Automatic Detection of Cerebral Microbleed Using Bounding Box Based Watershed Segmentation from MR Images

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Abstract:

Cerebral microbleeds(CMB) are also referred to as cerebral micro haemorrhages caused by structural abnormalities of the small vessels of the brain. They have been identified as a major diagnostic biomarker for many cerebrovascular diseases and cognitive dysfunctions. In current clinical routine CMBs are manually labelled by radiologists but this method is difficult, time wasting and error prone. In this paper, we propose a new automatic method to detect CMBs from magnetic resonance images (MR images).presently, the analysis of microbleeds is performed by skilled neurologist based on their database that is by scanning the image, detecting the black dots and identifying whether black dots are micro-bleeds or mimics. Medical image processing has made a great impact on medicine, diagnosis, and treatment. We propose a new automatic method to detect CMBs from magnetic resonance images (MR images). The most important part of image processing in medical is image segmentation. Watershed segmentation is an example of a robust technique for image segmentation. This conventional watershed algorithm for medical images is widespread because of its advantage to completely segment the medical images. However, the common drawback of watershed segmentation which is over segmentation and its sensitivity to false edges segmentation. This paper introduces a novel scheme to overcome the listed limitations by first applying the bounding box and watershed segmentation. This proposed method demonstrates a significant improvement that may serves as a computer aided tools for radiologists in detecting microbleeds in MRI images and achieved a high sensitivity of 98.58%

Keywords: cerebral microbleed; bounding box; watershed segmentation

I Introduction

Cerebral micro-bleed (CMB) is small perivascular hemosiderin deposits caused leaked through cerebral small vessels. They can result from Cerebra-vascular disease, dementia or simply from normal aging. The MRI sequence will visualize the microbleeds that are susceptible to hemosiderin deposition such as T2*-Gradient Recalled Echo (GRE) [1-2]. Modern imaging protocols such as susceptibility weighted imaging (SWI), that are routinely run at high resolution ($\leq 1mm^3$), long echo time, and use the phase image to enhance contrast, are much more sensitive in detecting small bleeds than traditional protocols [3]. Recent publications have shown that when SWI is compared with standard gradient echo imaging there is a three to six-fold increase in the number of CMBs seen [4]. The investigation of microbleeds are laborious and time wasting, as the radiologist or experts need to verify microbleeds slice by slice while detecting the black dots to differentiate from mimics. Hence, the interest of microbleeds detection is high, especially for diagnosing large number of medical imaging. CMBs are prevalent in patients with cerebrovascular and cognitive diseases (such as stroke and dementia), as well as present in healthy aging individuals. Apart from indicating these vascular diseases, CMBs could also structurally damage their nearby brain tissues, and further cause neurologic dysfunction, cognitive impairment and dementia [5] The observer variability for the detection of CMBs is large [6]. Additionally, manual detection of CMBs is a time consuming task, which can take more than one hour per Traumatic brain injury (TBI) patient. A Computer Aided Detection (CAD) system can implies these drawbacks. Several CAD systems have been developed for the detection of CMBs in other patient populations the existence of CMBs and their distribution patterns have been recognized as important diagnostic biomarkers of cerebrovascular diseases. For example, the lobar distribution of CMBs suggests probable cerebral amyloid angiopathy [7]. Segmentation of image is very important and can be classified as the most difficult function in image processing. Segmentation is defined as the grouping of data which is share same characteristics such as colour intensities etc [8]. Generally, the watershed transformation is applied to image gradient and shows the segmentation results as watershed lines which separated the regions. This image gradient method usually produced result with noise and poor quality of segmentation or over-segmentation [9]. To reduce the effect of over segmentation, numerous approach been proposed. For example, watershed technique based on markers [10], scale space method [11], region merging method [12], partial different equations methods for image enhancements [13], the combined technique between wavelet transformation and watershed transformations [14] etc. In watershed segmentations, the separation of image basically depends on the image gradient. Theoretically, the image gradient corresponds to the homogenous gray level of the image. The nature of image that are low contrast will generate small area of gradient, resulted distinct regions to be erroneously merged [15]. In watershed segmentations, the separation of image basically depends on the image gradient. Theoretically, the image gradient corresponds to the homogenous gray level of the image. The nature of image that are low contrast will generate small area of gradient, resulted distinct regions to be erroneously merged [16] This paper will discuss on the segmentation of image by bounding box and watershed transform in which the image enhancement technique that are used to prevent over-segmentation and at the same time also reduce the noise.

2. Proposed Methodology

Fig. 2 shows an overview of the proposed framework, which is composed of two stages: pre-processing and segmentation . In the pre-processing stage, the image is converted into gray scale. The acquired converted image having noise, that noise is removed by anisotropic filter and thus the image is sharpened and smoothened.. Subsequently, in the segmentation, bounding box and watershed transformation is applied.

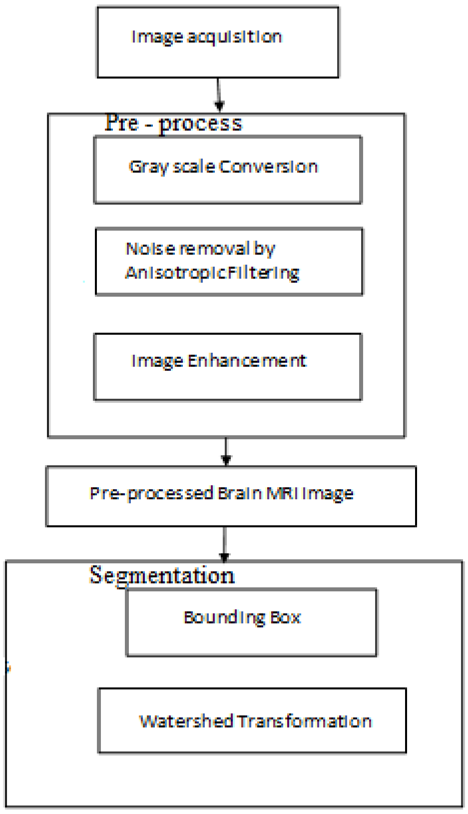
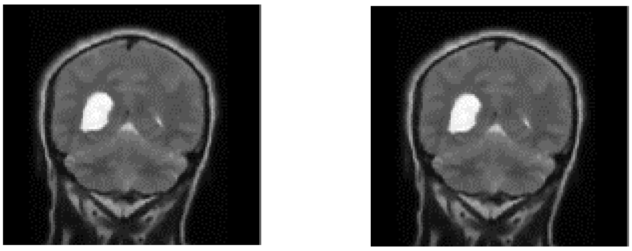


Fig.1 overview of proposed framework

2.1PREPROCESSING:GRAY SCALE CONVERSION AND NOISE REMOVAL

The first step of preprocessing is to convert RGB image into gray- scale image. The basic purpose of applying colour conversion is to reduce the number of colours. Noise refers to random pixel values acquired during image acquisition or transmission. Removing noise can improve image quality. Filtering is a technique for modifying or enhancing an image. High-frequency noise is present in magnetic resonance images and it is usually removed by a filtering process. The anisotropic diffusion filter (ADF) was proposed to adaptively remove the noise from CMB image, maintaining the image edges. After the image is converted to grayscale image,it is given as an input to the anisotropic filter. For basis of most sharpening methods anisotropic type of filter is used. When contrast is enhanced between adjoining areas with little variation in brightness or darkness image is sharpened. In the anisotropic filter the frequency is decreased which helps to keep the image with high frequency information. Anisotropic filter is used in order to increase the brightness of the center pixel kernel. A single positive value is found in the centre of the kernel array, which is totally surrounded by the negative values. Anisotropic diffusion filter is used for smoothening the magnetic resonance images. When comparing Anisotropic diffusion filter and Gaussian filter,ADF preserves the sharpness of edges better than Gaussian blurring.

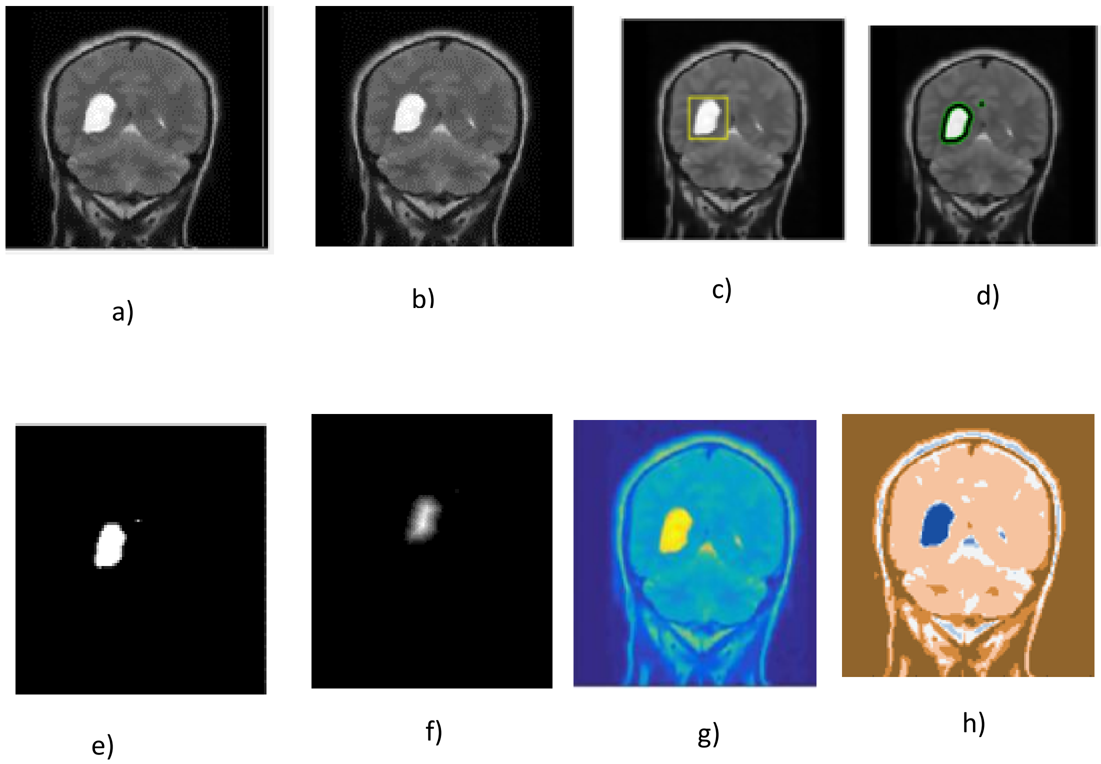


(a) Input image (b) filtered image

Fig.2 Input image VS filtered image

2.3 SEGMENTATION: BOUNDING BOX AND WATERSHED TRANSFORMATION

Image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify or change the representation of an image easier to analyse Watershed segmentation is an institutive and simple method in which parallelization is possible for fast computations. Complete partitioning of CMB image with poor contrast is possible with this approach and contour joining is not necessary. This method is entirely different from other edge based segmentation methods because the boundaries of an CMB image will be connected and closed. These boundaries of regions thus obtained belong to the contour of microbleeding image. The segmentation efficiency of above said algorithm increase if the foreground objects and background regions are verified and marked separately. This concept is referred to as marker controlled watershed segmentation (MCWS). Once the Bounding Box Segmentation is over region merging process is started. Different regions of an image are merged to form a single region with some similarity criterion. Bounding Box Segmentation is a fast and simple technique which can efficiently separate the pixels in a CMB image having similar properties to build large regions or objects. This method receives a predefined set of seed pixels along with the input image and these seed pixels point to the objects to be segmented. The seed pixel is compared to all unallocated neighbouring pixels in the image and this enables the region to grow iteratively.δ is the measure of similarity, which s defined as the difference between mean of pixels in is measured and these pixels are allocated to the corresponding region. This process repeats until all the pixels in the image are allocated to any one of the regions.



Experimental result of benign brain bleeding image (a)MRI image of bleeding affected brain (b)Anisotropic filter image (c)Locating Boundary Box image (d)Bounding Box image (e)Segmented region image (f)Distance Transform image (g) Watershed transformation Image (h)Final color output Image

Fig.3 segmented CMB using bounding box and watershed transformation

3.Results:

Metrics		Thrseholding[5]	Region growing [3]	Proposed method	
				Bounding Box	Watershed segmentation
Dice	Mean	92.44	90.44	98.10	98.58
	SD	5.56	6.84	3.66	1.28
Jaccard score	Mean	90.23	89.45	96.47	97.24
	SD	8.46	8.95	5.56	2.33

The proposed method had a very high sensitivity of 96%.The SVM classifier is able to remove most of the false positives at the loss of some sensitivity. The automated processing had an overall accuracy of 98.16% and specificity of 95.6%.

4. DISCUSSION AND CONCLUSION

Cerebral microbleeds(CMB) are also referred to as cerebral microhaemorrhages caused by structural abnormalities of the small vessels of the brain. They have been identified as a major diagnostic biomarker for many cerebrovascular diseases and cognitive dysfunctions. In current clinical routine CMBs are manually labelled by radiologists but this method is difficult, time wasting and error prone. In this paper, we propose a new automatic method to detect CMBs from magnetic resonance images (MR images).presently, the analysis of microbleeds is performed by skilled neurologist based on their database that is by scanning the image, detecting the black dots and identifying whether black dots are micro-bleeds or mimics. We propose an efficient and robust technique for segmenting the cerebral microbleeding image using bounding box and watershed segmentation. Before segmenting the image, the image is converted into gray scale and for removing the noise we use a anisotropic filter. There are many filters for removing the noise but how anisotropic filter is different from other filters means, there are some reasons. The drawbacks of some of the filters are 1.Gaussian filter not supported the grey colour.2.Bilateral filter is used only for sharpening not for smoothening.3.In histogram equalization intensity is low to peak.4.Adaptive equalization is only used for colour images. Above filters have no iteration. Because of these limitations, we propose anisotropic filter for preprocessing, which smoothens and sharpens the image and based on iteration it removes the noise. After filtering the image, bounding box with water shed transformation is applied in cerebral microbleed magnetic resonance images. when we apply this technique the black dots or bleeding are segmented clearly. By using the water shed transformation all the major and minor regions of bleeding portions are visible. Although the proposed method has achieved appealing performance with a high sensitivity of 93.16%.Experimental results demonstrate that the proposed method outperforms previous methods by a large margin with higher detection sensitivity and fewer false positives. The proposed method can be easily adapted to other detection and segmentation tasks.

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