Biomedical Image Analysis Using Enhancement & Segmentation Techniques

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Abstract

This paper presents an efficient edge detection enhancement &segmentation methods to highlight the tumors present in brain images. Using Enhancement technique& region-growing method we merge the adjacent detected pixels on homogeneity criteria, to obtain the tumor. Region growing starts with seed(s). The seed value is determined with the help of histogram analysis. The developed algorithm is explained and applied on the biomedical images and some preliminary results are shown which are found encouraging. . In this paper currently used well known edge detection algorithms are also presented.

Key words- Image enhancement, edge detection, Image segmentation, region growing, tumor detection, seed, and homogeneity

1. Introduction

Image processing encompasses the mathematical and engineering methods for manipulating digital images to extract useful information from the image. Some of the most fundamental manipulations are depicted in Fig.1. An acquisition device generates a digital image. Such devices include a digital camera, an electronic microscope, an MRI, an X-ray radiograph or an ultrasound imaging system etc. The images obtained by such devices suffer from additive noise, linear distortion, non-linear distortion, low contrast and possibly some lost samples [1].

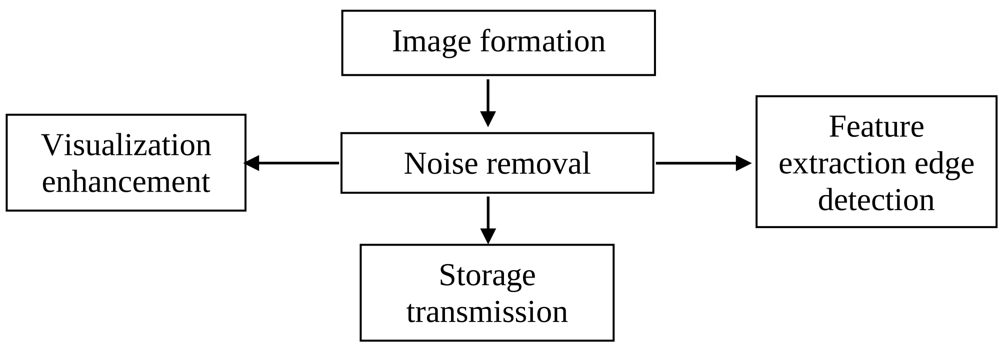


Fig. 1: Fundamental stages in image processing

The image restoration involves the removal of noise and distortions. It also involves filtering methods and statistical techniques. The visualization of image can require some enhancement in order to improve the perception of image. Enhancement techniques include grayscale modification, edge enhancement, and contrast modification. Finally, there is a need to understand the structure of the image in more detail. The image understanding process requires the extraction of important features using automatic procedures. Edge detection is one of the most fundamental requirements in image understanding [2].

2. Image Enhancement

The purpose of image enhancement is to process an acquired image for better contrast and visibility of features of interest for visual as well as subsequent computer aided analysis. The enhancement methods improve the perception of image through modification of intensity functions, image spectral content or a combination of these functions. Image enhancement includes gray level and contrast manipulations, noise reduction, edge crispening and sharpening (or Edge Detection), filtering, interpolation and magnification, pseudo coloring etc [14]. In the present work, three aspects of image enhancements have been used which are as following:

1. Gray level and contrast modification
2. Noise reduction
3. Edge Detection

A brief description of these aspects is presented below:

2.1 Gray Level and Contrast Modifications

The various gray level and contrast modification techniques are:

(i) Contrast stretching

(ii) Power law transformation (or Gamma correction)

(iii) Histogram equalization

2.1.1 Contrast stretching

Contrast generally refers to the difference in luminance or grey level values in an image and is an important characteristic. Contrast ratio can be defined as the ratio of the maximum intensity to the minimum intensity over an image. Contrast ratio has a strong bearing on the resolving power and detectability of an image. Larger this ratio, more easy, it is to interpret the image. Contrast enhancement techniques expand the range of brightness values in an image so that the image can be efficiently displayed in a manner desired by the analyst.

In a linear approach of contrast stretching, a density number in the low range of the original histogram is assigned to extremely black and a value at the high end is assigned to extremely white. The remaining pixel values are distributed linearly between these extremes. The features or details that were observe on the original image will be clear in the contrast stretched image. Fig. 2.2 shows a typical contrast stretching transformation, which can be expressed as

$$v = \begin{cases} pu, & 0 = u < a \\ q(u-a) + v_a, & a = u < b \\ r(u-b) + v_b, & b = u < L \end{cases}, \qquad (1)$$

The slope of the transformation is chosen greater than unity in the region of stretch where gray level u ϵ [0, L] is mapped into a gray level v ϵ [0, L] according to the transformation v = f(u). Slope of p, q, r determines the relative contrast stretch shown in Fig. 2. The parameters a and b can be obtained by examining the histogram of the image. For example, the gray scale intervals where pixels occur most frequently would be stretched most to improve the overall visibility of a scene [14].

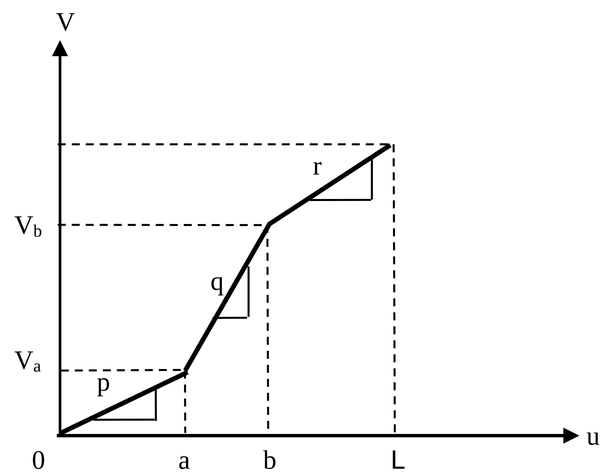


Fig. 2 : Contrast stretching transformation. For dark region stretch $p > 1$, $a \approx L/3$; mid region stretch, $q > 1$, $b = 2/3\,L$: bright region stretch $r > 1$.

3. Image Segmentation

Segmentation of an image has always been a key problem in computer vision. Image segmentation is a process in which regions or features sharing similar characteristics are identified and grouped together. Image segmentation is based on thresholding, edge detection, region detection or combination of any of these techniques. The segmentation should separate the regions that are homogenous to the particular criteria chosen for analysis, so that the variations of segmented area should be considerably less than the variation at borders. The segmented area should have smooth shedding and texture. There should not be large variation in homogeneity criteria with in a single segment. Small data must be clear for further analysis and the position of border obtained after segmentation must match with local maxima, ridges and saddle points of local gradient the measurements [1-2].

Segmentation basically divides an image into segments having of the following characteristics.

- Looks uniform
- Belongs to single object
- Have some uniform attributes
- All pixels related to it are connected

Most segmentation techniques are either based on discontinuity or similarity criteria. Region growing is one of the similarity-based techniques.

Region based technique is based on the grouping of the common patterns of intensity values within a cluster of neighboring pixels. The cluster is represented as region. The regions grouped according to their function or anatomical role, are basically based on criteria of homogeneity. So the segmentation is a process of extracting and representing information from an image in the form of group of pixels having homogeneity. Different criteria like texture, colour, gray level etc. can be used, even in combination for region-based segmentation. Goal of the technique is to determine the regions on the basis of pre-defined homogeneity criteria. Two of the most widely used methods are split and merge and region growing [10-11]

Region growing technique gives good results where borders are difficult to detect and to generate better results in noisy images. We applied the region growing approach for segmentation of weld images. The region growing starts with seed and small areas are merged to obtain a region having all the pixels having predefined criteria. Merging of regions is often based on comparing the difference of their feature measure with a predefined value known as segmentation threshold. An appropriate threshold is crucial to get successful region growing results. In the existing method, the most suitable threshold value is determined by histogram analysis. Although single threshold may be sufficient to segment an image but multiple thresholds give better results in complex image. With the help of iteration the threshold value that gives best results can be obtained easily. Existing algorithms applied for region growing have multiple threshold and these are clubbed together to get best results. It is a position dependent threshold method determined using a prior knowledge about image or by local thresholding techniques applied on different parts of image [12-13]. Local thresholding technique is used on different parts of image to select the most suitable threshold for merging.

4. Region growing Methodology

Region growing is a technique, which helps to extract boundary of an image. In this process the pixels are grouped or sub regions are combined to form large regions, based on predefined criteria. The predefined criteria may be based on different homogeneity properties of an image i.e. intensity value of pixels texture, motion, shape, size, variance and colour. In region growing, the basic idea is to divide an image into zones of maximum homogeneity [14-15].

Basic purpose of region growing is to segment entire image R into smaller sub images R_i =1,2.....N which satisfy the following conditions.

a) $R = \bigcup_{i=1}^{N} n \; R^{i}$;

b) $P(R^{i})$ = True ; i=1,2.......N ;

c) $R^{i} \cap R^{j} = \emptyset$, $i \neq j$

Where R_i and R_j are adjacent

d) $P(R_i \cup R_j)$ = False, $i \neq j$

In region growing, an initial set of small areas is iteratively merged according to similar constraints. Starting up with seed point and compare it with neighboring pixels, region is grown from the seed pixel by adding in neighboring pixels that are similar in predefined criteria. The size of the region increases by using 4 adjacent or 8-adjacent neighbor. When the growth of one region stops, the other seed pixel, which does not belong to any region, is chosen and process of region growing is started again. This whole process is continued until all pixels belong to some region. It gives good result that corresponds well to observed edges. Starting with one seed gives bias results in favors of seed chosen first, so simultaneous region growing technique are used. A number of regions are allowed to grow simultaneously and similar regions will gradually merge with each other. In region growing adjacency is major control it can be 4 neighbor (adjacent) or 8 neighbor (adjacent) , pixel similarity is secondary

4	3	2	3	4			2	2	2	2	2
3	2	1	2	3			2	1	1	1	2
2	1	0	1	2			2	1	0	1	2
3	2	1	2	3			2	1	1	1	2
4	3	2	3	4			2	2	2	2	2

Fig 3.Proximity; define connection between image pixels 4 neighbor (adjacent) or 8 neighbor (adjacent)

Suppose A= (p1, q1), B= (p2, q2) are two image points;

$$D(A,B) = \sqrt{(p1 - p2)^2 + (q1 - q2)^2}$$

$$D_4(A,B) = |p1 - p2| + |q1 - q2|$$

$$D_8(A,B) = \max\{|p1 - p2|, |y1 - y2|\}$$

Region Growing Algorithm

- Start at some location (s) (seeds)
- Propagate from seed or seeds to its neighbor
- Only add adjacent pixels that satisfies with homogeneity criterion of region
- Repeat the Steps from 2 to 3 until it reaches the boundary of the region
- Can grow multiple regions in parallel and in competition [16-17]

5. Results and Discussions

In region growing approach the segmentation of welding images start with 'seed' and small areas get merged to obtain a region having all the pixels with pre-defined characteristics. Merging of region is often based on comparing the difference of their feature measure with a predefined value known as segmentation threshold. Threshold determination is difficult. The selection of an appropriate threshold is crucial to get successful region growing results. In the applied algorithm, the threshold value is determined by histogram analysis. The valleys and peaks of histogram help in determining the threshold values. Although single threshold may be sufficient to segment an image but multiple thresholds give better results in complex images. With the help of iteration method, the threshold which gives best result can be obtained easily.

Existing algorithms applied for region growing have multiple thresholds and these results are clubbed together to get best results. It is a position dependent threshold method. Local thresholding technique is used on different parts of image to select the most suitable threshold for merging two regions.

Fig.4 shows a original image having tumor. Tumors are clearly identifiable after the application of algorithm .The thresholded & segmented image, depicting the tumor is shown in Fig. 5 & 6. Also other modality of image is compared here .

Fig.4 Original image having Tumor

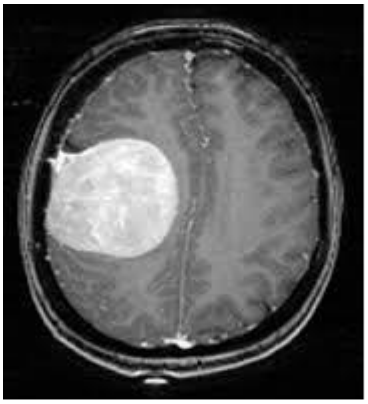
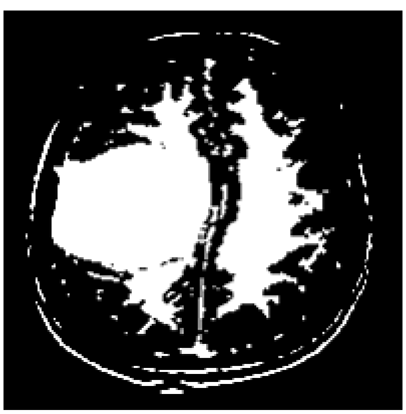


Fig.5 Thresholded image

Fig.6 Segmented image is superimposed on original image with Tumor



6. Conclusions

It is very useful to detect flaws in industrial application to improve the quality and reduce the cost of product. The image obtained after the implementation of region growing technique produced high quality segmentation on the wide range of gray scale of various biomedical modality images. It can easily be adapted to different image applications by substituting the suitable feature measure. By using region-growing technique the size and position of tumors can be depicted more accurately A limitation of this algorithm is that the threshold value has to be judged by the medical expert, based on histogram of the image. Further development i.e. next algorithm will be comparison of all segmentation techniques with Fuzzy Segmentation

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