

From Prediction to Prompt: Leveraging nnU-Net Outputs to Guide SAM for Active Learning in 3D Dental Segmentation

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Problem Statement:

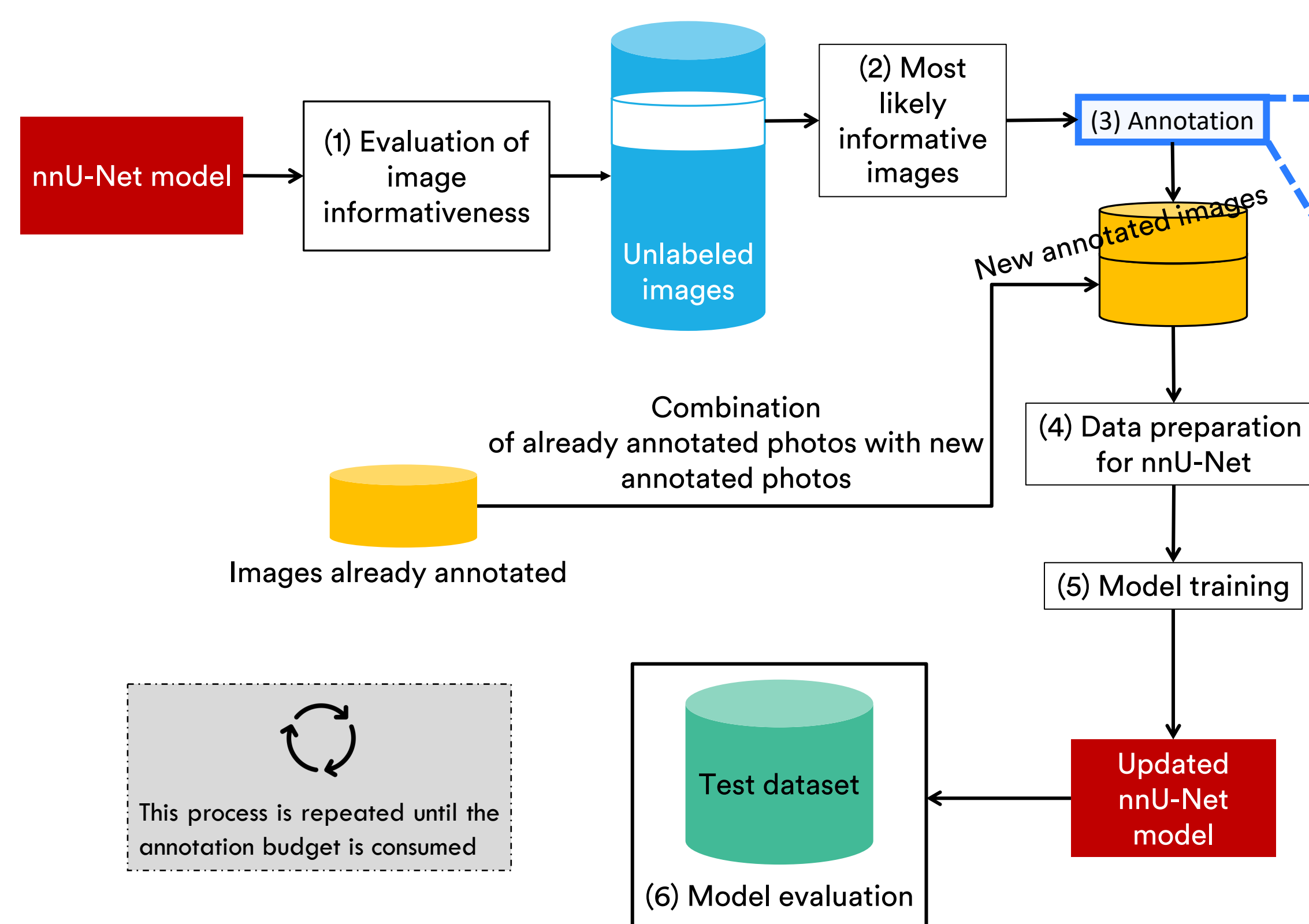
- 3D CBCT segmentation relies on costly and time-consuming manual annotations
- Segment Anything Models (SAM) require prompts (boxes/points), impractical in clinical routine

Research question: Can segmentation model predictions be used as prompts for a SAM-like model to facilitate Active Learning in 3D dental segmentation?

Approaches

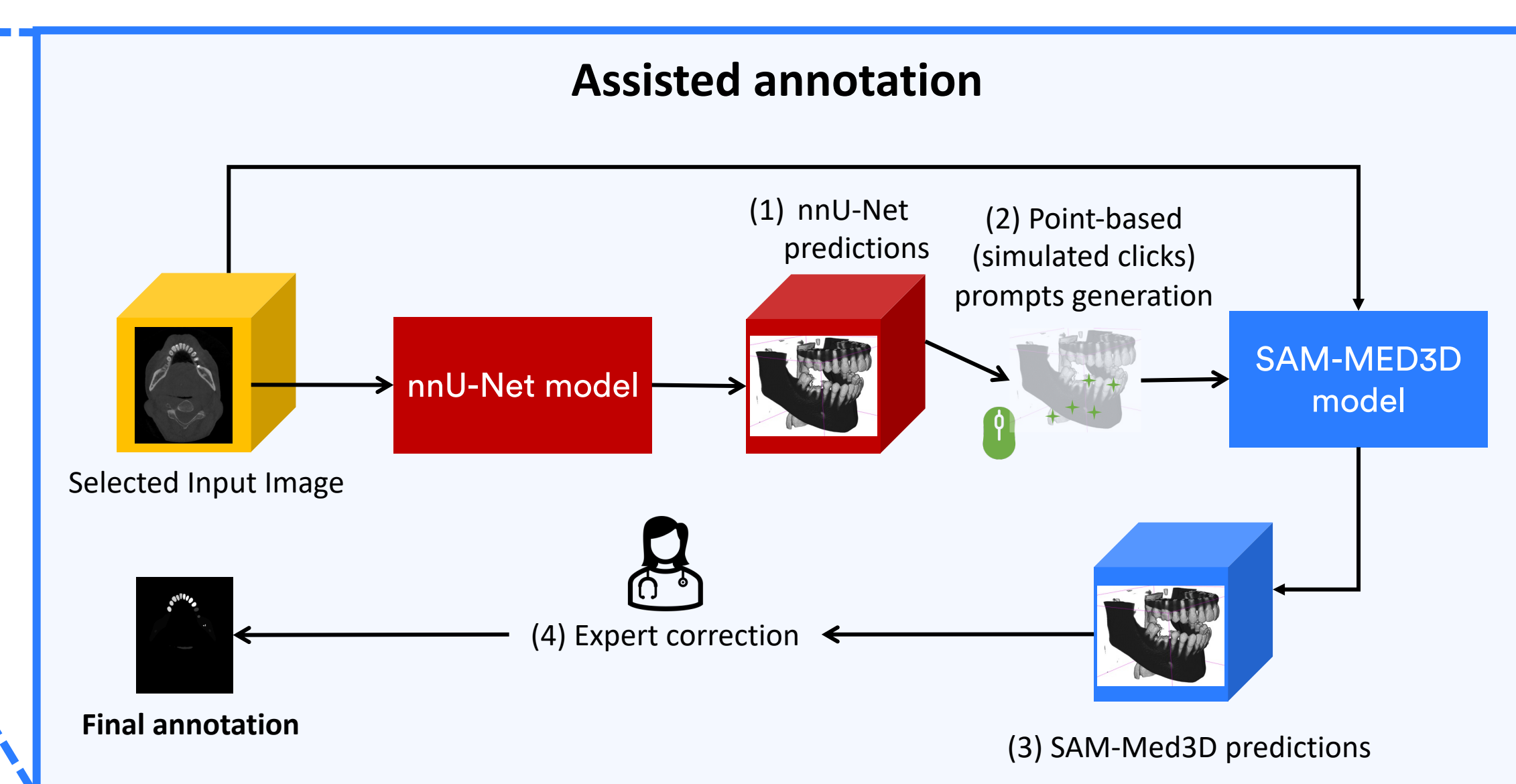
Active Learning (AL) Sampling

Select the most informative images to annotate at voxel level



Prompt-based segmentation

Facilitate voxel annotation by using nnU-Net predictions as prompts for SAM-Med3D

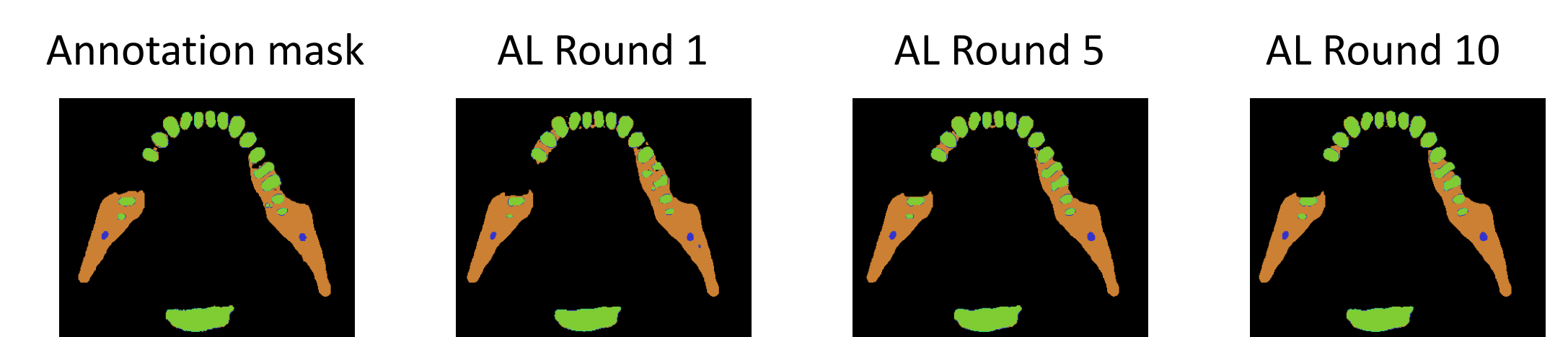


Experiments

- Dataset: ToothFairy2 (3D CBCT scans, grouped into 6 anatomical classes)
- Models:
 - Segmentation: nnU-Net
 - Segment Anything Model: SAM-Med3D

Impact of AL sampling method (10 rounds)

Method	Average	Jawbones	IAC	Sinus	Pharynx	Teeth	Training time	Data used
	DSC	DSC	DSC	DSC	DSC	DSC	Hours	%
Full dataset (FD)	70.92	90.31	71.34	64.81	95.66	73.17	NA	100
Random Sampling AL	74.33	98.50	88.38	0.00	96.73	88.38	5	18
Least confidence sampling AL	73.70	98.00	86.02	0.00	96.82	87.67	27	18
Internal Test FD	74.33	98.15	88.38	0.00	96.74	88.37	5	100



- AL achieves similar performance with <20% annotations
- Random sampling $\approx$ complex strategies, at much lower cost

Impact of prompts on annotation corrections

Number of prompts	Average	Jawbones	IAC	Sinus	Pharynx	Teeth
	Normalized Symmetric Difference (%)					
1 click	62.61	88.92	37.94	98.60	98.97	0
5 clicks	50.75	76.59	37.58	98.12	97.38	0
10 clicks	51.52	69.34	35.58	97.56	97.30	0

- nnU-Net + SAM-Med3D reduces manual effort:
 - ~40% with 1 click
 - ~50% with 5 clicks or more

Future works

- Extend to more classes (e.g., individual teeth) instead of grouped categories
- Address failures in underperforming structures (e.g., sinus)
- Evaluate the full integration of SAM-Med3D in nnU-Net

Details:

