

Automated Diagnosis of Periodontal Diseases Using Image Processing Techniques

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ABSTRACT: Dental Radiographs have a valuable aid in the diagnosis of periodontal diseases and the evaluation of treatment effects. Computer-based image acquisition and processing techniques will now further increase the importance of radiography in periodontal diagnosis. Digital Subtraction Radiography (DSR) requires a pair of images with identical gray-level distribution and projection geometry is needed to identify the periodontal diseases. In DSR, a pair of identical images can be obtained without mechanical alignment of patient, film and x-ray source. The drawback of this technique is, if there is any mechanical alignment in the camera view then mismatching will occur in the result. This paper presents a method for automated diagnosis of periodontal diseases using a single radiographic X-ray image which eliminates the requirement of pair of images.

KEYWORDS: Bifurcation, Contour detection, Dental Radiography, Image Enhancement, Morphological operations, Pre-processing.

I. INTRODUCTION

Teeth are supported by gums or gingiva. A tooth's root is anchored to its socket by fibres called periodontal ligaments. Periodontal diseases are serious bacterial infections that destroy the gum and surrounding tissues of the mouth. Periodontal diseases affect the gums, bones around the tooth and membrane of the tooth.

Gum Eroded Region is also called "Gum Recession". Gum Recession occurs when the protective tissue around the base of the tooth erodes, leaving the root of the tooth exposed. If left untreated, gum recession can cause tooth sensitivity and can also lead to further gum and bone loss. There are two causes for gum recession. (i). Tooth-Brushing Practices (ii). Periodontal Diseases. Many cases of receding gums occur due to gum disease. When gum disease occurs, plaque and tartar collect at the gum line, irritating the gums. If left untreated, the gums begin to pull away from the teeth, forming deep, bacteria-filled spaces called pocket. The direct and indirect digital imaging system in medicine and dentistry has created a wide selection of Computer based methods for diagnostic imaging.

In Clinical diagnosis, such applications include image enhancement, analysis and visualization. Image enhancement algorithms offer a wide variety of approaches for modifying diagnostic images to achieve visually acceptable images. The

choice of such techniques is a function of the specific task, image content, observer characteristics, and viewing conditions. The focus of the article [1] is on spatial domain methods, which directly manipulate the image data array, either by point processing or area point processing or area processing. The point processing can be classified into Linear and Non-linear point processing. There are infinite ways in which gray levels can be modified in a nonlinear fashion. Exponential, logarithmic intensity modifications, Gray level slicing, lookup table approach and Histogram modification. Among these methods, Histogram modification is most frequently used method. The Drawback of this method [1] is that they may lead to loss of visual quality of images for certain areas and increased visibility of noise.

Temporal changes of lesion [2] can be made easily visible by means of subtraction radiography based on digital images. This process requires a pair of images with identical gray-level distribution and projection geometry. The gray-level distribution and perspective projection of images can be corrected by means of digital image processing. A pair of identical images can be obtained without mechanical alignment of patient, film and x-ray source [2].

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II. PROPOSED METHODOLOGY

The block diagram given in Fig.1 indicates the main processing steps which are followed to find the Gum Regions in Dental Radiographic X-ray films. The automated diagnosis of periodontal disease mainly consists of three stages: Pre-processing, Contour detection and Bifurcation.

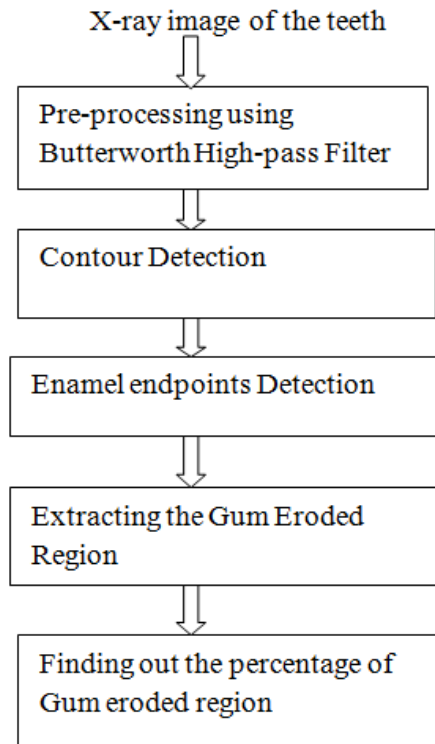


Fig.1 Block Diagram of the proposed method

2.1 Pre-Processing

Pre-processing is to improve the quality of images. If the image is too noisy or blurred, they should be filtered and sharpened. In Image processing, filters are mainly used to suppress either the high frequencies in the image (i.e smoothing the image) or the low frequencies. (ie Enhancing or detecting edges in the image). An image can be filtered either in the Frequency Domain or Spatial Domain. In this paper, we used Frequency Domain filters for pre-processing. The first step involves transforming the image into the frequency domain. Then, multiplying it with the frequency filter function. Finally, retransforming the result into the spatial domain.

In the present work frequency processing analysis via Fourier transformation is used to enhance the X-ray films of different dental images. The 2-D, *discrete Fourier transform* (DFT), $F(u, v)$, of image $f(x, y)$ of size $M \times N$, is given by the equation

$$F(u, v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \exp(-j2\pi(ux/M + vy/N)). \quad (1)$$

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Equation (1) represents the *frequency domain* which is simply the coordinate system spanned by $F(u, v)$ with u and v as (frequency) variables. The foundation for linear filtering in both the spatial and frequency domains is the convolution theorem. If $H(u, v)$ represents filter function, then the convolution theorem may be written as:

$$f(x, y) * h(x, y) \Leftrightarrow H(u, v)F(u, v) \tag{2}$$

where $h(x, y)$ is the filter mask.

The transfer functions of Butterworth low-pass filter (BLPF) of order n , with a cut-off frequency at a distance D_0 from the origin is given by Eq. (3):

$$H(u, v) = \frac{1}{1 + \left[\frac{D(u, v)}{D_0} \right]^{2n}} \tag{3}$$

The transfer functions of Gaussian low-pass filter (GLPF) can be represented as the following equation:

$$H(u, v) = e^{-D^2(u, v) / D_0^2} \tag{4}$$

High-pass filtering is the essential primary step to enhance the image. Given the transfer function $H_{lp}(u, v)$ of a low-pass filter, the corresponding transfer function of the high-pass filter can be determined as the following:

$$H_{hp}(u, v) = 1 - H_{lp}(u, v) \tag{5}$$

The different filter types, i.e. ideal, Butterworth and Gaussian, are used for high-pass filtering that is given in Eq.(5) for the purpose of comparison and also to define which filter type is much suitable for the subsequent processing. In this work, Butterworth high-pass filter has given better performance with $d_0=10.5$ for detecting the gum eroded region.

2.2 Contour Detection

Contour Detection is defined as an outline or a boundary of an object. Contour detection deals with detecting various objects in an image specifically. Use of contour detection in image processing is to locate objects and their boundaries in images. In this work, Laplacian of Gaussian is used for detecting the contours. Since the input image is represented as a set of discrete pixels, we have to find a discrete convolution kernel that can approximate the second derivatives in the definition of the Laplacian. Two commonly used small kernels are shown in Figure 2.

0	-1	0	-1	-1	-1
-1	4	-1	-1	8	-1
0	-1	0	-1	-1	-1

Figure 2 Two commonly used discrete approximations to the Laplacian filter.

Using one of these kernels, the Laplacian can be calculated using standard convolution methods. Because these kernels are approximating a second derivative measurement on the image, they are very sensitive to noise. To counter this, the image is often Gaussian smoothed before applying the Laplacian filter. This pre-processing step reduces the high frequency noise components prior to the differentiation step. The 2-D LoG function centered on zero and with Gaussian standard deviation σ has the form:

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$$LoG(x, y) = -\frac{1}{\pi\sigma^4} \left[1 - \frac{x^2 + y^2}{2\sigma^2} \right] e^{-x^2+y^2/2\sigma^2}$$

and is shown in Fig.3.

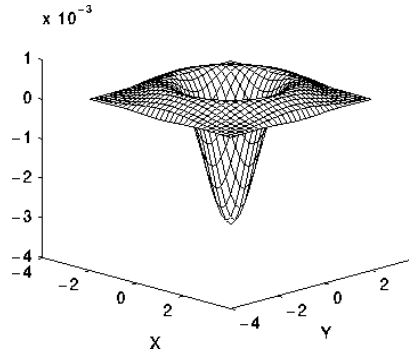


Fig.3. The 2-D Laplacian of Gaussian (LoG) function. The x and y axes are marked in standard deviations (σ).

Thinning is a morphological operation that is used to remove selected foreground pixels from binary images, somewhat like erosion or dilation.[3],[4]. It can be used for several applications, but is particularly useful for skeletonization. In this mode it is commonly used to tidy up the output of edge detectors by reducing all lines to single pixel thickness. Thinning is normally only applied to binary images, and produces another binary image as output. The thinning operation is related to the hit-or-miss transform.

Thinning Operation may be defined by the following expression:

$$A \phi B = A - (A \otimes B) \dots \dots \dots (6)$$

2.3. Enamel End Points Detection

Enamel end points are detected using Bifurcation techniques. Bifurcation is defined as a point where a ridge fork or diverges into branch ridges. In bifurcation technique, first step is the minutiae Extraction [5]. In this step, binarized image is taken as an input image. Let T be the template which is in same size as binarized image and I be input dental radiographic X-ray image which we are trying to match. Then the sliding neighborhood window operation is performed over the binarized image.[6]. I and T may not have the same number of feature points which are compared to obtain the minutiae points. The second step in detection is the right and left enamel end points. This can be identified using the Centroid detection formula,

$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2} \quad (7)$$

2.4. Extracting Gum Eroded Region

Gum Eroded Region is also called “Gum Recession”. Gum Recession occurs when the protective tissue around the base of the tooth erodes, leaving the root of the tooth exposed. If left untreated, gum recession can cause tooth sensitivity and can also lead to further gum and bone loss. There are two causes for gum recession. (i). Tooth-Brushing Practices (ii). Periodontal Diseases. Many cases of receding gums occurs due to gum disease. When gum disease occurs, plaque and tartar collect at the gum line, irritating the gums. If left untreated, the gums begin to pull away from the teeth, forming deep, bacteria –filled spaces called pocket. Then by the right and left enamel end points the gum regions can be extracted from the input image.

2.5. Percentage of Gum Eroded Region

The percentage of Gum Eroded Region can be calculated by finding the number of eroded pixels in an image. The percentage of erosion can be shown in Table-1.

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Table-1 Percentage of Gum Eroded region

	TOOTH 1 AND 2	TOOTH 2 AND 3	TOOTH 3 AND 4	EFFECT
MANDIBLE TEETH	7%	14%	23%	HIGH SEVERITY (AFFECTED)
MAXILLA TEETH	7%	11%	12%	HARMLESS

III. RESULTS AND DISUSSIONS

In this paper, we worked with MATLAB 10.0 version. The input image of size 153 X 207 is used which is shown in Fig.4.

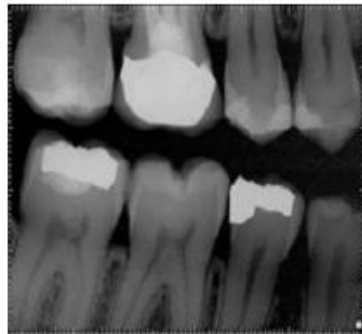


Fig.4 Input Image

The input x-ray image is pre-processed using second order Butterworth High Pass Filter .The radius considered for filter cut-off frequency is 10.5. The resultant edge enhanced image is shown in Fig.5.

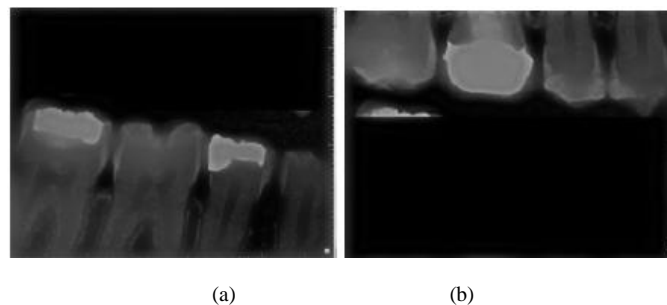


Fig. 5. Pre-Processed output for (a). Mandible Teeth and (b).Maxilla teeth

The Pre-Processed output is then sharpened using Laplacian of Gaussian. The resultant image is shown in Fig.6.

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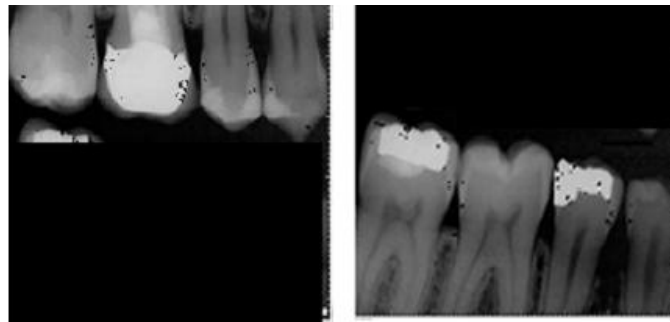


(a)

(b)

Fig.6. Laplacian of Gaussian output for (a).Maxilla Teeth and (b).Mandible Teeth

The Enamel End points are detected using the bifurcation detection. The bifurcated output is shown in Fig.7



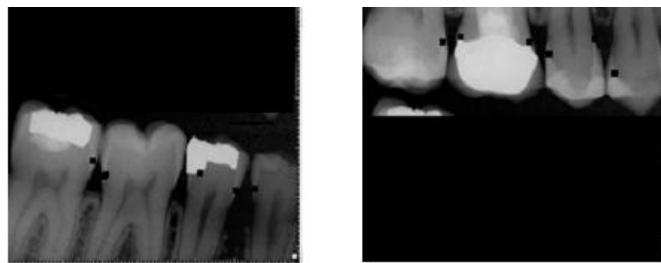
(a)

(b)

Fig.7. Bifurcated output for (a).Maxilla and (b). Mandible Teeth

In Healthy Teeth, the gum region lies between the enamel end points of adjacent teeth. If the teeth are affected by gum disease, the gum region is eroded below the enamel end points.

The enamel end points are extracted to find the gum region. The extracted enamel end points are shown in Fig.8.



(a)

(b)

Fig.8 Enamel End Point Detection (a). Mandible Teeth and (b) Maxilla Teeth

The Eroded Gum Region for the Mandible and Maxilla teeth is detected from enamel end points which is shown in Fig.9:

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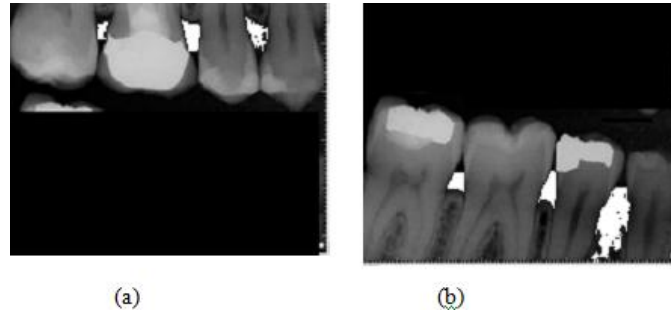


Fig.9 Gum Eroded Region Output for (a).Maxilla and (b). Mandible Teeth.

The Percentage of gum erosion can be calculated as shown in Table-1.

IV.CONCLUSIONS

This paper presents, an efficient technique for the diagnosis of periodontal diseases using a single radiographic x-ray image. This technique is tested for about 15 samples of images. The proposed method gives better results when compared with the previous technique. This study will help the dental surgeon to read an accurate diagnosis and treatment planning over the radiographs.

REFERENCES

- [1]. M.Analoui, "Radiographic Image Enhancement using Spatial Domain Techniques", Dentomaxillofacial Radiology (2001).
- [2]. E.Hekmatiana DDS, S.Shariff DDS, N.Khodaian DDS,"Literature Review Digital Subtraction Radiography in Dentistry", (2008).
- [3]. Mr. Anjan Bikash Maity, Mr. Sandip Mandal, Mr. Ranjan Podder," Edge Detection Using Morphological Method and Corner Detection. Using Chain Code Algorithm", International Journal of Computer Science Issues, Vol. 8, Issue 4, No 1, July 2011.
- [4]. Roli Bansal, Priti Sehgal & Punam Bedi " Effective Morphological Extraction of True Fingerprint Minutiae based on the Hit or Miss Transform ", International journal of Biometrics and Bioinformatics(IJBB), Volume (4) : Issue (2),July 2009.
- [5]. E. Hastings, "A Survey of Thinning Methodologies", Pattern analysis and Machine Intelligence, IEEE Transactions, vol. 4, Issue 9, pp. 869-885, 1992.
- [6]. Manvjeet Kaur, Mukhwinder Singh, Akshay Girdhar, and Parvinder S. Sandhu," Fingerprint Verification using Minutiae Extraction Technique", World Academy of Science, Engineering and Technology 2008
- [7]. Philippe Parra," Fingerprint minutiae extraction and matching for identification procedure".
- [8]. Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins,"Digital Image Processing using MATLAB", 2nd edition, pp 440-488