Week 3 Ming Zhong Weekly Report

(Lizard Jaw Segmentation)

Time-Log

What did you do this week?

- Meeting Manager Role
    - Sent transcript and video recording of bi-weekly meeting with Computation Advisor to Slack channel and Planner app
    - Sent transcript and video recording of weekly meeting within internal team to Slack channel and Planner app
- Re-summited Method document after syncing up with prior researcher working on the project
- Meet with Philip (previous student researcher) to fully understand the previous efforts made
- Attended bi-weekly meeting with computation advisor regarding current project progress, and collect feedback
- Attended weekly internal meeting with Philip, walking us through the data loading and labeling process using 3D slicer
- Collected online resources to quickly understand fundamental concepts on 3D computer vision

What are you going to do next week?

- Finish onboarding by going through the existing github repo codebase
- Grasp basic understanding on computer vision via online resources collected
- Fulfill my meeting manager responsibilities and attend required meetings

Are there any blockers, things you want to flag, or problems

- Haven't received feedback regarding the submitted method documentation

Abstract

This study introduces a novel deep learning approach for 3D teeth scan segmentation and labeling, designed to enhance accuracy in computer-aided design (CAD) systems. Our method is organized into three key stages: coarse localization, fine teeth segmentation, and labeling. In the teeth localization stage, we employ a Mask-RCNN model to detect teeth in a rendered three-channel 2D representation of the input scan. For fine teeth

segmentation, each detected tooth mesh is isomorphically mapped to a 2D harmonic parameter space and segmented with a Mask-RCNN model for precise crown delineation. Finally, for labeling, we propose a graph neural network that captures both the 3D shape and spatial distribution of the teeth, along with a new data augmentation technique to simulate missing teeth and teeth position variation during training. The method is evaluated using three key metrics: Teeth Localization Accuracy (TLA), Teeth Segmentation Accuracy (TSA), and Teeth Identification Rate (TIR). We tested our approach on the Teeth3DS dataset, consisting of 1800 intraoral 3D scans, and achieved a TLA of 98.45%, TSA of 98.17%, and TIR of 97.61%, outperforming existing state-of-the-art techniques. These results suggest that our approach significantly enhances the precision and reliability of automatic teeth segmentation and labeling in dental CAD applications.

Link: https://www.sciencedirect.com/science/article/pii/S0010482524016202

Summary

The paper "TSegLab: Multi-stage 3D dental scan segmentation and labeling" introduces a novel multi-stage deep learning pipeline for accurately segmenting and labeling 3D intraoral dental scans. Key highlights include:

Approach

1. Coarse Localization: A Mask-RCNN model identifies teeth in a 2D representation of the scan, reducing computational complexity.

2. Fine Segmentation: Detected teeth are mapped to a 2D harmonic parameter space for precise segmentation of the crown, leveraging curvature-based features.

3. Teeth Labeling: A Graph Neural Network (GNN) incorporates both tooth shape and spatial relationships for labeling, using novel data augmentation techniques to handle variations like missing teeth.

Performance

- Tested on the Teeth3DS dataset (1,800 scans from 900 patients), the method achieved:
  - Teeth Localization Accuracy (TLA): 98.45%
  - Teeth Segmentation Accuracy (TSA): 98.17%
  - Teeth Identification Rate (TIR): 97.61%
- Outperformed existing methods in segmentation accuracy, precision, and robustness.

Contributions

- Enhanced segmentation accuracy using harmonic mapping and curvature analysis.

- A new GNN architecture for effective tooth labeling, considering shape and spatial arrangement.

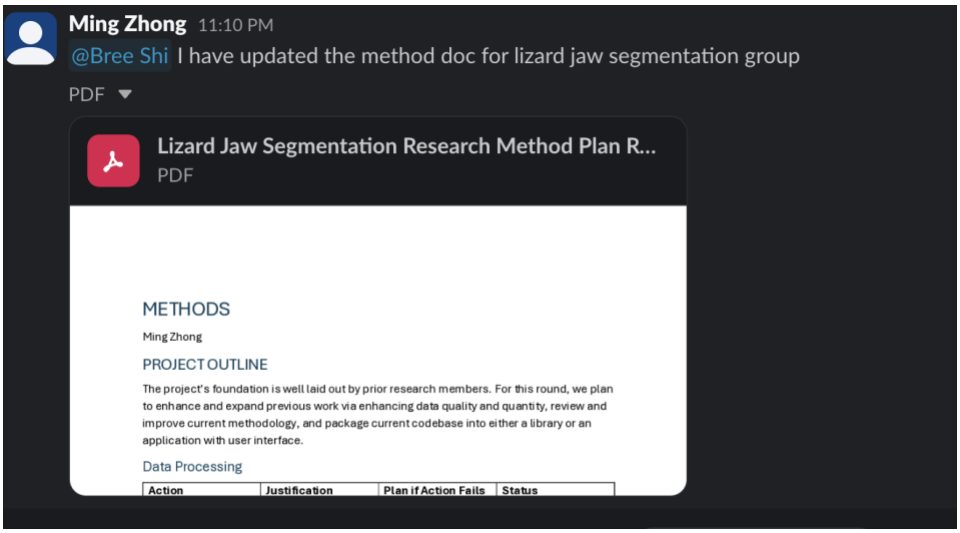
- Comprehensive validation and benchmarking on a large-scale dataset.

Applications

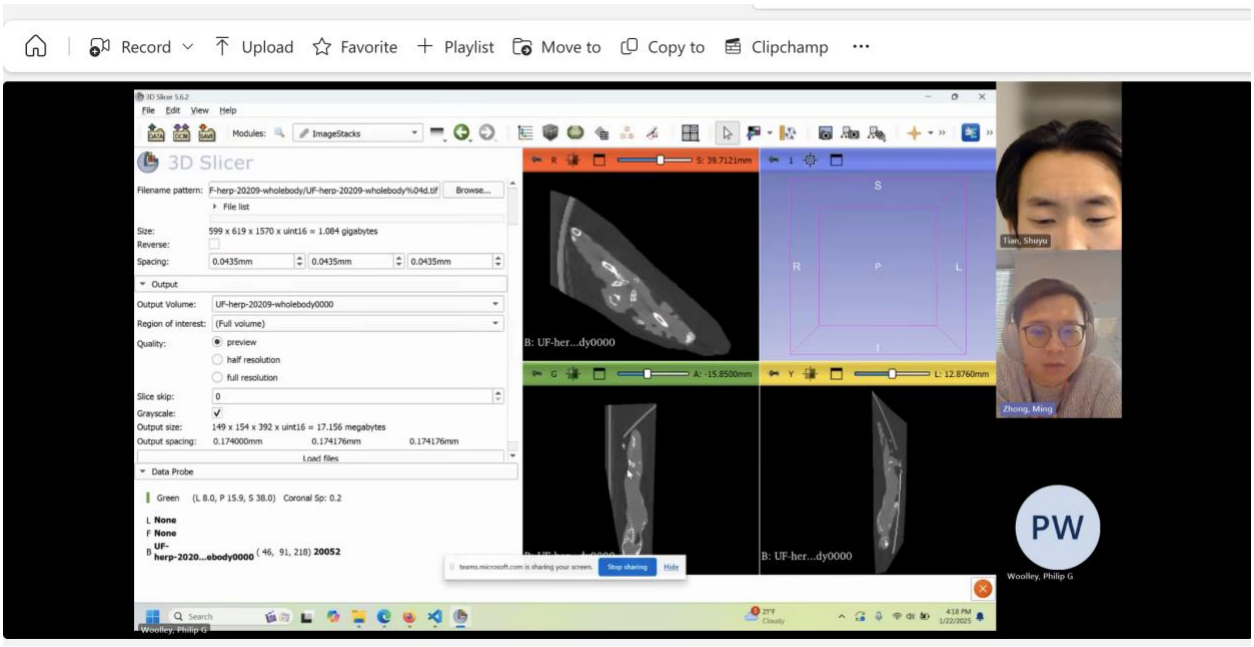
The method significantly improves the precision and efficiency of computer-aided dental applications like diagnosis, orthodontics, and restorative treatment planning.

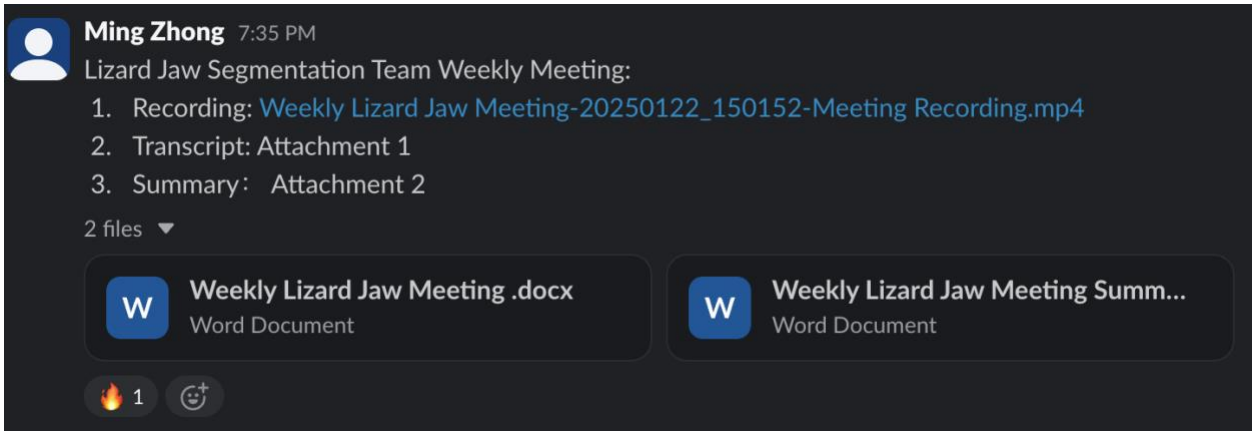
What You Did and Proof

- Method Doc resubmit



- Host KT session with Philip regarding how to load data into 3D slicer and label teeth



- Attend meetings and fulfill my meeting manager responsibilities
  - 

- Going through online resources for 3D computer vision
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