IntelliDent: Machine Learning Approach for Dental Deficiency Detection

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Misdiagnosis remains a critical challenge in dental radiography. In a study where 151 Egyptian dental professionals were surveyed, 94.7% identified it as urgent issue, with over 90% reporting diagnostic error rates of up to 40% of the cases. To address this, we developed IntelliDent, an AI-based system for detecting dental caries, impacted teeth, and periapical lesions through panoramic radiographs. The system employs a two-stage deep learning pipeline: a YOLO-based model for localizing regions of interest, followed by a U-Net-based model for precise segmentation. In addition to incorporating an explainable AI module using Layer-CAM generating high-resolution attention maps, which are translated into natural language explanations using a LLaMA3.2 model. Training was conducted on 60,000 anonymized radiographs split in a 70:15:15 ratio for training, validation, and testing, with an external test set of 10,000 images. The YOLO model achieved F1-scores of 93.6% (caries), 92% (deep caries), 93.1% (periapical lesions), and 91.2% (impacted teeth), with stable external test set F1- scores of 91.9%, 90.5%, 91.3%, and 90.1% respectively. The U-Net model achieved Dice coefficients of 96.8% (caries), 95.9% (deep caries), 96.5% (periapical lesions), and 95.2% (Impacted teeth), maintaining strong external test set results of 95%, 94.1%, 94.7%, and 93.2% respectively, reflecting effective generalization without overfitting. Regarding explainable AI, the context precision is 90.5% and context recall is 89.1%, indicating effective information retrieval with low noise. However, the slightly lower faithfulness of 88.2% indicates minimal hallucinating. Additionally, answer relevancy of 88.8% reflects generally appropriate responses.

Awards Won:
Association for the Advancement of Artificial Intelligence: Honorable Mention (do not read aloud). Winners receive a student level membership. Information is included separately in the SAO Portal.