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Dental Image Analysis and Doctor Consultation using Machine Learning Technique

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ABSTRACT: In medicine, artificial intelligence has offered new possibilities for accurate, effective, and convenient diagnosis. The primary objective of the project is to create an intelligent system with the capability for the analysis of dental images and consultation with physicians. Employing sophisticated image processing techniques, deep learning algorithms such as Convolutional Neural Networks, and object detection pipeline, the system automatically detects, classifies, and analyzes dental anomalies from radiographic images, i.e., cavities, periodontal disease, impacted teeth, and bone loss. A user interface presents the result of the analysis, giving patients and dentists a better sense of their oral health. A system also has an online consultation module by which patient can communicate with treatment-certified. This approach allows for better communication between patient and dental report, particularly in remote or underprivileged populations.

KEYWORDS: Dental image analysis, Convolutional Neural Networks, YOLOv8, image processing, virtual consultation.

I. INTRODUCTION

The dental image analysis combined with this physician consulting will enable patients to be provided with accurate and tailored treatment options. Evaluated photos can be used by the dentists to monitor healing after procedures, show patients the problem area and treatment planning for procedures such as implants or root canals. Clinics can help improve diagnosis accuracy, reduce human error, streamline doctor consultations and save time by incorporating AI-powered dental image analysis into the workflow, ultimately leading to more confidence on the patient side of things. Machine learning for dental image analysis utilizes large datasets of annotated dental radiographs to train deep convolutional neural networks that can identify, categorize and segment different dental anatomic structures as well as pathologies from intraoral and extra oral images of teeth. Convolutional neural networks has been one of the approaches that have demonstrated patterns in bite wing images and successfully extracted features from complex dental images. Machine learning models can be used to automate the detection process and reduce diagnostic variability, allowing dentists to make smarter decisions. In this case, machine learning for dental image analysis and consultation has made tremendous progress, helping to usher in a new era of smart dentistry. When the time needed for diagnosis is shorter, clinicians can devote more of their attention to patient care and complex decision-making. Despite these benefits there still needs to be further exploration of research areas related to data privacy, generalizability of population-wide models and regulatory approval. As those advances happen, AI will become an indispensable practice in arenas of modern dentistry.

CNNs, which are a class of deep learning models that is tailored for image processing tasks, can autonomously learn and then extract the crucial feature in dental radiographs without human annotation. CNNs can be trained on vast datasets of annotated dental images so that the model is able to correctly identify periodical lesions, dental caries, periodontal disease, and impacted teeth this not only helps in faster diagnosis, but also provides dentists with intelligent decision support. The integration of CNN-based dental image analysis in doctor consultation systems has a number of benefits. The integration of a model for analysis of dental images to optimize the physician consultation system offers many potential benefits. Convolution Neural Networks a type of machine learning have drawn significant interest due to their high precision in the interpretation of medical images, including dental radiographs. CNNs utilize layers that mimic the manner in which the human brain processes visual information in an attempt to process and identify patterns in image data. Lacking the dependence on manually crafted features or measurements, CNNs can automatically identify and classify dental image analysis feature such as carious lesions, root fracture, bone abnormalities, and apical infection. Automatic processes to identify major dental problems and abnormalities can be made through the

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combination of YOLOv8 and dental x-ray analysis. Under tele-dentistry platform, this enables remote doctor consultation, assists dental professions decision making and enables early diagnosis.

II. LITERATURE SURVE

Bilgir E. et al., (2021) [1], For detecting and numbering teeth automatically, introduced an AI solution employing panoramic radiographs. The research employed a Faster R-CNN Inception v2 model over a database of 2482 images and attained good sensitivity (95.6%) and precision (96.5%), demonstrating the power of deep CNNs in dental imaging. Such improvements indicate the ability of AI to replace manual assessment in standard clinical procedures, enabling quicker and more uniform diagnosis. Nonetheless, limitations in model generalizability, the requirement for more extensive datasets, and incorporation into clinical practice are constraints on large-scale implementation.

Chang H et al., (2021) [2], in dental panoramic radiograph analysis, the work demonstrate the use of convolutional neural networks (CNNs) in achieving automatic tooth numbering and condition determination. The technology allows for rapid and accurate dental charting, enabling efficient clinical decision-making and relieving manual burden. Widespread utilization is limited by problems such as image diversity, small annotated dataset availability, and real-world dental complexity. Scalability in public health systems also concerns integration into existing diagnostic workflows and computational resource demands.

Chen Y. et al., (2023) [3], for peri-implantitis diagnosis, this study proposes the utilization of a CNN-based system for peri-implantitis damage degree automatic estimation from periapical radiographs. These developments offer rapid and reliable monitoring of the implant status, for better therapeutic efficiency. Their large-scale application is hindered by the unavailability of high-quality annotated images as well as different image acquisition protocols. The scalability of public health systems is also influenced by workflow integration difficulties, cost, as well as external verification demands in various clinical settings.

Duong D.L et al., (2021) [4], for caries screening, the present study highlights smartphone color photography and a two-step SVM classifier linked with ICDAS II in detecting occlusal lesions with high sensitivity (e.g., 92.37% for C vs VNC+NSC). Rapid, low-cost screening is enabled by such technology. Large-scale use is hindered by variability of smartphone image quality and need for standardized acquisition/annotation and external validation; scalability in public health systems is also hindered by workflow integration, training, and data management challenges.

Hamamci I.E et al., (2023) [5], Moreover, this study proposed a new benchmark, DENTEX topbox, for tooth type and its related quadrant detection in panoramic X-rays using hierarchically annotated datasets of quartered-tooth level to diagnosis. This supports the use of AI-based methods for efficient and accurate identification of dental abnormalities. However, the implementation on a large scale is hindered by the lack of annotated data, inter-protocol variabilities in imaging protocols, and need for multi-centric annotation validated metrics.

Hwang J.J et al., (2019) [6], This systematic review of Classical and Convolutional Neural Networks (CNNs) based deep learning in dental radiology gives a brief overview about the growing number of publications using CNNs in various tasks (eg. region of interest detection for teeth, gingiva/periodontium, osteoporosis, anatomical landmarks etc.) across different imaging techniques (intraoral, panoramic CBCT), modalities and their training set sizes since 2016. These advancements mean quicker and more accurate analysis of images.

Joda T. et al., (2020) [7], This paper discribes as the digital revolution in dental medicine as a 21st-century game-changer. It isolates five leading innovations—rapid prototyping (RP), virtual and augmented reality (AR/VR), artificial intelligence (AI) with machine learning (ML) support, personalized dental medicine, and tele-healthcare. These technologies contain immensely powerful diagnostic, treatment planning, educational, and patient-centered care tools.

Kuhnisch J. et al., (2022) [8], This diagnostic study uses a CNN (MobileNetV2) as an educational tool for caries detection on intraoral photographs to identify tooth surfaces, healthy and noncavitated caries, cavitation based on 2,417 images with ~92.5% accuracy (AUC 0.964), in general, and 93.3% accuracy (AUC 0.955) in cavitation detection specifically. It is human-body, fast scanning, accurate intelligent inspection.

Muramatsu C. et al., (2021) [9], for the classification and detection of teeth, the current study indicates the development of a double input layer network-based CNN system for dental chart filing automatically through panoramic radiographs. With multi-sized input data as used in a double input layer network, the method improved classification

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performance compared to single-size models. Such advancements enable quick and accurate tooth type and status identification, enabling forensic identification and screening of dental conditions before examination.

Widiasri M et al., (2022) [10], in dental implant planning, the research suggests the application of a YOLO-based deep learning system (Dental-YOLO) for the identification of alveolar bone and mandibular canal anatomical structures from CBCT images. These advancements permit speedy and accurate determination of critical anatomical structures, hence enabling safer and more efficient implant surgery.

Yaxin GG el al., (2025) [11], Performed an experiment on dental teeth X-ray image classification with artificial intelligence (AI). Their research investigated the use of deep learning models, specifically YOLOv5, to categorize teeth into "normal", "implant", "root", "erupting", and "missing." The article mentions that conventional diagnosis techniques suffer from subjectivity and ineffectiveness, and suggests an AI-model for improved accuracy and effectiveness.

Yuksel A.E et al., (2021) [12], dental counting and treatment detection, suggested a deep learning–driven system on panoramic X-rays for automatic identification of teeth and detection of several dental treatments. This also facilitates rapid and precise dental diagnostics, minimizing dependency on human interpretation.

III. PROBLEM STATEMENT

Although they are two of the world's most prevalent health disorders, oral diseases like tooth caries, periodontal infection, and other pathology are generally underdiagnosed as a consequence of the subjective character of manual diagnosis and restricted access to professional care. Dentists' knowledge and provision are the main determinants of traditional methods of diagnosis, which can result in inconsistent interpretation, delayed treatment, and higher medical expenditures.

The requirement for an automated, real-time, and accurate diagnosis system is due to the growing volume of dental images taken by radiography, intraoral cameras, and mobile phones. The issues encountered by existing computer-based diagnostic systems are low detection accuracy, lack of sufficient generalizability across different datasets, and limited interaction with doctor-patient consultation websites. To overcome these challenges, this paper proposes a YOLOv8 deep learning-based object detection model-driven dental image inspection and doctor consultation system. Both highly precise automatic identification of dental illnesses and categorization from images and an integrated platform for real-time medical consultations are the goals of the technology.

IV. PROPOSED METHODOLOGY

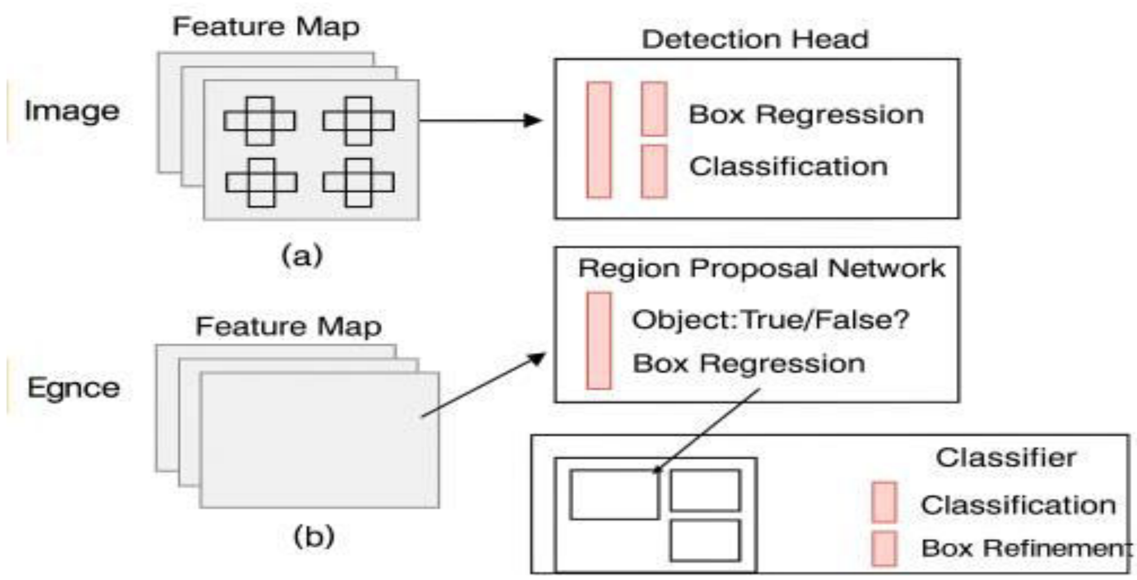

Fig 1: Architecture of YOLO V8

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The project follows a systematic approach that integrates dental image processing, detection using deep learning, and consultation assistance. The process starts with acquisition and pre-processing of radiographs in dentistry to ensure consistency and quality of image.

The methodology is organized into phases:

- Data preparation
- Model development
- Model training and validation
- Doctor consultation systrm

1. Data preparation:

Dental image sets are accessed from panoramic X-rays, bitewing (BW) radiographs, and periapical radiographs. Dental image sets are accessed from panoramic X-rays, bitewing (BW) radiographs, and radiographs. Images are marked up to locate regions of interest such as teeth, caries, missing teeth, and implants.

2. Model evaluation:

YOLOv8 Framework:

- A state of the object detection model is used for dental feature detection.

Training Process:

- Radiographs with pre-processing as input. The final product is bound boxes labelled.

Layer Type	Configuration	Function
Input	640×640×3 (RGB dental X-rays)	Image reception
Conv + C2f	Multiple filters	Low-level feature extraction
SPPF	Multi-scale pooling	Context and multi-scale feature learning
FPN	Feature fusion layer	Combine features at different scales
YOLO	Bounding box + class prediction	Detection and classification of dental conditions
Output	Bounding box + labels	Annotated results for doctor consultation

Figure1: Model Architecture

3. Doctor consultation system:

Integration:

The trained YOLOv model is integrated into a web.

Functionality:

Where doctors upload dental x-rays and the system highlights detected conditions with bounding boxes and labels.

Consultation support:

Doctors can review AI-detected results confirm findings and provide treatment advice.

V. RESULT AND DISCUSSION

The YOLOv8 model could identify and classify dental conditions from images with great precision. The system's clear visual outputs with bounding boxes around infected regions were more intuitive for patients and physicians to grasp. YOLOv8 performed better in terms of precision, recall, and real-time speed compared to previous approaches.

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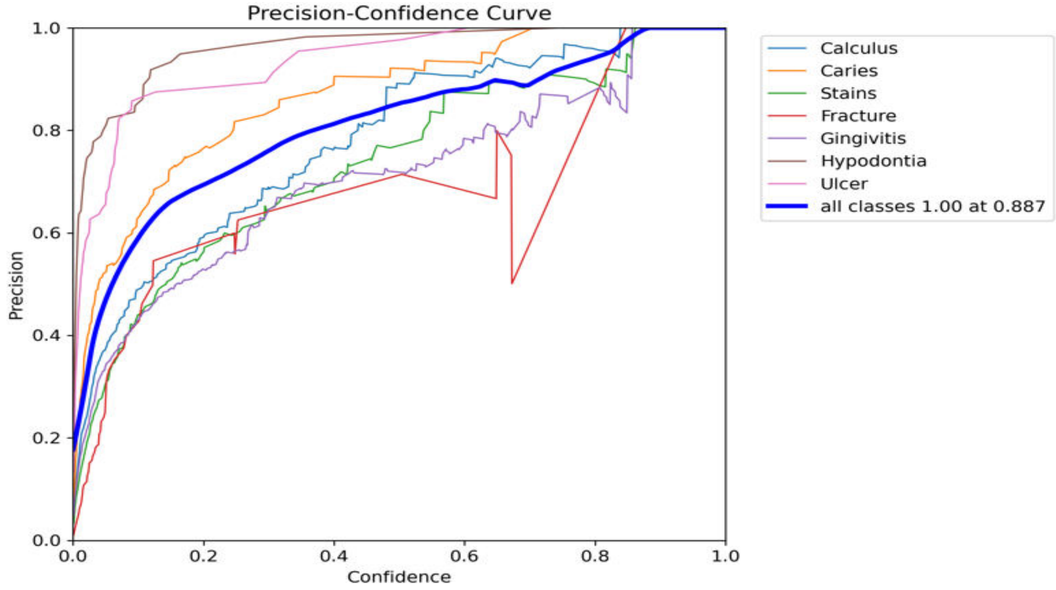

Figure 3: Precision Confidence Curve

The outcomes prove that the YOLOv8 model can identify the overwhelming majority of dental issues accurately and reliably. Because the method has outstanding accuracy at high confidence thresholds, it minimizes false positives, which is crucial in medicine. Although there is variation in some categories, such as fracture, the overall performance of the system is adequate for medical decision support.

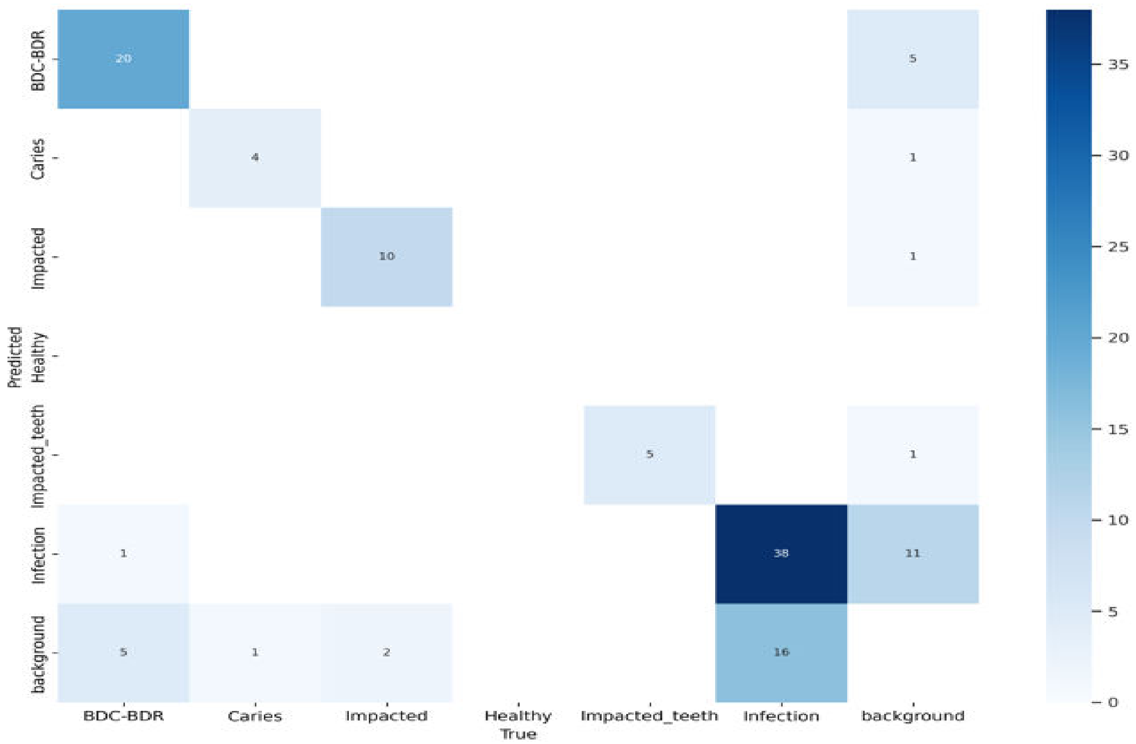

Figure 4: confusion metrics

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It can be seen from the confusion matrix that the model works well at identifying infection and BDC-BDR since most predictions are on the diagonal. But more misclassifications in other classes, such as Caries and Background, show that either there is not enough data to train these classes or that their visual features overlap.

VI. FUTURE ENHANCEMENT

Integrating multi-modal data such as X-rays and patient history, including more varied photos to the database, and developing mobile or cloud-based platforms for easy accessibility are all means to further improve the proposed technique. Trust will be increased by pairing tele-dentistry technology to increase convenience of access in the rural areas and with explainable AI capabilities. Ongoing learning with dentist comments will increasingly enhance accuracy and reliability.

Through automated therapy suggestions and real-time monitoring of illness progression across multiple visits, the system can be more clinically useful. Integration with language support and electronic health record (EHR) systems will enhance accessibility and usability. In order to provide patient trust and data protection, advanced privacy-preserving techniques such as encryption and federated learning can be used. The system will turn into a more solid, complex, and reliable dental care device with these upgrades.

V. CONCLUSION

Automated diagnosis of oral disease was demonstrated within this research using YOLOv8 for dental image processing and reference by the clinician. The model effectively recognized problems like cavities, calculus, infection, and fractures easily and in real-time due to the secure visual input given by bounding boxes and labels. The method reduces errors and increases access to dental care by bridging the gap between computerized diagnosis and clinical decision-making by combining AI-based analysis and expert advice. By facilitating remote diagnostics, promoting early diagnosis, and reducing appointment time, the suggested method cumulatively illustrates how deep learning can improve dental healthcare.

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