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Diagnosis of Proximal Caries on Radiograph by Designing System Based on Machine Learning Techniques

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ABSTRACT

Background: Dental Caries are one of the most common dental diseases around the world and diagnosis it is a challenging task. If the caries is caught early, it can be treated.

Objective: This study aim to designing system based on machine learning techniques for diagnosis of proximal caries.

Patients and methods: This paper applied machine learning techniques on X-rays for 200 teeth which collected in the dental clinics of the college of dentistry in university of Thi_Qar to diagnosing the stages of surface caries . In order to remove the noise and corrupted pixels we used the Gaussian blur filter then segmented the image by K means clustering technique to extract the region of interest Then we used Grey Level Co Concurrent Matrix (GLCM) algorithm for feature extraction. Features extracted by GLCM inputs into Naive Bayes classifier (NBC).

Results: Our proposed approach of detecting and classifying dental caries achieve the results of 96% ,97% ,98%,98% for F1,recall ,precision and Accuracy values, respectively.

Conclusions: The experimental results indicate that dental caries could be detected accurately by this diagnostic system. The key benefits of the suggested approach are its ease of use, quick computation, and simplicity of implementation.

Keywords: *Dental Caries, Dental Radiography, Machine Learning Techniques*

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INTRODUCTION

Dental caries is a serious and chronic tooth infection that can cause both adults and teens worldwide[1]. The majority of traditional caries diagnostic techniques focus on visual examination of the teeth. Both large, clearly visible carious lesions and those that are only partially visible but may be seen with a handheld mirror can be treated with these techniques[2]. Dental X-ray highly helpful in identifying the first stages of interdental deterioration. Bone loss, cavities, and hidden dental features that cannot be detected during a visual examination are all visible on X-ray images[3]. Machine learning is one of artificial intelligence (AI) applications that offers systems the able to automatically learn through experience rather than by explicit programming[4]. Machine learning requires input data, such as text or images, in order to obtain an output utilizing a model. Medical image segmentation is one of important techniques in medical image processing field . It is used to extract interest region from the background[5].

The K-means algorithm is a simplicity and high convergence rate machine learning model therefore it is widely used method for segmentation[6]. The Gray Level Co-occurrence Matrix (GLCM) technique used to analyze the performance of feature extraction from dental caries images. The pixel and quantization values of the GLCM are determined using this technique to create an automatic classification system for different forms of dental caries[7]. The matrices are used to estimate the measure of spatial relations between pixels.. In machine learning algorithms, The Naïve Bayes algorithm has the well-known flexibility to irrelevant and a high number of feature In the task of caries identification from dental images, there can be a many of independent extracted features. Therefore, we proposed the Naïve Bayes algorithm to solve this problem. This paper proposes design Diagnosis of Proximal Caries system using machine learning . The proposed system uses some machine learning methods such as The K-means algorithm and Naive Bayes classifier (NBC).

RELATED WORKS

In this section we display some previous papers which proposed methods for caries detection by using machine learning and image processing techniques. F. Casalegno et al[2] convolutional neural network (CNN) training for a semantic segmentation task was suggested as a method. On a 5-class segmentation task, they employed 185 training samples, and their model received an overall average (IOU) score of 72.7%. CNN training for a semantic segmentation task was suggested as a method. On a 5-class segmentation task, they employed 185 training samples, and their model received an overall average (IOU) score of 72.7%. .For proximal and occlusal carious lesions it achieved an IOU score of 49.5% and 49.0%, respectively. S. Ahmed[6] Suggested a method for detecting hidden dental caries lesions in bitewing radiographs which employs data segmentation to bring the total number of dental images in the data set up to 11,114 images. They used Gaussian blur filters for preprocessed the image. In their paper Thresholding , erosion, and dilation morphology were used to handle image segmentation. While the active contours method was used to determine image boundaries .The deep learning-based network in Keras uses blob detection to extract features from the images.. Using Support Vector Machine and Decision Tree in Classification Learner, P. K. Navarro et al [8] suggested a method for locating and detecting smooth surface carious regions in frontal teeth images. The study's accuracy rates utilizing Decision Tree and SVM were 84% and 78%, respectively, and they were highly significant .D. Verma et al [9] utilized a SVM to classify the image as either normal or abnormal based on the recovered features after using a Convolutional Neural Network to extract features from the image.

Y. Jusman et al [10]Their approach makes use of 10-folds cross validation. 90% of the training data (1256 photos) and 10% of the testing data (132 images) are divided in this cross validation. The Zernike moment method is used to extract features. The average training accuracy for KNN, SVM, and DT, respectively, is 94.55%, 84.24%, and 88.46%, and the average training times are 0.74, 1.63, and 0.77 seconds.

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METHODOLOGY

In our proposed system (Figure.1) diagnosis of dental caries include: pre-processing, using gray scale conversion and Gaussian blur filter, image segmentation by K-means clustering method, utilization Grey Level Co-Concurrent Matrix (GLCM) algorithm for feature extraction then we used the obtained feature as inputs for NBC classifier. Finally, evaluate the performance of our proposed system. We implemented our system using MATLAB 2017a. for validating system we implemented evaluation using WEKA (Waikato Environment for Knowledge Analysis).

Image Acquisition

The database collected in the Dental clinics of the college of dentistry in university of Thi_Qar. It consists 200 x-ray images .

Pre-processing

The pre-processing consist of three main procedures are grayscale conversion, image enhancement, and noise removal. firstly we converted all the images into grayscale. Then we used Gaussian filter for image enhancement and noise removal. Gaussian filter smoothes the image and remove speckle noise from image.

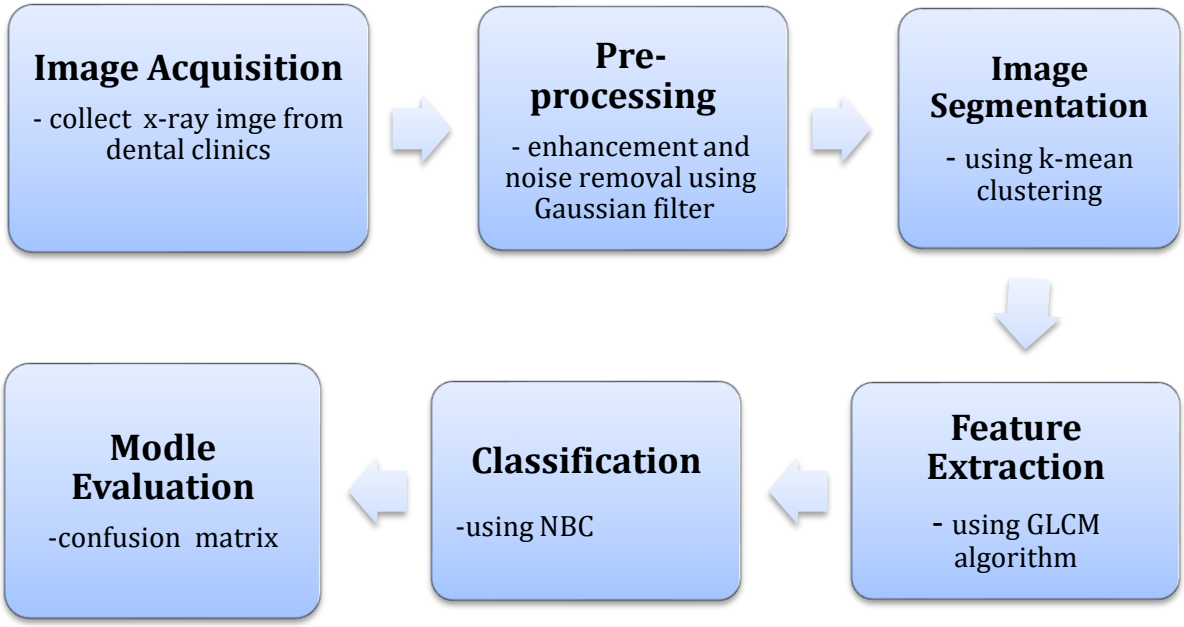

FIGURE 1 : Proposed system

Image Segmentation

Segmentation is extracting teeth or particular tooth form the image background. Each tooth or object that was extracted from the image is a region of interest (ROI), which includes important data that will be used in subsequent steps. In this paper, we used k-mean clustering method to do the segmentation. Firstly, it calculates the k centroid and then each point is taken to the cluster with the nearest centroid from that respective data point. One of the most used methods for determining the distance to the closest centroid is the Euclidean distance. Once the clustering is completed, a new centroid is recalculated for each cluster and based on that centroid a new Euclidean distance is computed between each center and each data point and maps the points in the cluster that have the minimum Euclidean distance. The point to which the total distances from all the objects in a cluster are minimized is the centroid for each cluster. Therefore, K-means is an iterative algorithm that minimizes the sum of distances between each object and its cluster centroid across all clusters.

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Feature Extraction

After extraction of a region of interest (ROI) , The next step is extracted a set of features from it. The idea of feature extraction is to get information from the images that will allow for accurate description of the objects in the image. In this paper, we used Grey Level Co-Concurrent Matrix(GLCM) algorithm for feature extraction. This method is one of the most successful features extraction methods. GLCM method was first presented by [13]. The main idea behind this method is to produce features base on gray-level co-occurrence matrices. The purpose of the matrices is to estimate the measure of spatial relations between pixels.

$$Precision = \frac{TP}{TP + FP} \quad (1)$$

$$Recall = \frac{TP}{TP + FN} \quad (2)$$

$$F1 = 2 \times \frac{(Precision \times Recall)}{(Precision + Recall)} \quad (3)$$

$$\text{Accuracy} = \frac{TP + FP}{(TP + TN + FP + FN)} \quad (4)$$

TP refer to true positive; which means that the model predicted a positive value, and the actual result was positive.

FP refer to false positive; which means the actual value was false and the model predicted a positive value.

TN refer to true negative; which means the model predicted a Negative value, and the actual result was Negative.

FN refer to false negative ; which means that the result is false and the model prediction is negative.

Precision: is a classifier's ability to detect pertinent data points.(Equal. (1)).

Recall: is a measurement used to assess how well a model has identified the positive classes in our dataset.(Equation (2)).

Classification by NBC

NBCs are a set of probabilistic classifiers generally used as a machine learning algorithm .This classifier based on Bayes theorem . In Naive Bayes classifier, the value of a certain feature is unrelated of any other feature in the given class. NBC is used to classify normal or caries images.

Evaluation

In order to evaluate the performance of our method we used The confusion . The confusion matrix is a specific array that displays the classifier's performance.it is also known as the error matrix. The mathematical evaluate equations metrics are defined as follows:

F1: is the accuracy measurement of the model on the dataset.(Equation (3)).

Accuracy :is the metric that assesses a model's efficiency at identifying patterns and relationships between dataset's features(Equation (4)).

RESULTS

The confusion matrix that described in section (3.6) was used to evaluate the proposed system. Our proposed approach is giving higher value of recall (96.5%), Precision (98.5%), accuracy (98.5%) and F1(0.96).Table 1 gives the comparison of performance measures of our proposed method with other published approaches.

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DISCUSSION

In This section, we discuss the experimental results of our proposed method. WE collected 200 images from the Dental clinics of the college of dentistry in university of Thi Qar and This images was stored in dental image database. 80% of the images were used for training and 20% for the testing.

Firstly, Digital X ray image of teeth loaded to the system for preprocessing . The second step is reduce or eliminate unwanted distortions in the image, we implemented image pre-processing through Gaussian filter (figure 2 b). Segmentation step implemented via k-mean clustering method to extract region of interest (ROI) from the image(figure 2 c)

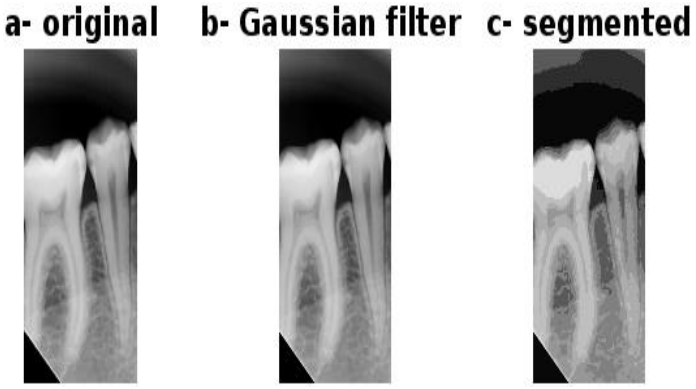

FIGURE 2: (a)original image(b)enhanced image c-segmented image

Features extract step were performed through Gray Level Co-occurrence Matrix (GLCM) to get information from the images that will allow for accurate description of the objects in the image.Smoothness,entropy,skewness,energy,hom ogeneity,performance,constrast and correlation along with shape and geometry were The features extracted from the images .Finally, The set of dental images are run through the Naive Bayes classifier.

TABLE 1: Comparison of our proposed caries Diagnosis approach with other published approaches

Ref	F1	Recall	Precision	Accuracy
[8]	0.80	0.81	0.78	0,81
[11]	0.87	0.89	0.86	0.87
[12]	-	0.98	0.98	0.98
[13]	-	0.69	-	0.86
[14]	-	-	0.73	0.64
Our proposed approach	0.96	0.97	0.98	0.98

CONCLUSION

In this study, an diagnosis of proximal caries system based on machine learning techniques is proposed, in which Naive Bayes classifier (NBC) is used to diagnosis caries . In this system, the Gaussian blur filter is used to remove the noise and corrupted pixels. K-means clustering method is used for segmentation .For feature extracting Grey Level Co-Concurrent Matrix (GLCM) is implemented. The experimental results indicate that dental caries could be detected accurately by this diagnostic system.

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The key benefits of the suggested approach are its ease of use, quick computation, and simplicity of implementation. Our proposed system has achieved 96.5%, 97.5%,98.5% and 98.5% for F1,recall, precision and accuracy ,respectively.

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