IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2024

DOI: 10.17148/IJARCCE.2024.133104

ORAL SQUAMOUS CELL CARCINOMA DETECTION USING DEEP LEARNING ON HISTOPATHOLOGICAL IMAGES

Ravinarayana B[1], Ananya [2], Aparna P[3], Divija[4], Eeksha Jain[5]

Student, Dept. of Computer Science & Engineering, Mangalore Institute of Technology & Engineering, Moodabidre, India[2-5]

Dept. of Computer Science & Engineering, Mangalore Institute of Technology &Engineering, Moodabidre, India[1]

Abstract: The most prevalent type of head and neck cancer is oral or mouth neoplasm, namely oral squamous cell carcinoma (OSCC).Despite its impact on mortality, it is invariably diagnosed late due to the ineffectiveness of early detection screening techniques. Early detection and treatment of oral squamous cell carcinoma (OSCC) is crucial for improved patient outcomes. Deep learning (DL) offers a promising approach for automated OSCC detection and classification. DL models can extract complex features from histopathological image dataset, achieving high accuracy in OSCC detection and classification. Studies have demonstrated DL is effective in distinguishing OSCC from benign lesions and classifying OSCC into different stages. DL-based OSCC detection and classification can improve diagnostic accuracy and efficiency, leading to earlier detection and treatment. However, further research is needed to validate DL models' clinical performance and ensure data quality and model interpretability. Overall, DL holds promise for revolutionizing OSCC diagnosis and management, enabling more accurate and personalized patient care.

Keywords: Deep learning(DL), Convolutional Neural Networks (CNNs), Oral Squamous Cell Carcinoma (OSCC), Histopathological

I. INTRODUCTION

Oral squamous cell carcinoma (OSCC) is a form of cancer that develops in the lining of the mouth accounting for, more than 90% of oral cancer cases. It falls under the category of head and neck cell carcinoma (HNSCC) which is a significant global health concern. Factors that contribute to the risk of developing OSCC include alcohol consumption, smoking, poor oral hygiene, exposure to papillomavirus (HPV) genetic predisposition, lifestyle choices, ethnicity and geographic location. Early detection plays a vital role in treating OSCC and improving survival rates since this type of cancer has a challenging prognosis with an average cure rate of 50%. Currently the standard diagnosis relies on analyzing tissue samples through biopsy analysis. However this process can be time consuming and prone to errors. Therefore there is a need for diagnostic tools that can assist pathologists in assessing and diagnosing OSCC. Recent advancements have explored the use of Artificial Intelligence (AI) and Deep Learning (DL) to enhance medical diagnostics by leveraging diagnostic imaging techniques. DL has shown success in analyzing images for various diagnoses, within medical image processing. Computer aided diagnosis (CAD) systems based on DL have been widely adopted for diagnosing types of cancers. However researchers are focusing on utilizing DL for diagnosing cancer from pathological images.

II. LITERATURE SURVEY

Jelena Musulin et al,(2021),This paper demonstrates the enormous potential of using AI-based algorithms to achieve an accurate prognosis of OSCC and increase people's chances of survival. For the multiclass classification problem authors compared various deep learning models with different configuration settings in order to achieve satisfactory classification performance.[1]

Premanand Ghadekar et al,(2021),This paper presents cancer detection using Histopathological scanned images implemented using CNN models to classify if a particular scan of lymph node is cancerous or not. Tagged Image format is used which gives great result in the field of Computer-aided imaging detection and diagnosis.[2]

Chiagoziem C. Ukwuoma et al,(2022),This paper presents a deep learning model for early detection of Oral Squamous Cell Carcinoma (OCSCC) using microscopic images. Departing from traditional methods, it introduces a novel layer-sharing approach that improves classification accuracy. While dataset limitations are recognized, this research marks a crucial step in enhancing OSCC detection, leveraging advanced deep learning for more effective early diagnosis.[3]

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Mohanad A. Deif et al,(2022),This paper likely focuses on a computer-aided diagnosis approach for differential of OSCC. Feature extraction using deep learning models like ResNet50,VGG16,Inception V3 and feature selection using BPSO. The best classification accuracy can be obtained when using Inception V3 along with BPSO. This approach significantly contributes to improving the diagnostic efficiency of OSCC.[4]

Santisudha Panigrahi et al,(2023),This paper reviews the use of transfer learning with pretrained deep convolutional neural networks for binary classification of oral histopathological images as benign or malignant lesions. Various pretrained models were evaluated, like the ResNet50 model achieving the, and the baseline CNN model. The study offers a cost-effective screening method for Oral Squamous Cell Carcinoma, with potential for future improvements using residual blocks and larger datasets.[5] A significant deficiency identified in the papers mentioned above is the scarcity of images in their datasets. A limited test data sample may not accurately reflect data obtained in the real world, resulting in poor distribution coverage in training data. Therefore, our project is dedicated to rectify this issue by ensuring well-populated image dataset for training and analysis. A larger and more diverse dataset allows for better training of deep learning models. With more data, the models can learn more representative features and patterns, potentially leading to improved accuracy in OSCC detection and diagnosis.

Sl.No	Title	Authors	Inference	Methodology
1	Automated Grading of Oral Squamous Cell Carcinoma into Multiple Classes Using Deep Learning Methods	Jelena Musulin, Daniel Štifanić, Ana Zulijani, Sandi Baressi Šegota, Ivan Lorencin, Nikola Anđelić, Zlatan Car	This paper demonstrates the enormous potential of using AI-based algorithms to achieve an accurate prognosis of OSCC and increase people's chances of survival.	InceptionV3, InceptionResNetv2, DenseNet, NASNet, EfficientNet
2	Histopathogical Cancer detection using Deep Learning	Premanand Ghadekar,Anesh Khandelwal,Prateek Roy, Abhijeet Gawas,Chaitanya Joshi	The proposed system can save a lot of manual work and time for the biopsy image.	ResNet50
3	Detection of Oral Cavity Squamous Cell Carcinoma from Normal Epithelium of the Oral Cavity using Microscopic Images	Chiagoziem C. Ukwuoma, Qin Zhiguang, Md Belal Bin Heyat, Haider Mohammed Khan, Faijan Akhtar,MahmoudS. Masadeh, Olusola Bamisile, Omar AlShorman, Grace. U. Nneji	This paper's key contribution is developing the first layer- sharing Ensembling approach using microscopic images for early- stage OCSCC detection.	DenseNet, Xception, VGG16, EfficientNetB7, GoogleNet InceptionResNet

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4	Diagnosis of Oral Squamous Cell Carcinoma Using Deep Neural Networks and Binary Particle Swarm Optimization on Histopathological Images	Mohanad A. Deif, Hani Attar, AymanAmer, Ismail A.Elhaty, Mohammad R. Khosravi, AhmedA.A. Solyman, Grace. U. Nneji	This paper likely focuses on a computer-aided diagnosis approach for Differential of OSCC.	VGG16, AlexNet, InceptionV3, ResNet50
	Classifying histopathological images of oral squamous cell carcinoma using deep transfer learning	Santisudha Panigrahi, Bhabani Sankar Nandab, Ruchi Bhuyanc, Kundan Kumard, Susmita Ghoshe, Tripti Swarnkar	the concept of transfer learning over pretrained deep convolution neural networks (DCNN) has been successfully employed for binary classification of oral histopathological mages into benign and malignant lesions	VGG16, VGG19, InceptionV3, ResNet50, MobileNet

III. SCOPE AND METHODLOGY

Aim of the project

The aim of the project is to develop robust deep learning models capable of accurately detecting oral squamous cell carcinoma (OSCC) in medical imaging data, particularly histopathological images. By extracting relevant features from these images and optimizing feature selection techniques, the goal is to enhance the model's discriminatory power for identifying cancerous regions within the images. The project seeks to promote the adoption of these deep learning models in clinical practice, aiming to facilitate early detection of OSCC and support timely and accurate treatment decisions. Furthermore, the project aims to improve the speed and efficiency of OSCC detection compared to traditional methods, such as manual review by pathologists, thus expediting the diagnostic process. Additionally, by leveraging historical patient data, the project aims to provide early detection capabilities for OSCC and other health issues, ultimately contributing to the improvement of treatment effectiveness and patient outcomes. Overall, the project endeavors to advance the field of medical imaging technology by harnessing the potential of deep learning for OSCC detection, with the ultimate goal of enhancing clinical decision-making and patient care

Scope of the Project

The scope of the project is to develop and deploy deep learning models for the accurate detection of oral squamous cell carcinoma (OSCC) from histopathological images. This involves collecting and preprocessing a diverse dataset of histopathological images, optimizing deep learning architectures for OSCC detection, and evaluating the models using performance metrics like accuracy and AUC. The project also includes deploying the trained models into a user-friendly software platform for healthcare professionals, with potential validation through clinical trials and collaboration with medical institutions. Through these efforts, the project seeks to enhance cancer diagnostics, improve patient outcomes, and advance the field of medical imaging technology.

Methodology

The project methodology begins with the collection of a diverse dataset comprising oral histopathological images, encompassing both normal and OSCC-affected tissue samples. Subsequently, a pre-trained CNN model, such as ResNet, is utilized to extract high-level features from these images, focusing on intermediate layers to capture relevant information. Feature selection techniques are then applied to identify the most informative features among those extracted from ResNet. Following this, a deep learning model architecture is designed specifically for OSCC classification, incorporating fully connected layers for effective classification. The dataset is divided into training and validation sets, with the selected features serving as input data for model training. The deep learning model is trained using an optimization algorithm to adjust model parameters. Hyperparameters, such as learning rates and batch sizes, are fine-tuned to enhance the model's training efficiency and effectiveness. Finally, the trained model undergoes evaluation using a separate test dataset, ensuring robust assessment of its performance in classifying OSCC from oral histopathological images, with the test dataset unseen during training or validation.

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System Architecture

The system architecture for oral squamous cell carcinoma (OSCC) detection using deep learning on histopathological images follows a systematic process. It commences with the acquisition of histopathological images, typically stained to highlight cellular features. Subsequently, a pre-trained deep convolutional neural network (CNN) known as ResNet-50 is employed for feature extraction from these images. ResNet-50 is adept at extracting intricate features through its convolutional layers, crucial for image classification tasks. The extracted features are then utilized to train a classifier, with the Adam optimizer employed to optimize the model's parameters during training. This optimization process aims to minimize the discrepancy between predicted classifications and actual labels in the training images, thereby enhancing the model's accuracy. Finally, the trained classifier is deployed to classify new, unseen images as either cancerous or non-cancerous, facilitating the diagnosis and treatment of OSCC. This architecture seamlessly integrates image processing, feature extraction, deep learning classification, and optimization techniques to achieve precise detection of oral squamous cell carcinoma from histopathological images, contributing to improved patient outcomes in clinical practice.

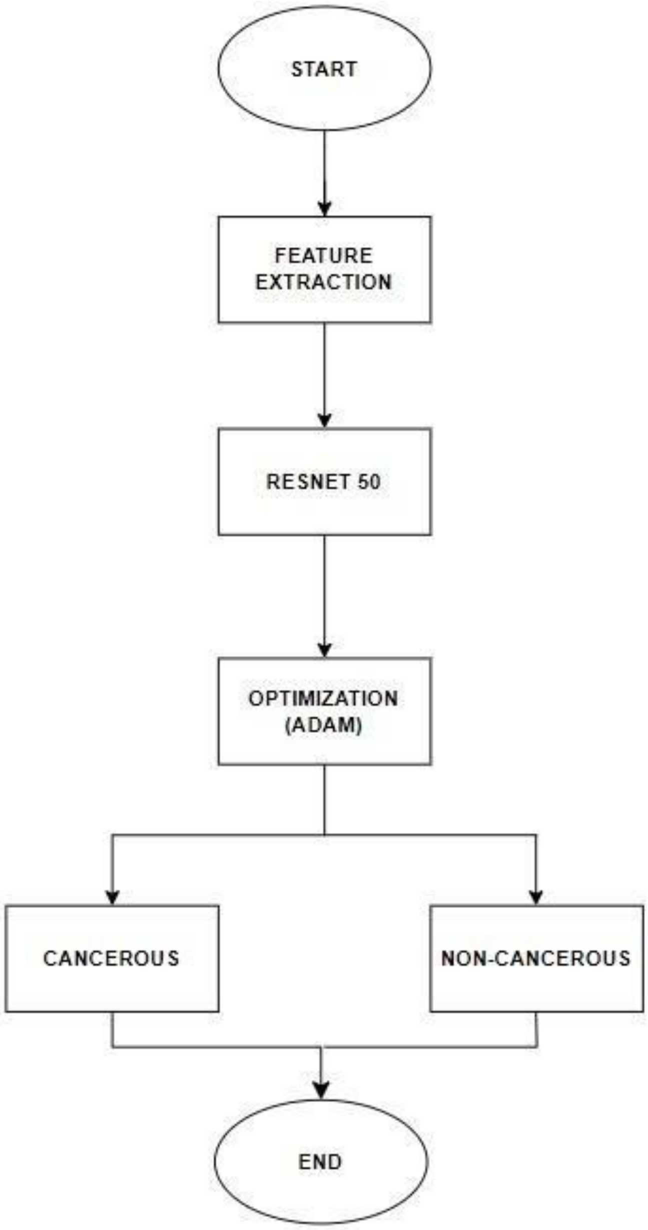

Fig 1. System Archiecture

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IV. CONCLUSIONS

The utilization of deep learning techniques for oral squamous cell carcinoma (OSCC) detection from histopathological images presents a promising avenue for improving diagnostic accuracy and patient outcomes. Through the integration of advanced technologies such as pre-trained convolutional neural networks like ResNet-50, feature extraction, and optimization algorithms like Adam, the developed system demonstrates notable capabilities in accurately distinguishing between cancerous and non- cancerous tissues. By leveraging these methodologies, healthcare professionals can expedite the diagnostic process, leading to timely interventions and personalized treatment strategies for OSCC patients. Furthermore, the system's effectiveness in classifying unseen images underscores its potential for real-world clinical applications, offering a valuable tool for oncologists and pathologists in their decision-making processes. Overall, the successful deployment and validation of the proposed system signify a significant step forward in enhancing oral cancer diagnosis and management, ultimately contributing to improved patient care and outcomes in the field of oncology.

V. RESULTS

The OSCC detection model achieved an overall accuracy of 87.5% for the ResNet50 model in detecting oral squamous cell carcinoma (OSCC) from histopathological images underscores its effectiveness in automated lesion classification. However, while accuracy is an important metric, a comprehensive evaluation involves considering precision, recall, and F1 score. By leveraging strategies such as data augmentation to increase dataset diversity, fine-tuning model hyperparameters for optimization, and exploring ensemble learning techniques for improved generalization, the model can be fine-tuned to achieve a more robust and reliable OSCC detection capability, ultimately enhancing diagnostic accuracy and patient care.

The confusion matrix is a crucial tool for evaluating a binary classification model's performance. It succinctly summarizes the model's predictions, with the rows and columns representing the two classes. Diagonal cells indicate correct classifications, while off-diagonal cells denote classification errors. For instance, in a cancer detection scenario, correctly classified instances of cancer and non-cancer are represented in the bottom-right (1,1) and top-left (0,0) cells, respectively. Analyzing the matrix provides valuable insights into the model's strengths and weaknesses, guiding improvements for enhanced accuracy.

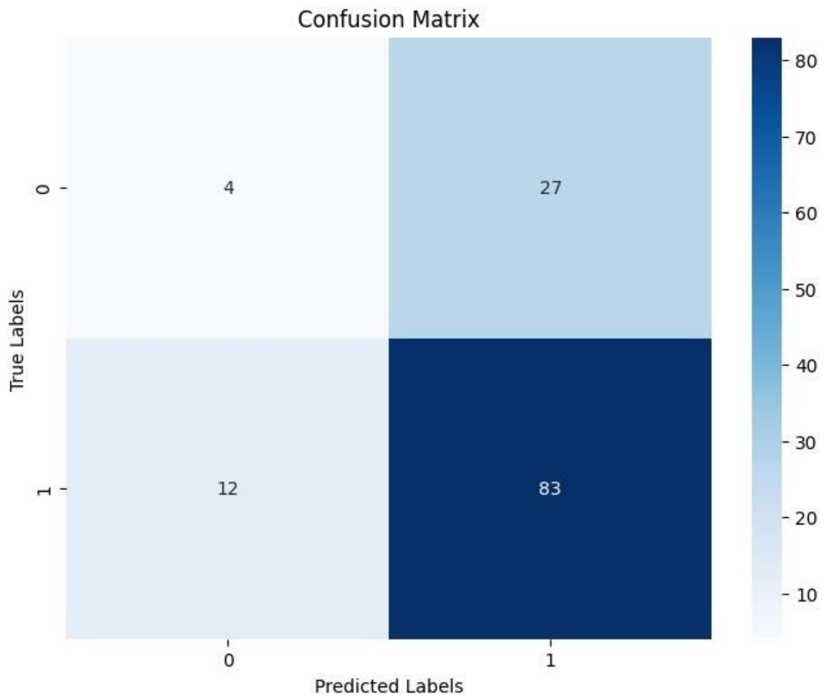

Fig 2 Confusion Matrix

Fig 3 shows The graph to compare the model's performance on familiar training data (blue line) with its performance on a different dataset (orange line). This helps us understand how well the model might perform on new cases it hasn't seen before.

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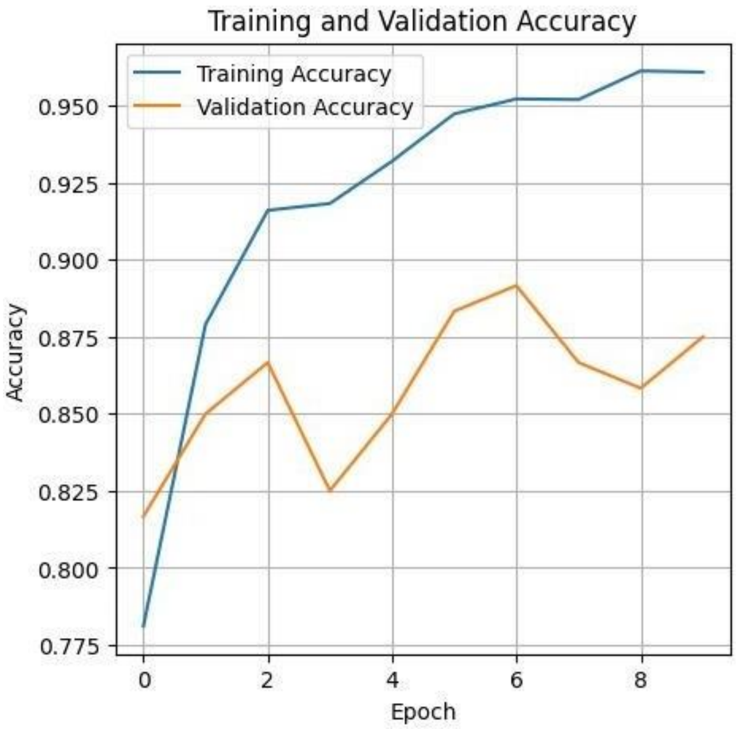

Fig.3 Training and Validation Accuracy

Fig 4 This graph depicts the precision of an OSCC detection model during training (blue line) and its ability to generalize to unseen data (orange line). As the training progresses (X-axis), the precision for both training and validation data (Y-axis) increases, suggesting the model is effectively learning to identify OSCC cases.

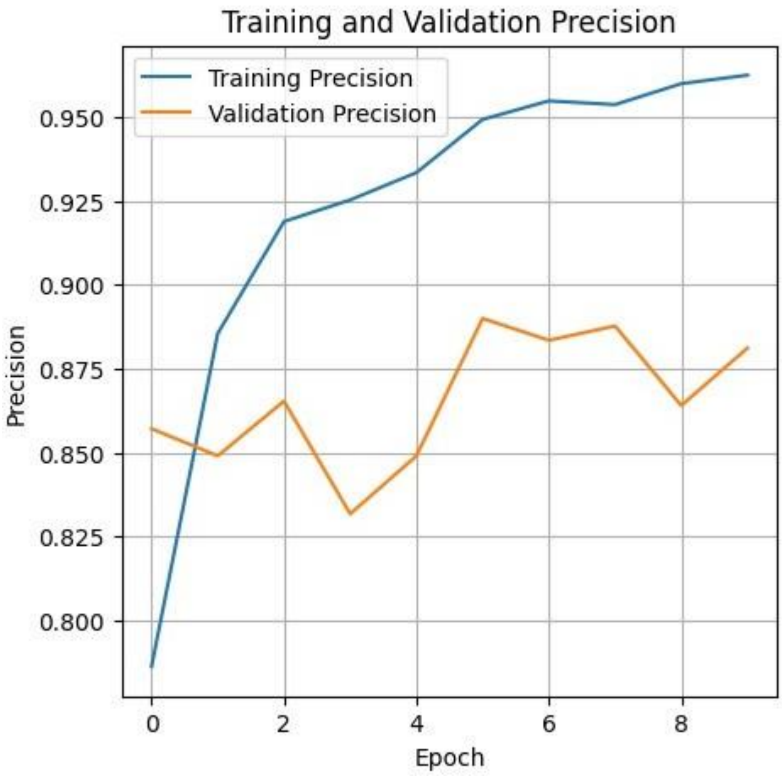

Fig 4 Training and Validation Precision

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