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Detection of Proximal Caries at The Molar Teeth Using Edge Enhancement Algorithm

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ABSTRACT

Panoramic X-Ray produces the most common oral digital radiographic image that it used in dentistry practice. The image can further improve accuracy compared to analog one. This study aims to establish proximal caries edge on enhancement images so they can be easily recognized. The images were obtained from the Department of Radiology, General Hospital of M. Djamil Padang Indonesia. Total file of images to be tested were 101. Firstly, the images are analyzed by dentists who practiced at Segment Padang Hospital Indonesia. They concluded that there is proximal caries in 30 molar teeth. Furthermore, the images were processed using Matlab software with the following steps, i.e. cropping, enhancement, edge detection, and edge enhancement. The accuracy rate of detection of edge enhancement images being compared with that of dentist analysis was 73.3%. In the edge enhancement images proximal caries edge can be found conclusively in 22 teeth and dubiously in eight teeth. The results of this study convinced that edge enhancement images can be recommended to assist dentists in detecting proximal caries.

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1. INTRODUCTION

Tooth decay also called dental cavities or dental caries. One type of dental caries detected using radiographic images is proximal or interproximal caries [1]. Caries is a problematic diagnosis [2]. The proximal tooth surface can hardly be approached or visualized directly, therefore, the caries on this surface are often diagnosed with the aid of radiographs [3]. Various methods in radiography have been performed to diagnose proximal caries [4-6]. Each method has its techniques, advantages, and disadvantages. But automatic diagnosis is still a challenging and unsolved problem [7], so that suitable technique is required in certain situations [8].

The radiographic image is the image used to prove the dentist's perception in diagnosing the dental caries disease [9]. Panoramic radiography produces an image that includes both maxillary and mandibular dental arches and the surrounding structures [10][11]. This image has an important role in clinical diagnosis and dental care. The dental clinical diagnosis usually includes the disease, the type of disease and the severity of the disease on the teeth. The image generated from radiography does not provide sufficient detail for tooth decay treatment and treatment procedures as it often overlaps with anatomical structures [12].

The machine of Panoramic X-Ray produces two outputs, namely analog (film) and digital images. Panoramic digital image provides better accuracy than analog [13], but the accuracy is still low in

comparison to other mode of radiographic image in caries detection [14]. And there was no significant difference in proximal caries detection using a variety of radiographic modes [15].

To observe the information in Panoramic X-Ray digital images more easily; it is necessary to perform image processing to improve the quality of the medical image [16]. Several studies have been done to improve the quality of the image to diagnose dental caries. Valizadeh et al. (2015) conducted a study to develop and assess the function of diagnostic computer software designed for evaluation of approximal caries in posterior teeth [17]. Miri et al. (2015) conducted a study evaluated the diagnostic accuracy of the reverse contrast mode in intraoral digital radiography for the detection of proximal dentinal caries, in comparison with the original digital radiographs [18]. Na'am et al. (2017) conducted a study to facilitate the identification of proximal caries in the Panoramic Dental X-Ray image [19]. Tikhe et al. (2016) conducted a study to present an algorithm using digital periapical radiographic images to detect enamel caries and interproximal caries [20].

In this study, we proposed a method of digital image processing of Panoramic X-Ray in edge detection to enhance image of proximal caries on molar tooth. The edge of teeth that curved into the tooth area is the identity of the proximal caries. The result of the digital detection is compared with clinical diagnosis of the dentist to obtain the level of accuracy of the study.

2. RESEARCH METHOD

This study aims to establish a proximal caries tooth edge in a digital image of molar teeth with improved quality. The stages of image processing performed are Cropping, Filtering, Enhancement, Segmentation, and Edge Detection with the result of enhanced edge detection. The whole process will produce four image files, i.e., as cropping image, enhancement image, edge detection image and enhancement image that has formed edge detection. Stages of the process performed are shown in Figure 1.

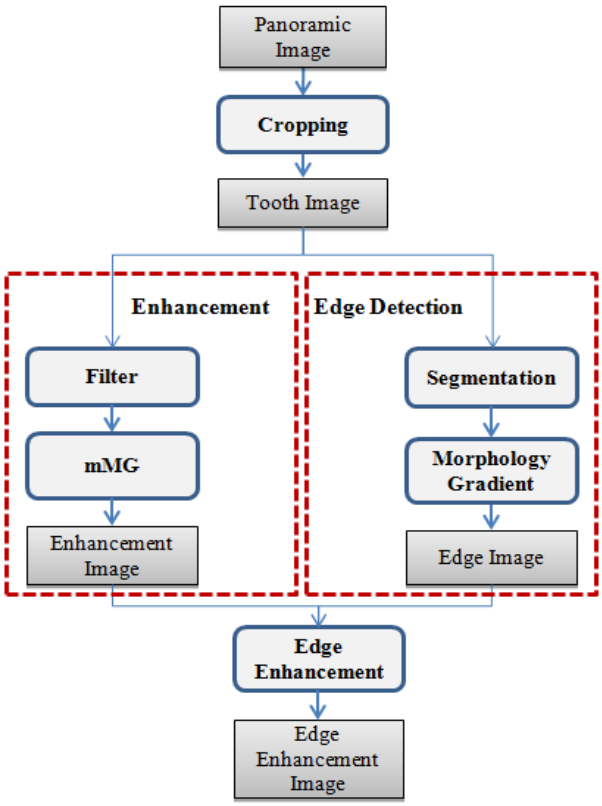


Figure 1. Stages of Image Processing

Images of this research data were obtained from the Radiology of Central General Hospital Dr. M. Jamil Padang Indonesia. The hospital is a government type B as educational hospital located in the city of Padang, Indonesia. The Panoramic X-Ray equipment used in this hospital is branded Pantos DG XP

products from BlueX Italia. This tool produces an image plate with a size of 15x30 centimeters and gray level digital image with Portable Network Graphics (PNG) format. The pixel size of the digital image is 2764x1330 pixels. In Figure 2 below is one of Panoramic X-Ray digital image that is processed and has its tooth numbering.

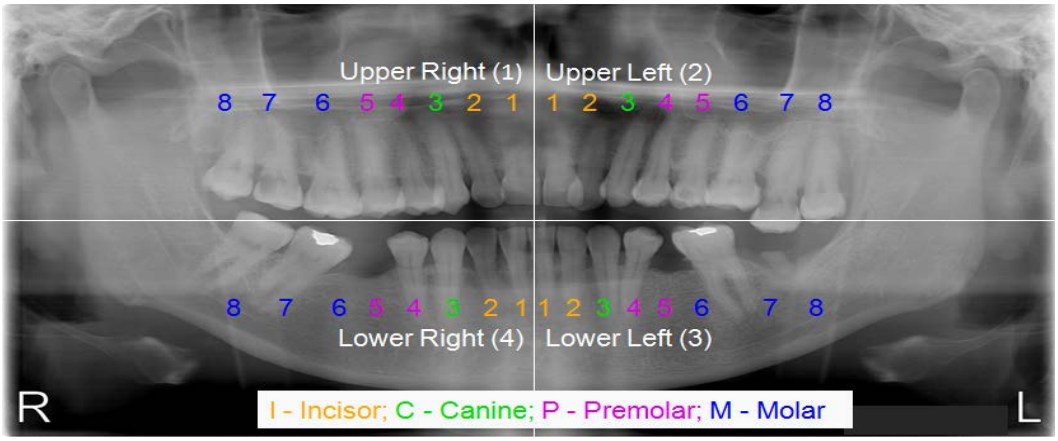


Figure 2. Notation of teeth [21]

The total of digital images processed in this study was 101 images. All images analyzed by dentists of Semen Padang Hospital to detect proximal caries in a molar tooth. The result of the analysis was that there were 23 Panoramic X-Ray images of proximal or interproximal caries. Previously, these photos were used to study accuracy using multiple Morphological Gradient (mMG) [22]. In these 23 Panoramic X-Ray images, there are 30 molar teeth of proximal caries sufferers. These 30 teeth images were processed in this study with Matlab software.

3. RESULTS AND ANALYSIS

The image presented in this paper is Panoramic X-Ray image in Figure 2. The result of analysis by the dentist that there are proximal caries in the molar teeth, i.e. number 17 (upper right number 7) and 27 (upper left number 7). Furthermore, we proceed with cropping process.

3.1. Cropping

The cropping is the process of taking the tooth area to be processed next. The cropping technique used in this study was still manual [23]. This method produces a square area with the determination of the starting point which is drawn diagonally. The diagonal starting point could start at any point, such as the upper left; top right; bottom left; or bottom right. Next we draw the diagonal to get the endpoint, so that the cropping area model could select one of the following four models, such as Figure 3. The cropping model used for the test image is from the top right to the lower left. The cropped image is shown in Figure 4. The cropped image represents the area of the proximal caries that has been separated from the Panoramic X-Ray area. This area is already separating the teeth for the next process.

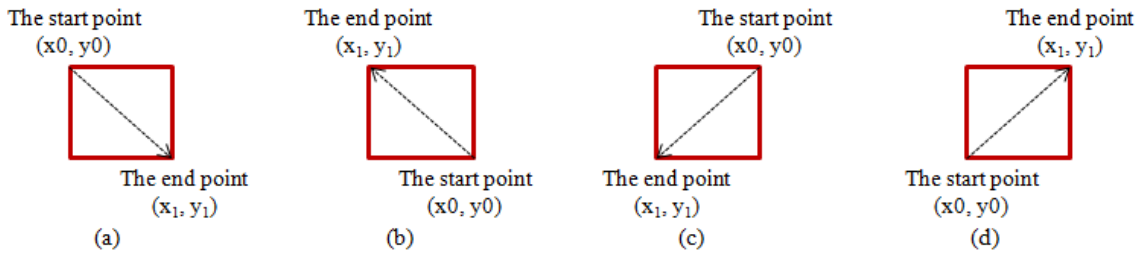
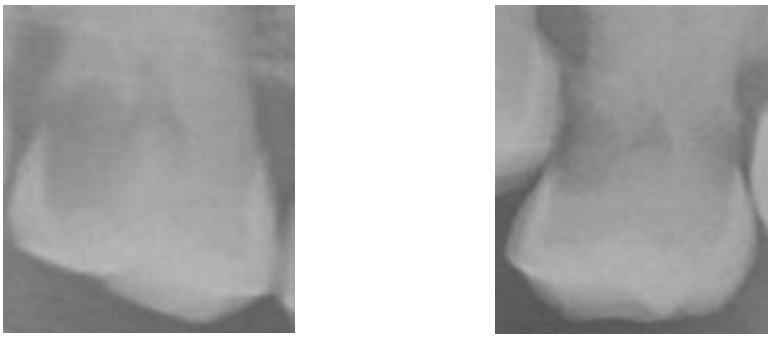


Figure 3. Models of cropping area (a) the top left to the bottom right, (b) the right down to the top left, (c) top right to the bottom left, (d) the bottom left to the top right

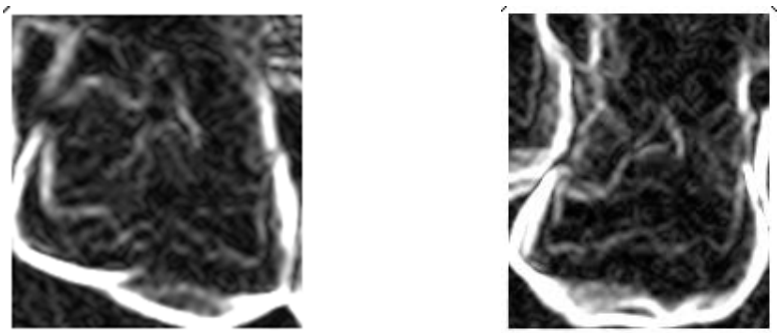


(a) (b)

Figure 4. The cropping image (a) 17th tooth, (b) 27th tooth

3.2. Enhancement

Image quality and accuracy are the core factors, image quality assessment, as well as improvement, are depending on the enhancement [24], [25]. Enhancement aims to improve image quality while edge detection form the edge of the tooth. Both of these processes have different algorithms, so both processes were separated. Enhancement aims to clarify the information contained in the cropped image. Enhancement process consists of two stages, namely Filtering and mMG. The filtering is the process of removing noise that is eliminating the pixel value that is too low, or the value that is too high from the value of surrounding pixels in an image. These noise pixels are scattered randomly and improperly. The filtering technique is performed using Gaussian method [26]. Next, the filtered image is processed by mMG method [27]. The result of Enhancement images process can be seen in Figure 5.



(a) (b)

Figure 5. The result of enhancement process (a) 17th tooth, (b) 27th tooth

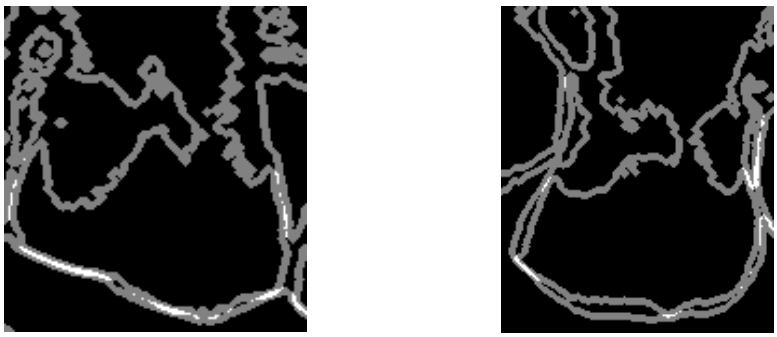
In the enhancement process it has been able to form objects clearly. This method works to increase the pixel value that makes up the object and the pixel value of the fixed background. However, the edge of the object has not been set clearly. The reason is that the difference in pixel values of objects is not so significant. For that, a separate process for edge detection is performed.

3.3. Edge Detection

The edge detection process aims to form the edge of each object of the cropped image clearly. This process consists of 2 stages, namely segmentation and forming an edge. Medical image segmentation will seek to improve the accuracy, precision, and computing speed of the segmentation method, as well as reduce the number of manual interactions [28]. Process segmentation is performed using Otsu [29], and edge technique is performed using Morphology Gradient. The purpose of Morphology Gradient is to reduce the result of Dilation Morphology with Erosion Morphology [30]. The equation as follows:

$$Ed=Md(o)-Me(o) \quad (1)$$

where: Ed: The result of edge detection image
Md: Dilation morphology
Me: Erosion morphology
o: The result of Otsu image
The result of edge detection image can be seen in Figure 6. In the result of edge detection image, the boundary edge of the object has been formed clearly.



(a) (b)

Figure 6. The result of edge detection process (a) 17th tooth, (b) 27th tooth

3.4. Edge Enhancement

Furthermore, the process of forming edge detection of enhancement image based on the pixel of edge position on edge detection image. So to clarify the edge borders on the enhancement is the formation of edges based on a pixel position at edge detection. The edge pixel position on the edge detection image is adjusted to the location of the enhancement image and then replaced with the highest value in the enhancement image. Then the edges of the image enhancement can be seen clearly. The algorithm used edge enhancement with equation as follows:

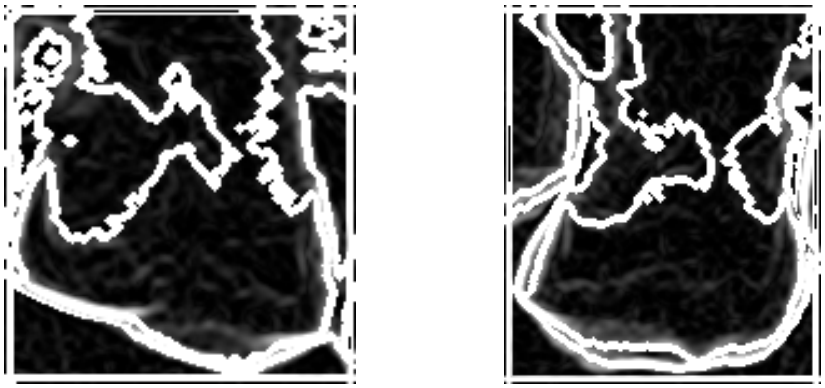
$$mMG(x,y) = mMGmax \mid Ed(x,y) = 128 \quad (2)$$

Code of algorithm is as follows:

Edge enhancement algorithm

```
Input: mMG, Ed
Output: mMG
    Initialization i, j
    Get line, column, max
    [line,column] = size(mMG)
    max=0
    for i = 1 to line do
        for j = 1 to column do
            if max < mMG(i, j)
                max = mMG(i, j)
            end if
        end for
    end for
     for i = 1 to line do
        for j = 1 to column do
            if Ed(i, j) =128
                mMG(i, j) = max
            end if
        end for
    end for
```

The result of edge enhancement image can be seen in Figure 7.



(a) (b)

Figure 7. The result of edge enhancement process (a) 17th tooth, (b) 27th tooth

Edge enhancement results have been clearly detected directly against the proximal caries, the edge of the tooth that protrudes into the tooth. The entire process tested on 30 molar teeth found in proximal caries that have been analyzed by the dentist. The detection result is 22 recognized from 30 teeth. Thus, the accuracy is as follows:

Accuray = (Total of detected/Total of teeth tested)x100%
= 22/30x100%
= 73,3%

So the accuracy of this method is 73.3%.

4. CONCLUSION

Based on the image tested, that can form edge on the image enhancement as the edge of proximal caries, this study may be recommended to assist dentists in reducing the hesitation in detecting proximal caries. The existence of an unclear edge, because the edge of caries overlaps with the edge of other teeth.

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