

A Review on Computer Aided Detection Techniques of Oral Cancer

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Abstract— Oral cancer is the most common cancer found in both men and women. Early Detection of Oral Cancer is important in saving life. Dental Radiographs assists experts in identifying cancers grown inside the mouth. To help radiologists, Computer Aided Detection and Computer Aided Diagnosis algorithms are developed. The algorithms help to identify cancers by reducing the need for Biopsy. This paper gives a review of Computer Aided Techniques that have been developed for detection and classification of oral cancers.

Index Term— Radiographs, Computer Aided Detection, Computer Aided Diagnosis

I. INTRODUCTION

In recent years, the Computer Aided mechanisms are used widely in Medical Fields. Early Detection is very important to discover any disease especially for cancers. Oral cancer is a common cancer found in both men and in women. With the advances in Computer Aided mechanisms Experts / Radiologists will have opportunities to decrease the death rate and error rate. Oral cancer ranks as the fourth most frequent cancer among men and eighth for women worldwide. Oral Cancer at an earlier stage saves life [1]. Most oral cancers are identified at a later stage where, treatment becomes less successful. Despite advances in surgery, radiation and chemotherapy, the mortality rate associated with oral cancer has no improvement in the last 40 years. Eventually, 50 percent of people who have oral cancer die as a result of the malignancy. Since early diagnosis improves chances for survival, it is important for oral cancer and precancerous lesions to be found as soon as possible. Tumors can be benign, premalignant or malignant. Benign tumors are harmless and do not spread. Premalignant tumors can transform into Malignant. Malignant tumors are cancerous. Oral cancer can affect any area of the oral cavity including the lips, gum tissues, tongue, cheek lining and the hard and soft palate. The common oral precancerous lesions are leukoplakia, erythroplakia, and oral sub – mucous fibrosis (OSF). The diagnosis of Oral precancer and cancer remains a challenge to the dental profession, particularly in the detection, evaluation and management of early phase alterations or frank disease. Some Oral cancers are located on the tongue, jaw and bone where detection becomes complicated. If a cancer is suspected, the dentist may recommend any one of the following options 1) Recommend for Biopsy 2) Provide proper medications 3) Remove Completely.

The organization of the paper is as follows: Section 2 discusses the current literature review in oral cancer. Discussions and Comparisons are made in Section 3. Finally

section 4 summarizes and concludes the section.

II. CANCER DETECTION APPROACHES

The symptoms for an oral cancer at an earlier stage [2] are: 1) Patches inside the mouth or on lips that are white, red or mixture of white and red 2) Any sore or area in the mouth which does not heal for discolored more than 14 days 3) Bleeding in the mouth 4) Difficulty or pain when swallowing 5) A lump in the neck. These symptoms identify the suspect for a cancer. There are various research works carried out by researchers to assist oncologists, surgeons for detection and classification of cancers.

A) Image Processing

A segmentation method is carried out in [3] for the Histological OSF images using region growing and hybrid segmentation algorithm. Misclassification rate were calculated for both the algorithms. Finally, Hybrid Segmentation method found to be suitable for segmentation of cancers in OSF images.

The application of active color models for the segmentation of oral lesions in medical color images is proposed. The proposed work also classifies cancerous and non – cancerous lesions. The automatic segmentation algorithm simplifies the analysis of oral lesions and can be used in clinical practice to detect potentially cancerous lesions [4].

An automatic color – based feature extraction system is proposed [5] for parameter estimation of oral cancer from optical microscopic images. Parameter comparisons between four cancer stages are conducted, and only the mean parameters between early and late cancer stages are statistically different. The proposed system provides a useful and convenient tool for automatic segmentation and evaluation for stained biopsy samples of oral cancer.

[6] used watershed segmentation algorithm for medical confocal image analyses towards in vivo early cancer detection. This technique is used to overcome artifacts from in vivo images and provide real time, accurate analysis of nuclear size, density and nuclear – cytoplasmic ratio, critical visual markers of epithelial precancers. The algorithm was first calibrated using optical images of microfluidic droplets, and then applied on confocal images of oral cavity tissues. All images were segmented successfully to provide accurate count (95% with 6.2% standard deviation) of cells or droplets.

A technique is proposed for oral cancer detection using Optical Coherence Tomography [7]. For the imaging depth of 2-3 mm, OCT is suitable for oral mucosa. They also detected oral cancer in 3-D volume images of normal and precancerous lesions.

B) Neuro Fuzzy Approaches

A fuzzy model was developed to detect occurrence of cancer from plethysmography images. This method helps people to get rid of the glitches of cancers and also to cure the cancer at earlier stages [8].

Oral Cyst detection and the severity measurement of cysts using Image Processing and Neural Networks is proposed [9]. The suspicious cyst regions are diagnosed using Radial Basis Function Network. The severity of the cysts is calculated using circularity values and the results show the part of the cysts extracted.

A novel neural network based automated system is proposed to identify and quantify the severity of cysts using dental radiograph images [10]. A template matching approach was used to slide over the input image to obtain the Normalized Cross Correlation and Extended Normalized Cross Correlation images (ENCC). ANN is trained using the ENCC images to locate the suspicious regions.

A tool for early diagnosis of Oral cavity disorders was developed [11]. Diagnostic performance was analyzed using Spectral Intensity Ratio (SIR), and Principal Component Analysis followed by Linear Discriminant Analysis (PCA-LDA). Method of SIR yielded 96% sensitivity and 100% specificity and an overall 100% for PCA-LDA respectively for efficient differentiation of the lesions. The results showed that PCA-LDA or SIR applied to AF spectroscopy is a useful tool for the differential diagnosis of oral cavity disorders.

C) Wavelet Approaches

A novel wavelet neural network based pathological stage detection technique for an oral precancerous condition was proposed [12]. The wavelet coefficients of transmission electron microscopy images of collagen fibres from normal oral submucosa and OSF tissues were used to choose the feature vector which, in turn, was used to train the artificial neural network. The trained network was able to classify

normal and oral precancer stages (less advanced and advanced) after obtaining the image as an input.

D) Genetic Algorithms Approach

Oral cancers are diagnosed using Genetic Programming. This system proposed an introductory work on a classification system. The Technique proposed solved many complex problems [13]. The comparison between a Genetic Programming system and Neural Network model was provided. The Genetic Programming system played a major advantage in diagnosing the tumor. The results obtained were good and accurate.

E) Data Mining Approaches

Data Mining Techniques are widely used in medical fields. Many researchers used Data mining techniques to predict and diagnose cancers. A method to detect and classify oral cancers using Data Mining is proposed [14]. Naïve Bayesian and Support Vector Machine were implemented and compared the results to identify the best. The accuracy achieved using Naïve Bayesian method was 48.45%, while with SVM the accuracy obtained was 71.65%.

A framework was proposed in [15] which was used to develop a Data Mining model for Early Detection and prevention of malignancy of Oral cavity. The framework developed organized relevant data, detected cancer patterns, and compared with the original database.

A unified and orchestrated approach based on Dynamic Bayesian Networks (DBNs) for the prediction of oral cancer reoccurrence has been proposed [16]. Cancer was segmented using Region growing algorithm and features were extracted. Six features from first order statistics, Forty eight features from spatial gray-level dependencies matrix, twenty features from gray-level differences matrix, twelve features from Law's texture energy measurements and three features from fractal dimension measurements were extracted. And later, DBN was used to find the reoccurrence of cancer.

III. CANCER CLASSIFICATION APPROACHES

A) Image Processing

Classification accuracy based on textural features for the development of a computer assisted screening of oral submucous fibrosis (OSF) is improved in [17]. This approach used to grade the histopathological tissue sections into normal, OSF without dysplasia (OSFWD) and OSF with dysplasia (OSFD), which would help the oral oncopathologists to screen the subjects rapidly.

Cyst and Tumor lesions are classified using SVM on Dental Panoramic Images [18]. Feature Extraction Techniques such as First Order Statistics, GLCM and GLRLM were used to extract features from ROI. Combinations of these techniques

are also made to yield a better accuracy. Performance evaluation is 0.9278 for all the three methods.

Cyst and Tumor lesions from dental panoramic images were classified using Active Contour Model [19]. An average accuracy rate of 99.67% is obtained to show that segmentation with snake model can be used for cyst and tumor lesion on dental panoramic images.

A new method of Feature Selection using Mean – shift and Recursive Feature Elimination techniques is proposed [20] to increase discrimination ability of the feature vectors. Performance of the algorithm is evaluated on an in-vivo recorded LIF data set consisting of spectra from normal, malignant and pre-malignant patients. Sensitivity of above 95% and specificity of above 99% towards malignancy are obtained using the proposed method.

A novel image feature extraction approach that is used to predict oral cancer reoccurrence is proposed [21]. Several numeric image features that characterize tumors and lymph nodes are also proposed. In order to automatically extract those features Registration and supervised segmentation of CT/MR images from the base of automated extraction of geometric and texture features of tumor and lymph nodes. Higher accuracy and robustness is achieved compared to today's clinical practice.

Epithelial lining architecture in radicular cysts and odontogenic keratocysts applying image processing algorithms to follow traditional cell isolation based approach is analysed in [22]. This formed the basis for later estimation of tissue layer level and architectural analysis of oral epithelia.

A screening support system for oral mucosal disease was developed [23]. As the results of the experiment, the discrimination rates of squamous cell, leukoplakia and lichen planus were 87%, 70% and 87%, respectively. The results suggest that the proposed method is effective in discriminating oral mucosal diseases.

A new color – based approach is proposed [24] for automated segmentation and classification of tumor tissues from microscopic images. The algorithm is evaluated by comparing the performance of the proposed fully – automated method against semi – automated procedures. The experimental results shows consist agreement between the two methods. The proposed algorithm provides an effective tool for evaluating oral cancer images. It can be applied to other microscopic images prepared with the same type of tissue staining.

An automatic color – based feature extraction system is proposed [25] for parameter estimation of oral cancer from optical microscopic images. Parameter comparisons between four cancer stages are conducted, and only the mean parameters between early and late cancer stages are

statistically different. The proposed system provides a useful and convenient tool for automatic segmentation and evaluation for stained biopsy samples of oral cancer.

Classification of radicular cysts and Odontogenic Keratocysts was investigated [26]. The classification was made using Cascaded Haar classifier. Three separated classifiers were trained respectively for each type of cyst to process unseen histological images in turn, to return a statistical count of the number of each corresponding cyst nuclei type present. The experimental results show the success of these classifiers in locating individual cells nuclei and in classifying the cyst types.

OSF histological images were segmented using Hybrid Segmentation Algorithms and Region Growing Algorithm [27]. The segmentation algorithms were compared by calculating the segmentation misclassification. The classification error is less in Hybrid Segmentation algorithm when compared to Region Growing Algorithm. It also provided a good accuracy during segmentation of an OSF. But the algorithm is not fully automatic due to the choice of the two thresholds. Also, criteria for the automatic detection of the number of layers present need to be determined.

In an approach to classify cancers, a histogram based feature extraction was proposed [28]. This system classified normal images and OSF images using SVM. An attempt is made to provide an enhanced knowledge about computer aided diagnosis of this potentially malignant disorder, to health care providers in order to help in differentiating the OSMF affected tissue from normal. Experiments showed significantly satisfactory results with an accuracy of 94%.

(B) Wavelet Approaches

A wavelet based texture classification for oral histopathological sections is proposed [29]. As the conventional method involves in stain intensity, inter and intra observer variations leading to higher misclassification error, a new method is proposed. The proposed method, involves feature extraction using wavelet transform, feature selection using Kullback – Leibler (KL).

(C) Neural Network Approaches

A simulated neural network system is proposed to categorise normal, premalignant and malignant oral smears. Each network was trained by back propagation, internal cross validation and tested on additional data [30]. A neural network differentiated between normal/non-dysplastic mucosa and dysplastic/malignant mucosa (specificity 0.82, sensitivity 0.76). These early results suggest that integrating neural networks and image analysis, as well as investigating additional criteria, could enhance automation and accuracy of smear techniques in diagnosing oral malignancy.

A method for oral lesion classification using true color images was proposed [31]. Five different color representations were studied and their use for color image analysis of mucosal images evaluated. Four common classifiers (Fisher's Linear Discriminant, Gaussian quadratic, KNN nearest neighbor and Multilayer perceptron) were chosen for the evaluation of classification performance. Classification accuracy was estimated using resubstitution and 5 – fold cross validation methods. The best classification methods were achieved in HIS system and linear discriminant function.

(D) Data Mining Approaches

The performances of data mining techniques were compared [32] for oral cancer prediction. The two data mining techniques used are Multilayer Perceptron Neural Network model and tree Boost model. For Training data as well as validation data, Multilayer Perceptron Neural Network and Tree Boost indicates the same specificity and sensitivity. Misclassification of data is not seen in both training and validation data in Multilayer Perceptron, Neural Network as well as tree boost model. Also the most important variable for the prediction of malignancy is "Presence of Lymph Node" as seen on USG. As per the study, Tree Boost Classification Model and Multilayer Perceptron Neural Network model both are optimal for predicting malignancy in patient have proposed.

An automated oral classification system using Data mining Techniques is developed in [33]. In this work, datasets are obtained from different diagnostic centers which contains both cancer and non – cancer patients information and collected data is pre-processed for duplicate and missing information and also to proposes a three various classification algorithm are utilized that is C 4.5, Random tree, and multilayer perceptron neural network model. The best accuracy for the given datasets is achieved in C4.5 algorithm match up to other Classification algorithm and also predictions of oral cancer.

IV. COMPARISON OF METHODS

Various methods discussed are compared and are shown in Table

Table 1. Comparison of methods

Ref	Description	Results
9	The severity of the cysts is calculated using circularity values	Severity of cysts is measured. For each dental image, accuracy is calculated for classification of cysts
3	Misclassification rate were calculated for both the algorithms.	Finally, Hybrid Segmentation method found to be suitable for segmentation of cancers in OSF images.

8	The work compared the classification accuracy of the TNM staging along with that of the Chi – square Test and Neural Networks.	ANN was significantly more accurate than the TNM staging system.
4	Segmentation of oral lesion is obtained in single band images from true color images	To further automatize and improve segmentation, additional or enhanced energy terms and more human knowledge should be incorporated
12	The feature vectors were extracted from each contiguous 64 x 64 blocks by wavelet decomposition	In case of less advanced stage of disease, some of the blocks are showing the signature of normal collagen image, whereas some are having the signature of advanced stage of OSF. As a result, the false detection rate is high in this less advanced stage but the PCBI is always greater than 50%. As the final decision is taken based on the magnitude of PCBI, it always leads to correct diagnosis.
28	The proposed method, involves feature extraction using wavelet transform, feature selection using Kullback – Leibler (KL) divergence and diagnostic classification using Bayesian Approach and Support Vector Machines	
13	The comparison between a Genetic Programming system and Neural Network model was provided.	The Genetic Programming system played a major advantage in diagnosing the tumor. The results obtained were good and accurate
28	Classification is performed to differentiate normal and OSF images	Experiments showed significantly satisfactory results with an accuracy of 94%.

V. CONCLUSION

The importance of earlier detection improves the diagnostic accuracy. Oral cancer (Pre malignant lesions) detection at an

earlier stage is a challenging task for dentists and radiologists. The approaches discussed above helps to detect and classify oral cancers. These adjuncts for detection and diagnosis have the potential to assist in early detection, leading to early diagnosis and improved treatment outcomes.

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