DENTRAZE: DIGITAL DENTAL IMAGING AND CEPHALOMETRIC LANDMARK PLATFORM

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College : A. J. Institute of Engineering & Technology, Mangaluru
Branch : Department of Information Science and Engineering
Guide(s) : Prof. Arpitha Kumari G
Student(s) : Mr. Aayush Shetty
Mr. Ayush
Mr. Gaurav T Sanil
Mr. Harthik S Poonja

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Introduction:

Dental radiographs are essential for diagnosing oral diseases, planning treatments, and performing orthodontic analysis. However, traditional interpretation of X-ray images is done manually by dentists, which is time-consuming and prone to human error. Tasks such as tooth identification, cavity detection, and cephalometric landmark marking require precision and may lead to inconsistent results across different practitioners.Variations in image quality, noise, overlapping structures, and presence of metal objects further complicate manual diagnosis. These challenges highlight the need for an automated system that improves accuracy and reduces diagnostic time. With the advancement of artificial intelligence, deep learning models can be effectively used to automate dental image analysis.

To address these issues, the proposed system “DENTRAZE: Digital Dental Imaging and Cephalometric Landmark Platform” is developed. It integrates multiple AI models to perform tooth detection, cavity and metal segmentation, and cephalometric landmark identification. This approach reduces manual effort and enhances consistency in diagnosis.The system workflow begins with image upload followed by preprocessing steps such as noise reduction, normalization, and resizing to improve image quality. The processed image is then analyzed using deep learning models trained on annotated datasets.

The design diagram of the system, shown as Figure 1, illustrates the complete workflow including data collection, annotation, preprocessing, model training, evaluation, and deployment. It also shows how YOLOv8 models are used for tooth, cavity, and metal detection, while U-Net with ResNet is used for landmark detection.In Figure 1, the processed image is passed through detection modules, and the extracted features are used to calculate cephalometric measurements. The final output includes visual overlays such as tooth numbering, landmark points, and segmented regions. Thus, the system provides a faster, reliable, and automated approach to dental diagnostics, improving clinical efficiency and reducing human error.

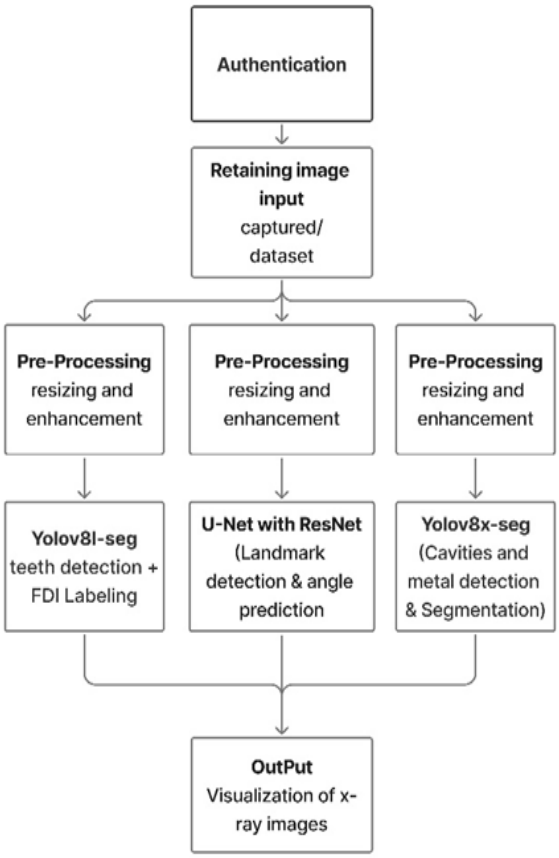

Figure 1: Design

Objectives:

1. To develop an AI-based system for automated dental image analysis.
2. To detect and label teeth using deep learning models.
3. To identify cavities and metallic objects accurately.
4. To perform cephalometric landmark detection and analysis.

Methodology:

The project “DENTRAZE: Digital Dental Imaging and Cephalometric Landmark Platform” here system follows a structured methodology to automate dental image analysis using deep learning. Initially, dental radiographs such as panoramic and cephalometric images are collected and annotated with relevant features including teeth, cavities, metal objects, and landmarks.

In the preprocessing stage, images are resized, normalized, and enhanced to improve quality and ensure consistency across different datasets. Noise reduction and augmentation techniques are applied to improve model robustness.For tooth detection and segmentation, YOLOv8l-seg is used to identify individual teeth and assign FDI numbering. This helps in structured dental analysis and easy identification of each tooth.Cavity and metal object detection is performed using YOLOv8x-seg, which segments regions corresponding to

caries, fillings, crowns, and implants. These regions are highlighted using colored overlays for better visualization.
Cephalometric landmark detection is carried out using a U-Net with ResNet-based architecture. The model identifies key anatomical points required for orthodontic measurements and analysis.
Based on the detected landmarks, the system calculates cephalometric angles and distances required for diagnostic evaluation. These measurements assist in orthodontic treatment planning.
The results are visualized by overlaying tooth labels, segmentation masks, and landmark points directly on the X-ray image. This provides a clear and structured output for clinicians.
Model performance is evaluated using metrics such as mAP, RMSE, and confusion matrix to ensure accuracy and reliability.
Finally, the system is deployed as a web-based platform that allows users to upload images, view results, and generate reports efficiently.

Result and Conclusion:

The DENTRAZE system successfully automates dental image analysis by integrating multiple deep learning models. It accurately detects teeth, identifies cavities and metal objects, and maps cephalometric landmarks. The system reduces manual effort and significantly decreases diagnostic time.The generated visual overlays improve clarity and assist dentists in making better clinical decisions. The system ensures consistency in results compared to manual analysis.Overall, the platform enhances diagnostic efficiency, reduces human error, and provides a modern solution for dental imaging and orthodontic analysis.

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Future Scope:

The future scope of this project includes:

1. Integration of Advanced AI Models: The system can be enhanced by incorporating advanced architectures such as HRNet and transformer-based models to improve the accuracy of cephalometric landmark detection and segmentation tasks.
2. Real-Time Clinical Deployment: DENTRAZE can be extended into a fully deployable cloud-based or mobile application that enables real-time dental diagnosis in clinics, improving accessibility and scalability across multiple healthcare centers.
3. Expansion of Diagnostic Features: The platform can be expanded to include additional modules such as periodontal disease detection, bone density analysis, and automated treatment planning to provide a more comprehensive dental diagnostic system.