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An Medical Image Segmentation Using Regional Maxima Based Watershed Algorithm

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Abstract: Imaging has become an essential component in many fields of medical research and clinical practice for creating a visualization of an inner human body for medical image analysis. Image segmentation is one of the most important parts of image processing. In image analysis, segmentation is partitioning of an original image into its several constituents also known as super pixels. It is the preprocessing step to understand and analyze the images. The use of the watershed algorithm for segmentation is widespread because it can able to produce a complete division of the image. There is a problem of image degradations such as blur, noise and color or contrast imperfection which severely affect the segmentation process. The proposed watershed transformation is used as a particular method of a region-based approach to segment the image. Region-based methods are robust because more pixels are covered than the edges and contain more information to characterize the image regions. Generally region growing methods are better in noisy images. The over-segmentation can reduced to a better segmentation by merging adjacent segments. A region merging of two adjacent segments are achieved by removing their common boundary. The merging of two segments includes two different types of criteria, evaluating the edge strength of the common boundary and comparing the region characteristics. Thus, the proposed region-based watershed algorithm is to extract the continuous boundaries of each region to give solid results which require low computation and performs well with noisy images.

Key words: Image segmentation · Region grow · Watershed algorithm · Medical image

INTRODUCTION

Image segmentation extracts object or regions of interest (ROIs) and it has an essential role in medical image analysis and interpretation and it used for diagnosis, treatment planning and in monitoring treatment response. Medical image segmentation can be done manually or in an automated or semi-automated fashion. Manual segmentation is time consuming, operator-dependent and poorly reproducible. Fully automated and application driven image segmentation algorithms [1] have been developed for specific body organs, e.g., the liver with computed tomography (CT) and the prostate with magnetic resonance (MR) imaging.

The image segmentation [2, 3] algorithms based on two characteristics of the luminance: discontinuity and similarity. Edge detection algorithms [4, 5] based on the discontinuity is to partition an image based on abrupt changes in intensity, such as edges [6]. Similarly, the threshold [7] processing, region growing, region separation and polymerization based on similarity on partitioning an image into regions [8] that are similar according to predefined criteria. Watershed algorithm [9] which is a mathematical morphological method for image segmentation based on region processing [10]. The result of the watershed algorithm is border closure, high accuracy and global segmentation. Watershed algorithm is to visualize a gray level image into its topographic representation which includes three basic

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notions: minima, catchment basins and watershed lines. There are three types of points to consider in the topographical surface (1) points belonging to the different minima; (2) points at which water would fall with certainty to a single minimum; and (3) points at which water would be equally likely to fall to more than one minimum. The first type of points forms different minima of the topographic surface. The second type points which construct an interior gradient region is called catchment basin.

Medical image segmentation is an important field of medical science. Medical images such as CT, MRI or X-Ray are used to visualize the information of internal organs are important for doctor's diagnoses as well as medical teaching, learning and research. Image segmentation [11] is to partition an image into regions on a particular application. Segmentation is the process of highlighting the particular portion of an image according to the problem defined based on measurements. After segmentation, the representation of the image changed into more meaningful for easy analysis. Two different categories involved in segmentation algorithms namely discontinuity and similarity. Edge based segmentation [12] based on the discontinuity by partitioning edges of an image based on abrupt changes in intensity where region based segmentation based on similarity by partitioning an image with the similar characteristics or predefined criteria. Similarly, thresholding and polymerization are based on similarity.

Watershed [13] can be defined by highpoint and ridgelines in a basin like a landform that descends into lower elevations and stream valleys. It is a mathematical morphological method for image segmentation based on region processing to visualize a gray level image into its topographical representation. It includes three basic notions such as minima, catchment basin and watershed lines. In a topographic interpretation it is important to consider three types of points in a surface of gray level image (1) points belonging to the different minima; (2) points at which water would fall with certainty to a single minimum (the catchment basin or watershed of that minimum); and (3) points at which water would be equally likely to fall to more than one minimum (the divide lines or watershed lines). The first type of points forms different minima of the topographic surface. The second type of points which constructs an interior region of a gradient is called catchment basin. For example, if you imagine that bright areas are high and dark areas are low then it might look like the topographical surface. With surface, it is natural to think regarding catchment basins and watershed lines. The key behind using the watershed transform for segmentation: change your image into another image whose catchment basins are the objects that want to identify

Related Work: In [11], when compared to segmentation of single color space, the authors proposed an approach to give accurate segmentation result by combining the segmentation of various color spaces such as RGB, HSV, YIQ and XYZ. Images are segmented using K-Means and Effective robust kernelized fuzzy c-means (ERKFCM). MSE and PSNR is used to evaluate the performance. In [14], fuzzy c-means clustering in segmentation is shown where the image segmentation method is proposed. To classify pixels into appropriate segments this method uses membership grades' of pixels based on a basic region growing method. Feature space was used L*u*v* color space where images are in RGB color space. With the color image segmentation, the experimental results are very effective but it is very difficult to simplifying borders.

In [15], Magnetic Resonance Imaging (MRI) brain images are segmented by an optimized fuzzy logic method based on a modified fuzzy c-means (FCM) clustering algorithm. Clustering is done by using the FCM algorithm that incorporates spatial information into the membership function. The advantages of FCM algorithm are less sensitive to noise and it yields regions more homogeneous than other techniques.

In [16], the authors proposed a new fuzzy c means algorithm to segment very large color images. This algorithm allows faster and more accurate convergence that relies on a new efficient cluster center initialization and color quantization. The experimental result shows the efficiency of the algorithm on real images regarding both accuracy and computation time. In [17], a novel approach for clustering based image segmentation is used. In this segmentation, first RGB image is converted to LAB. K-Means algorithm is then used to segment the LAB image with Cosine distance measure. The segmented image is then filtered with sobel filter. To obtain the final segmentation the filtered image is sent as input to the Watershed algorithm. The results are found in terms of MSE and PSNR values.

In [18], a new method watershed transformation using mathematical morphology is proposed for image segmentation. The topological gradient method is adopted to avoid over-segmentation. As a result, segmentation of images is found very efficient. In [19], a modified version of the watershed algorithm is presented. Before combining the segmentation from each channel to the final one it overcome the over segmentation problem of the watershed algorithm using an adaptive masking and a threshold mechanism over each color channel. This approach enhances the segmentation result and the experimental result is found more accurate by the obtained values of image quality assessment metrics such as PSNR, MSE, PSNRRGB and Color Image Quality Measure (CQM) based on reversible YUV color transformation.

In [20], Laplacian and Sobel edge detectors are the two most commonly used edge detection methods are discussed. The Sobel edge detection algorithm is found performing better than Laplacian algorithms. In both cases, the false edges are high for blurred or low-resolution images. The authors proposed a new algorithm and set of filters (kernels) similar to sobel method to solve this problem. The proposed method highlights regions of high spatial frequency corresponding to edges and performs a 2-D spatial gradient quantity on an image. The kernels are designed to respond maximally to edges running diagonally in addition to vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations.

Problem Definition: The major problem is image degradations such as blur, noise and color or contrast imperfection which severely affect the segmentation process. The watershed transformations along with region merging have been used for segmenting medical images. Segmentation is used to partition an image into several segments. The main difficulties in segmentation are:

- Noise
- The bias field (the presence of smoothly varying intensities inside tissues)
- The partial-volume effect (a voxel contributes in multiple tissue types)

Proposed Work: Watershed transform in a mathematical morphology is a segmentation method. In geography, a watershed is a ridge drained by the different river system to divides areas. The morphological gradient-based segmentation technique is used in the watershed transform. Correspond to different heights with different gradient values, the gradient map of the image is considered as a relief map. The water level will rise over the catchment basins (CB) by pouring the water continuously. A dam is built between them, when two different bodies of water meet. These processes continue until all the points in the map are immersed. Finally, the whole image is segmented by the dams are called watersheds and the segmented regions are referred to as catchment basins (CB). A catchment basin (CB) is drained into a river or reservoir in a geographical area. These ideas are applied to gray-scale image processing to solve a variety of image segmentation problem using the watershed algorithm. The region growing starts with a seed, which is selected in the centre of the tumor region. The pixels in the neighbor of seed are added to region-based on homogeneity criteria during the region growing phase thereby resulting in a connected region.

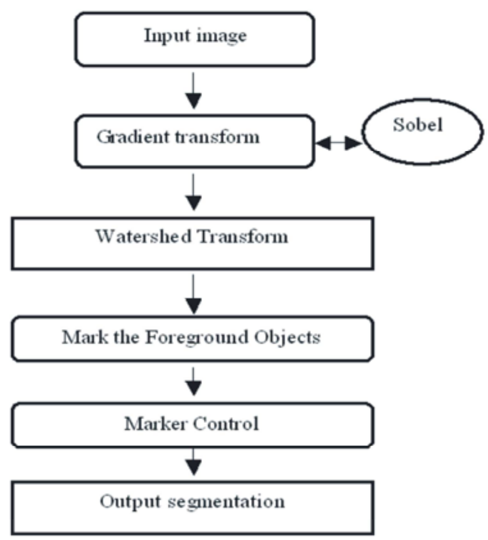

Fig. 1: System Architecture

Gradient Transform: The true color image RGB is converted to the grayscale intensity image I is done by I = rgb2gray (RGB). By eliminating the hue and saturation information, the rgb2gray function converts RGB images to grayscale by retaining the luminance. The aim is to segment the image by computing the gradient from the subband images. The simplest option is integration of the gradient images formed from the subbands. But a simple summing of the gradient images will not produce the desired texture gradient. Before the application of the gradient operator, the solution is to smoothen the texture subband magnitudes. In this case, rather than an extended area of texture, the "noise" in question is any wavelet response with a small spatial extent indicating a local edge. Median filtering is well known as a nonlinear edge-preserving smoothing or noise removal technique.

The edge detection methods work on the assumption, if there is a discontinuity in the intensity function or a very steep intensity gradient in the image then the sobel edge occurs. Using this assumption, where the derivative is maximum, then the edge could be located, if one take the derivative of the intensity value across the image and find points. The gradient is a vector, whose components measure how the rapid pixel value are changing with distance in the x and y direction.

Watershed Transform: Watershed transformation can be particularly used as a region-based segmentation approach and the concept of this algorithm is derived from geography. In geography, the term “watershed”, means the ridge that divides areas drained by different river systems. The watershed lines determine boundaries to separate image regions, when an image is viewed as geological landscape. The watershed transform computes catchment basins and ridgelines (also known as watershed lines). The catchment basins were corresponding to image regions and ridgelines relating to region boundaries.

In the proposed approach, a watershed algorithm is used for the final segmentation stage. The watershed algorithm consists of the following basic steps:

- Add neighbors to the priority queue, sorted by value.
- Choose local minima as region seeds.
- Take top priority pixel from queue.
- If all labelled neighbors have the same label, assign to pixel.
- Add all non-marked neighbours.
- Repeat step 3 until finished.

Mark the Foreground Objects: Morphological reconstruction can be thought of conceptually as repeated dilations of an image, called the marker image until the contour of the marker image fits under a second image, called the mask image. The peaks in the marker image referred to "spread out," or dilate in the morphological reconstruction. The final dilation is the reconstructed image. (i.e., the actual implementation of this operation in the toolbox is done much more efficiently).

The foreground objects which must be connected blobs of pixels inside each of the foreground objects. The morphological techniques called "opening-by-reconstruction" and "closing-by-reconstruction" to "clean" up the image. These operations will create flat maxima inside each object that can be located using regional maxima.

By comparing Iobrcbr with Ioc, reconstruction-based opening and closing are effective than standard opening and closing at removing. To obtain good foreground markers the regional maxima Iobrcbr is calculated.

Mark Control: When the object is not segmented properly in the result, then the mostly-occluded and shadowed objects is not marked. Also, the foreground markers in some objects go right up to the objects edge. That means the edges of the marker blobs are cleaned and then shrink them a bit. This can be done by closing followed by erosion. The background pixels are in black, but ideally; to segment the background markers don't want to be too close to the edges of the objects. Then "thin" the background by computing the "skeleton by influence zones", or SKIZ, of the foreground of bw. This can be done by computing the watershed transform of the distance transform of bw and then looking for the watershed ridge lines (DL == 0) of the result.

Region Based Watershed Segmentation: In imaging regions, segmentation of MRI image exists in the homogeneous aspects of pixels that make getting information about the image’s subject is difficult because of the MRI image.

According to a prescribed criterion, the region growing examines the properties of local groups of pixels. The goal of region growing is to map the input image data into sets of connected pixels, called regions. Initially the region growing starts from a pixel in the proximity of the seed point that is selected by the user. Based on the distance from the seed point or the statistical properties of the neighbourhood, the pixel can be chosen. Then each of the 4 or 8 neighbors of that pixel is visited to determine if they belong to the same region. This growing expands further by visiting the neighbors of each of these 4 or 8 neighbors pixels. Until either some termination criterion met, this recursive process continues or all pixels in the image can be examined. The result is a set of connected pixels within the region of interest.

Followed by the region growing process, segmentation becomes semiautomatic starting with an interactive seed point selection step. As a result, it let the region growing to locate all features of similar properties and the user needs to find a few representatives features in the same region.

RESULTS AND DISCUSSION

The proposed algorithm is implemented using Matlab and tested for medical images. The input for the experiments is collected from MRI images and CT Image Segmentation dataset.

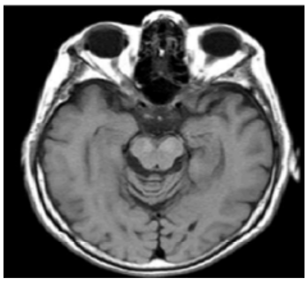

Fig. 2: Input Image

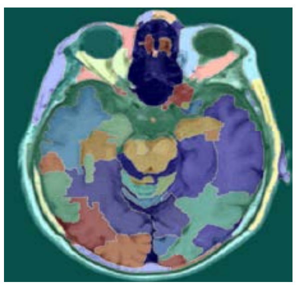

Fig. 3: Output Image

Following two measures are used to find the accuracy of the segmentation result:

The MSE (Mean Squared Error) is the cumulative squared error between the segmented image and the original image, whereas PSNR (Peak Signal to Noise Ratio) is the peak error.

Table 1: MSE and PSNR values for Proposed Approach

MSE	PSNR
MSE(:,:,1) =2.4114e+03	PSNR(:,:,1) =14.3082
MSE(:,:,2) =2.2762e+03	PSNR(:,:,2) =14.5587
MSE(:,:,3) =3.4920e+03	PSNR(:,:,3) =12.7000

CONCLUSION

The region based watershed algorithm has been proposed for segmenting medical images. It is the best method to segment the different types of human disease but it suffers from over-segmentation of a gradient image of the original. The over-segmentation can reduced to a better segmentation by merging adjacent segments. A region merging of two adjacent segments can achieve by removing their common boundary. The merging of two segments includes evaluating the edge strength of the common boundary and comparing region characteristics. Thus, the proposed region-based watershed algorithm is to extract the continuous boundaries of each region to give solid results and intuitively provides better performance on noisy images. Thus, the segmented output is more pleasing without over segmentation with less complex time.

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