RESEARCH ARTICLE OPEN ACCESS

A Review on Digital Dental Radiographic Images for Disease Identification and Classification

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ABSTRACT
Nowadays a research on dental disease is very helpful in the clinical sections for automatic interpretation of disease within less time and with more accurate results. The objective is to study and identify types of teeth disease, to develop a robust, simple, cost effective and more accurate interpretation algorithm. There are many difficulties in defining objective such as it is difficult to interpret diseases because there are very minute variations in X-rays, Poor image quality representation and segmentation of each teeth in radiographic image.
Keywords: Dental caries, Digital dental X-ray images, Teeth segmentation, Horizontal and Vertical projection profile, Gap Valley.

I. INTRODUCTION

Medical imaging technology is used to analyze healthcare related datasets. Medical Imaging is increasingly playing a vital role in areas like ophthalmology, cardiology, gynecology, orthopedics, dentistry and neurology. In the recent years, different techniques of processing on image have been actively used for the diagnosis of oral diseases in dentistry. There are various diagnostic methods for dentistry which include, Computed Axial Tomography (CT Scan or CAT scan), Ultrasonography (US), Scintigraphy, Panoramic Imaging, Intra Oral and Extra Oral Radiography and MRI. These imaging systems are helpful in confirming the different types of dental disease infections.

By using the radiographs of teeth, experts can found the number of diseases. the diseases such as, Fracture of tooth, Abrasion, Dental Caries, Attrision, Gingivitis, Periodontitis, Abscess, Interdental bone Loss, Supernumerary Teeth, Impacted teeth, Cysts, Malignancies, Developmental defects, Future Malocclusion etc.

Preliminary stage detection of teeth caries is very important. There are three types of dental caries, the first type is the **Enamel Caries**, that is preceded by the formation of a microbial dental plaque. Secondly the **Dentinal Caries** which begins with the natural spread of the process along with great numbers of the dentinal tubules. Thirdly the **Pulpitis** that corresponds to the root caries or root surface caries.

1.1 Digital Dental Radiograph (X-rays)

Dental Radiographs are electromagnetic radiated picture of the teeth and mouth. They have large energy for penetration in the body for the image formation on film. Generally on film, air appear as black, and teeth, soft tissue, and fluid appear as different gray shades. Dental X-rays find problems related to teeth, mouth, and jaw. Dental X-ray image show bone loss cavities, hidden dental structures (such as wisdom teeth), which cannot be seen during a visual examination. They are very useful in detecting the early stages of decay between teeth. Compared to traditional X-rays, only half the dosage of radiation is needed for obtaining a dental X-rays of comparable quality.

They do not require time for film development, so dentists need to wait for only a few seconds before the acquired image is displayed. Dentists can take another image instantly if the acquired image is not of good quality, so in general digital dental X-rays in a patient's record have better image quality than conventional dental X-rays. Mainly due to their advantages in speed, storage, and image quality, digital dental X-rays are now routinely used.

Here are some benefits of digital radiography such as the image quality is very high which helps to identify the diseases, it is faster and easier to use as compared with conventional method, also it requires lower dosage of radiation and no chemicals for developing.

1.2 Types of Dental Radiographs

1.2.1 The Bitewing X-ray

The bitewing types of X-ray is when the patient bites on a paper tab. In this view, the crown portions of the Upper and lower teeth are visible. Figure 1(a) shows bitewing view. These X-rays are used to check different dental disease present in the upper and lower teeth. The planes of the detector and the cone are aligned parallel in bitewing X-rays. This arrangement makes bitewing X-rays give exact view of the internal structure of the teeth.

1.2.2 Periapical X-ray

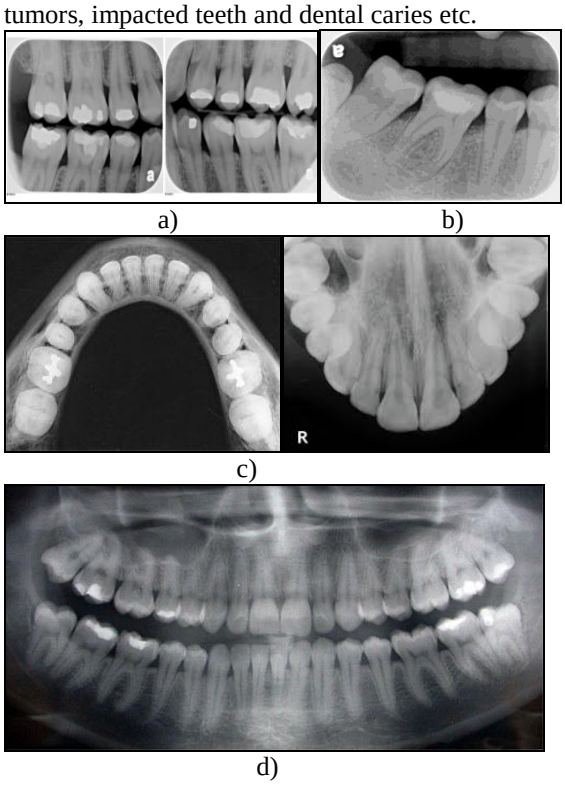
The objective of periapical x-ray is to capture the tip of the root on the film. This shows one or two complete teeth from crown to root as shown in figure 1(b). This used to determine teeth caries in a particular teeth, because it allows a dentist to visualize the whole tooth as well as the teeth surrounding cavities of bone.

1.2.3 Occlusal View

This type of X-ray captures all the upper and lower teeth in one shot while the film rests on the biting surface of the teeth.

1.2.4 Panoramic View

Panoramic X-rays shows the whole teeth structure with jaws and teeth in single view. These type of X-rays are used to detect different infections or problems present in teeth such as cysts, fractures, tumors, impacted teeth and dental caries etc.



a) b) c) d)

Fig 1 a): Bitewing View b): Periapical View c): Occlusal View d): Panoramic View

II. BACKGROUND

2.1 Basics of Tooth Structure

The study of human tooth structures is come under the field of dental anatomy. The teeth are made up of a group of hard substances present in the oral cavity. Teeth are generally used to masticate the food, provide shape to mouth and also used in producing the speech. the main parts of the tooth are crown and root.

Each tooth is an organ consisting of three layers: Enamel, Dentin and Pulp

• **Enamel:** Enamel is outermost white colored and hardest part of teeth and made up of calcium phosphate. It can be damaged by decay if teeth are not cared for properly.

• **Dentin:** It is a teeth layer lies just below the enamel. It is made of living cells, which secrete a hard mineral substance.

Fig 2: Tooth Structure

• **Pulp:** Pulp of the teeth carries blood vessels and nerves. Root canal Treatment procedure required if tooth decay reaches the pulp, to avoid pain.

• **Cementum:** It is a layer of connective tissue which binds the roots of the teeth to the gums and jawbone.

A normal adult person has 32 teeth, which are Incisors (8 total), Canines (4 total), Premolars (8 total), Molars (8 total), and Wisdom teeth or third molars (4 total). Basic tooth structure is shown in figure 2.

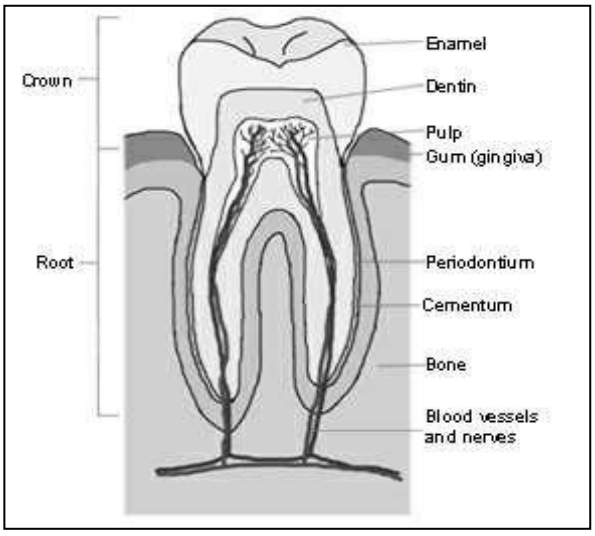


Fig 2: Basic Tooth Structure

2.2 Types of Diseases

2.2.1 Enamel Caries:

In dental x-ray images, enamel caries can be recognized by a loss on the interproximal surfaces of the enamel. To be detectable on a radiographic image there must be a 30% to 50% change in the mineral content of the enamel lesion.

2.2.2 Dentinal Caries

Dentinal Caries can be recognized by noting the focal loss of dentinal radiopacity. Dentin caries may be discerned inter-proximally, on the occlusal surface, buccally/lingually, or on root surfaces.

2.2.3 Pulpitis

Dental Caries, commonly known as tooth decay or cavities extends below the tooth dentin and it affects the nerves or the blood vessels, the it is known as the pulpitis.

III. REVIEW

is an art and science of diagnosis and treatment of diseases and disorders of the oral cavity and its associated structures. The components of dentistry includes, periodontics, oral pathology, orthodontics, oral and maxillofacial surgery, pedodontics, prosthodontics, forensic odontology, geriatric dentistry and dental implantology. Periodontics deals with diseased gums , Oral pathology concentrates in the diagnosis , Orthodontics aids in the correction of mal-aligned teeth, oral and maxillofacial surgery is concerned with major surgical procedures related to the dental and associated structures , pedodontics deals with children and prosthodontics accounts for the rehabilitation process . Forensic odontology consists of the gathering and the use of dental evidence in human identification that is primarily documenting and verification of identity . Geriatric dentistry is the delivery of dental care to senior adults involving the diagnosis and treatment of problems associated with age related diseases . Dental implantology is a recent milestone in dentistry and in this method the dental images play a vital role in the selection and correct placement of implants.

Common dental diseases are tooth decay and gum diseases. Other dental related disorders include , discolored front tooth, fractured teeth from trauma, over-retained primary teeth, abnormal eruption of wisdom teeth, tempero-mandibular joint disorders and pathological lesions like dental cyst, plague, cancer and tumor. In recent years there is increasing awareness among people about the fact that the dental problems can cause other serious health implication. Prevention and early treatment of dental diseases may contribute to overall health. The conventional diagnostic procedures include tracing the history, measurement of pocket depth and clinical attachment level, and assessment of tooth mobility and displacement, and the increase in local temperature.

The goal of this research is to automate the process of representation and extracting different features of dental x-ray images to use in further applications.

3.1 Existing Systems

A. J. Solanki et al. performed ISEF edge detection to check the depth of dental caries in decayed tooth. Morphological filtering used for image enhancement and edge detection is completed by using ISEF method. For detection and decision of caries region of interest was decided [1]. Classification of dental caries based on the edge detection. The dental x-ray image is segmented into individual tooth and then it is converted into binary image of the tooth. The edge detection gives the border of the dental cavity. The number of carries affected pixels is determined. The carries is classified as *pulpal* if black caries region is next to the white border enclosing the tooth. If 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. For the implementation of the proposed algorithm a specialized object oriented image processing software is used [2].

Dr. C. K. Modi proposed feature extraction technique for dental X-ray image. There are different features for radiographic image such as shape and texture. For shape analysis Fourier descriptor features and to describe texture analysis of the extracted tooth GLCM properties such as contrast, Energy, Correlation and Homogeneity are used. Also the author suggested future work in the given system is finding a novel feature extraction technique which explores the geometry of teeth which remains inherently unique to each individual [3]. Shape extraction algorithm is developed using contour information and mahalanobis distance measure is done for matching dental records. Integral intensity projections is used to segment upper and lower jaw and also to segment individual tooth. Shape extraction is improved by fast connected component labeling [4]. Grayscale contrast stretching transformation to improve the performance of teeth segmentation, also offered a mathematical morphology approach to the problem of teeth segmentation, which used a series of morphology filtering operations to improve the segmentation, and then analyzed the connected components to obtain the desired region of interests (ROIs) [5].

Tooth isolation in upper jaw and lower jaw and the visibility of the dental plaque is improved by K-Means clustering based pseudo coloring. The tooth isolation is done by using histogram aided spectral spatial classification [6]. To identify Periodontal Diseases digital subtraction radiography (DSR) is used. It requires a pair of images with identical gray-level distribution and Projection geometry is needed for identification of periodontal disease. The drawback of this technique is if there is any mechanical alignment in the camera view then mismatching will occur in the result [7]. The

classification of types of dental cyst using texture parameters estimation based on Gray Level Co-occurrence Matrix (GLCM) approach and the K-mean classifier to classify the dental cyst based on the features. the following process can be applied to classify the dental disease. Dental cyst images are given as input then preprocessing such as image negative and special stretching is applied on image, then GLCM calulations are done and the process is followed by texture parameter estimation and lastly classification is done by using K-mean classifier [8]. Classification of dental diseases is decided on the basis of certain criteria, such as based on the lesion, whether it is within enamel, dentin or whether it touches the pulp[9].

Abdolvahab Ehsani Rad, used a digital dental radiographs to perform segmentation using Level set method and Texture Feature Extraction using gray level co-occurence matrix and also developed a system to enhance the quality of input X-Ray image for segmentation and extacted textural features for each dental x-ray image[10]. An algorithm is developed for human identification based on SIFT feature extraction from the image. Both radiograph and photograph are used in this system. The system developed such that, it requires less computational time and an automated approach for extracting and matching teeth features[11]. This paper gives the review on the digital image processing techniques for intraoral dental diseases. In this the review section is divided in to three subsections in which first section different image enhancement methods are discussed. the second section focuses on image segmentation and feature extraction techniques used by various authors. and third section covers the brief review on the software's used by dentists to analyze x-rays based on various parameters [12].

A cost effective caries detection technique is developed by using image processing. It is efficient and precise in determining the tooth caries. The input image is in format of rgb. To find the caries present in the teeth the red plane is used [13]. For segmentation of dental radiographs, this method proposes the automatic selection of region of interest. The system uses binary edge intensity integral curves. to implement the automatic system it used region growing approach followed by canny edge detector. It automatically finds the ROI both for gap valley and tooth isolation [14]. A semiautomatic algorithm is proposed for measuring the root canal length based on morphological features. The basic prepocessing steps are done such as histogram equalization, denoising , and enhancement. Then morphological operations are used to extract pulp of teeth in a radiography image. Based on that root canal length is measured by giving some threshold value [15]. This paper presents an edge flow model for detection of various types of image boundaries within single framework and demonstrated the use of this model in segmenting a large variety of natural images [16]. this paper presents a very effective and fully automatic tooth isolation method which is an important pre-processing step of both computer-aided dental diagnosis system and automatic dental identification system. This method contains four major steps: upper-lower jaw separation, single tooth isolation, isolation-curve verification for over-segmentation, and missing-teeth detection for under-segmentation. Vertical and horizontal integral projection method is used for isolation of teeth. Furthermore this can be used to indicate the locations of missing teeth [17].

A method for dental classification based on multiple fuzzy attributes for periapical radiographs is proposed. Each tooth is analyzed based on various criteria such as are/perimeter ratio, and width/height ratio. For tooth isolation integral projection is used and then features are extracted from isolated tooth such as area, perimeter, height, width etc. These features are used to classify the teeth using multiple fuzzy attributes [18].

IV. DISCUSSION

The major researchers make use of thresholding and morphological operation for feature extraction and segmentation. Much of the work have been done for teeth segmentation, but very few researchers have applied and realized the methods for diagnosis purpose. Interactive portions of X-ray selected for further processing specifically for the purpose of diagnosis is the need of the hour as it would help both doctor and patient to understand the problem and depth of disease. Researchers up till now have been found concentrating on image enhancement or segmentation for extracting features for forensic sciences. No much research has effectively contributed for the diagnostic methods. Automated or semi-automated diagnosis of aforesaid objectives would be quiet useful for doctor as well as patient.

ACKNOWLEDGEMENTS

The authors are highly thankful to Dr. Kartik Raman, City Dental Center, Aurangabad for rendering immense knowledge of oral radiology and scope of image processing in this field of dentistry. The authors also thank and acknowledge Dr. Kartik Raman for providing his dentistry images.

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