



HKU Dentistry

Faculty of Dentistry · The University of Hong Kong

香港大學牙醫學院

SemiT-SAM: Building a Visual Foundation Model for Tooth Instance Segmentation on Panoramic Radiographs

Team Leader: Jing HAO

E-Mail: jinghao@connect.hku.hk

Team Members: Moyun Liu, Lei He, Lei Yao, James Kit Hon Tsoi, Kuo Feng Hung

CONTENTS

1. Introduction of SemiT-SAM

2. Training protocols

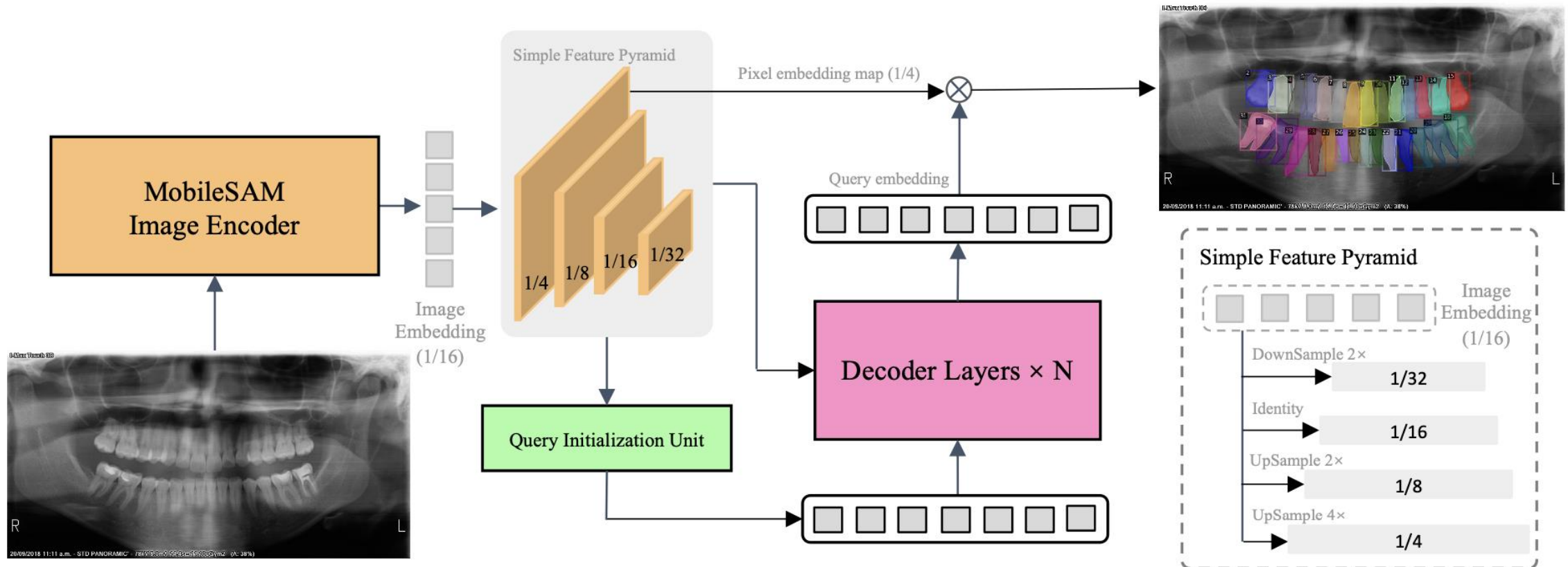
3. Results

01.

Introduction of SemiT-SAM

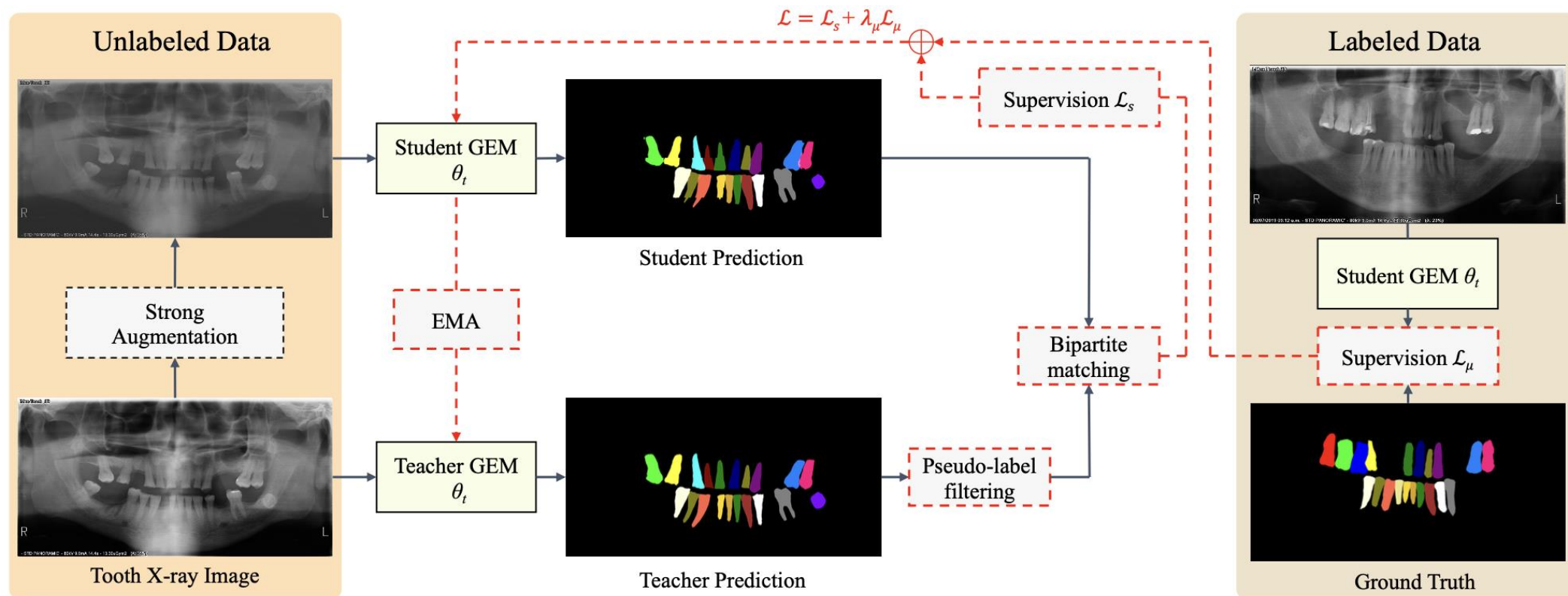
Model Architecture

- ViT-Tiny derived from MobileSAM
- Generating multi-scales features by simple feature pyramid module (from ViTDet)
- Initializing query in the decoder using a query initialization unit.



Semi-Supervised Training

1. **Teacher pre-training:** The teacher model, parameterized by θ_t , is exclusively trained on annotated data.
2. **Enhanced burn-in process:** The student model, parameterized by θ_s , is trained on both labeled and unlabeled data using pseudo-labels generated by the teacher model in the first pre-training stage. The teacher model is frozen.
3. **The student continues to be trained on both labeled and unlabeled data as before. The teacher model is updated using an exponential moving average (EMA) of the student's weights.**



Loss Function

During the training phase, the total loss consists of the supervised and unsupervised losses, which share the same loss function, defined as follows:

$$\mathcal{L}_{total} = \mathcal{L}_{sup} + \lambda_{unsup} \mathcal{L}_{unsup}$$

The unsupervised loss weight λ_{unsup} is 2 in our experiments. The loss function is structured as a weighted sum of five loss components:

$$\mathcal{L}_{sup/unsup} = \lambda_{L1} \mathcal{L}_{L1} + \lambda_{giou} \mathcal{L}_{giou} + \lambda_{focal} \mathcal{L}_{focal} + \lambda_{ce} \mathcal{L}_{ce} + \lambda_{Dice} \mathcal{L}_{Dice}$$

Datasets for Building the Foundation Model

We carefully collected a large-scale dataset, TSI15k, from several open-sourced datasets for training the teeth segmentation foundation model. The dataset is available at: <https://huggingface.co/datasets/Bryceee/TSI15k-Dataset>

Our code and checkpoints of teeth foundation model are available at: <https://github.com/isbrycee/SemiTNet> (accessed on 4 August 2024)

02.

Training protocols

Training protocols

1 Fine-tuning our teeth segmentation foundation model using the provided 30 labeled data in this challenge.

This step was necessary to align the category space because we had originally defined 32 classes in our teeth segmentation foundation model, whereas this challenge defined 52 classes.

2. The unlabeled data were used for semi-supervised training.

	Teeth Segmentation Foundation Model
Network initialization	
Batch size	4
input image size	1024×1024
Total iterations	30000
Optimizer	AdamW
Initial learning rate (lr)	1e-4
Lr decay schedule	StepLR (decreased by 0.1 after 25k and 28k iters)
Training time	14 hours
Number of model parameters	21.6 M
Number of flops	107.3 G
Number of queries	100

03.

Results

Results

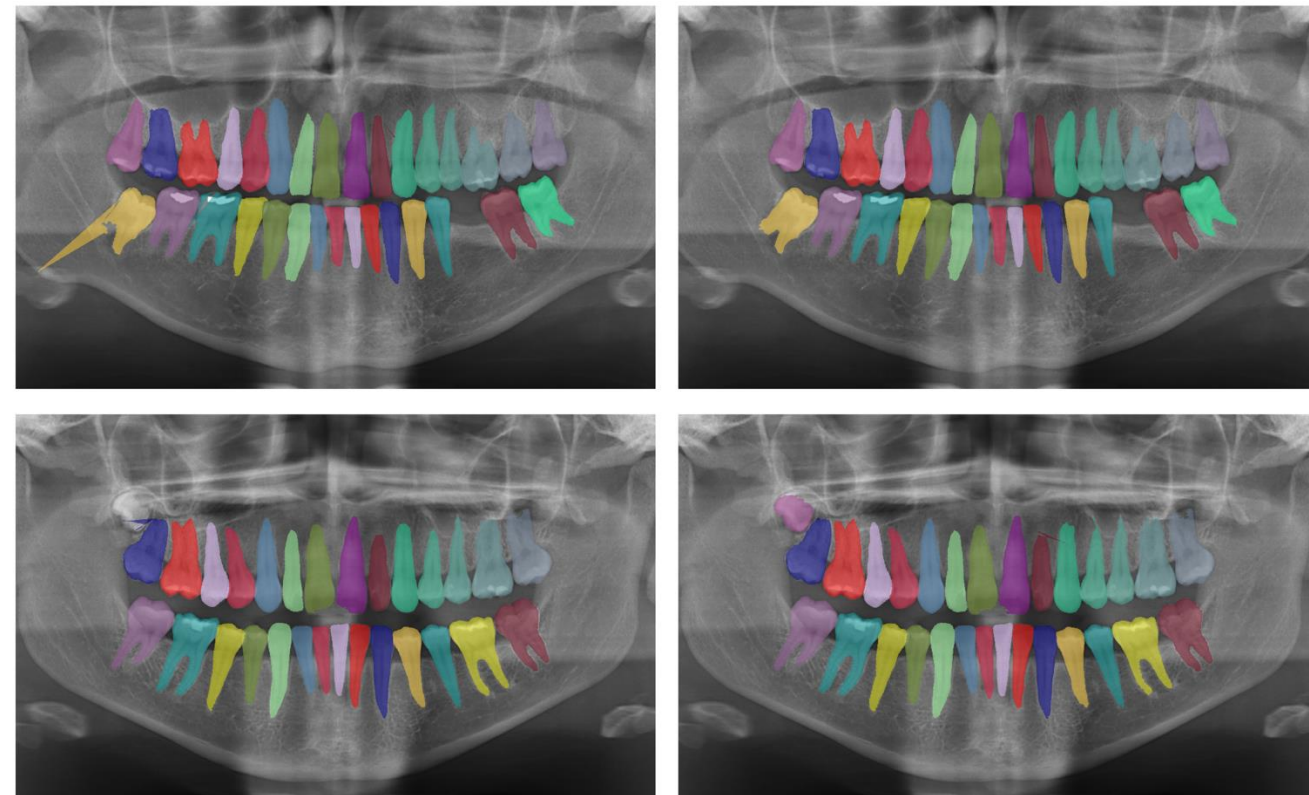
With the help of unlabeled data and semi-supervised training strategy, the performance could be further improved.

All metrics, with the exception of the instance-level Dice, have shown improvement, that is, the enhancements resulted in increases of 1.01% (image-level Dice), 1.28% (image-level IoU), 1.12% (image-level NSD), 0.86% (instance-level IoU), 1.10% (instance-level NSD), and 2.20% IA.

We believe that since the teeth segmentation foundation model already provides a strong baseline for tooth instance segmentation capabilities, the improvement brought by unlabeled data is limited.

Method	image-level			instance-level			
	Dice (%)	IoU (%)	NSD (%)	Dice (%)	IoU (%)	NSD (%)	IA (%)
SemiT-SAM	86.89	77.63	90.52	84.93	67.59	76.85	76.00
SemiT-SAM _{unlabeled data}	87.90	78.91	91.60	83.88	68.45	77.95	78.20

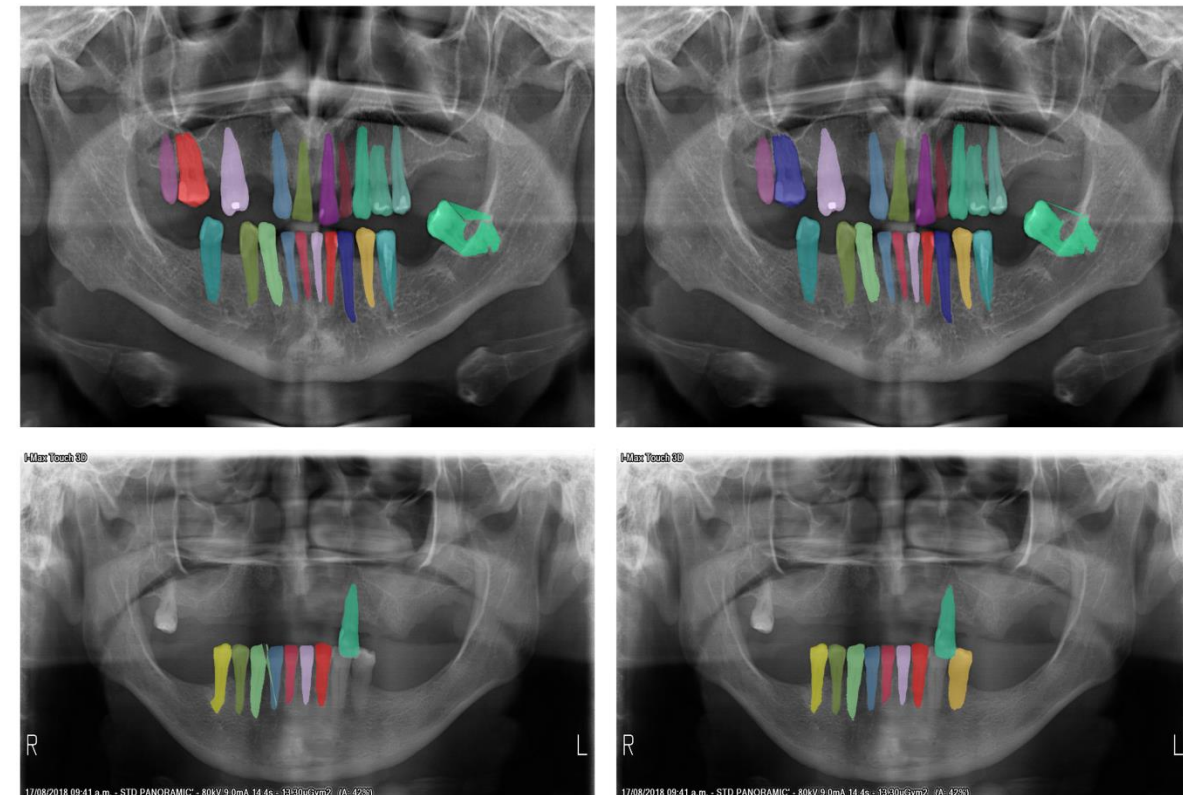
Successful cases



(a) Before semi-supervised learning

(b) After semi-supervised learning

Failure cases



(a) Before semi-supervised learning

(b) After semi-supervised learning



HKU Dentistry
Faculty of Dentistry · The University of Hong Kong
香港大學牙醫學院

THANKS

Jing HAO