Carotid Artery Segmentation from Ultrasound Images

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Abstract— For diagnosis of atherosclerosis, Ultrasound imaging has been widely used. The main cause of atherosclerosis is stroke. To precisely diagnose the carotid plaque, the affected region should be segmented from the ultrasonic image of carotid artery. Image segmentation is the important processes to segment the high quality images from the noisy images and it is an important component in image analysis and computer vision tasks. To acquire a high quality image, pre-processing is the first step to be done. The pre-processing step is carried out for noise removal. For the removal of noise, the median filter and log filter is used. The segmentation method involves pixel segmentation, edge segmentation and texture segmentation. The Performance of pre-processing techniques are evaluated using Mean Square Error (MSE), Peak Signal Noise Ratio (PSNR). The performance of these segmentation method is calculated by Jaccard distance. From the experimental result, texture segmentation is best method suitable for segmentation.

Keywords: Stroke, Pre-processing, Segmentation, Jaccard

I. Introduction

Image segmentation is the process of segmenting an image from the original image which is the most important technique in image analysis. Segmentation is used to partition the digital image into multiple segments which is also called as super pixels[1]. These algorithms works on the basis of discontinuity and similarity of image intensity values. To partition an image based on abrupt changes in intensity is an discontinuity approach and partitioning an based on regions is an similarity segmentation[2].

The pre-processing steps involves the over segment an image into super pixels using normalized cut. Pre-processing removes noise and improves the image contrast, its accuracy mainly impacts the results of segmentation. Weak boundaries and unrelated parts can be removed using pre-processing. Noise can get introduced into an image during storage, transmission, processing or it might be present when the image was created[3].

Active contour is an important method in image segmentation. Edge based is an active contour methods. Chan-Vese models can be used for segmenting noisy images. Though Chan-Vese level set segmentation provides best recall, regions of interest cannot be segmented accurately in all cases. Identification process for lesions should be done only in the relevant areas of the image. The efficiency of this system strongly depends on the accuracy of result segmentation. Segmentation can be done in many ways few of the method are compared with their efficiency. Edge based segmentation is used for region boundary and identifying the edges for adjusting the intensity values. The pixel segmentation is used to identify the pixels over the image and used to replace the rigid structure.[4]

II. Materials and Methods

A. Datasets

The dataset consists of totally 80 2D ultrasound images of carotid artery .These images has been acquired using ATL HDI-3000 ultrasound scanner. The scanner usually consist of computer, video screen and transducer. This lab is one of the leading success in systematic procedure for the advancement of ultrasound technology and also used for medical facilities in ultrasound equipment. Based on the reflection of the waves, the ultrasound images are produced in the body structure.

B. Histogram Equalization

The histogram is spread to cover the entire dynamic range instead by changing the shape of the histogram. It can be visualized as an intensity distribution or probability density function. The function is used for adjusting the contrast and also the quality of an image is controlled by normalizing the histogram to a flat profile or by transforming it into a target histogram profile.

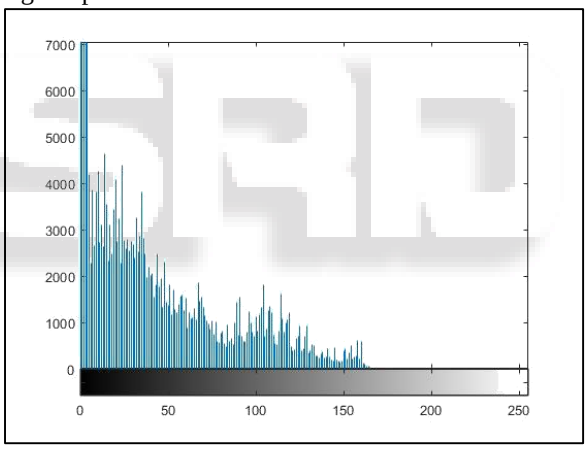

Fig. 1: Histogram Equalization

C. Image Enhancement

Enhancing the brightness to increase the clear vision of objects in the scene is between images and their backgrounds. The contrast stretch is followed by a tonal enhancement. The aggressive area of the image is used to increase the contrast spread differences uniformly whereas tonal enhancements is used to improve the differences in the shadow(dark), midtone (gray's), bright regions which is the loss of the brightness differences in the other regions.

D. Contrast Stretching

The histogram defines the measure of its aggressive range or the spread in the entire range of intensity values contained within an image. The maximum pixel value minus the minimum pixel value is used for calculation. The dynamic range of the image is calculated from 0 to 255. It is also called as normalization. By stretching the range of intensity values the image is improved. The values of an input image is mapped with the values of the output image. To determine the

limits over which the image intensity values is extended. The upper and lower limits will be called as a and b which is used for standard 8-bit gray scale picture and limits are 0 and 255.The slope and the threshold value is controlled .If the slope is less than 1,the dynamic range is reduced. The dynamic range reduction is a condition where the dark regions become darker. When the slope is greater than 1, the brightness of bright region is increased. The contrast of an image is controlled by controlling the parameters of the function

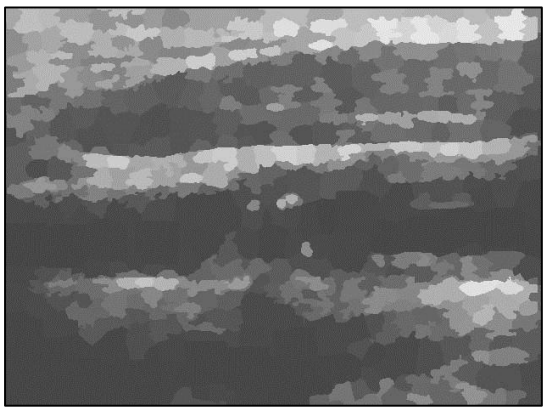

Fig. 2: Contrast Stretch

E. Contrast Limited Adaptive Histogram Equalization (CLAHE)

This method is used to impede the adaptive histogram equalization that gives rise to prevent the over amplification of noise. This procedure is applied to neighbourhood from which all the transformation function is derived. It has large changes in the pixel gray levels and also increases contrast more than other techniques. The contextual region of a pixel is calculated for histogram. The value within the display range is transformed to the pixels intensity is proportional to the local intensity histogram of pixel intensity rank . The CLAHE has two key parameters: block size(N) and clip limit(CL).To control image quality ,this two parameter is used.

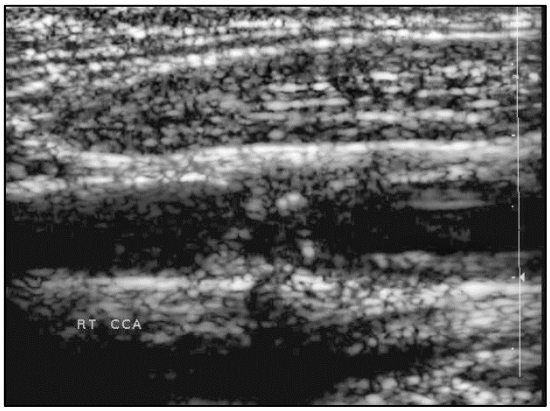

Fig. 3: CLAHE

III. DATA PREPROCESSING

Pre-processing removes noise and improves the image contrast, its accuracy mainly impacts the results of segmentation. Weak boundaries and unrelated parts can be removed using pre-processing. Noise can get introduced into an image during storage, transmission, processing or it might be present when the image was created. It can be removed through various pre-processing techniques. One of the pre-processing technique used in this paper is median filter[5]

A. Median Filter

The non-linear filtering technique that decreases salt and pepper noise while preserving the sharpness of the edges in an image. This works better than the mean filter as it removes noise, while mean filter spreads the noise evenly. Median is the middle value of its neighbouring pixels where half of the neighbour pixels are smaller and half are larger. The advantage of median filter is that it treats noise and fine detail in a similar manner and hence it removes fine details also[5]

B. Logarithmic Filter

By replacing each pixel value with its logarithm that can be compressed is the dynamic range of an image. The low intensity pixel values are enhanced by this effect. The pixel logarithm operator is applied to an image where the dynamic range may be too large to be displayed in a screen. The logarithmic curve is the mapping function that each point processor can operate. The range of the input values can be adjusted by controlling the degree of compression. The function is linear when it is close to the origin and the compression is smaller when it contains the small input values .The mapping function is given by equation 1

$$Q(i,j) = c \log(|P(i,j)|) \quad (1)$$

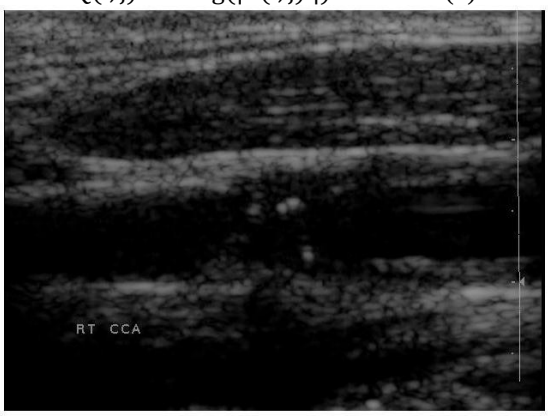

Fig. 4: Logarithmic Filter

IV. SEGMENTATION

A. Super pixel Segmentation

The images of fixed size is covered with overlapping square patches. The task is assigned to each pixel and each pixel is covered by several patches. There is no penalty if two neighboring pixels are assigned to same patch and if it belongs to different patches there will be stitching penalty that is inversely proportional to the intensity difference between the pixels. The stitching energy function is regularized by boundaries .A super pixel cannot be too high, not higher than a patch size. Only a small super pixel are used because it only contributes a cost to high stitching energy[6]

B. Super Linear Iterative Clustering(SLIC)

Based on color similarity and proximity in image plane, SLIC generates superpixels by clustering pixels .The five dimensional [labxy]space is used .[lab] is the pixel color vector and xy is the pixel position used in CIELAB color

space. It is considered as perceptually uniform for small color distance.

The clustered centres and moving them to seed locations is done by sampling K with regularly spaced cluster , that corresponds to the lowest gradient position in 3×3 neighborhood. This can be done by reducing the chances of choosing a noisy pixel which also avoids by placing them at an edge[7].

1) Algorithm

1) Initialize cluster centers
2) perplex cluster centres in an nXn neighborhood,to the lowest gradient position.
3) repeat
4) for each cluster center $_{Ck}$ do
5) Assign the best matching pixels from a 2SX2S× 2S squared neighborhood around the cluster center according to the distance measure
6) end for
7) compute new cluster centers and residual error E
8) until E≤ threshold
9) Enforce connectivity.

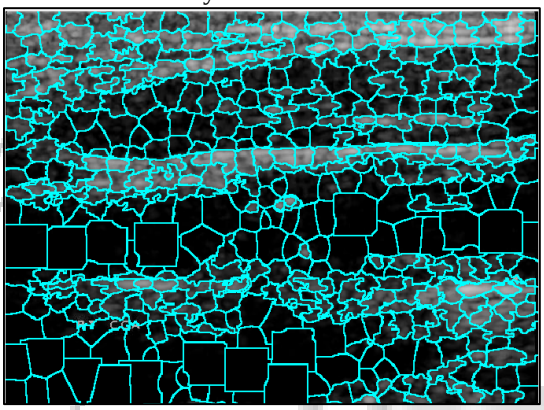

Fig. 5: (a) color

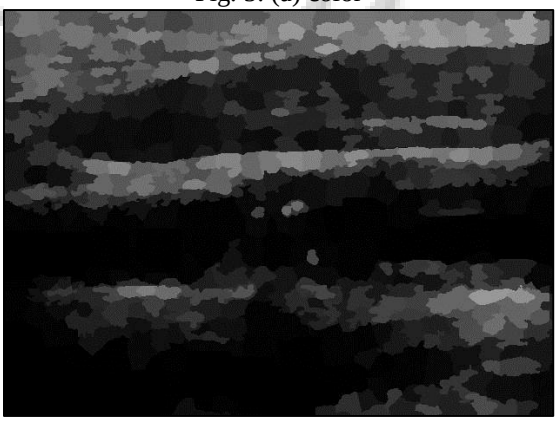

Fig. 5: (b) SLIC

C. Edge Segmentation

One of the fundamental tool for image segmentation that is used to extract the exact edge. This segmentation transform the filtered images into edges that benefits the changes of gray tones in the image. By detecting the physical and geometric properties of an object is the localization variations of a gray level image .To detect the discontinuities in intensity values edge detection is used. The discontinuities are detected by spatial masks [8]

D. Robert Edge Segmentation

The 2-D spatial gradient measurement on an image is simple, quick and easy to compute. The regions of high spatial frequency that corresponds to edges is emphasized by this method. The usage of this technique is that input to the operator is a gray image that is same as the output. The magnitude of the spatial gradient is the estimated completion of the input image that is represented by the pixel values is the output in every point.

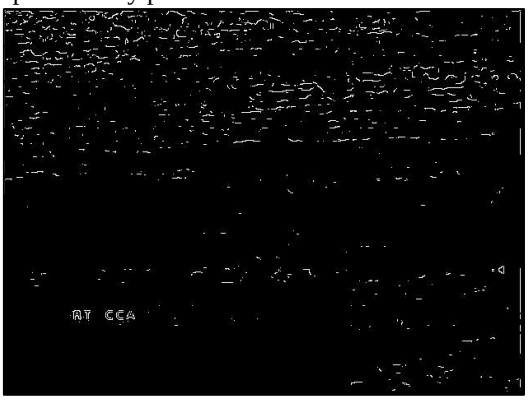

Fig. 6: Robert

E. Sobel Segmentation

The sobel approximation is the derivative that finds the edges. If the gradient is high it precedes the edges at those points. The region highlights the high spatial frequency that corresponds to edges. The spatial gradient is performed by 2D quantity on an image. The estimated gradient magnitude in an n input gray scale image is absolute at each point.

Fig. 7: Sobel

F. Canny Edge Segmentation

The first step in canny involves the seperation of noise from the images before finding the edges in a image. It is the best method without disturbing the aspects of the edges in the image by applying the behaviour to find the edges and the values for the threshold[9]

The algorithm steps

1) The Gaussian function that convolve images involves f(r,c) to get smooth image f^(r,c)
2) To compute edge strength the difference in gradient operator is applied and then edge magnitude and direction are obtained.
3) The non-maximal or analysis suppression is applied to gradient magnitude.

4) The threshold is applied to non-maximal suppression image.

G. Texture Segmentation

The element or pattern on a surface is the regular repetition is called as texture. The process of partitioning an image into regions by applying different textures containing similar group of pixels. The boundary extraction between texture is extracted by this method. The important method in texture segmentation involves Gabor filter which is used for frequency and orientation representation .In a 2 D spatial domain, Gabor filter is known as Gaussian kernel function that is modulated by sinusoidal plane wave. The impulse response that is defined for harmonic function is multiplied by a Gaussian function[9]

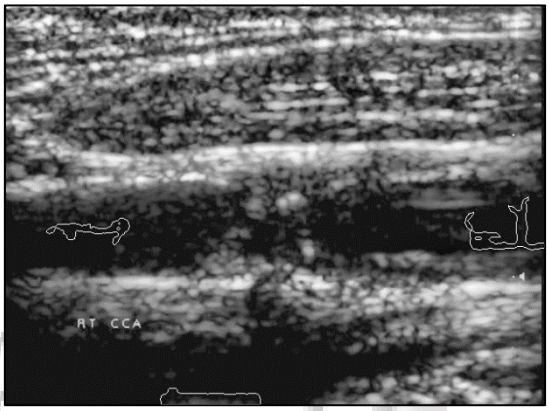

Fig. 8: Texture

V. RESULTS

A. Pre-processing Interpretation Results

1) Mean Square Error(MSE)

To know the average of the squares of the errors or deviation. The difference between the estimator and what is estimated is the procedure for estimating an unobserved quantity measures which is known as mean squared error(MSE) or mean squared deviation(MSD) [11].

The MSE is measured between the encoded and the original image which is defined by an cumulative square error

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \quad (2)$$

2) Peak Signal to Noise Ratio(PSNR)

The ratio between the maximal available value(power) of a signal and the power of deceiving noise is termed as peak signal to noise ratio. Which affects the condition of its representation. It is usually expressed in log decibel scale and the noise will be compressed in original data .It is an approximation of reconstruction quality in human perception.

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \quad (3)$$

S.no	Filters	PSNR	MSE
1	median filter	33.96	32.17
2	log filter	36.60	31.20

Table 1: comparison of MSE and PSNR values for filters

3) Jaccard Distance

Jaccard index=(the number in both sets)/(the number in either set)*100

The formula for calculation is,

$$J(X,Y) = |X \cap Y|/|X \cup Y| \quad (4)$$

The Jaccard distance is a measure of how dissimilar the two sets. It is the complement of the Jaccard index and found by subtracting the Jaccard index from 100%[9].

$$D(X,Y)=1=J(X,Y) \quad (5)$$

B. Segmentation Interpretation Results

S.No	Methods	Jaccard distance
1	SLIC	0.3095
2	Texture	0.7154
3	Canny Edge	0.6680
4	Sobel	0.6996
5	Robert	0.6917
6	Prewitt	0.6877

Table 2: Calculation of Jaccard distance

VI. DISCUSSION

The result of pre-processing followed by segmentation is a method that together screens the entire image, or a set of contours extracted from the image .Each of the pixels or group of pixels s in a region are similar with respect to some distinctive or measured property, such as color, intensity, or texture. Segmentation methods which are based on gray level techniques like pixel-based and edge based methods are the simplest methods .The texture segmentation is applied for finding the texture in the images .From the experimental results, texture segmentation is the method suitable for segmentation. By integrating with other techniques, the performance of techniques can be improved.

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