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Segmentation of Tumors from Ultrasound Images with PAORGB

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Abstract

Segmentation is an unavoidable process for computer-aided diagnosis in medical image processing. Due to complex artifacts accurate extraction of tumors in medical images remains a challenge. The existing system deals with the manual cut of the tumor centered image along with robust graph based segmentation for accurate extraction of tumor. The input image can be obtained from any type of modality. There are different ways to segment breast tumor images. This paper focuses on a novel technique called parameter automatically optimized robust graph based (PAORGB) segmentation. Particle swam optimization is incorporated with robust graph based segmentation in order to obtain a global solution. The new method may be a effective way to segment breast tumors than the robust graph based method and to also reduce the computational time.

1. Introduction

Cancer is a class of diseases that cause death among humans and there are different types of cancer. There is an increase in breast cancer for the past few decades among women. The tumor needs to be identified for further analysis. Detection of tumor plays an important role for the treatment of any cancer. The tumor can either be a benign tumor or malignant tumor. The tumor can either be identified by the radiologist in a manual way or automatic detection of tumor can be done by the system without the interference of the radiologist. Medical image processing is a wide area with various advancements and it is still under research. Breast cancer is related to the area of medical image processing since cancer can be identified with various types of modalities. There are different types of modalities that can be used for the identification of any type of cancer like ultrasound, computed tomography and magnetic resonance imaging. Computed tomography is a modality that is used to create clear images about the cross-sections of the human body. It is used to differentiate the various types of tissue. Later after
the invention of computed tomography there came to existence a new modality called the magnetic resonance imaging. Since this paper is focused on breast cancer the most preferred modality would be ultrasound. Mammography is a method that is adopted for the early detection of breast tumors in case of no symptoms. This method was effective because low energy X-rays were used to examine the breast cancer and it was used as a screening tool. But ultrasound proved to be an adjunct to the previously adopted mammography method.

In order to differentiate benign tumor from malignant tumor there lies some important features for classifying them. The features that are classified better by ultrasound technique are texture intensity color and morphology. Occurrence of speckles shadows and noise are mandatory in medical images especially in breast cancer. Any type of filter can be adopted for the removal of noise yet bilateral filter has proved to be more effective. All the various stages mentioned above are a step towards computer aided diagnosis in medical images.

In the literature there have been various methods proved for segmentation of medical images. Active contour method, fuzzy c-means, watershed transform are some of the methods. In the active contour method the parametric equations and geometric curves needs to be analyzed and set for further analysis. Whereas in fuzzy c-means the parameter needs to be manually assigned and in the watershed transform method the initial contour needs to be set. There are also gradient vector method and balloon snake method in which the parameters are compared and assigned. All these various drawbacks lead to the adoption of a new graph cut method called robust graph based segmentation. Here in the RGB method the particles we considered as nodes and particles of similar intensities were grouped together to progress towards a minimum spanning tree. Due to which it is proved that the robust graph based method also heavily relies on setting of parameters. There are some algorithms that are chosen as a solution to optimization problems.

Particle swam optimization is a new technique that is used to evaluate the RGB of each particle and update the particle position in an evolutionary manner. It also encompasses finding of optimal parameters for RGB of each particle. This paper is focused on a new technique called PAORGB known as parameter automatically optimized robust graph based method which is a combination of robust graph method and particle swam optimization. PAORGB has been discussed in section (3) as the proposed technique. This method has been examined using a breast ultrasound image and experimental results are proved.

2. Background

2.1. PRE-PROCESSING

In pre-processing, a speckle reduction procedure is adopted to enhance the visual representation of images, because there are plenty of artifacts (e.g. attenuations, speckles, shadow and signal dropout) in medical images. Bilateral filter is applied to the input breast tumor image obtained from the user. The input tumor image is obtained from the user by means of an ultrasound technique [1]. The ultrasound technique is performed a sonographer whose applies a lubricating jelly on the infected area. A handheld device called a transducer is moved over the region where the lesion is formed. The image is captured by means of sound waves that are emitted and sent to the system. These sound waves are too high for the human ear to hear. The image that is obtained is further analysed.

Bilateral filter is used to reduce the speckles shadows and noise on the obtained ultrasound image and these terms to be as its main purpose. In this filter the tumor part that is deviated from the other parts is considered to be as a speckle or the tiny spots on the human skin can be speckles. These speckles need to be removed for further processing. The co-efficient of the particles are multiplied and the closeness of each particle from the centre particle is analysed. The intensity value of each particle is replaced by its weight according to Gaussian distribution. A threshold value is set with the minimum and maximum range the particle that cross the maximum range are filtered and sent. This is done in order to preserve the edges.
2.2 BILATERAL FILTER

Bilateral filter is applied to an input image \( c(d) \) obtained by an ultrasound technique which then produces a target image [1] as follows:

\[
(d)=k_{d-1}(d)\int f(\epsilon)x(\epsilon,d) \, d\epsilon\rightarrow\infty
\]

(1)

where \( x(\epsilon, d) \) calculates the closeness between the neighbour particle centre \( d \) and a nearby point \( \epsilon \). The distance between two particles is calculated in order to find out the range. The threshold value has to be set. We obtain \( k(d) \) as a factor when the closeness is kept as a constant and measured.

\[
k(d)=\int x(\epsilon,d) \, d\epsilon\rightarrow\infty
\]

(2)

Range filtering is similarly measured based on the threshold that is set and thus calculating the minimum and the maximum particles and is defined:

\[
c(d)=kr^1(d)\int f(\epsilon)s(f(\epsilon),f(d))d\epsilon
\]

(3)

The normalization constant is replaced by measuring the similarity of the pixels

\[
k(d)=\int s(f(\epsilon),f(d))d\epsilon\rightarrow\infty
\]

(4)

Combination of domain and range filtering can be described as follows:

\[
C(d)=k^1(1)\int f(\epsilon)x(\epsilon,d)s(f(\epsilon),f(x))d\epsilon\rightarrow\infty
\]

(5)

Normalization function is calculated in order to scale to an exact value

\[
(d)=\int x(\epsilon,d)s(f(\epsilon),f(d)) \, d\epsilon
\]

(6)

Combined domain and range filtering will be noticed as bilateral filtering. It replaces the pixel value at \( x \) with an average of similar and nearby pixel values. In smooth regions, pixel values in a small neighbourhood are similar to each other, and the normalized similarity function \( k^1 \) is close to one. Hence bilateral filter proved to be a better filter in order to reduce the noise from the pixels and provide a clear image.

3. Manual Cut Of Tumor Centered Image

In manual cut the radiologist identifies the tumor infected area in the breast tumor image. Manual cut works based on the tumor centered pixel. At first find out the infected area i.e., major region after that find out end point of the region. Manual cut works based on the operators ability. Once the medical image is obtained after pre-processing manual cut of the tumor centered image is done by the radiologist. This is done in order in order to extract the tumor by deviating it from the other parts. Manual cut of the tumor centered image is done for further clear analysis of the infected area. The major infected area is thus extracted with the interference of the radiologists.

4. Robust Graph Based Segmentation

The RGB segmentation algorithm the detailed algorithmic procedures [1] for segmentation of breast tumors in US images is summarized as follows.

1. Performed the speckle and noise reduction and boundary preservation in a US image.
2. Construct the graph \( G=(V,E) \) for the image and set all edges to be invalid.
3. Sorted the edges \( E \) into \( p=(01……06) \) by non decreasing edge weight. Let \( i = 1 \).
4. Picked the i-th edge in the sorted edges. If the i-th edge connected different sub graphs and the boundary between the two sub graphs should be eliminated the two sub graphs were merged into a larger sub graph and their edge was set to be valid. The l and r of the new sub graph were updated.
5. Let i = 1 + 1. Repeated step 4 until all edges had been traversed.

When all edges had been traversed, each tree in the obtained forest was a MST corresponding to a segmented sub region in the image.

Fig 1. (a) An original image; (b) tumor centered image cut from (a) [1]

5. The Proposed Method PAORGB

Parameter automatically optimized robust graph based segmentation is a combination of both graph cut segmentation and particle swarm optimization. At first graph cut segmentation is done to the obtained image and then particle swarm optimization is applied so that the best global or optimal solution can be found. The tumor centered image is obtained after that set the population size np and randomly initializes the particles in the exploration space. Iteratively traverse all the particles and execute the RGB segmentation algorithm. In graph cut segmentation algorithm the pixels are represented as nodes. The nodes of similar intensities are found and are grouped together. Thus a sub graph representing nodes of similar intensities is formed.

Graph cut segmentation an image which is initially regarded as a graph the RGB method aims to merge spatially neighbouring pixels which are of similar intensities into a minimal spanning tree (MST) which corresponds to a sub graph (i.e. a sub region of the image) [5]. The image can therefore be grouped into several sub regions (i.e. a forest of MST). Obviously, the step for mergence of pixels into a MST is the key, determining the final segmentation results. In the particle swarm optimization algorithm each pixel represents a particle and each particle is initialized in a random search of individuals. The algorithm searches the global solution by updating the positions of the each particle in a timely manner. The particle swarm optimization (PSO) algorithm is chosen for finding the optimal parameters in the RGB and the PSO algorithm not only shares many advantages with evolutionary computing algorithms but also possesses improved computational efficiency. Thus parameter automatically optimized robust graph based segmentation is done and the best global solution is obtained after the iteration is complete.

The procedure for segmentation of an image is the basic step. First construct a graph G=(V, E) for a tumor image. In G each pixel corresponds to a vertex and an edge connects two spatially neighbouring vertices. The edge weight is defined by absolute intensity difference between two adjacent pixels. Each vertex can be regarded as a sub graph and all of the edges forming an edge set E are valid. Then sort the edges in E in non descending order in terms of the edge weight. Set q = 1. Pick the ith edge in the sorted edges. If the ith edge is a valid edge and the boundary between the two sub graphs can be avoided with respect to the pair wise region comparison predicate, the two sub graphs are
merged into a larger sub graph and this edge is set to be invalid. Let $i = i + 1$. repeat the process until all edges in $E$ are traversed.

Particle swam optimization is incorporated with robust graph based segmentation. According to the search space set up the population $n$ size an randomly initialize the particles. Iteratively initialize the particles. In each traverse evaluate every particle based on a defined objective function and update its position accordingly. Repeat the above step until all the particles positions have been converge to an acceptable extent or the iterative number has reached

The PAORGB method is summarized as the following.

Step 1: Manually delineate the TCI from the original breast tumor image.
Step 2: Use the bilateral filter to reduce the speckles in the image.
Step 3: Set the population size $n_p$ and randomly initialize the particles in the search space.
Step 4: Iteratively traverse all the particles. Let $i = 1$.
Step 5: In the $q$th traversal, for each particle use its position $x_i = (k_i; \alpha_i)$ to execute the RGB segmentation algorithm. The segmentation result is evaluated and the particle's position is updated accordingly.
Step 6: Repeat Step4 until all particles have been converted to a certain condition (i.e. the updating of $k$ is below 1 and that of $\alpha$ is below 0.00001 for all the particles) or $q = N$, where $N$ is the predefined maximum number of generations.

When the iteration process is over, the global best particle position corresponds to the optimal or approximately optimal combination of $\alpha$ and $k$. The method is depicted in the flow chart as represented below.

6. Experimental Evaluation

In the experiments the evolution of the PAORGB begins with assuming the pixels that are stored in the matrix in the form binary digits as nodes. Each node represents a vertex and the weight of two vertices are assumed as the weight of one edge. The intensity of each node is calculated. Later the nodes are grouped into clusters based on minimum and maximum values according to the assumed value. Iterations are made in an increasing order and the positions of each particle are updated in an evolutionary order. Thus based on the values of $k$ and alpha iterations and updation are made.

Fig 2 (a) parameter automatically optimized graph segmentation for benign tumor. (b) Result of optimization combined with segmentation.
7. Conclusion

In this paper manual cut of the tumor centered image is done for breast tumor images. The tumor centered image is extracted by the help of the radiologist and for this purpose well trained operator is required. Manual delineation of the tumor centered image is done in order to extract the lesion deviating it from the other parts. The proposed work is a new technique called PAORGB method for segmenting breast tumors images incorporating particle swam optimization is introduced in the paper. This method is a quasi automatic process and a better way to segment the tumor in breast ultrasound images. A notable drawback is the computational time. In the future better segmentation techniques can be adopted and the computational time can be reduced by computerized segmentation.

REFERENCES