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Segmentation of Periapical Dental X-Ray Images by applying Morphological Operations

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***Abstract* - Segmentation of Dental X-ray images is done using various image processing techniques which are useful in medical diagnosis, clinical purposes and real-time applications. These methods aim to define the segmentation of different tooth structures present in the Dental X-ray images which will be used for the early detection of caries, tooth fractures, root canal treatment and periodontal diseases etc. which plays a key role in the identification of diseases. Manual segmentation of Dental X rays images for the medical diagnosis, from the large databases in clinical routine, is very complex and time consuming process. In this paper, we propose a three-step procedure for the segmentation of each individual tooth, firstly preprocessing is done using a top hat and bottom hat filtering then Otsu's thresholding with morphological operations are employed to separate the tooth structures from the Dental X-ray images. Performance evaluation is done using 10 periodical X-ray images and the accuracy of the method is measured as 97% approximately.**

Index Terms — Dental X ray images, Morphological operations, Top hat and Bottom hat filtering.

1. INTRODUCTION

Dental experts today are progressively using dental radiographs (computerized X rays) to better recognize and analyze dental diseases. Different types of machines are used by dentists for dental X-ray imaging and hence resolution, contrast, noise, luminance of these images may also be different [1]. X-ray images are taken by doctors for the particular area where a patient feels discomfort or pain and to diagnose a problem or monitoring a treatment whether it is going in the proper way or not. Situations that may entitle for a dental X-ray include tooth fractures, decay, growth of tooth, root canal treatment, periodontal diseases etc. Segmentation of dental X-ray images are very useful in various applications namely person recognition or forensic and to help dentists for the medical diagnosis, counting of teeth, estimation of age and so on. Segmentation of different features of tooth is used for different purposes and goals [2]. One of the most significant applications of Dental X-ray image segmentation and classification is forensic recognition [3]. Forensic odontologists normally rely on the shape or structure of teeth and also dental restorations specifically fillings, root canal treated tooth etc. to identify a person in the mass disaster after postmortem [1]. As compared to different biometric features, structure and geometry of tooth crown and root remains same for long period of time [1].

In this paper, we are using periapical dental X-ray images which come into the category of intra oral images in which film is placed inside the mouth and dental X ray contains the complete tooth information from crown to the root which is very helpful for the treatment of root canal, interproximal caries and bone loss between the teeth. Some examples of a dental Periapical X rays as shown in Fig. 1 (a) Teeth (without any problem) (b) Inter-proximal caries (c) Restoration done and (d) Tooth under root canal treatment. It provides detailed information about the growth of teeth, structure of jaws and soft tissues around the tooth whether any disease occurs or not, which is not visible by human naked eyes.

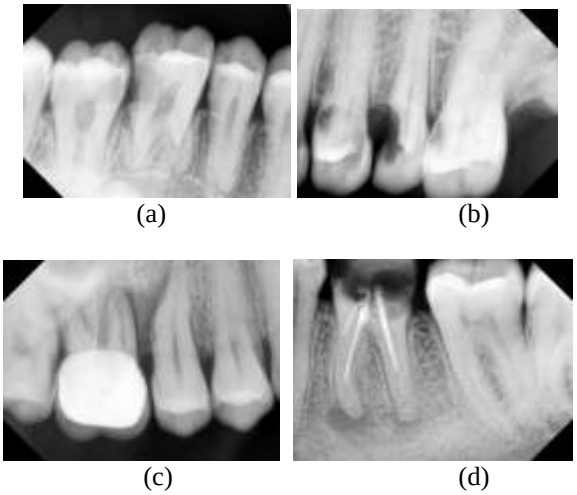

Fig. 1 (a) Teeth (without any problem) (b) Interproximal caries (c) Restoration done (d) Tooth under root canal treatment.

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We can see that different abnormality types in the dental X-ray images in Fig. 1, but most of the time existence of unwanted noise and low illumination in the X ray images creates a problem for the doctors to understand the abnormalities. To reduce this problem image processing methods like enhancement of X-ray image, and removal of unwanted noise using filtering, and segmentation of tooth structures etc. becoming more popular now a days in the field of medical treatments.
This work mainly concentrates on segmentation of Periapical dental X ray images and based on the shape of the segmented tooth to identify the abnormal teeth.

II. LITERATURE REVIEW

There are several techniques for dental X-ray image segmentation. Lin et al. [4] proposed an approach in which bones and teeth are separated by iterative thresholding. Jain and Chen suggested a contour based shape extraction method [3]. However, the algorithm fails to detect the contour if X-ray images are of low contrast or blurred. Said et al. [5] proposed a method based on mathematical morphology. Firstly, the quality of images is enhanced based on filtering and then connected component analysis is used to obtain the desired result. Nomir and Mottaleb [6] suggested a method used to identify a person in case of disaster based on ante and post-mortem dental X-ray images. A method for the missing tooth detection and counting the number of teeth using dental X-rays is given by Aeini and Mahmoudi [7]. Zhou and Mottaleb [8] proposed a method which employs integral projection to separate the upper and lower jaws and then active contour model is used for the isolation of individual tooth. A segmentation technique for dental X-rays primarily based on a supervised learning approach for texture reputation. Firstly, features are accomplished by means of computing moments, and statistical features. Bayesian classifier used the acquired information and after the training of data, tooth region is separated from the background [9].

Patanachai et al. [10] used wavelet transformation and morphological operation to identify the edges of teeth from the dental X-ray images. The difficulties faced by the segmentation algorithm occur due to the similarity between the bones and the teeth, impacted tooth, gap valley between teeth, missing tooth etc. [11]. Wisdom teeth and extra teeth create problems when no space available for the extra teeth. Due to these problems, other teeth are affected and become partially impacted [12].

For the treatment of periodontal diseases or Periapical lesion like abscess, periapical X-ray images gives a complete view of three to four teeth, which is best selection for the type of anomalies which occurs nearer to the tooth boundaries, can be detected very easily. Lin and Lai [13] proposed an approach that used the homogeneity criteria to enhance the tooth structures then edge value and entropy is used by the k-means clustering. Finally, the clustering results are evaluated with the set of membership functions.

In this paper, we propose an efficient method to segment teeth in dental periapical X-ray images based on top hat and bottom hat filtering and Otsu's thresholding with morphological operations. The efficiency of the proposed method is supported with experimental results of 10 Dental X-ray images. The rest of this paper is planned as follows. In Section III proposed approach is explained. Experimental results and accuracy measurement are provided in Section IV. At last, conclusions are specified in Section V.

III. PROPOSED APPROACH

The process flow diagram of proposed approach is given in the Fig. 2. In the first step, preprocessing is done using top hat and bottom hat filtering, then Otsu's thresholding is used to separate the background and tooth structures from the image, after that morphological operations used to refine the segmented results.

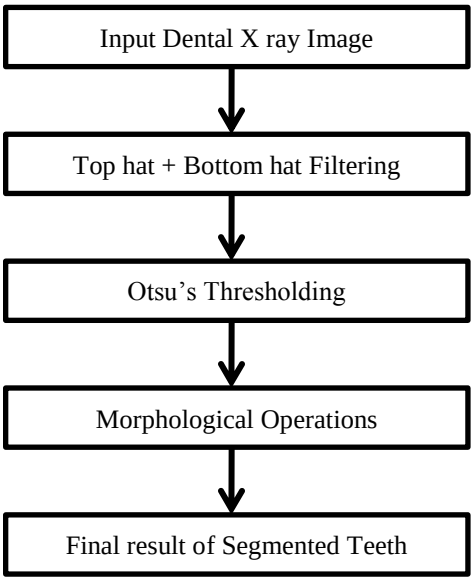

Fig. 2 Process Flow

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Preprocessing

Preprocessing is very useful to achieve the fine segmentation, because dental X-ray images always suffer from unwanted noise, low illumination. To overcome this problem Top hat and bottom hat filtering is used to enhance and visualize the more valuable information from the dental X-rays. Top hat transformation is used to find the small details from the images and improve the contrast of images by using morphological methods. It is obtained by finding the difference between original image and its opening. Top hat transformation behaves like a high pass filter and extracts the bright region of the image [14]. It is defined by the following equation:

$$Top\_hat(\mathbf{I}) = \mathbf{I} - (\mathbf{I} \circ \mathbf{B}) \quad (1)$$

where 'I' is the original image and 'B' is the structuring element. Bottom hat transformation is difference between the closing of image and its original image
It is defined by the following equation:

$$Bottom\_hat(\mathbf{I}) = \mathbf{I} \bullet \mathbf{B} - \mathbf{I} \quad (2)$$

It is likely to take account of the bright region to the image and subtract the dark region. As a consequence, there will be an enhancement in the contrast between bright and dark regions:

$$\mathbf{I}_0 = \mathbf{I} + Top\_hat(\mathbf{I}) - Bottom\_hat(\mathbf{I}) \quad (3)$$

The results of applying the Top hat and Bottom hat enhancement on the periapical dental X ray image are shown in Fig. 3. As compared to the original X ray image, the image after the preprocessing contains more detailed information.

(a) Original image

(b) Original + Top hat – Bottom hat

Fig. 3(a) Original image (b) After preprocessing

Segmentation

In the segmentation procedure, dental X-ray images consist of different regions, background, teeth and bone structure area around the teeth. Mostly bright gray scale values indicate the tooth region, middle range of grey values shows the bone region and the background always maps the dark region. The main goal of the proposed segmentation algorithm is to find the shape of every individual tooth and based on that detection of abnormal tooth present in the dental X-ray images and segmentation is improved by using morphological operations.

Thresholding

After minimizing the unwanted noise from the images, we apply threshold process to divide the teeth from the background. Binary image is produced after applying thresholding that renders image examination simpler. In most of the dental images, we observe the occurrence of a shading consequence that manifests as a rise of image intensity. Therefore, taking only single threshold value is not preferable for the reason that it may result in loss of information pixels. The histogram of the filtered image contains the percentage of image pixels under a given grayscale level, after reducing the noise gives the percentage of pixels that are set to zero. As per the experimental results of 9 images using three threshold values produces the most qualified results.

Morphological Operations

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Mathematical morphology is used to refine the segmentation and extracting structural features in an image and is helpful for contour information characterization. An image is considered as a set (binary image) or a function (gray scale image), structuring element is used for the non linear operations. The structuring elements such as square, disc etc are used to find the shape features. The two fundamental morphological operators are erosion and dilation. Brightest value in a neighbourhood of structuring element is selected by dilation. Erosion is opposite of dilation, which selects the darkest value. Several additional operations are derived from these operations. Dilation and erosion are defined as follows:

$$D(A,B) = A \oplus B = \bigcup_{\beta \in B} A + \beta \quad (4)$$

$$E(A,B) = A - (-B) = \bigcap_{\alpha \in B} A - \alpha \quad (5)$$

IV. EXPERIMENT AND RESULTS

In the proposed method, periapical dental X-ray data set taken from Indian Institute of Technology (IIT), Roorkee hospital and the step by step results are shown in Fig. 4 below:

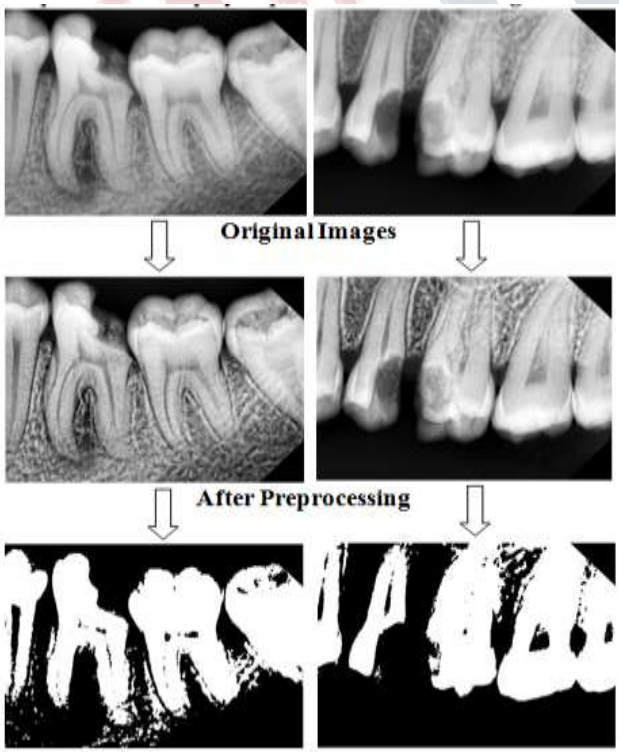

Fig. 4 Results of proposed method

From the Fig. 4 we can see that results contains the shape of tooth part, in which most of the tooth crown shape is not fully curved at the top, it means loss of tooth region because of cavity.

This method is applied on 10 periapical dental X ray images and accuracy of the proposed method is approximately 97%. Moreover, this paper can help the dentist interpret X-ray films and support the diagnosis in case of tooth extraction.

V. CONCLUSION

In this paper, we propose an automatic method for the segmentation of dental X-ray images of teeth for the diagnosis of anomalies based on the shape of the segmented teeth. In the experimental results, background and bones parts are distinguished very efficiently. The proposed method is also beneficial for person identification by matching teeth shape. The experimental results identified in this paper will positively helpful to the doctors and Forensic odontologist in automated dental identification system. In future work, classification approach may be implemented to find the canine, incisor, molars and premolars teeth.

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