**Generation of Teeth Caries Features for Human Dental Caries Classification**

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| **Abstrak :**  Many dental diseases are experienced by humans, one of which is dental caries, there are three types of human dental caries, namely enamel caries, dentin caries and pulp caries. This study contains the detection of caries disease in human teeth using two-dimensional images and radiological results of x-ray periapical radiographs from a test image dataset that has a number of pixels between 374x288 to 672x514 pixels with an image resolution of 96 DPI. The original data of existing dental images was processed using Matlab language to obtain caries features through three stages of the processes: pre-processing stage which are stages of the preprocessing process that converts data from a two-dimensional color image (row/height, column/width) that is stored using three channels Red, Green and Blue (RGB), into a grayscale image with one channel, the process of extracting dental caries features by performing calculations caries area and calculate the distance of the caries area to the nerve canal (pulp), and the process of building learning or reference data from dental caries using 24 radiograph periapical data on molar tooth images processed using Matlab. Dental caries features extraction process and the features learning process to generate references features from dental caries is the main objective of this research. This study result was references features for human dental caries classification. | **Keywords**:  dental image,  detection,  features,  learning data,  dental caries,  periapical radiograph.  **Article history:**  Received Jul 30, 2021  Revised Sep 10, 2021  Accepted Sep 10, 2021  **DOI**: 10.22441/incomtech.v10i3.7777 |

**1. INTRODUCTION**

Imaging technology in the medical field is used to analyze data sets related to health data. Medical Imagery in fields such as ophthalmology, cardiology, gynecology, orthopedics, periodontics and neurology is increasingly playing an important role. Oral disease diagnosis in dentistry has used image processing actively in recent years. Intra Oral and Extra Oral Radiography is a diagnostic technique used in dentistry. Various types of dental infections can be identified and found using this imaging system. Using dental radiographs, experts can detect a number of diseases such as: dental caries, gum disease, abscesses and others [1]

Image is a representation of the information contained there in so that the human eye can analyze and interpret the information in accordance with the expected goals. Image information content can be divided into two parts, namely basic information and abstract information. Basic information is information that can be processed directly without the need for special knowledge. This basic information is color (colour), shape (shape), and texture (texture). Abstract information is information that cannot be processed directly except with the help of additional special knowledge. Mathematically, an image can be defined as a two-dimensional function f(x, y), where x and y are the spatial coordinates (plane) and f is the color intensity value at the x and y coordinates. The values of f, x and y are all finite values [2].

Radiograph is a tool to provide treatment solutions to patients by doctors in diagnosing a disease. The use of radiographs can display a lot of information contained in various diseases in the patient's body including detecting various forms of bone including fractures and other bone abnormalities, so that it can help provide treatment solutions that suit the needs, detection of dental caries can also use this technique [3].

There are two types of radiographic techniques, namely intraoral radiographic techniques and extraoral radiographic techniques. Intraoral radiograph technique is a technique for examining teeth and tissues around the teeth using radiographs placed in the patient's oral cavity. One of the intraoral radiographic techniques is the periapical radiograph technique, which is a radiographic technique that clearly displays four teeth as a whole, bone and surrounding tissue [4].

Dental image is a part of the data that is used to assist in detecting a dental disease. Dental images are obtained from x-rays, which now can be in the form of softcopy or files in \*BMP and \*JPG file formats. Dental x-ray images are usually used to identify various problems related to dental, mouth and jaw diseases[5].

Teeth are one part of the oral cavity. The main functions of teeth are to chew food, give shape to the mouth and are also used for speech. The main parts of a tooth are the crown and root. Each tooth is an organ consisting of three layers, namely enamel, dentin and pulp. Dental caries is one of the chronic dental diseases that exist in humans and is one of the most common global dental and oral health problems in the world today. Worldwide, about 2.43 billion people (36% of the population) have dental caries in permanent teeth, while in baby teeth about 620 million people or 9% of the population [6].

Caries is a disease of the teeth that is often experienced by humans. Dental caries can affect humans in various ways, namely through toothache, infection or stomatognathic dysfunction. Signs and symptoms of caries differ depending on the location and area of caries experienced. Dental caries based on the location and area of the tooth layer is divided into three, namely enamel caries which is visible caries with loss of the surface of the enamel, dentinal caries is visible caries with loss of radiopacity of dentin and pulpal caries is visible caries due to extensive damage to the canal. nerve. Dental caries based on the tooth surface is divided into two, namely recess and fissure caries, and smooth surface caries[7].

The selection of features from a number of variables contained in the available datasets can help improve the performance of the algorithm model that will be used so that it is faster. This feature will later be extracted so that it gets features that will be used for the development of the classification algorithm[9].

Classification is a group formed from the results of systematically arranging datasets and based on categories of features. Image classification is formed to reduce the difference between the ability of the machine (computer) perspective and the ability of the human perspective. Image classification builds image data groups as reference data for machine learning based on the results of feature extraction [10].

Image processing uses color features which are important and important features. Common in determining an object of research because it is not sensitive to size, rotation, zoom and image. The features in the image are divided into two, namely texture features which contain a collection of pixels from the image that have certain characteristics. Shape features use region based and contour based, the contour method performs feature calculations from its boundaries regardless of its contents, while the region or area method performs feature calculations from the entire region or area [8].

Learning data or reference data is an in-depth study of an image data that will find in-depth knowledge of the image data. Classification is easily done by humans directly but will be a major problem if done by machines. This learning data or reference data that will be used for machine learning from an image object with an unknown pattern is compared with how to detect it so that the right category is found and can be used in the classification process [11].

**2. METHOD**

Processing stages to obtain caries dental features and generate reference features are: pre-processing stage, caries extraction features stage and stage of building learning data or dental caries reference. This research has obtained ethical approval from the medical faculty of Padjajaran University with an ethics number 0620080779. Scientific research has stages of a scientific approach that is used to gain knowledge which can be in the form of steps, methods or procedures using methods that are clearly described objectively, so that from this research scientific research is produced and can be used. be held accountable

Actually. [12] Reference caries features were developed from multiple individual features from known dental images based on expert opinion (learning data). These stages can be seen in Figure 1.

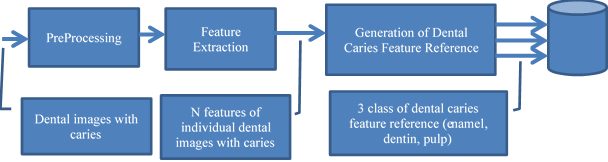


Figure 1. Dental Caries Features Generation Schema

The first stage of the process carried out is the preprocessing stage, because of the available dataset is raw data taken from different sources or devices and data formats so that the existing data still has noise or data, others that are not needed. The data is processed first before entering various algorithms for use in research [13].

The second stage is the stage of the dental caries feature extraction process, where the results of the preprocessing process are used as an input. The extraction process can be done after detection, which is a process to distinguish the object of research from the background of other objects, so that the difference can be seen [14].

The third stage is the stage of the process of building dental caries feature references (learning process using learning data), the results of the caries extraction process stage is processed to obtain references that will be used for the classification process. This reference data becomes a data group for the process of determining an object into the correct category by the machine [15]. All dental images in this study or dental images dataset are categorized of dental caries disease, namely enamel caries, dentin caries and pulp caries.

**2.1 Periapical Image Data of Human Teeth**

This study used a collection of test data obtained from the patient's original tooth image which was used as input data. The original image of the patient's teeth used is a periapical image (Periapical Radiograph) in the form of a file in \*.BMP or \*.JPG format and includes a two-dimensional color image stored in three RGB channels. The number of pixels of dental images is between 374x288 to 672x514 pixels, with an image resolution of 96 DPI.

The entire original tooth image dataset used is Periapical Dental X – Ray from the radiology installation section of the Dental and Oral Hospital (RSGM) Universitas Padjadjaran Bandung. Figure 2 is an example of a periapical image of a healthy tooth and a tooth with caries.

There are two explanations related to dental image, namely teeth with black markings are healthy teeth, while teeth objects with red marks are identified as having caries, see Figure 2. In this study, twelve (12) human tooth periapical data sets were used, with the following details: four (4) periapical data for teeth with enamel caries, four (4) periapical data for teeth with dentinal caries, and four (4) periapical data for teeth with pulp caries. Table 1 is a picture of twelve dental periapical image test data.

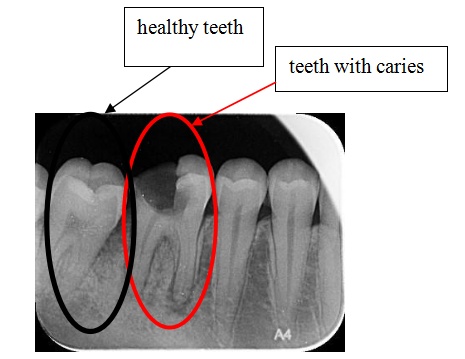


Figure 2. Periapical image data of healthy teeth and teeth with caries (Source: Radiology Installation of RSGM Padjadjaran University Bandung)

Table 1. Original periapical image of human teeth (Source: Radiology Installation of RSGM Padjadjaran University Bandung)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Original image of caries email | Image of caries enamel 1a | Image of caries enamel 1b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps2.png | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps3.png |
|  | Original Image of caries dentin | Image of caries dentin 2a | Image of caries dentin 2b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps4.png | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps5.png |
|  | Original image of caries pulp | Image of caries pulp 3a | Image of caries pulp 3b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps6.png | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps7.png |

Table 1. is a table of original periapical images of human teeth which contains three groups of periapical images. The first group original periapical image of human tooth with enamel caries: image of caries enamel 1a, image of caries enamel 1b. The second group of original periapical images of human teeth with dentinal caries: dentin caries image 2a, dentin caries image 2b. The third group is the original periapical image of a human tooth with pulp caries: caries pulp image 3a, caries pulp image 3a.

**2.2 Pre-processing Stage**

The pre-processing stage for caries detection is to convert data from a two-dimensional color image (row/height, column/width) that is stored using three channels Red, Green and Blue (RGB), into a grayscale image with one channel. The process begins by entering the original image data as input data and then checking that the data is included in the color image or not, and has how many channels. The entered image is checked for how many channels, if it has three channels then the image conversion is carried out into one grayscale channel (imbin) but if the image entered already has one channel, it is immediately entered in the next process (imbin).

The conversion algorithm from a Red Green Blue (RGB) color image to a greyscale image is:

1. Read the original image

2. Get information about the channel in the periapical input image, if the input image is a single channel image, then goes to number 4. The input image has three channels then go to number 3.

3. change the input image three-channel into a single-channel

4. Save the image input single-channel (imbin)

5. Show the input image one channel

**2.3 Feature Extraction Stage**

Process from periapical images of human teeth is to calculate the caries area of the tooth, which is to calculate the caries area of the email, the area of caries dentin and the area of the caries pulp. The next step is to calculate the distance between each caries area and the dental nerve canal, namely the distance from the caries email area to the nerve canal, the distance from the caries dentin area to the nerve canal and the distance from the caries pulp area to the nerve canal.

The algorithm for determining the image of the dental caries detection area by determining the seed point (SP) of the growing region (RG) is:

1. Read the resulting image with the selected ROI and region growing (RG).

2. Show caries area detection image.

3. Calculate the caries area in the caries area image with region growing.

4. Calculate the distance of the caries area to the nerve canal (pulp).

**2.4 Generation of Feature Reference**

The process of determining the study data or dental caries reference which will later be used as data to support the classification process of caries. Dental image data that has been identified as caries by experts will be processed using Matlab prototypes, namely: twelve (12) reference data consisting of four (4) data on teeth with enamel caries, four (4) data on teeth with dentin caries, four (4) data on teeth with pulpal caries. The process is carried out to obtain learning data or references from processing the original dental image data using the Matlab program on the twelve-learning data, namely the area and distance of the caries area with the nerve canal. The results of processing data from the calculation of the area of four teeth with enamel caries and the results of processing data from the calculation of the distance from four teeth with enamel caries to the nerve canal. teeth with dentin caries to the nerve canal, as well as the results of processing data from the calculation of the area of four teeth with pulp caries and the results of processing data from the calculation of the distance from four teeth with caries pulp to the nerve canal.

Actually, this stage is training process to obtain feature reference based on statistical calculation form known several image data according to expert opinion. Testing process is the stage to obtain accuracy of classification algorithm and this stage will be conducted in the next step.

Table 2. Periapical image resulting from the preprocessing process (Source: Radiology Installation RSGM Padjadjaran University, Bandung)

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Image of preprocessed image of caries email | Image of caries email 1a | Image of caries email 1b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps8.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps9.jpg |
| 2. | Image of preprocessed image of caries dentin | Image of caries dentin 2a | Image of caries dentin 2b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps12.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps13.jpg |
| 3. | Image of preprocessed image of caries pulp | image of a caries pulp 3a | image of a caries pulp 3b |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps16.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps17.jpg |

**3. RESULTS AND DISCUSSION**

**3.1 Pre-processing stage result**

Algorithm to convert the input image color RGB three-channel into the input image greyscale one chanell implemented in the

programming language Matlab, Table 2 shows the image grayscale conversion results.

Table 2. is a table of periapical images resulting from the preprocessing process. Contains three groups of periapical images, namely the first group of periapical images resulting from the preprocessing process with caries email: caries email image 1a, caries email image 1b. The second group of periapical images resulting from the preprocessing of dentinal caries: dentin caries image 2a, dentin caries image 2b. The third group of periapical images resulting from the pre-processing of pulp caries: caries pulp images 3a, caries pulp images.

Table 3. Periapical image of the caries detection process (Source: Radiology Installation of RSGM Padjadjaran University Bandung)

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Image of caries email detection process | Image of caries email 1a | Image of caries email 2a |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps32.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps33.jpg |
| 2 | Image of caries dentin detection process | image of dentin caries 1a | image of dentin caries 2a |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps36.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps37.jpg |
| 3 | Image of caries pulp detection process | Image of pulp caries 1a | Image of pulp caries 2a |
|  |  | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps40.jpg | C:\Users\a\AppData\Local\Temp\ksohtml2804\wps41.jpg |

**3.2 Individual Dental Caries Feature**

The results of the caries detection process by calculating the caries area and calculating the distance from the caries area to the nerve canal can be seen in Table 3.

Table 3, is a table of images resulting from the caries detection process which contains three groups of periapical images, namely the first group of periapical images resulting from the caries detection process with enamel caries: image of caries email 1a, image of caries email 1b. The second group of periapical images resulting from the caries detection process with dentinal caries: dentin caries image 2a, dentin caries image 2b. The third group of periapical images resulting from the caries detection process with pulp caries: caries pulp image 1a, pulp caries image 2a, pulp caries image 3a, and pulp caries image 4a.

Table 4 Features of the area and distance of the tooth periapical image with caries email

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No | Patient image files | Size (Pixels) | Area (mm2) | Distance  (Pixels) | Distance  (mm2) |
| 1. | Karies\_email\_1a | 1073.00 | 283.90 | 47.89 | 12.67 |
| 2. | Karies\_email\_2a | 1154.00 | 305.33 | 98.49 | 26 06 |
| 3. | Caries\_email\_3a | 824,00 | 218.02 | 32.76 | 8.67 |
| 4. | Karies\_email\_4a | 1042.00 | 275.70 | 79.40 | 21.01 |
|  | The average value of caries email | 1023.25 | 270.7375 | 64.635 | 17.1025 |

Table 5 Features of the area and distance of the tooth periapical image with caries dentin

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Patient image file | Area (Pixels) | Area (mm2) | Distance  (Pixels) | Distance  (mm2) |
| 1. | Caries\_dentin\_1a | 2080.00 | 550.33 | 69.35 | 18.35 |
| 2. | Caries\_dentin\_2a | 1034.00 | 273.58 | 28.28 | 7, 48 |
| 3. | Caries\_dentin\_3a | 384.00 | 101.60 | 20.81 | 5.51 |
| 4. | Caries\_dentin\_4a | 2346.00 | 620.71 | 35.34 | 9.35 |
|  | The average value of caries dentin | 1461 | 386.555 | 38.445 | 10.1725 |

Table 6 Features of the area and distance of the tooth periapical image with caries pulp

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | Patient image file | Area (Pixels) | Area (mm2) | Distance  (Pixels) | Distance  (mm2) |
| 1. | Caries\_pulpa\_1a | 2169.00 | 573.88 | 17.03 | 4.51 |
| 2. | Caries\_pulpa\_2a | 4623.00 | 1223.17 | 18.03 | 4, 77 |
| 3. | Caries\_pulpa\_3a | 3844.00 | 1017.06 | 51.74 | 13.69 |
| 4. | Caries\_pulpa\_4a | 4498.00 | 1190.10 | 42.05 | 11.13 |
|  | The average value of caries pulp | 3783.5 | 1001.053 | 32.2125 | 8.525 |

This stage produces learning data features as presented in Table 4, Table 5 and Table 6. The results of processing four (4) email caries data are made by making the average results for email caries by adding up the four email caries data and dividing with the total number of email caries data. The results of the processing of four (4) dentinal caries data were carried out to make the average results for dentinal caries by adding up the four dentinal caries data and dividing by the total number of dentinal caries data. The results of processing four (4) pulp caries data are carried out to make an average result for pulp caries by adding up the four pulp caries data and dividing by the total number of pulp caries data.

* 1. **Dental Caries Feature Reference**

At this stage, based on learning data features, dental caries feature references are obtained as presented in Table 7. The results of the average data become learning data or references which are feature data that will be used in the classification process. This feature data will be used as the basis for determining whether a dental caries is classified as: email caries, dentin caries or pulp caries, or not classified as dental caries.

Table 7 Calculation of the average caries area and distance in pixels and mm2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. | The average value of caries | Area (pixels) | Area (mm2) | Distance  (pixels) | Distance  (mm2) |
| 1. | Email caries | 1023.25 | 270.7375 | 64,635 | 17.1025 |
| 2. | Dentin caries | 1461 | 386.555 | 38.445 | 10.1725 |
| 3. | Pulp caries | 3783.5 | 1001.053 | 32.2125 | 8.525 |

Table 4 describes the result of the average number of pixels for the caries area of the email is 1023.25 pixels (270.7375 mm2) and the distance from the caries area of the email to the nerve canal (pulp) is 64,635 pixels (17.1025 mm2).

Table 5 describes the results of the mean values The average number of pixels for the dentinal caries area is 1461 pixels (386.555 mm2) and the distance from the dentin caries area to the nerve canal (pulp) is 38.445 pixels (10.1725 mm2).

Table 6 describes the results of the average number of pixels for the caries pulp area was showed that 3783.5 pixels (1001.053 mm2) and the distance from the caries pulp area to the nerve canal (pulp) was 32.2125 pixels (8.525 mm2).

Table 7 describes the results of calculating the average caries area and the distance from the caries area to the nerve canal. Based on these data, the area of dentin caries is the smallest, the area of dentin caries is moderate and the area of caries is wide, largest pulp. When viewed from the data, the distance from the caries area to the nerve canal is the distance from the caries area of the enamel to the farthest nerve canal and the distance from the caries area to the nerve canal is moderate, for the distance from the caries area of the pulp to the nerve tract is short.

Table 4,5 and 6 are the result of caries area and distance to nerve for each classification (3 classes). This result is then calculated to obtain the average value as presented in Table 7. These values are used as feature reference in classification step. Other researcher used color or texture to identify caries [13,14,15], this article proposes other method as feature reference used in classification process.

**4. CONCLUSSION**

Processing of human dental periapical image data using Matlab prototypes from the preprocessing process, dental caries feature extraction process and the process of building dental caries feature reference based on learning data has been carried out with good results. In the preprocessing process, changes are made from the original two-dimensional image data with three channels to a greylevel with one channel. The caries detection process in human teeth is carried out by calculating the caries area using the region of interest (ROI) and region growing (RG). Calculation of the distance of the caries area with the dental nerve canal is done by calculating the center distance of the region of interest (ROI) to the dental nerve canal. The results of the caries detection process are used for the process of building dental caries feature references using the features of area and distance images of email caries, dentin caries and pulp caries.

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