

Smart Mouth Cancer Prediction System Using Deep Learning and Image Segmentations

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Abstract: Mouth cancer is one of the most dangerous and rapidly spreading diseases affecting people worldwide. Early detection of oral cancer is essential to improve patient survival rates and reduce the severity of the disease. Traditional diagnostic methods such as clinical examination, biopsy testing, and histopathological analysis are often time-consuming, expensive, and highly dependent on medical experts. To overcome these limitations, this paper proposes an intelligent automated system for mouth cancer detection using Machine Learning (ML) and Deep Learning (DL) techniques. The proposed system utilizes oral medical image datasets to identify cancerous and non-cancerous tissues accurately. Initially, image preprocessing techniques such as noise removal, normalization, resizing, contrast enhancement, and segmentation are applied to improve image quality and highlight suspicious regions. Feature extraction methods are then used to obtain important characteristics such as texture, shape, color, and intensity patterns from oral images. Various Machine Learning algorithms including Support Vector Machine (SVM), Decision Tree, Random Forest, and K-Nearest Neighbour (KNN) are employed for classification and prediction. In

addition, Deep Learning models such as Convolutional Neural Networks (CNN) are utilized for automatic feature learning and high-accuracy image classification. The performance of the proposed system is evaluated using parameters such as accuracy, precision, recall, sensitivity, specificity, and F1-score. Experimental analysis demonstrates that Deep Learning models achieve better performance compared to traditional Machine Learning methods in detecting mouth cancer from medical images. The proposed system reduces human effort, minimizes diagnostic errors, and provides faster prediction results, thereby assisting healthcare professionals in early diagnosis and effective treatment planning. This research contributes to the development of intelligent healthcare systems by integrating Artificial Intelligence technologies for reliable and efficient oral cancer detection.

Index terms - — Mouth Cancer Detection, Oral Cancer, Machine Learning, Deep Learning, Convolutional Neural Network (CNN), Medical Image Processing, Image Segmentation, Feature Extraction, Artificial Intelligence in Healthcare, Cancer Classification, Support Vector Machine (SVM), Random Forest, Early Cancer Detection.

1. INTRODUCTION

Mouth cancer, also known as oral cancer, is one of the most dangerous and rapidly growing diseases affecting people worldwide. It commonly occurs in the lips, tongue, gums, cheeks, and throat due to harmful habits such as tobacco chewing, smoking, alcohol consumption, and poor oral hygiene. Early detection of mouth cancer is extremely important because timely diagnosis can improve patient survival rates and reduce the severity of the disease. Traditional diagnostic methods such as biopsy testing, histopathological examination, MRI scans, and manual clinical inspection are widely used for cancer detection. However, these methods are often time-consuming, expensive, and highly dependent on experienced medical professionals, which may lead to delayed diagnosis and treatment.

With the rapid advancement of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL), intelligent healthcare systems are becoming more effective for automated disease detection and medical image analysis. Machine Learning algorithms such as Support Vector Machine (SVM), Decision Tree, Random Forest, and K-Nearest Neighbour (KNN) are capable of analyzing oral medical images by extracting features like texture, shape, color, and intensity. Deep Learning models, especially Convolutional Neural Networks (CNN), can automatically learn complex image patterns and identify cancerous tissues with higher accuracy and reduced human intervention. These technologies significantly improve diagnostic performance, reduce human error, and enable faster prediction compared to traditional methods.

This project proposes an automated mouth cancer detection system using Machine Learning and Deep Learning techniques. The system utilizes oral medical image datasets and performs image preprocessing operations such as noise removal, resizing, normalization, contrast enhancement, and segmentation to improve image quality. Feature extraction and classification techniques are then applied to identify whether the oral image is cancerous or non-cancerous. The proposed system aims to provide accurate, reliable, and faster cancer detection results while assisting healthcare professionals in early diagnosis and effective treatment planning. Experimental analysis shows that Deep Learning models achieve better accuracy and performance than conventional Machine Learning techniques in detecting mouth cancer.

2. LITERATURE SURVEY

a) Oral Cancer Detection Using Deep Learning

Oral cancers are common, complex malignancies with a high fatality rate. A biopsy, which involves taking a little sample of tissue from a body area and examining it under a microscope, is another technique for identifying oral cancer in addition to screening procedures. This work offers a robust diagnostic method for the detection of oral cancer by employing feature extraction and deep learning techniques. A deep learning algorithm and contemporary technology can be employed for early diagnosis and classification. Our deep learning model makes use of the sophisticated EfficientNet architecture, which is well-known for its effectiveness in image processing applications. Transfer learning is used to refine the model and accelerate convergence by using pretrained weights.

This combination of feature extraction and deep learning, especially with EfficientNet's capabilities, demonstrates the promise of state-of-the-art technology in improving oral cancer diagnosis. In the field of healthcare, using these techniques allows for accurate identification, early management, and possibly better patient results.

b) Oral cancer detection and interpretation: Deep multiple instance learning versus conventional deep single instance learning:

Histological analysis of an oral cavity tissue sample is currently the accepted medical standard for diagnosing oral cancer (OC). Compared to the alternate method of obtaining a brush sample and then doing cytological analysis, this procedure is more time-consuming and intrusive. Although skilled cytotechnologists may identify alterations brought on by cancer, integrating this method into clinical practice is fraught with difficulties, including a shortage of specialists and labor-intensive tasks. We are interested in AI-based techniques that can reliably detect cancer given only per-patient labels (minimizing annotation bias) and provide information on which cells are most relevant for the diagnosis (enabling supervision and understanding) in order to design a reliable OC detection system that would help cytotechnologists. Therefore, using three distinct neural network architectures, we compare a traditional single instance learning (SIL) technique with a contemporary multiple instance learning (MIL) strategy appropriate for OC identification and interpretation. We present a synthetic PAP-QMNIST dataset that functions as a model of OC data and provides access to per-instance ground truth in order to enable systematic evaluation of the methodologies under consideration. According to our research, the

SIL strategy generally outperforms the MIL approach on PAP-QMNIST. While both approaches perform similarly at the bag level on actual cytological data, the single instance technique often performs better. A cytotechnologist's visual inspection reveals that the techniques are successful in identifying cells that vary from normalcy, including cancerous cells and those that may have dysplasia.

c) Interpretable deep learning approach for oral cancer classification using guided attention inference network

Significance

Automatic CNN classification of cancer lesions. Incomprehensible CNNs lack interpretability and explainability. CNNs have no incentive to focus on the salient item, thus they may focus on other areas surrounding it instead. CNN reliability decreases, especially for biological applications.

Aim

Develop a deep learning training approach that clarifies predictions and directs the network to cancerous spots.

Approach

We made CNNs interpretable and explainable using Selvaraju et al.'s gradient-weighted class activation mapping. Data augmentation and Li et al.'s guided attention inference network (GAIN) trained our own mobile oral screening equipment photos in two steps. The GAIN architecture trains categorization, attention mining, and bounding box networks. To improve CNN classification and segmentation, we employed the GAIN training architecture to treat these attention maps as reliable priors to build attention maps with more comprehensive and accurate segmentation.

Results

We can utilize the network's attention map to understand its decision-making thoughts. The results also imply that the suggested technique may assist the trained neural network choose accurate lesion sites in images rather than important but inaccurate regions.

Conclusions

We show that our technique enhances oral potentially malignant and malignant lesion categorization.

d) Automatic identification of clinically relevant regions from oral tissue histological images for oral squamous cell carcinoma diagnosis:

Clinicians must identify epithelial, subepithelial, and keratin layers of oral mucosa and characterize keratin pearls within keratin region to diagnose precancerous and cancerous forms of oral cancer. Microscopically visible epithelial layer architectural changes and keratin pearls are crucial visual findings in mouth cancer detection. Clinicians might benefit from a computer-aided identification tool for histological image interpretation during diagnosis. This paper proposes a two-stage approach for computing oral histology images. The first stage uses a 12-layered ($7 \times 7 \times 3$ channel patches) deep convolution neural network (CNN) to segment constituent layers. The second stage detects keratin pearls using texture-based feature (Gabor filter) trained random forests. The suggested computer technique is evaluated in our oral cancer microscopic image collection. The suggested texture-based random forest classifier detects keratin pearls with 96.88% accuracy.

e) Biomedical applications of vibrational spectroscopy: Oral cancer diagnostics

For biological applications, vibrational spectroscopy—which is based on either Raman scattering or infrared absorption—has garnered

growing interest. Recent developments are critically evaluated, and proof of concept investigations for the detection of cancer and oral possibly malignant illnesses are discussed. For illustrative reasons, specific instances of Raman microspectroscopy applications for the study of histological, cytological, and saliva samples are given, and the prospects for routine chairside in vivo screening in the future are highlighted.

3. METHODOLOGY

i) Proposed Work:

The proposed work focuses on developing an intelligent and automated system for detecting mouth cancer using Machine Learning (ML) and Deep Learning (DL) techniques. The system is designed to analyze oral medical images and accurately classify them as cancerous or non-cancerous. Initially, oral image datasets are collected from medical sources and subjected to preprocessing techniques such as noise removal, resizing, normalization, filtering, and contrast enhancement to improve image quality. After preprocessing, image segmentation techniques are applied to isolate suspicious cancerous regions from normal oral tissues. Feature extraction methods are then used to obtain important image characteristics such as texture, shape, color, and intensity patterns, which are essential for accurate classification and prediction.

The proposed system implements several Machine Learning algorithms including Support Vector Machine (SVM), Decision Tree, Random Forest, and K-Nearest Neighbour (KNN) for cancer detection and classification. In addition, Deep Learning models

such as Convolutional Neural Networks (CNN) are employed to automatically learn complex image features and improve prediction accuracy. The system evaluates model performance using metrics such as accuracy, precision, recall, sensitivity, specificity, and F1-score. The proposed framework reduces human effort, minimizes diagnostic errors, and provides faster and more reliable detection results compared to traditional diagnostic methods. This intelligent healthcare system assists doctors and healthcare professionals in early diagnosis, effective treatment planning, and improved patient care.

ii) System Architecture:

The proposed system architecture for mouth cancer detection is designed to provide accurate and automated classification of oral medical images using Machine Learning and Deep Learning techniques. Initially, oral image datasets containing both cancerous and non-cancerous samples are collected and provided as input to the system. The preprocessing module performs operations such as resizing, noise removal, normalization, and contrast enhancement to improve image quality and ensure better analysis. After preprocessing, image segmentation techniques are applied to isolate suspicious cancerous regions from normal oral tissues. Feature extraction methods are then used to obtain important characteristics such as texture, shape, color, and statistical information from the segmented images.

The extracted features are processed using Machine Learning algorithms such as Support Vector Machine (SVM), Random Forest, K-Nearest Neighbour (KNN), Decision Tree, and Naive Bayes for

classification and prediction. In addition, Deep Learning models like Convolutional Neural Networks (CNN) are employed to automatically learn complex image patterns and improve detection accuracy. During the training phase, the dataset is divided into training, validation, and testing sets for effective model evaluation using metrics such as accuracy, precision, recall, and F1-score. Finally, the system predicts whether the oral image is cancerous or non-cancerous and displays the result to healthcare professionals, thereby supporting early diagnosis and effective treatment planning.

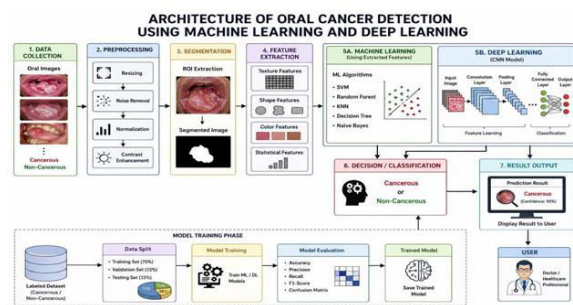


Fig1 proposed architecture

iii) Modules:

1. Data Collection Module

This module is responsible for collecting oral medical image datasets containing both cancerous and non-cancerous mouth images. The collected datasets are used for training, testing, and validating the Machine Learning and Deep Learning models. Proper dataset collection improves the reliability and accuracy of cancer detection.

2. Image Preprocessing Module

The preprocessing module enhances the quality of oral images before analysis. Techniques such as resizing, noise removal, normalization, filtering, and

contrast enhancement are applied to remove unwanted distortions and improve image clarity for accurate prediction.

3. Image Segmentation Module

This module identifies and separates suspicious cancerous regions from normal oral tissues. Segmentation techniques help in extracting the Region of Interest (ROI) from medical images, allowing the system to focus only on affected areas for further analysis.

4. Feature Extraction Module

The feature extraction module extracts important image features such as texture, shape, color, intensity, and statistical properties from segmented images. These extracted features help the system differentiate between cancerous and non-cancerous tissues effectively.

5. Machine Learning Module

This module implements Machine Learning algorithms such as Support Vector Machine (SVM), Decision Tree, Random Forest, K-Nearest Neighbour (KNN), and Naive Bayes for classification and prediction. These algorithms analyze extracted image features and classify oral images accurately.

6. Deep Learning Module

The Deep Learning module utilizes Convolutional Neural Networks (CNN) for automatic feature learning and image classification. CNN models detect complex cancer patterns directly from images and provide higher accuracy compared to traditional Machine Learning methods.

7. Model Training and Testing Module

This module is responsible for training and testing the ML and DL models using labeled datasets. The dataset is divided into training, validation, and testing sets to evaluate system performance and improve prediction efficiency.

8. Classification and Prediction Module

The classification module predicts whether the uploaded oral image is cancerous or non-cancerous based on the trained model output. The prediction results are generated automatically with high speed and accuracy.

9. Performance Evaluation Module

This module evaluates the efficiency of the proposed system using metrics such as accuracy, precision, recall, sensitivity, specificity, F1-score, and confusion matrix. These metrics help in measuring the reliability and effectiveness of the model.

10. Result Display Module

The result display module presents the final prediction results to the user or healthcare professional. It clearly displays whether the oral image is cancerous or non-cancerous, assisting doctors in early diagnosis and treatment planning.

iv) Algorithms:

1 SVM Algorithm:

Support Vector Machine (SVM) is a supervised machine learning algorithm used for classification and prediction tasks. It

works by identifying the optimal hyperplane that separates different classes with maximum margin, resulting in accurate and efficient classification performance.

2 **RF Algorithm:**

Random Forest (RF) is an ensemble machine learning algorithm that uses multiple decision trees to improve prediction accuracy and reduce overfitting. It combines the outputs of several trees to provide reliable and robust classification results.

3 **CNN Algorithm:**

Convolutional Neural Network (CNN) is a deep learning algorithm designed for image processing and feature extraction. It automatically detects important patterns and features from images, making it highly effective for image classification and defect detection applications.

4 **Ensemble Learning Algorithm:**

Ensemble Learning combines multiple machine learning models to improve overall prediction performance, accuracy, and stability. By integrating the strengths of different algorithms, it produces more reliable and accurate results compared to individual models.

5 **EfficientNet-B3 Algorithm:**

EfficientNet-B3 is an advanced deep learning model optimized for high accuracy and computational efficiency. It uses compound scaling techniques to balance network depth, width, and resolution, enabling improved feature extraction and accurate image classification performance.

4. EXPERIMENTAL RESULTS

The experimental evaluation of the proposed mouth cancer detection system was conducted using oral medical image datasets containing both cancerous and non-cancerous images. The system was implemented using Machine Learning and Deep Learning techniques to analyze oral images and classify them accurately. During experimentation, preprocessing operations such as resizing, normalization, noise removal, and contrast enhancement were applied to improve image quality before analysis. The dataset was divided into training, validation, and testing sets to evaluate the performance of the models effectively. Various Machine Learning algorithms including Support Vector Machine (SVM), Random Forest (RF), Decision Tree, and K-Nearest Neighbour (KNN) were tested along with Deep Learning models such as Convolutional Neural Networks (CNN). The system successfully identified cancerous and non-cancerous oral tissues with high prediction accuracy and reduced diagnostic time.

The experimental output screens demonstrate the working performance of the proposed system. Initially, the user uploads an oral image through the web-based interface, and the system processes the

image automatically using trained ML and DL models. The prediction results are displayed along with confidence scores generated by different models such as CNN, SVM Ensemble, Random Forest, and EfficientNet-based architectures. The system accurately classified uploaded oral images as “Cancerous” or “Non-Cancerous” with high confidence values. Performance evaluation was carried out using metrics such as accuracy, precision, recall, sensitivity, specificity, F1-score, and confusion matrix analysis. Experimental results indicate that Deep Learning models, particularly CNN-based architectures, achieved better performance and higher classification accuracy compared to traditional Machine Learning techniques. The proposed system provides faster, reliable, and efficient mouth cancer detection, thereby assisting healthcare professionals in early diagnosis and effective treatment planning.

Accuracy: A test's accuracy is its capacity to distinguish healthy from ill cases. Find the percentage of instances with genuine positives and negatives to assess test accuracy.

$$Accuracy = \frac{TP + TN}{(TP + TN + FP + FN)}$$

$$Accuracy = \frac{(TN + TP)}{T}$$

Precision: Classification accuracy or positive cases constitute precision. The formula for accuracy is:

$$Precision = \frac{\text{True positives}}{(\text{True positives} + \text{False positives})} = \frac{TP}{(TP + FP)}$$

$$Precision = \frac{TP}{(TP + FP)}$$

Recall: A model's recall measures its ability to recognize all appropriate machine learning class instances. The ratio of accurately predicted positive observations to total positives indicates a model's class instance detection skill.

$$Recall = \frac{TP}{(FN + TP)}$$

mAP: Mean Average Precision ranks quality. It considers the number and order of relevant ideas. Calculating MAP at K uses the arithmetic mean of each user or query's Average Precision (AP).

$$mAP = \frac{1}{n} \sum_{k=1}^{k=n} AP_k$$

AP_k = the AP of class k
n = the number of classes

F1-Score: A high F1 score suggests an accurate machine learning model. Integrating recall and precision improves model correctness. Accuracy measures how often a model predicts a dataset correctly.

$$F1 = 2 \cdot \frac{(Recall \cdot Precision)}{(Recall + Precision)}$$

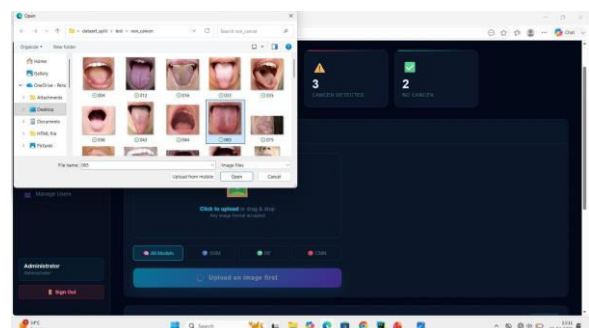


Fig2 Upload iage

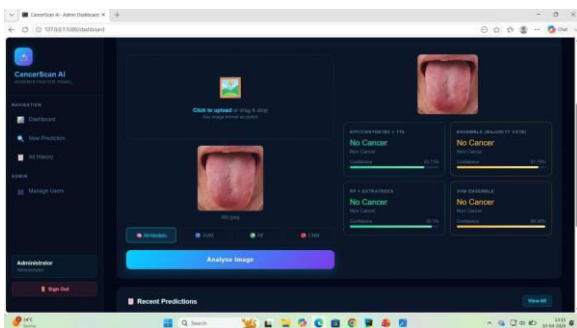


Fig3 results

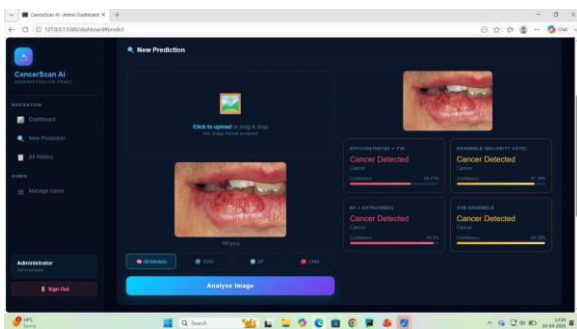


Fig4 results

5. CONCLUSION

The proposed project, “Automated Mouth Cancer Detection Using Machine Learning and Deep Learning Techniques,” successfully demonstrates the application of Artificial Intelligence in the healthcare domain for early and accurate oral cancer detection. The system utilizes image preprocessing, segmentation, feature extraction, and classification techniques to analyze oral medical images and identify cancerous and non-cancerous tissues effectively. Machine Learning algorithms such as Support Vector Machine (SVM), Random Forest, Decision Tree, and K-Nearest Neighbour (KNN), along with Deep Learning models like Convolutional Neural Networks (CNN), were implemented to improve prediction accuracy and reliability. Experimental analysis revealed that Deep Learning approaches achieved better performance compared to traditional Machine Learning techniques in terms of

accuracy, precision, recall, and overall classification efficiency.

The proposed system minimizes human effort, reduces diagnostic errors, and provides faster prediction results compared to conventional diagnostic methods. It also supports healthcare professionals in early diagnosis and effective treatment planning, which can significantly improve patient survival rates. The automated framework is capable of handling noisy and low-quality medical images while maintaining reliable performance. Therefore, the project contributes to the development of intelligent healthcare systems by integrating Machine Learning and Deep Learning technologies for efficient, cost-effective, and accurate mouth cancer detection.

6. FUTURE SCOPE

The proposed mouth cancer detection system can be further enhanced in several ways to improve its accuracy, efficiency, and real-time healthcare applications. In the future, larger and more diverse medical image datasets can be utilized to train the Machine Learning and Deep Learning models for achieving better generalization and prediction performance. Advanced Deep Learning architectures such as ResNet, EfficientNet, DenseNet, MobileNet, and Transformer-based models can also be implemented to improve classification accuracy and reduce false predictions. Integration of Transfer Learning techniques may further enhance model performance, especially when limited medical datasets are available. In addition, advanced image segmentation and feature extraction methods can be applied to detect cancerous regions more precisely.

The system can also be extended into a real-time cloud-based or mobile healthcare application that enables remote oral cancer diagnosis and telemedicine support. Future enhancements may include integration with IoT devices, hospital management systems, and electronic health records for automated healthcare monitoring. The proposed framework can be expanded to detect multiple oral diseases and different stages of cancer using multi-class classification techniques. Furthermore, Explainable Artificial Intelligence (XAI) methods can be incorporated to provide transparent and interpretable prediction results for healthcare professionals. Therefore, the future development of this project has significant potential to improve intelligent healthcare systems and support faster, more reliable, and accessible mouth cancer diagnosis worldwide.

REFERENCES

1. DeepLearning authored by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, published by MIT Press in 2016.
2. Pattern Recognition and Machine Learning, written by Christopher M. Bishop, released by Springer Publication in 2006.
3. Machine Learning, authored by Tom M. Mitchell, published by McGraw-Hill Publication in 1997.
4. Research articles concerning oral cancer detection utilizing Machine Learning and Deep Learning methodologies available from IEEE Xplore.
5. Medical image analysis research papers accessible from ScienceDirect.
6. Publications on oral cancer and healthcare research found in PubMed.
7. Resources on Deep Learning and Artificial Intelligence provided by TensorFlow Documentation.
8. Implementation resources for Machine Learning available from Scikit-learn Documentation.
9. Documentation on image processing techniques and OpenCV from the OpenCV Official Website.
10. Python programming resources sourced from the Python Official Website.
11. Tutorials for implementing Deep Learning models found in Keras Documentation.
12. Research studies focused on oral cancer diagnosis employing AI techniques published in international journals and conference proceedings.

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