جامعة عبد المالك السعدي
Université Abdelmalek Essaadi

Pole for Doctoral Studies
Center for Doctoral Studies Sciences and Techniques and Medical Sciences

ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE

Ms. BOUALI Rime

Will present their research work with the aim of earning a Doctorate

Doctoral program: Engineering Sciences (IS)
Discipline: Computer Sciences
Specialty: Artificiel Intelligence

On 23/07/2026 at 10H30 at the Meetings Hall, National School of Applied Sciences of Tetouan, UAE
Under the Theme

Advanced Deep Learning Approaches for Teeth Segmentation and Diagnostic Support in Panoramic Dental Radiography

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. AL ACHHAB Mohammed	ENSA of Tetouan, UAE	President
Pr. EL HICHAMI Outman	ENS of Tetouan, UAE	Reviewer
Pr. EL YADARI Mourad	ENSAM of Rabat, UM5	Reviewer
Pr. EL MADANI EL ALAMI Yasser	ENSIAS of Rabat, UM5	Reviewer
Pr. MOUTAKKI Zakaria	ENSA of Tetouan, UAE	Examiner
Pr. OMARA Hicham	FP of Taza, USMBA	Examiner
Pr. LAZAAR Mohamed	ENSIAS of Rabat, UM5	Co-Supervisor
Pr. MAHBOUB Oussama	ENSA of Tetouan, UAE	Supervisor

Host Research Structure: Equipe Sciences et Technologies Avancées (STA)

Abstract

Recently, deep learning has profoundly transformed the analysis of medical images, particularly in dental radiology, where panoramic X-rays play a central role in diagnosis and treatment planning. This thesis focuses on the development of advanced deep learning methods to automate the analysis of these images, with the goal of proposing accurate, robust, and clinically applicable models. This work follows a step-by-step approach, in which each stage addresses a limitation identified in the previous one. It begins with a review of recent AI applications in dental imaging, emphasizing the possible uses of convolutional neural networks as well as the challenges related to data diversity and model generalization.

First, we propose a method for semantic segmentation of teeth based on the U-Net architecture and its advanced variants (Attention U-Net, U-Net3+, and Transformer U-Net), trained using transfer learning, achieving Dice coefficients ranging from 94.64\% to 96.98\%. However, this step reveals a limitation: the inability to distinguish an individual tooth from its neighbor. This finding guide subsequent work toward instance segmentation using YOLOv8-Seg models, enabling precise localization of each tooth, which is particularly useful in orthodontics and forensic dentistry.

An end-to-end deep learning system based on YOLOv11 was then developed for the automatic detection, segmentation, numbering, and diagnosis of teeth from raw panoramic radiographs, achieving an average precision (AP) of 0.987 for detection and segmentation. However, pathological classification stagnates at an F1 score of 0.82 due to the imbalance between rare and common pathological classes. This imbalance is then addressed using generative diffusion augmentation (Stable Diffusion XL), which generates realistic synthetic samples for the minority classes; when combined with a ViT+ResNet50 hybrid model, this approach raises the F1 score to 96.41\% (precision 95.77\%, Cohen's Kappa 0.947, MCC 0.948).

This research offers solid, experimentally validated methodological advances, from semantic segmentation to instance segmentation, then to a unified diagnostic system and a generative solution to address class imbalance, bringing automated dental imaging closer to real-world clinical use that is fast, comprehensive, and reliable.

Keywords: Deep learning; Panoramic dental X-rays; Semantic segmentation; Instance segmentation; Tooth detection and numbering; Pathological classification; Class imbalance; Diffusion models; Transformer vision.