Analysis of Liver MR Images for Cancer Detection using Genetic Algorithm

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Abstract- Image segmentation denotes a process by which a raw input image is partitioned into non-overlapping regions such that each region is homogenous and connected. This paper directly deals with locating and thus measuring the size of cancer affected area. It also proposes to reduce the time and manual efforts included in studying the MR images of the patient, thus saving the precious time of the doctors. The aim of this paper is to simplify the obnoxious study problems related to the study of MR images. Over the time, study of MR images related to cancer detection in the liver or abdominal area has been difficult. The reason is countered as the shape complexity and over lapping of liver with other organs. Watershed technique has been used as the base technique to compare the results with the proposed technique Genetic algorithm. A tabular comparative analysis has been given on the bases of results of both the techniques.

Keyword: Image Processing, Liver Segmentation, Cancer Detection, Mutation, Genetic Algorithm, Watershed Algorithm, MR Images

INTRODUCTION

Humans are considered as the most unique creation of nature. Over the periods of evolution of human life, the body has adapted itself in the most conducive shape and thus the complexity of internal structure poses a threat to the medical study and diagnosis. Cancer being one of the most deadliest and widespread disease is the most fatal one. Across the globe efforts are being made to cure it and eradicate the disease [1]. No 100% cure has yet been developed but treatment like chemotherapy and other intense radiation passing on the affected area are helpful treatments in controlling the disease [7]. The treatment lies on the secondary side, the prime job of the doctor is to detect the affected area in time. This becomes even more crucial, if there is a medical emergency. Though cancer can be detected in human body through MRI images, but the intensity of MR images and also the shape complexity of organs pose a threat to accurate detection. Also during the diagnosis and treatment phase the doctors are majorly interested in the problem area and not the entire human body. That is the reason that image segmentation comes into play [10]. Segmentation sub divides the area of interest to provide a better and clear view of the organ or part under observation. It should be noted that, segmentation is only a pre treatment step. The detection of cells or of structures interior to cells can be considered as an image segmentation problem within digital image analysis [4]. Different algorithms can be employed to segment an image. The algorithm discussed in this paper is Genetic algorithm.

Watershed algorithm: Multi threshold values in CT images are interpreted on the basis of grey levels. Comprehensive methods take advantage of de-noising and gradient construction [5]. The grey level of a pixel is interpreted as its altitude. Local minimum values are set. Intuitively, the watershed of a relief corresponds to the limits of the adjacent catchment basins of the drops of water.

Generic Algorithm: Using the binary strings, optimization problems are solved. This algorithm is inspired by natural evolution. Once the random variables are generated, these can be improved by iteratively applying operators, termed selection, crossover and mutation that mimic the corresponding processes of natural evolution. In fact, selection lets only the fittest individuals to be present in the next generation (iteration of the algorithm); crossover lets them exchange tracts of their DNA (corresponding substrings) to generate offspring (new solutions), while mutation randomly introduces new genes (by flipping one or more bits of a solution) [12].

Image processing is a developing and growing field in context to the medical application. Many methods have been developed and replaced with the newer methods. So it becomes of prime importance to develop and select newer methods to suit the requirements of the current times and problem specifications. Likewise 3D image analysis, reconstruction of the MRI slices and accurate boundary detection are of prime importance. Softening of cells is a major problem in cancer, and various 3D orthogonal planes (sagittal, coronal, transverse) are acquired [2]. Due to the shape of liver, its overlapping regions with lungs and heart and the artifacts of motion and pulsation automatic liver segmentation is a difficult process, also the CT images show grayish values of range between 90-92 out of 0-255 for a normal tumor free liver, but if there is tumor then the images become darker and the range is also ambiguous. So it is felt that it's high time to design and implement a quick responsive and exact calculative liver segmentation method for medical image analysis, which supports to analyze the benefits and problems of liver transplantation and the treatment method of liver tumors. Magnetic resonance imaging is a far better method than CT scan for the reason of being free of ionizing radiation and also gives a better image of soft tissue in terms of visualization [3].

Genetic algorithm (GA) is a computing model that will result as biological heredity, mutation of evolutionary process in the nature and manifests thoughts through selection, crossover and mutation operators. Its main characteristics are the searching strategy, exchanging of information between individuals in a group. It is particularly appropriate for complex and nonlinear problems which were difficult to be resolved dealing with traditional methods, demonstrates its unique charm in combinatorial optimization, adaptive control, artificial life and other application areas. It is one of the intelligent computing technologies. [1]

In the paper [6] contour based segmentation using Genetic algorithm is discussed. Also manual segmentation of a structure of interest is time-consuming and infeasible in clinical environment is discussed. Genetic algorithms are optimization techniques in which solutions of an optimization problem are encoded as binary strings. Once the first set of random solutions is generated further they can be improved by applying operators such as crossover, mutation and selection iteratively. The selection operator is based on the natural evolution phenomenon that is the survival of the fittest individual. In cross over the offspring are generated by letting the exchange of tracts of the DNA of parents. In mutation operator the new genes are introduced randomly by interchanging one or more bits of a solution. [6]

In paper [3] liver segmentation stating that a few prevailing segmentation techniques are Region Growing, Threshold based, Level Set method, Statistical model, Active Contour, Clustering algorithm, Histogram Based approach and Gray level methods are discussed. The Region Growing based approach starts with the provision of a small region as a seed point and proceeds with the addition of neighboring pixels. Thresholding based approach is implemented using global thresholding, to select the global threshold value is the main drawback of this method. Level set method adjusts the segmentation using a speed function obtained from a pixel classification algorithm. Model based approach utilizes the statistical shape model and it has the best performance among all the approaches. Histogram based approach is fully automatic segmentation by eliminating neighboring abdominal organs. Gray level based approach starts with a single user-defined pixel seed inside the liver then the mean and the variance of the rectangular neighborhood around the pixel is computed. Clustering based approach combines the K-means and is the simplest unsupervised learning algorithm. [7]

In the paper [18] it is stated that segmentation is based on contour let transform and watershed algorithm. A medical image usually contains a region of interest which holds the important diagnostic information. Due to irregular shapes of human organs, different imaging equipments the medical images have low resolution, low contrast and large noise. The new algorithm contains three steps which are: contour let transformation of original image, obtained low frequency image is divided using watershed algorithm and then reverting the low frequency image into high frequency by using contour-let inverse transform. A watershed is a basin-like landform defined by highpoint and ridgelines that go down into lower elevation and stream valleys. Simple direct projection in vertical and horizontal direction leads into blur edges and loss of information; to overcome this problem contour let inverse transformation is used. [11]

Problem Definition

The problem defined in the paper is to detect the cancer in the liver and thus to identify its correct location and size. Time required for this detection has been reduced as compared to the base algorithm. A new technique has developed, that can analyze the data set of the patient before its treatment, taking care of the points that manual process of checking data sets is time consuming and not accurate and also the cost is a factor. The problem is based on the tabular form comparative analysis of Watershed algorithm and Genetic algorithm.

So there is a dire need to design and implement a quick responsive and exact calculative liver segmentation method for medical image analysis that is also cheap.

The major problems that are faced while analysis of the data sets of a patient manually is that

- *The manual segmentation of the liver parenchyma is extremely laborious and time consuming [6].*
- *Existing methods are cost intensive and cost becomes an important factor while treating a patient [7].*
- *Manual analysis is not accurate as compared to a computer based analysis [10].*

- *The results are not precise and hence the doctors again have to input time for manual analysis after the computer has performed operation, which again results as loss of time.*

Thus it is vital to sense the root cell in the MRI images for which liver images are segmented [7]. So the problem discussed in this paper is to develop a technique that can analyze the data set of the patient before its treatment, taking care of the points that manual process and other existing methods of checking data sets are time consuming and not accurate and also the cost is a factor.

Objectives

Considering the problem formulated and the objectives of the paper is de-noise the image and find ROI. For checking the data sets of the patient, in case of cancer in liver, its size, volume, and shape; structure of its vessels; and location(s) are important. Hence the objective of this dissertation presents a technique that can be used to de-noise the image and to calculate the region of interest. To achieve this objective it is required to develop a technique that can analyze the data set of the patient before its treatment. The technique proposed is based on GA, for dataset comparison, watershed technique has been used as the base technique. The analysis and comparison is done on the basis of area of tumor, time taken for analysis, no of iterations of genetic algorithm which are fixed in both techniques, pixel difference. The objective thus defines to implement a technique that can analyze the data set and provide results on basis of area of tumor, taking lesser time as compared to the existing technique. The main objective includes:

- *Acquire an image and perform pre-processing, that includes de-noising*
- *Find Region of Interest (ROI) and perform segmentation with algorithm to be proposed.*
- *Compare performance of proposed algorithm with existing technique, on the bases of area of tumor, time taken for analysis and no of iterations of genetic algorithm.*

PROPOSED ALGORITHM

The algorithm is presented as:

The region of interest (ROI) has been selected out of the de-noised image by making the fuzzy coded binary map. The binary map values were selected and their inverse was mixed with de-noised values. These values were then given to an empty matrix, this results as segmented liver images. Out of the selected region of the segmented MRI image, using GA the cancer can be detected.

1. *Select the image.*
2. *Generate the random noise in the image*
3. *Denoise the image using contour based filtering method.*
4. *Select the desired area.*
5. *Obtain results by varying iterations.*
6. *Tabular comparison of results obtained for base and proposed technique.*

Select the MR Image to be segmented and pre process it for further computation

↓

De-noised MR Image

↓

Selecting Region mask for the second level G. A. Processing

↓

Displaying Results: (In Term of Area calculation, Time taken by the algorithm , No. of GA Iterations)

Figure1: Algorithm

RESULTS AND COMPARISON

The graphical user interface is shown in Figure 2; it is used to select both the algorithms on the same image. Get the image and add noise to it. De-noise the image using the contour based filtering method so as to remove all the noise from the image. Once the noise is removed the image is available for the further application of the base and the proposed algorithm.

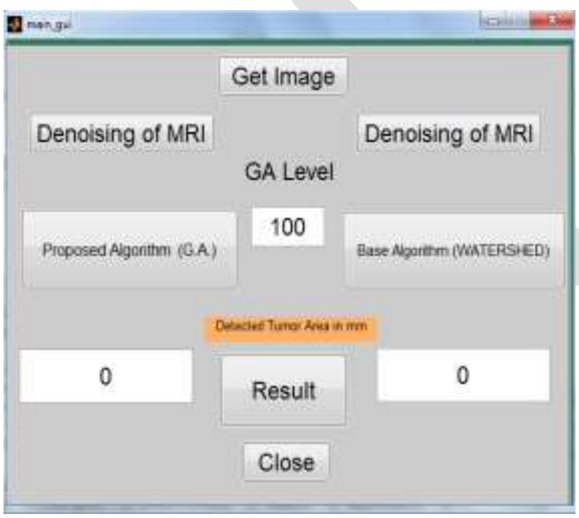

Figure 2: Graphical user interface

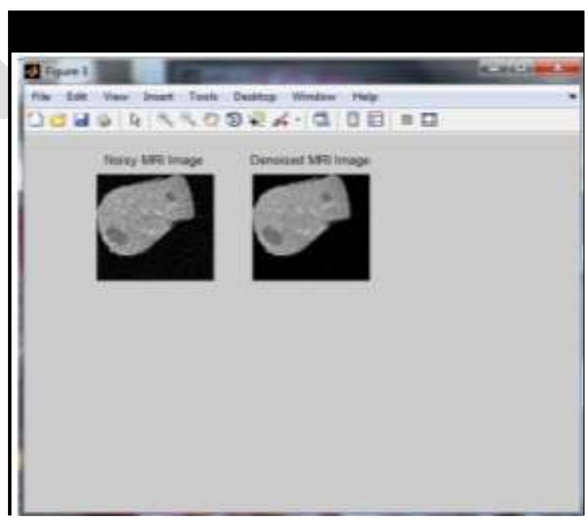

Figure 3: Image selection with and without noise

As the GUI is ready the desired image is selected from the data set and is noised as shown in figure 3, after the application of contour based filtering the noise is removed and the pre processing of the image is done to get the region of interest.

With the removal of noise after using the filters, the base technique Watershed is applied. Figure 4 represents the results of Watershed technique. The results are given on the bases of area, no of iterations, pixel difference and time consumed.

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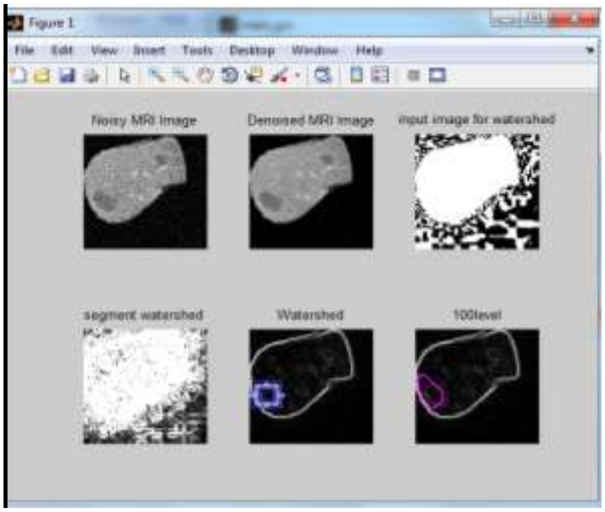

Figure 4: Results with Watershed Technique

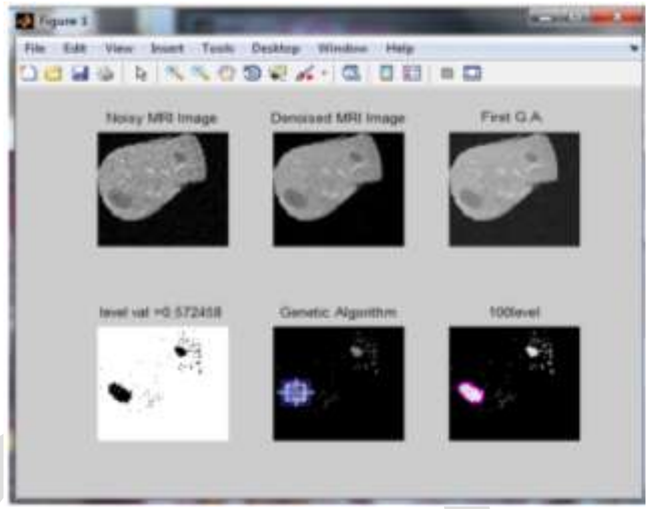

Figure 5: Results Genetic algorithm

Table 1 represents the results of Watershed technique. For 100 iterations the area calculated was 19.62 sq mm and time consumed was approximately 60 sec and it generated a pixel difference of 1968. Approximately 1minute is consumed to analyze the desired area.

Technique	**Area**	**No of iterat-ion**	**Pixel difference**	**Time**
Watershed	19.62 sq mm	100	1968	59.87 sec

Table 1: Results of Watershed technique

Genetic algorithm is applied on the same image and results are obtained for the same parameters. Figure 5 represents the results of Genetic algorithm technique.

Technique	**Area**	**No of iteration**	**Pixel difference**	**Time**
Genetic algorithm	12.87 sq mm	100	1287	40.59 sec

Table 2: Results of Genetic algorithm

Table 2 represents the results of Genetic algorithm. For 100 iterations the area calculated was 12.87 sq mm and time consumed was approximately 40 sec and it generated a pixel difference of 1287. As the smaller area represents that a precise region has been selected, thus better segmentation has taken place in lesser time.

From the results represented in Table 1 and Table 2, a combined tabular form is generated, which is shown in table 3.

Technique	Area	No of itera-tion	Pixel difference	Time
Watershed	19.62 sq mm	100	1968	59.87 sec
Genetic algorithm	12.87 sq mm	100	1287	40.59 sec

Table 3: Results comparison of Genetic algorithm and Watershed technique

From Table 3 it is clear that in terms of time, area and pixel difference Genetic algorithm provided better results as compare to the base technique, watershed. Genetic algorithm takes lesser time and minutely analyzes the problem area keeping its area small. The results can be varied and improved by varying the number of iteration.

CONCLUSION AND FUTURE SCOPE

A. Conclusions

In this paper a new automatic segmentation technique for liver cancer detection has been developed. The new proposed strategy introduced is based on Genetic algorithm. From the result and generated analysis it can be concluded that Genetic Algorithm can be considered as a new advance for liver cancer detection. Moreover, results obtained from this work it is clear that current work is able to segment the cancerous region of liver that is quite consistent with the regions identified by doctors. Also by the results presented in tables, it can be observed that the proposed Genetic algorithm based technique performs better than the Watershed in terms of performance measures used.

B. Future Scope

In the initialization stage experts are required to enter the initial values in order to start the initial contour, the future work associated with current research is to automate this initialization process completely. To develop a program that can compute the area of liver cancer based on 2D segmented boundaries. In addition, development of a similar technique for 3D liver segmentation can be subject for further work.

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