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Accuracy of Panoramic Dental X-Ray Imaging in Detection of Proximal Caries with Multiple Morpological Gradient (mMG) Method

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***Abstract*— Dental caries is tooth decay caused by bacterial infection. This is commonly known as tooth decay. Classification of caries by location consists of; occlusal caries, proximal caries, root caries and caries enamel. Diagnosis of dental caries in general carried out with the help of radiographic images is called Dental X-Ray. Dental X-Ray consists of bitewing, Periapical and Panoramic. Identification of proximal caries using Dental Panoramic X-Ray lowest precision was compared with both other Dental X-Ray. This study aims to perform sharpening and improving the quality of information contained in the image of Panoramic Dental X-Ray to clarify the edges of the objects contained in the image, making it easier to identify and proximal caries severity. The methods and algorithms used are multiple Morphology Gradient (mMG). The results obtained are increased accuracy in identifying proximal caries 47.5%. Based on the severity of it, that level of enamel = 47.37%; dentin rate = 42.1% and the rate of dentin = 1.3%. Accuracy level of accuracy in identifying proximal caries a higher level of email, so that patients with proximal caries early levels can be tackled early handling by the dentist.**

***Keywords*— Proximal Caries; Caries; multiple Morphological Gradient (MMG); Panoramic X-Ray; Smoothing and Sharpening the Edges of Objects.**

I. INTRODUCTION

Image pattern recognition is a science to classify or describe something by the quantitative measurement of the image or the nature of the object. The pattern itself is an entity defined, can be identified and given a name. Patterns can be a collection or monitoring and measurement results. It can be expressed in a vector or matrix notation [1]. In the image pattern recognition can also be done the selection process to get the kind of image that will be used in image processing [2]. Image used in this image processing, consists of various types of image file formats such as * .bmp, * .tif, * .png or * .jpg [3].

In medicine, image processing is an example of the application of information technology in the medical world. Information technology in the medical world increasingly broad and very important, such as CT Scan (Computed Tomography Scan) or sometimes called CAT scan (Computerized Axial Tomography Scan), which can be used to view the piece or a cross-section of the human body. Tomography is the process to produce a two-dimensional image of the object three-dimensional pieces of a number of one-dimensional scanning results. One of the concepts of information technology applied is to perform image processing to perform sharpening or improve the quality of information contained in the image, so it can be interpreted correctly by the human eye [4].

Panoramic Dental x-rays is a tool that produces a two-dimensional image to help in finding the caries [5]. Dental caries is a process of chronic, regressive begins with the dissolution of minerals enamel, as a result of disruption of the balance between the enamel and surrounding areas caused by acid formation of microbes on the substrate (medium food for bacteria), followed by the onset of destruction of organic components which eventually happened cavitation or holes [6]. Hole created will cause the occurrence of damage to the tissues of the tooth ranging from enamel, dentin and to the pulpa. Tooth holes starting from the enamel to the pulpa spaces contain nerve fibers and blood vessels that are causing the pain [7], can even lead to heart disease and stroke [8].

Types of dental caries can be distinguished into four types, namely Oklusal, Proximal, Email and root [9]. The fourth type of caries, the most difficult to detect is the proximal caries [10]. This type cannot be detected visually or manually by simply using the tool of dental Explorers (diagnostic) teeth [11], so that the examination be radiography x-ray image is indispensable to facilitate in identifying the proximal caries [12], [13].

The image of X-ray can show cavities (caries), teeth are hidden, and the bone that seems to disappear which can not be seen during visual examination [14], [15]. Types of Dental X-Ray used to detect dental caries consists of bitewing, periapical and panoramic [16].

The third type of Dental X-Ray on the least thoroughness in identifying proximal caries is Panoramic Dental X-Ray [17] - [25]. It is necessary for the process of improving the quality of the image. it is very important in medical imaging analysis, in order to identify further improved proximal caries.

II. MATERIALS AND METHOD

In the system of Image Processing in Medicine Dental Panoramic X-Ray, there are several stages of the process and sub-process in order to produce images that are easily observed and checked by the user in identifying proximal caries. The process steps starting from image acquisition, but this stage is not depicted in the system because the image required have been taken directly into the Radiology Dr M. Djamil Padang.

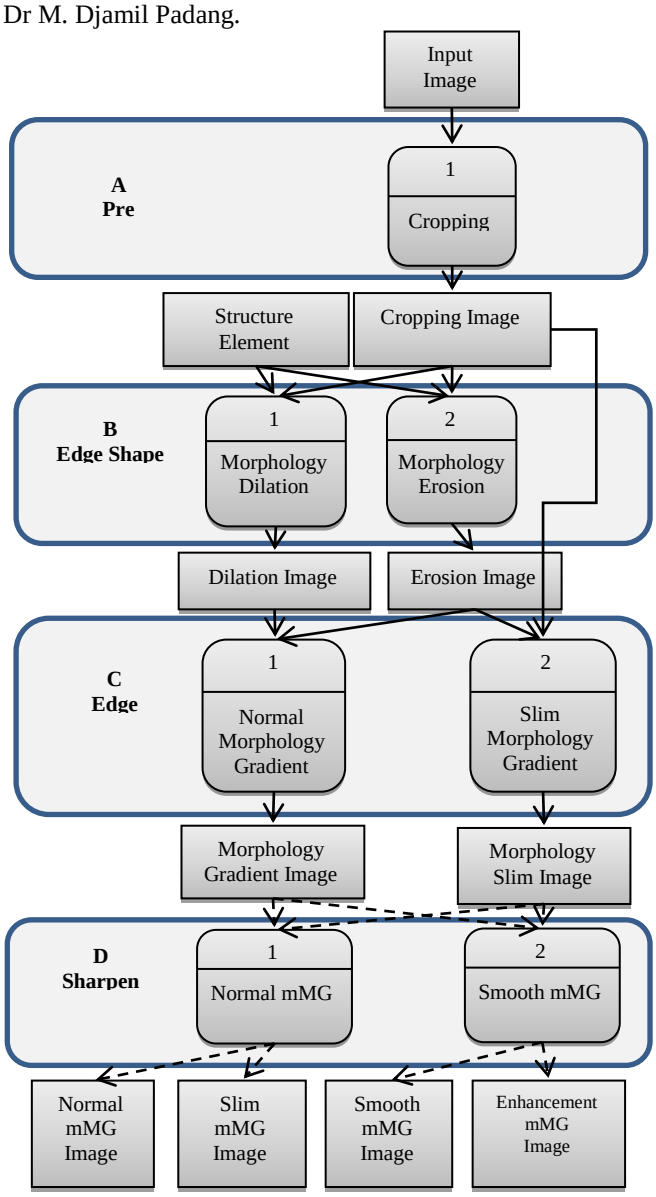


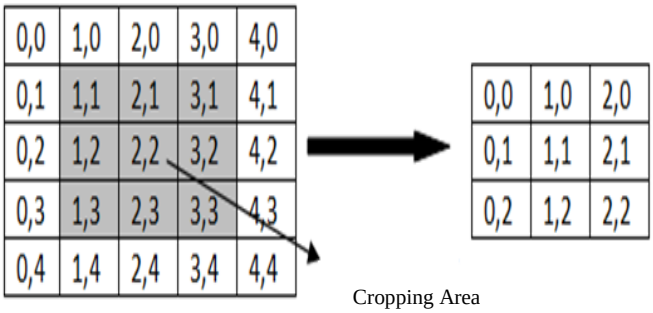
Fig. 1 Flow Diagram mMG Process

The image is processed is the image of Panoramic Dental X-Ray grayscale as a file format * .png and a pixel size of 2764 x 1330. The image consists of 101 files softcopy imagery. The image of the entire first examined by a dentist with the results of the image 58 patients with no caries; Image 27 patients with proximal caries; and 16 patients with caries image of the other.

Image processed by the system is just the image of patients suffering from proximal caries, image 27 files. This image file into the Input Image in the system. After that the process illustrated in the flow diagram mMG following process (Fig. 1).

A. *Pre-Processing*

Cropping is the process of cutting the image area, only the area required as input. it for further processing. Cropping technique used is the separation of horizontally and



vertically and horizontally [26], [27], [28], [29], as shown in Fig. 2.

Fig. 2 Ilustration of Cropping [32]

Cropping is aiming to eliminate unnecessary parts and only get the required area (Region of Interest) in the next process. on the side and the top of the bottom image Panoramic Dental x-rays there are other parts that are not needed (noise). Teeth on image Panoramic Dental x-rays are present in one group, then for the cropping process required two point coordinates. One point coordinates for the part (point) top left (the position of the patient's right or [R]ight) and one point coordinates for the part (point) lower right (the position of the left side of the patient).

B. *Edge Shape*

Edge shape is the process to form the edges of objects on images by using the process morphology. Morphology is a process that uses mathematics as a tool for taking a useful image component to display and describe the region shape (such as boundaries, skeletons and convex hull). Mathematical morphology to function as a means of extracting useful image components in the representation and description of the form region. Process morphology that is used consists of morphology dilation morphology and erosion.

Morphological image processing is carried out in a way her passing a structuring element to an image. This way is almost the same as the image convolution. it aims to obtain information about the form of an image by adjusting the shape and size of a structural element.

Structuring element (strel) can be likened with the mask on the image processing (not by morphology). Strel also have a shaft (also known as the point of origin). Point of origin is marked with a black dot. If there is no sign of black dots then assumed the point of origin is in the Centre of symmetry [31]. Strel has two key components, namely the shape and size, both of which greatly affects the results of the operations of the morphology and axis point also owns strel (also known as the point of origin). Point of origin is marked with the sign of the black box. Strel is used in this research is shaped disks with a size of 2 x 2.

1	1
1	1

Fig. 3 Element disk Stucture [2x2]

Effects of strel is:

- on morphological dilation, do not generate the object the more wide
- on the morphological erosion, then no object is missing.

1. *Morphology Dilation*

It's the process of widening or growing areas (objects). Area or object in question is an area that has a high intensity on image gray level. Image of A dilation by the structure of the elements of the matrix B with dilation with notation as follows:

$$A \oplus B = \{z \mid (B)_z \cap A \neq 0\} \quad (1)$$

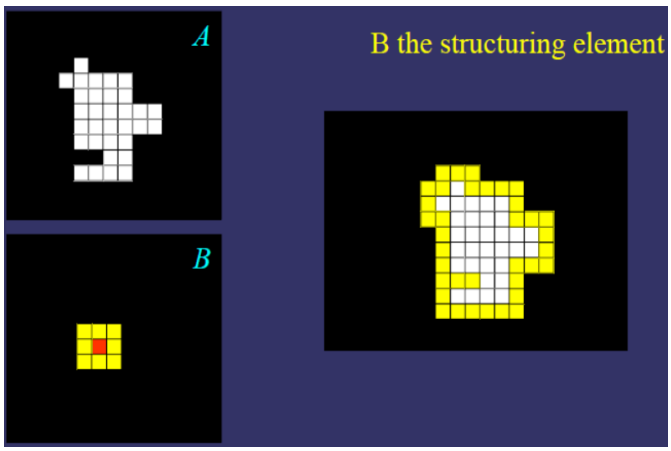


Fig. 4 Ilustration of Dilation

2. *Morphology Erosion*

This is a process shrink or diluting the area or object. An area or object in question is one that has high intensity on gray level image. This operation is opposite to the dilation operation. Erosion image A by matrix B element structure denoted as follows:

$$A \Theta B = \{z \mid (B)_z \subseteq A\} \quad (2)$$

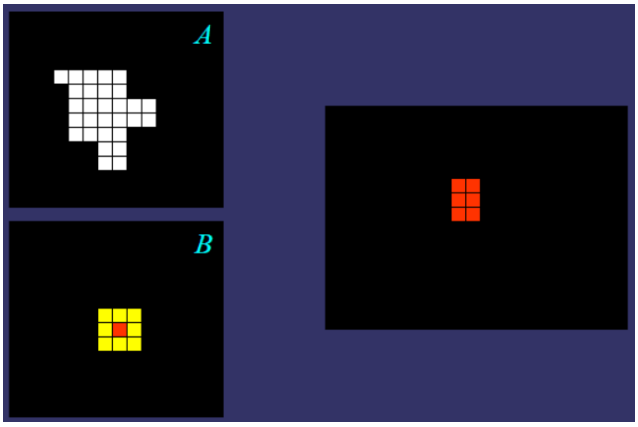


Fig. 5 Ilustration of Erosion

C. *Edge Detection*

The image data input in the form of a grayscale image Panoramic Dental X-Ray. It's processed to form the edges of objects, so that the objects contained in the image can be observed, especially the edges of objects caries. From a number of existing algorithms, the most appropriate use is morphological gradient. This process can widen and clarify the edges without removing or filtering out a lot of information.

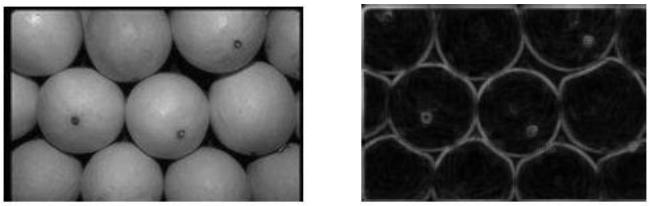


Fig. 6 Ilustration of Edge Detection [9]

Widening edge elements can be arranged through the structure and operation of morphological gradient itself. Operation morphological gradient used consisted of two, namely reducing the dilation results in erosion of the so-called normal morphological gradient; and reduce the cropping with the erosion of the so-called slim morphology gradient.

1. *Normal Morphology Gradient*

Normal morphology gradient is the process that produces an output in the form of an image obtained from a reduction in dilation results with the results of erosion. In this process can form the edges of the objects contained in the image. Notation morphological gradient is denoted as follows:

$$g = (A \oplus B) - (A \ominus B) \quad (3)$$

2. *Slim Morfologi Gradient*

Slim morphological gradient is the process that produces an output in the form of an image obtained from a reduction in cropping results with the results of erosion. In this process can form the edges of the objects contained in the image thinner than normal morphology gradient. Notation slim morphological gradient is denoted as follows:

$$g = A - (A \oplus B) \quad (4)$$

D. Sharpen Edges

Sharpen Edges is a process to clarify the edges of objects on the image. The process that occurs in Sharpen Edges consist of mMG normal and mMG smooth. MMG is a multiple Gradient Morphology that do the process over and over against the edge detection

At this stage of the process of edge detection. the image of Panoramic Dental x-rays, the resulting image has been able to form the edges of the object by either including the edge object caries, but looks a bit Dim. This is due to the intensity of caries objects contained in a lower gear than the object of the tooth itself. On the basis of this need for sharpening or increase the intensity from the edge of the object so that the object can be clearly recognized by the naked eye and each object in the image can be identified. To sharpen the edges of the objects, a process mMG with the following formula:

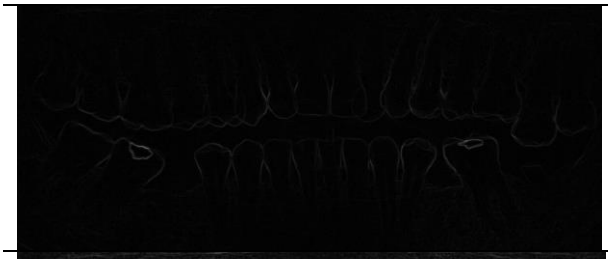
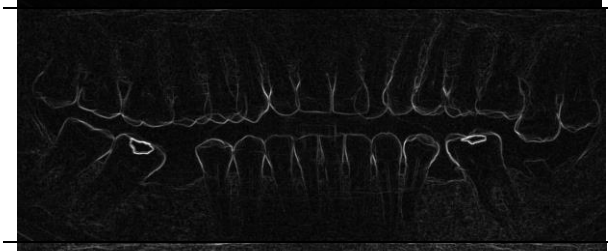
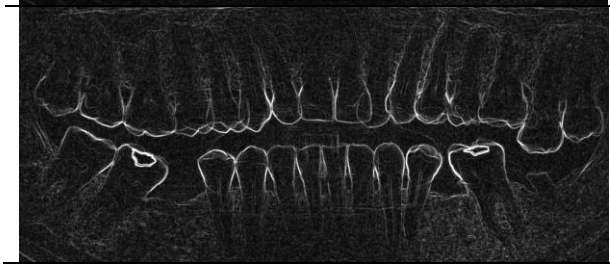
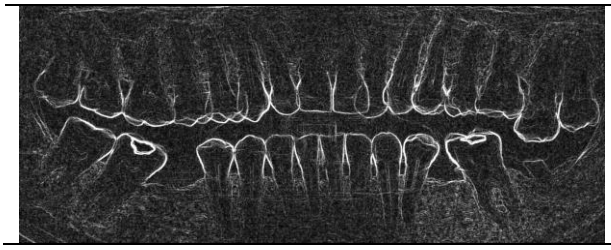
$$mMG = m.g \tag{5}$$

m is a lot of looping, this value based on the intensity of the image. The higher value of the an image intensity, then the value of m increases. The formula to get the value of *m* with the following notations:

$$m = \frac{\max(\max((A \oplus B) - (A \Theta B)))}{w} \tag{6}$$

w is bit.depth x 256. Bit.depth a bit depth of an image containing information on the number of colors that exist in each pixel of the image. *m* is a lot of looping process morphology gradient

TABLE I
STAGES OF THE PROCESS MMG

STAGES mMG	N
	1x
	4x
	8x
	12x

mMG process consists of two algorithms, yatu normal and smooth mMG [32].

1. *Normal mMG*

   Normal mMG process by multiplying all pixel image of the edge detection with m. The results obtained are two types of images, the appropriate type of edge detection is used, whether normal morphology gradient image of the normal form of mMG Image or slim-type morphology gradient image of the slim pickings in the form of mMG Image.

2. *Smooth mMG*

   Smooth mMG functioning sharpens and smoothes the edges of objects in the image. The process is carried not all pixels multiplied by m, But the pixels of value greater than or equal to the minimum value of Multi Thereshold

To obtain the minimum value Multi Threshold [33] used the formula

$$T(A) = \begin{cases} 0, A < q \\ m, A \geq q \end{cases} \tag{7}$$

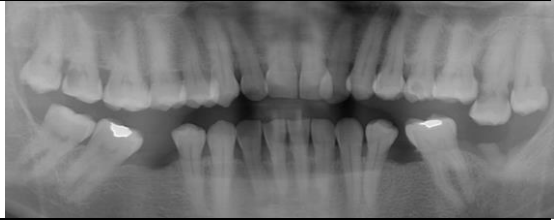
Where $0 < q \leq A_{max}$.

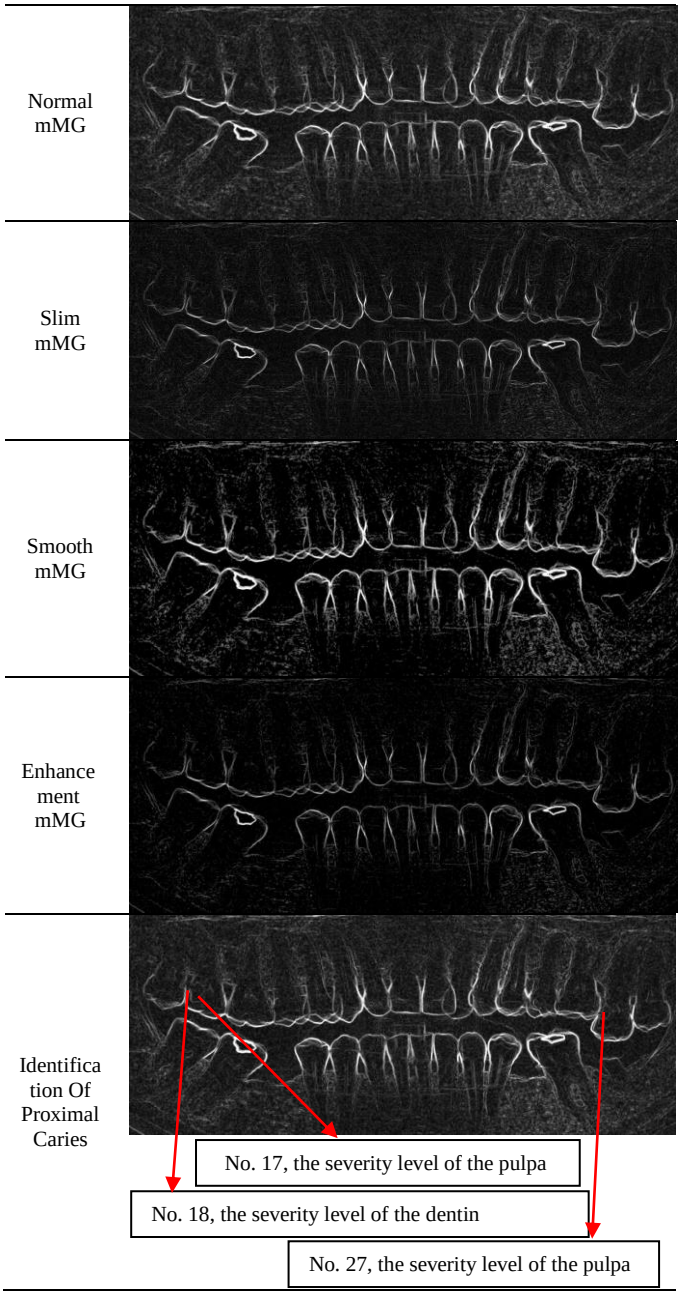
So the notation mMG

$$mMG = m.g, \text{ jika } g >= T(A) \tag{8}$$

In the table below is an image of the shape of each process from the overall process of this system

TABLE III
PROCESSING WITH MMG

Process	Citra
Input	
Cropping	



After all stages of the image of the proximal caries patients, the identification by the two dentists with proximal caries characteristics of the object as follows:

- boundary edges that connect teeth as proximal caries identity
- boundary edge that protrudes into the tooth (email, dentin or pulp) as an indicator of severity.

The results of the testing and data processing can be seen in the following table:

TABLE IIIII
RESULTS AND PROCESSING DATA

No	File Name	Before			After		
		G	T	amount	G	T	amount
1	RSUP-Pano-001	47	3	1	47 3 17 1		2
2	RSUP-Pano-006	22 3 32 3		2	22 3 32 3		2
3	RSUP-Pano-008	21 2 22 2 41 2		3	21 2 22 2 27 1 41 2		4
4	RSUP-Pano-009	36	3	1	36	3	1
5	RSUP-Pano-010	17	3	1	17 3 18 1 27 3		3
6	RSUP-Pano-026	13 2 36 2 46 2		3	13 2 36 2 46 2 47 1 26 2		5
7	RSUP-Pano-030	38 3 46 3		2	38 3 46 3 27 2		3
8	RSUP-Pano-032	37	2	1	37	2	1
9	RSUP-Pano-039	47 3 48 3		2	47 3 48 3		2
10	RSUP-Pano-045	46	3	1	46	3	1
11	RSUP-Pano-046	47	3	1	47	3	1
12	RSUP-Pano-048	27	2	1	27 2 17 1		2
13	RSUP-Pano-062	37	3	1	37	3	1
14	RSUP-Pano-066	17 3 18 3		2	17 3 18 3		2
15	RSUP-Pano-069	47	2	1	47 2 18 1		2
16	RSUP-Pano-072	27 3 48 3		2	27 3 48 3		2
17	RSUP-Pano-073	47	3	1	47	3	1
18	RSUP-Pano-079	24	3	1	24 3 16 2		2
19	RSUP-Pano-080	23 2 24 3 26 3		3	23 2 24 3 25 3 26 3		4
20	RSUP-Pano-082	37	2	1	37 2 47 2		2
21	RSUP-Pano-084	47	2	1	47 2 38 2		2
22	RSUP-Pano-087	38	2	1	38	2	1
23	RSUP-Pano-093	37 3 47 3		2	37 3 47 3		2
24	RSUP-Pano-095	46	3	1	46 3 17 1 18 1		3
25	RSUP-Pano-096	46	3	1	46 3 27 2		2
26	RSUP-Pano-097	16	2	1	16 2 17 2 18 1		3
27	RSUP-Pano-101	26 3 35 2		2	26 3 35 2 34 2		3
	Amount			40			59

Information :

- G: Number of proximal carious teeth
- T: The severity (1-Enamel; 2-Dentin; 3-pulp)

Improved accuracy for proximal caries detection with image processing:

$$\frac{59-40}{40}\times 100\% = 47.5\%$$

TABLE IVII
DETECTION PROXIMAL CARIES 27 PANORAMIC IMAGE BASED ON THE SEVERITY LEVEL BEFORE AND AFTER IMAGE PROCESSING

The severity	Pre-processing the image	Post-processing the image
Enamel	0	9
Dentin	15	23
Pulpa	25	27
Amount	40	59

Information:

- Severity: 1-Enamel; 2-Dentin; 3-pulp
- Many dental patients with proximal caries were identified after processing whereas prior to processing is not identified as much as 59-40 = 19 teeth.
- Improved accuracy for the identification of proximal caries after processing is:

$$\frac{19}{40}\text{x}100\% = 47{,}5\%$$

Distribution of proximal caries identification accuracy improvement based on severity are as follows:

TABLE VV
DISTRIBUTION FOR INCREASING THE ACCURACY IDENTIFICATION BASED PROXIMAL CARIES SEVERITY

No	The severity	Percentage		
1	Enamel	$\frac{9-0}{19}\times 100\%$	=	47.4%
2	Dentin	$\frac{23-15}{19}\times 100\%$	=	42.1%
3	Pulpa	$\frac{27-25}{19}\times 100\%$	=	10.5%
	Amount			100%

Based on the results of the calculation accuracy increase in distribution towards the proximal caries severity based on the above, the increased accuracy of identification of proximal caries with email being the highest level, i.e., 47.4%, so that the system is better in detecting proximal caries rate of email or the initial level, so the patients sufferers of proximal caries of early responses can be solved by a dentist before becoming more severe.

III. CONCLUSIONS

The methods and algorithms mMG can clarify the image of Panoramic Dental X-Ray, so the intensity of the objects contained in the teeth can be improved as compared to the intensity of the tooth itself. mMG is much easier to identify proximal caries and caries severity of it, so it can be one of the indicators for the treatment of patients properly by a dentist. Improved detection accuracy of 47.5% with a correlation coefficient of 0.7181. mMG is also more precise method for identifying proximal caries enamel stage (beginning), so that patients with proximal caries can be treated early.

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