Characterization and Classification of Oral Squamous Cell Carcinoma from Histopathological Images: Quantitative Microscopy Approach

Abstract

Microscopic image evaluation from an oral biopsy sample is the gold standard for oral squamous cell carcinoma (OSCC) diagnosis. Keratin, mitotic cell, and cellular features are the main parameters considered for OSCC diagnosis. In conventional procedure, experts manually identify these targeted histopathological parameters under the light microscope and categorize into healthy, low, and high grade category. The accuracy of this manual assessment fully depends upon the pathologist's expertise and experience. This evaluation leads to diagnostic inaccuracy towards OSCC grading. The main aim of this study is to design improved computational methodology for analyzing histopathological parameters from light microscopic images of the oral tissue sample to detect OSCC and classify the disease state.

The structural variations of epithelial layers and the presence of keratin pearls, which can be observed in microscopic images, are the key visual features in OSCC diagnosis. A two-stage methodology is proposed for analyzing oral histology images, where 12-layered (7x7x3 channel patches) deep convolution neural network (CNN) are used for segmentation of constituent layers in the first stage and in the second stage the keratin pearls are detected from the segmented keratin regions using random forests classifier trained with texture-based feature (Gabor filter).

Identification of abnormal mitotic cells, a potential malignant image marker for oral squamous cell carcinoma (OSCC), is an important task. An efficient methodology using Deep CNN with Haar wavelet decomposed image patches is proposed for automatic detection of abnormal mitotic cells. The proposed approach is shown to be robust in automatic detection of normal, abnormal mitotic image marker, emphasizing the presence of malignancy in the oral cavity.

Characterization of the nucleus from oral tissue histology images is important for oral squamous cell carcinoma (OSCC) diagnosis. A three-stage methodology is proposed for automatic nucleus detection, delineation, and further quantification to aid the clinician in OSCC diagnosis. In the first stage, deep CNN architecture is proposed to localize the nucleus from OSCC images with wavelet decomposed patch as input. After localization, 81×81 image patches were extracted from detected nucleus regions and processed through the second stage of the proposed pipeline to segment the exact boundary of nucleus using active contour (Chan-Vese model) model supported by edge enhancing nonsubsampled contourlet transform. In the final stage, nuclei from three types of oral tissue images (healthy, low grade and high grade) are classified by stacked autoencoder using morphology, intensity, and texture information.

Machine learning approaches like deep CNN has been utilized widely for disease recognition and classification task. This type of algorithm performs well after training with the huge dataset. A methodology is designed to classify individual oral tissue image frame into healthy, low grade and high grade using fine-tuned transfer learned approach without considering traditional histological parameters. The proposed study includes limited training dataset. Hence, the trained parameters from the pre-trained Resnet50 model are utilized for the proposed model.

Overall, this doctoral research work would certainly help the clinician to overcome the limitations of manual analysis, makes the detection task fast and errorless, and thus promises better accuracy. The proposed approach can be used as an assistive tool for pathologists to take decision in efficient manner.

Keywords: Oral squamous cell carcinoma, deep CNN, keratin pearl, mitotic cell, nonsubsampled contourlet, Haar wavelet, stacked autoencoder, Resnet50.