Identification of Proximal Caries from Panoramic Dental X-Rays Images

Harshini S[1], Hasini M S[2], Shenbagavalli A[3], Nirmala K[4]

UG Student, Dept. of BME, SSN College of Engineering, Chennai, Tamilnadu, India[1]

UG Student, Dept. of BME, SSN College of Engineering, Chennai, Tamilnadu, India[2]

UG Student, Dept. of BME, SSN College of Engineering, Chennai, Tamilnadu, India[3]

Assistant Professor, Dept. of BME, SSN College of Engineering, Chennai, Tamilnadu, India[4]

ABSTRACT:Dental caries is the scientific term for tooth decay or cavities. It is caused by specific types of bacteria. They produce acid that destroys the tooth's enamel and the layer under it, the dentin. Inter proximal caries are the lesions develop between the contacting proximal surfaces of two adjacent teeth. Presence of proximal caries is analysed using bitewing x-rays images. Even though bitewing x-rays gives accurate results, they have certain disadvantages such as difficulty in positioning of patient, radiographs are not reproducible, it requires more time for image acquisition and it is not patient friendly. On the other hand thePanoramic dental x-rays images are also used for identification of proximal caries as it requires lesser time period for acquisition and it produces less radiation when compared to bitewing x-rays. Automated detection of caries from panoramic image involves image processing techniques. In this paper, the input images are enhanced using median filter and CLAHE to remove the quantum noise from the signal of an image and to increase the contrast of the image for better quality of the image respectively. Further features are obtained using GLRLM (Gray Level Run Length Matrix) and significant features are obtained using T-TEST and fed to SVM classifiers for detecting the presence of proximal caries.

I.INTRODUCTION

Dental caries are permanently damaged areas in the teeth that develop into tiny holes, and cause severe tooth pain. It is caused by bacteria, which produce acid that dissolves the hard tissue of the teeth. There are more than 10 million casesreported per year, in India. Worldwide 32% of the population have dental caries. It is common among individuals in all age groups (3 to 60+). Dental caries, alsoknown as tooth decay or cavities, is a breakdown of teeth due to acids made by bacteria. The cavitiesmay be a number of different colours from yellow to black. In Fig1.1(a) and (b) Full view of normal panoramic x-rays and infected tooth image is shown respectively.During early stage of tooth decay only the top level of the enamel is affected (Stage1), Fig2. During this stage, the patient feels no pain. And it is the best time to treat a cavity.When decay reaches the dentin (light brown), the tooth becomes sensitive to hot and cold. The patient may feel intermittent pain. At this stage it is still early enough to treat the problem just with a restoration (Stage 2 & 3). When the decay attacks the dental pulp (contains the blood vessels), the pain becomes severe and persistent (Stage 4). The patient has no choice but to have major restorative work and requires a root canal treatment. To analyse the severe state dentists prefer for x-rays images of tooth.

Proximal caries lesions develop between the contacting proximal surfaces of two adjacent teeth. Owing to the large size of the proximal surfaces of posterior teeth and the subtle mineral loss initially presented by lesions on these surfaces, proximal caries on posterior teeth are usually difficult to identify on radiographs. The early and accurate diagnosis of a proximal caries lesion enables immediate operative therapy, thereby preventing extensive tooth loss. Proximal caries

take an average of four years to pass through enamel in permanent teeth. Commonly used radiography to detect the proximal caries are the Bitewing X rays. Bitewings help diagnose gum disease and cavities between teeth. Some of the limitations of the bitewing X rays includes difficulty in positioning the patient, radio graphs are not reproducible, it requires more timefor image acquisition and it is not patient friendly. To overcome the above issues the panoramic x-ray images can be used to identify the presence of proximal caries.Panoramic x-rays have shorter acquisition time period and it produces less radiation when compared to bitewing x-rays.
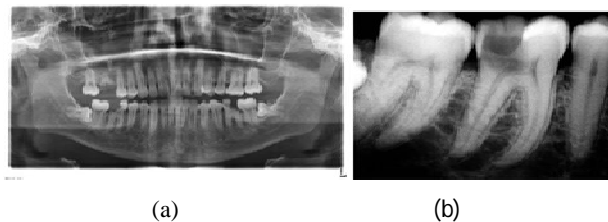

(a)   (b)

Fig 1 Panoramic x-rays (a) Full View (b) Infected Tooth

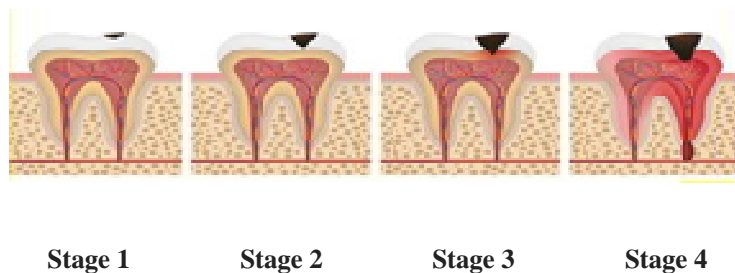**Stage 1**   **Stage 2**   **Stage 3**   **Stage 4**

Fig 2 Stages of Tooth Decay

The early research on detection of proximal caries included many image processing techniques. JufriadifNa`am etal. implemented multiple morphology gradient algorithm to identify the presence of proximal caries from panoramic dental x-ray. VeenaDivyaetal. explained the details about hybrid negative transformation applied for dental panoramic images to detect dental caries. This transformation algorithm is applied for a sample of 10 Image datasets.Valizadehet al. conducted a study on the digital enhancement diagnosis of proximal caries showed that digital enhancement did not have a significant effect on improving the diagnostic accuracy in incipient enamel lesions. However, with caries progression and penetration into the outer and inner depths of the dentin, the caries is better diagnosed with the enhancement options.ShubhangiVinayakTikhe et.al.proposed an algorithm to detect enamel caries and interproximal caries. This algorithm involves three modules preprocessing, segmentation and identification. Yusra Y. Amera,et al described a method to extract wisdom teeth automatically from panoramic images. The method included pre-processing ROI extraction and post-processing. The segmented ROI is used to classify the extracted teeth as wisdom teeth or not, and then classify the wisdom teeth according to a specific problem i.e. impaction.LGráfová et.al has objectively demonstrated a clear advantage of edge detection on OPGs to provide exact root positions in cases of complicated extraction.From the early research image processing techniques are implemented to identify the presence of proximal caries from the panoramic dental x ray images.

II.METHODOLOGY

This work aims to identify the proximal caries using Panoramic Dental X-Rays. An algorithm was developed to identify proximal caries using mat lab software. The region of interest was extracted from the x-ray images and these sub- images were processed. After pre-processing gray level run length matrix was obtained and features were extracted from it. Significant features were identified using T-TEST and these features where fed into a SVM classifier. The classifier was used to identify normal and caries infected tooth. The workflow for the identification of proximal caries from panoramic dental X ray images is depicted in Fig 3.The forty eightPanoramic dental X-ray image of size

2440 x 1292 were collected for our work. Normal and images with caries were used for our work.A Region of Interest (ROI) is a subset of an image or a dataset identified for a particular purpose. In our work the four proximal teeth coordinates are considered as ROI. First the whole x-ray image is equally divide into upper and lower portions from which four quadrants are cropped exactly such that it covers the proximal tooth which include wisdom and molar tooth in all the four quadrants.
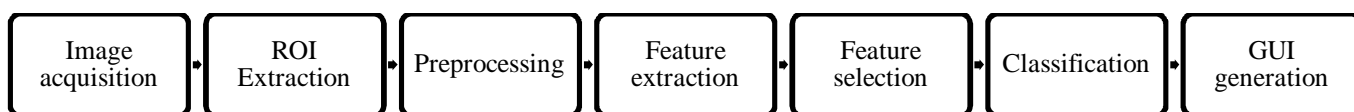
| Image acquisition | ROI Extraction | Preprocessing | Feature extraction | Feature selection | Classification | GUI generation |

Fig 3 Methodology to identify proximal caries from panoramic dental Xray images.

A. PREPROCESSING

The cropped images are enhanced to improve the contrast and to remove the noise. The acquired images are pre-processed using different techniques such as Histogram Equalization, Contrast Stretching and filters which include Laplacian, Arithmetic Mean, Geometric Mean, Median, Adaptive Median, Minimum, Maximum and Wiener filter. Most suited image enhancement methods are obtained by computing and analysing the performance metrices namely Contrast Enhancement Factor (CEF),Absolute Mean Brightness Error (AMBE), Mean Square Error(MSE), Mean Absolute Error (MAE), Peak Signal to Noise Ratio(PSNR).Histogram equalization produces an output image in that Gray level differentiation of the tooth is lost. Adaptive histogram equalization (AHE) is used to improve local contrast by computing several histograms, each corresponding to a distinct region of the image and the individual tiles are combined and produces grainy image, which has high AMBE. In CLAHE, there is a limiting factor that can be applied to each neighbourhood that prevents oversaturation of the image specifically in homogeneous areas. And the results for the histogram equalization processes are tabulated as shown in Fig 4. In the Fig 4 the first and the third row shows the output of infected tooth and normal tooth, second and fourth row shows the histogram plot of respective output image. The performance metrics for every pre-processing method implemented was calculated and tabulated in Table 1. From the table it can be interpreted that the median filter and CLAHE are identified as the best suited methods for enhancing the proximal dental x ray images as MSE, MAE, AMBE are low, signal to noise ratio is high.

Table1 Performance measures for enhancement methods

Enhancement methods	CEF	AMBE	MSE	MAE	PSNR
Images with caries					
HE	1.689	-0.994	111.83	0.111	28.461
AHE	1.427	11.398	88.16	0.083	30.009
CLAHE	0.975	-3.539	25.14	0.050	34.58
Median filter	0.99	0.00338	1.27	0.0039	47.170
Gaussian filter	0.993	-0.00062	1.526	0.0028	46.29
Weiner filter	0.997	-0.006	2.074	0.006	45.04
Low pass filter	0.742	15.206	2.223	0.089	44.67
Images without caries					
HE	1.750	-21.957	120.385	0.120	27.439
AHE	1.492	-14.050	89.415	0.091	28.979
CLAHE	0.981	2.475	33.534	0.058	33.524
Median filter	0.998	0.004	0.918	0.003	48.673
Gaussian filter	0.993	-0.0004	1.466	0.002	46.471
Weiner filter	0.997	-0.007	1.577	0.005	46.302
Low pass filter	0.767	15.987	2.185	0.093	44.742

B. FEATURE EXTRACTION

Feature extraction starts from an initial set of measured data and builds derived values (features) intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be redundant (e.g. the same measurement in both feet and meters, or the repetitiveness of images presented as pixels), then it can be transformed into a reduced set of features (also named a feature vector). Determining a subset of the initial features is called feature selection. GLRM (gray level run length matrix)method is used for extracting the features.
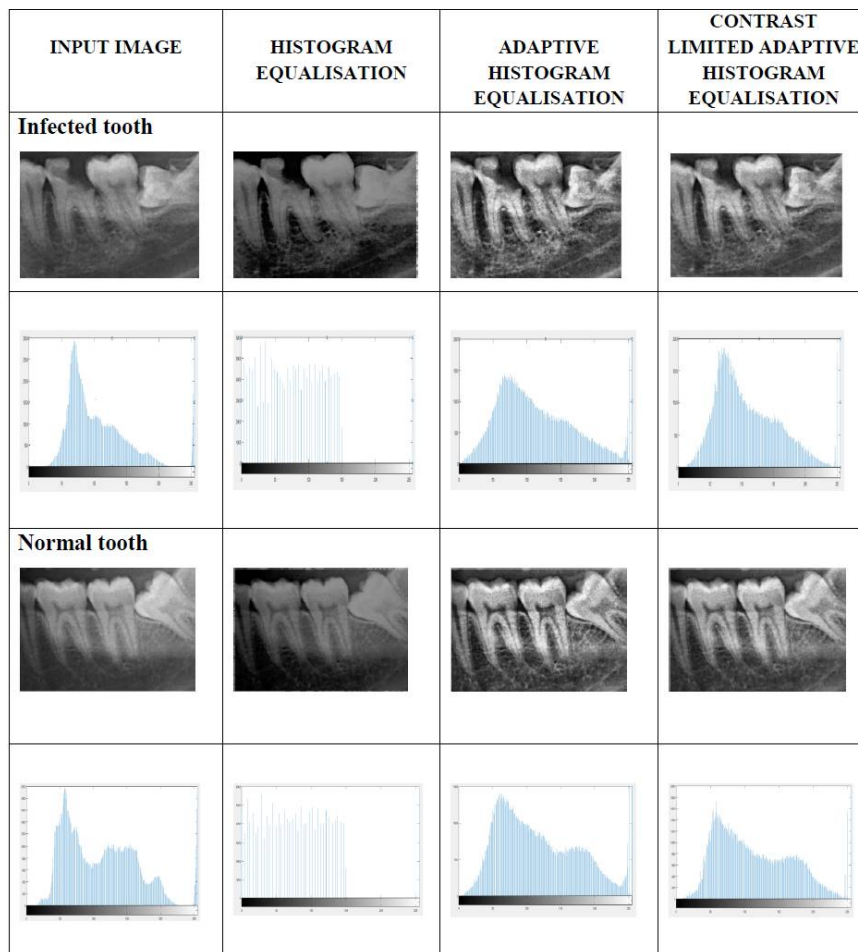

Fig 4 Histogram equalisation of proximal dental X ray images

The Grey-Level Run Length Matrix (GLRLM) gives the size of homogeneous runs for each grey level. This matrix is computed for the 4 different directions in 2D and for each of the 7 texture indices derived from this matrix, the 242D value is the average over the 4 directions in 2D. The element $(i,j)(i,j)$ of GLRLM corresponds to the number of homogeneous runs of jj pixels with intensity ii in an image and is called GLRLM(i,j) thereafter. After the calculation of the matrix GLRLM and before the extraction of the textural indices, the matrix is cropped (grey-level axis of GLRLMs cropped between minimum and maximum observed grey-levels and run-length axis of GLRLMs cropped to maximum observed run-length). This moves indexes $(i,j)(i,j)$ of the matrix and thus the values of the resulting textural

indices. Generally, Gray level run is defined as a set of consecutive, collinear pixels having the same gray level. Seven texture descriptors calculated to capture the texture properties and differentiate among different textures are as follows,

1. Short-Run Emphasis (SRE)
2. Long-Run Emphasis (LRE)
3. Low Gray-level Run Emphasis (LGRE)
4. High Gray-level Run Emphasis (HGRE)
5. Gray-Level Non-Uniformity(GLN)
6. Run Length Non-Uniformity (RLN)
7. Run Percentage (RP)

C. FEATURE SELECTION:

In machine learning and statistics, feature selection is the process of selecting a subset of relevant features Feature selection techniques are used to simplifythesystem to make them easier to interpret by classifiers,shorter training times, to avoid the curse of dimensionality, enhanced generalization by reducing over-fitting. T-TEST is used to select the extracted features using GLRLM.A t-test is an analysis of two population's means through the use of statistical examination; a t-test with two samples is commonly used with small sample sizes, testing the difference between the samples when the variances of two normal distributions are not known. The t-value measures the size of the difference relative to the variation in your sample data. Among the extracted features significant features are selected by performing T-TEST for the seven texture features and the values of the T-TEST are shown in Table 2.

Table 2 T-Test Result

Features	Ranking(T-Test)
SRE	0.850035
LGRE	0.557695
RP	0.080962
LRE	0.004161
RLN	0.00416
GLN	0.000149

D. CLASSIFIER:

SVM classifier is linear binary classifier that uses input features into two classes. The significant features of GLRLM obtained using T-test is fed to the binary SVM classifier. 5 fold cross validation is used for training and testing the SVM classifier. The performance of the classifier are analysed by computing the True positive rate, False positive rate, True negative rate, False negative rate, accuracy, precision. Table 3 shows the performance of the classifier.

Table 3 Performance of classifier

Performance Measures	Values
True positive rate	70%
False positive rate	13%
Accuracy	81%
Misclassification rate	18%
Specificity	13%
Precision	7%
Prevalence	31%

E. GRAPHICAL USER INTERFACE

GUI is an important part of software application programming in the area of human–computer interaction. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline named usability. Typically, users interact with information by manipulating visual widgets that allow for interactions appropriate to the kind of data they hold. GUIDE (GUI development environment) provides tools to design user interfaces for custom apps in MATLAB. Using the GUIDE Layout Editor, a User Interface can be graphically designed.The GUI was created for the doctors to load image and obtain result within a minute. Fig 5 depicts the GUI created for automated detection of proximal caries from panoramic dental X ray images.
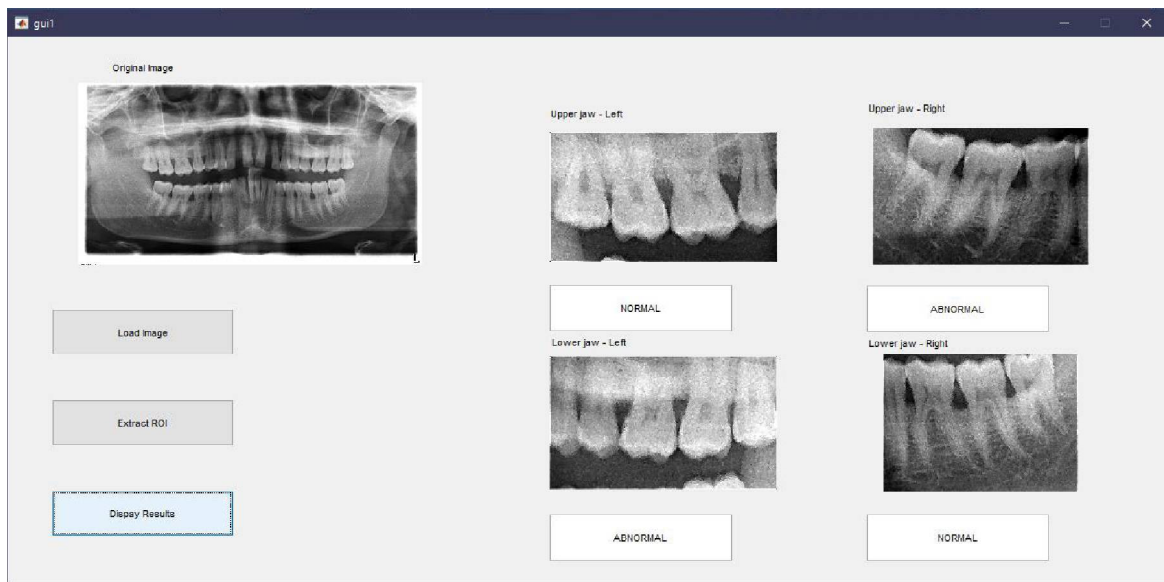

Fig 5 GUI for detection of Proximal caries

III. CONCLUSION

Dental caries are permanently damaged areas in the teeth that develop into tiny holes, and cause severe tooth pain. Even though techniques are available such as bitewing x-rays, peri apical to identify the caries these methods have their own limitation. Hence panoramic dental x-rays are used to identify the proximal caries. In this work the region of interest (ROI) are extracted from the panoramic x-rays. Further the extracted image is been pre-processed to remove the noise

and to enhance the image quality. Then to identify the presence of caries the texture features are extracted from the processed image. Using GLRLM (Gray level Run Length Matrix) seven features are obtained among them three significant features is selected using T-TEST. Then the selected features are fed to the SVM classifier and the performance of the classifier are analysed. Accuracy of the classifier is obtained as 81.25%. GUI is created to make it as user friendly.Further the work can be progressed to identify the stages of the caries using panoramic x-rays.

REFERENCES

[1]   JufridifNaam, EriPrasetyo,andSarifuddinMadenda," Imageprocessing of panoramic Dental X-ray for identifying proximal caries", TELKOMNIKA, Vol.15, No.2, pp. 702-708,June 2017.

[2]   L Gráfová, M Kašparová, S Kakawand, A Procházka, and TDostálová,"Study of edge detection task in dental panoramic radiographs",Advanced Science Engineering Information Technology,Vol.6, No. 6,pp.1012-1017,June 21, 2013.

[3]   ValizadehS,RahimianS,andBalali M, AziziZ.,"Effect of Zooming, Colorization, and Contrast Conversion on Proximal Caries Detection", Avicenna Journal of Dental Research, Vol.10, No.5, pp. 612-619,July26, 2015.

[4]   VeenaDivya.K, Dr. AnandJatti, Dr. Revan Joshi, and Dr.DeepuKrishna.S," Characterization of dental pathologiesusing digital panoramic X-ray images based on textureanalysis",Tencon,Vol.10,pp.592-595, September 2017.

[5]   Yousif Mohamed Y. Abdallah, and Reham I.Abdelwahab,"Improvement of Orthopantography (OPG) Images usingTexture Analysis",International Journal ofScience and Research (IJSR),Vol.05, pp. 719-725,August 2014.

[6]   Yusra Y.Amer and Musbah J.Aqel,"An efficient segmentation algorithm for panoramic dental images",Procedia Computer Science,Vol 8, pp. 718-724,september 2015.

[7]   Hyunsup Yoon, Youngjoon Han and Hernsoo Hahn, 2009, "Image Contrast Based Sub-Histogram Equalization Technique without Over Equalization Noise", International Journal of Electrical and Electronics Engineering, Vol. 3, no. 6, pp. 323-329.

[8]   Chouhan R, Rajib Kumar Jha and Prabir Kumar Biswas, 2013, "Enhancement of dark and low-contrast images using dynamic stochastic resonance", IET Image Processing, Vol. 7, no. 2, pp. 174-184

[9]   Jaya V. L and Gopikakumari R, "IEM: A New Image Enhancement Metric For Contrast and Sharpness Measurements", International Journal of Computer Applications, Vol. 79, no. 9 pp. 1 – 9, Oct. 2013.

[10]   L. Zhang, L. Zhang, X. Mou, and D. Zhang, "FSIM: A feature similarity index for image quality assessment", IEEE Trans. Image Process.,vol. 20, no. 8, pp. 2378–2386, Aug. 2011.

[11]   A. Beghdadi and A. L. Negrate, "Contrast enhancement technique based on local detection of edges", Comput. Vis, Graph., Image Process., vol. 46, no. 2, pp. 162–174, May 1989.

[12]   T. Arici, S. Dikbas, and Y. Altunbasak, "A histogram modification framework and its application for image contrast enhancement", IEEE Trans. Image Process., vol. 18, no. 9, pp. 1921–1935, Sep. 2009.