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# Advancing Dental Diagnostics with AI: UNet for Precision in Treatment and Anatomy Mapping


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## INTRODUCTION & AIM

The traditional method for diagnosing dental cysts, tumors, or abscesses often involves an invasive biopsy procedure, followed by microscopic examination by an oral pathologist. While effective, this approach is subject to limitations, such as the skill level of the practitioner, the accuracy of sample collection, and potential inter- and intra-observer variability. Inadequate or non-representative samples can necessitate repeated procedures, causing delays, additional costs, and discomfort for the patient.

In recent years, imaging modalities have become essential tools in diagnosing and planning treatments for dental pathologies. Among these, cone-beam computed tomography (CBCT) has emerged as a valuable diagnostic since it provides detailed views of dental structures, aiding in the assessment of pathological conditions such as dental abscesses, cysts, and tumors. Its ability to capture the spatial relationships of structures in the maxilla and mandible makes it particularly useful for comprehensive evaluations and treatment planning.

CBCT is non-invasive and offers clinicians detailed anatomical insights, facilitating early detection and precise characterization of lesions. However, the complexity of CBCT data poses challenges for manual interpretation, particularly when identifying subtle or small structures. This has prompted the development of computer-aided diagnostic systems, which leverage advanced image analysis techniques to improve accuracy and efficiency. Automatic segmentation, powered by AI models like UNet, enables precise identification of anatomical features and abnormalities, significantly reducing operator workload and variability.

These advancements highlight the transformative potential of integrating CBCT imaging with AI-based tools in dental diagnostics, offering a pathway to enhanced patient care and more efficient clinical workflows.

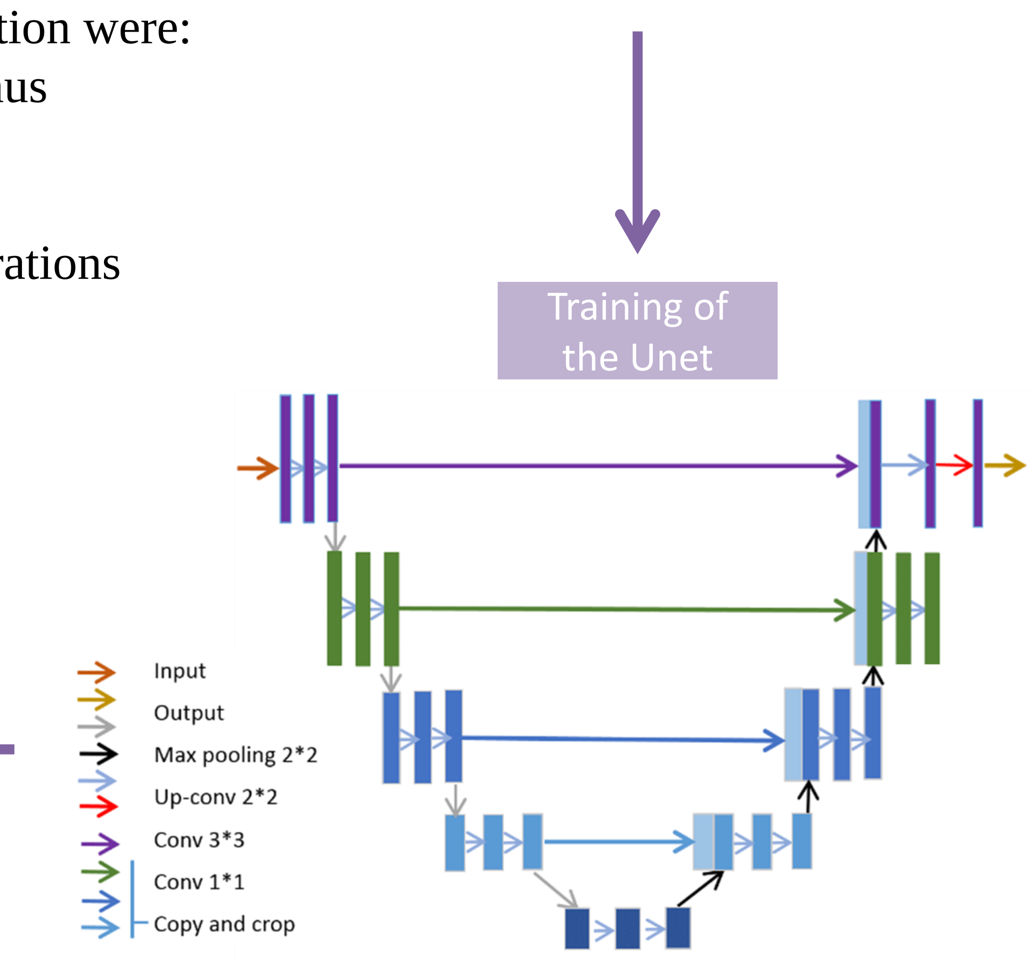
## METHOD

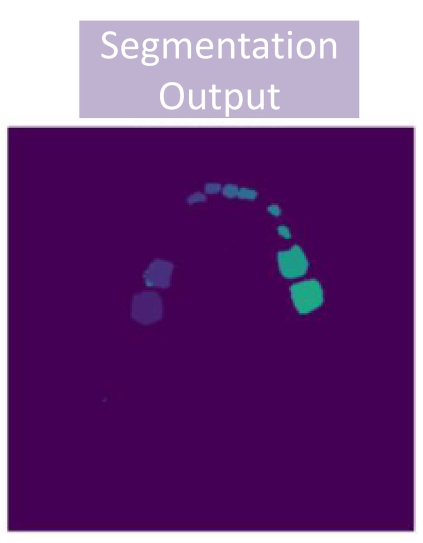
CBCT scans were collected from six patients (3 males, 3 females, aged 29–61) undergoing various dental treatments. A dataset of annotated CBCT images was used to train a UNet model for pixel-wise segmentation, enabling precise localization of dental structures and abnormalities.

The UNet architecture, with its encoder-decoder design, facilitated accurate boundary delineation while maintaining input-output dimensional consistency.


The selected regions for segmentation were:

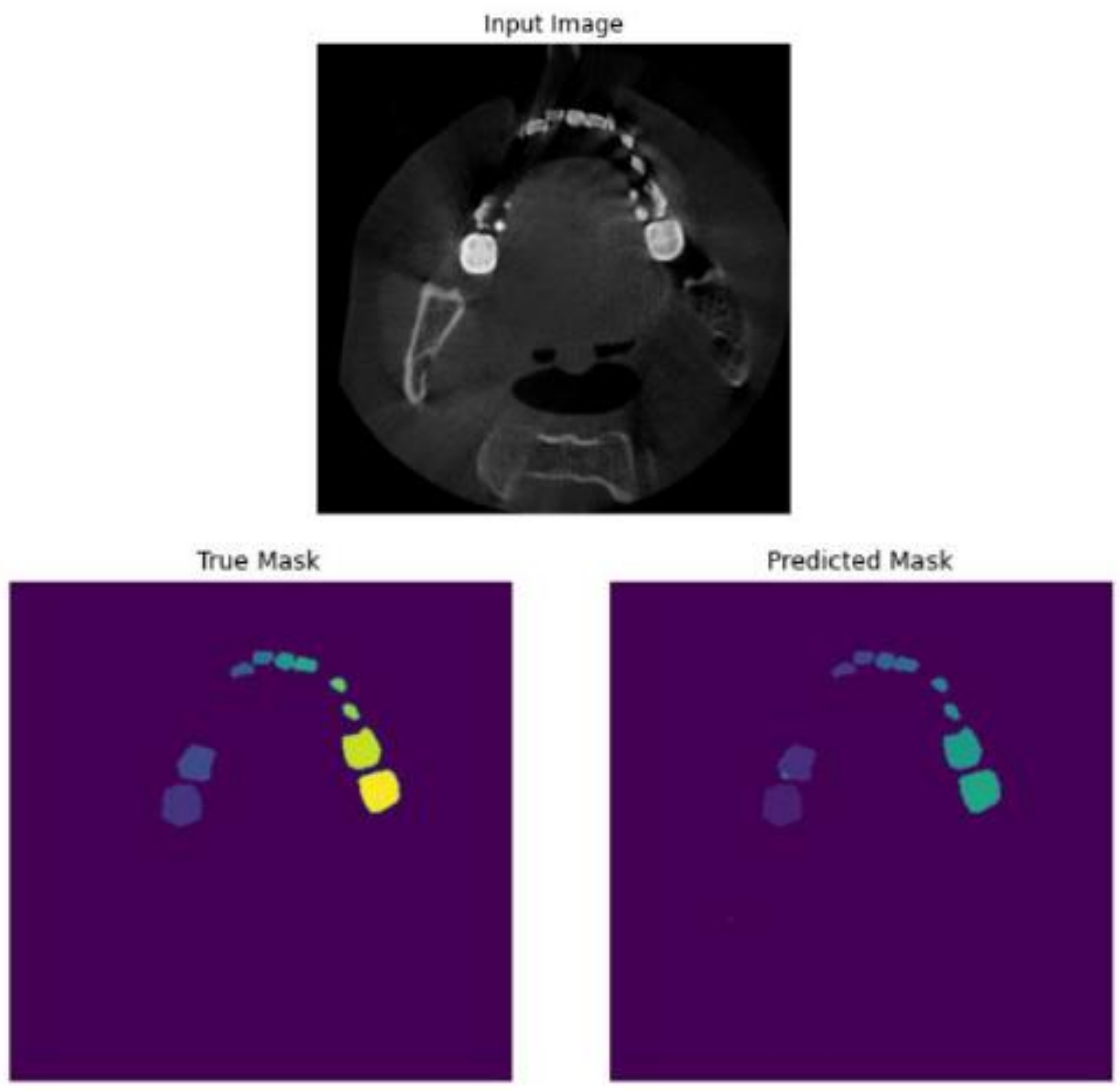
- Crown, roots , R/L maxillary sinus
- Endodontic treatments
- Dental implants
- Composite/amalgam dental restorations



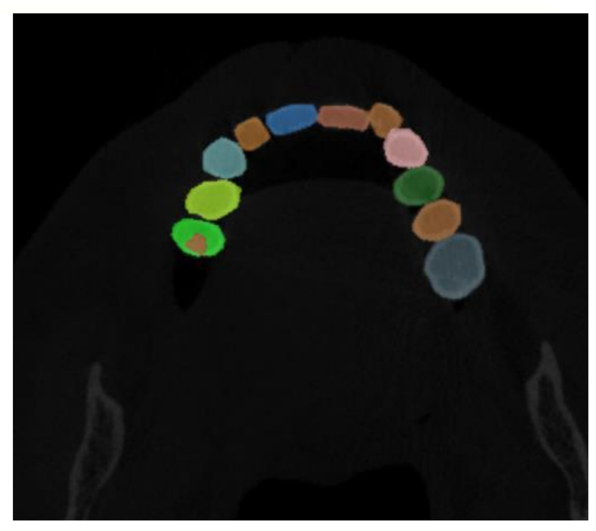




## RESULTS & DISCUSSION

The UNet model demonstrated high accuracy in segmenting and identifying dental structures and abnormalities in CBCT images. It effectively delineated crowns, single and multiple roots, maxillary sinuses, endodontic treatments, dental restorations, implants, and fixed prostheses. The model excelled in detecting smaller and complex structures, reducing the need for manual segmentation by clinicians. Quantitative evaluation on the test dataset showed robust performance, with precise localization and minimal errors in boundary identification. This automation significantly decreased operator workload, enhancing efficiency and consistency in dental diagnostics.




The network is able to detect even small-scale features, such as the reconstruction present in the second premolar. This highlights the software's capability to handle detailed segmentation tasks, providing a valuable resource for clinicians and significantly reducing manual workload.



These findings underscore the value of integrating AI-based systems into dental workflows, offering a pathway to improved diagnostic accuracy and streamlined processes. Future work will focus on expanding the dataset, refining the model for broader clinical scenarios, and exploring real-time implementation in clinical environments.

## CONCLUSION

By accurately segmenting and highlighting key dental structures, including small and complex features, the application of the UNet model to CBCT imaging enhances clinical evaluation, reduces manual workload, and supports precise treatment planning. The ability to distinguish structures such as crowns, roots, restorations, and prostheses using automated segmentation provides a reliable and efficient tool for dental practitioners.

## FUTURE WORK / REFERENCES

Future works include to use the segmentation results to develop a complete 3D model, where each anatomical region will be automatically assigned its specific biomechanical and structural properties. This model will be integrated with finite element analysis (FEM) techniques, enabling precise simulations of bone behaviour under various loading conditions. This approach will further enhance fracture prediction and the optimization of personalized treatment plans.