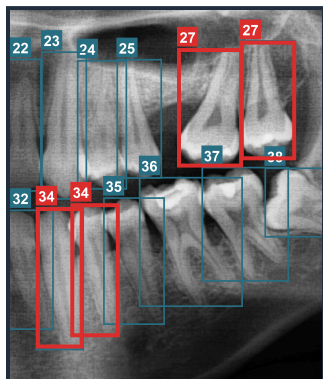
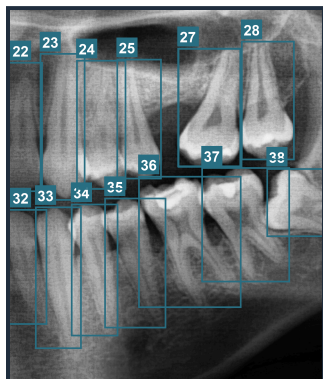


Anatomy-Constrained Duplication Loss for Tooth Detection in Panoramic Radiographs



Baseline — 27, 34, 46
predicted twice



+ $\mathcal{L}_{\text{dup}}$ — same model,
no repeats

Detectors score boxes **independently**, so a tooth number can appear twice — **1.5–7 duplicates per image** for YOLOv11n. Duplicates rarely overlap, so NMS misses most of them.

Penalise probability mass above one per tooth number

$$\mathcal{L}_{\text{dup}} = \sum_{j=1}^{32} \max(0, q_j - 1), \quad q_j = \sum_i p_{ij}$$

- No new parameters, no architectural change
- Zero inference overhead — training only
- Upper bound only: missing teeth never penalised

Fewer Duplicates, Higher F1 — Two Datasets, Four Resolutions

-26%

duplicates, HITL 640 px

+2.6

mAP50, HITL 640 px

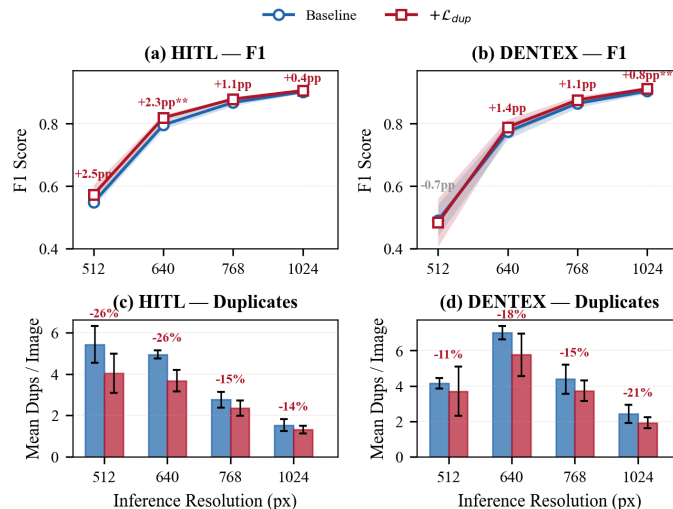
8 / 8

settings with fewer duplicates; F1 up in 7

0.932

best F1, DENTEX — loss + per-class dedup

Inference-time dedup removes duplicates by discarding recall; the loss keeps recall — and the two are **complementary**.



Mean $\pm$ SD, five seeds, 512–1024 px.

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