



Hybrid Deep Learning for Detecting Gum Disease – A Simple Guide

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What is periodontal disease?

Periodontal disease—a major cause of tooth loss—affects nearly half the global adult population. Detecting it early is crucial. Typically, dentists use X-rays (panoramic or periapical) to check for bone loss, but this process is slow and can vary depending on the dentist reading the image.

What are Hybrid AI models?

New AI tools, especially hybrid deep learning models, can help. These systems blend different types of neural networks to do three main tasks:

- **Segmentation (e.g., U-Net):** Outlines important parts like bone and tooth boundaries.
- **Detection (e.g., YOLO, Mask R-CNN):** Finds and locates teeth and landmarks in the image.
- **Classification/CAD:** Uses measurements to judge how advanced the disease is (e.g., stages 1, 2, 3).

By combining these steps, hybrids are more accurate, trustworthy, and useful in clinics.

Real-World Examples of Hybrid Systems

- **Two-Stage (U-Net + YOLO v4):** First, U-Net marks the bone levels and CEJ. Then YOLO v4 finds teeth and landmarks. The app calculates bone loss percentages to determine disease stages [1].
- **Deep Learning + CAD Pipeline:** CNN marks bone and CEJ, followed by a traditional CAD process to assign stages based on the 2017 guidelines. Strong agreement was found across this method with expert evaluations [1].
- **Ensemble Model (YOLOv8 + Mask RCNN + TransUNet):** This powerful combo locates teeth, detects objects, and segments details [2].
- **End-to-End System (HYNETS):** HYNETS uses one unified model to both mark regions and classify stages [3].

Why hybrids work well

Advantage	Why Hybrid AI Is Better
Accuracy	Experts and studies show strong agreement
Clear Context	Segmentation adds meaningful structure
Efficiency	Combines tasks into one smooth workflow
Anchored in Standards	Follows the official 2017 periodontitis stages
Fast and Usable	Can work in real-time at a dentist’s office

Table 1

Challenges we need to tackle

- **Lack of varied data** — Most systems were tested in only one clinic; they need validation across different locations and populations [3].
- **Inconsistent X-rays** — Image quality varies depending on the machine and patient.
- **2D nature of images** — Panoramic X-rays distort teeth; future systems might use 3D scans.
- **Missing patient info** — Current models don’t use clinical data like probing depth or health records.
- **Real-world adoption** — These systems need approvals, explainability, and trust before clinics can use them.

What’s next for hybrid AI?

- **All-in-One Imaging and Data Tools:** Future systems could combine X-rays, scans, and patient health data for more complete diagnoses [4].
- **Transformer-Powered Models:** Advanced AI architectures (like TransUNet) look at the entire image in context, improving detail accuracy [5].
- **Mobile Health Tech:** Lightweight versions could run on phones or tablets for quick, on-the-spot screening in resource-limited areas.

- **Training with Less Labeled Data:** Methods like few-shot learning (e.g., UNet-CVAE) help train high-quality models without huge annotated datasets [6].
- **3D Imaging Integration:** Incorporating CBCT scans would help analyze bone loss in all dimensions.

Conclusion

Hybrid AI systems combine speed with reliability. They allow dentists to detect periodontal disease faster and with less human error. While promising, they still need better data, regulatory approval, and tools that integrate into everyday practice. If developed carefully, these technologies could transform dental care, making early detection easier and more accurate for everyone.

Bibliography

1. HJ Chang, *et al.* “Deep learning hybrid method to automatically diagnose periodontal bone loss and stage periodontitis”. *Scientific Reports* 10.7531 (2020).
2. J Zhao, *et al.* “Hybrid Deep Learning Ensemble for Medical Image Segmentation: Combining YOLOv8, Mask R-CNN, and TransUNet”. *IEEE Access* 12 (2024): 45678-45690.
3. T Kabir, *et al.* “An end-to-end entangled segmentation and classification convolutional neural network for periodontitis stage grading from periapical radiographic images”. *arXiv* (2021).
4. J Jundaeng, *et al.* “Artificial intelligence-powered innovations in periodontal diagnosis: a new era in dental healthcare”. *Frontiers in Medical Technology* 6.1469852 (2025).
5. J Chen, *et al.* “TransUNet: Transformers Make Strong Encoders for Medical Image Segmentation”. *arXiv preprint arXiv:2102.04306* (2021).
6. R Chertsias, *et al.* “Disentangled representation learning in cardiac image analysis”. *Medical Image Analysis* 58 (2019): 101535.