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Development and Validation of an AI-Driven Automated Tooth Segmentation Algorithm for Intraoral Scans

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INTRODUCTION

This study develops an automated tooth segmentation algorithm for intraoral scans (IoS) and evaluates its performance against a validated ground truth. Intraoral scans are essential in modern dental practices, particularly in orthodontics and prosthodontics, as they enhance treatment planning and communication. However, manual tooth segmentation is time-consuming and error-prone, making automation crucial for improving workflow efficiency and accuracy.[1] This study introduces a novel AI-driven, explainable approach that enhances transparency, interpretability, and clinical acceptability through a two-step noise reduction strategy, requiring smaller labelled datasets for efficient training.[2] The algorithm's performance is validated against a reliable expert-developed reference standard, ensuring robustness and clinical applicability.

MATERIALS AND METHODS

This study developed and validated an automated tooth segmentation algorithm for intraoral scans (IoS) using a two-dataset approach. The first dataset included 80 intraoral and dental cast scans, while the second consisted of 32 expert-annotated scans for validation. A two-step noise reduction method was applied, utilizing YOLOv8 and U-Net deep learning models. The dataset was preprocessed by voxelizing 3D meshes into 2D images, which were annotated by a general dentist. YOLOv8 was trained on 80 images, augmented to 195, and U-Net was trained on 74 segmented scans to produce binary masks. The model's performance was validated using Dice Similarity Coefficients for segmentation accuracy.

RESULTS AND DISCUSSION

The results demonstrated strong performance across both object detection and segmentation tasks. The object detection model achieved a high mean average precision (mAP@0.5) of 0.98, with class-specific scores ranging from 0.93 to 0.99, and showed strong precision-recall performance, particularly for most tooth classes. Misclassifications primarily occurred between similar incisor teeth. The segmentation model, trained for 30 epochs, achieved a high Dice Similarity Coefficient (DSC) of 0.94 on the validation set, with training and validation losses decreasing steadily, indicating effective learning without overfitting. Validation on a separate dataset of 28 scans showed a DSC of 0.83 (95% CI: 0.81–0.85), with higher performance for posterior teeth (DSC = 0.84) compared to anterior teeth (DSC = 0.83). The lower arch exhibited higher segmentation accuracy (DSC = 0.889) compared to the upper arch (DSC = 0.79). Notably, the first premolar, second premolar, and canine groups demonstrated the most consistent segmentation performance, while the first molar and incisor groups showed greater variability, particularly for the first incisor.

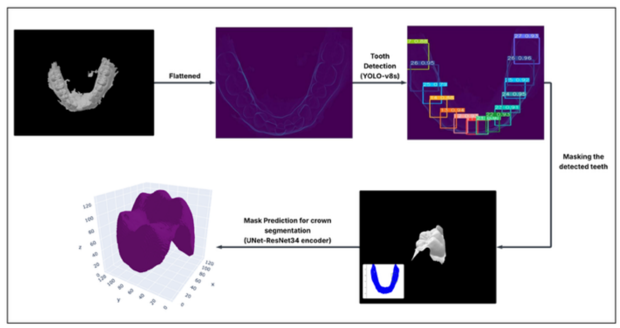

Fig 1 Tooth- Segmentation Algorithm Workflow

CONCLUSIONS

In conclusion, the automated segmentation algorithm demonstrated strong performance, with high precision and effective segmentation across most tooth types. These results underscore its potential to enhance efficiency and accuracy in dental practices. Future efforts should focus on refining the segmentation of more challenging tooth types and expanding the dataset to further improve the algorithm's robustness and clinical applicability.

REFERENCES

[1] Yomna M. Yacout, *Am J Orthod Dentofacial Orthop.***166(3)**:282-291.el, 2024
[2] Rosenbacke R, *JMIR AI* **30;3**:e53207, 2024

Table 1: Summary of Model Performance Across Different Tooth Types

	First Molar	Second Premolar	First Premolar	Canine	Second Incisor	First Incisor
Accuracy (mean ± std)	0.76 (0.18)	0.85 (0.18)	0.88 (0.19)	0.85 (0.20)	0.80 (0.23)	0.81 (0.20)