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REMOVING STRUCTURE NOISE BY TECHNICAL DERIVATIVE OF THE ORIGINAL IMAGE IN DIGITAL DENTAL RADIOGRAPHY

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ABSTRACT

The use of digital image processing has gained acceptance in dental diagnostic science. The major limitation of direct digital radiography (D D R) is noise. Noise in digital radiography may result from sources other than variation in projection geometry during exposure. Structure noise consists of all anatomic features other than those of diagnostic interest. Limitations of plain radiographs in detecting early, small bone lesions are also due to the presence of structure noise. This study will be under taken to apply image processing as an attempt to remove structure noise in digital dental radiography by using derivative original image. After derivative original image, the validity of the digitized image in detecting disease is enhanced.

KEYWORDS: Digital radiography, structure noise, bone lesions, derivative image.

1. INTRODUCTION

The dental radiographic image [1] is an essential appliance for the diagnosis of periapical bone lesions. These are pathological processes situated at or surrounding the apex of a tooth accompanied with local resorption of bone.

Detection and interpretation of the radiographic features leading to a diagnosis is carried out by human observers. Because this introduces subjectivity in the results, a high degree of variability might be expected.

Several investigations have not only confirmed this interobserver variability, but also revealed the intraobserver variability. This means that an observer does not always draw the same conclusions at different occasions[2-5].

The aim of this study is to develop a computer aided detection technique for periapical bone lesions. The purpose of computerizing the procedure is to make maximum use of the radiologic features, to objectify detection process, and ultimately to enable bone lesions to be assessed quantitatively. It described an application of

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digital image analysis for the description of periapical bone lesion in dental radiography. These techniques enable the problem of observer variability to be circumvented, and can eventually be used for the quantitative assessment of bone lesions[8-11].

Since periapical bone lesions appear radiographically as dark are as compared with their surrounding tissues, an edge-detection method is developed to extract the boundaries between anatomy and pathology. The original data were transformed in such a way that only the outlines remained. The lesion is assumed by a continuous outline, so all the contour points not being part of a continuous outline are excluded. With only limited operator interaction, the lesion contour could be projected successfully onto the original image.

The result of this operation is a simplified diagnostic examination process promising a higher degree of objectivity in periapical bone lesion detection. It is concluded that the results encourage further development of image processing techniques suitable for the definitive detection and diagnosis of periapical bone lesions[12-15]. We are tried by image processing and matlab program to calculate a first derivative of the next equations, denoted the derivative image and by using this method, we could remove structure noise in original image. Description of technical method and implementation of derivative formulation are shown respectively later.

2. DESCRIPTION OF TECHNICAL METHOD

Since improvement of overall image quality would automatically help to detect specific structures [1], in this study two assumptions are made: 1) a periapical bone lesion was considered dark in relation to its surroundings, 2) the outline of a periapical bone lesion was a closed contour. These assumptions imply a search for edges, in this case defined as boundaries between two regions with different mean gray levels. Usually we have to deal with smooth changes in gray level, with different kinds of noise superimposed. Edge detection was carried out by calculating a derivative function in eight directions [6] , [7]. Considering g (i, j) as the original data, the convolution function to calculate a first derivative is given by :

$$g'(i, j) = \max \Bigg[\left| \sum_{m=0}^{1} \sum_{n=-2m}^{2m} g(i+2n, j-2m-2) - g(i+2n, j+2m+2) \right|,$$
$$\left| \sum_{m=0}^{1} \sum_{n=-2m}^{2m} g(i-2m-2, j+2n) - g(i+2m+2, j+2n)) \right|,$$
$$\left| \sum_{n=0}^{2} \sum_{m=2-n}^{2} (g(i-2n, j-2m) - g(i+2n, j+2m)) \right|,$$
$$\left| \sum_{n=0}^{2} \sum_{m=2-n}^{2} (g(i-2n, j+2m) - g(i+2n, j-2m)) \right| \Bigg] \quad (1)$$

where g (i , j) denotes the original image and g' (i , j) the derivative image; i and j are pixel coordinates in a rectangular coordinate system.

This procedure resulted in high values (bright pixels) for regions with great gray level changes, and low values (dark pixels) for more homogeneous regions.

Next the picture was segmented into a binary image. The chosen threshold (T) was the mean gray level of the processed image (2):

$$T = \text{int}\left[\frac{\sum g'(i,j)}{256^2} + 0.5\right] \qquad (2)$$

The result of this operation is a binary image which shows a pattern roughly resembling the contour of the bone lesion being sought. When the contour of the presumed lesion is not continuous, the operator is required to indicate two points in the bright area, one on each side of a gap in the lesion contour, after which the gap is closed by finding a path of maximum values between those two points.

For testing the procedure, different endodontic radiographs with visible periapical bone lesions are selected. They are analyzed as described above, and the results are judged by comparison with direct observation of the original image. To test the reproducibility, a single image is analyzed many times, subsequently introducing three variables:

1) Repeated analysis of the same digitize image,
2) Repeated digitization and analysis with repositioning, and
3) Repeated digitization and analysis with repositioning. Repositioning was done by taking the radiograph from light box, and putting it back again in place in a reproducible way.

Because the relationship between gray level changes due to anatomical structures and due to pathological structures is not always favorable, the outline of the lesion contour is not always continuous. Although the remaining gaps usually are not very big, more specific features for distinguishing periapical lesions could reduce the problem, and with that the role of the operator will be reduced too. Further research should aim at this subject.

Considering the results of the repeated analysis of a single radiograph, the main influencing variables are the effect of operator interaction, and the inherent characteristics resulting from the imaging system. Although the influence of the operator is small already, the detection method should reduce this influence to a minimum.

It is concluded that the procedure may provide a more quantitative and reproducible assessment of periapical lesions than conventional interpretation of radiographs. Radiographic information can be used more effectively, while inter- and intra-examiner variability can be reduced.

Further investigations will focus on :

1) The development of methods of image processing which encompass the relationship between volume and area, as well as the relationship between radiographic and real extent of periapical lesions, and

2) The sensitivity and specificity of the procedure when applied to clinical radiographs, compared with observers.

3. IMPLEMENTATION OF DERIVATIVE FORMULATION

The derivative of the original image is resulted in high values (bright pixels) for regions with great gray level changes, and low values (dark pixels) for more homogeneous regions. The structure noise region in original image has a great gray level (bright pixels), after derivative original image, the bright pixels become dark pixels. Then structure noise is removed.

Edge detection [6] is an important problem in recognition of objects in images. When the edge detector is applied to an image, a picture is obtained consisting of edge points. Several general operations can be performed on this edge picture such as thinning of edges, tracing edge segments, joining edges, and so on. Algorithms are given that perform those operations. To show the power of the edge detector, an experiment is described in which rib boundaries are extracted in chest X-ray photographs.

A new edge detection system [7] is described, which is suitable for combining the detection and coding of visually significant edges in natural images. The edges are defined as amplitude discontinuities between different regions of an image.

The edges are defined as amplitude discontinuities between different regions of an image. The edge detection system makes use of 3 x 3 compass gradient masks, which are well suited for digital implementation. Edge angles are quantized to eight equally spaced directions, suitable for chain coding of contours. Use of an edge direction map improves the simple thresholding of gradient modulus images.

The concept of local connectivity of the edge direction map is useful in improving the performance of this method as well as other edge operators such as Kirsch and Sobel. The concepts of an "edge activity index" and a "locally adaptive threshold" an introduced and shown to improve the performance even further.

In recent years, computed radiography (CR), which provides direct digital acquisition of X-ray images, has been developed and widely accepted. Conventional radiographs have had problems in image data production and transfer, but a CR technique has resolved some of these limitations, although image quality apparently is inferior to that of conventional radiographs.[8-15].

Digital subtraction radiography scheme established for aligning clinical in vivo radiographs based on the implementations of an automatic geometric registration method and a contrast correction technique[16-18]. Matrix inversion tomosynthesis (MITS) uses linear systems theory, along with a priori knowledge of the imaging geometry, to deterministically distinguish between true structure and overlying tomographic blur in a set of conventional tomosynthesis planes[19,20]. Cone beam computed tomography (CBCT), which provides a lower dose, lower cost alternative to conventional CT, is being used with increasing frequency in the practice of oral and maxillofacial radiology.

RESULTS

Matlab program is used to verify every term and to indicate the maximum of all terms in Eq. (1) and the threshold chosen (T) in Eq. (2). After inserting the original image shown in Fig. (1) in the Matlab program, the final image shown Fig. (3) after derivative became a very clear image, and rendered edge detection of the lesion more sharp because structure noise is removed. Fig. (2) and Fig. (4) show histogram of original image and the final image respectively intensity of gray level at (x) axis and number of pixels at (y) axis.

4. CONCLUSIONS

After removing structure noise, digital radiographs increased diagnostic accuracy over digital radiography with structure noise. Removing structure noise offered a superb method of diagnosing periapical lesions affecting dental structures and clearly demonstrated any effects on the teeth and surrounding vital structures.

The human errors inherent with visual interpretation of dental diseases from images will be minimum due to increasing the image characteristics after noise removal. This is a step forward in achieving accurate diagnosis as well as increasing the utility of digitized radiographs in providing qualitative and quantitative information concerning the investigated diseases.

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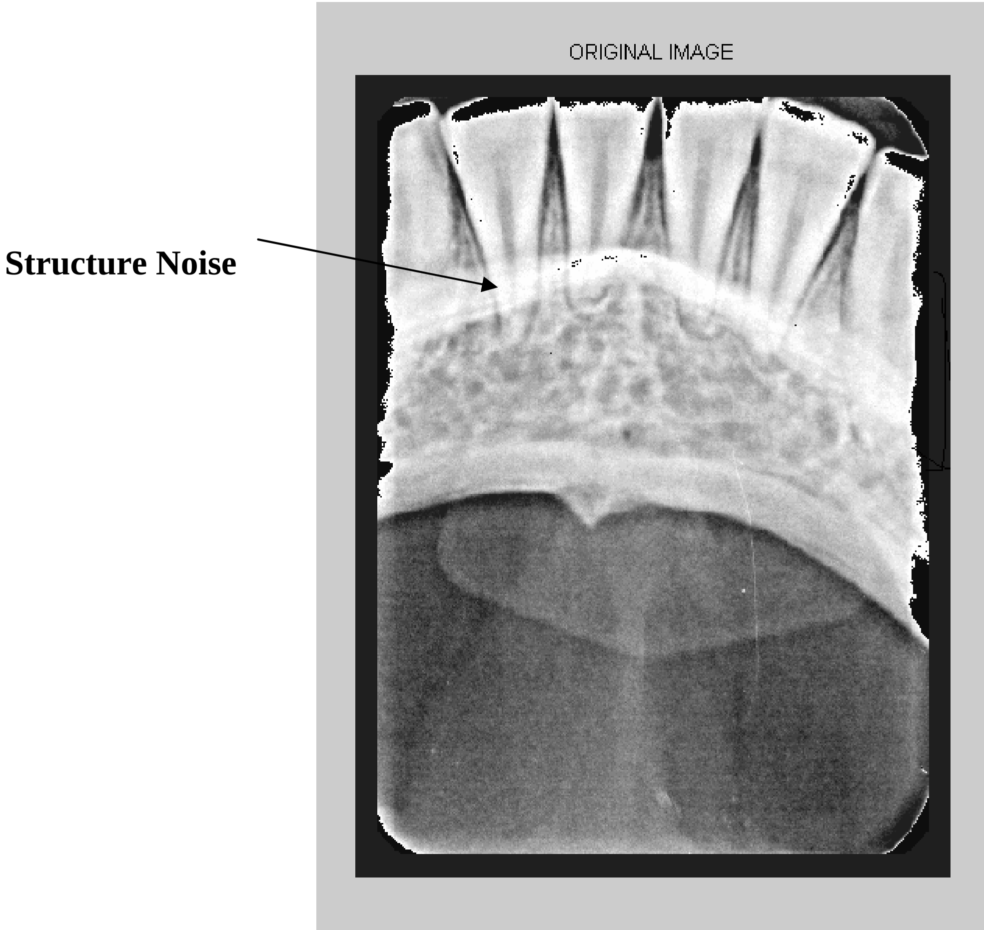


Fig.1. Original image with structure noise

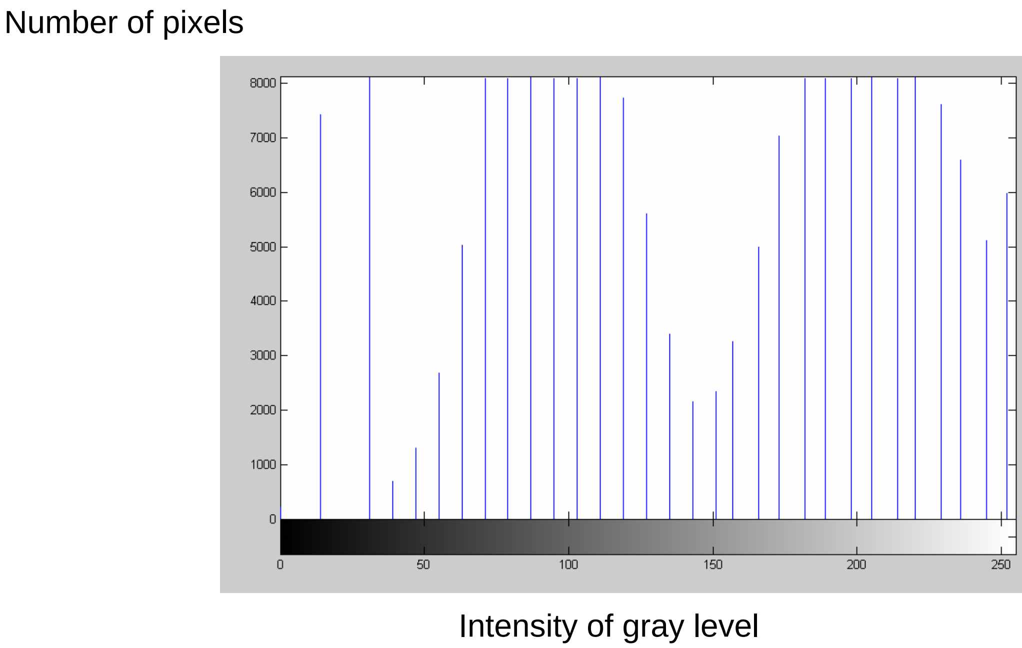


Fig. 2. Histogram of original image

Structure Noise

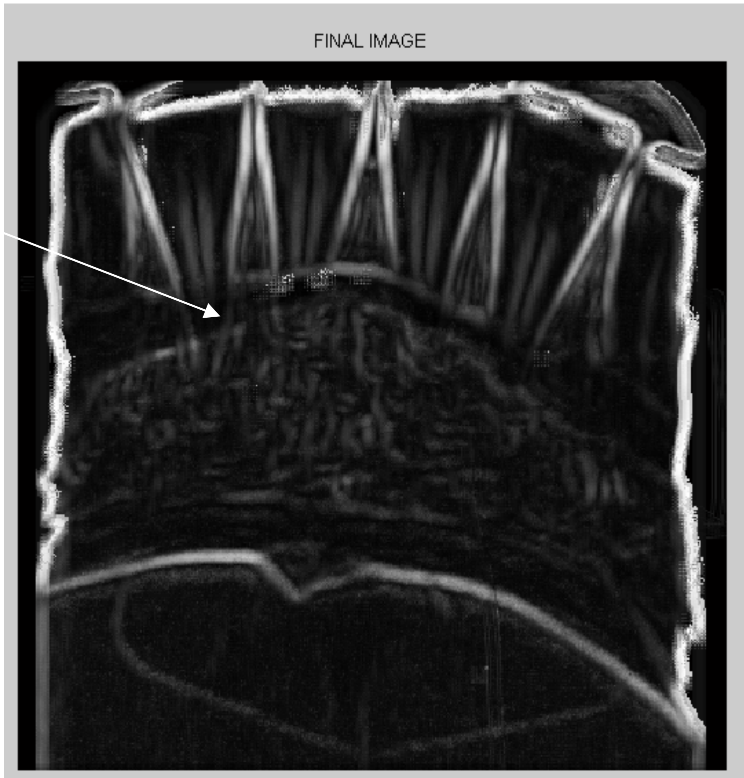
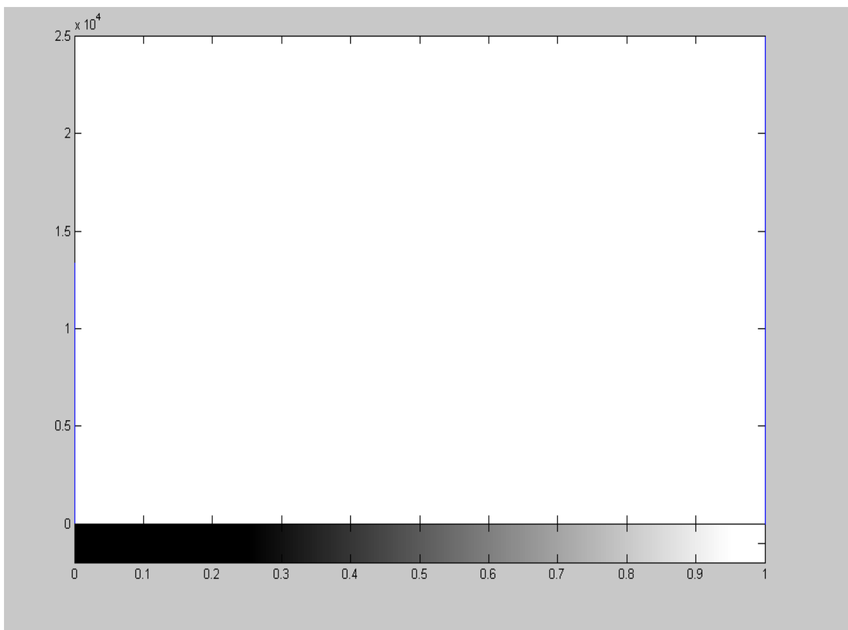


Fig. 3. Final image of original image with removing structure noise

Number of pixels



Intensity of gray level

Fig. 4. Histogram of final image