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Cavident: Smart Cavity Detection using Deep Learning

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Abstract - In recent years, dental caries is one of the most common oral diseases. Due to lack of awareness and limited access to dental care mainly in rural areas so the early detection is neglected. The already existing treatment methods are based on clinical expertise or some of the specialized imaging and x-rays which are not always accessible and cost-effective. The early detection is very much needed to prevent the progressive tooth decay which in return reduces the need for invasive treatment. This paper presents the usage of YOLOv8 applied to standard photographic images which leads to the automatic dental cavity detection and risk assessment system. The system performs real-time localization of cavity regions through object detection and further leading to the analysis of the detected lesion using image processing techniques to procure clinically related features such as lesion size, colour intensity, texture irregularity, and boundary characteristics. The proposed system is integrated with a rule-based clinical reasoning module to generate interpretable textual explanations which addresses the disadvantages of black-box deep learning models. In addition to this, a quantitative risk scoring mechanism is initiated to classify dental caries into three categories such as low, medium and high-risk based on the extracted features. Experimental evaluation shows that the preferred system achieves reliable detection performance and provides a very transparent and clear clinically meaningful outputs. The system is designed in order to operate on non-specialized images while making it suitable for mobile-based prior screening and tele-dentistry applications. This work come up with the development of accessible, explainable, and also a very cost-effective AI approach for early awareness and dental diagnosis, particularly in underprivileged areas.

Key Words: Dental Cavity Detection, YOLOv8, Image Processing, Lesion Analysis, Feature Extraction, Explainable AI, Risk Assessment, Oral Health Screening.

1. INTRODUCTION

Dental Cavity is one of the most wide spread oral health problems worldwide. This dental caries affects people of all age groups. This is a disease which is caused due to the demineralization of the tooth structure progressively mainly because of the bacterial activity which leads to pain, infection, and might even cause tooth loss if left untreated. The detection of these caries at the early stage is crucial for preventive care and to avoid expensive treatment. However, conventional diagnostic methods mostly rely on clinical expertise, visual inspection and radiographic imaging, while they may not always be accessible in rural or underprivileged regions. The advancements in computer vision and deep learning have put forth the development of automated systems for medical image analysis. The potential in accurately identifying regions of interest in the images has been shown significantly using object detection models such as YOLOv8. Many studies have applied deep learning concepts to dental images, however the existing systems primarily focuses on either detection or classification but the interpretability is limited. These systems are referred to as "black-box" model while they mainly focus on offering predictions without explaining the underlying reasoning and hence reduces their clinical reliability and user trust. To bridge these limitations, this work proposes an automated dental caries detection and risk assessment system using photographic images. This system is implemented using YOLOv8 for real-time detection and localization of cavity regions. This system will not only stop with detection, it further performs detailed feature extraction from the identified lesion, along with parameters such as lesion size, colour intensity, texture irregularity, and boundary characteristics. The extracted features is then utilized in a rule-based reasoning module to generate human-understandable clinical reasoning and explanation. Additionally, a quantitative risk scoring mechanism is used to classify detected cavities into low, medium, and high-risk categories. This ensures detection and as well the severity assessment which supports the early diagnosis and decision-making. The system operates with non-specialized images which are captured using cameras, making it more convenient for mobile-based applications and tele-dentistry platforms. The major contributions of this system includes the development of a YOLOv8-based model which ensures accurate cavity detection and localization, integrating the feature extraction techniques for lesion analysis, implementing an explainable AI for generating textual clinical reasoning, designing of a risk assessment system for severity classes and lastly for a practical framework for easily accessible and cost-effective dental screening. The main purpose of

this work is organised into different sections where one section reviews related work in dental image analysis and deep learning detection methods, the other section describes the methodology which includes model architecture, feature extraction and risk scoring. The following sections emphasizes experimental results, performance evaluation, discussing the findings and demerits and concludes the paper with further research directions.

2. LITERATURE REVIEW

1) Machine Learning for Caries and Periodontitis Detection.

This work is a narrative review which was published by Elsevier in 2023 on machine learning methods for periodontitis and dental caries detection which uphold the traditional machine learning models and early deep learning methodology which were widely used for automated diagnosis with the help of dental radiographs and clinical data. These methods provide reasonable performance in noticing the caries, however they are limited to classification and rely on manually extracted or the less optimized features. This work does not provide precise localization of lesions. This review stresses the lack of real-time detection capabilities and the absence of explainable AI. In addition to this, the current studies do not include severity assessment or risk based classification which in turn reduces the usefulness in treatment planning schedule.

In contrast, the work which is proposed incorporates a YOLOv8 based model which enables real-time cavity detection and localization. It also ensures the automated feature extraction and lesion analysis. Additionally, the integration of explainable AI makes the system more transparent as it provides the clinical reasoning behind the predictions made in order to have better decision-making, a novel risk scoring mechanism is utilized in classification of cavity severity. The integration of detection, localization, explainability, and severity assessment makes the work more extensive, practical and cost-effective dental application in comparison with the existing approaches.

2) Deep Learning for Caries Detection.

This existing deep learning-based method for dental caries detection, as mentioned in studies such as 2022 Journal of Dentistry systematic review and the 2024 Bioengineering review, shows that Convolutional Neural Networks and relevant methodologies improves detection accuracy by learning features from dental radiographs and intraoral images automatically. These models removes the need for manual feature extraction and improving high classification performance. However this work is limited to image-level classification and does not provide precise cavity localization which is critical for treatment planning. This work lacks the explainability and transparency which reduces the trust in real world and increases computational complexity when tried to access real-time data.

In contrast, the work which is proposed incorporates a YOLOv8 based model which enables real-time cavity detection and accurate localization. It also ensures the automated feature extraction and lesion analysis. Additionally, the integration of explainable AI makes the system more transparent as it provides the clinical reasoning behind the predictions made in order to have better decision-making, a novel risk scoring mechanism is utilized in classification of cavity severity. The integration of detection, localization, explainability, and severity assessment makes the work more comprehensive, practical and interpretable solution for dental application in comparison with the existing detection methods.

3) Neural Networks for Dental Caries.

This early neural network based mainly focuses on dental caries detection, based on the studies such as 2020 review which was published by content Reference which primarily used artificial neural networks (ANNs) and basic convolutional neural networks (CNNs) to categorize the presence of cavity through dental radiographs. These models emphasizes the potential of automated treatment by learning patterns from the collected images. However, the performance of this work was limited due to the lack of sufficient dataset sizes, no feature generalization mechanism and dependance on image-level classification instead of detailed analysis. Additionally, there was the absence of understandability which restricted the usefulness of diagnosis planning.

In contrast, the work proposed incorporates a YOLOv8 based architecture which enables real-time cavity detection and precise localization. It also ensures the automated feature extraction and lesion analysis. Additionally, the integration of explainable AI makes the system more transparent as it provides the clinical reasoning behind the predictions made in order to have better decision-making, a novel risk scoring mechanism is utilized in classification of cavity severity such as low, medium or high. The integration of detection, localization, explainability, and severity assessment enhances the work and makes it more robust, practical and clinically applicable when compared to the existing works.

4) Caries Segmentation and Detection Survey.

This studies on dental caries segmentation and detection, which was reported in 2022 in the Scientific World Journal, concentrates on the importance of image segmentation mainly for the identification of lesion boundaries and also in order to improve the treatment precision. This work methodology includes thresholding, region-based segmentation, and deep learning models identify the cavity affected regions in dental images. These systems have a complicated architecture to improve

the accuracy in lesion classification and are computationally intensive and require extensive pixel-level annotations but their major drawback is that they limit their suitability for real-time application. Their focus is on boundary detection but not on other functionalities such as explainability and risk assessment.

In contrast, the work proposed involves a YOLOv8 based object detection framework which enables real-time cavity detection and precise localization. It also ensures the automated feature extraction and lesion analysis. This approach does not require the dense pixel-level annotations. Additionally, the integration of explainable AI makes the system more transparent as it provides the clinical reasoning behind the predictions made in order to have better decision-making, a novel risk scoring mechanism is utilized in classification of cavity severity such as low, medium or high. The integration of detection, localization, explainability, and severity assessment enhances the work and makes it more , practical and clinically applicable when compared to the existing segmentation and detection works.

5) AI for Dental Imaging and Caries Detection.

The present studies on AI for dental imaging and cavity detection based on 2023 review and recent systematic reviews in the year 2024 and 2025 will showcase that AI methods, especially convolution neural networks (CNNs) have enabled the diagnostic accuracy and efficiency in noticing the dental caries from the radiographs and intraoral images. This work highlights the potential of AI in monitoring clinical diagnosis and treatment planning. It also emphasizes on automated feature extraction which in return improves the performance. However, even with their high accuracy rate, they are just doing either classification or detection and hence lack the precise lesion localization capabilities. In addition to this, the existing AI models function as black-box systems with no more information regarding the explainability. This particular work also has certain challenges such as limited dataset diversity, variations in imaging conditions, and the absence of decision-support characteristic such as severity assessment.

On the other hand, the proposed work have few advanced features when compared with the existing systems. By employing a YOLOv8 based model, it enables real-time caries detection assuring the accurate localization of the lesion. Furthermore, it includes the automated feature extraction capabilities in order to enhance the diagnostic insights. The presence of explainable AI which is integrated with the system will overcome the limitations of black-box systems. The interesting feature such as risk scoring mechanism will defend this work in comparison with the existing works. Overall this work addresses the lack of accessible and explainable dental diagnosis system which makes the cavity detection more practical and interpretable.

3. SYSTEM ARCHITECTURE

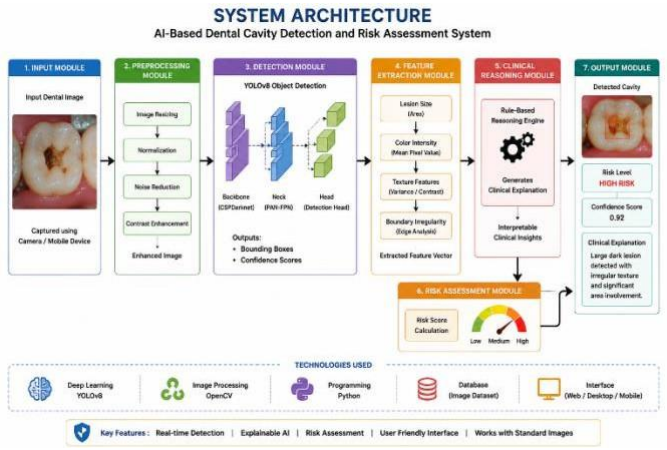

Fig -1: System Architecture

The proposed system follows a modular approach for automated dental cavity detection, analysis, and risk assessment. The system is responsible to process standard dental images which are collected through publicly available sources and dental clinics while generating clinically meaningful outputs, including lesion localization, explanation, and risk level. The architecture consists of five major components: input module, detection module, feature extraction module, reasoning module, and output module. First we will upload the dental images which is captured followed by operations such as resizing, normalization, noise reduction and enhancements are done to the image to improve its quality. The enhanced image is given to YOLOv8 detection model for identifying and localizing the lesion. Further, the model is responsible to give confidence score showing the probability of caries presence. Later after detection, the feature extraction process will take place. Thereafter, these features extracted will be processed by clinical reasoning module and gives an understandable explanation for it. The risk assessment module will be computing the risk score with the help of the extracted features and the confidence value. Based on the calculated score, the system classifies the detected caries into low, medium, or high-risk categories for severity evaluation. Finally, the output module displays the detected cavity region.

4. COMPARATIVE METHODOLOGY TABLE

REFERENCE PAPER	METHODOLOGY USED	ADVANTAGES	DISADVANTAGES
1. H. Qiu et al.,“ Machine Learning Techniques for Periodontitis and Dental Caries Detection: A Narrative Review,” 2023	This work involves traditional ML techniques such as SVM, Random Forest, Decision Trees, and early deep learning methods with dental radiographs and clinical datasets.	Work provides comprehensive overview of ML techniques for dental treatment planning, highlights importance of automated diagnosis, and discusses datasets and evaluation metrics .	Work mostly focuses on classification only, limited lesion localization, many manual methods are needed for feature extraction, and no explainability or severity scoring.
2. J. Schwendicke, T. Krois, and S. Paris, “Deep Learning for Caries Detection: A Systematic Review,” 2022	Used CNN-based deep learning models for automatic feature extraction and cavity classification from dental X-rays and intraoral images.	Led to high detection accuracy, eliminating manual feature engineering, and ensured better performance than traditional ML methods.	Mainly focused on classification, lack of real-time localization, and behaves as black-box which reduces clinical understandability.
3. J. Schwendicke et al., “Dental Caries Diagnosis and Detection Using Neural Networks: A Systematic Review,” 2020	Involves Artificial Neural Networks (ANNs) and early CNN architectures for dental image analysis and caries prediction.	Demonstrated feasibility of AI-based diagnosis , and enhanced automation in caries detection.	Small datasets reduced strength of the system, poor generalization capability , and no lesion-level analysis or explainability.
4. S. Srivastava et al., “A Survey of Dental Caries Segmentation and Detection Techniques,” 2022	Applied image segmentation techniques such as thresholding, region-based segmentation, and deep learning segmentation models like U-Net.	Improved lesion boundary identification , and upgraded segmentation precision.	Computationally expensive , needed pixel-level annotations, and difficult for real-time deployment.
5. D. Prasetyo et al., “Artificial Intelligence for Caries and Tooth Detection in Dental Imaging: A Review,” 2023	Discussed AI-based dental imaging techniques using CNNs and object detection models for caries identification.	augmented image-based diagnosis, faster automated analysis , and enhanced detection performance.	Primarily focused on detection only, limited localization precision, and no risk assessment or severity analysis.

5. CONCLUSIONS

The proposed system follows a modular approach for the automated dental cavity detection, analysis, and risk assessment. The system is responsible to process standard dental images which are collected through publicly available sources and dental clinics while generating clinically meaningful outputs, including lesion localization, explanation, and risk level. The architecture consists of five major components: input module, detection module, feature extraction module, reasoning module, and output module.

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REFERENCES

[1] H. Qiu, L. Zhang, X. Wang, and Y. Chen, "Machine learning techniques for periodontitis and dental caries detection: A narrative review," International Journal of Medical Informatics, vol. 176, p. 105123, 2023.
[2] J. Schwendicke, T. Krois, and S. Paris, "Deep learning for caries detection: A systematic review," Journal of Dentistry, vol. 124, p. 104225, 2022.
[3] J. Schwendicke, G. Singh, T. Krois, and S. Paris, "Dental caries diagnosis and detection using neural networks: A systematic review," Journal of Clinical Medicine, vol. 9, no. 11, p. 3572, 2020.
[4] S. Srivastava, R. Kumar, and A. Sharma, "A survey of dental caries segmentation and detection techniques," Scientific World Journal, vol. 2022, Article ID 1234567, 2022.
[5] A. Albahri, A. Zaidan, O. S. Albahri, B. B. Zaidan, and M. A. Alsalem, "The use of artificial intelligence in caries detection: A review," Bioengineering, vol. 11, no. 9, p. 936, 2024.
[6] M. Geetha, R. Karthikeyan, and S. Priya, "Applications of AI-based deep learning models for detecting dental caries on intraoral images: A systematic review," Evidence-Based Dentistry, 2025.
[7] R. Mehta and P. Singh, "Development of deep learning techniques for dental caries detection: A systematic literature review," Journal of Engineering and Technology Innovation, vol. 4, no. 2, pp. 45–58,
2024.
[8] D. Prasetyo, A. Nugroho, and H. Santoso, "Artificial intelligence for caries and tooth detection in dental imaging: A review," Indonesian Journal of Computer Science, vol. 12, no. 3, pp. 1123–1135, 2023.