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Different Image Segmentation Techniques for Dental Image Extraction

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ABSTRACT
Image segmentation is the process of partitioning a digital image into multiple segments and often used to locate objects and boundaries (lines, curves etc.). In this paper, we have proposed image segmentation techniques: Region based, Texture based, Edge based. These techniques have been implemented on dental radiographs and gained good results compare to conventional technique known as Thresholding based technique. The quantitative results show the superiority of the image segmentation technique over three proposed techniques and conventional technique.
Key Words: Thresholding based technique, region based, texture based, edge based techniques.

I. INTRODUCTION

Digital Images are used as one of the most important medium for carrying information in the field of computer vision. By image segmentation, we can extract information or objects of images. This information can be used for other functions for example: human identification, detection of cancerous cells, synthetic aperture radar (SAR) images. So the image segmentation is the first step in the image analysis.

Image segmentation is a fundamental step in many areas of computer vision including stereo vision and object recognition. It provides additional information about the contents of an image by identifying edges and regions of similar colour and texture, while simplifying the image from thousands of pixels to less than a few hundred segments. Additionally, image segmentation has applications separate from computer vision; it is frequently used to aid in isolating or removing specific portions of an image.

Image segmentation methods are categorized on the basis of two properties discontinuity and similarity. Methods based on discontinuities are called as boundary based methods and methods based on similarity are called Region based methods. Segmentation is a process that divides an image into its regions or objects that have similar features or characteristics. Mathematically complete segmentation of an image R is a finite set of regions R1…Rs.

R = Ụi =1 RiRi ∩ Rji≠j

The following sections present the study of basic image segmentation called Threshold based and proposed techniques Region based, Texture based, Edge based. These techniques have been tested on dental radiographs to identify the similarities like infected teeth. In this paper these techniques segment the dental image into regions called dental work (DW). The result section provides simulation results of segmentation techniques. Based on source data (area of DW, distance between DW, angle between DW) of image of different techniques, this paper shows the superiority of technique over proposed and existing techniques.

II. IMAGE SEGMENTATION TECHNIQUES

A. Existed technique:

Thresholding Technique:

It is simple image segmentation technique but powerful approach for segmenting images. From a gray scale image, thresholding can be used to create binary images. This technique is based on space regions i.e on characteristics of image. In thresholding process, first convert gray scale image into binary image, by choosing proper threshold value T, divide image pixels into several space regions and separate objects from background. For example f(x,y) is intensity value of image pixel of object, if it is greater than or equal to T i.e., $f(x,y) \geq T$ then it belongs to that object otherwise it belong to background. There are two types of thresholding methods with regarding selection of threshold value T: global and local thresholdings. In global thresholding threshold value T is constant where as in local thresholding valueT is variable because of uneven illumination. Threshold selection is typically done interactively however, it is possible to derive automatic threshold selection algorithms.

Threshold technique can be expressed as:

T=*T(x,y),p(x,y),f(x,y)*…………………(1)

Where T is threshold valuex,y are the coordinate of the threshold value point. *p(x,y),f(x,y)* are points of gray scale image.
The threshold image g(x,y) is defined as:

g(x,y) =1 if *f(x,y)*≥T= 0 if *f(x,y)*≤T …..……(2)

B. Proposed Techniques:

Texture based segmentation:

Texture segmentation is important task in image processing. It works at segmenting a textured image into several regions having similar patterns. Texture segmentation has been effective and efficient technique, so used in many applications like in analysis of biomedical images, seismic images. The texture feature extraction methods can be classified into statistical, structural and spectral. . In statistical approaches, texture statistics such as the moments of the gray-level histogram, or statistics based on gray-level co-occurrence matrix are computed to discriminate different textures. In structural approaches, "texture primitive", the basic element of texture, is used to form more complex texture patterns by applying grammar rules, which specify how to generate texture patterns. Finally, in spectral approaches, the textured image is transformed into frequency domain.

Region based segmentation:

Region based algorithms are relatively simple and more immune to noise. Region-based segmentation is based on the connectivity of similar pixels in a region. There are two main approaches to region-based segmentation: region growing and region splitting. Let R represent the entire image region. Segmentation is a process that partitions R into sub regions, R1,R2,…,Rn, such that

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

(b) R_i is a connected region, $i = 1,2,..., n$

(c) $R_i \cap R_j = \phi$ for all i and $j, i \neq j$

(d) $P(R_i) = \text{TRUE}$ for $i = 1,2,..., n$

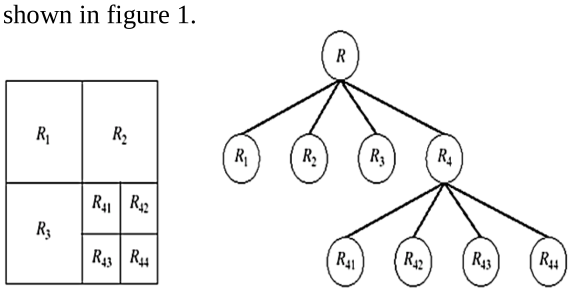
(e) $P(R_i \cup R_j) = \text{FALSE}$ for any adjacent regions R_i and R_j

Where P(Rk): a logical predicate defined over the points in set Rk. For example: P(Rk)=TRUE if all pixels in Rk have the same gray level. Region splitting is the opposite of region growing. Region splitting and merging method can divide an image into a set of arbitrary unconnected regions and then merge the regions in an attempt to satisfy the conditions of reasonable image segmentation. Region splitting and merging is usually implemented with theory based on quad tree data.

In region splitting and merging method the procedure is as follows:
Let R represent the entire image region and select a predicate Q

i) We start with entire image if Q(R) = FALSE we divide the image into quadrants, if Q is false for any quadrant that is, if Q (Ri) = FALSE, We subdivide the quadrants into sub quadrants and so on till no further splitting is possible.
ii) If only splitting is used, the final partition may contain adjacent regions with identical properties. This drawback can be remedied by allowing merging as well as splitting i.e. merge any adjacent regions Rj&Rk for which, Q (Rj U Rk) = TRUE.
iii) Stop when no further merging is possible.

The portioned and corresponding quad tree is shown in figure 1.



(a) (b)

Figure 1. (a) partitioned image (b)corresponding quad tree image.

Edge based segmentation:

An object can be easily detected in an image if the object has sufficient contrast from the background. Edge-based segmentation represents a large group of methods based on information about edges in the image. There are three basic types of gray-level discontinuities in a digital image: points, lines, and edges. The most common way to look for discontinuities is to run a mask through the image. We say that a point, line, and edge has been detected at the location on which the mask is centered if |R|≥T
Where R=w1z1+w2z2........+w9z9

Canny edge detection method is a more robust gradient-based edge detection algorithm. It uses linear filtering with a Gaussian kernel to smooth the noise in the image, then it computes the strength and direction of the edge for every pixel in the smoothed image by differentiating the image in the horizontal and vertical directions. Next, it computes the gradient magnitude as the root sum of squares of the derivatives and the gradient direction using arctangent of the ratio of the derivatives. Finally, the edge strength of each edge pixel is set to zero if its edge strength is not larger than the edge strength of the two adjacent pixels in the gradient direction. The remaining pixels after this process are labelled as candidate edge pixels and an adaptive thresholding method is applied on the thinned edge magnitude image to obtain the final edge map.

The canny edge detection follows below algorithm:

i. Compute fx and fy.

$$f_x = \frac{\partial}{\partial x}(f * G) = f * \frac{\partial}{\partial x} G = f * G_x$$

$$f_y = \frac{\partial}{\partial y}(f * G) = f * \frac{\partial}{\partial y} G = f * G_y$$

$G(x, y)$is the Gussian function

$G_x(x, y) isthederivateof G(x, y) withrespectto$

$$x: G_x(x, y) = \frac{-x}{\sigma^2} G(x, y)$$

$G_y(x, y) isthederivateof G(x, y) withrespectto$

$$y: G_y(x, y) = \frac{-y}{\sigma^2} G(x, y)$$

ii. Compute the gradient magnitude

$$magn(i, j) = \sqrt{{f_x}^2 + {f_y}^2}$$

iii. Apply non-maxima suppression.

iv. Apply hysteresis edge linking.

III. SIMULATION RESULTS AND DISCUSSIONS

In this paper the image segmented techniques have been implemented in MATLAB 2009a. The test images are shown in figure 2a and figure 3a represents dental radiographs and corresponding segmented images are shown in figures (2b-2e) and (3b-3e).

The source data of different techniques are tabulated for test images are tabulated in Table 1 and Table 2 for comparison purpose.

IV. CONCLUSIONS

Image segmented methods are very useful in image processing applications. In this paper, we proposed a comparative study of three image segmented techniques: region based, texture based, edge based. Three conclusions we have made on characteristics of dental works (DW).

i. Based on area dental work: In region based method area for minute detail is considered. So that the area in region based is larger as the total area is considered. The results obtained by texture method similar when compared to other methods but the one advantage is that it can be implemented to color images. Compared to three methods edge based segmentation gives better results.

ii. Based on distance between DWs: In region based method the area, which is considered may be varied accordingly the distance between DW also varies. This gives the advantage of detection of any minute abnormalities in dental images. In both texture and edge methods the distance between DW same as existing methods.

iii. Based on angle between DWs: In all the methods the angle is same as existing method.

Comparing three proposed methods, Region: Gives the freedom for selecting the area of minute detail for dental process. Texture: This method can be implemented for color images and helps when bleeding occurs in dental process. Edge: This is the best method when compared with the above methods as area and angle between DW is accurate.

Table 1. The source data of techniques of dental image 1

Source Data	Thresholding (Existing method-Reference)	Region	Texture	Edge
Area of DW	573 869 363	666 1 1052 1 1 463	573 869 363	664 956 460
Distance Between DW	104 117 0 14	97 103 NaNNaN 117 0 7 NaNNaN 20 0 0 NaNNaN 14 0 0 0 NaNNaN 0 0 0 0 NaN	104 118 0 14	103 117 0 13
Angle Between DW	359 360 0 5	360 359 NaNNaN 360 0 345 NaNNaN 359 0 0 NaNNaN 6 0 0 0 NaNNaN 0 0 0 0 NaN	359 360 0 6	359 360 0 6

Note: NaN = Not a Number.

Table 2. The source data of techniques of dental image2

Source Data	**Thresholding (Existing method-Reference)**	**Region**	**Texture**	**Edge**
Area of DW	387 1006 40907	387 1006 40907	387 1006 40907	447 1124 42624
Distance Between DW	17 232 0 221	17 232 0 221	17 232 0 221	17 232 0 221
Angle Between DW	305 354 0 357	305 354 0 357	305 354 0 357	305 354 0 357

Note: NaN = Not a Number.

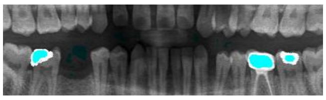


Figure 2a. Test image radiograph 1

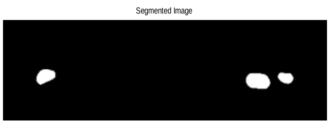


Figure2b. Threshold segmented image

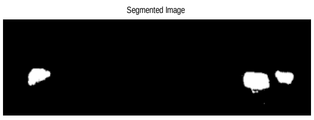


Figure2c. Region based segmented image

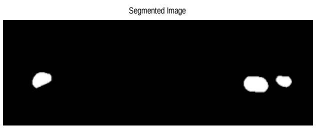


Figure2d. Texture based segmented image

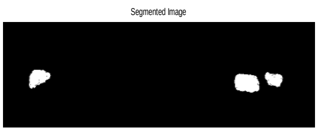


Figure 2e. Edge based segmented image

Figure 2: Original & Segmented dental images for sample 1

Figure 3a. Test image radiograph 2

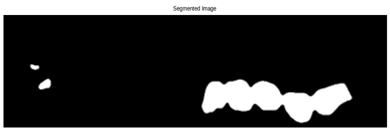


Figure 3b. Threshold segmented image

Figure 3c.Region based segmented image

Figure 3d. Texture based segmented image

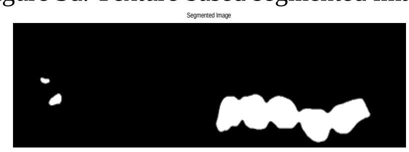


Figure 3e. Edge based segmented image

Figure 3: Original & Segmented dental images for sample 2

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BIOGRAPHIES

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