Data analysis, modeling, and prediction of underperforming cochlear implant patients based on individual anatomy (CT), brain signals (EEG), and audiological tests

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Introduction

1. Understanding the causes for poor cochlear implantation outcomes is a difficult research challenge[1].

- Investigate both technological factors and biological factors.
- Combine audiological results and anatomical factors for understanding and ultimately predicting the outcomes of cochlear implantation.

2. Getting insight into a patient's specific anatomy through CT imaging of the temporal bone is critical for the otologists to perform cochlear implantation[2] ,but manually segmenting the anatomical structures[2] is difficult.

- Create a 3D automated classification and segmentation pipeline (on 3D temporal bone CT scan).
- Start with a 2D binary classification and localisation of single/multiple slice(s) of 3D CT scans (cochlear's presence).

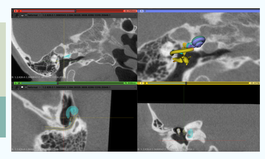
Methods

Data Preparation

Currently we have 10 anonymous patients manual segmented CT scan

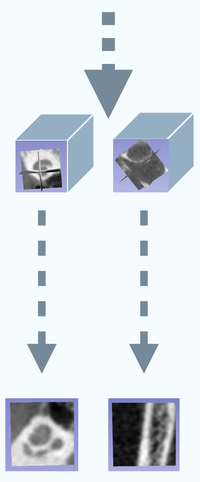
Manually segmenting(define fiducial points) on clinical 3D CT scans

Segmenting the cochlear (and other anatomical structures) on 3dSlicer



Crop 3D cochlear and background volume (model input data)

Cochlear volume: based on the manually defined fiducial points	Background volume: based on the random manually defined fiducial points

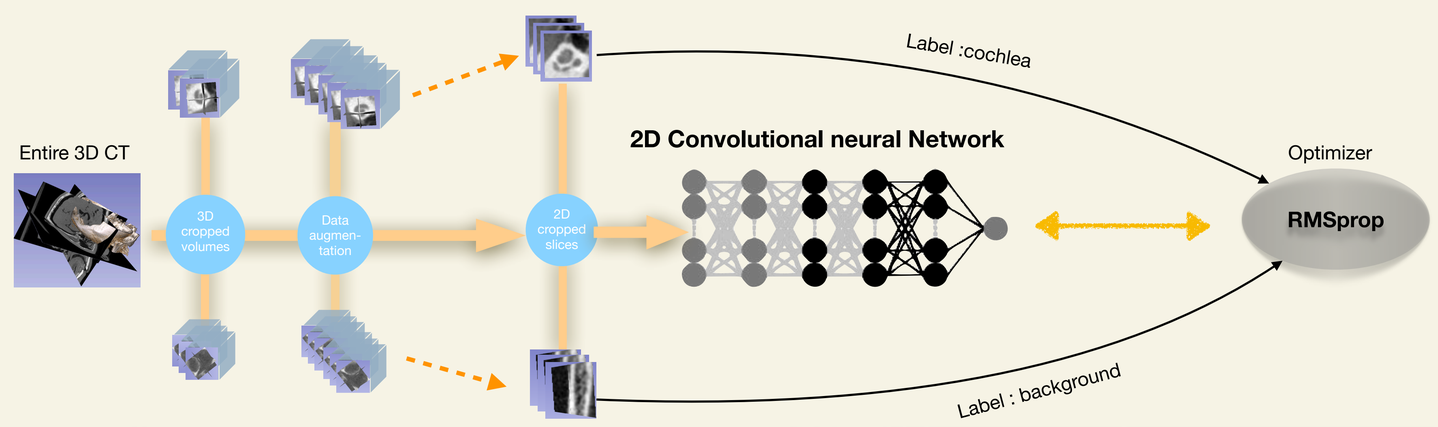


Data Augmentation

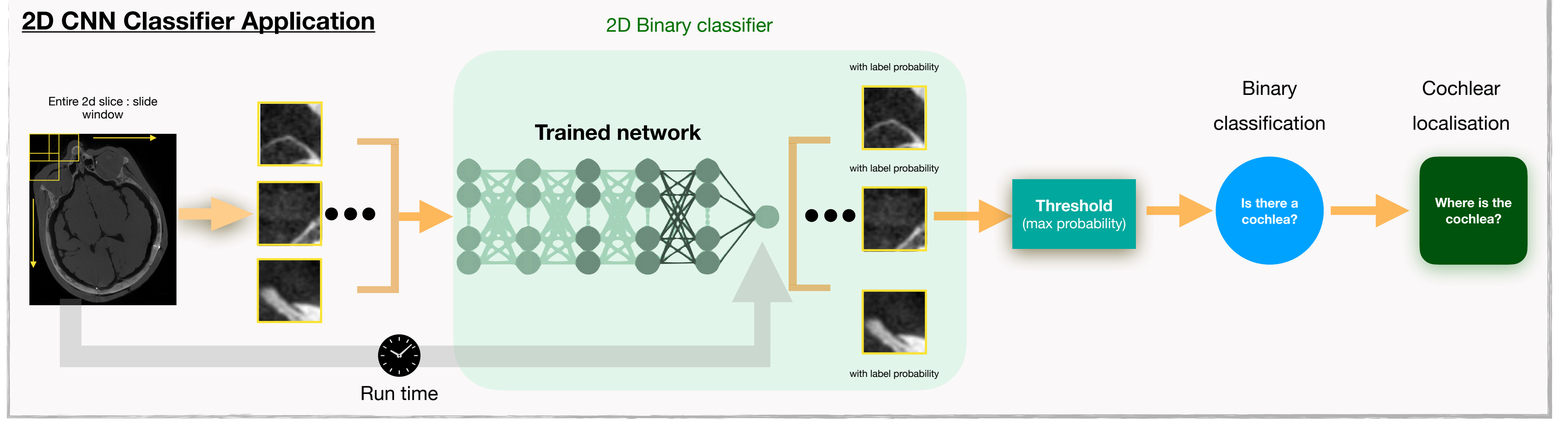
Crop 2d slice from augmented cropped 3D volume

Cochlear slice	Background slice

2D CNN Classifier Training

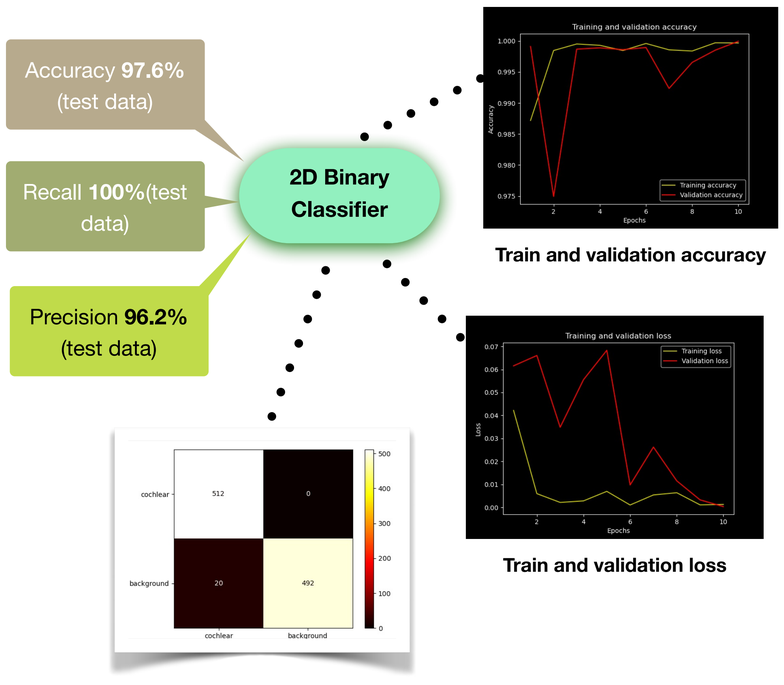


2D CNN Classifier Application

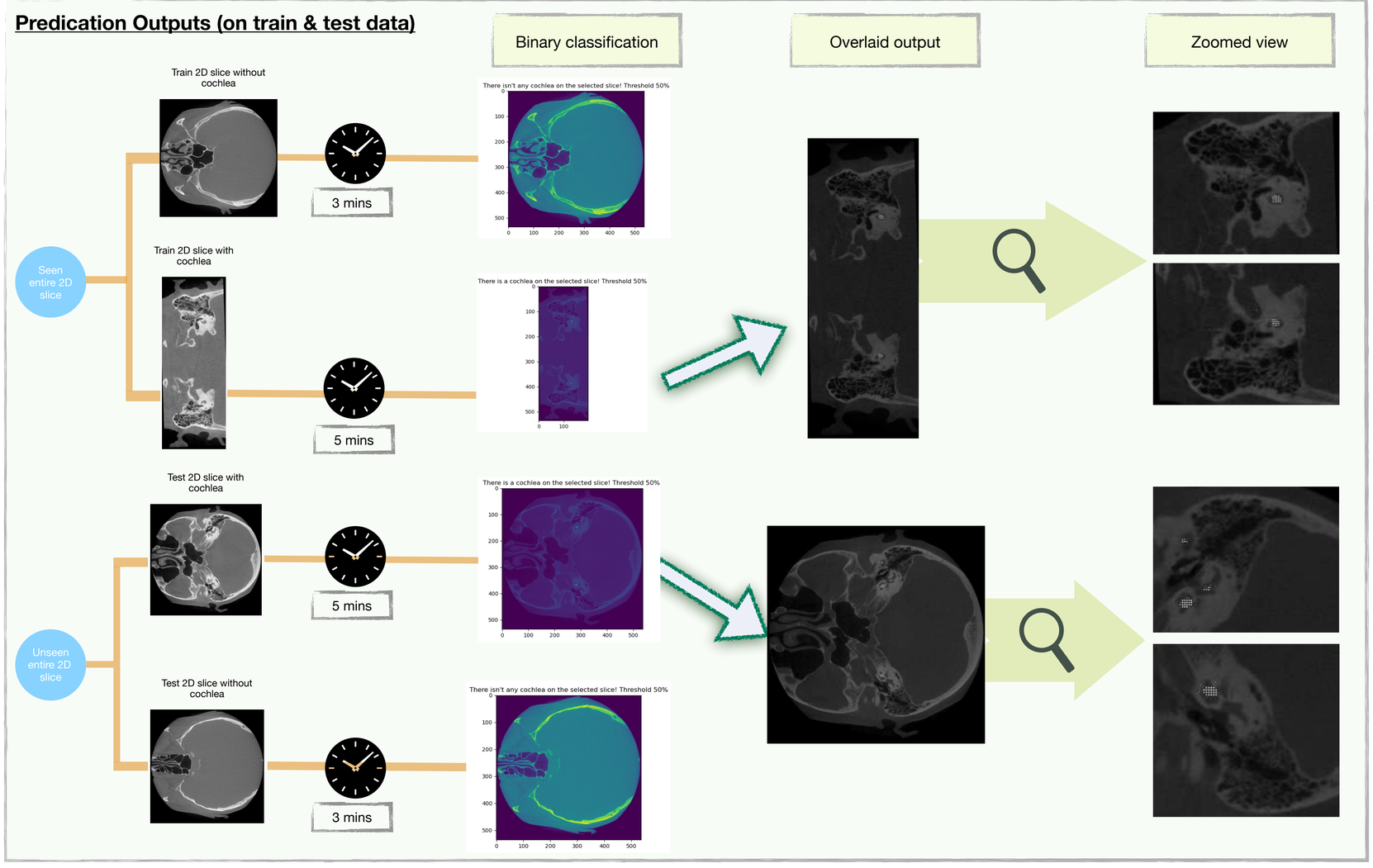


Results and Discussion

Binary Classifier



Predication Outputs (on train & test data)



Conclusions and future direction

- The results are preliminary.
- High 2D binary classification accuracy on CT scans from the same scanner.
- Resolution pyramid could be applied for speeding up the application of classifier (on 2D selected slice).
- More data sets and manual segmentation will be included.
- Combine 2D result to locate cochlea in 3D (apply 2D classifier on multiple slices).
- Build directly 3D classifier and apply it on 3D volumes (instead of 2D slices of 3D volumes).
- We may also load a parametrised 3D model of the cochlea based on the localisation of interested structure.

References:

1. Pisoni D. B., Kronenberger W. G., Harris M. S., Moberly A. C. (2017). Three challenges for future research on cochlear implants. World Journal of Otorhinolaryngology-Head and Neck Surgery, 3(4), 240–254. https://doi.org/10.1016/j.wjorl.2017.12.010
2. Neves C. A., Tran E. D., Kessler I. M., Blevins N. H. (2021). Fully automated preoperative segmentation of temporal bone structures from clinical CT scans. Sci Rep,11(1):116. https://doi.org/10.1038/s41598-020-80619-0

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