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Liver Tumour Segmentation Using Ant Colony Optimization

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Abstract— ***Segmentation is a technique that can be used for analysis and diagnosis of tumour in CT-scan liver image. This paper presents Ant Colony Optimization (ACO) algorithm for liver tumour segmentation. Segmentation becomes easier if the image is clear with the absence of noise, but it becomes difficult if the image is too noisy, as it get corrupted or damaged due to additional noise. So the technique that is capable of segmenting liver tumour in a noisy image needs to be developed. This paper proposes an automatic liver tumour segmentation method that uses Discrete Wavelet Transform for decomposition of image and Adaptive Median Filter for removing noise from the image in a pre-processing step. The pre-processed image is then segmented by using Ant Colony Optimization algorithm which is used to solve optimization problems. ACO is an iterative algorithm that gives optimal solution. The results show the tumour region in the CT-scan liver image.***

Keywords— Liver Tumour Segmentation, Ant Colony Optimization (ACO), Discrete Wavelet Transform (DWT), Adaptive median filtering, Decomposition, Noise Removal.

I. INTRODUCTION

Liver disease is one of the most common diseases in the world, liver performs significant operations in human body, and there is no other technique or device that can compensate for the absence of liver. But the only option is liver transplantation, which is a major and risky surgery and also there is a shortage of cadaver donation in recent years.

An image processing technique takes an image as input and its output will be either image or a set of characteristics of image or parameters related to that image. Here image is treated as two-dimensional signal [6].

An automatic liver tumour segmentation method can be used in medical image analysis for detecting liver tumour and it reduces the work load of doctors by measuring the variation of liver tumour. It would help physicians in clinical routine by simplifying and speeding up their work. This would eliminate the traditional segmentation method which involved long and tedious manual process and it also allow for systematic delineation of the lesions.

The segmentation technique proposed in this paper uses CT-scan liver image as input, which is pre-processed before segmentation. First, the CT-scan liver image is applied with Discrete Wavelet Transform (DWT) technique for decomposition. DWT decomposes image into different sub-band images namely, low-low (LL), low-high (LH), high-low (HL), and high-high (HH). The decomposed image will be retained in LL sub-band [9]. Decomposition can be exercised through different levels, but in this paper, decomposition is stopped after two levels. This decomposition reduces the size of an image since it has undergone compression. DWT removes noise from the image to quite an extent [6]. The remaining noise from the image is removed by using Adaptive Median Filter [11] [12] [14], which is the second pre-processing step. The standard median filter is a non linear digital filtering technique often used to remove noise [19]. The main idea of median filter is to run through the image and replacing each pixel with the median of neighbouring pixels. But median filter removes both the noise and fine detail since it cannot differentiate between the two. And so Adaptive Median Filter is used in this paper which can easily distinguish between noise and fine detail of image. Adaptive Median Filter performs its operation by comparing pixel intensities to determine which pixels in the image have been affected by noise. This filter can remove noise from the required pixels where ever it is necessary.

Finally, segmentation technique is applied on the pre-processed image using ACO algorithm [7] [10]. The optimization techniques are used to faster the processes. The process of obtaining best results under given circumstances is called optimization. One such optimization algorithm is ACO which is based on original ant behaviour. This technique works in accordance with movement of ants over the image which deposit pheromone around the region of interest on the image. And the resultant image that is obtained shows the tumour region separated from the CT-scan liver image.

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II. LITERATURE SURVEY

A. Modified Fuzzy C Means With Optimized Ant Colony Algorithm For Image Segmentation [7]

Fuzzy C Means clustering allows one piece of data to belong to two or more clusters. This algorithm performs cluster analysis by relating data points to corresponding cluster center by evaluating distance between data point and cluster center. The membership of data towards the cluster center is more if the data is nearer to it.

This algorithm have been widely used in the segmentation because they can preserve more information from the original image than other segmentation method. This is also helpful in extracting useful information in large databases. But this is not efficient due to the limitations in initialization that the number of clusters and the cluster centre must be initialized before the segmentation process.

B. Edge Preserving Multi-Scale Image Decomposition With Customized Domain Transform Filter [2]

Domain Transform Filter is used for edge preserving smoothing which removes noise in a flat region, it neither blur the sharp edges nor destroy the details of the boundary of region. It has the ability to sharpen blurred image. If we have multiple images to filter then use DT filter to avoid extra computation on initialization stage. This filter is not used because it may not work properly if the image contains more amount of noise since it is more sensitive to noise.

C. Extracting The Liver And Tumor From Abdominal CT Images [3]

Seeded Region Growing method is a region based method. It involves selection of initial seed point. In this approach, the neighbouring pixels of initial seed points are examined whether to add them to the region.This method can correctly separate the regions that have the same properties that are defined and provide the original images which have clear edges with good segmentation results. Here, only small number of seed points are needed to represent the desired property, then grow the region. In this method identifying the seed is very difficult as it uses centroid method.

D. Discontinuity Based Method [5]

In this approach, the partitions or sub-division of an image is based on some abrupt changes in the intensity level of images. It mainly focuses on identification of isolated points, lines and edges in an image. It can be classified into Point detection, Line detection, and Edge detection. A point is the most fundamental type of discontinuity in a digital image. In point-detection method, the point is detected at a location (x, y) in an image where the mask is centred. In the line-detection method, we have two masks so that the corresponding points are more likely to be associated with a line, the direction of the one mask as compared to another. An edge is a boundary between two regions having distant intensity level. It is very useful in detecting of discontinuity in an image, when the image changes from dark to white or vice-versa. But constraints are, for all type of images, single operator doesn't suits and size of operator and computational intricacy are proportional to each other.

E. Intensity-Based Thresholding [4]

Threshold is the simplest way of segmentation. Utilizing thresholding technique, regions can be relegated on the substratum of range values, which is applied to the intensity values of the image pixels. Thresholding is nothing but the transformation of an input image to an output segmented binary image. In image thresholding the pixels are classified based on the property quantified from the image that falls below threshold and equal or exceeds threshold. Thresholding creates binary images from grey-level ones by turning all pixels below threshold to zero and all pixels above that threshold to one. It is simple to implement, fast especially if repeating on similar images. Only intensity is considered in thresholding and not any relationship between pixels, which is a major problem with it. There is no assurance that the pixels identified by thresholding process are contiguous. When we use thresholding, there is possibilities of losing too much of the region and getting too many extraneous background pixels.

III. ANT COLONY OPTIMIZATION

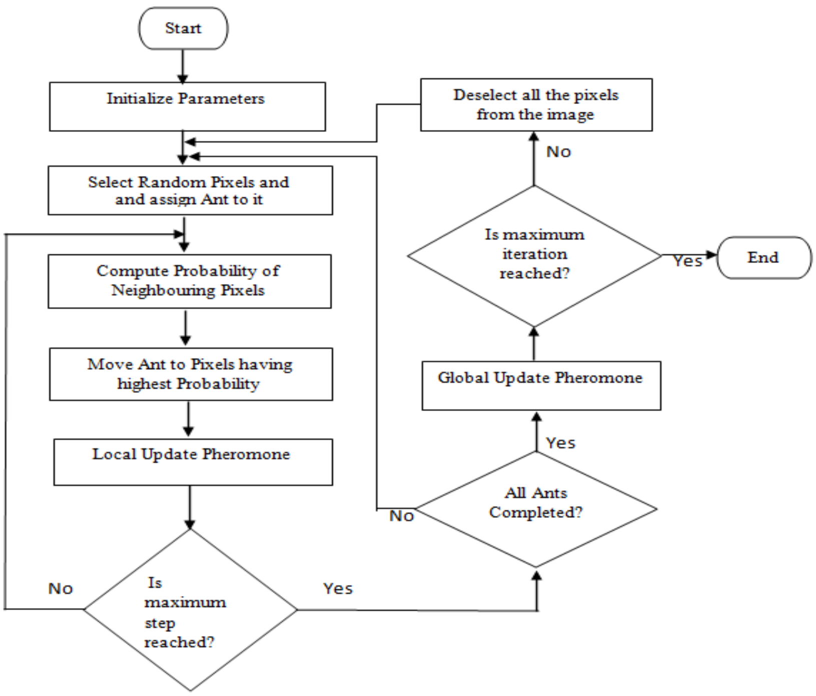

Figure 3.1 Flow chart for ACO

Ant Colony Optimization algorithm is a nature inspired algorithm that is based on original ant behaviour. ACO is an iterative procedure that is mainly used for finding optimal solution, where ant's behaviour is used to find optimal solution. The ants move randomly in different directions to find the path to food. While travelling along the path ants release a chemical substance called pheromone so that the other ants can follow the same path. Hence, these ants give shortest path for other ants. The number of ants that uses the image will output the results of the path. These outputs are stored in the memory positions for each number of iterations. In ACO algorithm, a set of artificial ants search for better solution for a given optimization problem. The solution can be obtained by local search on the image. Ants move to its neighbouring pixels by calculating probability of all its neighbours, and ants are moved to the pixel having greatest probability. ACO involves two update operations [] namely, local update and global update. These updates are performed over pheromone matrix. The first update (local update) is done when each time ants travel to their neighbouring pixels that is, after each construction step. The local update makes the next iterating ants to search their path easily. The second update (global update) is done when all ants complete one cycle of iteration individually. Figure 3.1 shows the flow chart of ACO algorithm.

IV. PROPOSED METHOD

The proposed method for segmentation of liver tumour from the CT-scan image is shown in the figure 4.1. It includes image enhancement and image segmentation.

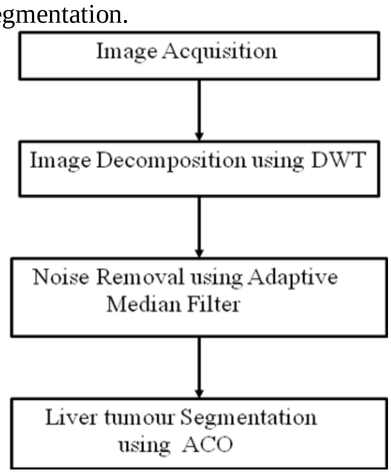

Figure 4.1 Block diagram of liver tumour segmentation

1. Image acquisition

The action of retrieving an image from some source, customarily a hardware-predicated source, so it can be passed through whatever processes need to occur afterward is known as acquisition of image. It is always first step in workflow sequence because without an image, no processing is possible in image processing. The image that is acquired is consummately unprocessed and is the result of whatever hardware was habituated to engender it. One of the ultimate goals of this process is to have a source of input that operates within such controlled and measured guidelines that the same image can , if necessary, we nearly perfectly reproduce under the same conditions so anomalous factors are easier to locate and eliminate.

2. Image Decomposition

Decomposition is achieved by using DWT which is a process of representing information in the compact form. In decomposition, the wavelets are depicted using a pair of waveforms, in which one represents high frequencies corresponding to the detailed components of an image and another represents low frequencies that is smooth components of an image [9]. Diminishing the storage space of images which will be helpful in raising storage and transmission process performance can be attained by compression.

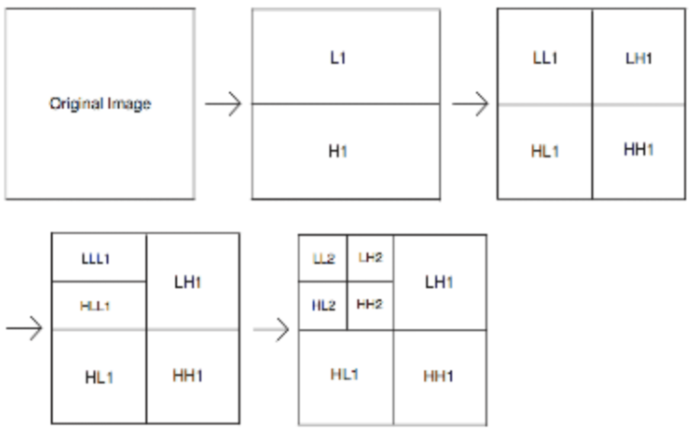

Figure 4.1 2-level decomposition using DWT

Wavelet transform divides information of an image into approximation and detail sub-bands. The approximation sub-bands shows the general information of pixel value and detail sub-bands shows changes in the images. The LL sub-band is approximately located at half the original image. The HH sub-band contains the high frequency details of the image. On the other hand, HL-LH conveys the changes of the image. A 2-D DWT can be seen as a 1-D DWT scheme which transform along the rows and then a 1-D DWT along the column [8]. The rows of the array are processed first with one level of decomposition. This essentially divides the array into vertical halves, with the first half storing the average coefficients, while the second half stores the detailed coefficients. This process is repeated again with the columns, resulting in four sub-bands within the array defined by filter output.

3. Noise Removal

Decomposed image is further processed for removing noise. Noise from the image is removed by applying Adaptive Median Filter. The image is often corrupted by noise during coding, collecting, transmitting etc. The noise decides the quality of an image and which cause problems for further processing. The noise should be removed in the pre-processing step to improve the quality of an image. Median filter identify the noisy pixels in the image by finding the median of pixel matrix. This is used to remove noise from required pixel wherever it is necessary. It is mainly used to identify the pixels in an image those have been affected by noise. It classifies pixel as noisy pixel by comparing each pixel in the image to its surrounding neighbours [11]. These noisy pixels are then replaced by the median value of the pixels in the neighbourhood.

4. Image Segmentation

ACO algorithm is used for image segmentation. An ant colony is highly organized, in which one ant interacts with other ant through pheromone in a perfect harmony. Optimization problems can be solved through simulating ant's behaviour. It is a metaheuristic algorithm in which, a colony of artificial ants co-operate in finding good solutions to difficult discrete optimization problems. Artificial ants gradually build the solutions by integrating suitably defined solution components to a partial solution under construction.

V. CONCLUSION

In this paper, an efficient approach for segmentation is presented. It proposes automatic segmentation of liver tumour from CT images. A very essential pre-processing step for accurate tumour segmentation involves decomposition and filtering of image where DWT and Adaptive Median Filter techniques are used respectively. Use of these techniques, improve the performance of the proposed algorithm by reducing computational complexities. DWT provides precise position for image features and also provides sufficient information both for analysis and synthesis of original image. Repeated applications of Adaptive Median Filter will not erode away useful information from image. Use of ACO algorithm, which is an iterative results in obtaining optimal solution. The results conclude that the proposed methodology yields better efficiency and improved performance in separating tumour from the CT-scan liver image.

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