Automatic Segmentation of Brain Tumor from MR Image Using Region Growing Technique

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Abstract: This paper proposes a new algorithm for segmentation of tumor images with automatic seed point selection to region growing segmentation. Region growing is based on selecting initial seed points and adding neighbouring pixels to the region depending on the suitable membership criteria such as z-score technique used. The results of region growing segmentation depend on seed point's extraction in the tumor image. Initially seed points of regions are identified based on derivatives of local neighborhood density chances.

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1. Introduction

Imaging plays a central role in the diagnosis and treatment planning of brain tumor. Tumor volume is an important diagnostic indicator in treatment planning and results assessment for brain tumor. The measurement of brain tumor volume could assist tumor staging for effective treatment surgical planning. Imaging of the tumors can be done by CT scan, Ultrasound and MRI etc. The MR imaging method is the best due to its higher resolution [1]. The methods to segment brain tumors are snakes segmentation; level set segmentation, watershed segmentation, region-growing segmentation etc. The region growing segmentation is preferred for its wide range of applications and automatic features. MR imaging is currently the method of choice for early detection of brain tumor. The task of manually segmenting brain tumors from MR imaging is generally time consuming and difficult. An automated segmentation method is desirable because it reduces the load on the operator and generates satisfactory results [2]. First image segmentation is done by using region growing segmentation. The segmented image shows the unhealthy portion clearly.

2. Related works

Chang et al., [9] proposed a region-growing framework for image segmentation. This process is guided by regional feature analysis and no parameter tuning or a priori knowledge about the image is required. For region growing, seeds can be automatically or manually selected their automated selection can be based on finding pixels that are of interest, e.g. the brightest pixel in an image can serve as a seed pixel. They can also be determined from the peaks found in an image histogram. On the other hand, seeds can also be selected manually for every object present in the image. The method is employed to segment an image into different regions using a set of seeds. Each seeded region is a connected component comprising of one or more points and is represented by a set S. The set of immediate neighbors bordering of the pixel is calculated. The neighbors are then examined and if they intersect any region from set S, then a measure δ (difference between a pixel and the intersected region) is computed. If the neighbors intersect more than one region, then the set is taken as that region for which difference measure δ is maximum. The new state of regions for the set then constitutes input to the next iteration. This process continues until the entire image pixels have been assimilated into regions. Hence, for each iteration the pixel that is most similar to a region that it borders is appended to that region. The SRG algorithm is inherently dependent on the order of processing image pixels. The method has the advantage that it is fairly robust, quick, and parameter free except for its dependency on the order of pixel processing.

Mehnert & Jackway et al. [4] improved the above seeded region-growing algorithm by making it independent of the pixel order of processing and making it more parallel. Their study presents a novel technique for Improved Seeded Region Growing (ISRG). ISRG algorithm retains the advantages of Seeded Region Growing (SRG) such as fast execution, robust segmentation and no parameters to tune. The algorithm is also pixel order independent. If more than one pixel in the neighborhood has same minimum similarity measure value, then all of them are processed in parallel. No pixel can be labeled and no region can be updated until all other pixels with the same priority have been examined. If a pixel cannot be labeled, because it is equally likely belong to two or more adjacent regions, then it is labeled as 'tied' and takes no part in the region growing process. After all of the pixels in the image have been labeled, the pixels labeled 'tied' are independently re-examined to see whether or not the ties can be resolved. To resolve the ties an additional assignment criterion is imposed, such as assigning a tied pixel to the largest neighboring region or to the neighboring region with the largest mean. ISRG algorithm produces consistent segmentation because it is not dependent on the order of pixel processing. Parallel processing ensures that the pixels with the same priority are processed in the same manner simultaneously.

Gambotto *et al.* [5] proposed an algorithm that combines the region growing and edge detection methods for segmenting the images. The method is iterative and uses both of these approaches in parallel. The algorithm starts with an initial set of seeds located inside the true boundary of the region. The pixels that are adjacent to the region are iteratively merged with it if they satisfy a similarity criterion. A second criterion uses the average gradient over the region boundary to stop the growth. The last stage refines the segmentation. The analysis is based on cooperation between the region growing algorithm and the contour detection algorithm. Since, adding segments to a region, some pixels that belong to the next region and to the previous region, may be misclassified performs the growing process. A nearest neighbor rule is then used to locally reclassify them.

Hojjatoleslami & Kittler *et al*. [7] proposed a new region growing approach for image segmentation, which uses gradient information to specify the boundary of a region. The method has the capability of finding the boundary of a relatively bright/dark region in a textured background. The method relies on a measure of contrast of the region, which represents the variation of the region grey-level as a function of its evolving boundary during segmentation. This helps to identify the best external boundary of the region. The application of a reverse test using a gradient measure then yields the highest gradient boundary for the region being grown. The unique feature of the approach is that in each step at most one candidate pixel will exhibit the required properties to join the region. The growing process is directional so that the pixels join the grown region according to a ranking list and the discontinuity measurements are tested pixel by pixel. The algorithm is also insensitive to a reasonable amount of noise. The main advantage of the algorithm is that no a priori knowledge is needed about the regions.

'Region growing' is a procedure that groups pixels or sub regions into larger regions based on predefined criteria. The basic approach is to start with a set of "seed" points and from these grow regions by appending to each seed those neighboring pixels that have properties similar to the seed. Selection of the seed depends on the nature of the problem. When a priori information is not available, the procedure is to compute at every pixel the same set of properties that ultimately will be used to assign pixels to regions during the growing process. The selection of similarity criteria depends not only on the problem under consideration but also on the type of the image data available. For example, the analysis of land use satellite imagery depends heavily on the use of color. Grouping pixels with the same gray level to form a region without paying attention to connectivity would yield a segmentation result that is meaningless in the context of this discussion. Another problem in region growing is the formulation of a stopping rule. Basically, growing a region should stop when no more pixels satisfy the criteria for inclusion in that region. Criteria such as gray level, texture and color are local in nature and do not take into account the history of the region growth. Additional criteria that increase the power of a region growing algorithm utilize the concept of size, likeness between a candidate pixel and the pixels grown so far and the shape of the region being grown. In the region growing segmentation, the first aim is to determine the initial seed points. In this application, it is known that the pixel of defective welds tends to have the maximum allowable digital value. Based on this information, we selected as the starting points all pixels having values of 255. The points thus extracted from the original image [6] [8] [10].

Seed-Based Region Growing (SBRG) as implemented in [3] It starts by selecting a seed pixel which is located within the area of abnormality. Seed pixels are often chosen near to the center of the region as illustrated in Fig. 1.

The growing process will produce a single region containing pixels with similar properties as the seed pixel. The application of this SBRG algorithm comprises of a specification of two variables. These are the window size and the absolute difference of the grey level value between the grown regions with the seed pixel. Based on the results produced, the window size is chosen to be 3x3 pixels and the absolute grey level threshold is set to 10. The mean value for the MxM neighborhood is calculated using (1) and the seed expands the region based on a criterion that is defined to determine the similarity between pixels of the region.

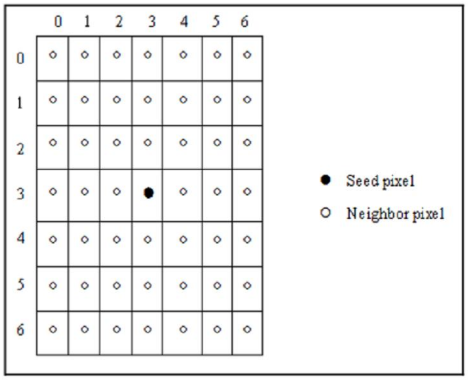

Figure 1. Location of seed pixel and its 7x7 neighbourhood

There are three possible ways for the seed pixel to grow which are: (a) towards its 4 adjacent neighbors, (b) 4 diagonal neighbors and (c) 8 surrounding neighbors. Figs. 2, 3 and 4 show the pictorial representations of each of the growth mentioned.

$$\text{Mean} = \frac{\text{Total grey level pixels value in MxM neighbourhood}}{\text{Total no. of pixels in MxM neighbourhood}}$$

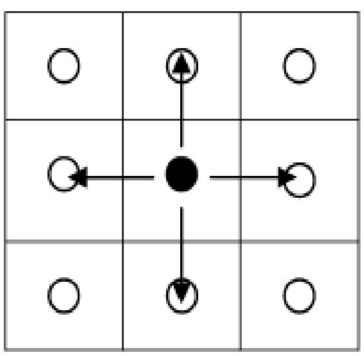

Figure 2. The 4 adjacent neighbour's growth

The algorithm decides on the similarity of the neighboring pixels to the other points in the region starting from the seed point. For every growth from the seed pixel to one of its neighbor, the calculated mean value and the grey level of the particular neighbor is compared as in (2). If the absolute difference of the two pixels is less than a pre-defined threshold, the neighbor pixel will be included into the growing region.

$$| G_i - M | < T \qquad (2)$$

Where

G_i = grey level of the particular neighbor pixel

M= calculated mean value of the SBRG

T = pre-defined threshold

The mean value for the region needs to be updated for every inclusion of a neighbor pixel into the region. The growing process is repeated iteratively until all the points are considered.

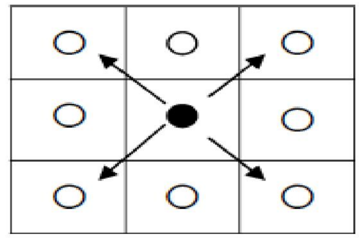

Figure 3. The 4 diagonal neighbour's growth

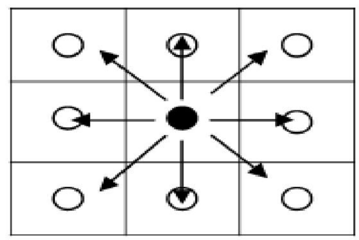

Figure 4. The 8 surrounding neighbour's growth

3. Module description of proposed algorithm

The process of proposed region growing algorithm for this paper is described below Figure 5.

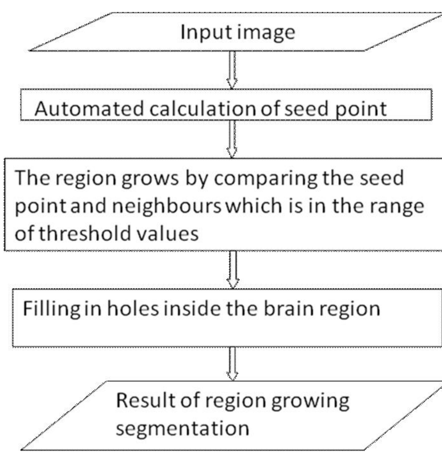

Figure 5: Step Processing of Region Growing Algorithm

The region growing algorithm is given below: **1**. IF all pixels have been labeled, then END, ELSE take an unlabeled pixel and assign a new unused region number. **2.** IF the difference in grey-level between the newly labeled pixel and its neighboring pixels (4 adjacent pixels) is less than a given threshold, THEN merge the pixels and assign them the same region number. **3.** Iterate step 2 until no pixels adjacent to the newly labeled region can be merged. **4**. Go to step 1. 5. END.

The Seed point Selection from an image can be grouped into homogeneous regions in which the pixels intensity is almost equals or little difference. In proposed system, homogenous regions are found out and selected the coordinates which have highest density values. The coordinate which selected from density measurements are considered as the seed point to region growing segmentation.

In Pixel Density Measurement, the image consists of pixels. Each pixel's density is measured among neighboring pixels and itself. A pixel and its neighboring pixels having intensity value are equal, the pixel is highly dense and its value would be zeros. To avoid complexity measurements, we simply used sum square difference between a center pixel and its neighboring pixels. Each pixel of image density is measured with two different sizes of neighboring pixels, we have neighboring size 4x4 and 10x10.

Pseudo code of Algorithm

Function Seed Points (Image)

D4=DENSITY (image, 4) -The function measure the density of each pixel contains in the image with neighboring size of 4 and results of density is stored on variable D4.

D10= DENSITY (image, 10) - The function measure the density of each pixel contains in the image with neighboring size of 10 and results of density is stored on variable D10.

HD=ABS (D10-D4) < 1 - Highly dense pixels are extracted from results of two density measurements. The two densities D4 and D0 are subtracted and high dense pixel selected from thresholding technique. The difference of the densities is lower than the threshold is considered as dense points otherwise not.

HDC=IMCLOSE (HD) - The result of dense pixel selection has some holes, block pixels are surrounded by white pixels, so that

to remove the holes and make separate region Morphological close operation was used and block pixels filled with kernel size2

L=BWLABLE (HDC) - Labeling is the operation of assigning unique to each separate regions. The numeric values put from 1 to N on each region.

SP=MERGING (L) - After labeling, merging operation was taken place to select seed points from each separate regions. Here we use center of each region as seed points of the process.

Function End.

3.1 Region Based Segmentation

The main goal of segmentation is to partition an image into regions. Some segmentation methods such as thresholding achieve this goal by looking for the boundaries between regions based on discontinuities in gray levels or color properties. Region based segmentation is a technique for determining the region directly. The basic formulation for Region based segmentation is

$$(a)\bigcup_{i=1}^{n} R_i = R \qquad -(1)$$

(b)Ri is a connected region, $i = 1, 2, \ldots, n$.

(c)P (R_i) = TRUE for i = 1, 2... n.

(d) p is probability of regon

$$(e)P(R_i U R_j) = False for any adjascent region R_i and R_j$$

(a) means that the segmentation must be complete; that is, every pixel must be in a region.

(b) requires that points in a region must be connected in some predefined sense.

(c) indicates that the regions must be disjoint.

(d) deals with the properties that must be satisfied by the pixels in a segmented region. For example $P(R_i)$ = TRUE if all pixels in R_i have the same gray level.

(e) indicates that region R_i and R_j are different in the sense of predicate *P*.

3.2 Homogeneity Criteria For Region Growing

The homogeneity predicate can be based on any characteristic of the regions in the image such as

* average intensity
* variance
* color
* texture
* motion
* shape
* size

4. Experimental Results

Region growing is a procedure that group pixels into larger regions based on predefined criteria and it started growing with the selected seed point. The segmentation by region growing worked by appending neighboring pixels of a seed point that was automatically selected based on the centre point of the maximum region area of the axial MRI image.

4.1 Seed point selection

The seed point is selected by choosing the centre point of the maximum region area within the brain image shown in Fig.6.

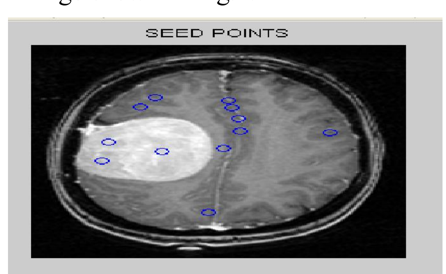

Fig 6: seed point selection

4.2 Growing predicates and stopping criteria

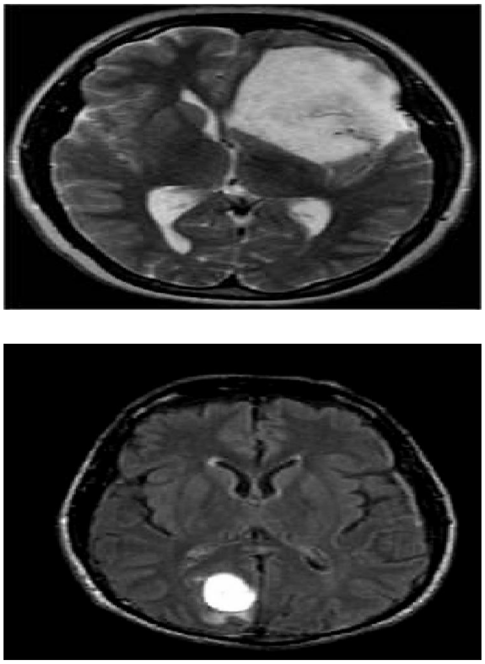

Fig 8: Segmentation

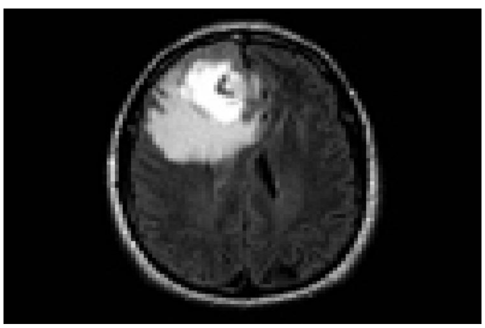

Fig 9: Segmentation Input

The region grew by comparing all 8-neighbouring pixels of the original image with the seed point which is within the range of defined threshold values. The region stopped if the neighbouring pixels are outside the range of the threshold values.

4.3 Segmented portions

Region growing is highly computational since the algorithm requires all neighbouring pixels of the seed points to be visited. Region growing requires the correct selection of seed point and threshold values. Thus Region Growing segmentation module was used to segment the tumor present in human brain.

5. Conclusion

Region growing requires the correct selection of seed point and threshold values, as different seed point and threshold values will produce different results. Since the growing process is directional, i.e., pixels joining the grown region according to a ranking list. The method does not necessarily include all the pixels with the same grey level to the region. This contrasts with thresholding methods where all the pixels exceeding a certain threshold are included in the segmented region. Thus the algorithm for segmentation of tumor images with automatic seed point selection to region growing segmentation was proposed.

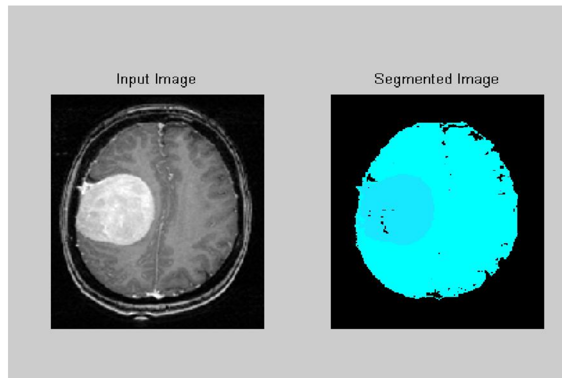

Fig 10: segmentation

6. Future work

In region growing segmentation, the pixels are added into a group, based on conditional value of that group. If a pixel does not meet the condition, it is not added even if their neighboring pixels are added. Such problem are rises when the clustering the images corrupted by noises and leads inaccuracy of region clustering and not to be robust to the noised pixels. To withstand the noise in the image, in addition to group condition, spatial information (neighboring information) the pixels are also considered as the condition to add the pixels into groups.

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