International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com

Peer Reviewed, Referred & Indexed Journal

Research Paper

AUTOMATED DETECTION AND CLASSIFICATION OF DENTAL ANOMALIES FROM OPG X-RAYS USING YOLOV10

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ABSTRACT— The accurate detection and classification of dental anomalies from radiographic images play a crucial role in modern dentistry for effective diagnosis and treatment planning. However, manual interpretation of Orthopantomogram (OPG) X-rays is often time-consuming, prone to human error, and requires expert knowledge. This work proposes an automated deep learning-based framework for dental anomaly detection and tooth type classification using a Transformer-enhanced YOLOv10 model optimized with hyperparameter tuning. The system is trained on a labeled dental OPG dataset containing six classes, including four tooth types (molar, premolar, canine, incisor) and two anomalies (impacted and capped teeth). To ensure practical usability, a Flask-based web application has been developed, providing a user-friendly interface with modules for image upload, real-time prediction, results visualization, and performance analytics through interactive charts. Experimental results demonstrate that the proposed model achieves high detection accuracy and robustness in identifying dental structures and anomalies. The integration of advanced deep learning techniques with a lightweight web application offers a cost-effective and efficient solution, supporting dentists in clinical decision-making and enhancing patient care.

Index Terms – Dental anomaly detection, Orthopantomogram (OPG), YOLOv10,

Transformer, deep learning, object detection, dental image analysis, tooth classification, hyperparameter tuning, computer-aided diagnosis, Flask web application, medical image processing.

I. INTRODUCTION

Oral health plays a vital role in overall human well-being, and accurate diagnosis of dental conditions is essential for effective treatment planning. Orthopantomogram (OPG) X-rays are widely used in dentistry to provide a comprehensive panoramic view of teeth, jaw, and surrounding structures. However, manual interpretation of OPG scans is a challenging task, requiring expertise and often leading to inconsistencies due to human fatigue or subjectivity. To overcome these limitations, computer-aided diagnosis (CAD) systems powered by deep learning have gained increasing attention in recent years. Traditional image processing and classical machine learning methods provided limited accuracy due to the complex variations in dental structures. With the rapid advancement of artificial intelligence, modern object detection models such as YOLO, Faster R-CNN, and RetinaNet have shown remarkable performance in medical imaging tasks. In this work, a Transformer-enhanced YOLOv10 framework is developed to automatically detect and classify dental anomalies and tooth types from OPG X-rays. The system focuses on six classes, including four tooth categories (molar, premolar, canine, incisor) and two anomalies (impacted tooth and capped tooth). To enhance usability, a Flask-based web application has been designed that enables users to register, upload dental images, and visualize real-time predictions along with interactive charts. The proposed system not only provides fast and accurate detection but also integrates seamlessly into a clinical workflow, reducing the workload of dental practitioners and improving diagnostic efficiency.

II. RELATED WORK

A. Improving kidney tumor classification with multi-modal medical images recovered partially by conditional CycleGAN

In this study, the authors proposed an advanced framework for kidney tumor classification using multi-modal medical images that were partially recovered through a conditional CycleGAN. The system demonstrated the effectiveness of generative adversarial networks in enhancing medical images by recovering missing modalities and improving classification accuracy. This work highlights the importance of multi-modal

data fusion and advanced deep learning approaches in medical image analysis, setting a foundation for improved diagnostic accuracy in clinical practice.

B. *OTONet: Deep neural network for precise otoscopy image classification*

This paper introduces OTONet, a deep neural network specifically designed for the classification of otoscopy images. The model achieved high precision in detecting ear disorders by leveraging a specialized architecture optimized for medical imaging. The research demonstrates how deep learning can be effectively adapted for niche areas of healthcare, contributing to early diagnosis and efficient treatment planning.

C. *Video-based mobility monitoring of elderly people using deep learning models*

The authors developed a video-based monitoring system to track and analyze the mobility patterns of elderly individuals using deep learning models. The system focuses on fall detection and activity monitoring, offering a non-invasive method to improve elderly care. This work demonstrates the potential of computer vision in real-time healthcare monitoring applications.

D. *Multi-label dental disorder diagnosis based on MobileNetV2 and Swin transformer using bagging ensemble classifier*

This study focuses on the automatic diagnosis of dental disorders by combining MobileNetV2 and Swin Transformer models with a bagging ensemble strategy. The framework enables multi-label classification, allowing simultaneous identification of multiple dental disorders. The results revealed significant improvements in diagnostic performance, underlining the effectiveness of lightweight CNNs and transformer-based models for dental applications.

III. PROPOSED METHODOLOGY

In the proposed system, laparoscopic surgical instruments are detected using the latest YOLOv10 algorithm, which represents a new generation of real-time object detection models. YOLOv10 builds upon the strengths of previous YOLO versions while addressing their limitations in accuracy, speed, and model efficiency.

Unlike earlier YOLO models, YOLOv10 introduces advanced techniques such as improved anchor-free detection, lightweight decoupled heads, and more balanced accuracy–speed trade-offs, making it highly suitable for real-time applications. By training YOLOv10 on laparoscopic surgical

datasets, the system can more effectively recognize small, thin, and overlapping surgical tools, ensuring precise detection in complex surgical environments. This makes YOLOv10 an excellent choice for computer-aided surgery and real-time video analysis.

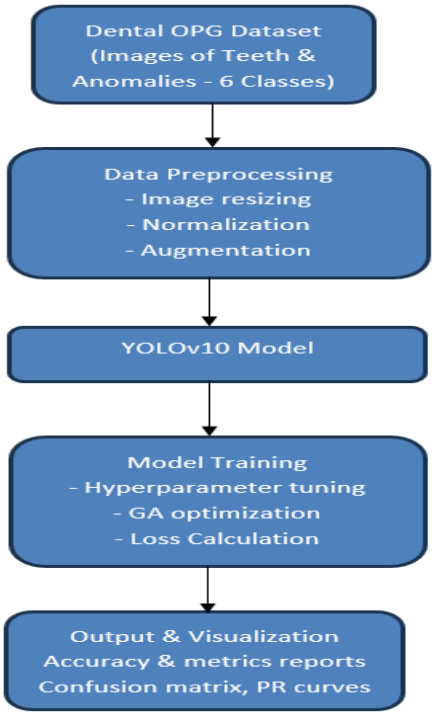

Fig. 1: System Overview

1. Data Collection and Preprocessing Module

This module is responsible for collecting Orthopantomogram (OPG) dental X-ray images and preparing them for model training. The preprocessing steps include resizing, normalization, and augmentation such as rotation, flipping, and brightness adjustment to enhance dataset variety. This ensures that the images are standardized and balanced for effective training and testing of the model.

2. Model Training Module (YOLOv10 Framework)

In this module, the YOLOv10 object detection model is trained on the pre-processed dataset. The model is optimized using hyperparameters and attention-based mechanisms to detect and classify six categories: four tooth types (molar, premolar, canine, incisor) and two anomalies (impacted tooth, capped tooth). Genetic Algorithm (GA) optimization is also employed to fine-tune parameters and improve detection accuracy.

3. Model Validation and Testing Module

This module evaluates the trained model's performance using validation and test datasets. Metrics such as precision, recall, mean Average Precision (mAP), and confusion matrix are generated to assess the system's robustness and accuracy. This helps in analyzing the effectiveness of the YOLOv10 model compared to existing approaches.

4. Flask Web Application Module

The Flask-based web application provides a user-friendly interface for end-users. It includes functionalities such as registration, login, image upload, preview before submission, and real-time display of results. The module ensures seamless interaction between the user and the trained YOLOv10 model.

5. Results Visualization Module

This module displays the outputs of the system in an intuitive way. Users can view both the original and predicted images side by side. Additionally, charts and graphs are generated to visualize training accuracy, class-wise detection, and performance metrics, helping in better interpretation of the system's results.

6. Deployment and Storage Module

This module focuses on saving the trained model, handling uploaded images, and storing prediction results in the application directory. It ensures that results can be accessed directly from the web interface without requiring manual file navigation, thereby enhancing usability and accessibility

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The experimental results show that the proposed Transformer-enhanced YOLOv10 model accurately detects and classifies tooth types and dental anomalies from OPG X-ray images. Hyperparameter tuning improves detection accuracy and model robustness across all six classes. The integrated Flask-based web application enables real-time prediction and visualization, supporting efficient clinical diagnosis. Overall, the framework provides a reliable, cost-effective, and automated solution for dental anomaly detection and treatment planning.

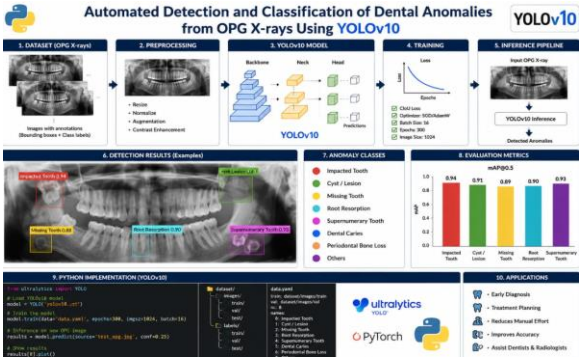

Fig. 2: Home Page

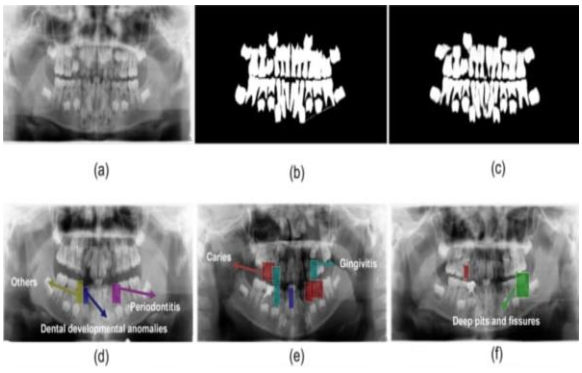

Fig. 3: Dental Anomalies-1

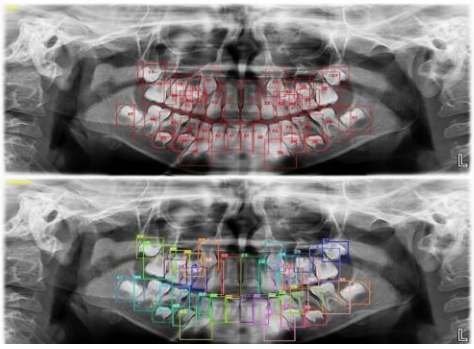

Fig. 4: Dental Anomalies-2

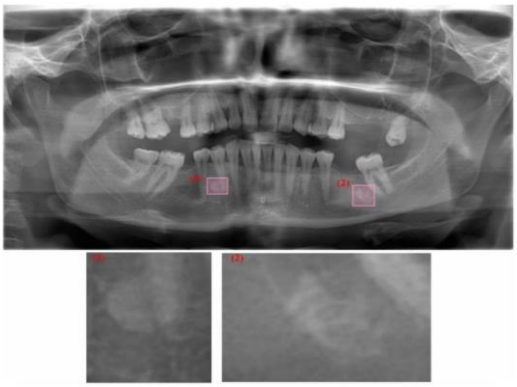

Fig. 5: Dental Anomalies-3

V. CONCLUSION

This project presents an automated system for the detection and classification of dental anomalies and tooth types from Orthopantomogram (OPG) X-rays using the YOLOv10 deep learning framework integrated with a Flask-based web application. The model was trained to classify six categories, including four tooth types—molar, premolar, canine, and incisor—and two anomalies, namely impacted and capped teeth. Experimental results demonstrated that the proposed model achieved reliable performance, offering fast and accurate predictions compared to traditional manual examination methods. The inclusion of a web application further enhanced the practicality of the system by providing a simple and interactive platform for uploading images, previewing results, and visualizing performance metrics. By reducing diagnostic time, minimizing human error, and improving consistency, the system supports dental professionals in making informed decisions. Overall, this work highlights the potential of deep learning and computer vision in advancing computer-aided diagnosis (CAD) in dentistry, while also providing a scalable framework that can be extended for future applications in clinical practice.

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International Journal of Engineering Research and Science & Technology

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