Project Management and Software Development for Medical Applications

Salivary Glands Segmentation from PET/CT Images for Dosimetry Applications in Nuclear Medicine

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I. Project Description and Motivation

Review

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1.1 Introduction

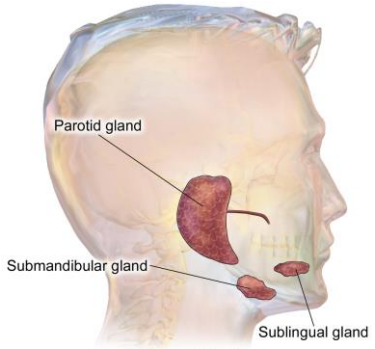
Background and Motivation

Radionuclide Therapy:

- Treatment for cancer through radiopharmaceuticals components. [1]
- Deliver high radiation to cancer cells. [1]
- Possible side effect:
  - Deliver radiation to healthy cells, like salivary glands. [2]
  - Disfunction in salivary glands. [2]

Problem Statement and Solution:

- Patients avoid and refuse to do radiotherapy treatment.



Salivary Glands

"Salivary_gland", https://en.wikipedia.org/wiki/Salivary_gland

[1] International Atomic Energy Agency. "Radionuclide Therapy" https://www.iaea.org/topics/radionuclide-therapy
[2] Cancer Research UK. "Side effects of radiotherapy" https://www.cancerresearchuk.org/about-cancer/mouth-cancer/treatment/radiotherapy/side-effects

1.1 Tasks and Goal

Tasks:

- Generate and annotate dataset for salivary glands.
  - Bounding Boxes
  - Pixel Wise annotation
- Train network for the segmentation of salivary glands

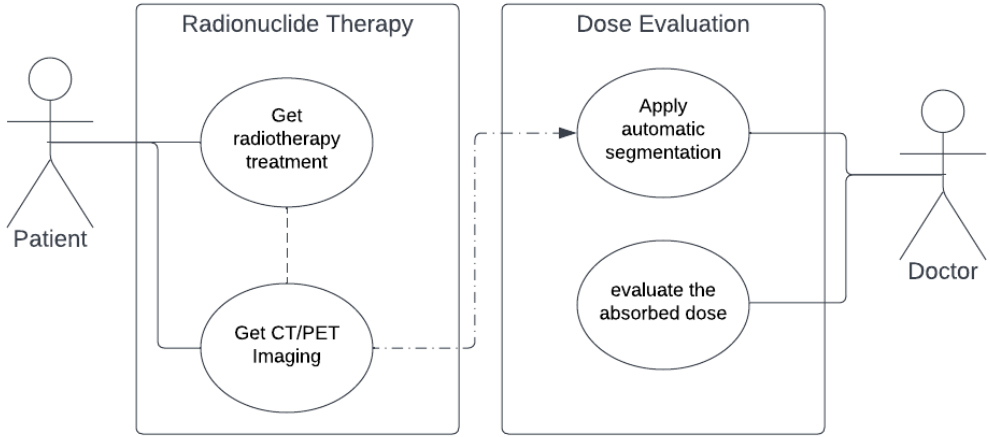


Fig 2. Salivary gland use case diagram

II. Progress and Results

Dataset and Model Architecture

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2.1 Dataset

- **Public Dataset:** MICCAI Challenge 2015 dataset [1]
  - Submandibular and **Parotid salivary glands**
  - 28 CT scans for training
  - 10 CT scans for validation
  - 10 CT scans for testing

- **IFL Dataset:**
  - +100 CT/PET scans

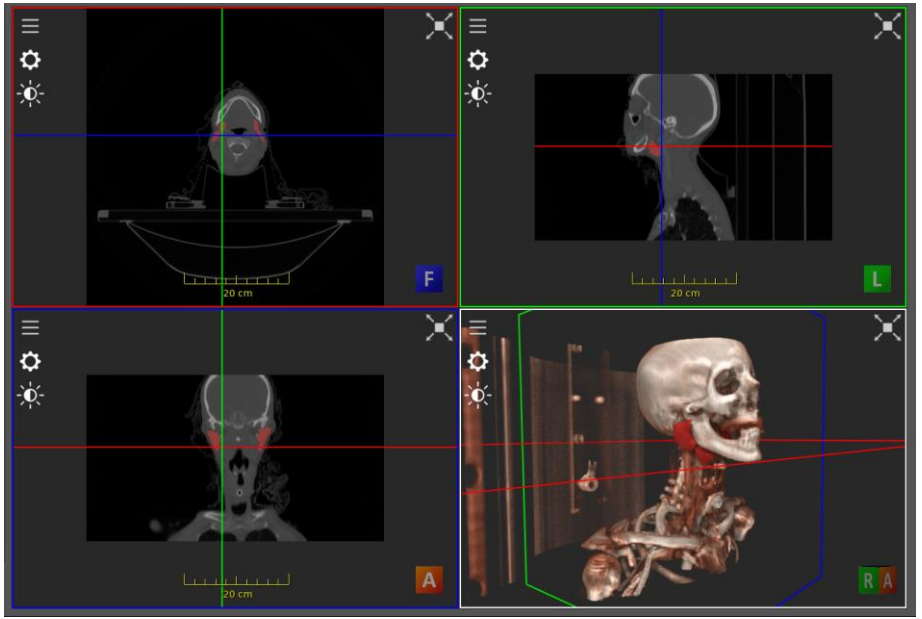

Fig 3. MICCAI dataset sample in ImFusion

[1] https://www.imagenglab.com/newsite/pddca/

2.1 Dataset

- **Data preprocessing:**
  - SimpleITK library
  - Change image format (*nrrd -> NIFTI*)
  - Isotropic Image: Resampling
    - **3x3x3 mm**
    - 1x1x1 mm
  - Generate bounding boxes

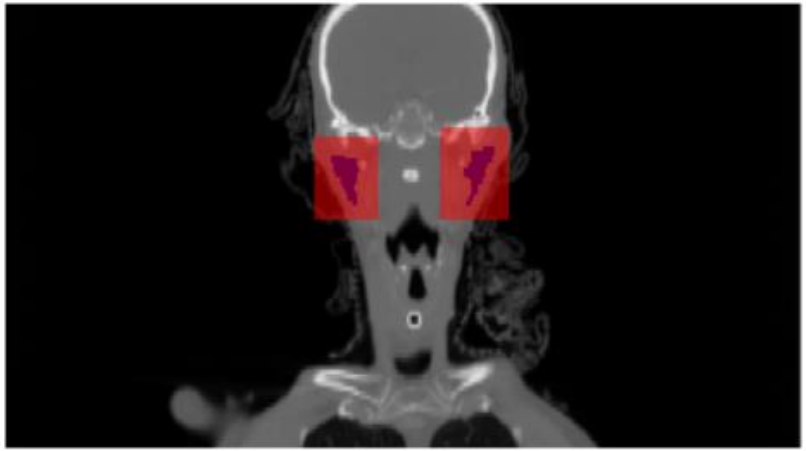

Fig 4. Bounding box in MICCAI dataset sample

2.2 Architecture

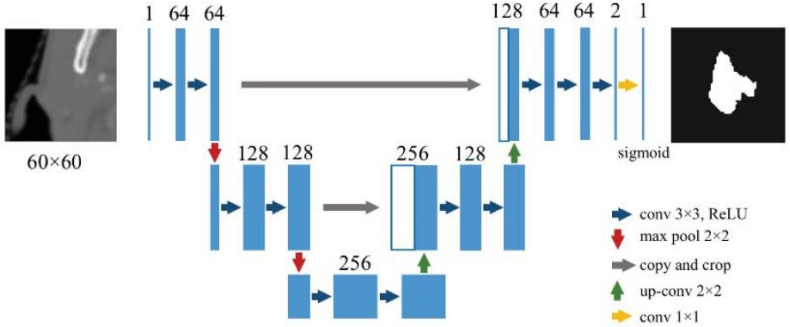

Fig 5. Unet for segmentation the ROI [2]

Fig 6. Face and neck region crop

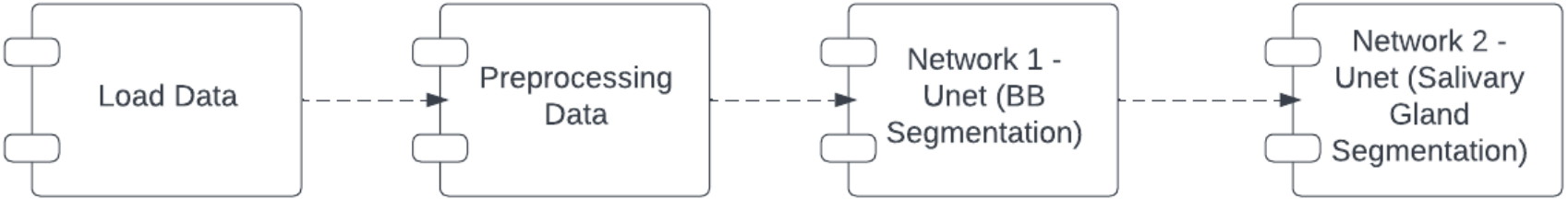

Fig 7. Model Architecture

[2] Q. Yang, S. Zhang, X. Sun, J. Sun and K. Yuan, "Automatic segmentation of head-neck organs by Multi-mode CNNs for radiation therapy," 2019 International Conference on Medical Imaging Physics and Engineering (ICMIPE), 2019, pp. 1-5, doi: 10.1109/ICMIPE47306.2019.9098166.

2.2 Architecture

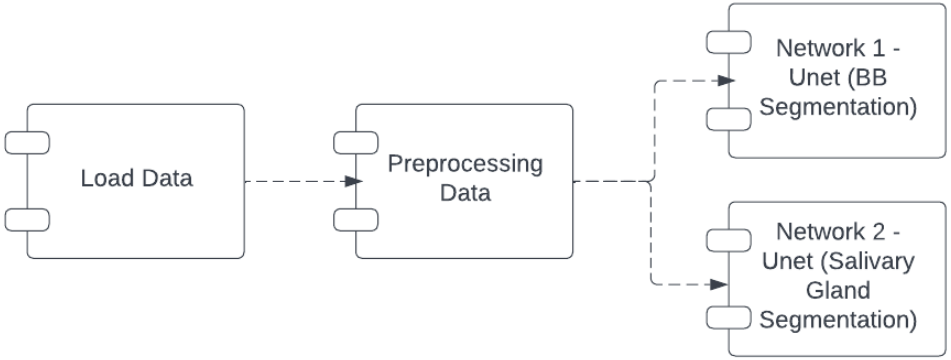

Fig 8. Model Architecture

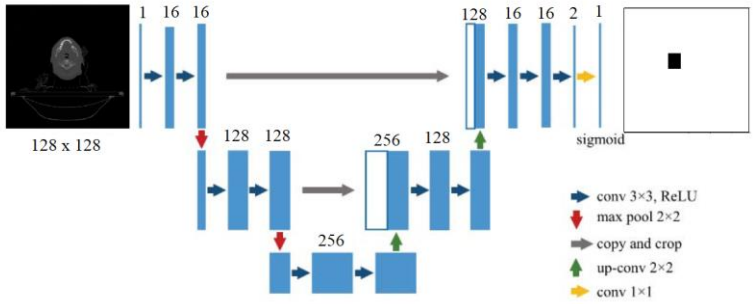

Fig 9. Network 1 – ROI Localization

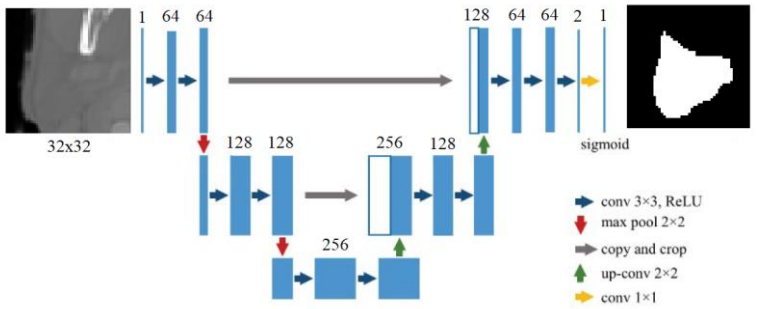

Fig 10. Network 2 – Pixel Wise Segmentation

2.2 Architecture

Table 1. Hyperparameters

Hyperparameters	Net 1	Net 2
	Value	
Optimization	Adam	
Learning Rate	0.002	
Loss Function	Dice Loss	
Metric	Dice Score	
Epochs	Early Stopping	
Batch Size	100	65

2.3 Results – Network 1 - Left Side

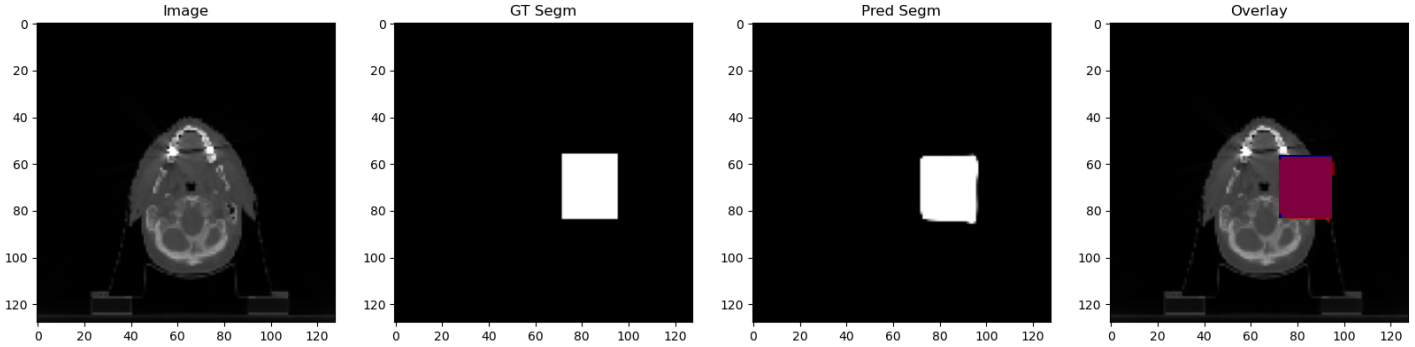

Fig 11. Network 1 results in test sample – Left Side

Table 2. Network 2 scoring – Left Side

	Data Aug.	Training	Validation	Test
Dice Score (%)	**Yes**	86.85 ± 2.7	78.18 ± 1.8	74.97 ± 1.3
	No	90.67 ± 3.0	79.84 ± 3.2	76.25 ± 3.6

2.3 Results – Network 1 – Left Side

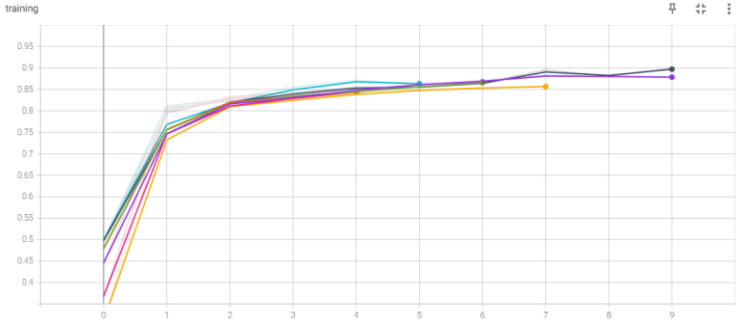

Fig 12. Network 1 - Training Dice Score Curve with DA – Left Side

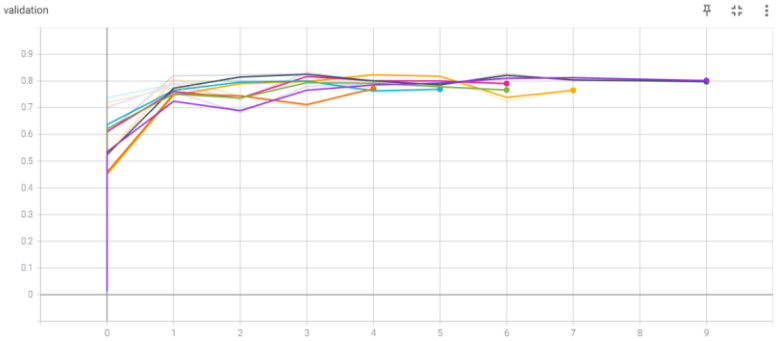

Fig 13. Network 1 Validation Dice Score Curve with DA – Left Side

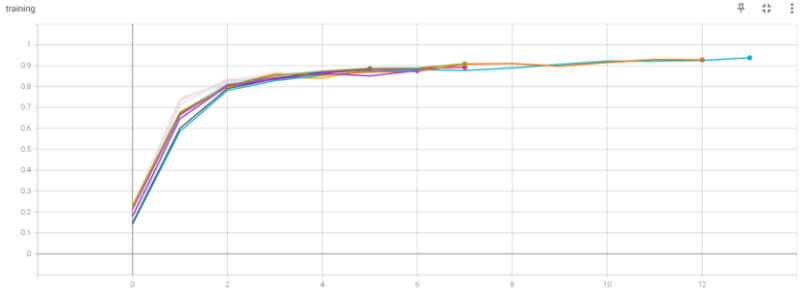

Fig 14. Network 1 Training Dice Score Curve without DA – Left Side

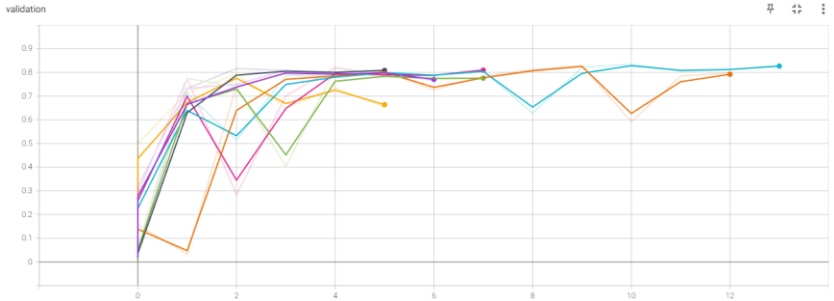

Fig 15. Network 1 Validation Dice Score Curve without DA – Left Side

2.3 Results – Network 1 - Right Side

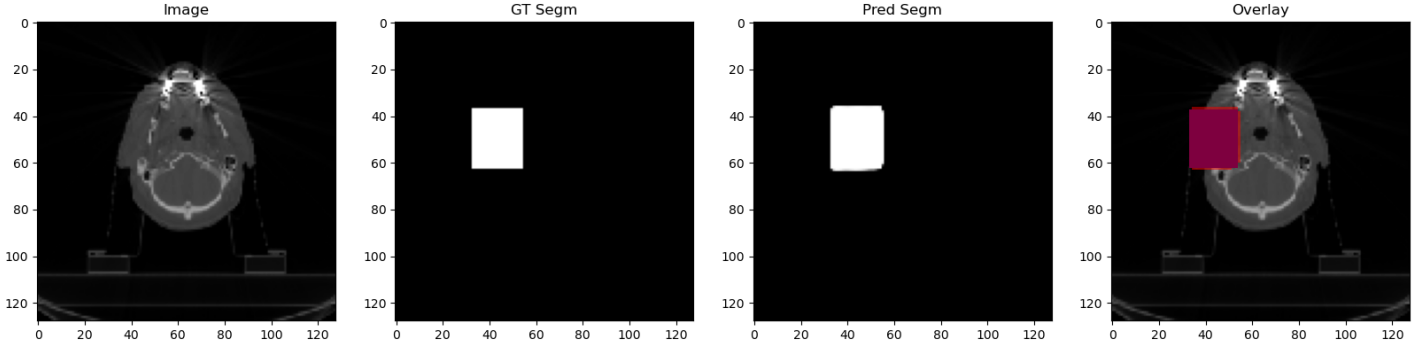

Fig 16. Network 1 results in test sample – Right Side

Table 3. Network 1 scoring – Right Side

	Data Aug.	Training	Validation	Test
Dice Score (%)	**Yes**	87.51 ± 2.3	74.37 ± 2.0	75.63 ± 2.7
	No	90.01 ± 2.9	72.71 ± 3.9	76.71 ± 3.3

2.3 Results – Network 1 – Right Side

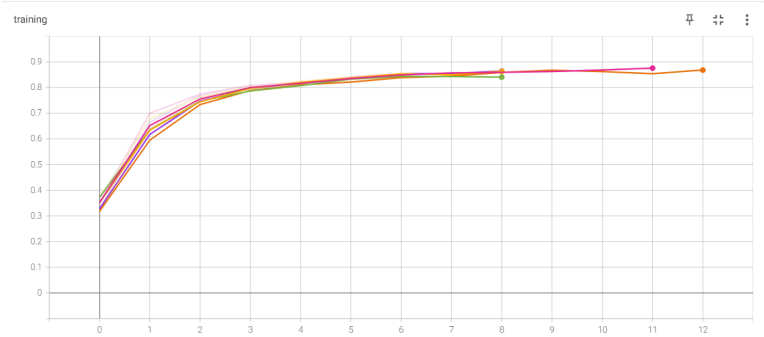

Fig 17. Network 1 Training Dice Score Curve with DA – Right Side

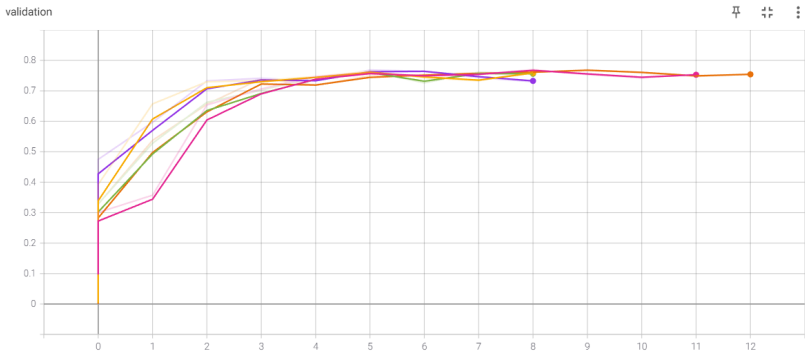

Fig 18. Network 1 Validation Dice Score Curve with DA – Right Side

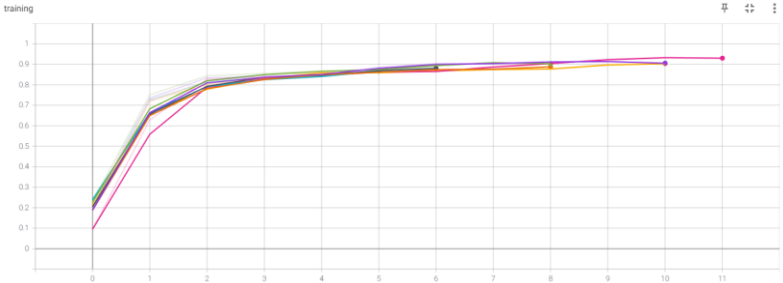

Fig 19. Network 1 Training Dice Score Curve without DA – Right Side

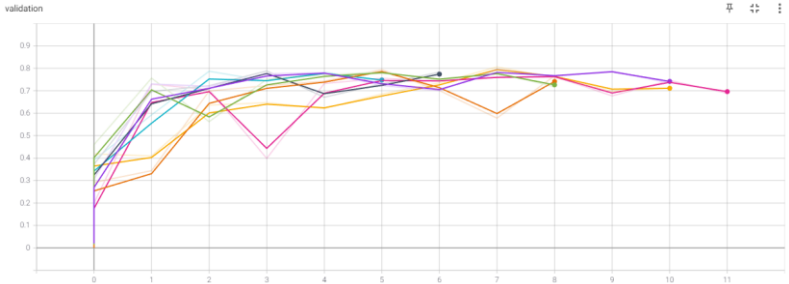

Fig 20. Network 1 Validation Dice Score Curve without DA – Right Side

2.3 Results – Network 2 – Left Side

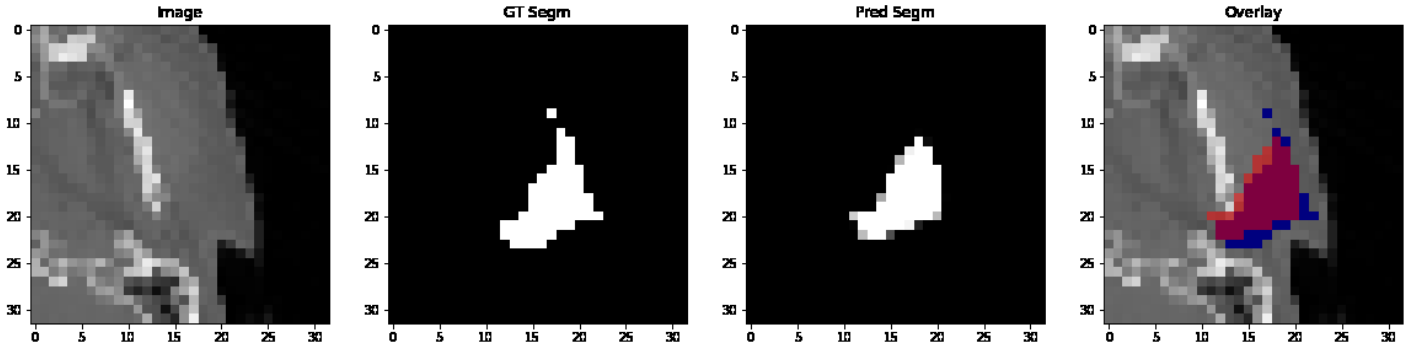

Fig 21. Network 2 results in test sample – Left Side

Table 4. Network 2 scoring – Left Side

	Training	Validation	Test
Dice Score (%)	86.40 ± 1.8	75.19 ± 1.7	74.64 ± 1.1

2.3 Results – Network 2 – Left Side

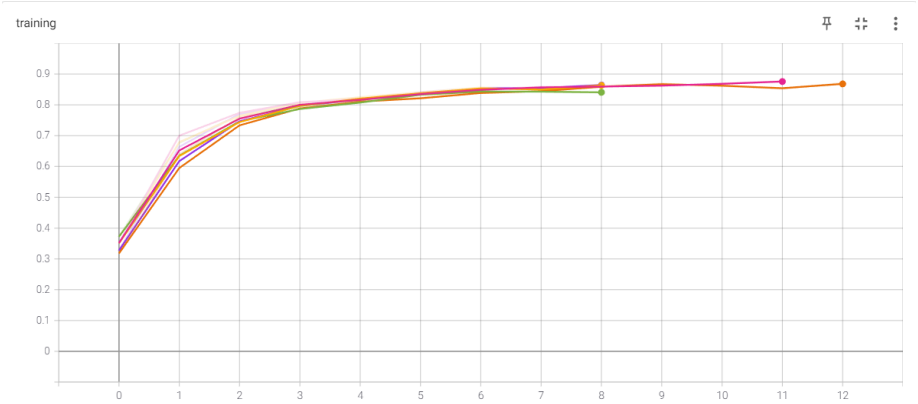

Fig 22. Network 2 Dice Score Curve Loss – Left Side

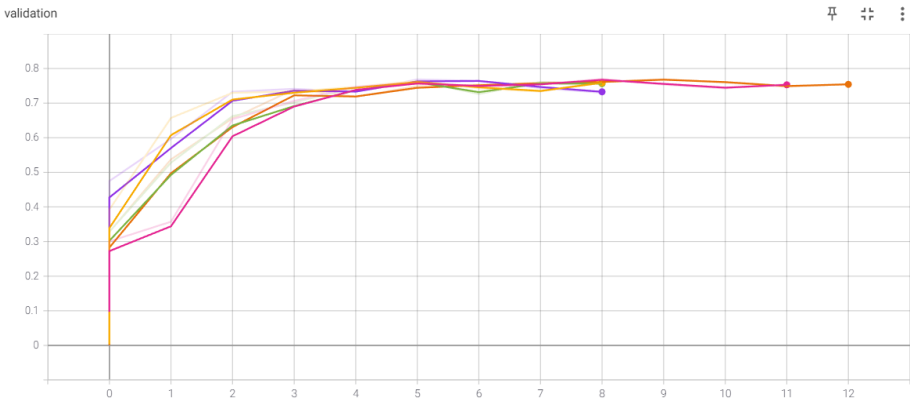

Fig 23. Network 2 Validation Dice Score Curve – Left Side

2.3 Results – Network 2 – Right Side

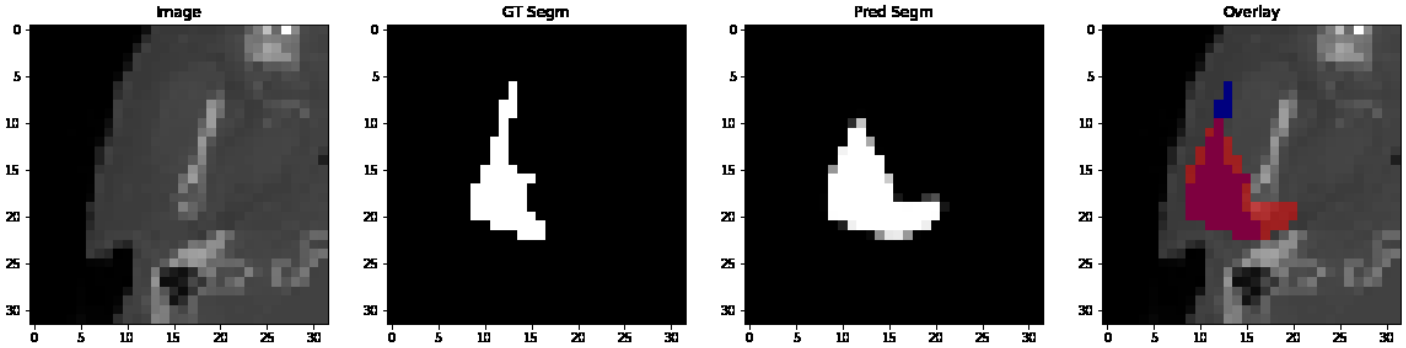

Fig 24. Network 2 results in test sample – Right Side

Table 5. Network 2 scoring – Right Side

	Training	Validation	Test
Dice Score (%)	87.25 ± 2.4	75.44 ± 1.7	75.05 ± 1.2

2.3 Results – Network 2 – Right Side

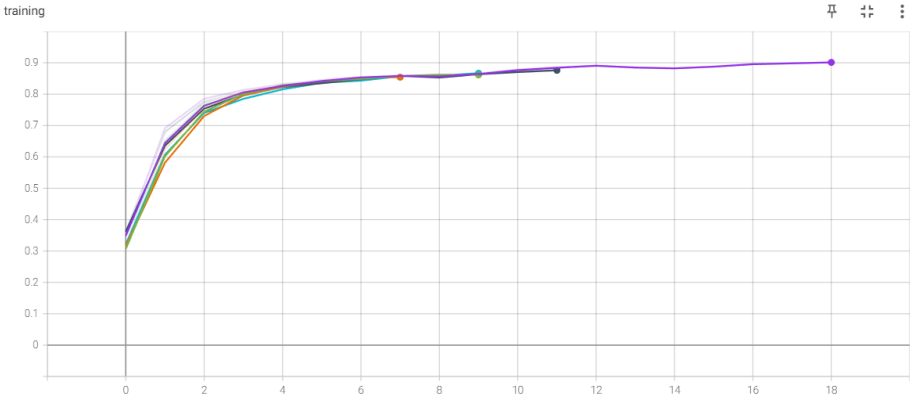

Fig 25. Network 2 Training Dice Score Curve – Right Side

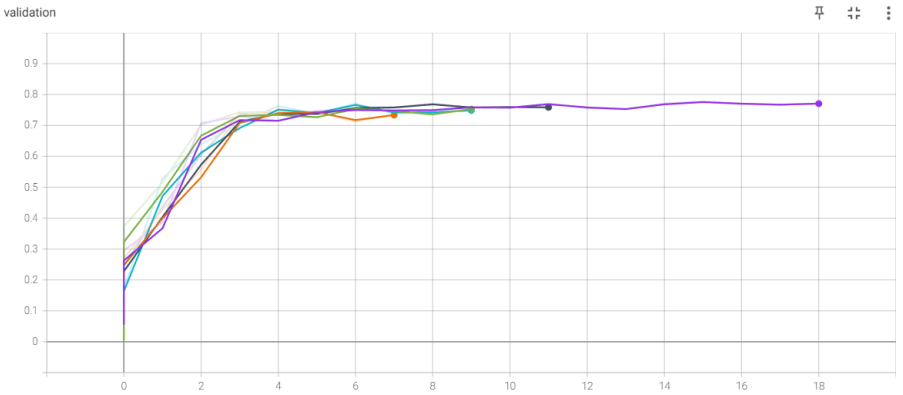

Fig 26. Network 2 Validation Dice Score Curve – Right Side

2.3 Results – Comparison with paper

Table 6. Comparison with paper scores

	Parotid Gland Left		Parotid Gland Right	
	Paper	Network	Paper	Network
Dice Score (%)	80.7 ± 2.2	74.64 ± 1.1	81.1 ± 2.6	75.05 ± 1.2

Table 7. Spatial Resolution Differences

Spatial Resolution	
Paper	Network
1x1x3 mm	3x3x3 mm

III. Discussion and Conclusions

Sum-up

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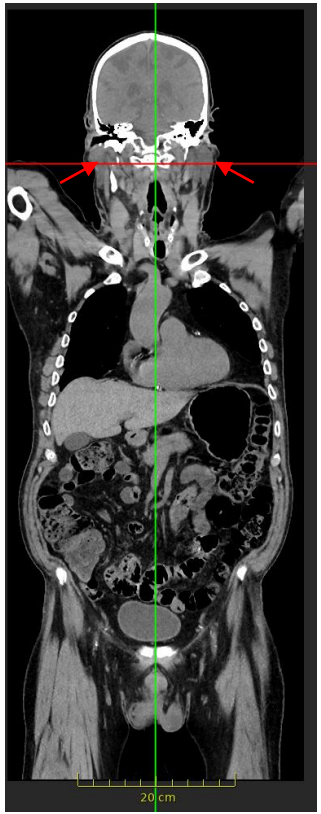
3.1 Tasks

- Literature Research
- Public Dataset of Salivary Glands with annotations
- Bounding Boxes Algorithm
- Development of segmentation architecture
  - Bounding Boxes
  - Pixel-Wise Segmentation

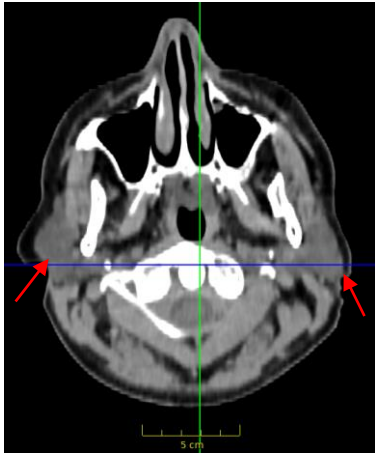
- Annotate IFL Dataset
- Apply model architecture in IFL Dataset

3.2 Future Work

- Run the model in Polyaxon
  - Apply Data augmentation
    - Translation and Rotation
  - Resample of 1x1x1mm
  - Change the windowing
  - Apply the architecture in submandibular glands
- Make the annotation in the IFL Dataset
  - Apply bounding box algorithm
  - Apply the model architecture
- Run both networks sequentially



a. Coronal View

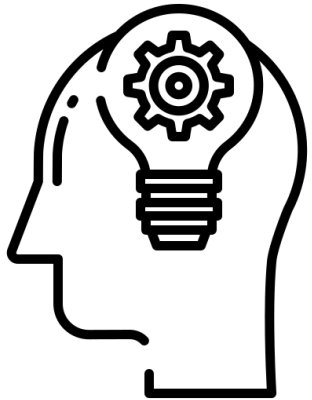


b. Axial View

Fig 27. IFL sample data

3.2 Lessons Learned

- Public annotated dataset
  - Challenging to found
  - Crucial for the project development
- IFL dataset annotation
  - Challenging
  - Time consuming
- Polyaxon
  - Good to run data with better spatial resolution
  - There is a Learning curve
- Clean and efficient code
- Weekly meetings
  - Helpful to solve doubts and problems



https://www.flaticon.com/de/kostenloses-icon/brainstorming_4341881

Thank You!
Any Questions?

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