Characterization of Dental Pathologies using Digital Panoramic X-Ray Images based on Texture Analysis

Veena Divya.K, Dr. Anand Jatti, Dr. Revan Joshi, Dr. Deepu Krishna.S

Abstract—**Dental caries and the cysts of jaws are frequently occurring pathologies encountered in a dental practice. Imaging of these dental anomalies is done with radiographic examination. Panoramic radiography/ Orthopantomography (OPG) is a common modality to screen patients with an advantage of ease of imaging and reduced exposure to patients. The panoramic images obtained with this equipment are exploited by noise embedded during its acquisition making the detection of this dental caries difficult. Detection and characterization of dental caries and various other maxilla-facial pathologies can be achieved by the application of computer aided image processing algorithms applied on dental panoramic images. This paper presents two distinct image processing algorithms for detection of dental anomalies. The first part of this paper presents a novel approach for detection of dental caries using hybridized negative transformation. The second part of paper presents, statistical texture analysis for the dental images containing cysts along with dental caries. The texture analysis is used when the objects to be segmented based on texture content rather than intensities. The texture of panoramic image is characterized by Gray Level Co-occurrence Matrix (GLCM). The texture features obtained from the GLCM are energy, entropy, homogeneity, contrast and correlation. These texture features can be used to find texture boundaries to obtain segmentation about the region of cysts. Results obtained by both the methods were satisfactory correlating with the diagnosis made by the maxillofacial radiologists.**

I. Introduction

This Dental Caries is the commonest disease of oral cavity. It is defined as an infectious microbiologic disease of the calcified tissues of the teeth. Early diagnosis of this disease in a routine dental checkup visit to a dentist plays a vital role in preserving the health and function of the oral cavity. Apart from clinical examination radiological assessment is a critical tool in the diagnostic set up. Though radiographs imaging the specific areas of the oral cavity (intra-oral periapical radiographs/ bite-wing radiographs are the best to diagnose the dental caries, Panoramic Radiographs or Orthopantomograph (OPG) are off late gaining more acceptance as mode for preliminary survey. The panoramic images have an advantage of imaging both the jaws along with very minimal radiation exposure. Treatment of dental caries depends on whether it involves enamel, dentine or pulp. When dental caries involves pulp, they may lead to jaw cysts [1].

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Cysts are defined as a fluid filled pathological cavity lined by the epithelium inside the body. A vast variety of cysts are known to affect the jaw bones. The cysts of jaw bones are typically known to cause facial asymmetry, loss of tooth and bone and may also lead to tumors if left untreated [4]. The characterization of cyst in terms of its extent, nature of the margins, homogeneity of the content will help in diagnosis and thus help in treatment planning and suggestion of prognosis. Further during the radiographic follow up of these cases similar characters help us monitoring the progression of the disease or quantifying the effects of the treatment.

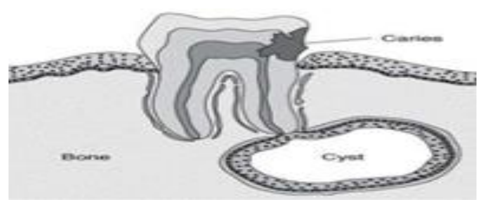


Figure 1: Cysts and dental caries affecting tooth [4]

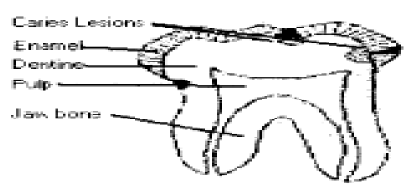


Figure 2: Illustration of tooth with dental caries [3]

II. NEGATIVE TRANSFORMATION FOR DETECTION OF DENTAL CARIES

This phase depicts hybridized negative transformation algorithm applied on OPG or dental panoramic images for detection of Dental Caries. The hybridized negative transformation algorithm is based on point operations using negative or inverse transformation. The negative transformation is linear gray-level transformation. Traditionally, this linear transformation function maps each pixel gray level value of an image into different gray level according to a linear function at the same position. The hybridized negative transformation makes it easier to notice interesting details such as cystic lesion, caries from the processed dental panoramic images. The steps involved in the hybridized negative transformation are shown in figure 3. Firstly, it involves conversion of panoramic images into gray scale image. This is followed by the contrast adjustment. Next the negative of the original image is obtained. Negative image is obtained by reverse scaling of the gray levels. Later difference of negative and adjusted image is computed showing dental caries and radiolucent cysts.

1. Algorithm for detection of Dental Caries

Step 1: Capture the dental panoramic image.

Step 2: Convert the input panoramic image into grayscale image.

Step 3: Apply contrast adjustment for the Panoramic image.

$$f[i,j] = g(i,j) * m \qquad (1)$$

Step 4: Take image negative of original panoramic image.

$$g[i,j] = 255 - f(i,j) \qquad (2)$$

Step 5: Take the difference between negative of the image and
contrast adjusted image.

$$c[i,j] = g(i,j) - f(i,j) \qquad (3)$$

Step 6: Display the output image

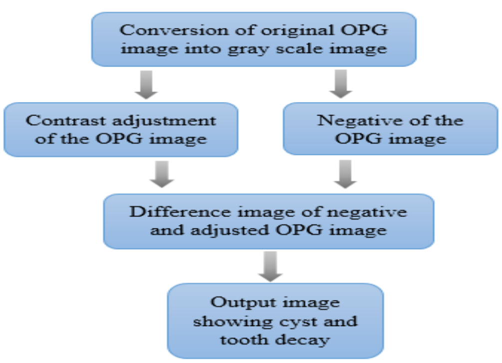


Figure 3: Block diagram for Detection of Dental Caries

2. Implementation

Hybrized negative transformation algorithm is applied on image dataset of ten collected from the hospital. In this regard, images with cysts and dental caries were taken for analysis. Out of these ten-images, algorithm proved to give true positive results for seven images showing the presence of dental caries. It shows better performance in terms of recognition for dental caries along with the visualization of cysts which is not clearly seen on the original panoramic images. All the processed image set has been validated by the doctor and was rated for more than seven out of ten for efficient detection of dental caries and visualizing radiolucent cyst. With the application of hybridized negative transformation, the root canal in the images is shaper than in the original images and also shows for the improvement in cyst delineation. The input image is acquired from the digital dental x-rays. Figure 4 shows the input panoramic image of resolution 2440x1292 subjected for hybridized negative transformation.

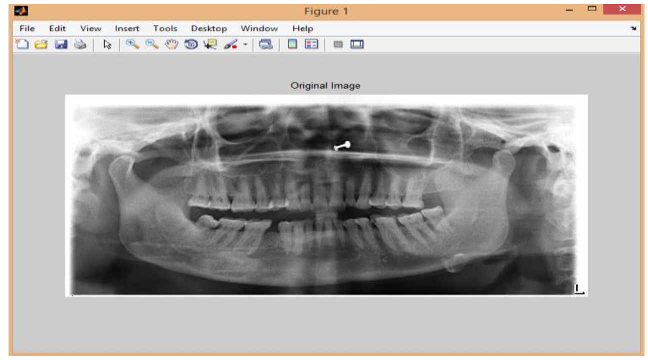


Figure 4: Original dental panoramic image

The first step involved in the hybridized negative transformation is contrast adjustment by normalizing all the pixels by a constant to improve its brightness. Figure 5 shows the result of contrast adjustment on original image.

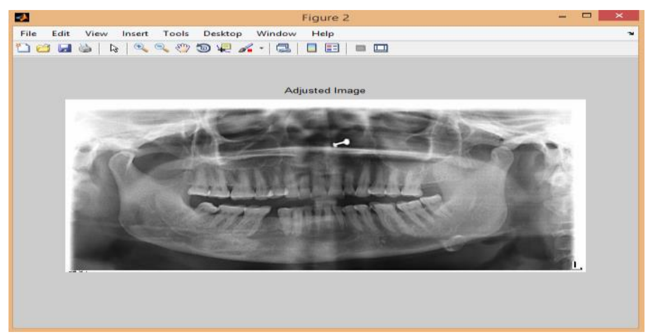


Figure 5: Result of contrast adjustment for the input image

Figure 6 showing the result of negative transformation i.e., Negative image obtained for input panoramic image. This negative transformation highlights the radiopaque regions which are not seen earlier on the original panoramic image.

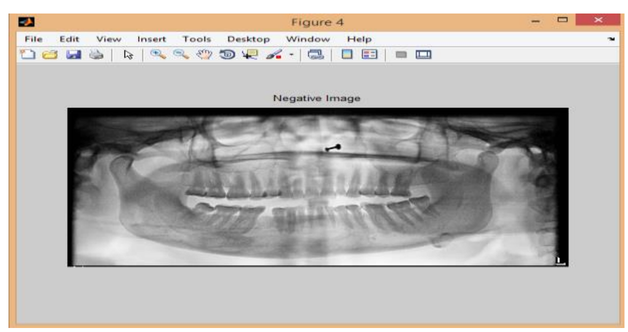


Figure 6: Input image subjected for negative transformation

Next, the difference of contrast adjusted image and the negative image is obtained. Basically, these image subtraction techniques improve the appearance of the radiolucency’s found with the dental anomalies such dental caries, radiolucent cyst and root canal as seen in the figure 7. With this transformation, Dental Caries can be easily identified with the processed image aiding in the early diagnosis. Figure 7 shows the caries affected to the dentine in the proximity of tooth.

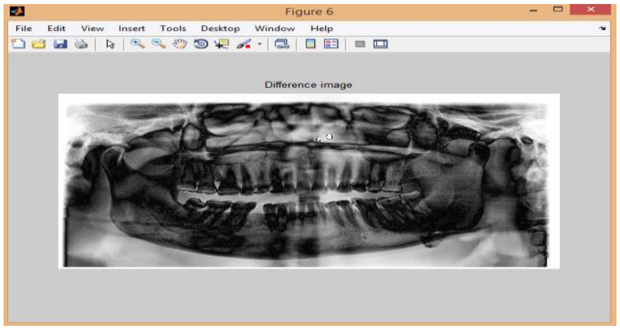
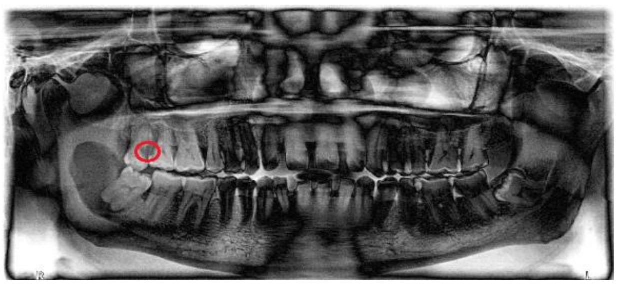
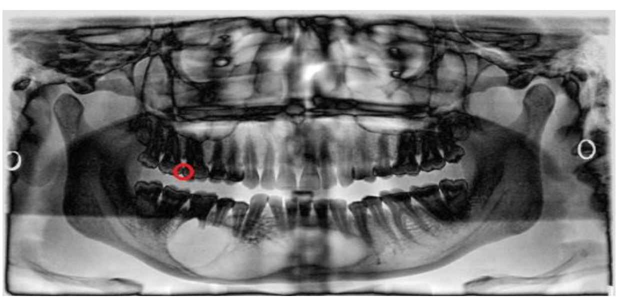


Figure 7: Difference image of negative image and contrast adjusted image showing dental caries



(a)



(b)

(c)

Figure 8: Result of negative transformation applied on different panoramic images showing Dental Caries; (a)example of dental caries affected the pulp layer of tooth; (b)caries detected in the enamel of tooth; (c)Tooth with caries affecting its dentine layer.

III. TEXTURE ANALYSIS

The process of analyzing texture is known as feature extraction. The textural information for dental x-ray images are estimated using gray level co-occurrence matrix. The features extracted using this method can be used in object recognition system. Table 1 and 2 shows the features extracted for the OPG images containing cysts.
Gray-level co-occurrence matrix method is one of the most popular method of texture analysis. The co-occurrence matrix characterizing the texture information is obtained from GLCM are entropy, homogeneity, contrast, energy and correlation [11]. These texture features are important in analyzing the characteristics of cysts which can be used for image segmentation and classification.

Entropy refers to the quantity of energy that is permanently lost to heat ("chaos") every time a reaction or a physical transformation occurs. It is difficult to understand subjective wise as mathematically it given by

$$E_{entropy} = \sum_i \sum_j p(i,j) \log(p(i,j)) \qquad (1)\ [11]$$

In this context, Energy is, the opposite of entropy. Image exhibits its distinct energy forces acting internally and externally on the images. In this sense, Energy is useful in representing orderliness. That is the reason for finding Energy in texture measures.

$$E_{energy} = \sum_i \sum_j p(i,j)^2 \qquad (2)\ [11]$$

. The homogeneity weights values by the inverse of the contrast weight, with weights decreasing exponentially away from the diagonal. The homogeneity feature also called as inverse different moment.

$$E_{homogeneity} = \sum_i \sum_j \frac{1}{1=(i,j)^2} p(i,j) \qquad (3)\ [11]$$

The contrast is a measure of brightness variation between a pixel and its neighboring pixels. It is the amount of local variations present in an image.

$$E_{contrast} = \sum_{n=0}^{N_g-1} n^2 \{\sum_{i=1}^{N_g} \sum_{j=1}^{N_g} p(i,j)\}|i,j| \qquad (4)\ [11]$$

The correlation is a measure of how a pixel is correlated with respect to the neighboring pixels intensities in the image.

$$E_{correlation} = \sum_i \sum_j \frac{(i,j)p(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y} \qquad (5)\ [11]$$

Table 1: Features extracted using GLCM

Images	Entropy	Energy		Homogeneity	
		Min	Max	Min	Max
1	7.4732	0.0558	0.1303	0.7365	0.9626
2	7.3572	0.0664	0.1531	0.747	0.9688
3	7.3374	0.0663	0.1516	0.7604	0.9729
4	7.4873	0.0654	0.1515	0.7476	0.9668
5	7.5343	0.0568	0.1348	0.7437	0.9634
6	7.549	0.0577	0.1349	0.7539	0.9717
7	7.3117	0.0695	0.1558	0.7459	0.9645
8	7.5352	0.0529	0.1327	0.7305	0.9656
9	7.5762	0.0673	0.1431	0.7626	0.972
10	7.5135	0.0731	0.1561	0.7649	0.9733

Table 2: Features extracted using GLCM

Images	Contrast		Correlation	
	Min	Max	Min	Max
1	0.0809	1.1549	0.8558	0.9903
2	0.0686	1.0216	0.8513	0.9905
3	0.0607	1.1023	0.8364	0.9914
4	0.0729	1.1031	0.8446	0.9903
5	0.0801	1.3472	0.8045	0.9889
6	0.0611	0.9793	0.8756	0.9925
7	0.0771	0.9882	0.8517	0.989
8	0.0752	1.2923	0.8275	0.9904
9	0.0622	1.0764	0.8756	0.9931
10	0.0596	1.0831	0.848	0.992

IV. CONCLUSION

The paper details about hybrized negative transformation applied for dental panoramic images to detect dental caries. This transformation algorithm is applied for a sample of 10 Image datasets. Out of ten images the algorithm gives true positive result for seven images. These results have been evaluated with assessment by two maxillofacial radiologists and assures to be good in detection the radiolucency's associated with tooth such dental caries and cysts from the panoramic images. Also, the second phase of this paper presented for determining the texture feature for the panoramic images containing cysts and dental caries. The texture parameters such as entropy, contrast, homogeneity, energy and correlation are computed to study the characteristics of cystic images. Among these features energy and homogeneity did not show much variation. The important parameter found to be unique was energy in the range of 7.3117 0. 2645. Contrast and Correlation lies in the range of 0.6179 and 0.92305 respectively. These properties of GLCM can be used in the classification of cysts and tumors. The proposed approach can also be employed in the advance stages of pattern recognition and machine vision in automated image processing system in assisting to detect these dental anomalies for better diagnosis and faster treatment outcomes.

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