color and intensity (brightness) of immersion liquid will change. Due to this, the background intensity and color of the microscopic picture will vary. Though it is a larger dataset, researchers must create more background image, as background subtraction has to be performed for more number of images. Background subtraction method is found to be ineffective to our work, so we have proposed a new procedure. The steps are, initially background area of the images are identified. Next, the regions excluding the background region are identified and classified with particle area. Finally, the classified output has to be verified as particle area. This procedure provides the particle are more effectively.

I I. Methodology

The abnormal growth of cells in the liver is known as liver cancer or hepatic cancer. There are various image processing techniques involving Ni-LabView to detect and analyse the region affected by cancer in the liver. Here, the tumor is detected from computed tomography images. This project involves the detection, segmentation and analysis of cancer in the liver. This method will improve the diagnosis of liver cancer leading to earlier treatment and to a better quality of life for liver cancer patients.

2.1 AUTOMATIC THRESHOLD TECHNIQUES

When compared to manual thresholding, the automatic thresholding techniques does not require the lower and upper threshold level setting. Based on literatures, the automatic thresholding techniques are well applicable for the images which vary in light intensity. The best multi-class thresholding method is clustering technique, which results in creating tertiary or high-level images by operating on multiples classes. The other methods like entropy, moments, interclass and metric are to be used on binary thresholding techniques. The main criteria in image processing is choosing the right algorithm to apply on an image; this strictly depends upon the type of image. Prior to the implementation of automatic thresholding on the source image, the image may be inverted in grayscale to obtain better results. So, inverting the image in terms of grayscale can be performed on source images where the background is brighter than foreground.

2.2 CLUSTERING

Image segmentation is an important stage in processing the source image. Successful segmentation are achieved through clustering method. The clustering technique will segment or partition the given source dataset into number of groups, namely clusters. Certain literatures have proposed various clustering

techniques like K-means algorithm, Improved K-means, Fuzzy C-mean and Improved Fuzzy C-mean algorithm. Each algorithm varies from one another in certain characteristics like the number of iterations, complexity, computational efficiency, etc. The K-means clustering method is majorly used due to its simple implementations and good computational efficiency; whereas the Improved K-means clustering method brings an advantage in using them by reducing the number of iterations performed. The Fuzzy C-means abbreviated as FCM and Improved FCM vary by their implementation time i.e. FCM method is time consuming and it is overcome by Improved FCM. Additional advantage of FCM method is providing good flexibility to the pixels, to belong to n-number of classes with varying degrees of membership. Based on the experimental results, Improved FCM results in better segmentation compared to other clustering techniques, proved by providing great accuracy on segmenting input gray scale image. It is important to measure the quality of output image i.e. segmented image through certain statistical parameters like RI – Rand Index, GCE – Global Consistency Error, VOI – Variations of Information and BDE – Boundary Displacement Error.

2.3 ENTROPY

Histogram of an image is necessary to determine the average information or entropy present in the source image. Histogram is a bar chart like representation displaying all the probabilities of grey levels present in the given image. The entropy is useful, for example, for automatic image focusing: as the state of focusing of an image varies, so does its entropy is shown in Fig. 2. We propose a method with good accuracy and lower processing time to measure the entropy of image. In the proposed method, a simple approximation formula is derived to find the entropy of images. An existing method is utilized here to perform the analogue calculation of the proposed formula at TV speed, achieved through TV optical non-linear component. This ensures the usage of proposed method for focussing 2D or 3D images in real time TV system.

2.4 LOCAL THRESHOLDING

Binary images are created by segmenting the input grayscale image into two regions namely, the particle region and background image through a process called local adaptive thresholding. The global grayscale thresholding method, generally segments the image based on the pixels; it assumes the pixel comes under either particle region or background region taking into account the intensity statistics of the entire image; whereas the local thresholding utilizes the intensity statistics of neighbouring pixels.

2.4.1 NIBLACK ALGORITHM

The NiBlack algorithm is one among the other existing adaptive thresholding algorithms, concluded from OCR and map image segmentation applications. This method is widely accepted for display inspection and OCR, image thresholding applications. The window size has to be carefully designed as the algorithm is sensitive to it, thereby producing noisy image segmentation of image with large and uniform background. To categorize pixels properly, deviation factor is computed using NI Vision local thresholding.

The NiBlack algorithm is given as,

$$T(i, j) = m(i, j) + k \cdot \omega(i, j)$$

Where, $T(i, j)$ – local threshold value at pixel (i, j)

$m(i, j)$ – local sample mean

k – deviation factor

$\omega(i, j)$ – standard deviation

2.4.2 BACKGROUND CORRECTION ALGORITHM

The background correction algorithm has combined the concepts of local thresholding and global thresholding concepts. The figure 3 demonstrates the background correction algorithm.

The background-corrected image is given by,

$$B(i, j) = I(i, j) - m(i, j),$$

Where, $m(i, j)$ is the local mean at pixel (i, j) .

III. Liver Cancer Intensity Analysis

The severity of liver cancer are identified using Bayesian classifier and SVM classifier. The proposed classifier is to find the types of disease with most prior accuracy. In particle analysis of liver cancer image includes various image acquisition and image processing algorithms. The cancer image will be taken from liver of the person with appropriate CT instruments. The image can be acquired through image acquisition hardware in National Instruments or through serial communication from instruments to LabVIEW. Acquisition is a technique in the fields of image processing and computer vision wherein an image's foreground is extracted for further processing (particle recognition etc.). It is a computational process of extracting foreground objects in a particular scene. Generally an image's regions of interest are objects (disease, dust in image, nerves, tears from the eye etc.) in its foreground. After the stage of image pre-processing (which may include image de-noising etc.) object localization is required which may make use of this technique. Region of interest is a class of techniques for segmenting out objects of interest in a scene for applications such as liver cancer identification. There are many difficulties in implementing a better background subtraction algorithm. The reason for our work is to acquire a real-time framework which functions admirably in indoor work area sort of climate and is autonomous of camera situations, reflection, light, shadows, opening of entryways and other comparative situations which lead to blunders in fore-ground extraction.

IV. Liver Cancer Segmentation

Image segmentation plays a vital role in digital image processing and computer vision, doing the process of segmenting or dividing the input digital image into 'n' number of segments based on image objects. Image segmentation is used to achieve the goal of simplifying the source image representation into a meaning way, which is easier for future analysis and interpretation. To locate the objects and boundaries like lines, curves, edges, etc the segmentation is used. To insist more on concept of image segmentation, labels are assigned to each pixel in the source image, finally the pixels with similar labels have the similar characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. The pixels in the particular region of the source image are similar with certain characteristics of color, intensity or texture; whereas the adjacent regions are different with respect to same characteristics. When the segmentation algorithms are applied on a set of medical images, the final contours after segmentation is used for 3D reconstruction using certain interpolation algorithms.

Thresholding, distance transform, watershed transform, display watershed lines are certain steps followed in morphological segmentation of liver cancer. It acquires the image using IMAQ (Image acquisition). The input loaded image is make for one copy of it so that it can overlay the watershed lines later. The RGB image is initially converted into grayscale for thresholding. Then IMAQ Auto Threshold method applies computed threshold on the image, priorly calculates the optimal threshold of the image or interest. These processes are done in binary. Then IMAQ Danielsson returns s distance map based on the algorithm of Danielsson. It is processed with gradient image. Then IMAQ watershed transform computes the watershed transform on an image. It is processed with binarization. Lastly, to display the watershed lines IMAQ Threshold and IMAQ Mask is used.

V. Results And Discussion

5.1 LIVER CANCER TYPE DETECTION

There are two ways in classifying the liver cancer types. One is using the Bright objects and another one is using Dark objects.

5.2 METHODS FOR ANALYSIS THE CANCER TYPE

5.3 LIVER CANCER SEGMENTATION

The binary picture generally consists of feature and non-feature elements. The distance transformation is used to convert a binary image into an image where the distance to the nearest feature element is calculated. The computed distance values are found using the neighbours.

In watershed transformation, the different morphological tools used in segmentations are reviewed with more illustration. The process of image segmentation can be approached in 2 steps: 1. Boundary based method detecting the local changes; 2. Region based method, looks for pixel and region similarity.

When the criterion for image segmentation is the homogeneity existing among the gray values of the objects, then watershed transformation is used on the gradient image. The distance function can be employed on the images where the segmentation is performed based on object shapes.

This is the final step in analyzing the liver cancer image using segmentation process. Here the watershed lines help in diagnosing the cancer tissues.

Vi. Conclusion

There are many systems that are serving the same purpose. But those systems are difficult to use, expensive and a complex process. The proposed system overcomes all of the above problems and it is simply affordable with better accuracy. This system is helpful to every system setup. Thus this software would be good in quality and performance and able to be trusted by patients and Doctors. It is helpful for tracking cancer cells at the earliest phase and thus reduces the death rate. User can view the cancer particles clearly and thus can analyse the type of the cancer. Also they can diagnose using the intensity analysis and segmentation process. The programming language used is simple and can be modified easily. The product is easy to design and thus requires less maintenance.

This system would be good in quality and performance with simple software programs and cheap device comes as a boon for the young and elderly, a simple solution for those who identify the cancer at the metastasis stage. Since it is user friendly, it can find its use in every hospital that has medical supervision and can be marketed as an efficient solution for us. The main goal of the system is to provide early diagnose, tension free life to those who are affected with liver cancer problem and to provide it at an affordable cost. The cost would be affordable compared to other products available in the market.

Declarations

Data Availability:

Data obtained from hospital.

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The authors declare that they have no conflicts of interest to report regarding the present study.

Authors' Contributions:

Jeslin Libisha J and Ram Kumar C worked out almost all of the technical details of the manuscript. Sundar R wrote the main manuscript with inputs from all authors and implementation of the work. Pavithra G worked on the literature survey of the paper.

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The results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration (from you or one of your Contributing Authors) by another publisher. I have read the journal policies on author responsibilities and submit this manuscript in accordance with those policies. All of the material is owned by the authors and/or no permissions are required.

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Figures

Figure 1

Block diagram

Figure 2

Entropy of a cancerous image

Figure 3

Background correction algorithm

Figure 4

Block diagram of Intensity analysis

Figure 5

Liver cancer Image Morphological segmentation Flow

Figure 6

Figure 7

BO Niblack

Figure 8

DO Background correction

Figure 9

DO Niblack

Figure 10

Clustering

Figure 11

Entropy

Figure 12

Inter-class variance

Figure 13

Detection of cancer type

Figure 14

Segmented threshold image

Figure 15

Distance transform

Figure 16

Liver cancer morphological segmentation watershed transform

Figure 17

Watershed lines