# Image Processing Techniques used for Dental X-Ray Image Analysis

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***Abstract.*** *Classification of dental caries is important for the diagnosis and treatment planning of the dental disease, which has been affecting a very large population throughout the globe. It is also helpful for conducting detailed study and investigations about the nature of the dental disease. Classification of dental diseases is decided on the basis of certain criteria, such as based on whether the lesion is within the enamel, dentin or whether it touches the pulp. Dental caries are, clearly visible in the x-ray changes and it can be detected from the caries lesion present in the radiographs.*

*In this paper we propose to show how image processing techniques will help check the x-ray and examine the extent to which the caries lesion is present and then classify the type of caries present in the dental radiograph.*

## 1. INTRODUCTION

Some of the major applications of image processing that we have witnessed in the last two decades are in the areas of biometric and biomedical image processing [1], [2]. The human vision system comes across a large set of biometric features and biomedical images and recognizes them without any conscious effort. To impart this capability to a machine is, however, difficult [4], [5]. The biometric identification systems are useful in several applications such as commercial and law enforcement applications, especially in criminal identification, security system, videophone, credit card verification, photo IDs for personal identification, etc. Recognition of human faces, fingerprints, signatures, and many other such biometric images constitute an important area of research in the field of computer vision.

Similarly there are different types of biomedical non-evasive imaging modalities such as X-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound images, and many others, which are used in the medical field for disease diagnosis and treatment planning. These imaging modalities reflect the state of the internal anatomy and dynamic body functions. It is important to understand the principal imaging modalities and the processing techniques to enhance, filter, segment, and interpret such images. The radiations in diverse forms utilized in these imaging techniques interact with various tissues to produce images from which the anatomical and structural information of various organs are extracted [1], [2], [4]. The study of science and technology of such information transformation is essentially the studies of biomedical imaging. In this work we have presented some of these imaging

978-1-4244-3974-4/08/$25.00 ©2008 IEEE 

modalities and their analysis and processing techniques.

X-ray Imaging

X-rays are among the oldest sources of EM radiation used for imaging. The best known use of X-rays is medical diagnostics, but they also are used extensively in industry and other areas, like astronomy. X-rays for medical and industrial imaging are generated using an X-ray tube, which is a vacuum tube with a cathode and anode. The cathode is heated, causing free electrons to be released. These electrons flow at high speed to the positively charged anode. When the electrons strike a nucleus, energy is released in the form of X-ray radiation. The energy (penetrating power) of the X-rays is controlled by a voltage applied across the anode, and the number of X-rays is controlled by a current applied to the filament in the cathode. X-ray images are generated simply by placing the patient between an X-ray source and a film sensitive to X-ray energy. The intensity of the X-rays is modified by absorption as they pass through the patient, and the resulting energy falling on the film develops it, much in the same way that light develops photographic film. In digital radiography, digital images are obtained by one of two methods: by digitizing X-ray films; or by having the X-rays that pass through the patient fall directly onto devices (such as a phosphor screen) that convert X-rays to light. The light signal in turn is captured by a light-sensitive digitizing system [4].

Angiography is another major application in an area called contrast enhancement radiography. This procedure is used to obtain images (called *angiograms*) of blood vessels.

Perhaps the best known of all uses of X-rays in medical imaging is computerized axial tomography. Due to their resolution and 3-D capabilities, CAT scans revolutionized medicine from the moment they first became available in the early 1970s. Each CAT image is a “slice” taken perpendicularly through the patient. Numerous slices are generated as the patient is moved in a longitudinal direction. The ensemble of such images constitutes a 3-D rendition of the inside of the patient, with the longitudinal resolution being proportional to the number of slice images taken.

Techniques similar to the ones just discussed, but generally involving higher energy X-rays, are applicable in industrial processes. Such images, representative of literally hundreds of industrial applications of X-rays, are used to examine circuit boards for flaws in manufacturing, such as missing components or broken traces.

Industrial CAT scans are useful when the parts can be penetrated by X-rays, such as in plastic assemblies, and even large bodies, like solid-propellant rocket motors.

Dental x-ray image analysis is another major area of digital image processing. Dental caries and periodontal disease are the most common dental diseases in the world. Dental caries has affected human being widely in modern times.

Dental caries is an infectious microbiological disease that results in localized dissolution and destruction of the calcified tissues of the teeth. If untreated the caries results in the progressive distraction of the tooth and infection of the dental pulp takes place.

### *1.1. Dental caries*

Classification of dental caries is important for the diagnosis and treatment planning of the dental disease, which has been affecting a very large population throughout the globe. It is also helpful for conducting detailed study and investigations about the nature of the dental disease. Classification of dental diseases is decided on the basis of certain criteria, such as based on whether the lesion is within the enamel, dentin or whether it touches the pulp. Dental caries are, clearly visible in the x-ray changes and it can be detected from the caries lesion present in the radiographs.

Image processing techniques will help check the x-ray and examine the extent to which the caries lesion is present and then classify the type of caries present in the dental radiograph [3], [4]. A computer aided interpretation and quantification of angular periodontal bone defects on dental radiograph is performed by P.F. Van der Stelt and Wil G.M. Geraets. Capabilities of human observers to detect and describe small bone defects objectively are limited.

Digital image processing can provide a useful contribution to the diagnostic process. Their procedure was able to rank series of artificial periodontal bone lesions as accurate as experienced clinicians. Comparison of data from clinical inspection of lesions during surgery and quantitative result of the digitized procedure shows that the latter produced reliable information on the lesion size. Dental caries can be classified [1], [2] in a number of ways depending upon the clinical features, which characterize the particular lesion. Dental caries may be classified according to the location of the individual teeth as pit or pissure caries and Smooth surface caries.

According to the rapidity of the process dental caries can be classified as acute dental caries and mild dental caries.

Caries may also be classified according to other criteria.

» - Primary (virgin) caries: Depending on whether the lesion is a new one attacking a previously intact surface,

» - Secondary (Recurrent) caries: Depending on whether it is localized around the margins of a restoration.

According to the extent of attack dental caries may be classified as

1. Enamel caries: Caries of the enamel is preceded by the formation of a microbial (dental) plaque. The processes vary slightly, depending upon the occurrence of the lesion on smooth surfaces or in pit or fissures.

When the caries have affected the outer enamel portion alone and if the inner dentine and pulp regions are healthy then the type of caries is called enamel caries. Enamel caries can further be classified as (a) Smooth surface caries and (b) Pit and fissures caries.

2. Dentinal caries: Caries of the dentin begins with the natural spread of the process along the natural spread of great numbers of the dentinal tubules each which acts **as** a tract leading to the dentinal pulp along which the micro-organism may travel at a variable rate of speeds depending upon some factors. In some instances carious invasion appears to occur through an enamel lamella so that little if any visible alteration in the enamel occurs. Thus when lateral spread at the dentino-enamel junction occurs with involvement of under lying dentin, a cavity of considerable size may actually from with only slight clinically evident changes in the overlying enamel except for its undermining.

3. Pulpal caries: The carious lesion discussed prior to this point has been limited chiefly to coronal caries, and process has involved basically the enamel and dentin of that portion of the tooth. Another form of disease does exit which is known as root caries or root surface caries. At one time it was also referred to as caries of cementum. It is generally recognized that the longer life span of persons today, with the retention of teeth into the later decades of life has increased the no: of population exhibiting gingival recession with clinical exposure of cemental surfaces and thereby probably increasing the prevalence of root caries. Root surface must be exposed to the oral environment before caries can develop here. In this section dental caries classification is performed based on the edge detection: The caries affected tooth is selected, which is subsequently used for caries classification.

### *1.2. Dental Caries Classification Algorithm*

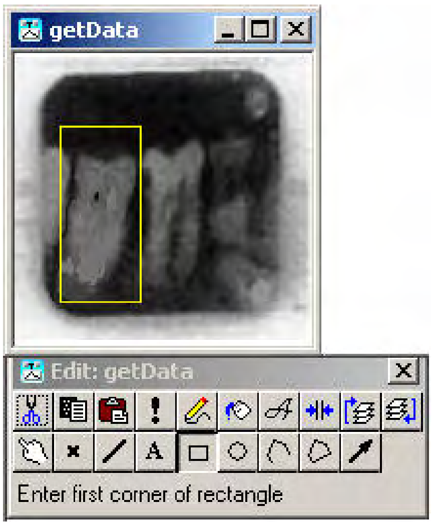
The dental caries classification algorithm is briefly explained below [3], [4], [5]. The radiographic image is first captured using an appropriate X Ray imaging device, connected to the image analysis system. The image is captured along a line parallel to the long axis of the tooth. The dental x ray image (figure 1.a) is initially segmented into individual tooth (figure 1. b, c) which is followed by binarization of the tooth pattern (figure 1.d). The edge detection of the segmented tooth yields the outline of the dental cavity. The classification may be achieved using a simple rule based system. By determining the number of carries affected pixels, the region area may be extracted (figure 1. f, g). If there exists only one black region and there is an adjacent white border, i.e., black carries region is adjacent to the white border enclosing the tooth, then the carries is classified as palpal. If on the other hand there exists two or more number of black regions and the width of the black region is less than 2 *mm* then it is Enamel carry. It may be pointed out here that the thickness of enamel around the tooth is approximately **2** *mm.*

Alternately if it is more than 2 *mm* that means it is dentinal carries.

## 2. DIGITAL IMAGE PROCESSING FOR DENTAL X-RAY IMAGE ANALYSIS.

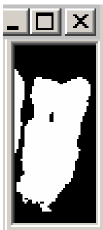
Diagram of the application (processing scheme with igraphs, a processing scheme in object oriented image processing software) for dental X-Ray image analysis using image processing techniques, is showed in figure 2, and intermediary, final results are showed in figures 1. a-g.


a. Dental X-ray image.

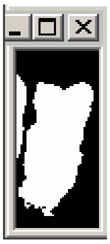



b. Selected tooth (tooth with caries).

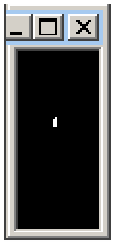
c. Segmented tooth with caries.



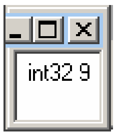
d. Binarization of the tooth (tooth pattern with caries).



e. Tooth pattern without caries.



f. Caries (carry) pattern.




g. Number (9) of carries affected pixels.

**Figure 1.** Digital image processing for dental x-ray image analysis.

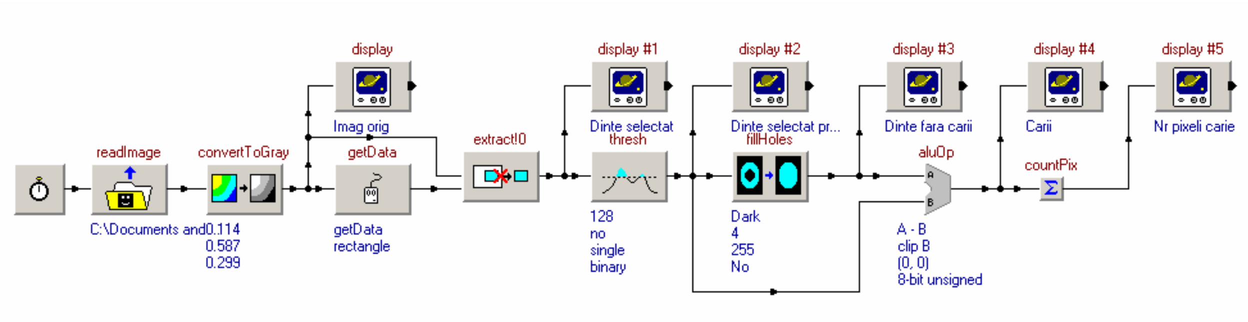



**Figure 2.** Processing scheme in object oriented image processing software.

In figure 1 we can easy follow the different processing just reading the names of the used operators.

The application breaks this process into the following steps:

Step 1: Read original image (*readImage* operator in figure 2);

Step 2: Convert to gray scale original image (*ConvertToGray* operator in figure 2);

Step 3: Display gray image (*display* operator in figure 2 and result in figure 1.a);

Step 4: Select tooth of interest (tooth with caries) (*getData* operator in figure 2);

Step 5: Extract tooth of interest (*extract!0* operator in figure 2 and result in figure 1.b);

Step 6: Display extracted tooth of interest (*display* #1 operator in figure 2 and result in figure 1.c);

Step 7: Threshold gray image of extracted tooth using 128 as tresh (*tresh* operator in figure 2);

Step 8: Display tresholded gray image (binary image) (*display* #2 operator in figure 2 and result in figure 1.d);

Step 9: Obtain image pattern of tooth without caries by filling holes in threshold gray image of extracted tooth (*fillholes* operator in figure 2);

Step 10: Display image pattern of tooth without caries (*display #3* operator in figure 2 and result in figure 1.e);

Step 11: Subtract image of tooth pattern with caries from image of tooth pattern without caries (*aluOp* operator in figure 2);

Step 12: Display difference image (*display* #4 operator in figure 2 and result in figure 1.f);

Step 13: Count carries affected pixels (*countPix* operator in figure 2);

Step 14: Display number of carries affected pixels (*display* #5 operator in figure 2 and result in figure 1.g).

## 3. Conclusions

The technique presented here, for dental x-ray image analysis using digital image processing, with minor modification should work in various digital image processing environments. In this paper, the implementation was made using an object oriented environment for image processing. The processing scheme (algorithm) can be adapted for other practical applications from other domains. This can be a part [3], [5] of a complex automated system.

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