Histopathological Variants of Oral Squamous Cell Carcinoma Using Artificial Neural Network

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Abstract— Squamous Cell Carcinoma is one of the most malignant tumor of oral cavity. Oral Squamous Cell Carcinoma diagnosis through computer vision approach is a newly introduced a technique in modern era. This paper aims on finding the histopathological variants of oral squamous cell carcinoma. The variants include verrucous carcinoma, adenoid squamous cell carcinoma, spindle cell squamous carcinoma, basaloid squamous cell carcinoma and papillary squamous cell carcinoma. Each variant has a unique histomorphological appearance. In this method, Noise is suppressed using median filtering. Image is enhanced using max filter. In order to discriminate the variants, Gabor filter has been applied to the photomicrograph. Principal component Analysis has been used for the dimensionality reduction. Further, the histopathological variants have been classified using Artificial Neural Network which gives the satisfactory results. This would result in a new diagnostic method, which would assist the early diagnosis of histopathological variants of oral Squamous cell carcinoma of the oral cavity.

Keywords— Oral Squamous Cell Carcinoma (OSCC), Verrucous Carcinoma (VC), Adenoid squamous cell Carcinoma(ADSCC), Spindle cell/sarcomatoid carcinoma(SCSC), adenosquamous carcinoma(ASC), Basaloid Squamous Cell Carcinoma(BSCC), papillary squamous cell carcinoma (PSCC), Artificial Neural Network (ANN).

I. INTRODUCTION

Squamous cell carcinoma is by far the most important and the most common malignant mucosal neoplasm of the head and neck accounting for over 90% of all malignancies. Conventional oral squamous cell carcinoma (OSCC) can present as several variants that make up in aggregate about 10-15% of all squamous cell carcinomas (SCC).[1] These variants include verrucous carcinoma (VC), adenoid/ acantholytic/pseudoglandular SCC (AdSCC), spindle cell/sarcomatoid carcinoma (SCSC), adenosquamous carcinoma (ASC), basaloid SCC (BSCC) and papillary SCC (PSCC). Each of these variants has a unique histomorphological appearance.

A. Verrucous Squamous cell carcinoma

Verrucous carcinoma usually debuts as an abnormal growth or as change in the consistency of a previous potentially malignant disorder of the oral cavity. All mucosal sites of the oral cavity can be affected [2]. However, the rate of malignant transformation of a leukoplakia to an OVC is 20.81 times higher if they are located in the gingiva in comparison with the tongue. Figure 1: shows the H & E staining of 20 x magnification of verrucous Squamous cell carcinoma.

Figure 1: Verrucous Cell Carcinoma

B. Spindle cell/sarcomatoid carcinoma(SCSC)

Spindle cell carcinoma is most commonly seen in head and neck region. It is a rare variant growth of Squamous cell carcinoma. In most cases it arises in the head and neck of the oral cavity, larynx, tonsil and pharynx. It is also known as pseudosarcoma, carcinosarcoma, sarcomatoid squamous cell carcinoma or polypoid squamous cell carcinoma. It is usually present as large polypoid, pedunculated neoplasm, protruding from the mucosal surface with ulceration. It is mostly predominant in male[6]. The predisposing factors are the same as SCC, including tobacco use, alcohol abuse, poor oral hygiene and previous irradiation to the site in which the tumor arise. Figure 2: shows the spindle cell/sarcomatoid carcinoma(SCSC) of H & E staining of 20 X magnification.

Figure 2: Spindle cell/sarcomatoid carcinoma

C. Adenoid squamous cell Carcinoma

Adenoid (acantholytic) squamous cell carcinoma (Adscce) is a squamous cell carcinoma with features of adenoid pattern due to acantholysis of squamous cell
cancer. Adenoid squamous cell of the oral cavity is rare, and is mostly seen in skin. Oral Adsc shows the pseudovascular morphology. Figure 3: shows the Adenoid squamous cell Carcinoma of H & E staining of 20 x magnification.

D. Papillary Squamous Cell Carcinoma

Papillary Squamous Cell Carcinoma of the oral mucosa is relatively rare but distinct variant of SCC of head and neck. The larynx is the most commonly affected site in the head and neck. Other sites of the involvement the oral cavity, oropharynx, sinonasal tract and nasopharynx. Figure 4: shows the Papillary Squamous Cell Carcinoma of H & E staining of 20 x magnification.

E. Adenosquamous Cell Carcinoma

Adenosquamous Cell Carcinoma is a rare tumour in the oral cavity and is characterized histologically by carcinomatous change in surface epithelium, in association with adenocarcinoma affecting the ducts of minor salivary glands [4]. Figure 5: shows the 20 X Magnification of H & E Stain.

But Adenosquamous Cell Carcinoma is a aggressive disease with 60 % of patients die of this disease. Figure 6: Shows the overall architecture of the proposed classification System.

II. PROPOSED METHODOLOGY

A. Pre-Processing

Microscopic images are multidimensional in terms of imaging angle. Images are taken from top-down, left-right, and front back perspectives. The data set used in this module had its best quality and most complete images from the front-back perspective [5]. All the images were uniformly resized to 255 x 255 size. In this method, Noise is suppressed using median filtering. Image is enhanced using max filter.

B. Feature Extraction

A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. A Gabor Filter is a linear filter used for edge detection in image processing which is named after Dennis Gabor. A sinusoidal plane wave has been modulating a 2D Gabor filter which is a Gaussian Kernal function in the spatial domain.

\[ s(x, y)g(x, y) = h(x, y) \]
\[ s(x, y) : \text{Complex sinusoid} \]
g(x, y) : 2-D Gaussian shaped function, known as envelope
\[ g(x, y) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{1}{2} \frac{x^2 + y^2}{\sigma^2}} \]

Where s(x, y) is a complex sinusoid, known as the carrier, and g(x, y) is a 2-D Gaussian-shaped function, known as the envelope.

The complex sinusoid is defined as follows,
\[ s(x, y) = \exp(j(2\pi(u_0x + v_0y) + P)) \]

where (u_0, v_0) v and P define the spatial frequency and the phase of the sinusoid respectively. This sinusoid can be represented as two separate real functions, conventionally allocated in the real and imaginary part of a complex function [8]. The real part and imaginary part of this sinusoid are,
\[
\text{Re}(s(x, y)) = \cos(2\pi(u_0x + v_0y) + P) \\
\text{Im}(s(x, y)) = \sin(2\pi(u_0x + v_0y) + P)
\]

The parameters u_0 and v_0 define the spatial frequency of the sinusoid in Cartesian coordinates. This spatial frequency can also be expressed in polar coordinates as magnitude F_0 and direction \( \alpha_0 \):
\[
F_0 = \sqrt{u_0^2 + v_0^2} \\
\tan(\alpha_0) = \frac{v_0}{u_0}
\]

Using this representation, the complex sinusoid is,
\[ s(x, y) = \exp(j(2\pi F_0^2(x \cos \alpha_0 + y \sin \alpha_0) + P)) \]

From one parent wavelet all filters can be generated by dilation and rotation, thus the gabor filters are self-similar.

The Gaussian envelope looks as follows:
\[ \Theta_k(x, y) = K \exp(-\pi(a'(x-x_0)^2+b'(y-y_0)^2)) \]

Where (x_0, y_0) is the peak of the function, a and b are scaling parameters of the Gaussian, and the r subscript stands for a rotation operation such that,
\[
(x - x_0) = (x - x_0) \cos \theta + (y - y_0) \sin \theta \\
(y - y_0) = -(x - x_0) \sin \theta + (y - y_0) \cos \theta
\]

The input image for Gabor Filter dimension is 255 x 255 x 3. The Gabor Filter identifies the image in 8 angular direction. And then the feature values are down sampled, it gives the 255 x 255 feature vector. The below figure shows the Gabor output of super-imposed normalized form. Figure 10: shows the Gabor Filter of super-imposed and normalized form.

C. Principal Component Analysis

The popular methods in the field of extracting features are Principle Component Analysis (PCA). The method linearly transforms the high-dimensional input vectors into low-dimensional ones in which the components would be uncorrelated [3]. This method using principal component analysis (PCA), which is based on the idea that a high-dimensional dataset is often described by correlated variables and therefore only a few meaningful dimensions account for most of the information. The PCA method finds
the directions with the greatest variance in the data, called principal components. In this 255x255 dimension is giving as the input to the PCA and then the dimension is reduced into 255x1

III. EXPERIMENTAL RESULTS

A. Dataset

Oral cancer is the cancer that starts in the mouth or oral cavity and is especially seen disadvantaged in elderly males. It is one among the 10 most common cancers worldwide, with 280,000 new cases of oral cancer found every year. It has been one of the serious cancers that affect the South Asian Countries. We have collected dataset from 100 cases from Raja Muttiah Dental College and Hospital. From the selected dataset 70% data is used for training, 15% data for testing and remaining 15% data is used for validation.

B. Performance Analysis

The experimental results is shown that the proposed method work in complex situation. True positive (TP) represents total number of correctly identified lane-mark edges by using the proposed approach. False positive (FP) represents the total number of in-correctly identified lane mark edges by using the proposed approach.

True Positive Rate (TPR) or Precision is defined as,

\[
Precision = \frac{TP}{TP + FP}
\]

Recall is defined as,

\[
Recall = \frac{TP}{TP + FN}
\]

Where, TP and FN are True Positive and False Negative. False Negative (FN) represents the total number of false detections. To compute, F-measure is defined as,

\[
F – Measure = \frac{2 X Recall \times Precision}{Recall + Precision}
\]

The below table show the values of each variants of OSCC.

**TABLE I. THE OVERALL DETECTION GIVES AN ACCURACY OF 87.92% USING THE DATASET**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Precision</th>
<th>Specificity</th>
<th>Sensitivity</th>
<th>Accuracy</th>
<th>Error Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>adenocarcinoma</td>
<td>0.9200</td>
<td>0.8689</td>
<td>0.9388</td>
<td>0.9119</td>
<td>0.0881</td>
</tr>
<tr>
<td>papillary carcinoma</td>
<td>0.8861</td>
<td>0.5263</td>
<td>0.9091</td>
<td>0.8333</td>
<td>0.1667</td>
</tr>
<tr>
<td>sarcomatoid carcinoma</td>
<td>0.8333</td>
<td>0.7500</td>
<td>0.9091</td>
<td>0.8421</td>
<td>0.1579</td>
</tr>
<tr>
<td>spindle cell varcinoma</td>
<td>0.9695</td>
<td>0.9130</td>
<td>0.9407</td>
<td>0.9337</td>
<td>0.0663</td>
</tr>
<tr>
<td>verrucous scc</td>
<td>0.8774</td>
<td>0.7547</td>
<td>0.9394</td>
<td>0.8750</td>
<td>0.1250</td>
</tr>
</tbody>
</table>

The above figure shows the maximum performance achieved in spindle – cell carcinoma with the maximum accuracy.

IV. CONCLUSION

In this work, identifying the particular type of oral cancer using microscopic images has been attempted. The texture features of the images are considered for performing the classification. The approaches used for feature extraction are Gabor filter and PCA. For classification, ANN has been used and the results prove to be very satisfactory as 90% and above are being achieved.

REFERENCES


