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Layer Wise Segmentation Of Dental X-Ray Images

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Abstract: Dental cavity is the major problem among adults and children. Early detection of cavity helps to recover the natural functionalities of the tooth. Radiographic examination is used to identify the caries at the earliest stage. Radiographic image collected from the different source may contain noise. Noise should be reduced before doing the further process. Dental tooth has the different layers. They are dental bone, root, pulp, dentin and enamel. Dentist find difficult to identify the caries and its existence in the tooth layers. Segmentation is the technique used in the image processing to extract the region of interest. Layer wise segmentation helps the dentist to detect the caries and also help them to plan the treatment stage by stage. In this paper bite viewing radiography image is taken for segment the images in layer wise. Anisotropic diffusion filter is used as preprocessing technique to filter the noise presence in the image. Contrast enhancement technique is used to improve the quality of the image. Texture information is collected from the image to identify the pixel variation. Canny edge detection is used to detect the edges before segmenting the image in layer wise. Intensity range for the different layers of tooth is observed and the layer wise segmented results are obtained.

Keywords: Anisotropic filter, binary image, canny edge detection, Contrast enhancement, Dental Cavity, texture information, threshold technique.

1. INTRODUCTION

Most of the adults and children have the problem of dental cavity. Dental cavity is the preventable disease if it is detected by the earliest stage. Dentists are using different examination to detect the cavity. They are visual and tactile examination, Fiber optic Trans illumination, Laser or light fluorescence and dental radiographic examination. Dental radiographic examination requires knowledge about the imaging modality. Different radiographic images are available in medical field. Panoramic radiographic images, bite viewing radiography images and periapical X-rays are the few types of imaging model. It provides information about anatomical structure, quality and quantity of the available bone, presence of bone lesions and size of the implant. Panoramic radiography provides structural information about the entire mouth. Identifying the caries in the panoramic radiography is difficult because of the low intensity variation in the pixel. Periapical radiography gives the periapical and occlusal views. It is used to identify the pit and fissure types of caries. Bite viewing radiography provide information about the specific region in the teeth surface. Bite viewing radiography image is taken for the analysis process. Most of the cases, dentist can

identify the cavity and structural variation. In very few cases, dentist need support either from the experience practitioner or image processing researchers. By using the image processing technique one can able to collect the pictorial information, transformation operation, image compression and so on. Images collected from the radiographic machines can be noisy image. Noise can be reduced or filtered using the preprocessing technique. Preprocessing technique can be used to reduce the noise, enhance the image information.

Farhad Ghazvinian Zanjani et all developed a deep learning approach to segment the teeth of the image. Developed semantic models learn the features details from the tooth. It achieves 0.94 IOU score [1].In2014, Ronneberger et all developed a dental segmentation technique in grand challenges event .U shaped segmentation technique used to segment the images in layer wise[2]. Cunha et all developed two stage network for detecting the intended regions of the teeth image. Preprocessing involves morphological operation. Histogram based thresholding technique used to identify the dental implant regions. It is found that correlation coefficient was 0.75[3]. Rad et all proposed level set based contour technique to segment the teeth regions. Features are extracted with gray level occurrence matrix and the result can be used in automatic dental development systems [4]. Modi et all proposed a novel approach to select the region of interest using region growing method and canny edge detection is used in the next stage. Results are showing 83% of the images extracted the region of interest without rotation [5]. Keshtkar et all developed a swarm intelligence approach to segment the region of interest in the dental image. It tries to find similar pixels in the adjacent position. It is guided by cellular automata method [6]. Lin et all developed a four stage model to segment the teeth in the periapical radiography. Adaptive power law transformation is used to enhance the images. Single tooth are separated using holder exponent model. Otshu's thresholding model with connected component analysis is used to segment the region of interest .Snake boundary tracking algorithm is used to take delineation of tooth[7].Texture based fuzzy inference system is developed to segment the images automatically instead of region based method. Result shows that proposed method outperforms the region based method effectively [8]. Correlation coefficient and regression model is used to detect the dental bone regions [9]. Mathematical morphology is used to segment the dental tooth where gray scale stretching is used to transform the images [10]. In 2012, Dighe et all proposed dental biometric matching techniques which uses preprocessing and segmentation methods [11]. Dental biometrics matching can be used in bulk disaster times. Dental biometrics are collected and stored in the database. During the disaster time dental tooth can be matched to identify the persons [12]. In 2013, Rad et all presented the different segmentation techniques that are used in dental research [13].Matching vectors can be generated from the images of ant mortem and post mortem. Distance vector reveals them how close the PM image with the existing database images [14]. Morphological operation with integral projection can be applied to segment the images where regions are distinguished by level set method [15]. Semi-automatic contour extraction is used to segment the tooth structure of the image [16]. Mathematical morphology and shape analysis is used to segment the radiograph images [17].In 2014,leo et all presented a review report by analyzing the digital images which is used for dental implant assessment[18]. In 2017,Ganesan et all presented a fuzzy based approach for segmenting the plant in an effective way[19]. Images quality can be reconstructed using convolutional neural network [20].In 2019,Leo et all proposed a selective median filter to reduce the various noises in the given dental images[21]. Dental panoramic radiography images can be segmented using fast marching method [22]. Plenty of segmentation techniques are used to segment the dental images. Segmentation results can be used in biometrics matching, detecting the dental cavity and help to plan the treatment steps in dental implant assessment. Section 2 explains the steps involved in this segmentation process and section 3 explains the results. Section 4 explains about the conclusion and future scope of this work.

2. EXPERIMENTAL METHODS

2.1 Image Pre-Processing

2.1.1 Anisotropic Diffusion Filter

Anisotropic diffusion filter is used to improve the image quality without reducing the precise information available in the images. It creates stage by stage blurred images based on the diffusion operation. Gaussian filter is used to reduce the image noises. Products between the image and Gaussian model gives the anisotropic output.

2.1.2 Image Enhancement using Contrast Stretching

Contrast stretching is a method to improve the image quality and a method of highlighting the hidden information available in the black and white regions. It can be achieved by varying the dynamic range or contrast of an image. It provides superior view of dental image. It makes the segmentation algorithm to function as an improved system. It stretches the image intensity variation into desired level.

2.2 Image Segmentation

2.2.1 Canny edge detection

In medical image segmentation, canny edge detection is used where the edge information plays a major role to segment the tooth regions. Edge information is used to extract the tooth structure from the background dark regions. Advantage of the canny edge detection method is the ability to detect the edges with the low error rate.

2.2.2 Otsu's thresholding method

Thresholding method is the intensity based method which is used to extract the specific regions of an image. Image pixel variation is analyzed. Histogram analysis is used. Probability analysis of intensity variation is calculated. Initial weight values are calculated and desired thresholding value is applied on images. Threshold intensity values vary depends on the regions. Canny edge detected image is given to threshold segmentation model. It extracts the regions into layer wise.

3. RESULTS AND DISCUSSION

Bite viewing dental radiography X-ray image is an input to the system. Given input image is shown in figure 2.a. Input images are in the size of 686x1112x3 uint8 pixels. It is color image. Image information should preserve as it is in order to segment the images using threshold method. So the given input images are not resized to standard size. Input image may contain the noise from the various sources. Figure 2.b shows the noise present in the input images. It may be salt and pepper noise, Gaussian noise and speckle noise. It should be filtered before the segmentation process. Anisotropic diffusion filter is used in the initial stage to filter the noise. Anisotropic filter is used to improve the texture information in the input image so that the image quality can be enhanced. It also filters the noises present in the image. Figure 2.c shows the enhanced output produced by anisotropic filter. Enhanced output is given to contrast enhanced module. Contrast enhancement technique is also a preprocessing technique use to improve the color variation by using the available color variation. Figure 2.d shows the contrast enhanced output image where the color variation is improved for further process. It enables the programmer to vary the threshold value in order to segment the image in layer wise. In medical image processing, preserving the edge information is important. Since edges are used to segment the image objects. Accuracy of the segment mainly relies on the edge information. Edge information is not detected properly

then the efficiency of the segmentation result decreases. In segmentation, canny edge detection is used to segment the edges of the tooth structures. Canny edge is an edge detection method which detects the edges using multiple algorithms. It applies different sequence of algorithm to detect the edges which varying in pixel values. Figure 2.e shows the canny edge detection output where edges of the tooth are highlighted. In next stage of segmentation, binary operation is applied on the edge detected image. It is used to convert the image into black and white images. It means that it has only two pixels, white and black. Figure 2.f shows the binary image which has narrower information to segment or make decision. But it highlighted the high intense pixels. By varying the limit we can able to vary the pixel ratio of black and white pixels. In the next stage texture information is calculated which shows the color variation in the image. Analysis on spatial arrangements of color gives an idea to select the threshold value for segmenting the different layers of an input image. After analyzing the texture information, images are undergone the threshold models. Enamel is the outer layer of the tooth. Figure 2.g shows the enamel layer of the tooth. Threshold value for selecting the enamel image is shown in table 1. Segmented enamel region is super imposed with the input image. Now the super imposed input has the variation of pixel intensity. Cavity is presence in the enamel region can be easily identified. Thus the dentist can easily predict the caries present in the enamel or not. Super imposed output is shown in figure 2.h. Dentin is the next layer in the tooth. Threshold value for segment the dentin image is shown in Table 1. Segmented dentin region is shown in figure 2.i. Segmented dentin region is superimposed with the input image. From this selected region if caries presence then it is easy to identify. Superimposed image is shown in figure 2.j. Next layer of the dental tooth is the pulp which is the soft layer. Intensity values of pulp are low compared to the other layers. Intensity range is shown in table 1. Segmented pulp region is shown in figure 2.k. Superimposed of segmented pulp region with input image is shown in figure 2.l. If caries presence in pulp layer then it is clearly visible in the superimposed image. Root of the dental image is shown in figure 2.m. Intensity range for the root region is showing in the table 1. Super imposed image to detect the caries in the root region is shown in figure 2.n. Next step in the segmentation is to extract the bone region of the tooth. Intensity range for the bone region is shown in figure 2.o. Superimposed image of the bone region is shown in figure 2.p. Thus the layer wise segmentation is done with the threshold technique. It can be useful for the dentist to identify the types of caries and its depth.

4. CONCLUSION AND FUTUREWORK

In this paper we present a method to segment the image using thresholding method. Sample images are collected and it is given to preprocessing unit. In preprocessing anisotropic diffusion filter with contrast enhancement technique is used to reduce the noise and enhance the image quality. Preprocessed output is given to canny edge detection model which extracts the edge features then it is given to Otsu's thresholding method. It segments the images in layer wise. Layer wise segmented output can be used to find the cavity presence in the particular region. It enables the researcher to apply machine learning techniques and also help them to plan the further process. Dentist can able to plan the treatment steps. In future an automated segmentation method can be developed for this purpose.

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Table 1: Pixel values for different layers of tooth

Name of the Layer	**Intensity Range**
Background	<82
Enamel	82-140
Dentin	140-178
Pulb	113-135

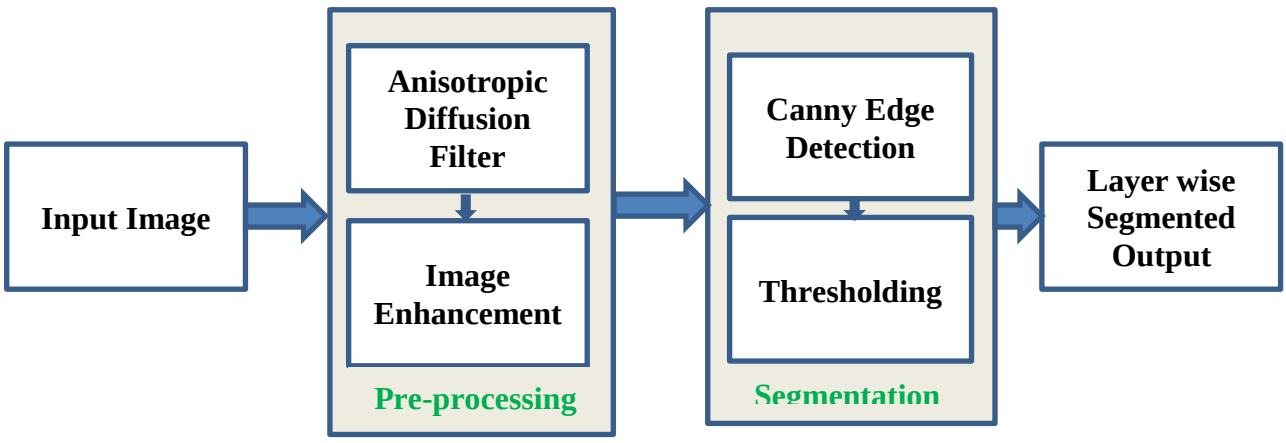
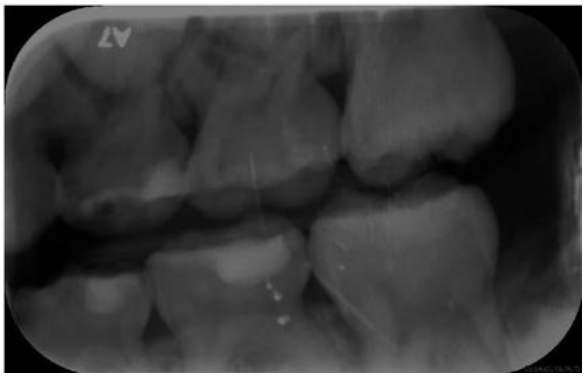


Figure 1: Block Diagram of the Experimental Method

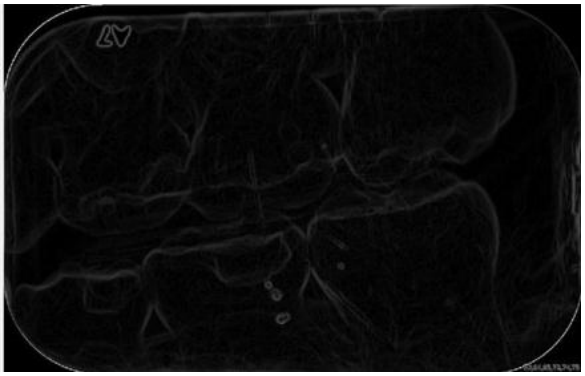
a. Input image

b. Noise Content in image before Denoising



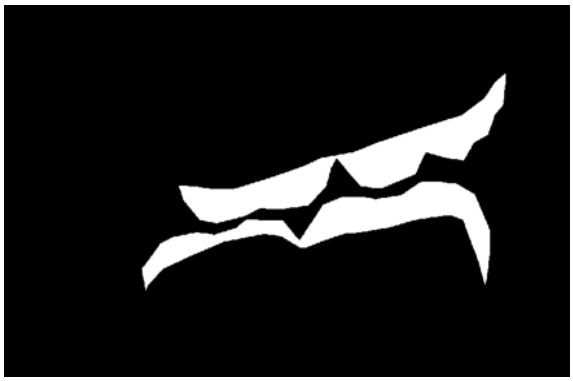
c. Filtered Image Using Anisotropic Diffusion Filter

d. Contrast Enhanced Image

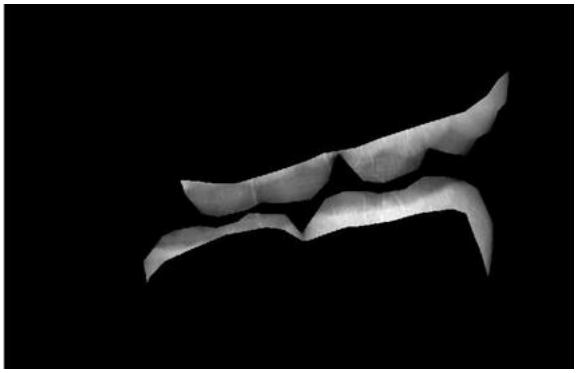


e. Canny Edge Segmentation

f. Binary Image

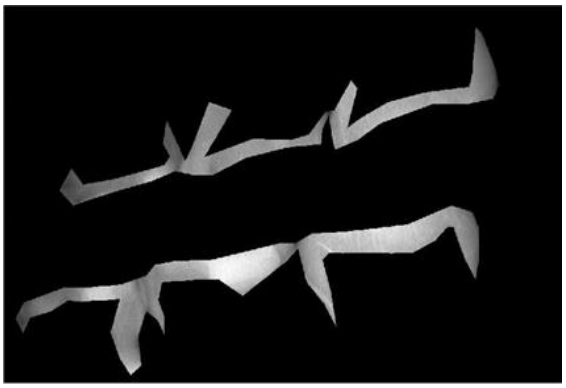


g. Segmentation of Enamel



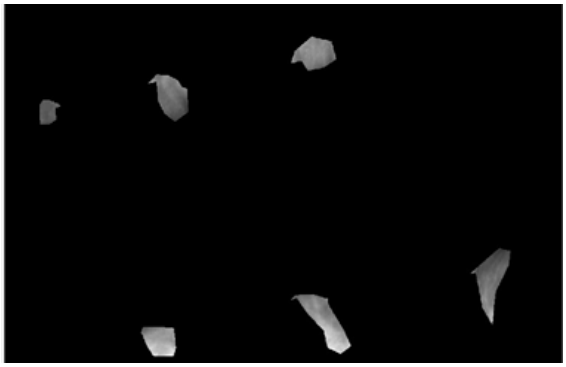
h. Superimposed Image of Enamel

i. Segmentation of Dentin



j. Superimposed Image of Dentin

k. Segmentation of PULP

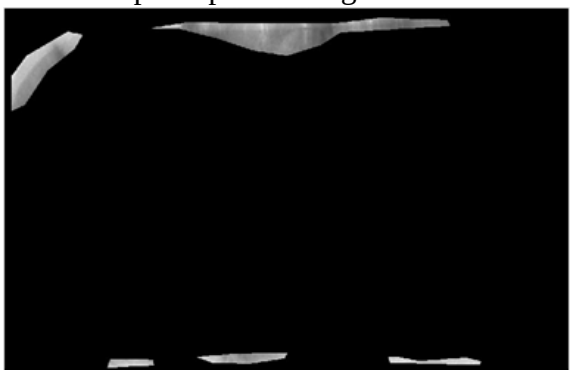


l. Superimposed Image of PULP

m. Segmentation of Root Canal

n. Superimposed Image of Root Canal

o. Segmentation of Bone



p. Superimposed Image of Bone

Figure 2: Segmentation of different layers of tooth and its superimposed output