DIAGNOSIS AND INTERPRETATION OF DENTAL X-RAY IN CASE OF DECIDUOUS TOOTH EXTRACTION DECISION IN CHILDREN USING ACTIVE CONTOUR MODEL AND DECISION TREE

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2014

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was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
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ACKNOWLEDGEMENTS

The success of this thesis can be succeeded by the attentive support from my major advisor Asst.Prof. Supaporn Kiattisin for her valuable advice in choosing thesis topic which were so much beneficial for successful of this thesis.

I am grateful to Dr. Manthana Musekapan from Oral Health Sciences, Major in Pediatric Dentistry, Hatyai Hospital, Songkhla for her assistance on capturing dental X-ray films. We are grateful to Co-advisor who provided helpful comments on a previous draft of this thesis.

Finally, I am very grateful to my family members for attending to my study, care and love and great encouragement. This successfulness I dedicate to my parents and all the teachers who's the main source of inspiration to push me to future success. And I would like to thank all of those who I have not listed above.

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ABSTRACT

Normally, children suffer from a tooth eruption because their permanent teeth do not push their way through the gums; therefore, the dentist will need to diagnose the dental X-ray image. This paper proposes image processing based on Active Contour Model and data mining for analyzing the ratio of teeth's gap area. In addition, the experiment relates to medical knowledge so as to evaluate the treatment. The results show that the ratio of teeth's gap area in a case of extraction is 20± 5, and the tooth extraction decision in expert's way is 78 ± 7%. In a case of no extraction, the ratio of teeth's gap area is 40 ± 4.5, and the tooth extraction decision in expert's way is 60 ± 6%. Therefore, if the teeth's gap area between the deciduous teeth and the permanent teeth is small, then the occasion of the tooth extraction will be higher. The decision to retain or extract a questionable tooth is one that occurs frequently in dental practice. There are many factors to consider when making this decision. This proposed method creates the decision model supported for the dental tooth extraction using C4.5 decision tree, and the accuracy is approximately at 98%.

KEY WORDS: DECIDUOUS TOOTH / TOOTH EXTRACTION / DECISION, DENTAL X-RAY IMAGE / ACTIVE CONTOUR MODEL / C4.5 DECISION TREE

49 pages

การวินิจฉัยและแปรผลภาพถ่ายรังสีทางทันตกรรม กรณีศึกษา: การตัดสินใจถอนฟันน้ำนมในเด็ก โดยใช้รูปแบบ ACTIVE CONTOUR MODEL และ DECISION TREE
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บทคัดย่อ

โดยทั่วไปเด็กส่วนใหญ่เมื่อฟันแท้ขึ้นมักมาพบแพทย์ด้วยอาการปวดฟัน เนื่องจากฟันแท้จะผลักดันตัวฟันเพื่อที่จะโผล่พ้นเหงือก ดังนั้นทันตแพทย์จึงต้องวินิจฉัยอาการด้วยวิธี X-ray ซึ่งจะพิจารณาระยะห่างระหว่างฟันน้ำนมกับฟันแท้ การวิจัยนี้ได้นำเสนอวิธีการประมวลผลภาพ โดยใช้ Active Contour Model และ Decision Tree เพื่อวิเคราะห์หาอัตราส่วนของพื้นที่ช่องว่างระหว่างฟัน ในการศึกษาจะอ้างอิงกับการประเมินผลการรักษาของทันตแพทย์ จากผลลัพธ์จะเห็นว่า อัตราส่วนของพื้นที่ช่องว่างระหว่างฟันในกรณีต้องถอนฟันน้ำนมโดยใช้อัลกอริทึมมีค่า 20± 5 และโดยการวินิจฉัยของทันตแพทย์มีค่า 78 ± 7% ในทางกลับกันกรณีไม่ต้องถอนฟันน้ำนม เมื่อใช้อัลกอริทึมมีค่า 40 ± 4.5 และโดยการวินิจฉัยมีค่า 60 ± 6% จึงสรุปได้ว่าหากพื้นที่ช่องว่างระหว่างฟันยิ่งน้อยโอกาสที่จะต้องถอนฟันก็จะสูงขึ้น การตัดสินใจที่จะถอนหรือไม่นั้นเป็นปัญหาที่พบในบ่อยในทางการแพทย์ เนื่องจากมีหลายปัจจัยในการพิจารณา ดังนั้นจากการวิจัยนี้เราสามารถนำอัลกอริทึม Decision Tree มาประยุกต์ใช้ เพื่อสนับสนุนการตัดสินใจของทันตแพทย์ ซึ่งมีความถูกต้องประมาณ 98%

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CHAPTER 1
INTRODUCTION

1.1 Background

During the past decade, dental evolution has strongly developed with the tools and materials that cause the decrease in tooth problems in children around the world. In order to prevent dental problems, it is important to take care of children's teeth since their first permanent teeth eruption.

Teeth extraction has 2 cases: (1) crowding tooth: it is caused when permanent teeth erupt and push themselves through primary teeth. The dentists will extract the primary teeth without doing dental x-ray. This is because if the primary teeth stay, they are going to push the permanent teeth through, make the permanent teeth lay against other teeth and be difficult to be cleaned. (2) Tooth decay and other tooth problems: the dental experts will do dental x-ray to help to consider whether to extract the teeth.

Most people have two sets of teeth during their lives. Both deciduous teeth and permanent teeth have fairly well-defined times of eruption. Any abnormalities of the root structure as well as surrounding bone structure can be searched for by Dental X-ray images. For example, it is employed to study predictors of root resorption in orthodontic treatment [1]. Moreover, it also plays an important role in human identification using teeth anatomy. For instance, if there is fire or collision, the parts of human body which are the hardest and the strongest are teeth. Therefore, they are likely to be the best choice for PM identification [2].

Image extraction is an important stage to segment any feature of shapes. There are several previous studies using active contour methods. They have been launched after the snake was proposed. Active contour can be classified into edge-driven, region-driven (or intensity-based) and prior-knowledge driven [3]. In 2011 contour points are used for describing a tooth's shape and to show the features of the other tooth such as hierarchical chamfer, signature vectors, chain code, fourier descriptors and the length of the tooth [4-5]. Nonetheless, this research not only proposed a method of active contour model but also used data mining for the analysis. Data mining is about the preprocessing, data transformation, and interpretation of the results. Clustering, classification, and regression are the most popular data mining techniques [6]. Therefore, this study focuses on a decision tree method which helps to interpret the data of the teeth's gap area.

1.2 Objectives of study

1.2.1 To study the diagnostic radiology in dental X-ray images for finding the appropriate solutions to assist a dentist or specialist in the hospitals and dental clinics.

1.2.2 To study how to interpret X-ray images of deciduous teeth in children.

1.2.3 To create the decision model supported for the dental tooth extraction in children.

1.3 Scope of work

1.3.1 The data comes from children with tooth troubles age between 7-10 years (both male and female).

1.3.2 To study tooth in molar type specially.

1.3.3 To study the ratio of teeth's gap area between deciduous teeth and permanent teeth.

1.4 Expected result

1.4.1 To learn and understand know-how about workflow of diagnosis of dental X-ray in children.

1.4.2 To diagnose and interpret X-ray images by using active contour model. Also, integrate with the expert's way.

1.4.3 The decision model supported for the dental tooth extraction using C4.5 decision tree with high accuracy.

CHAPTER 2
LITERATURE REVIEW

2.1 Fundamental Oral Anatomy

2.1.1 Deciduous

These are what we call 'primary teeth', 'baby teeth' or 'milk teeth', they are replaced by the permanent dentition. There are 20 teeth in the deciduous dentition of which there are 8 incisors, 4 canines and 8 molars. Most babies are born with no teeth and normally start to erupt at about 6 months to 1 year of age. Deciduous teeth have a relatively short life-span before they are exfoliated (shed), to be replaced by the permanent teeth.

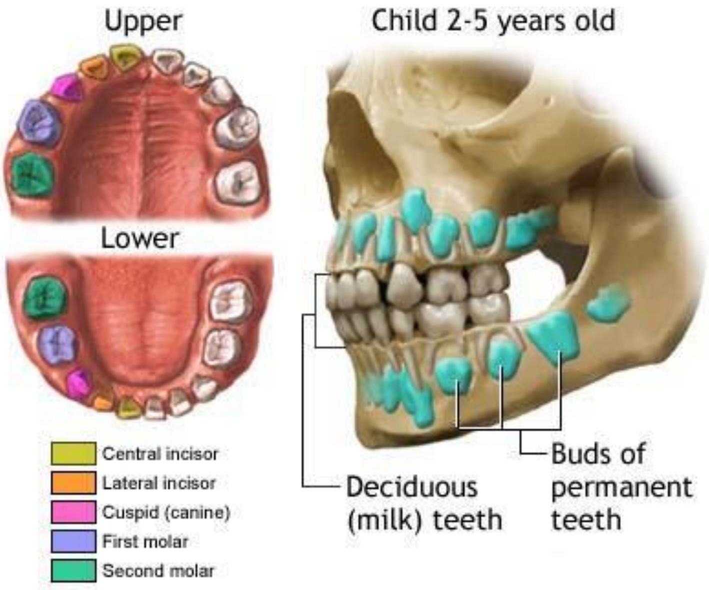


Figure 2.1 The Development of Baby Teeth

The deciduous teeth have fairly well-defined times of eruption. The ages listed are the normal ages that a baby tooth emerges.

Table 2.1 Shows the deciduous teeth have fairly well-defined times of eruption

UPPER	ERUPTS BY	LOWER	ERUPTS BY
Central incisor	8-10 Mo	Central incisor	6-9 Mo
Lateral incisor	8-10 Mo	Lateral incisor	15-21 Mo
Canine (Cuspid)	16-20 Mo	Canine (Cuspid)	15-21 Mo
First molar	15-21 Mo	First molar	15-21 Mo
Second molar	20-24 Mo	Second molar	20-24 Mo

2.1.2 Permanent

These are the 'adult teeth' and in the normal adult there are 32 teeth of which there are 8 incisors, 4 canines, 8 premolars and 12 molars. The first adult teeth start to erupt at about 6 years of age, these teeth are very important as they form the cornerstone of the adult dentition.

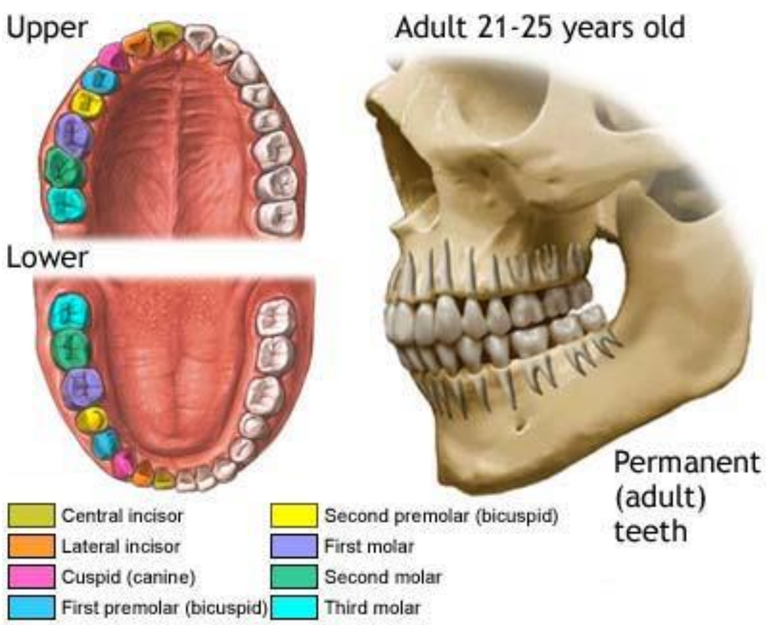


Figure 2.2 The development of permanent teeth

The permanent teeth have fairly well-defined times of eruption. The ages listed are the normal ages that a permanent tooth emerges.

Table 2.2 Shows the relationship between type of teeth and erupts

UPPER and LOWER	ERUPTS BY (Year)
Central incisor	7th
Lateral incisor	8th
Canine (Cuspid)	11-12th
First premolar (Bicuspid)	9th
Second premolar(Bicuspid)	10th
First molar	6th
Second molar	12-13th
Third molar	17-25th

2.2 Fundamental dental knowledge of x-ray film

There are two main types of dental X-rays: intraoral (meaning the X-ray film is inside the mouth) and extraoral (meaning the X-ray film is outside the mouth).

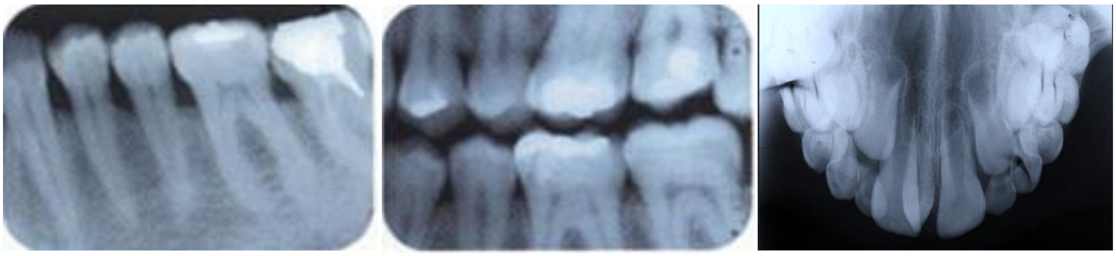
2.2.1 Intraoral X-rays

Intraoral X-rays are the most common type of X-ray taken. You have probably had many sets of these X-rays taken in your life already. These X-rays provide a lot of detail and allow your dentist to find caries, check the health of the tooth root and bone surrounding the tooth, check the status of developing teeth, and monitor the general health of your teeth and jawbone. There are three types of intraoral film as below.

- **Bite-wing X-rays** show details of the upper and lower teeth in one area of the mouth. Each bite-wing shows a tooth from its crown to about the level of the supporting bone. Bite-wing X-rays are used to detect decay between teeth and changes in bone density caused by gum disease. They are also useful in determining the proper fit of a crown (or cast restoration) and the marginal integrity of fillings.
- **Periapical X-rays** show the whole tooth, from the crown to beyond the end of the root to where the tooth is anchored in the jaw. Each periapical X-ray shows this full tooth dimension and includes all the teeth in one portion of either the upper or

lower jaw. Periapical X-rays are used to detect any abnormalities of the root structure and surrounding bone structure.

- **Occlusal X-rays** are larger and show full tooth development and placement. Each X-ray reveals the entire arch of teeth in either the upper or lower jaw.



(a) Periapical film (b) Bite-wing film (c) Occlusal film

Figure 2.3 Three types of intraoral film

2.2.2 Extraoral X-rays

Extraoral X-rays show teeth, but their main focus is the jaw and skull. These X-rays do not provide the detail found with intraoral X-rays and therefore are not used for detecting caries or for identifying problems with individual teeth. Instead, extraoral X-rays are used to look for impacted teeth, monitor growth and development of the jaws in relation to the teeth, and to identify potential problems between teeth and jaw and the temporomandibular joint (TMJ) or other bones of the face. There are five types of extraoral film as below.

- **Panoramic X-rays** show the entire mouth area – all the teeth in both the upper and lower jaws – on a single X-ray. Panoramic X-rays require the use of a special X-ray machine. This type of X-ray is useful for detecting the position of fully emerged as well as emerging teeth and aiding in the diagnosis of tumors.

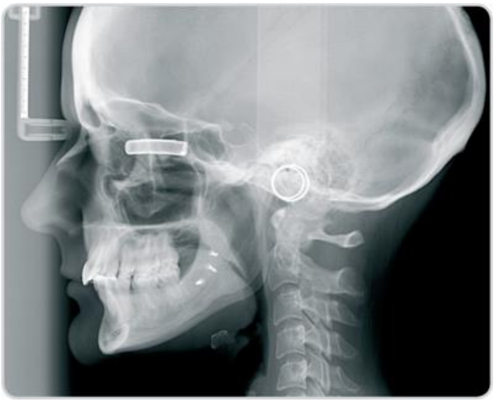
- **Tomograms** show a particular layer or "slice" of the mouth while blurring out all other layers. This type of X-ray is useful for examining structures that are difficult to clearly see – for instance, because other structures are in very close proximity to the structure to be viewed.

- **Cephalometric projections** show the entire side of the head. This type of X-ray is useful for examining the teeth in relation to the jaw and profile of the individual. Orthodontists use this type of X-ray to develop their treatment plans.

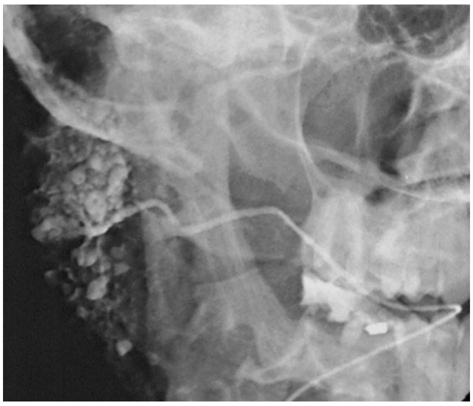
- **Sialography** involves visualization of the salivary glands following the injection of a dye. The dye, called a radiopaque contrast agent, is injected into the salivary glands so that the glands can be seen on the X-ray film. (The glands are soft tissue that would not otherwise be seen with an X-ray.) Dentists might order this type of test to look for salivary gland problems, such as blockages or Sjogrenâ's syndrome.
- **Computed tomography**, otherwise known as CT scanning, shows the body's interior structures as a three-dimensional image. This type of X-ray, which is performed in a hospital rather than a dentist's office, is used to identify problems in the bones of the face, such as tumors or fractures.

(a) Panoramic X-rays

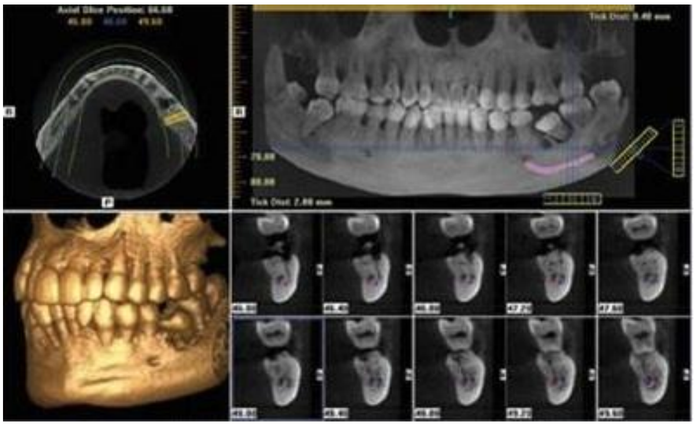
(b) Tomograms



(c) Cephalometric projections



(d) Sialography



(e) Computed tomography

Figure 2.4 (a)-(e) are types of extraoral film

The original images are intraoral X-rays which is the most common type of X-ray that provides a lot of detail and allows the dentists to find caries, check the health of the tooth's root and bone surrounding the tooth, check the status of developing teeth, and monitor the general health of teeth and jawbone to evaluate the treatment. The type of film is called "Periapical film" that is used primarily for radiographic examination of teeth and adjacent tissues to include the periapical region. The standard periapical film (type 2) used in the Army is 11/4 by 15/8 inches (31 mm x 41 mm), which is large enough to include a view of about three teeth. However, this study chose a small size periapical film (type O) which is also a standard item for using in radiography of children's teeth and is measured to be 7/8 by 13/8 inches (22 mm x 35 mm).

Radiolucent and radiopaque of landmark anatomy will appear in dental radiograph with different area. The experts can diagnose immediately when he sees a film. Therefore, the dentists will be able to estimate the difficulty level of teeth extraction process and decides to send a patient to experts or oral surgeons.

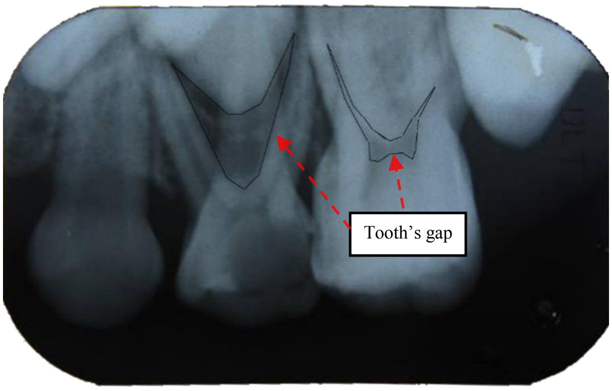


Figure 2.5 The teeth's gap area from an original film

2.3 Dental X-Ray Image Characteristics

Reading a dental X-ray, a black and white picture of the inside of a tooth and bone, requires professional dentistry training, a source of back-lighting and a magnifying device. Look at the X-ray to determine areas of darkness and light. The black areas are the soft objects such as decay and the nerves and blood vessels. The white parts are the solid parts such as the tooth enamel, fillings, crowns and dentin, the sensitive part of the tooth surrounding the nerve and blood vessels.

2.3.1 Characteristics of the Image

There are four characteristics of an X-ray image. These are: contrast, density, detail, and geometric distortion. Each is discussed in turn. The dentist requires properly processed radiographs with minimal distortion to be diagnostically acceptable. For example, a film that has been exposed to radiation twice, known as double exposure, is of no use.

A dental radiograph appears as black (radiolucent) and white (radiopaque) image that includes varying degrees of gray shade. A radiolucent image is produced due to the lack of density of the object, permitting passage of X-ray beam without any attenuation. A radiopaque image is produced by dense structures that absorb and resist the passage of X-ray beam. For example, the mineralized structures such as enamel, dentin, and bone cast radiopaque shadow. An ideal radiograph is one that provides a great deal of required information, with the images exhibiting proper density and contrast, and having sharp outlines; same shape; and same size.

2.3.1.1 Density: Radiographic density is the degree of darkness in the image. Density depends on the total amount of radiation that the film receives, the thickness of the bone, the developing/processing conditions, and the distance between the X-ray tube head and the patient. Density is controlled by the amperage (mA) setting. The overall density of the film affects the diagnostic value of the film (ideal density, too light, too dark)

Density influenced by:

- Exposure factors (mA, kVp, exposure time). An unnecessary increase in any of these factors results in an increase in film density.
- Object thickness: the larger the patient's head, the more x-rays that are needed to produce an ideal film density
- Object density: determined by type of material (metal, tooth structure, composite, etc.) and by amount of material
- Film fog: Increased film density from causes other than exposure to the primary x-ray beam (scatter, improper safelighting, improper film storage, expired film)

Figure 2.6 Example of Density

2.3.1.2 Contrast: This refers to the varying shades of gray present in the image. Contrast is dependent upon density and can be influenced by processing. Contrast is difference in densities. It is controlled by the voltage (kV) setting. A radiograph that exhibits only two densities (areas of black and white) has a "short-scale contrast", whereas, a radiograph that exhibits many densities (many shades of gray) has a "long-contrast scale". Scales of contrast can be measured by using a device called stepwedge.

Table 2.3 Shows Contrast is difference in densities

High Contrast		**Low Contrast**	
• Short Scale • Black and White (Few shades of gray) • Best for caries detection		• Long Scale • Many shades of gray • Best for periapical or periodontal evaluation	

Contrast influenced by:

- Subject contrast: Results from varying object densities within patient, this is determined by: thickness, density & composition of the subject
- kVp: Affects energy (penetrating ability) of x-rays.
- Film contrast: It refers to the characteristics of the film that influence the radiographic contrast, it is incorporated into film by manufacturer.

2.3.1.3 Detail: Detail is the sharpness and clarity of the image. Detail is affected by patient movement or X-ray tube head movement. Any movement during the exposure of an X-ray will cause the image to appear blurry and out of focus.

Sharpness of the radiographic image refer to how well a boundary between two contrasting radiodensities is delineated. Sharpness depends on focal spot size, film composition, and any movement of the subject or film during exposure. A fuzzy, unclear area surrounding a radiographic image is termed "penumbra" (Latin, pene meaning almost and umbra meaning shadow). A penumbra is defined as the sharpness or blurring of the periphery of a radiographic image.

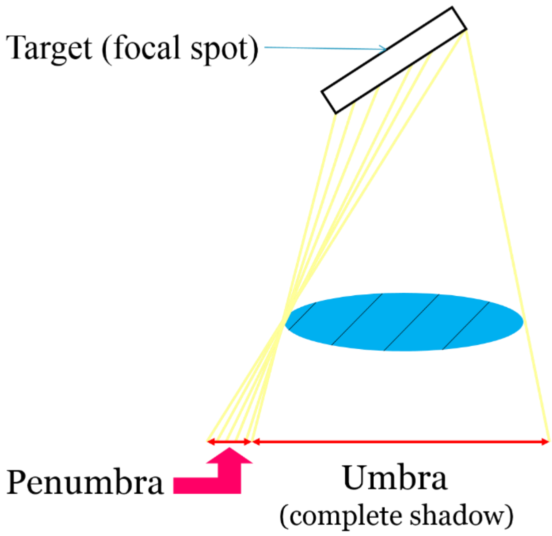
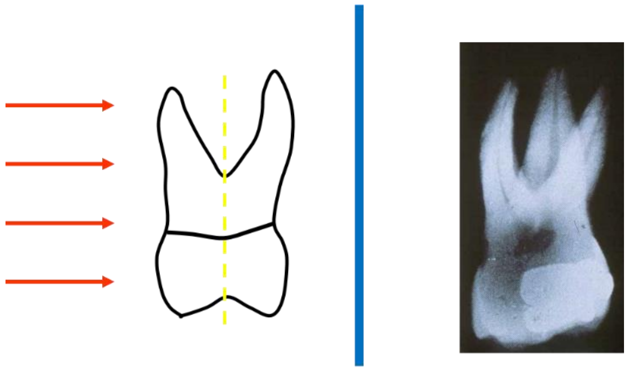


Figure 2.7 Sharpness: Penumbra

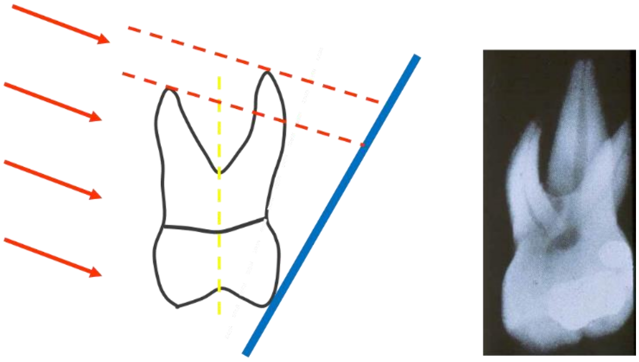
Sharpness influenced by:

- Focal spot size: Decrease focal spot size, increase sharpness.
- Source–object (teeth) distance: Increase source-object distance, increase sharpness.
- Object (teeth)-film distance: Decrease object-film distance, increase sharpness.
- Intensifying screens: Intensifying screens decrease sharpness.
- Film crystal size: The faster film contain larger crystal size that produce less image sharpness, and vice versa. Unsharpness occur because the large crystals don't produce object outline as well as smaller.
- Motion: Patient motion decreases sharpness.

2.3.1.4 Geometric Distortion: By increasing the object-to-film distance, a penumbra will be present. A penumbra is the lack of sharpness that surrounds the shadow. This results in an inaccurate duplication of the tooth since it is geometrically distorted. Also, if the patient makes any slight movement, the result will be a blurry image.



(a) Paralleling



(b) Bisecting angle

Figure 2.8 Distortion affected by: Beam alignment (a), (b)

2.4 Radiographic Interpretation Basic

Radiographic interpretation is an essential part of the diagnostic process. The ability to evaluate & recognize what is revealed by a radiograph enable us to detect diseases, lesions & conditions which can't be identified clinically.

Interpretation refers to an explanation of what is viewed on a radiograph while diagnosis refers to the identification of disease by examination or analysis. In other words the interpretation is a step in the diagnosis.

2.4.1 Rules of radiographic interpretation

- The area to be examined must be completely shown at optimal angulations

- All the boundaries of the area of interest must be shown with normal structures around it.
- Knowing and familiarity with all normal anatomical landmarks as well as all various pathological conditions that may affect the area of interest.
- Optimum viewing condition.

2.4.2 Interpretation of Dental Radiographs

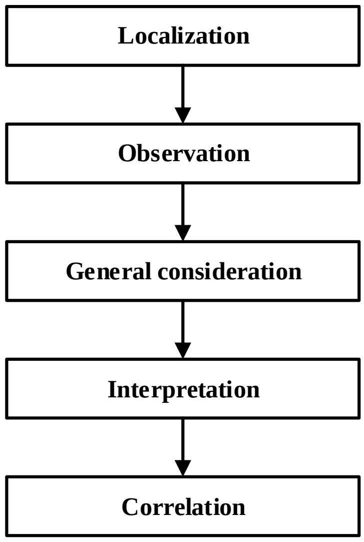


Figure 2.9 Step of interpretation

STEP 1: Localization

How to identify the position of the periapical film? Place the convex (raised) side of the dot so it is toward your eye. This orients the film as if you were looking at the patient from a few feet away in the same position as the radiograph tube when the film was taken. This is known as labial orientation (or mounting). Once the dot is toward your eye, do not flip the film over. Flipping the film over, so that the concave part is toward your eye, gives you the perspective of being a miniature person, standing on the patient’s tongue, surrounded by the teeth like the bars of a prison cell. This is known as lingual orientation (or mounting). Labial orientation is the accepted standard in veterinary dentistry. This step (and only this step) is automatically done for you when using a digital dental film system.

STEP 2: Observation

All shadows, other than the localized shadows of the normal landmarks must be observed. Determine if the film is of the maxillary or mandibular quadrant. If needed, rotate the film so upper teeth (maxillary) have the roots pointing up, just as if you were looking at the patient's mouth from outside. Mandibular quadrants are rotated, if needed, so that the roots point down, again just as if you were outside the patient's mouth looking in. It is difficult to evaluate the patient upside down, therefore rotate as needed to position the teeth as if the patient was in a normal standing position. Specific anatomic landmarks to help determine which quadrant you are viewing are listed in the table below. After a little practice, it is very easy to determine maxillary from mandibular films.

STEP 3: General consideration

A radiograph shows only 2 dimensions of a 3 dimensional object (width and height but not the depth). Cervical burnout: usually appears as cervical RL and misinterpreted by caries; this occurs due to less density and more penetration of rays. Pulp exposure never to be determined from radiograph but only the proximity to the pulp.

STEP 4: Interpretation

Studying the features of teeth and bone: Study the whole tooth such as crown, root enamel, pulp, number of teeth and finally supporting structures. Changes in bone may include: density, margin, inside the lesion, Effect on surrounding tissues and structure.

STEP 5: Correlation

The final step is to correlate all of the radiographic features to reach a radiographic differential diagnosis. Then to draw a final diagnosis, we have to correlate other data as case history, clinical examination, and other diagnostic aids with the radiographic differential diagnosis.

2.5 Image Enhancement

Image Enhancement is the reduction of noises in dental Images which converting the image data in order to create images that emphasizes the details or adjust the range of tones when compared with data or other details of the image. The previous works need to determine how to improve image in the several ways for do experiment. Each method will help interpret the images in different aspects. The common techniques that use to improve images as radiometric enhancement, spectral enhancement and spatial enhancement.

2.5.1 Gaussian filtering

The idea of Gaussian smoothing is to use this 2-D distribution as a `point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to produce a discrete approximation to the Gaussian function before we can perform the convolution. In theory, the Gaussian distribution is non-zero everywhere, which would require an infinitely large convolution kernel, but in practice it is effectively zero more than about three standard deviations from the mean, and so we can truncate the kernel at this point.

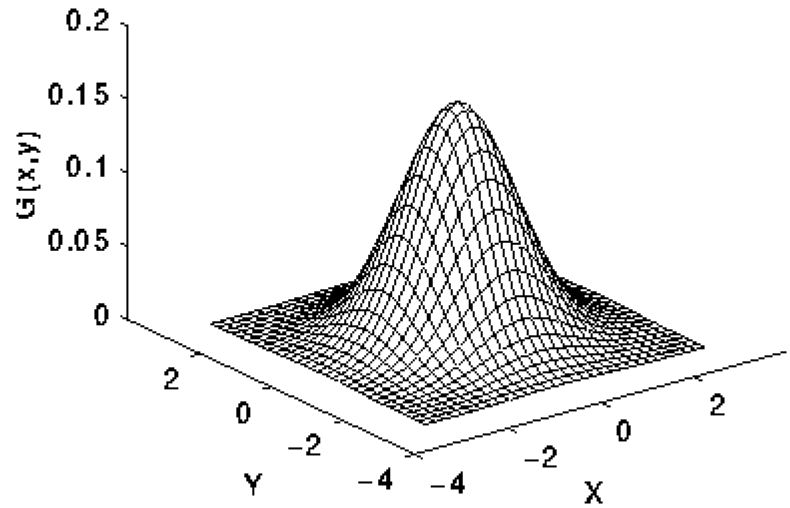


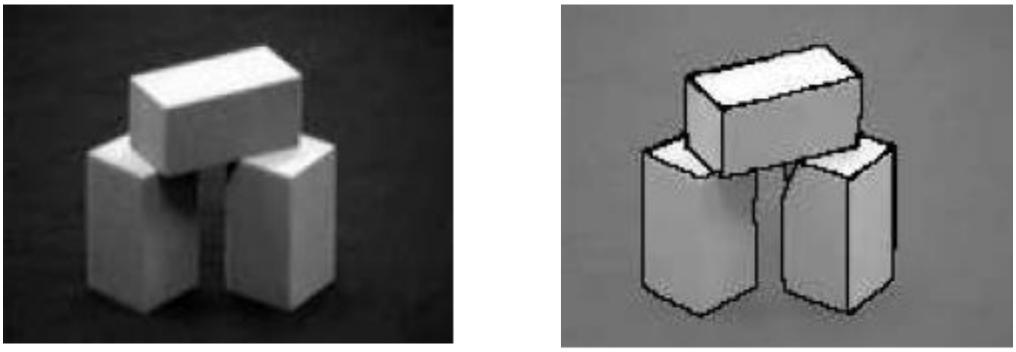
Figure 2.10 2-D Gaussian distribution with mean (0, 0) and σ =1

The noises can be gotten rid of by smoothing. In this work it uses Gaussian spatial filter for smoothening. It is more favored than Box filter because it preserves the edges. It is a low pass filter uses Gaussian function to build two-dimensional filter kernel. In this work Gaussian filter with kernel size 5x5 and sigma=1.4 is used. The two-dimensional digital Gaussian filter is shown as following

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

2.6 Image Segmentation

Image Segmentation is the process of partitioning a digital image into multiple regions or sets of pixels. Actually, partitions are different objects in image which have the same texture or color. The result of image segmentation is a set of regions that collectively cover the entire image, or a set of contours extracted from the image. All of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics.



(a) Original Image (b) Segmentation (by SMC)

Figure 2.11 Example Segmentations: Simple Scenes

Edge detection is one of the most frequently used techniques in digital image processing. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image, called edges. This observation combined with a commonly held belief that edge detection is the first step in image segmentation, has fueled a long search for a good edge detection algorithm to use in image processing.

2.6.1 Canny edge detection (Canny Method)

Most of the image processing applications require image segmentation to subdivide the images into its constituent regions or objects. Image segmentation algorithms generally are based on one of two basic properties of intensity values: similarity and discontinuity. Edge detection is by far the most common approach for detecting meaningful discontinuities in gray level. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning zero in uniform regions. The popular edge detection techniques involve masking based operators like Sobel, Prewitt, Roberts etc. to compute the gradient at each point of the image. Also, Laplacian of Gaussian (LoG) is a useful method for edge detection which works on the second derivative of the image.

Canny's edge detection algorithm [9] is well known as the optimal edge detection method. It works on three main principles: low error rate, well localization of edge points and one response to a single edge. To enhance the older edge detection methods, Canny proposed two new techniques in his algorithm, non-maximum suppression and double thresholding to select the edge points. However, these two thresholds used to segment the gradient image are set experimentally. An adaptive edge detection method based on Canny's operator was presented in [10], which used Otsu's thresholding method to determine the threshold values. In [11], the authors proposed an edge detection method based on fuzzy reasoning which incorporated human visual characteristics. Xiao et al. [12] proposed an improved version of the Canny's edge detector specially designed for images distorted by Gaussian noise. In [13], the Canny's edge detector was used to find the best region growing method for medical image segmentation.

The notion of the canny edge detection is differentiation to discover the data's maximum-minimum. It is believed that a point is the edge. Canny edge detection algorithm is classical. It is also a strong way for detecting the edge in gray-scale images. Furthermore, the two important parts of the method are NMS introduction (Non-

Maximum Suppression) and double thresholding of the gradient image. We proposed an efficient version of the canny edge step by step following this diagram.

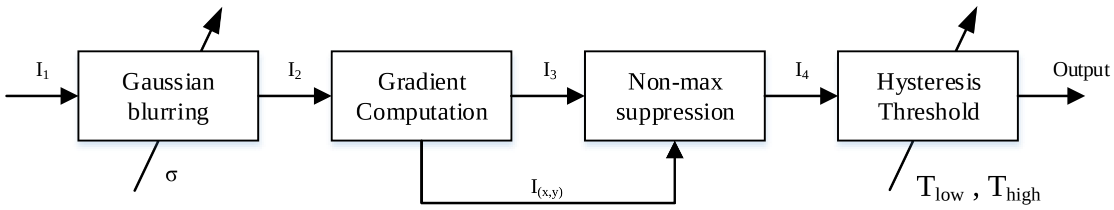


Figure 2.12 The algorithm of canny edge detection.

The Canny's edge detector follows the below mentioned steps as follow,

(a) It first smoothes the image using Gaussian filter to eliminate the noise.

(b) It then finds the image gradient using Sobel operator to highlight regions.

(c) Followed by suppression of any pixel that is not at the maximum (non-maximum suppression).

(d) Hysteresis is used to track along the remaining pixels that have not been suppressed. Double thresholding method uses two thresholds T_{low} and T_{high} which are used to classify the gradients in three groups,

- Gradients > T_{high} : definitely an edge point
- Gradients < T_{low} : definitely a non-edge point
- Otherwise, the decision is taken depending on the direction of the point and existing edge paths.

It is difficult to find the threshold values T_{low} and T_{high} automatically, especially when the image boundaries are vague.

First, we choose the Gaussian filter as our smoothing operator (I_1 as an X-ray film). Second, we implement of gradient filters by write the code with I_2 for filtering an image in the method gradient. Then, we have to compute the position of the points (Non-Maximum Suppression). Finally, the contour segments above a Thigh (high threshold) are grown in a way to include all connected points greater than T_{low} (low threshold)

In MATLAB, if for the Method parameter, you select Canny, the Edge Detection block finds edges by looking for the local maxima of the gradient of the input image. It calculates the gradient using the derivative of the Gaussian filter. The Canny method uses two thresholds to detect strong and weak edges. It includes the weak edges in the output only if they are connected to strong edges. As a result, the method is more robust to noise, and more likely to detect true weak edges.

2.7 Image Extraction (Contour Extraction)

The extraction involves simplifying the amount of resources required to describe a large set of data accurately. When performing analysis of complex data one of the major problems stems from the number of variables involved. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which overfits the training sample and generalizes poorly to new samples. Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.

2.7.1 Active contour model (snakes)

The active contour model was first proposed by Kass et al. [14] for representing image contours. Their basic snake model is an energy minimizing curve, which evolves under the influence of several forces. An energy minimizing spline guided by external constraint forces and pulled by image forces toward features:

- Edge detection
- Subjective contours
- Motion tracking
- Stereo matching

The image sets the points lining the edge of teeth's gap for locating x, y positions to calculate the gap position. After, the points are set, the definite is done by active contour to set the border of gap areas. The active contour is performed to set x, y points using snake function. If the points are set in teeth's gap area manually, then the program automatically deforms them to set image's border. The contour is represented as a set of snake points $v_i(x_i, y_i)$ for i = 0, ..., N-1 where x_i and y_i are the x and y coordinates of the i^{th} snake point, respectively and *N* is the total No. of snake point. The energy function which minimizes the snake is equation as below.

$$E_{snake}\,(v) = \sum_{i=0}^{N-1} \left(E_{continuity}(v_i) + E_{curvature}(v_i) + E_{external}(v_i)\right)$$

Where $E_{continuity}$, $E_{curvature}$ represent the internal energy term and $E_{external}$ represents the external energy term.

The internal energy of the snake is written as;

$$E_{internal} = (\propto (s)|V_s(s)|^2 + \beta(s)|V_{ss}(s)|^2/2$$

Where the first order term | $V_s(s)$ |^2 gives a measure of the elasticity and the second order term | $V_{ss}(s)$ |^2 gives a measure of the curvature of the deforming snake. The parameters α(s) controls the "tension" of the contour while β(s) controls the "rigidity". Therefore, the internal force holds the curve together (first order term) and keeps it from bending too much (second order term).

2.8 C4.5 or J48 Algorithm for Data Mining

The Data Mining is a technique to drill database for giving meaning to the approachable data. It involves systematic analysis of large data sets. The classification is used to manage data, sometimes tree modelling of data helps to make predictions about new data. This research is focus on C4.5 algorithm. Data Mining is an interdisciplinary field involving: Databases, Statistics, and Machine Learning. There are various techniques available for data mining as given below:-

A. *Association Rule Learning*: - This is also called market basket analysis or dependency modelling. It is used to discover relationship and association rules among variables.

B. *Clustering*: - This technique creates and discovers group of similar data items. This is also called unsupervised classification.

C. *Classification*: - This can classify data according to their classes i.e. put data in single group that belongs to a common class. This is also called supervised classification.

D. *Regression*: - It tries to find a function that model the data with least errors.

E. *Summarization*: - It provides easy to understand and analysis facility through visualization, reports etc.

Algorithm J48 decision tree or C4.5 algorithm is used to create a decision tree developed by Ross Quinlan [7]. J48 tree extension that is added to the algorithm ID3 decision tree. This structure could be used for J48 tree classification and this reason it is called frequently for the statistical classifier in the J48 tree to build decision trees from the same training data ID3 principle of information entropy [8]. J48 tree uses an accuracy of each list of attributes data for decision to split the data into sub-groups which will review the J48 tree normalized information gain (the difference in entropy).

The feature that applied in this research is weka.classifiers.trees.J48. There are information as:

- SYNOPSIS - Class for generating a pruned or unpruned C4.5 decision tree. For more information, see
- Ross Quinlan (1993). C4.5: Programs for Machine Learning. Morgan Kaufmann Publishers, San Mateo, CA.
- OPTIONS

1) binarySplits -- Whether to use binary splits on nominal attributes when building the trees.
2) confidenceFactor -- The confidence factor used for pruning (smaller values incur more pruning).
3) debug -- If set to true, classifier may output additional info to the console.
4) minNumObj -- The minimum number of instances per leaf.
5) numFolds -- Determines the amount of data used for reduced-error pruning. One fold is used for pruning, the rest for growing the tree.
6) reducedErrorPruning -- Whether reduced-error pruning is used instead of C.4.5 pruning.

7) saveInstanceData -- Whether to save the training data for visualization.

8) seed -- The seed used for randomizing the data when reduced-error pruning is used.

9) subtreeRaising -- Whether to consider the subtree raising operation when pruning.

10) unpruned -- Whether pruning is performed.

11) useLaplace -- Whether counts at leaves are smoothed based on Laplace.

- CAPABILITIES

1) Class -- Nominal class, Binary class, Missing class values

2) Attributes -- Date attributes, Empty nominal attributes, Binary attributes, Unary attributes, Nominal attributes, Numeric attributes, Missing values

2.9 Basic Evaluation Measures for Classifier Performance

2.9.1 Sensitivity and specificity

The words "sensitivity" and "specificity" have their origins in screening tests for diseases. When a single test is performed, the person may in fact have the disease or the person may be disease free. The test result may be positive, indicating the presence of disease, or the test result may be negative, indicating the absence of the disease.

Sensitivity

Sensitivity relates to the test's ability to identify positive results. The sensitivity of a test is the proportion of people that are known to have the disease who test positive for it. This can also be written as:

$$sensitivity = \frac{number\ of\ true\ positives}{number\ of\ true\ positives + number\ of\ false\ negatives}$$

Sensitivity is not the same as the precision or positive predictive value (ratio of true positives to combined true and false positives), which is as much a statement about the proportion of actual positives in the population being tested as it is about the test.

Specificity

Specificity can be defined as the proportion of patients without the disease who test negative. A test with 1.0 specificity would be able to correctly identify every person who does not have the target disorder (not predict anyone from the health group as sick). A test with high specificity would be able to determine the population that does not have the pathology. Specificity shows the true negatives. This can also be written as:

$$specificity = \frac{number\ of\ true\ negatives}{number\ of\ true\ negatives + number\ of\ false\ positives}$$

However, highly specific tests rarely miss negative outcomes, so they can be considered reliable when their result is positive. Therefore, a positive result from a test with high specificity means a high probability of the presence of disease.

Another method that can be used to select the appropriate the cut-off point is creating a Receiver Operator Characteristic (ROC) curve. To create a relationship graph between the true positive rate (Sensitivity) and false positive rate (1 - Specificity) by changing the cut - off point. In addition, creating a ROC curve also helps in comparison the efficiency of the diagnosis by comparing the area under the lines of each test. The area under curve represents the higher performance.

2.9.2 The area under an ROC curve (AUC)

An ROC curve is a 2D depiction of classification performance. The whole point of an ROC curve is to help you decide where to draw the line between normal and abnormal. This will be an easy decision if all the control values are higher (or lower) than all the patient values. Usually, however, the two distributions overlap, making it not so easy. If you make the threshold high, you won't mistakenly diagnose the disease in many who don't have it, but you will miss some of the people who have the disease. If you make the threshold low, you'll correctly identify all (or almost all) of the people with the disease, but will also diagnose the disease in more people who don't have it.

The area under a ROC curve quantifies the overall ability of the test to discriminate between those individuals with the disease and those without the disease. A truly useless test (one no better at identifying true positives than flipping a coin) has an area of 0.5. A perfect test (one that has zero false positives and zero false negatives) has an area of 1.00. Your test will have an area between those two values.

While it is clear that the area under the curve is related to the overall ability of a test to correctly identify normal versus abnormal, it is not so obvious how one interprets the area itself. There is, however, a very intuitive interpretation.

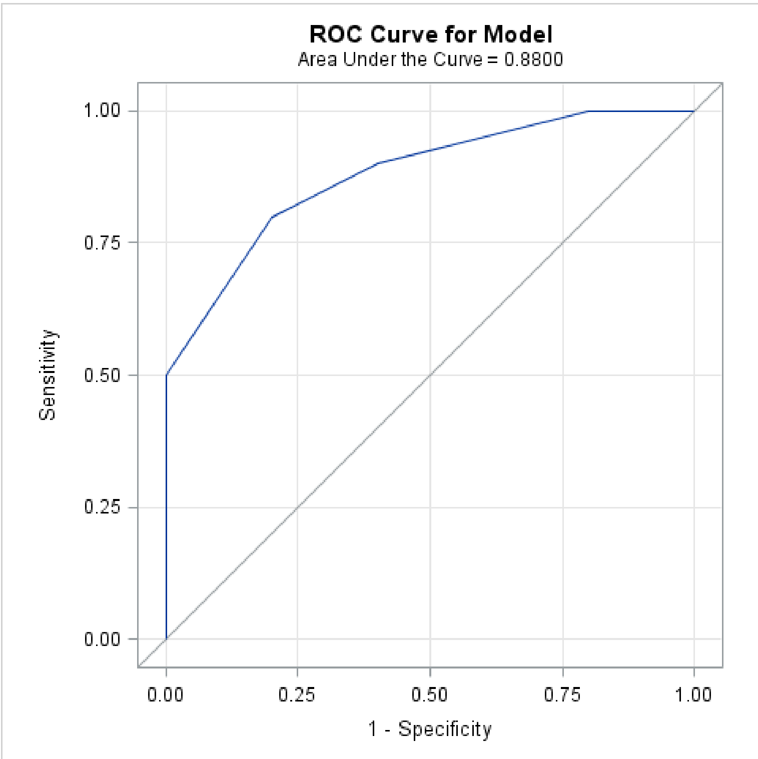


Figure 2.13 ROC curve: The relationship between Sensitivity and Specificity

Figure 2.13 if a graph curve approaches the point that is on the left corner, the slope graph is high and area under the curve is greater. It means that algorithm has a good performance.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Data Collection

Data come from X-ray images of the children with tooth troubles such as eruption of deciduous teeth, tooth decay, toothache and gum problems. There are 50 people (24 boys, 26 girls), age between 7-10 years from Pediatric Dentistry, Hatyai Hospital, Songkhla, Thailand.

3.2 Scope of Study

3.2.1 To study teeth in molar type especially because the dentist always have to making a decision to retain or extract tooth that occurs frequently in dental practice.

3.2.2 Normally, the primary teeth begin to shed between ages 6 and 7 years. This process continues until about age 12 years. So the target group of this research are children age between 6-12 years.

The criteria of study as follows.

- Gender (Boy/Girl)
- Age (Year)
- Ratio of teeth’s gap area
- Diagnosis of the experts

3.3 Methodology

The main process of this paper in order to diagnose and interpret dental X-ray films have 5 steps containing image enhancement, image segmentation, image extraction, finding teeth's gap area and diagnosis-interpretation.

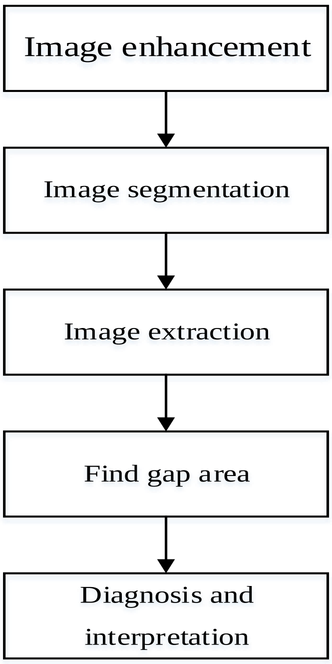


Figure 3.1 The block diagram of main process

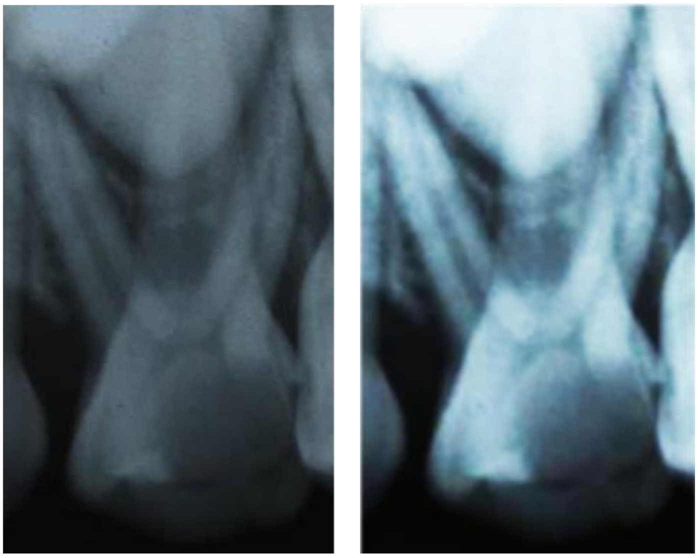
Step 1: Image Enhancement with Gaussian filter

The medical imaging device particularly X-ray is manufacturing overabundant pictures that are utilized by medical practitioners within the method of designation. These noises corrupt the image and sometimes cause incorrect designation. Every of those medical imaging devices are littered with differing types of noise. As an example, the x-ray pictures are typically corrupted by Poisson noise, salt and pepper noise, speckle noise. Denoising is a general process in pre-processing that widely used in X-ray film. This paper propose Gaussian filter to reduce noise for clearly image.

Among all linear filters, Gaussian filter perhaps plays the most important role in both theory and applications. Gaussian filtering is a commonly used image filtering technique which is a WAP with weights defined as $w_{ij} \propto \exp(-||x_i - x_j||), i \neq j$

$$w_{ij} = 0$$

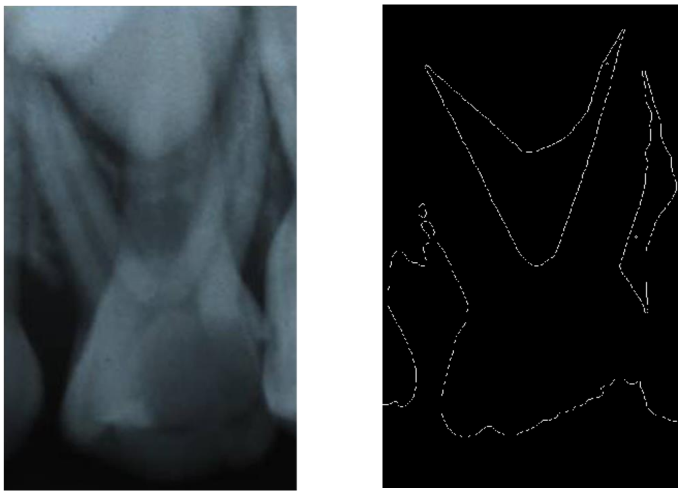
Where $\|.\|_2$ is the L2 norm. Because of the rapid decay of w_{ij} as a function of distance. Gaussian smoothing is effectively a local filtering method. As an image denoising algorithm Gaussian filter is well known to over smooth images, resulting in the loss of significant detail, especially edge sharpness.



a) Original image b) Gaussian filter

Step 2: Image Segmentation with Canny Edge

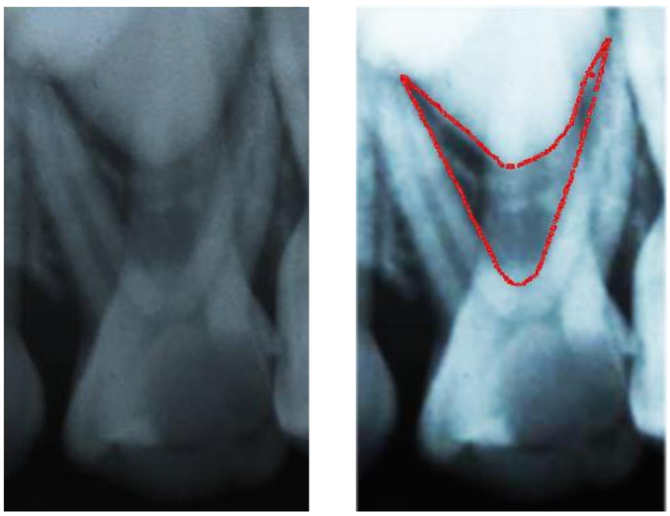
In general, we apply canny edge filter for detecting edges in a very robust manner. It is a multiple step process as above. However, the double threshold is suitable for strong edges. Edges with a strength below both thresholds are suppressed. The original images and their edge detection results are shown as follow indicating the values of T_{low} and T_{high} which are determined automatically.



a) Original image b) Canny Edge

Step 3: Image Extraction with Active Contour Model

Extracting the contour of an individual tooth is a very important step in automated dental classification and identification. The tooth's contour is then segmented using active contour method. The result of teeth's gap contour will define the boundary for area calculating in next step.



a) Original image b) Active Contour

Step 4: Finding Gap Area

We can define the boundary of teeth's gap after active contour method. This section is a measurement process because we need to compare with teeth's crown and root to calculate the ratio of area.

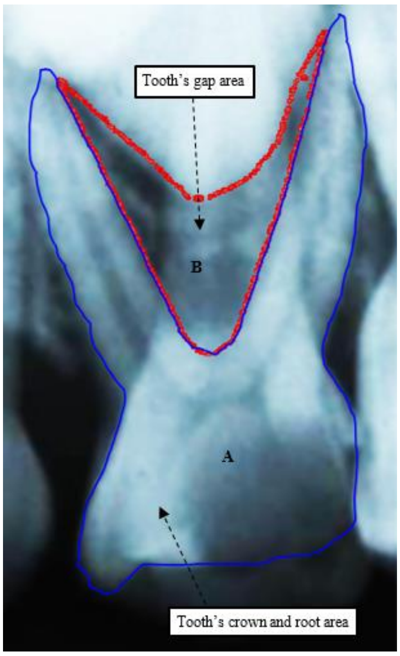


Figure 3.2 The teeth's gap area ratio.

A teeth's gap area ratio used to figure out the relationship between gap and crown-root. To calculate the ratio, you need to know the summation pixel of each area. The formula below demonstrates how to calculate.

$$Ratio = \frac{\sum pixel\ of\ A}{\sum pixel\ \ B}$$

Step 5: Diagnosis and interpretation

After finding the ratio of teeth's gap area, the data are combined with other factor of patients. There are (1) Age (2) Gender (3) Ratio of teeth's gap area and (4) Diagnosis of the experts. The proposed of this section is creating decision model for dental tooth extraction. C4.5 algorithm is a widely used one to construct decision trees. Decision tree algorithm has two phases: building and pruning. The building phase is also called as the 'growing phase'. C4.5 decision tree uses entropy based information gain as the selection criteria.

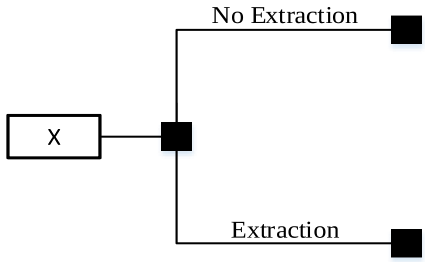


Figure 3.3 Decision tree for Tooth Extraction

3.4 Decision Tree Model Algorithm

This paper discusses applications of the Weka interface, which can be used for testing data sets using a variety of open source Machine Learning algorithms. The data sets were tested using the C4.5 decision tree-inducing algorithm, which was published by Ross Quinlan in 1993.

WEKA generates decision trees as output. To select the best decision tree model, comparison is done with respect to TP rate (true positive rate), FP rate (false positive rate), ROC (receiver operating characteristic) area and CCI (Correctly Classified Instances) for all the three data mining algorithms. After create decision tree, confusion matrix is one of the output from WEKA which is table with two rows and two columns that reports the number of false positives, false negatives, true positives, and true negatives. For best understanding confusion matrix detail is shown in as follows.

		actual value		
		p	n	**total**
prediction outcome	p'	TP	FP	P′
	n'	FN	TN	N′
	total	P	N	

Where p is positive actual outcome, n is negative actual outcome, p' is positive prediction outcome, n' is negative prediction outcome, P is total actual positive value, N is total actual negative value, $\mathrm{P}'$is total positive prediction outcome, N' is total negative prediction outcome, TP is true positive, FP is false positive, FN is false negative, TN is true negative

TP rate is the rate which model can predict correctly out of actual value, that is mean more TP rate is more performance of model, while FP rate is the rate which model cannot predict correctly out of actual value, that is mean less TP rate is more performance of model.

3.5 Tool and Measurement

3.3.1 MATLAB

3.3.2 Weka 3: Data Mining Software in Java

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results

Data comes from the children with tooth troubles such as eruption of deciduous teeth, tooth decay, toothache and gum problems. There are 50 people (24 boys, 26 girls), age between 7-10 years from Pediatric Dentistry, Hatyai Hospital, Songkhla, Thailand.

Table 4.1 Percentage of samples classified by Gender

Gender	Number (People)	Percentage (%)
Boy	24	48
Girl	26	52

From Table 4.1, gender is the attribute in the sample, there are boy 24 people and girl 26 people. The quantity of both are similar.

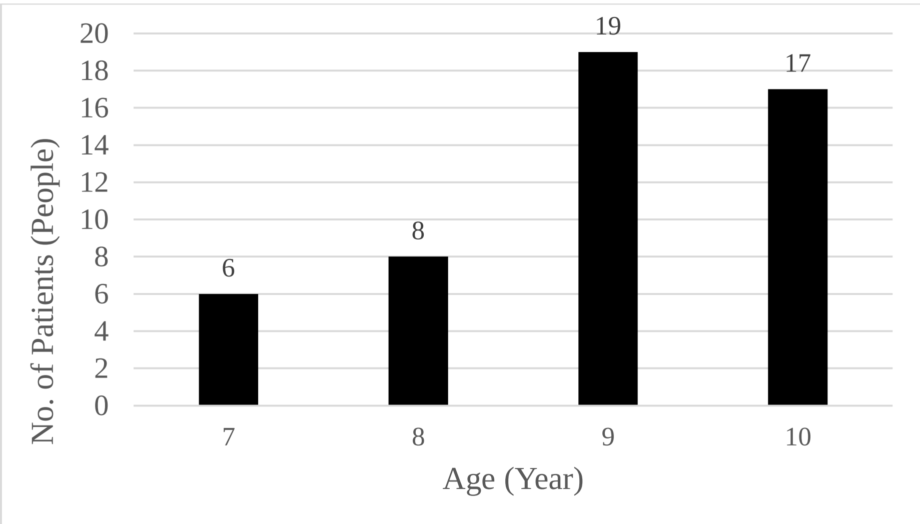


Figure 4.1 Number of samples classified by Age

From

Figure 4.1, Age is the attribute in the sample, the minimum is 7 years, the maximum is 10 years, the mean is 8.94 and S.D. is 0.998. We consider age between 7-10 years because normally, the primary teeth begin to shed between ages 6 and 7 years. This process continues until about age 12 years.

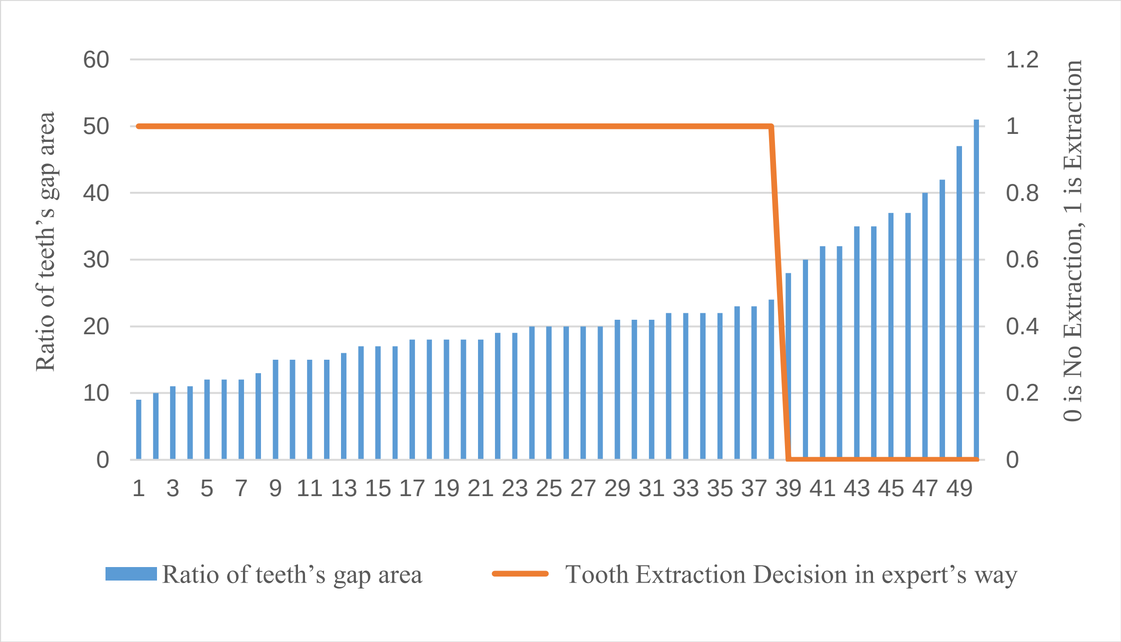


Figure 4.2 Shows the relationship of method and expert's way.

From Figure 4.2, this research compared the result of the experiment in part of image processing based on the know-how and experience of the dentists. First, the expert interpreted X-ray images and then making decision about tooth extraction. We used the diagnosis in the comparison of matching the relationship.

Table 4.2 The relationship of case decision between ratio of teeth's gap area method and expert's way.

Case decision	Ratio of teeth's gap area	Tooth Extraction Decision in expert's way (%)
Extraction	20 ± 5	78 ± 7
No extraction	40 ± 4.5	60 ± 6

From Table 4.2, the experiment is divided into two cases decision which are extraction and no extraction. The result show that the ratio of teeth's gap area compare with crown and root correlated with expert's decision as follows. In extraction case, if the ratio of teeth's gap area is 25, tooth extraction decision in expert's way is 71%. If the ratio of teeth's gap area is 15, tooth extraction decision in expert's way is 85%. In no extraction case, the ratio of teeth's gap area is 40 ± 4.5 and tooth extraction decision in expert's way is 60 ± 6%. So that teeth's gap area method and expert's way are inverse variation.

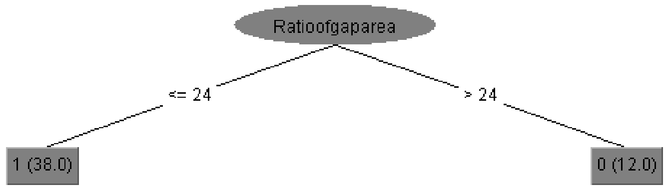


Figure 4.3 C4.5 decision tree. Define 0 is No Extraction, 1 is Extraction

From Figure 4.3, the decision tree was generated by function "Virtualize tree" that used 50 samples. In Tooth Extraction decision, C4.5 decision tree is used to classify the treatment (Extraction or not) with the criteria. There are age, gender, ratio of teeth's gap area and diagnosis of the experts.

Table 4.3 The performance of C4.5 decision tree.

TP Rate	FP RATE	ROC Area	Accuracy
0.974	0.05	0.987	98.0

From Table 4.3 shows that the True Positive value (or sensitivity) 0.974, Fault Positive value (or specificity) 0.05 and accuracy is 98%. ROC Area is 0.987 with C4.5 decision tree.

4.2 Discussion

To consider and decide whether to extract the teeth or not, there are several factors such as gender, age, root resorption and dental anatomy. From the previous related studies, it is found that most of the researchers will decide after they investigate the tooth resorption. However, the study is against the mentioned method because it is possible that there is a complication which results in no resorption. Hence, this study proposed the gap area of teeth as an alternative method. The process for deciding is often a gray area based mostly on an experience of the expert and rough predications on the long-term prognosis of the tooth in question. As a result, the clinician often makes decisions on their feelings rather than clinical parameter.

CHAPTER 5
CONCLUSION

We propose image processing based on Active Contour Model and data mining (J48 Tree) by integrating with the expert's way. The results show that the ratio of teeth's gap area in a case of extraction is 20 ± 5 and tooth extraction decision in expert's way is 78 ± 7%. In a case of no extraction, the ratio of teeth's gap area is 40 ± 4.5 and tooth extraction decision in expert's way is 60 ± 6%. Therefore, if the teeth's gap area between the deciduous teeth and the permanent teeth is small, then an occasion of the tooth extraction will be higher. This proposed method creates the decision model supported for the dental tooth extraction using C4.5 Algorithm, and the accuracy is approximately at 98%. Then we compare the result with dental information, the data related to the expert's way. Moreover, this paper can help the dentist interpret x-ray films and support the diagnosis in case of tooth extraction.

5.1 Future work

From this research found that the methods and algorithms are semi-automatic because there are some processes that we have to do manually. So the next step is creating application which reduce complicated steps for example, after the dentists get the X-ray films, they just scan and upload images to the application. Finally, the expert could know the output and how to do the appropriate treatment from decision model easily. Although nowadays, there is a dental digital X-ray (radiography) system but it comes with standard functions such as zoom in on a single tooth, rotate it, sharpen it and colorize it. If we add decision model, it will give more benefits in system. Moreover, the study can apply these methods with other medical materials such as CT scan or MRI to classify the diseases.

5.2 Suggestion

In this research, the researcher have 50 samples data for testing in the experiment. The sample plays an important role in hopefully representative collection of units from a population used to determine truths about that population. The factor that influence sample representativeness are sample size so we should increase the quantity of samples.

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APPENDICES

APPENDIX A
EXPERIMENTAL OUTPUT

C4.5 decision tree output

Scheme: weka.classifiers.trees.J48 -C 0.25 -M 2

Relation: test.txt-weka.filters.unsupervised.attribute.NumericToNominal-Rlast

Instances: 50

Attributes: 4

Age

Gender

Ratioofgaparea

Diagnosisofdentist

Test mode:10-fold cross-validation

=== Classifier model (full training set) ===

J48 pruned tree

Ratio of gap area <= 24: 1 (38.0)

Ratio of gap area > 24: 0 (12.0)

Number of Leaves: 2

Size of the tree: 3

Time taken to build model: 0.11 seconds

= = = Stratified cross-validation = = =

= = = Summary = = =

Correctly Classified Instances	49	98 %
Incorrectly Classified Instances	1	2 %
Kappa statistic	0.9467	
Mean absolute error	0.02	
Root mean squared error	0.1414	
Relative absolute error	5.3776 %	
Root relative squared error	32.9729 %	
Total Number of Instances	50	

= = = Detailed Accuracy By Class = = =

	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area	Class
	1	0.026	0.923	1	0.96	0.987	0
	0.974	0	1	0.974	0.987	0.987	1
Weighted Avg.	0.98	0.006	0.982	0.98	0.98	0.987	

= = = Confusion Matrix = = =

a	b	<-- classified as
12	0	| a = 0
1	37	| b = 1

APPENDIX B

DIAGNOSIS AND INTERPRETATION OF DENTAL X-RAY IN CASE OF DECIDUOUS TOOTH EXTRACTION DECISION IN CHILDREN USING ACTIVE CONTOUR MODEL AND J48 TREE

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***Abstract*—Normally, children suffer from a tooth eruption because their permanent teeth do not push their ways through the gums; therefore, dentist will need to diagnose dental X-ray image based on characteristics of the gap between deciduous teeth and permanent teeth. This paper proposes image processing based on Active Contour Model and data mining for analyzing the ratio of teeth's gap area. In addition, the experiment relates to medical knowledge so as to evaluate the treatment. The results show that the ratio of teeth's gap area in a case of extraction is 20 ± 5 and tooth extraction decision in expert's way is 78 ± 7%. In a case of no extraction, the ratio of teeth's gap area is 40 ± 4.5 and tooth extraction decision in expert's way is 60 ± 6%. Therefore, if the teeth's gap area between the deciduous teeth and the permanent teeth is small, then an occasion of the tooth extraction will be higher. The decision to retain or extract a questionable tooth is one that occurs frequently in dental practice. There are many factors to consider when making this decision. Some cases are very straightforward while others fall into an unclear area of decision-making. This proposed method creates the decision model supported for the dental tooth extraction using J48 tree, and the accuracy is approximately at 98%.**

Keywords—deciduous tooth, tooth extraction, decision, dental X-ray image, children, Active Contour Model, J48 Tree

I. INTRODUCTION

During the past decade, dental evolution has strongly developed with the tools and materials that cause the decrease in tooth problems in children around the world. In order to prevent dental problems, it is important to take care of children's teeth since their first permanent teeth eruption. Teeth extraction has 2 cases: (1) crowding tooth: it is caused when permanent teeth erupt and push themselves through primary teeth. The dentists will extract the primary teeth without doing dental x-ray. This is because if the primary teeth stay, they are going to push the permanent teeth through, make the permanent teeth lay against other teeth and be difficult to be cleaned. (2) Tooth decay and other tooth problems: the dental experts will do dental x-ray to help to consider whether to extract the teeth.

Most people have two sets of teeth during their lives. Both deciduous teeth and permanent teeth have fairly well-defined times of eruption. Any abnormalities of the root structure as well as surrounding bone structure can be searched for by Dental X-ray images. For example, it is employed to study predictors of root resorption in orthodontic treatment [1]. Moreover, it also plays an important role in human identification using teeth anatomy. For instance, if there is fire or collision, the parts of human body which are the hardest and the strongest are teeth. Therefore, they are likely to be the best choice for PM identification [2].

Image extraction is an important stage to segment any feature of shapes. There are several previous studies using active contour methods. They have been launched after the snake was proposed. Active contour can be classified into edge-driven, region-driven (or intensity-based) and prior-knowledge driven [3]. In 2011 contour points are used for describing a tooth's shape and to show the features of the other tooth such as hierarchical chamfer, signature vectors, chain code, fourier descriptors and the length of the tooth [4-5]. Nonetheless, this research not only proposed a method of active contour model but also used data mining for the analysis. Data mining is about the preprocessing, data transformation, and interpretation of the results. Clustering, classification, and regression are the most popular data mining techniques [6]. Therefore, this study focuses on a decision tree method which helps to interpret the data of the teeth's gap area.

II. FUNDAMENTAL BASIC IDEA

A. *Fundamental dental knowledge of x-ray film*

The original images are intraoral X-rays which is the most common type of X-ray that provides a lot of detail and allows the dentists to find caries, check the health of the tooth's root and bone surrounding the tooth, check the status of developing teeth, and monitor the general health of teeth and jawbone to evaluate the treatment. The type of film is called "Periapical film" that is used primarily for radiographic examination of teeth and adjacent tissues to include the periapical region. The standard periapical film (type 2) used in the Army is 11/4 by 15/8 inches (31 mm x 41 mm), which is large enough to include a view of about three teeth. However, this study chose a small size periapical film (type O) which is also a standard item for using in radiography of children's teeth and is measured to be 7/8 by 13/8 inches (22 mm x 35 mm).

Radiolucent and radiopaque of landmark anatomy will appear in dental radiograph with different area. The experts can diagnose immediately when he sees a film. Therefore, the dentists will be able to estimate the difficulty level of teeth extraction process and decides to send a patient to experts or oral surgeons.

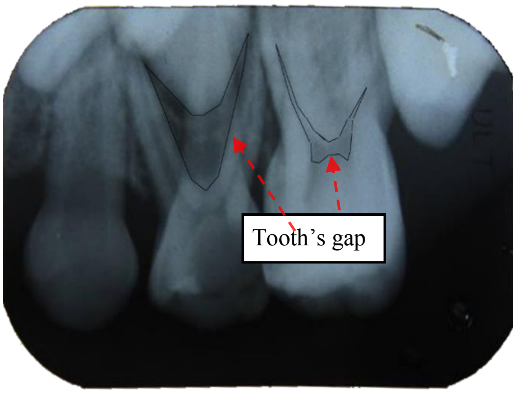


Figure 1. The teeth's gap area from an original film

B. *Image Enhancement*

Image Enhancement is the reduction of noises in dental Images which converting the image data in order to create images that emphasizes the details or adjust the range of tones when compared with data or other details of the image. The previous works need to determine how to improve image in the several ways for do experiment. Each method will help interpret the images in different aspects. The common techniques that use to improve images as radiometric enhancement, spectral enhancement and spatial enhancement.

The noises can be gotten rid of by smoothing. In this work it uses Gaussian spatial filter for smoothening. It is more favored than Box filter because it preserves the edges. It is a low pass filter uses Gaussian function to build two-dimensional filter kernel. In this work Gaussian filter with kernel size 5x5 and sigma=1.4 is used. The two-dimensional digital Gaussian filter is shown as following

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (1)$$

C. *Image Segmentation*

The notion of the canny edge detection is differentiation to discover the data's maximum-minimum. It is believed that a point is the edge. Canny edge detection algorithm is classical. It is also a strong way for detecting the edge in gray-scale images. Furthermore, the two important parts of the method are NMS introduction (Non-Maximum Suppression) and double threshold of the gradient image. We proposed an efficient version of the canny edge step by step following this diagram.

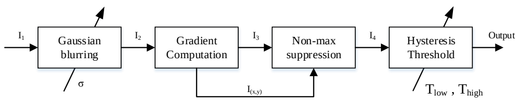


Figure 2. The algorithm of canny edge detection.

First, we choose the Gaussian filter as our smoothing operator (I_1 as an X-ray film). Second, we implement of gradient filters by write the code with I_2 for filtering an image in the method gradient. Then, we have to compute the position of the points (Non-Maximum Suppression). Finally, the contour segments above a T_{high} (high threshold) are grown in a way to include all connected points greater than T_{low} (low threshold).

D. *Image Extraction*

The image sets the points lining the edge of teeth's gap for locating x, y positions to calculate the gap position. After, the points are set, the definite is done by active contour to set the border of gap areas. The active contour is performed to set x, y points using snake function. If the points are set in teeth's gap area manually, then the program automatically deforms them to set image's border. The contour is represented as a set of snake points $v_i(x_i, y_i)$ for i = 0, ..., N-1 where x_i and y_i are the x and y coordinates of the i^{th} snake point, respectively and N is the total No. of snake point. The energy function which minimizes the snake is equation as below.

$$E_{snake}(v) = \sum_{i=0}^{N-1} \Big(E_{continuity}(v_i) + E_{curvature}(v_i) + E_{external}(v_i)\Big) \quad (2)$$

where $E_{continuity}$, $E_{curvature}$ represent the internal energy term and $E_{external}$ represents the external energy term.

E. J48 Decision Tree

Algorithm J48 decision tree or C4.5 algorithm is used to create a decision tree developed by Ross Quinlan [7]. J48 tree extension that is added to the algorithm ID3 decision tree. This structure could be used for J48 tree classification and this reason it is called frequently for the statistical classifier in the J48 tree to build decision trees from the same training data ID3 principle of information entropy [8]. J48 tree uses an accuracy of each list of attributes data for decision to split the data into sub-groups which will review the J48 tree normalized information gain (the difference in entropy).

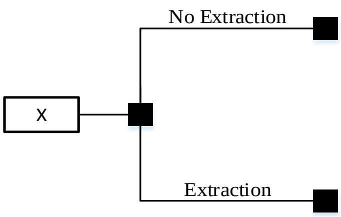


Figure 3. Decision tree for Tooth Extraction

III. EXPERIMENTAL METHODS

The main process of this paper in order to diagnose and interpret dental X-ray films have 5 steps containing image enhancement, image segmentation, image extraction, finding teeth's gap area and diagnosis-interpretation.

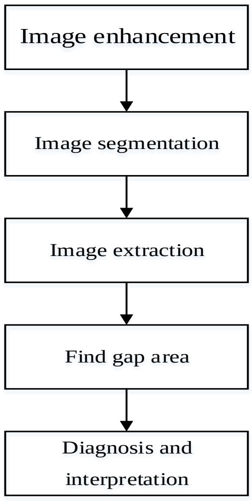


Figure 4. The block diagram of main process.

Step 1: Image Enhancement with Gaussian filter

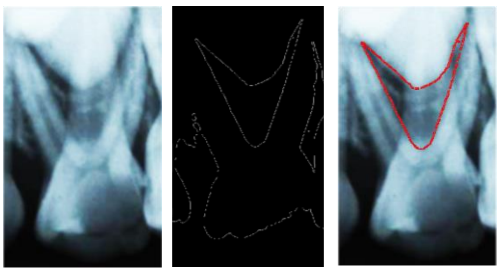
Denoising is a general process in pre-processing that widely used in X-ray film. This paper propose Gaussian filter to reduce noise for clearly image.

Step 2: Image Segmentation with Canny Edge

In general, we apply canny edge filter for detecting edges in a very robust manner. It is a multiple step process as above. However, the double threshold is suitable for strong edges. Edges with a strength below both thresholds are suppressed.

Step 3: Image Extraction with Active Contour Model

The result of teeth's gap contour will define the boundary for area calculating in next step.



a) Gaussian filter b) Canny Edge c) Active Contour

Figure 5. The output from each process.

Step 4: Finding Gap Area

We can define the boundary of teeth's gap after active contour method. This section is a measurement process because we need to compare with teeth's crown and root to calculate the ratio of area.

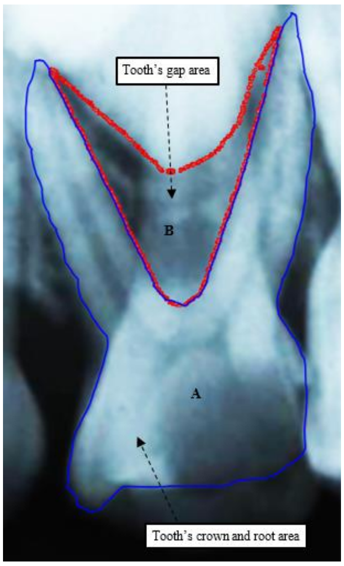


Figure 6. The teeth's gap area ratio.

A teeth's gap area ratio used to figure out the relationship between gap and crown-root. To calculate the ratio, you need to know the summation pixel of each area. The formula below demonstrates how to calculate.

$$Ratio = \frac{\sum pixel\ of\ A}{\sum pixel\ \ B}$$

Step 5: Diagnosis and interpretation

After finding the ratio of teeth's gap area, the data are combined with other factor of patients. There are (1) Age (2) Gender (3) Ratio of teeth's gap area and (4) Diagnosis of the experts. The proposed of this section is creating decision model for dental tooth extraction.

J48 algorithm is a widely used one to construct decision trees. Decision tree algorithm (J48) has two phases: building and pruning. The building phase is also called as the 'growing phase'. J48 uses entropy based information gain as the selection criteria.

IV. EXPERIMENTAL RESULT

Data comes from the children with tooth troubles such as eruption of deciduous teeth, tooth decay, toothache and gum problems. There are 50 people (24 boys, 26 girls), age between 7-10 years from Pediatric Dentistry, Hatyai Hospital, Songkhla, Thailand

Table I The relationship of case decision between ratio of teeth's gap area method and expert's way.

Case decision	**Ratio of teeth's gap area**	**Tooth Extraction Decision in expert's way (%)**
Extraction	20 ± 5	78 ± 7
No extraction	40 ± 4.5	60 ± 6

From Table I, the experiment is divided into two cases decision which are extraction and no extraction. The result show that the ratio of teeth's gap area compare with crown and root correlated with expert's decision as follows. In extraction case, if the ratio of teeth's gap area is 25, tooth extraction decision in expert's way is 71%. If the ratio of teeth's gap area is 15, tooth extraction decision in expert's way is 85%. In no extraction case, the ratio of teeth's gap area is 40 ± 4.5 and tooth extraction decision in expert's way is 60 ± 6%. So that teeth's gap area method and expert's way are inverse variation.

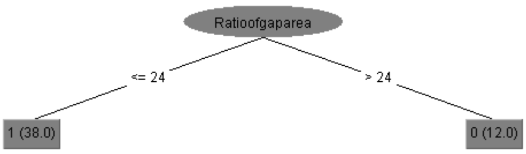


Figure 5. J48 decision tree. Define 0 is No Extraction, 1 is Extraction

In Tooth Extraction decision, J48 decision tree is used to identify the treatment (Extraction or not) with the criteria. There are age, gender, ratio of teeth's gap area and diagnosis of the experts.

Table II The performance of J48 decision tree.

TP Rate	**FP RATE**	**ROC**	**Accuracy**
0.974	0.05	0.987	98.0

From Table II shows that the True Positive value (or sensitivity) 0.974, Fault Positive value (or specificity) 0.05 and accuracy is 98%. ROC is 0.987 with J48 decision tree.

V. EXPERIMENTAL RESULT

To consider and decide whether to extract the teeth or not, there are several factors such as gender, age, root resorption and dental anatomy. From the previous related studies, it is found that most of the researchers will decide after they investigate the tooth resorption. However, the study is against the mentioned method because it is possible that there is a complication which results in no resorption. Hence, this study proposed the gap area of teeth as an alternative method. The process for deciding is often a gray area based mostly on an experience of the expert and rough predications on the long-term prognosis of the tooth in question. As a result, the clinician often makes decisions on their feelings rather than clinical parameters

ACKNOWLEDGMENT

The authors acknowledge Dr. Manthana Musekapan from Oral Health Sciences, Major in Pediatric Dentistry, Hatyai Hospital, Songkhla for her assistance on capturing dental X-ray films.

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