Classification of Digital Dental X-ray Images Using Machine Learning

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***Abstract*—Dental diseases like dental anomalies, periapical and dental caries is increasing day by day in children and adults. Artificial intelligence and neural network with its application in medical imaging is influencing the healthcare industry. X –ray imaging is the commonly employed technique to diagnose diseases of the teeth. Segmentation and classification of differing dental anomalies using neural network is proving to be a boon to the dental field. Application of neural algorithms aids in obtaining images with better detection accuracy. Automated detection reduces the workload of a dentist with classification being accurate. A better penetration of machine learning into these processes highlights its advantages to classify dental X ray images. Different machine learning techniques are deployed to identify and classify the dental abnormalities.**

Keywords—Classification, Dental X-Ray, Machine Learning, Neural network

I. INTRODUCTION

Tooth is a dense structure in the human body that decays due to many reasons. Countless conditions like Dental decay, Periodontal disease, Mesioangular impaction, Periapical abscess, Horizontal bone impaction,Vertical bone impaction, Apical periodontitis, Overhanging restoration, Irreversible pulpits, Cast post restoration, Radiopaque restoration, Proximal caries are detected using an X ray.

Digital images of human body have gained more attention in the field of medical image analysis research. Numerous image processing techniques are emerging to find solutions to diseases found in human body. Human organs are complex and difficult to diagnose. [1]An easiest imaging modality for dense structure of the body is X-ray. These rays penetrate the bones and produce an image which aids in diagnosis. Once anomalies are detected in an X-Ray, the doctor diagnosis the problem and prescribe the therapy.

Digital radiographic image is an advanced X- ray assessment technique which produces images immediately on a computer. X-ray sensitive plates capture the images during investigation and transfer it to the computer immediately. The incident x-ray radiation is converted into an equivalent electric charge and by a detector sensor to a digital image.

Recognition and analysis of dental images have been made easier with the introduction of digital X ray images.

The resolution, luminance, noises, contrast are different when different X ray machines are utilised to capture the images. Analysis of teeth images can be successfully performed by segmentation of the tooth and it forms an important step for treatment planning. Segmentation of the dental images can be done using different techniques like k-means and dual clustering, subtraction of background, methods based on histograms, region growing methodologies,etc. which help to differentiate the normal from the pathologically affected parts of the teeth. [2]

Application of the fundamentals of machine learning in dental imaging is making it easier to segment and classify images .[3] Based on the efficiency and performance of classification algorithms, few of the promising ones like SVM, ANN, KNN are applied on dental data set images.

II. LITERATURE SURVEY

Anuj Kumar, H. S. Bhadauria Nitin Kumar proposed Fuzzy Clustering with Level Set Segmentation for Detection of Dental Restoration [4]to extract the restoration part from the dental X-ray image by combining the Fuzzy clustering with the iterative level set active contour. Here median filter pre processes the image and segments using Fuzzy clustering.

Jiafa Mao, KaihuiWang ,Yahong Hu, Weiguo Sheng, Qixin Feng, presented Grab Cut algorithm [5] for dental X-ray images based on full threshold segmentation. They obtained the outline image set of Iwholen and Crowns. Morphological open operation and median filtering is applied to the synthetic image of contour and crown, and the resulted image used a Mask for Grab Cut to obtain the target tooth image.

Jie Yang, yuchen Xie, Lin Lui presented the Automated Dental Image Analysis Learning on Small Dataset [6]by Deep datasets, procedures, and results conducted to evaluate dental treatment qualities using periapical dental X-ray images taken before and after the operations. They acted as a support to clinicians to classify diseases as getting better, getting worse and no explicit change.

Said.E.H, Dias .E,M, Nasar .G.F proposed a methodology of Teeth segmentation in digitized dental X-Rays films using mathematical morphology. A grey scale contrast stretching transformation is done to improve the performance of teeth segmentation. They concluded that in addition to its capability of handling bitewing and periapical dental radiographs views, their approach exhibits the lowest failure rate[7][8].

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III. METHODOLOGY

The image dataset made use of in this work is a group of dental X-ray images gathered from dental hospitals, dental clinics and web source dental datasets. Different classes of dental caries and normal images are obtained and stored as database. Figure 1 depicts the stages of processing and analysis of the dental caries from digital X ray images. The unprocessed image is retrieved from the dataset and pre processed for enhancement of images and redundancy removed. This is followed by resizing of the images to reduce distortions and convert to gray scale images as processing of colours images will not give clear data. [9]

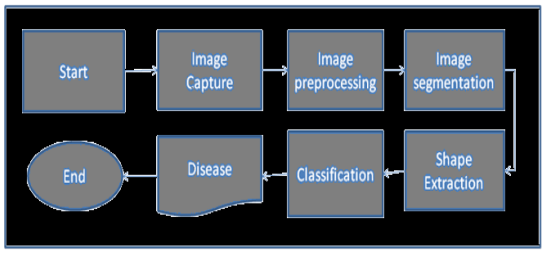

Fig. 1. Basic Block Diagram of process

The pre-processed and resized images are segmented into non-intersecting homogeneous regions based on the characteristic pixels and similar attributes of the image. Location and identification of boundaries like lines, curves in images are attained by segmentation. It also determines the accuracy of the computer based output.

Feature extraction produces a reduced group of features which can ease the processing when datasets are large. The features selected usually contain the required information and desired task can be performed using the extracted data. This work uses GLCM for feature extraction. The GLCM function characterises an image's texture by calculating how often pairs of pixels with specific values and in a specified spatial relationship appear in an image, generating a GLCM, and extracting statistical measures from this matrix. Further the images are classified from the dataset fed for training Nd testing.[10][11] Classification aids us to differentiate the various classes of dental diseases and strategically diagnose the type of dental disease.

Support Vector Machine (SVM), Artificial Neural Network (ANN) and KNN (Kernal Nearest Neighbour) classification algorithm determines whether there are pathological signs of dental diseases in the analyzed image. SVM generated an optimal classified model by obtaining data from an existing trained set. A promising approach by the application of ANN in the field of dentistry to classify dental caries and impacted teeth created a big influence in image analysis. By considering the best match of new records with an already trained record system, a supervised classification algorithm like KNN is found to reduce complexity.[12] The newest neighbour is found by the Euclidean distance and helps to classify accordingly.

IV. RESULTS AND DISCUSSIONS

This section describes the experimental results of the classification methods using digital dental X ray images for different classes of dental diseases. Dental images, belonging to various dental diseases like vertical impaction, periapical abscess, distal pulp horn caries, missed canal in root canal, etc are stored in the dental image database. The images were collected from dental clinics and hospitals. Our work consists of a total of 500 images belonging to assorted set of dental caries and normal tooth images. One half of the images were used for training and the other half for the testing.

Digital X ray images of the abnormal teeth are loaded into the system for pre processing.

Fig.2. Input Image of teeth

The goal of pre-processing is to reduce or eliminate unwanted distortions in image data, as well as to improve some image features that are important for subsequent processing. Median filters are employed for preprocessing in this work followed by resizing to a specified dimension and gray scale conversion for a better representation of the images.

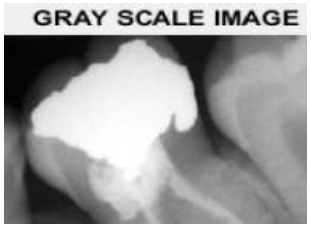

Fig.3. Gray Scale Dental X ray Image

Segmentation[13] is performed using Region of Interest (ROI) which separates the uninteresting pixels from the interesting pixels and reassigned with intensity values 0 or 1 for not required and required pixels respectively.

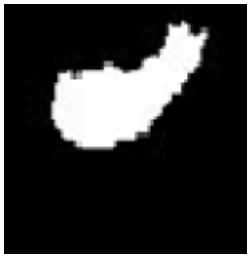

Fig.4. Segmented dental X ray Image

The main aim of feature extraction is to separate favourable characteristics from the image. Gray Level Co-occurrence Matrix (GLCM) is performed to extract the features. It extracts second order texture data from images. [14][15]The features extracted from the images stored in the dataset are Skewness, Smoothness ,Energy , Entropy ,Homogeneity, Performance, Contrast and Correlation along with shape and geometry.

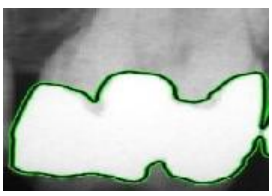

Fig.5. Featured Extracted Image

The Table 1 below gives the extracted feature of some of the dental diseases

TABLE I. EXTRACTED FEATURE VALUES OF DISEASED TEETH

Disease	Skewness	Smoothness	Energy	Entropy	Homogeneity	Performance	Contrast	Correlation
Dental caries under restoration	2.6047	0.9999	0.81	0.4798	0.9964	0.4044	0.0071	0.9614
Messioangular impaction	5.3254	0.9995	0.9372	0.2039	0.9992	0.6339	0.0016	0.9743
Proximal carries	6.4644	0.9993	0.9555	0.1544	0.9996	0.4289	0.0085	0.9804
Vertical impaction	2.5354	0.9999	0.8025	0.4921	0.9963	0.2681	0.0074	0.9613
Dental caries involving distal pulp	2.1802	0.9999	0.7618	0.5617	0.995	0.2036	0.01	0.9563

The images are trained according to the dataset that is been stored.

Fig.6. Training of images

The set of dental images are run through the mentioned classification techniques such as SVM, ANN and KNN. The segmented and classified images using the different classifier algorithms are presented in Figure 7.

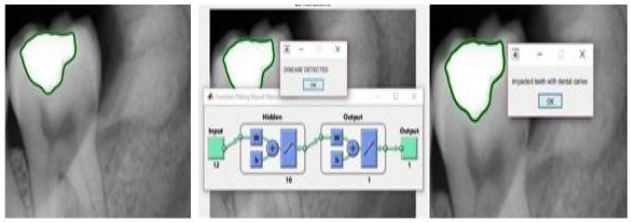

Fig.7. a) SVM Output b) ANN output c) KNN output

V.CONCLUSION

In this work, it is suggested that by utilising GLCM features and SVM, KNN and ANN classifiers, the teeth affected by dental caries can be set apart from the normal teeth in a more detailed manner. The automated teeth segmentation and classification provide radiologists with a faster and second opinion by reviewing medical images, increasing the sensitivity of disease detection. Hence it is able to produce results in a more precise manner efficiently.

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