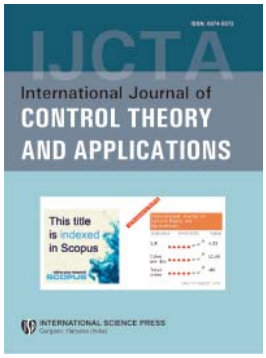

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A Survey: Segmentation in Dental X-ray Images for Diagnosis of Dental Caries

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Abstract : Dental caries is an infectious bacterial disease affecting hard surface of the teeth and remains the most prevalent chronic disease world-wide that affects most of the population. Although it is preventable, it causes a major tooth loss. The primary step is to detect dental caries in the early stage itself using diagnostic imaging techniques. The digital dental *x*-ray is the commonly used method to detect and diagnose dental caries. The segmentation of dental *x*-ray images could be difficult due to the shape and intensity variation within the same dental *x*-ray images and from one image to another. This makes a challenging process to segment the dental *x*-ray images for diagnosis of caries. In this paper, a survey has been presented on segmenting the digital dental *x*-ray images for diagnosis of caries.

Keywords: *Dental caries, dental X-rays, segmentation, diagnosis.*

1. INTRODUCTION

Dental Caries is defined as a localized disease that affects the hard tissues of teeth caused by the action of microorganisms that are found in plaque, on fermentable carbohydrates [1]. It is the most common dental diseases affecting 60-90% of school children and still a major public health problem [2]. Caries is also known as tooth decay or dental decay [3], which falls out on any tooth surface especially when there is continuous deposition of dental plaque. Plaque is an example of a biofilm, which means it is not a disorganized collection of bacteria but a group of metabolically active microorganisms attached to a surface [4]. So, it is important to detect caries using diagnostic devices.There are several devices commercially available for detecting caries such as Electronic Caries Monitor (ECM), X-rays, Fiber-Optic Trans illumination (FOTI), fluorescent techniques, Optical Coherence Tomography (OCT) and ultrasound techniques [5]. Among those, the most common method for detecting caries is X-rays, since X-rays are easy to access and cheaper when compared to other techniques. X-rays are commonly used in the field of dentistry for diagnostic purposes [6].

1.1. Dental X-rays

Dental X-rays or radiographs play a vital role in the diagnosis of dental diseases, such as cavities. Dentists often use radiographs especially in finding hidden dental structure, bone loss, malignant or benign masses and cavities that cannot be examined during visual examination [7]. Dental X-rays are purely essential, preventative and

diagnostic tool that provide valuable information. Radiographic interpretation of dental caries should always be undertaken with a clinical examination of the oral cavity. Caries can be detected radiographically only in the advanced stages when there is sufficient decalcification of tooth structures.

1.2. Different views of dental X-rays for diagnosis

In general, X-rays can be viewed into two categories: intraoral and extraoral. With intraoral X-rays, the X-ray film is placed inside the mouth, whereas in extraoral X-rays, the film is placed outside the mouth. The various types of intraoral X-rays are 1) Bitewing X-rays, which shows the back teeth of upper and lower jaws and as well, shows how the teeth touch each other in a single view. This type of X-rays is used to find out decay between teeth. 2) Periapical X-rays, which highlight only one or two teeth from crown to root at a time and used to observe abnormalities in root structure or surrounding bone structure.3) Occlusal X-rays are larger which highlight the full tooth development and placement and are useful in finding extra teeth, jaw fractures, teeth that have not yet broken through the gums, cysts or growths [8]. Extraoral X-rays are less detailed when compared with intraoral X-rays. The various types of extraoral X-rays are 1) Panoramic X-raysinclude all teeth in both upper and lower jaw in a single x-ray. This type of X-ray is useful for detecting the position of fully emerged as well as emerging teeth and used to identify affected teeth which help in the diagnosis of tumors [9]. 2) Cephalometric projections show entire side of the head. These X-rays are used to examine teeth in relation to the jaw and profile of the individual.3) Computed tomography, commonly known as CT scanning, shows the body's interior structures as the 3D image. A standard CT scan may be done to find out size and placement location for implants [10]. Among different views of dental X-rays, a digital radiograph is considering in this work.

1.3. Digital radiograph and its advantages

Apart from the various types of above X-rays, digital radiograph is one of the newest x-ray techniques. It is a form of *x*-ray imaging where digital *x*-ray sensors are used rather than traditional photographic film. Digital radiography utilizes digital image capture device instead of *x*-ray film which gives advantages of quick image preview and applied to special image processing techniques which will enhance the overall display throughout the image. Digital radiography offers improved imaging through lower dose and lack of chemical processing [11] and provided the possible to increase the diagnostic yield of dental radiographs. When compared to the dental x-ray films, digital dental radiographs are the most common method used for diagnosis of caries and widely used in clinical practice [12].

1.4. Role of image processing techniques on digital dental radiographs

An image processing techniques play a vital role on digital dental radiographic images to digitally acquire, manipulate, store, retrieve and exchange radiographic information [13]. Digital imaging radiography offers some discrete advantages over film based radiography, presents new and different challenges to overcome since it is growing an emerging technology [14]. Digital image processing techniques also offer a useful contribution to the diagnostic process.

Now a day's digital dental radiographs are widely used to do automatic segmentation or even semi-automatic segmentation for a diagnostic task which will make the dentist to identify caries easily. The computer-aided caries detection and diagnosis algorithm has been recently developed for better and faster decision on the diagnosis of caries and for further treatment.

This paper is structured as follows: Section 2 presents the literature survey onsegmentation of the digital dental X-ray images for diagnosis of caries. Section 3 gives conclusion part with the scope for future work of my research.

2. LITERATURE SURVEY:

This section includes some prior studies carried out on dental radiographs using various image processing techniques and presents a survey focusing on segmentation method for diagnosis of caries in dental radiographs.

Segmentation is a process which subdivides the image into its constituent regions or objects. The level of detail to which the subdivision is carried out appears on the problem being solved. That is, segmentation stops when the objects or regions of interest in an application has been detected [15]. Segmentation algorithm has a broad range of applications where certain objects in an image are expected to be identified and analysed and hence several general-purpose image segmentation algorithms have been developed [16].

Image segmentation is one of the most challenging problems especially in dental X-rays images and the outcome will aid dentists in the detection and diagnosis of dental diseases. Dental image segmentation helps not only in the identification of dental abnormalities but also in the field of forensic dentistry, dental biometrics, etc. for human identification [17]. The following survey focuses only on the various segmentation techniques for diagnosis of caries in digital periapical dental x-ray images. Fig. 1 depicts the periapical view of the dental radiograph.

Figure 1: Periapical view of the dental radiograph

2.1. Computer-aided diagnosis using level set method

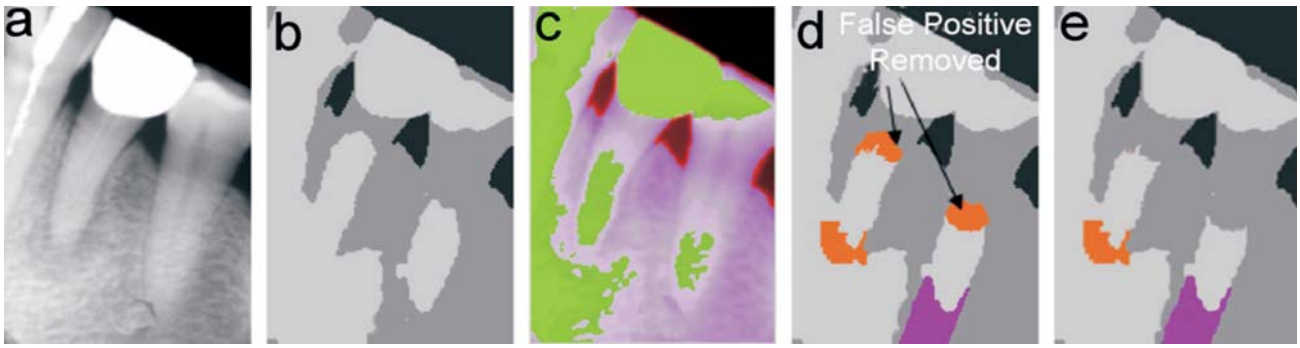

Figure 2: Results of Segmentation and lesion detection (a) Original image (b) Segmentation result (c) Lesion areas marked with color channel method (d) Removal of False positive (e) Lesion areas detected

A semi-automatic framework to segment periapical lesion (PL) and bifurcation lesion (BL) using the level set method from periapical dental X-rays was proposed in [18]. In [19], an automatic variational level set segmentation framework which used Window based feature extraction followed by principal component analysis (PCA) extracted. The images chosen manually are segmented using hierarchical level set region detection to train the support vector machine. The classifier furnishes initial contours closer to correct boundaries for

three coupled level sets driven by a proposed pathologically variationalmodeling which accelerates level set segmentation and provides an automatic pathological segmentation which naturally segments those problem areas. These two methods are successful in segmenting the lesions from the dental X-rays as shown in Fig.2 but they failed to remove those soft tissues and nerves part from problem areas and engaging more perverted algorithm to examine the segmented results which allow for more accurate indications to dentists. Targeting or segmenting the affected region alone may give more refined and accurate results to the dentists.

2.2. Fully-automatic segmentation method

In [20], the author proposed an algorithm for fully automatic segmentation of teeth images for dental diagnosis. This algorithm combined region growing method with an optimized elimination of false boundaries for achieving meaningful segmentation automatically as shown in Fig.3. The main advantage is that this algorithm performed better when more images are tested, but the problem is that the performance of this algorithm might be low when working with a large sample size of images and have some difficult in segmentation process to show the decayed tooth.

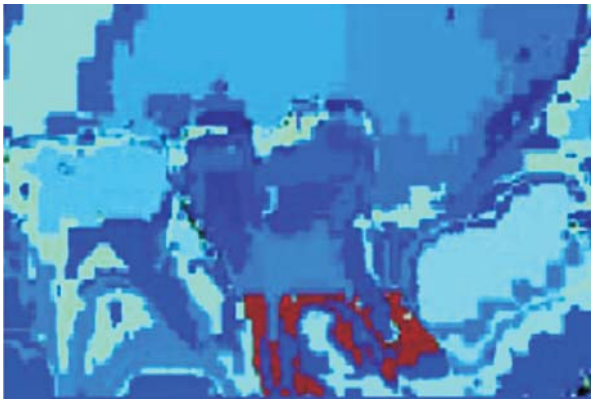

Figure 3: Segmented image showing decay

2.3. Edge detection method

The author in [21] and [22] presented a technique for dental x-ray image analysis to examine whether caries lesion was present or not using digital image processing and classified the type of caries in the dental x-ray images. The edge detection technique was used for segmenting decayed tooth which has been achieved using a simple rule-based system. The major drawbacks of these works were the classification of caries based on the measurement of regions, and manual segmentation has been done which is not effective. Since dental x-ray images are poor quality in nature and the proposed work did not use any enhancement technique. Thus, these works failed in the classification of caries.

2.4. Boundary and contour-based segmentation method

In [23], the author presented a method for segmentation and feature extraction of dental x-ray images. In the interest of segmenting tooth,k-means clustering method was used for clustering the image into 5 clusters for identification of dental caries as shown in Fig.4. To extract features, Gray Level Co-occurrence Matrices used for dental diagnosis systems such as dental caries detection or human identification systems. But this work failed in segmenting the individual tooth because bitewing x-ray images were used so that some overlapping has occurred. This problem has been overcome by the author in [24] using level-set method for segmentation in periapical x-ray images but still, this work also needs some improvements in segmentation step because tissues are attached along with segmented teeth.

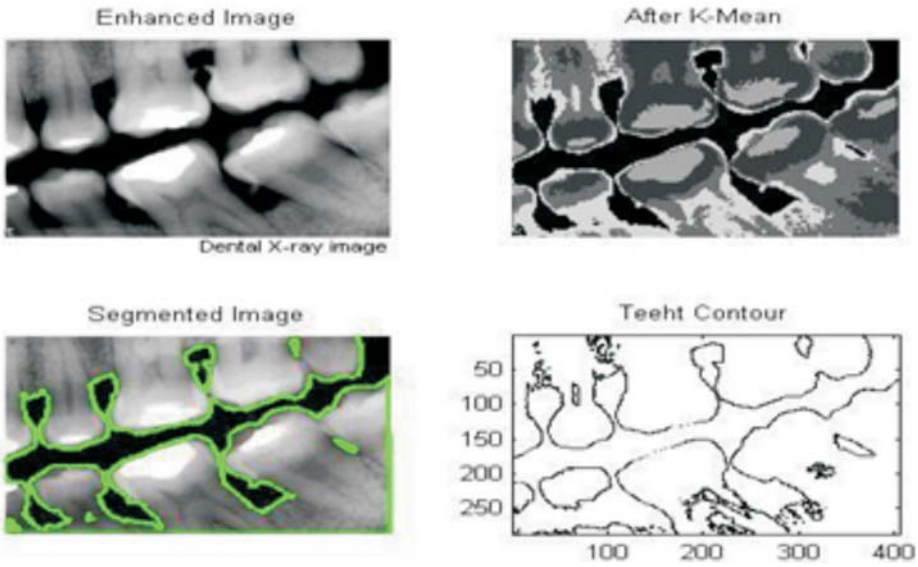

Figure 4: (a) Enhanced x-ray image (b) Result of k-mean algorithm (c) Segmented teeth with correspondence boundary around teeth (d) Contour of teeth image

In [25], Infinite Symmetric Exponential Filter (ISEF) has been applied for segmenting digital dental x-ray images. ISEF did the edge detection of caries affected tooth. The author used Hysteresis thresholding for eliminating the streaking problem. Based on the horizontal and vertical region of interest the treatment which should be undergone can be decided.

2.5. Clustering based segmentation method

In [26], k-means clustering method was used for segmenting the plaque portion has been performed by pseudocoloring to improve the visibility. Tooth isolation has been done by histogram aided method and spectral and spatial classification method for separating upper and lower jaw.

2.6. Edge detection and contour-based segmentation method

In [27], level set active contour method was proposed for image segmentation for identifying cavities in the dental x-ray images. For identification of cavity, Sobel operators were used for edge detection purpose. The level set active contour method was used for segmenting cavities and region near to the cavities. The images with size 512 x 512 were chosen because as the image size increases the time complexity is also increases. So, this algorithm will not work with images of size 64 x 64 and 256 x 256 because these images become very small and cannot be identify the cavities properly. As we go for images with size 1024 x 1024, the images become too large which increases the complexity of time and this image does not fit in the screen.

2.7. Computer-aided detection system method

In [28], an automatic segmentation and feature extraction method were presented for diagnosis of caries in dental x-ray images. An integral projection process has been used for separating individual tooth regions. The features such as entropy, intensity, etc. are extracted from ROI are compared with the nearest regions for finding the region contain caries or not. Dental expertise examines the features of caries area for caries detection process. Though segmentation using this method was successful, but in some images, the process of segmentation difficult due to variations of intensity region and difficult in tooth extraction may give the wrong result as shown in Fig.5. With the level set method for segmentation, the problem occurs when initial contour goes wrong or x-ray images has more noise.

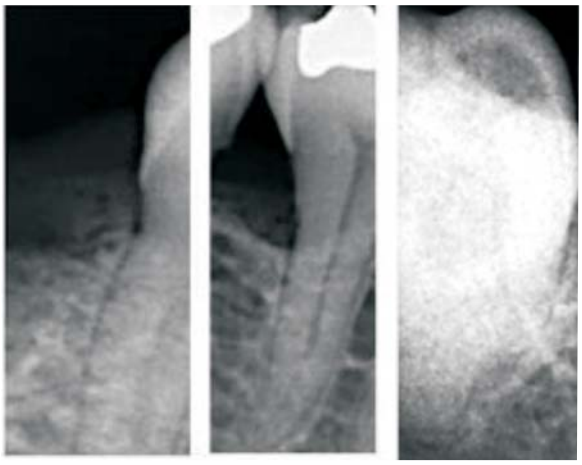

Figure 5: Some wrong false positive segmentations

From the above studies, the segmentation algorithm achieves a good result but with some error because of some manual interpretation. Most of the segmentation algorithm mentioned above done only in semi-automatic condition.

2.8. Fully automatic multistep segmentation method

Apart from this, we have done work on fully automatic segmentation of caries in [29]. In this work, a multistep algorithm was proposed for automatic segmentation of caries from dental x-ray images. This multistep algorithm has been implemented by the combination of Dual Tree Complex Wavelet Transform (DT-CWT), and watershed transforms methods. The proposed algorithm improved the performance in segmenting the caries as shown in Fig.6 when compared with region growing method with optimized elimination of false boundaries [20] and simple rule-based system [21] [22]. This algorithm effective in segmenting caries from periapical dental x-ray images which aid the dentists for further clinical treatment.

Figure 6: Segmented image

3. CONCLUSION

This paper reviews some influential papers in the dental x-ray segmentation literature. Among the methods proposed only very few are fully automatic, the manual interaction of dentist may lead to a time delay. Even though [20] – [25] tried to segment caries but some methods are not accurate in segmenting caries due to improper teeth segmentations and some of them due to noise, low contrast and unusual arrangement of teeth.

Still severity based classification of dental caries not performed yet. The future work will focus on retrieving dental x-ray images using content-based retrieval systems (CBIR). The future enhancement will also focus on technology such as mobile applications to segment caries and share the reports.

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