



Introduction

Accurate IOS-CBCT registration enables integration of dental crown surfaces with the tooth roots. Our solution is a landmark-driven coarse-to-fine framework matching dental and CBCT landmarks.



Intraoral scan

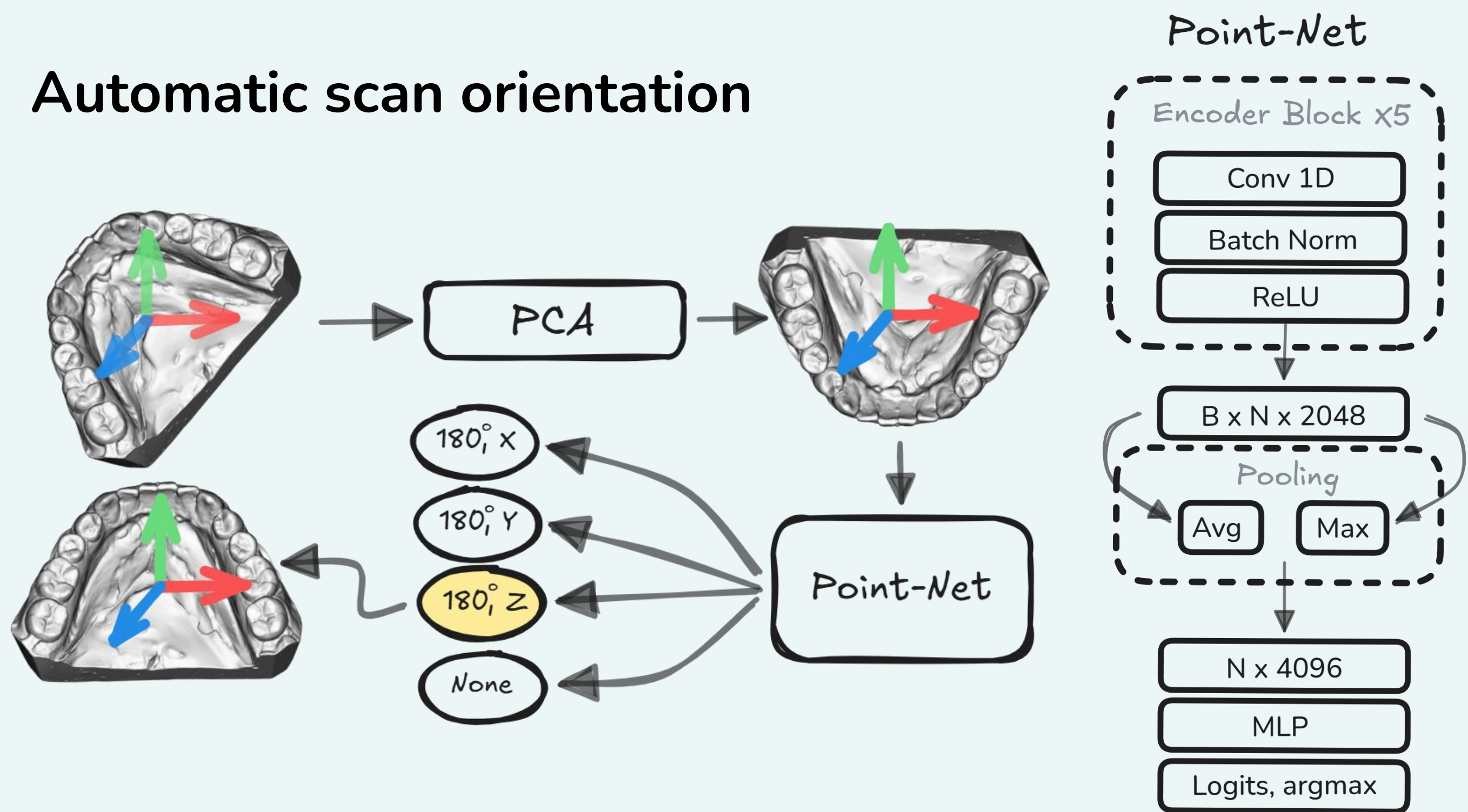
NORMALIZATION - SEGMENTATION - LANDMARKS



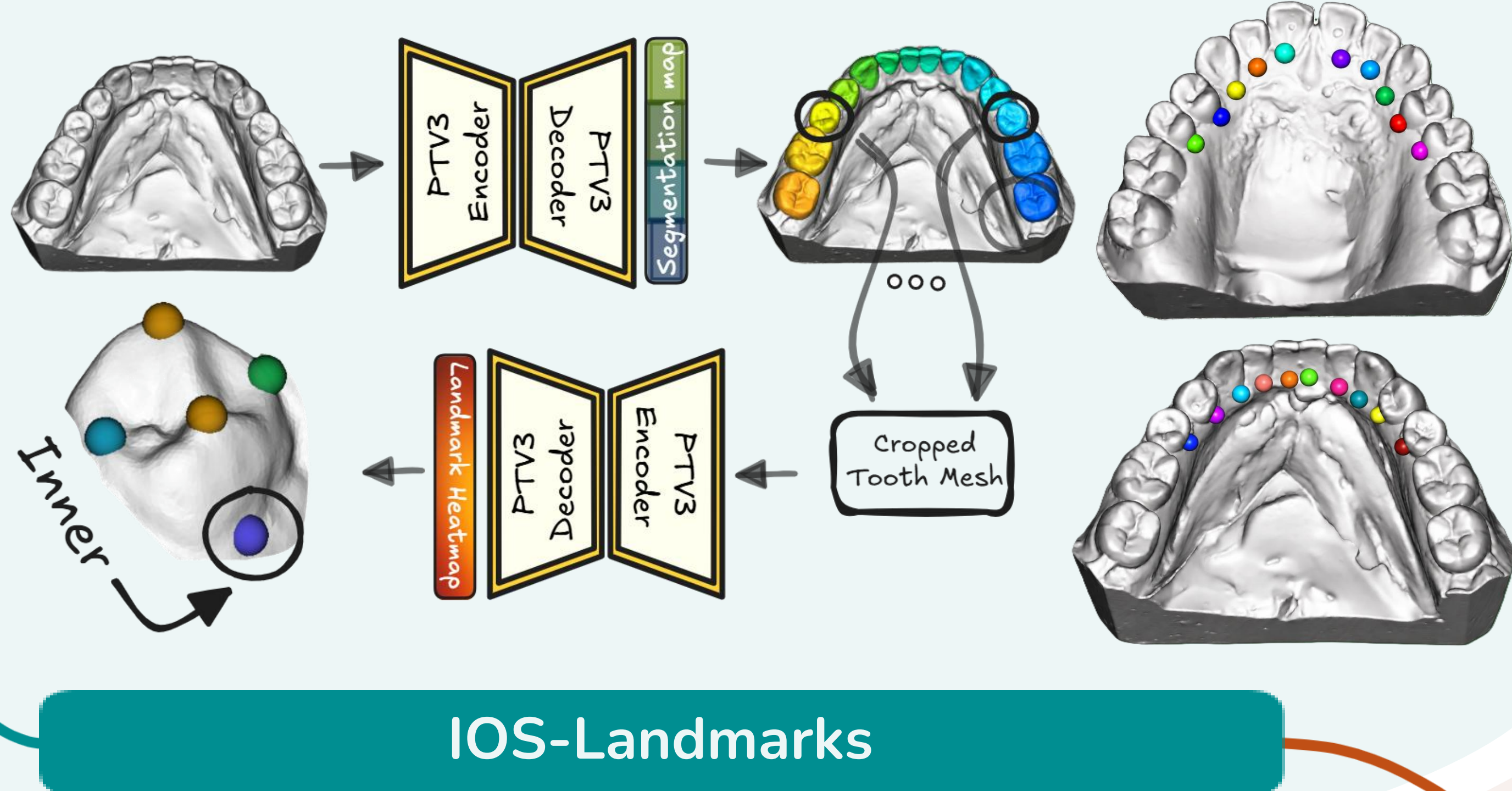
Cone-Beam CT

VOLUME - PATCHES - LANDMARKS

1 Automatic scan orientation

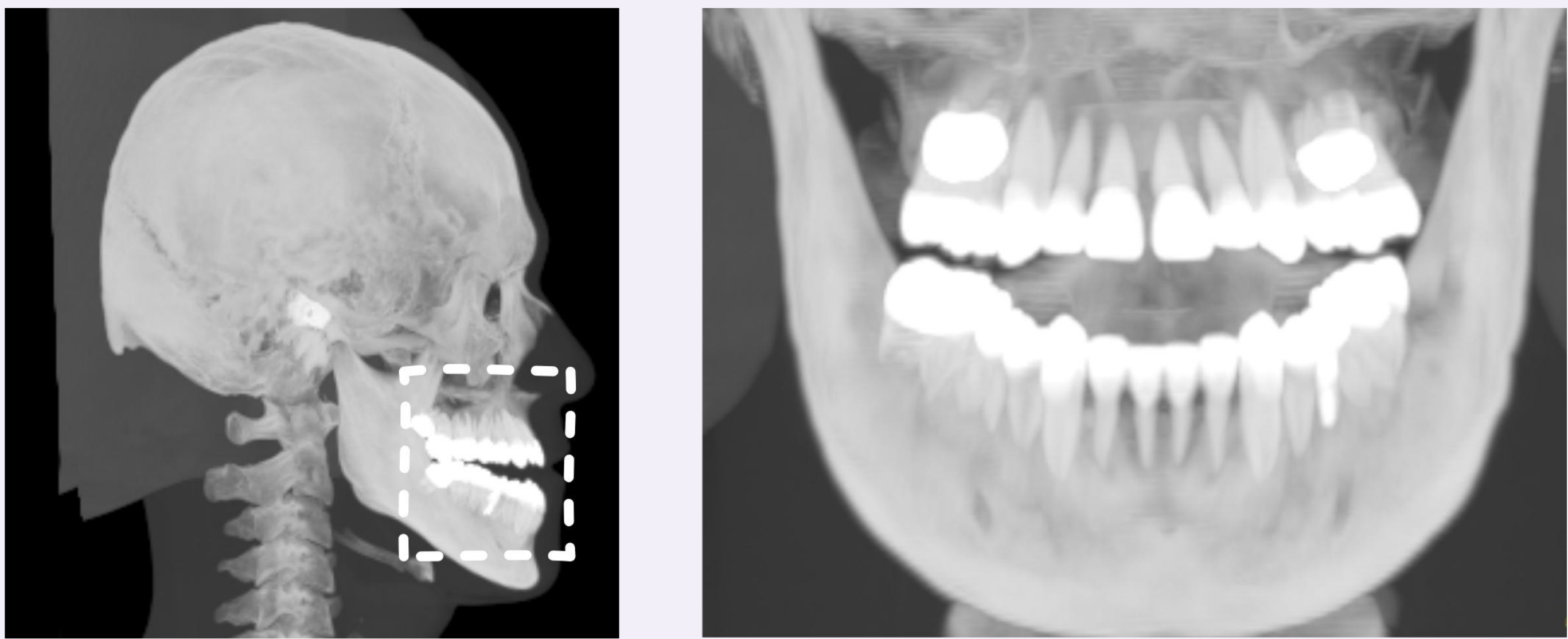


2 Segmentation and landmark prediction

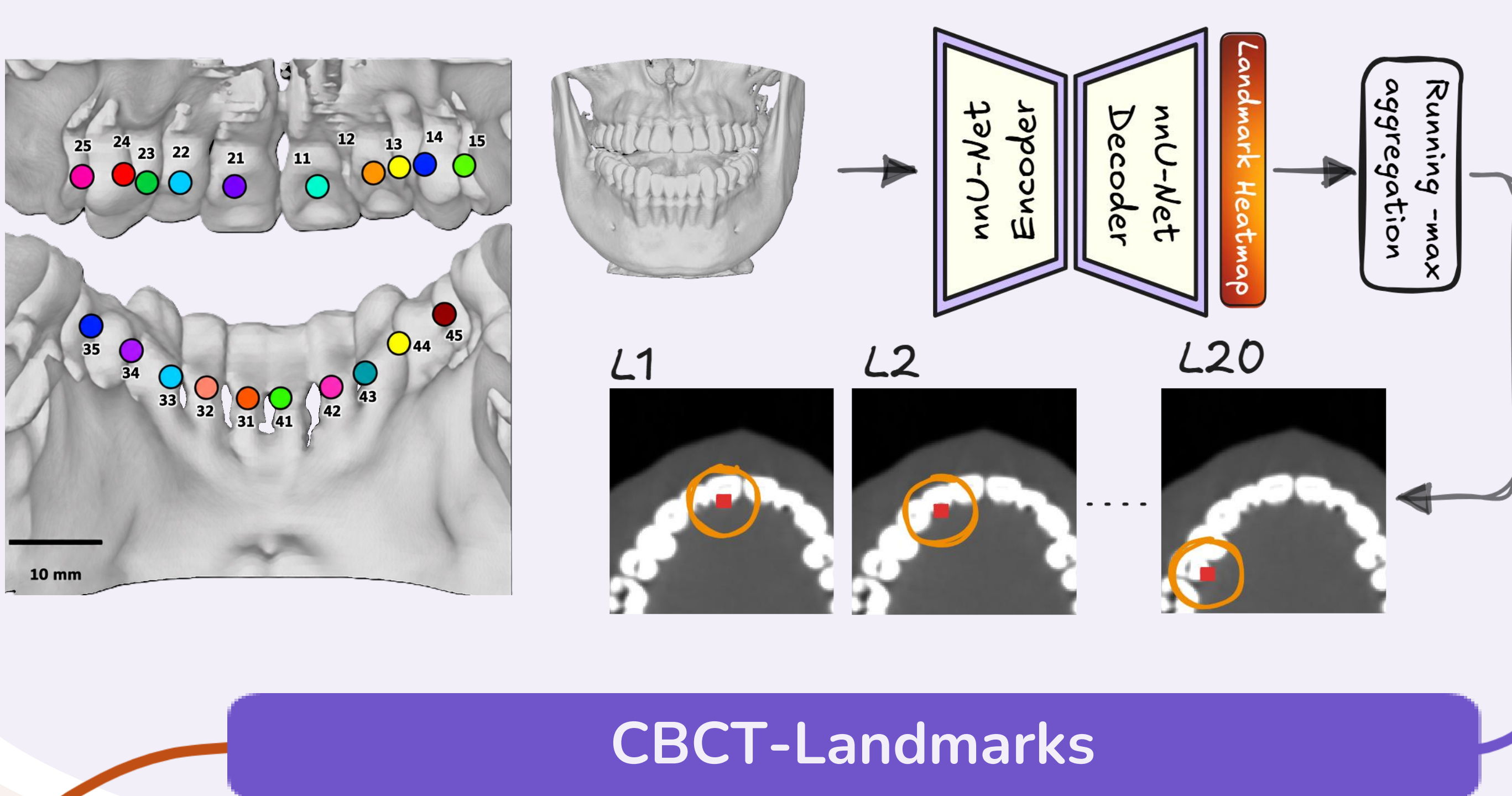


IOS-Landmarks

nnU-Net preprocessing on full volumes



Landmark prediction via running-max aggregation



CBCT-Landmarks

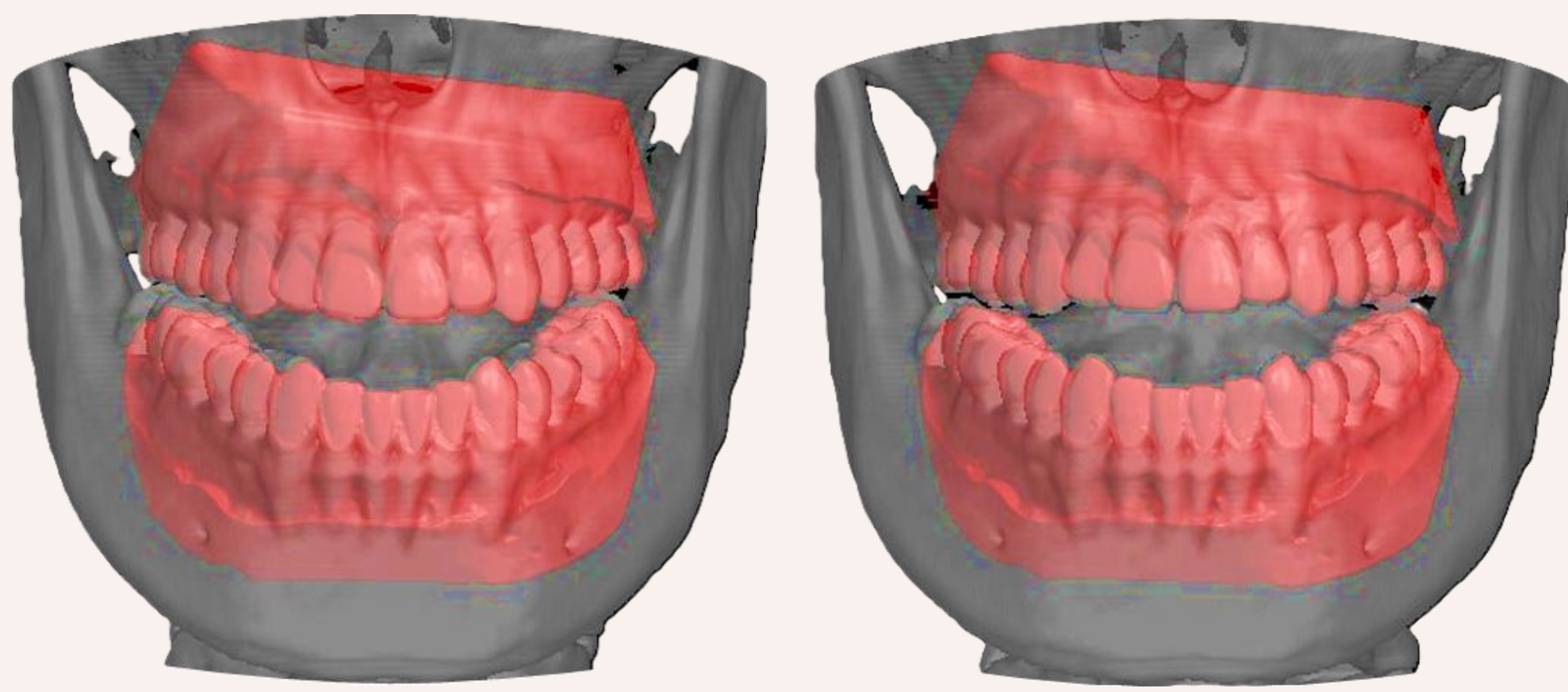
L2L-Registration

01 / COARSE ALIGNMENT

RANSAC + weighted Kabsch

Reject inconsistent correspondences. Estimate rotation and translation from confidence-weighted landmark pairs.

$$(R^*, t^*) = \underset{R, t}{\operatorname{argmin}} \sum_{p_i \in I} w_i \|R p_i + t - q_i\|_2^2$$



Patient ID 027

02 / LOCAL REFINEMENT

Point-to-plane ICP

Iteratively minimize surface mismatch to refine the previous rigid alignment. Final composition:

$$T_{\text{final}} = T_{\text{ICP}} \cdot T_{\text{RANSAC}}$$

Set	RANSAC	ICP	Flip ID>269	MTE (mm)↓	MRE (°)↓
Train Labeled	✗	✗	✓	13.759	3.993
Train Labeled	✓	✗	✓	8.708	2.619
Train Labeled	✗	✓	✓	7.959	1.997
Train Labeled	✓	✓	✓	1.813	0.891
Validation	✓	✓	✗	10.037	22.809
Validation	✓	✓	✓	4.988	1.421
Test corrected	✓	✓	✗	6.752	1.976

Proof:

We composed predictions for IDs > 269 applying the **YZ-plane reflection** and ranked **first** in the leaderboard.

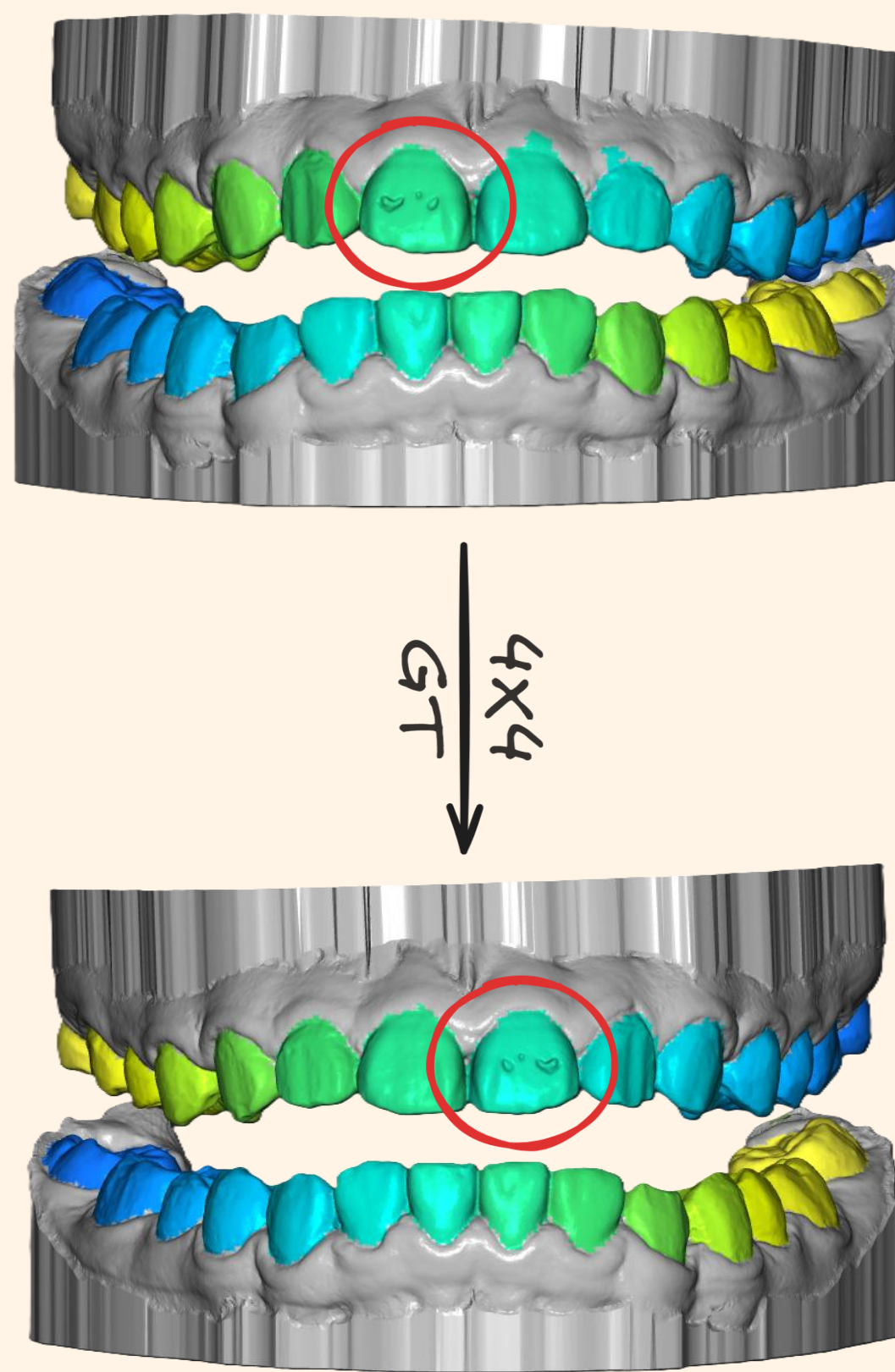
Finding:

In the labeled training set, we found that GT matrices (IDs > 269) had an **additional reflection** on the YZ plane.

$$\begin{matrix} \text{upper_gt} \\ \text{lower_gt} \end{matrix} \begin{matrix} \text{.npz} \\ \text{.npz} \end{matrix} \rightarrow \begin{matrix} R \\ \end{matrix} \begin{bmatrix} r_{11} & r_{12} & r_{13} & t_x \\ r_{21} & r_{22} & r_{23} & t_y \\ r_{31} & r_{32} & r_{33} & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \det(R) = -1$$

Hypothesis:

The **private validation** set ground truth also has reflections for IDs > 269.



Patient ID 274