A Smart Dental Care Application for Early Oral Cancer Detection and Clinical Management

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***Abstract*—Oral cancer remains a serious public health issue, especially in regions where tobacco and alcohol consumption are common. Early detection plays a crucial role in improving survival rates, yet many cases are diagnosed late due to limited screening facilities and insufficient access to specialists.**

This paper presents DentCare, an integrated dental healthcare application that combines AI-assisted oral cancer screening with patient–doctor management and orthodontic treatment monitoring. The screening module is accessible only to verified medical professionals, ensuring ethical and reliable clinical use.

Beyond screening, DentCare supports patient record management, appointment scheduling, and braces treatment monitoring using image comparison techniques. By integrating diagnostic support with healthcare management in a secure digital platform, DentCare aims to improve early diagnosis, simplify clinical workflows, and promote continuous dental care.

***Index Terms*—component, formatting, style, styling, insert.**

I. Introduction

Oral cancer poses a major global health challenge, particularly in developing regions where tobacco use, alcohol consumption, and betel nut chewing are widespread. Despite medical advancements, many cases are still detected at advanced stages because early screening facilities and specialist access remain limited. Detecting the disease early significantly improves survival rates and reduces treatment complexity and healthcare costs.

Modern dental practices also require efficient systems to manage patient information, appointments, medical history, and long-term treatment tracking. However, many clinics still rely on fragmented or manual systems, which often lead to delays, missed follow-ups, and inconsistent patient care. In orthodontic treatments like braces, progress evaluation is often subjective and may lack accuracy.

DentCare is proposed to address these challenges by providing an integrated digital platform that combines AI-assisted oral cancer screening with patient management and orthodontic monitoring. The platform offers role-based dashboards for doctors, patients, and administrators, ensuring secure data handling and ethical use of diagnostic tools. By merging intelligent screening with healthcare management features, DentCare aims to improve early diagnosis and enhance clinical efficiency.

II. Problem Statement

Early detection of oral cancer is often delayed because specialists and screening facilities are not easily accessible in many areas. Subtle early-stage lesions are sometimes overlooked during routine examinations, resulting in late diagnosis and poorer treatment outcomes.

Additionally, many dental clinics lack a secure and integrated system that combines diagnostic screening with appointment handling, consultation management, and patient record storage. Patient information is often stored across different disconnected systems, making follow-ups inefficient and increasing the risk of errors.

There is also concern regarding misuse of diagnostic tools when strict access control and professional verification are not enforced. Therefore, there is a need for a secure application that supports early oral cancer detection while integrating patient management, consultation workflows, and treatment monitoring in an ethical and reliable manner.

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III. Related Work

Recent research highlights the effectiveness of artificial intelligence, particularly deep learning techniques, in the early detection and classification of oral cancer. Convolutional Neural Networks (CNNs) have been extensively used to analyze oral cavity images and histopathological samples, achieving high accuracy and sensitivity in identifying oral potentially malignant disorders and cancerous lesions. Welikala et al. demonstrated the feasibility of automated oral lesion detection using deep learning models for early cancer screening [1]. Similar studies have shown that CNN-based architectures such as ResNet and DenseNet perform effectively in classifying oral lesions from photographic images [5], [6].

Mobile-based screening approaches have gained attention for improving accessibility in resource-constrained settings. Talwar et al. proposed an AI-assisted screening system using smartphone-captured images, showing promising results for community-level screening programs [2]. Lin et al. further validated the effectiveness of smartphone-based deep learning models for early oral cancer diagnosis, emphasizing their potential for large-scale deployment [11].

Several studies have explored advanced deep learning strategies, including multimodal and hybrid approaches. Devindi et al. introduced a multimodal CNN pipeline that integrates image data with clinical metadata to improve diagnostic performance [3]. GAN-assisted data augmentation techniques have also been applied to enhance model robustness when datasets are limited [9]. Survey-based studies highlight the growing role of AI in oral and skin cancer detection while emphasizing challenges such as dataset diversity and explainability [4], [16].

In addition to diagnostic systems, prior research underscores the importance of integrated digital healthcare platforms for managing patient data and clinical workflows. However, most existing solutions focus on isolated functionalities such as detection or record management without combining diagnostic intelligence with patient management and treatment monitoring. DentCare addresses this gap by integrating AI-assisted oral cancer screening, patient–doctor management, and orthodontic progress analysis within a single secure platform.

IV. Proposed System

DentCare is designed as a comprehensive dental healthcare platform that integrates AI-based oral cancer screening with patient management, appointment scheduling, and orthodontic treatment monitoring.

Access to the cancer screening module is limited to verified medical professionals to ensure proper clinical use. The platform provides different dashboards for doctors, patients, and administrators.

Doctors can upload and analyze oral images, review risk assessments, and track treatment progress. Patients can manage appointments, view reports, and receive reminders for follow-ups. Administrators oversee user verification and maintain system integrity.

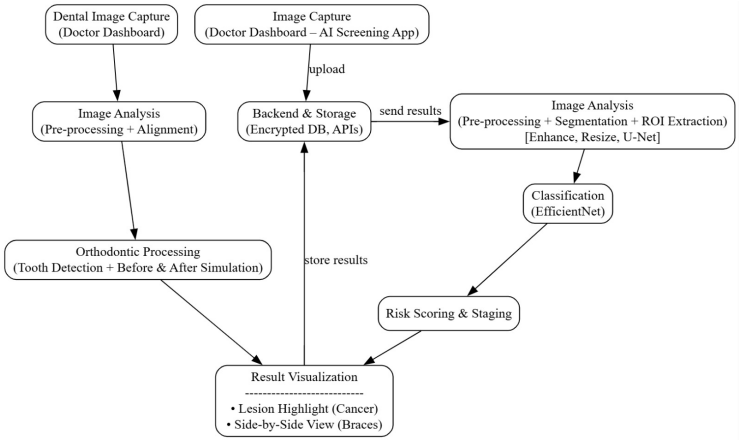

Fig. 1. System architecture of the proposed dental application

DentCare also enables comparison of before-and-after braces images, allowing objective evaluation of orthodontic progress. Automated reminders help reduce missed appointments and improve treatment continuity.

V. System Architecture

The DentCare system follows a modular and layered architecture consisting of:

- **Frontend Layer**: Developed using React Native to support cross-platform access.
- **AI Processing Layer**: Implements CNN-based models for lesion detection and image comparison for braces analysis.
- **Backend Layer**: Built using Node.js with MongoDB for secure data storage and API management.

This architecture ensures scalability, security, and efficient communication between system components.

VI. Methodology

The methodology of DentCare follows a systematic pipeline that integrates data acquisition, image processing, model development, system integration, and performance evaluation to ensure reliable and efficient operation.

A. Data Collection

Oral cavity images were collected from publicly available oral lesion datasets and supplemented with clinical images captured using smartphone cameras in controlled environments. The dataset contains approximately 1200 oral images, including normal, precancerous, and cancerous lesions. The dataset was divided into 80% for training and 20% for testing to evaluate the performance of the deep learning model. Along with image data, clinical metadata such as patient age, gender, and lifestyle habits were included to support contextual analysis

B. Preprocessing

Captured images undergo preprocessing steps including resizing, normalization, histogram equalization, and Gaussian filtering. These techniques enhance image clarity, reduce noise, and standardize inputs for the AI models.

C. Model Development

Deep learning models such as U-Net and ResNet are trained for lesion segmentation and classification. The models categorize oral images into normal, precancerous, or cancerous classes, supporting early risk identification.The dataset was divided into training (80%), validation (10%), and testing (10%) sets to ensure reliable evaluation and to prevent overfitting during model training.

D. System Integration

The system integrates the mobile frontend, preprocessing pipeline, AI engine, metadata fusion, and encrypted backend storage through secure APIs, ensuring seamless data flow and secure access.

E. Evaluation

Model performance is evaluated using metrics such as accuracy, sensitivity, and specificity to validate diagnostic reliability.

VII. Functional Modules

The major functional modules of DentCare include:

- User Registration and Authentication Module
- Oral Cancer Detection Module
- Patient Management Module
- Before and After Braces Analysis Module
- Image Preprocessing and Quality Enhancement Module
- Notification and Follow-up Module
- Admin and Data Management Module

VIII. Results and Discussion

The proposed DentCare system was evaluated using a dataset of oral cavity images categorized into normal, precancerous, and cancerous classes. The deep learning models were trained using the training dataset and evaluated using the testing dataset.

The experimental results demonstrate promising performance for early oral cancer detection. The ResNet-based classification model achieved an accuracy of 92.4%, sensitivity of 90.8%, and specificity of 93.1%. The model effectively identified suspicious lesions from oral images and provided risk predictions to assist medical professionals in early diagnosis.

The confusion matrix analysis indicates that the system performs well in distinguishing between normal and abnormal oral lesions. Additionally, the ROC curve shows strong discriminative capability with an AUC value of 0.94, indicating high diagnostic reliability.

To evaluate the effectiveness of the proposed approach, the performance of the ResNet model was compared with other baseline models such as VGG16 and MobileNet. Experimental results indicate that the ResNet architecture achieved higher accuracy and better generalization compared to the baseline models, making it suitable for deployment in the proposed mobile healthcare application.

The developed system demonstrates effective role-based access control, secure login, image upload functionality, and AI-assisted risk assessment for oral cancer detection.The doctor dashboard enables image analysis and result visualization, supporting informed clinical decisions. The integrated design improves workflow efficiency and reduces manual effort in patient follow-up and record management.

IX. Conclusion

DentCare presents a secure and integrated dental healthcare application that combines AI-assisted oral cancer screening with patient management and orthodontic treatment monitoring. The system supports early diagnosis, improves accessibility through a mobile-first approach, and enhances clinical workflow efficiency. Future work includes expanding datasets, improving model accuracy, and deploying the system in real-world clinical environments.

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