



Ecole Nationale  
Supérieure  
d'Ingénieurs  
de Tunis



# **MULTIMODAL SEGMENTATION OF HEAD AND NECK CANCER ORGANS AT RISK, USING DEEP LEARNING**

**Presented and publicly defended on : 09/05/2024**

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**In front of the jury :**

**Mrs. Ines ELOUEDI      President**

**Mrs. Afef KACEM ECHI   Supervisor**

**Academic Year: 2023-2024**

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**Introduction**



**State of the Art**



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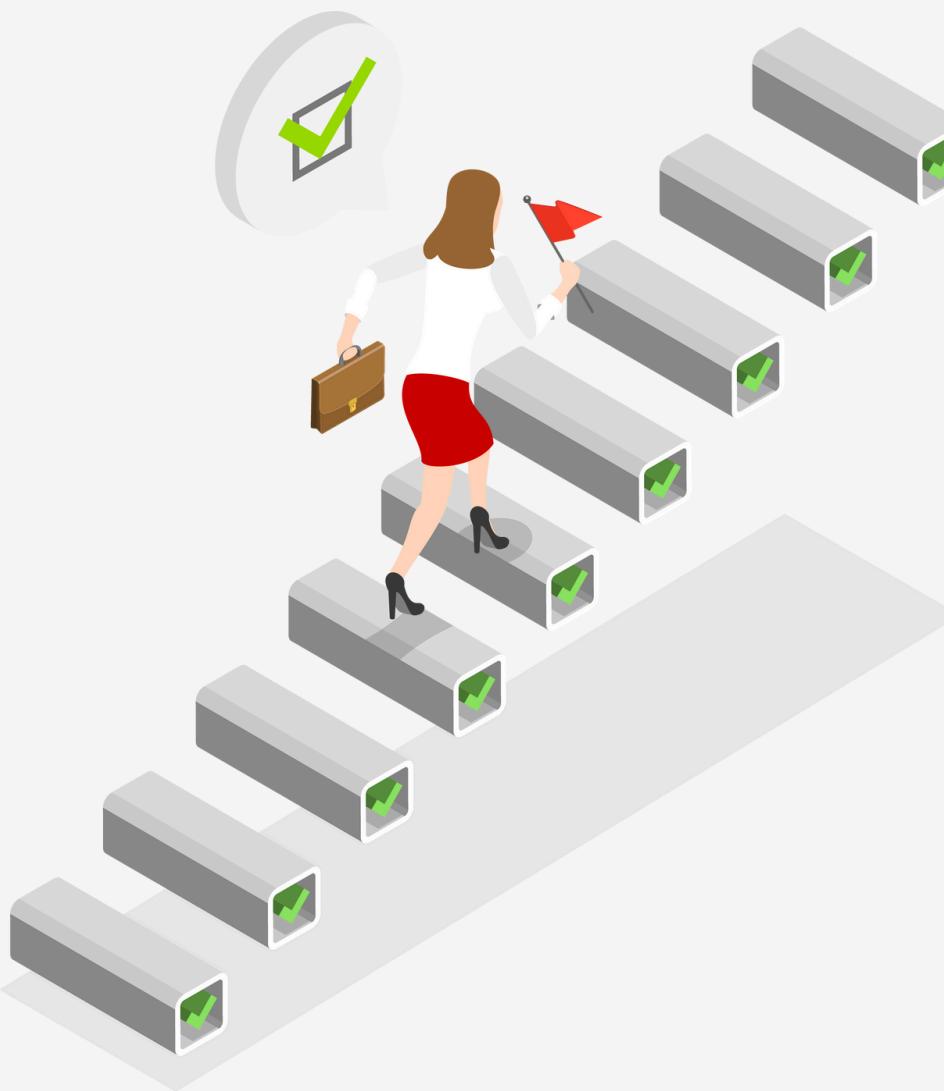
# INTRODUCTION



# Challenge purposes



**Identify Organs At Risk accurately & effectively**



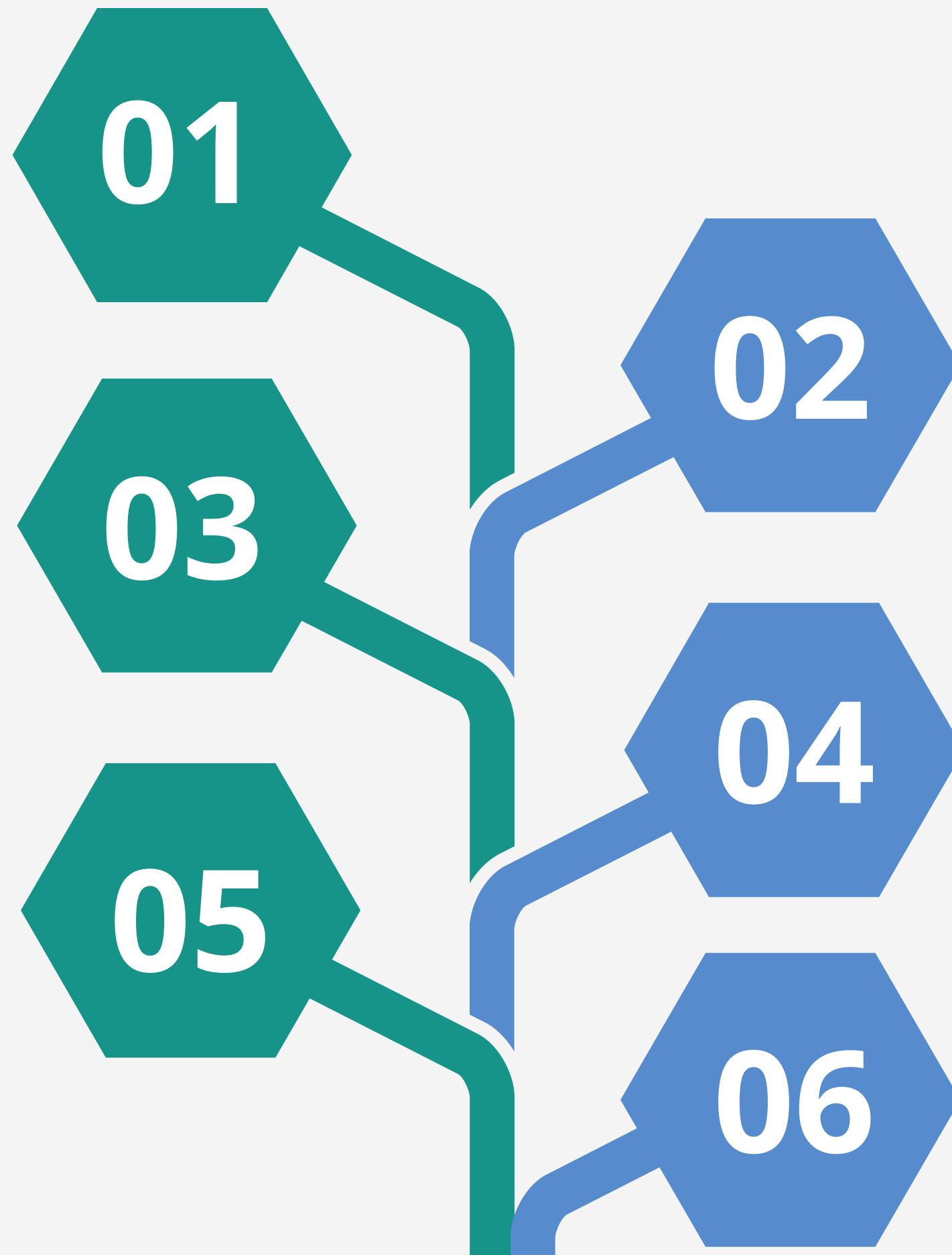
**Segmenting 30 Organs At Risk**

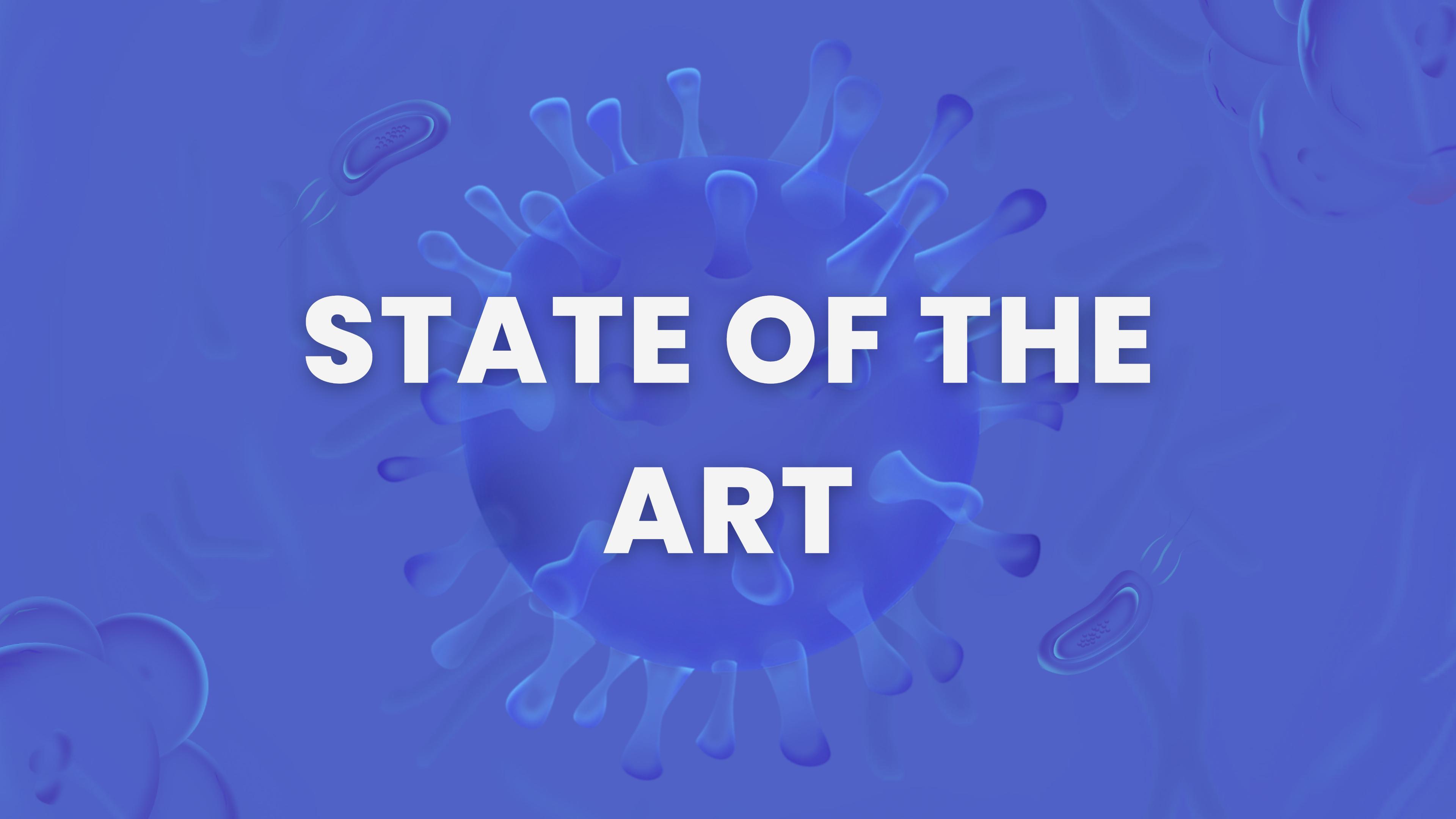


**Achieving multimodal segmentation  
using both CT and MRI images**

# Adopted Methodology

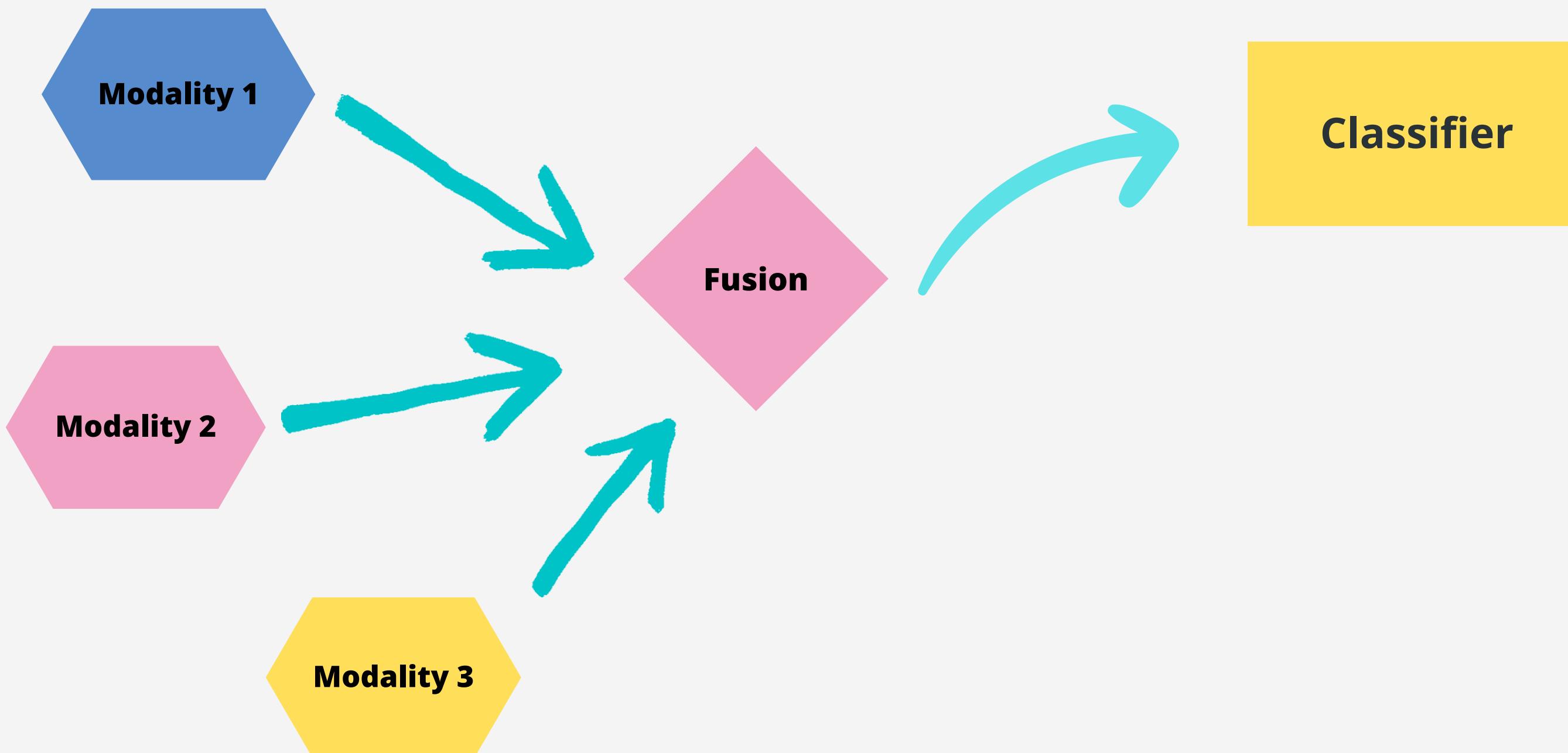
- 01 Business Understanding
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- 04 Modeling
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- 06 Deployment



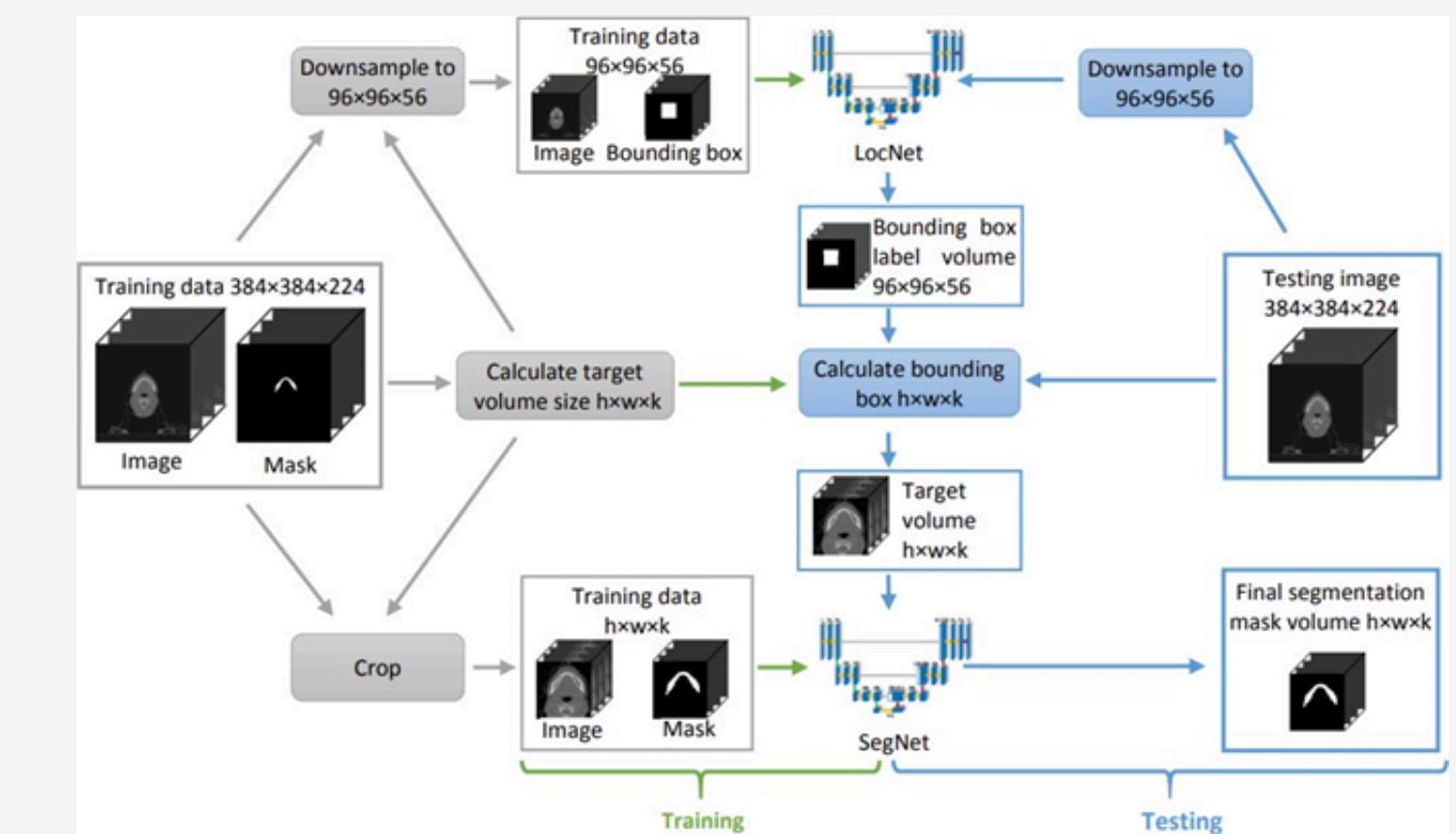
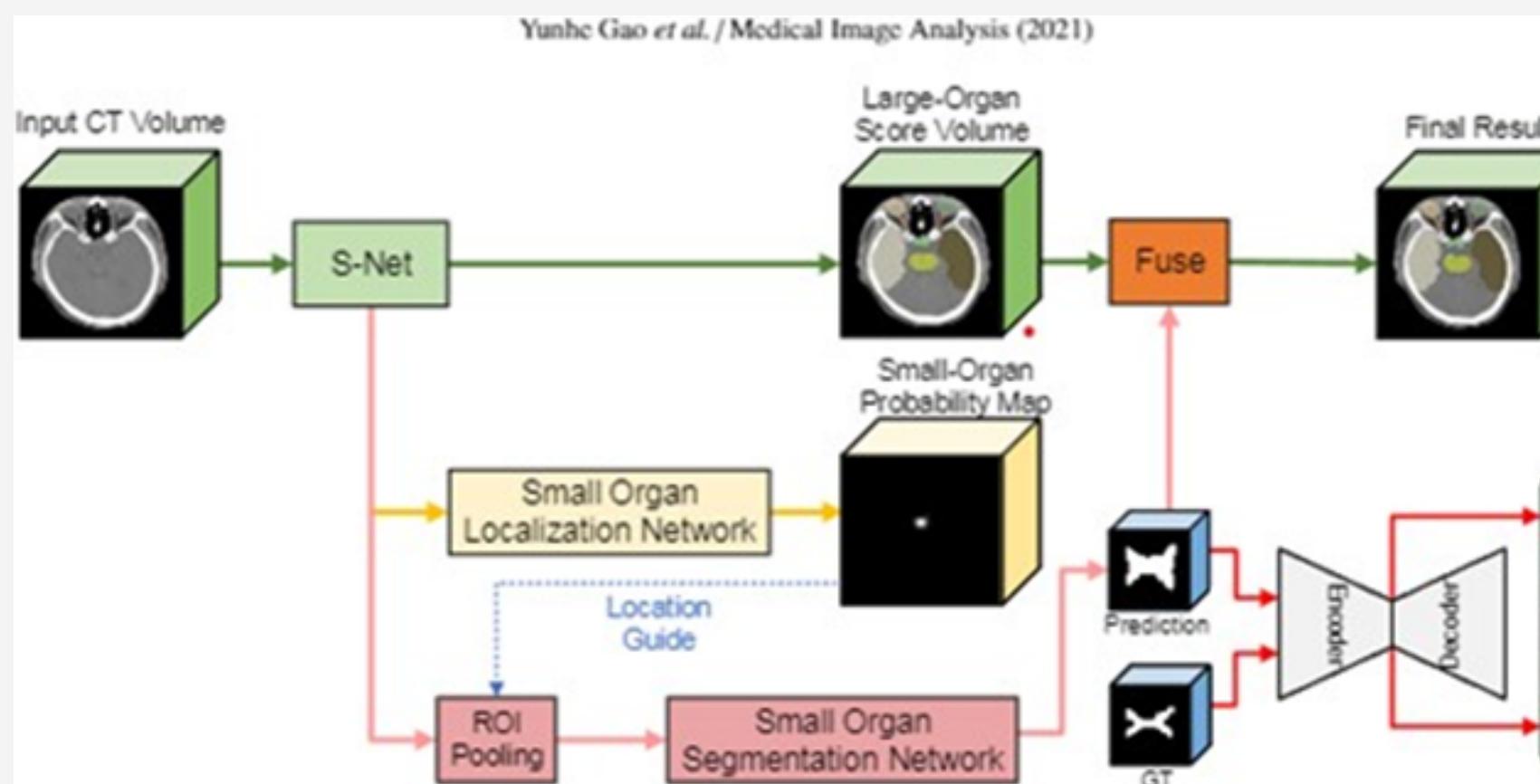


**STATE OF THE  
ART**

# Deep Learning-based Segmentation Strategies



# Deep Learning-based Segmentation Strategies



# Different architectures limits



**Limited shape constraints for small organs due to sampling imbalance.**



**Complexity of multi-step training process**



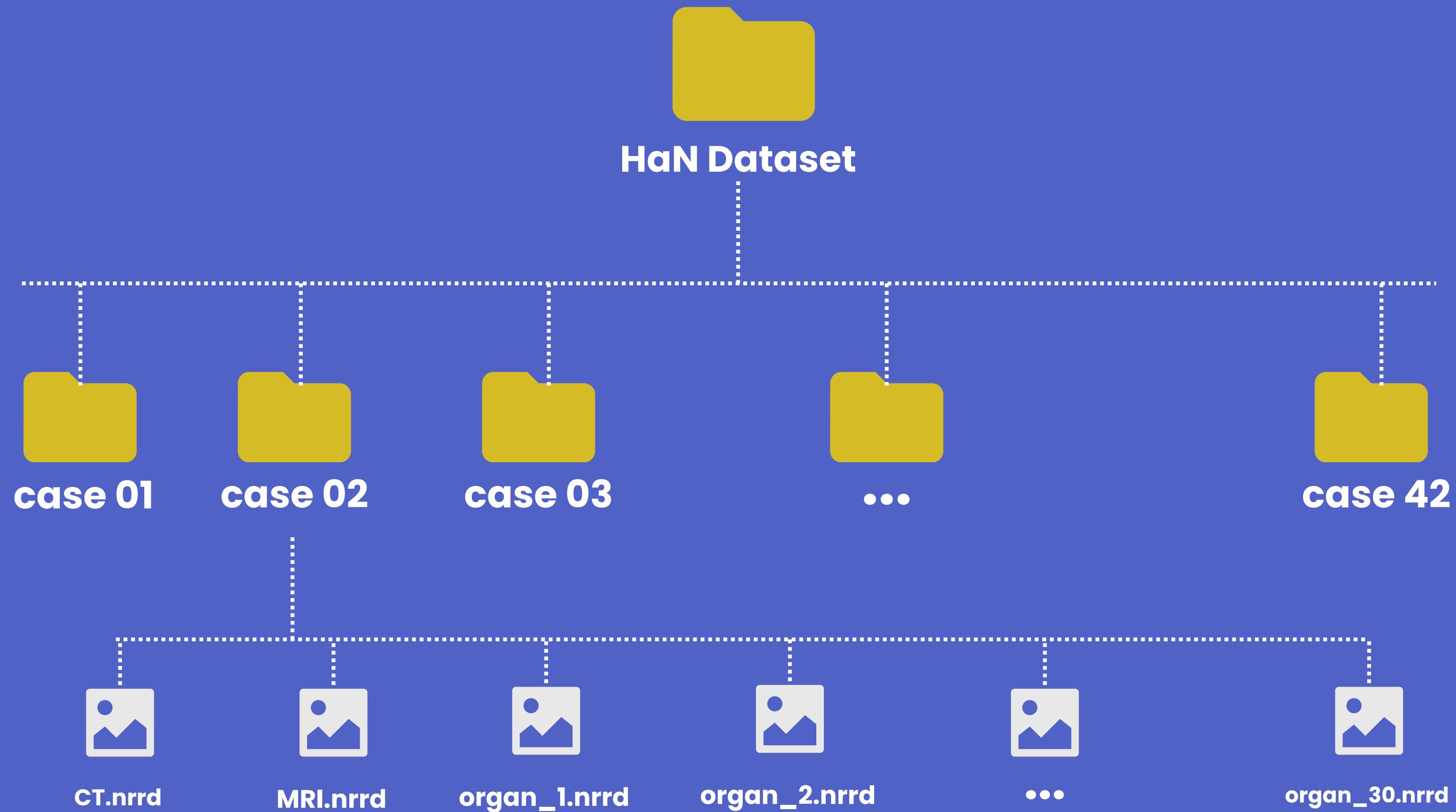
**Memory limitations when processing high-resolution images**



**Downsampling**

# DATA UNDERSTANDING

# 1- PARTITION



## 2-VISUALIZATION

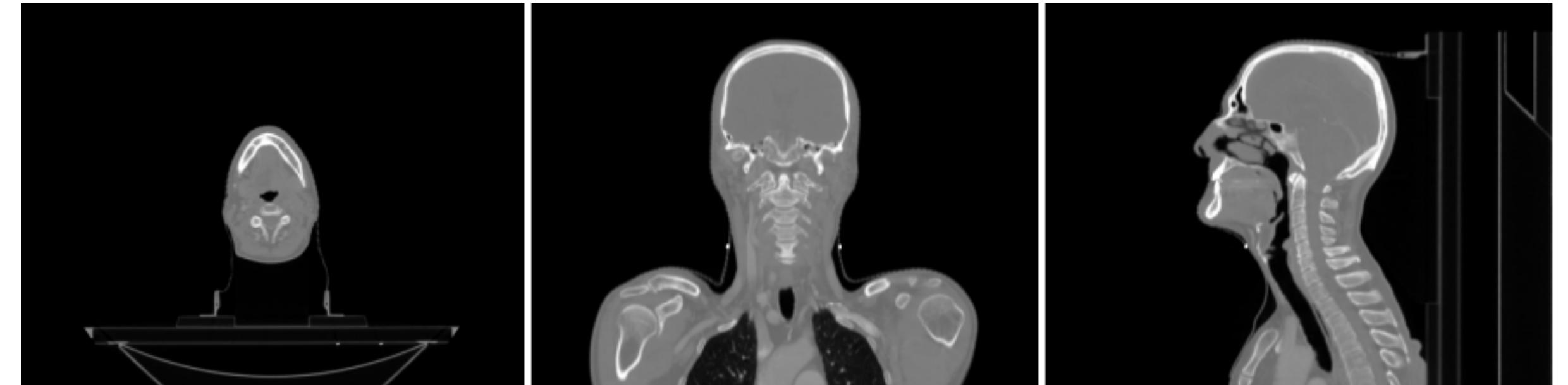
### CT - CASE 01:

**AXIAL**

**CORONAL**

**SAGITTAL**

1024



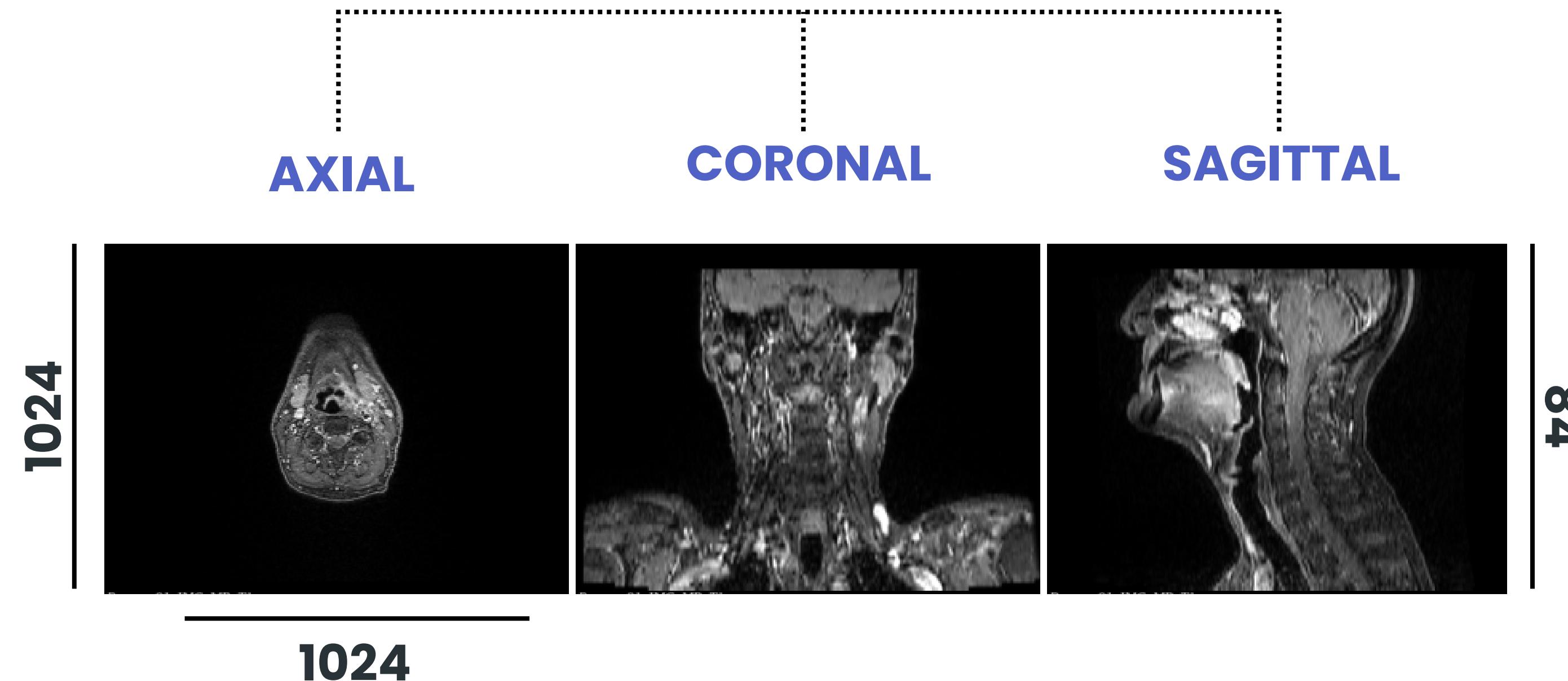
202

1024



## 2-VISUALIZATION

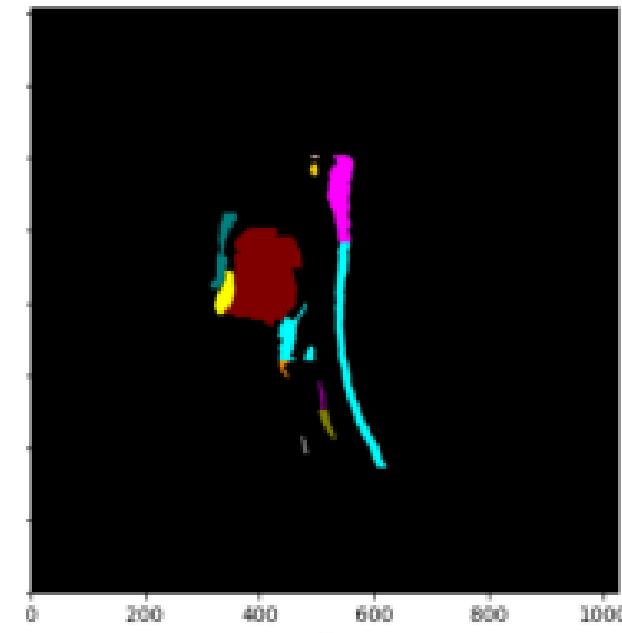
### MRI+ - CASE 01:



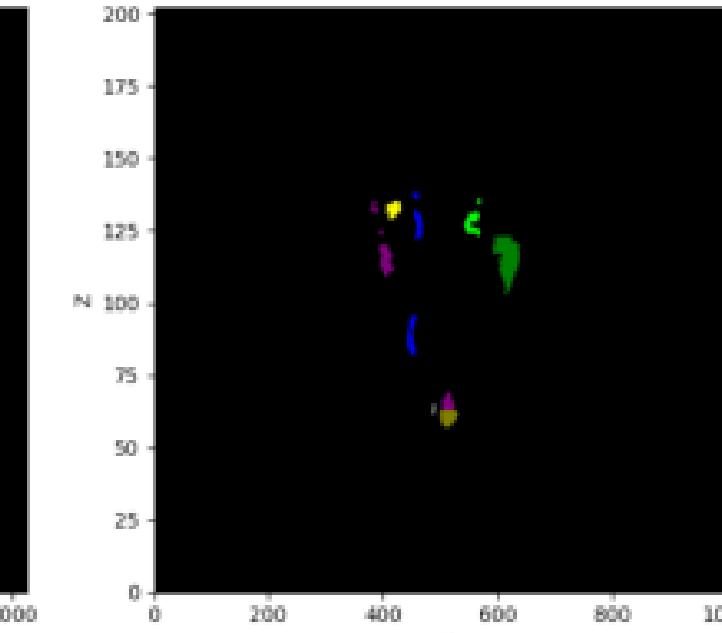
# 3-MASK MAP

## FULL MASK

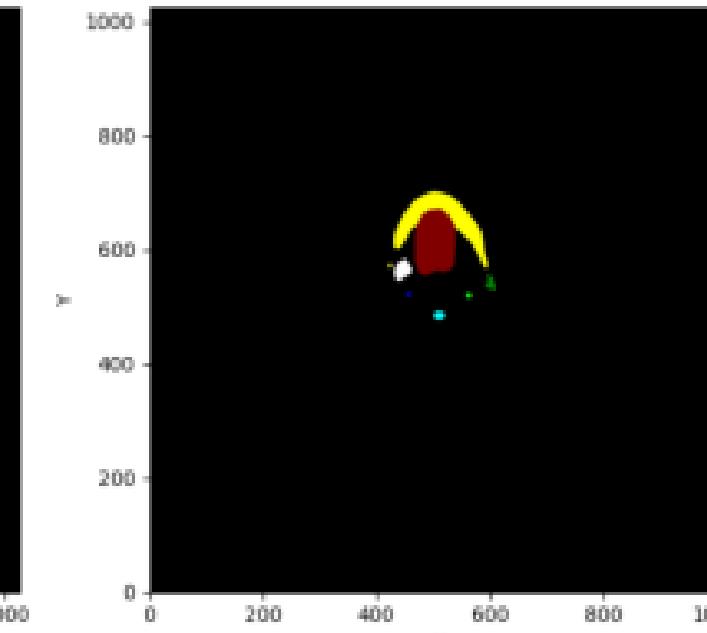
SAGITTAL



CORONAL



AXIAL



# DATA CHALLENGES

01

MISSING MASKS

02

Modalities-  
Related Issues

03

CLASS IMBALANCES

Uncentered Masks

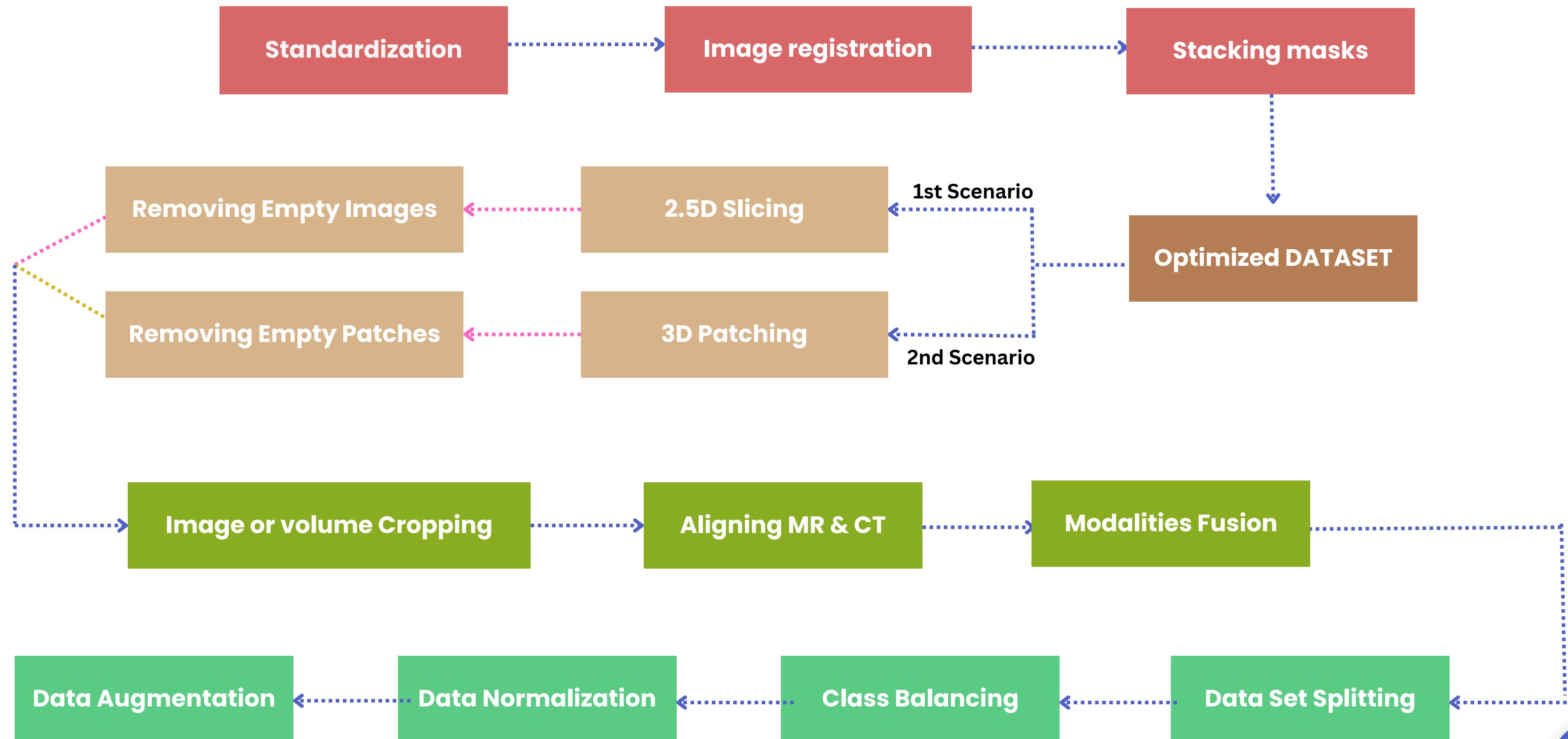
Image Size Discrepancy

Image Intensity Disparities



# **DATA PREPARATION**

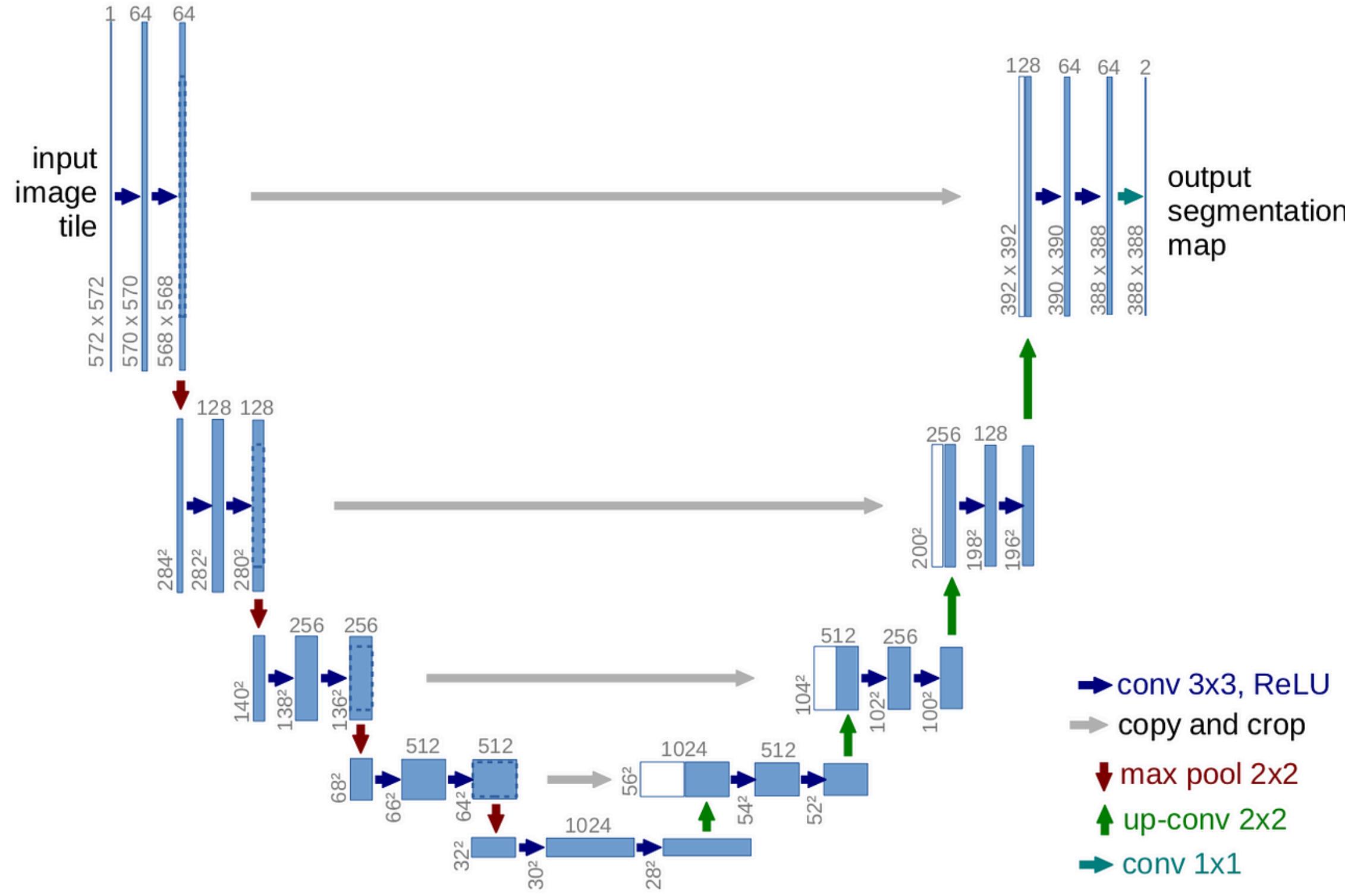
# DATA PREPROCESSING PIPELINE



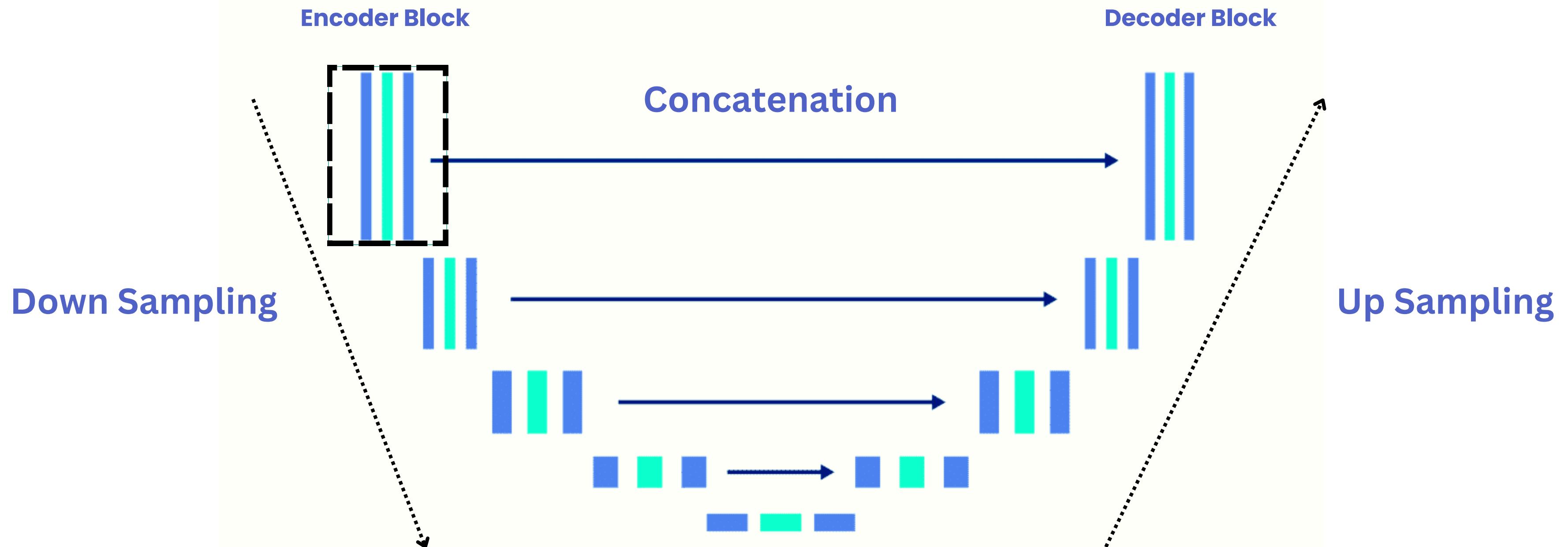
# MODELING

# UNET ARCHITECTURE

from the official paper



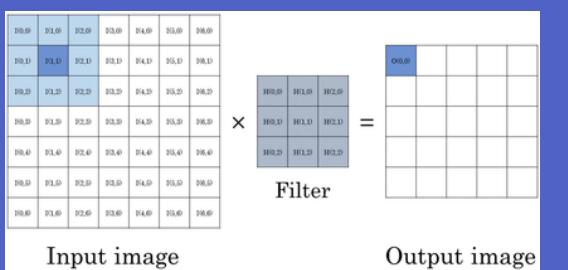
# UNET ARCHITECTURE



# ENCODER

- **Convolutional Layer**

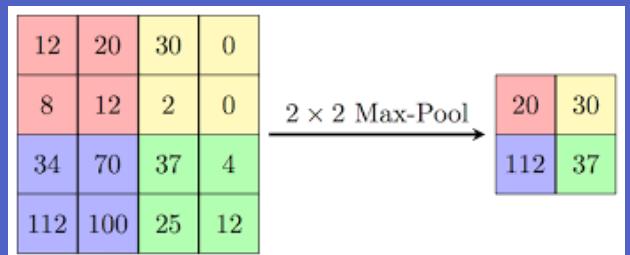
For feature extraction



**Encoder:** Feature extraction layer.

- **Max Pooling**

Downsampling using maximum



**Batch normalization:** Normalize activations within batches

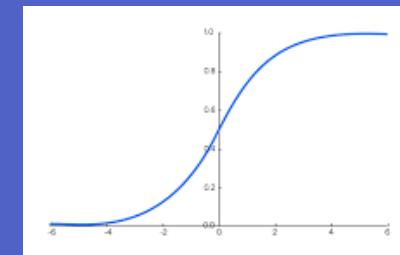
# DECODER

- **Transpose:** to upsample feature maps.

**Concatenation:** To concatenate feature maps.

- **Activation Layer:**

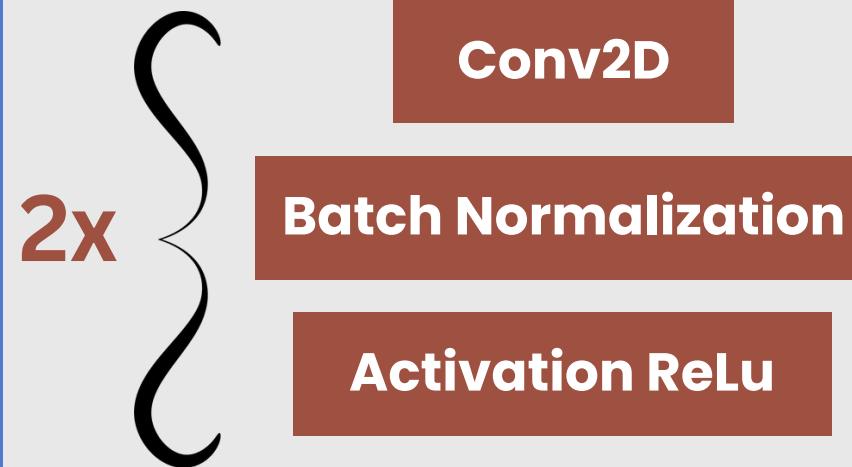
To introduce non linearity



**Decoder:** Reconstruction layer.

## Encoder Block

**Conv block (number filters = 64)**



**Max Pooling 2D**

## Central Block (Bridge)

**Conv2D**

**Concatenate (x, skip)**

**Conv block (number filters = 64)**

**Conv2D**

**Batch Normalization**

**Activation ReLu**

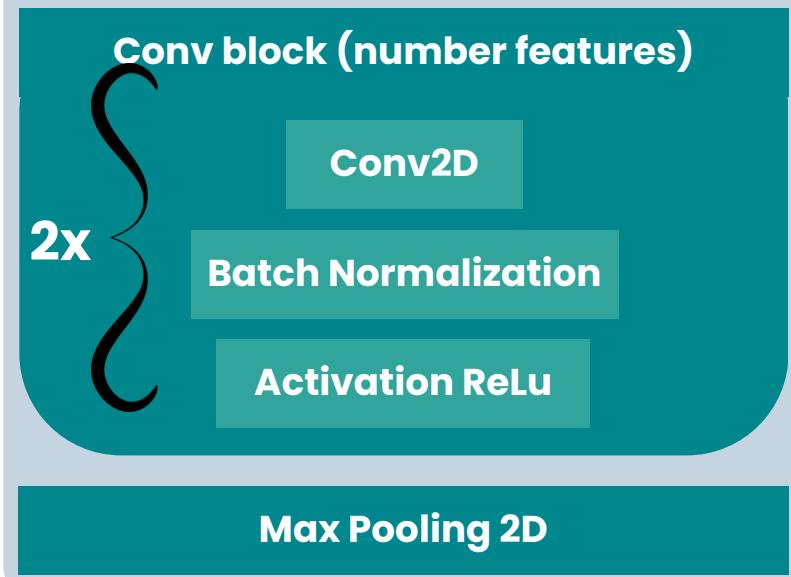
## Outputs

**Conv block**

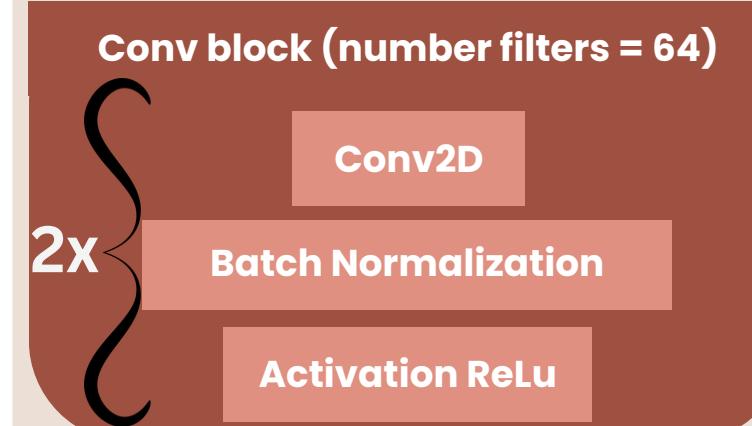
**Conv2D**

**Activation Softmax**

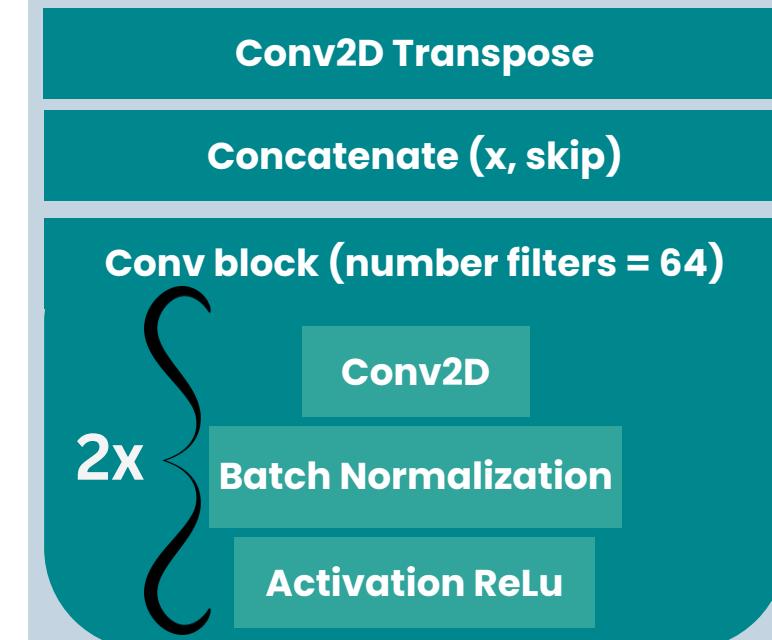
## Encoder Block

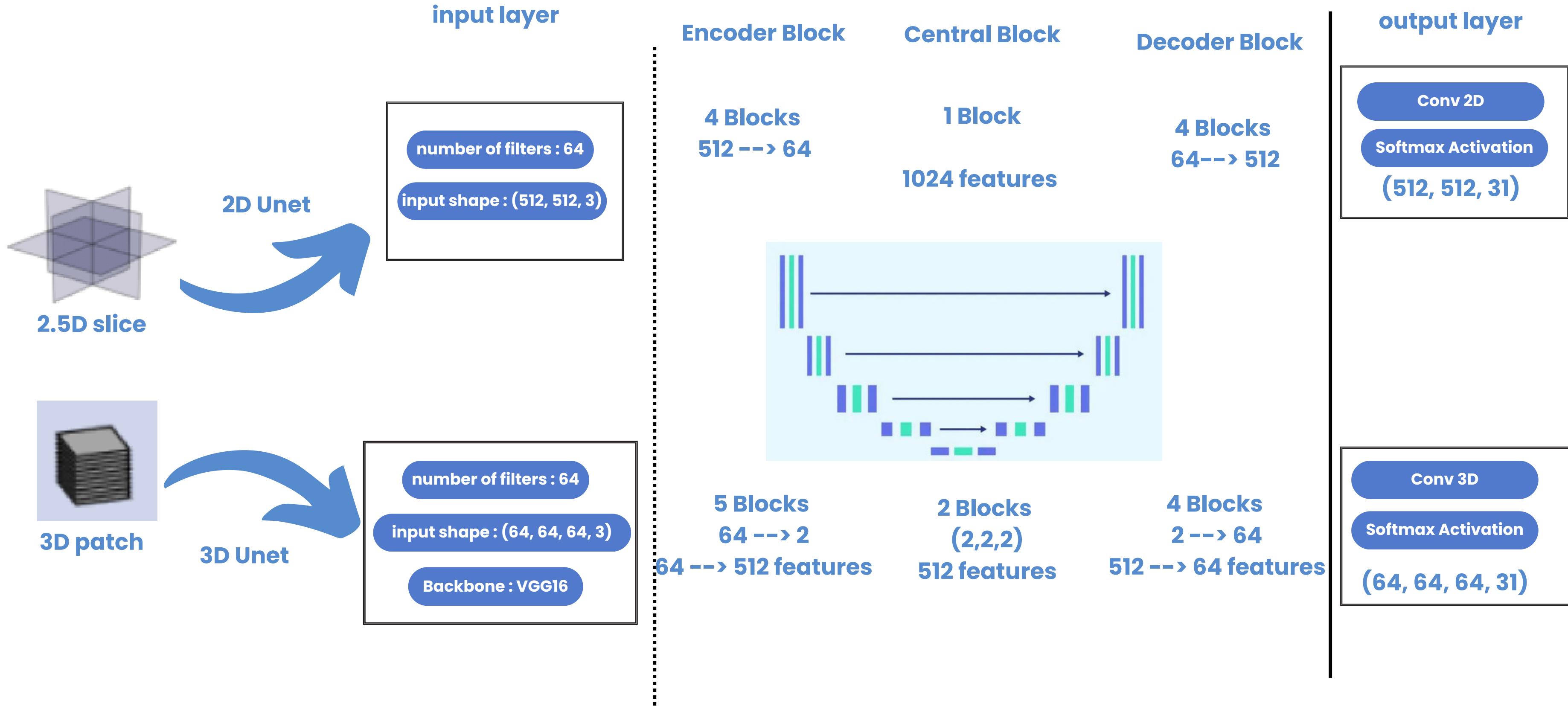


## Central Block (Bridge)



## Decoder Block





# Compiling

monitoring and optimizing the training process of machine learning models

**categorical focal cross-entropy**

Used To deal with class imbalances

**Optimizer**

Adam

# Training callbacks

monitoring and optimizing the training process of machine learning models

**Checkpoints**

save the model progress periodically,  
useful in case of interruptions

**learning rate reduction**

dynamic rate from validation loss trend  
with 5 epochs patience

**CSV logging**

records key training metrics

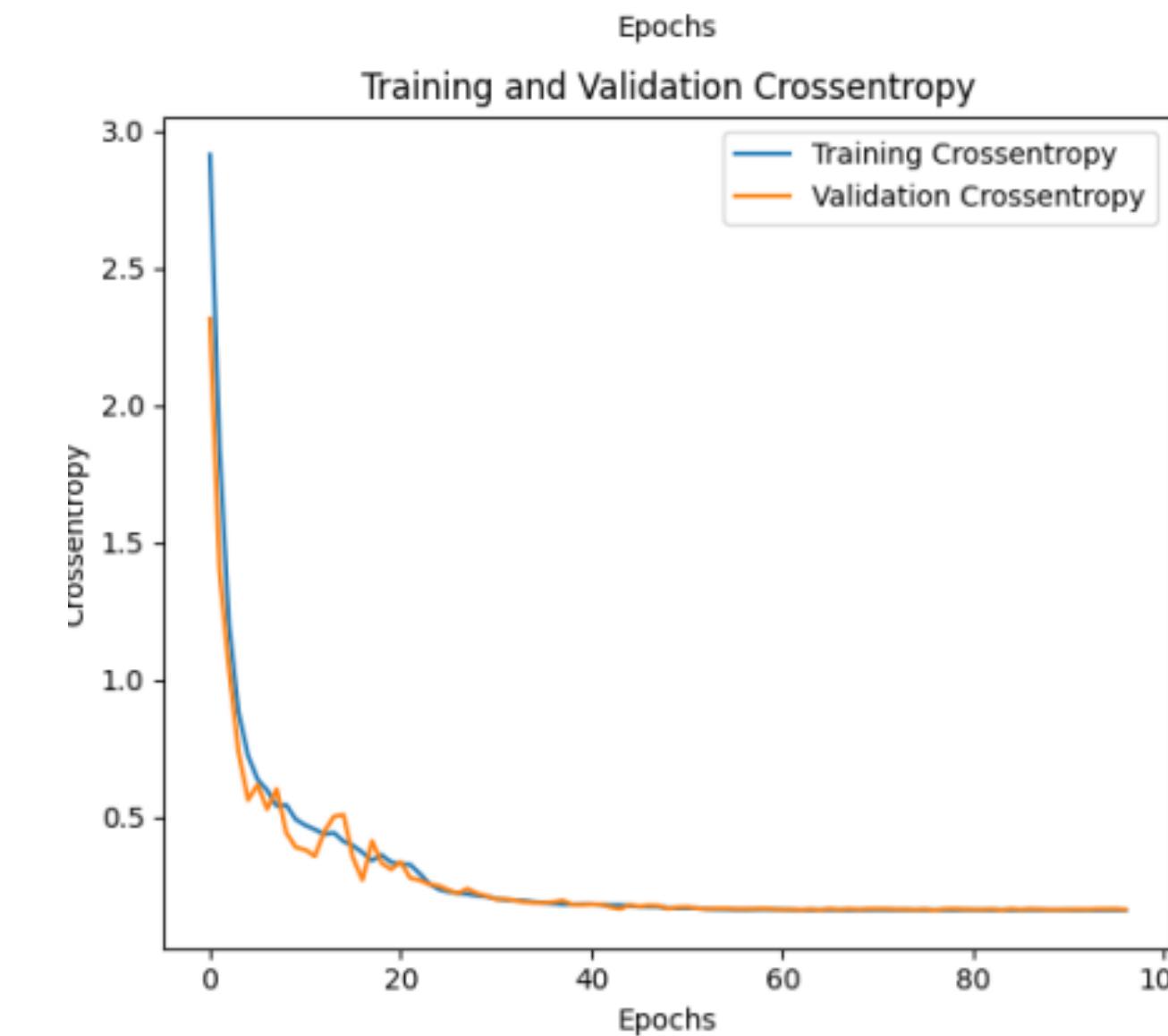
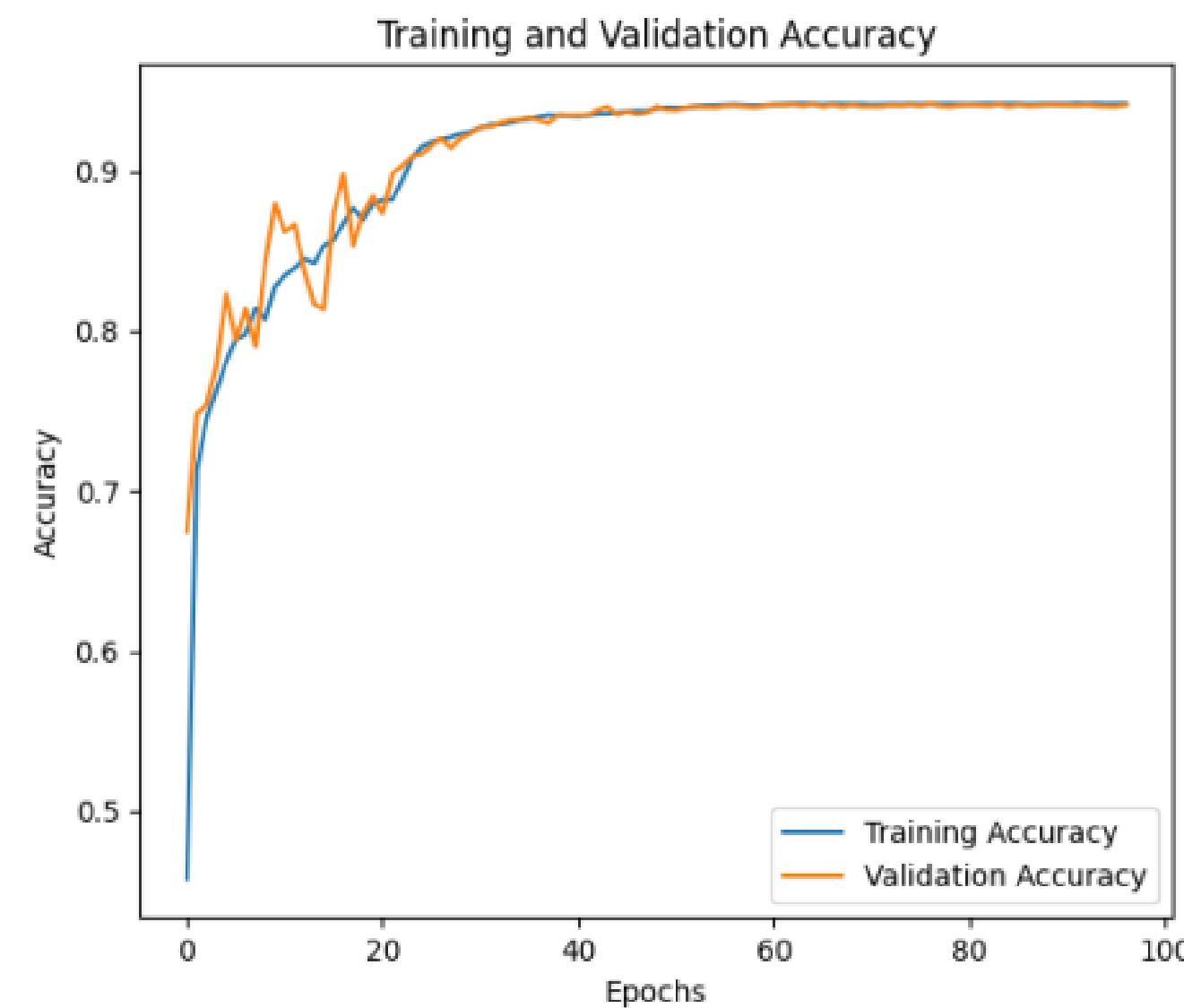
**Early stoping**

prevents overfitting with a patience of 20 epochs



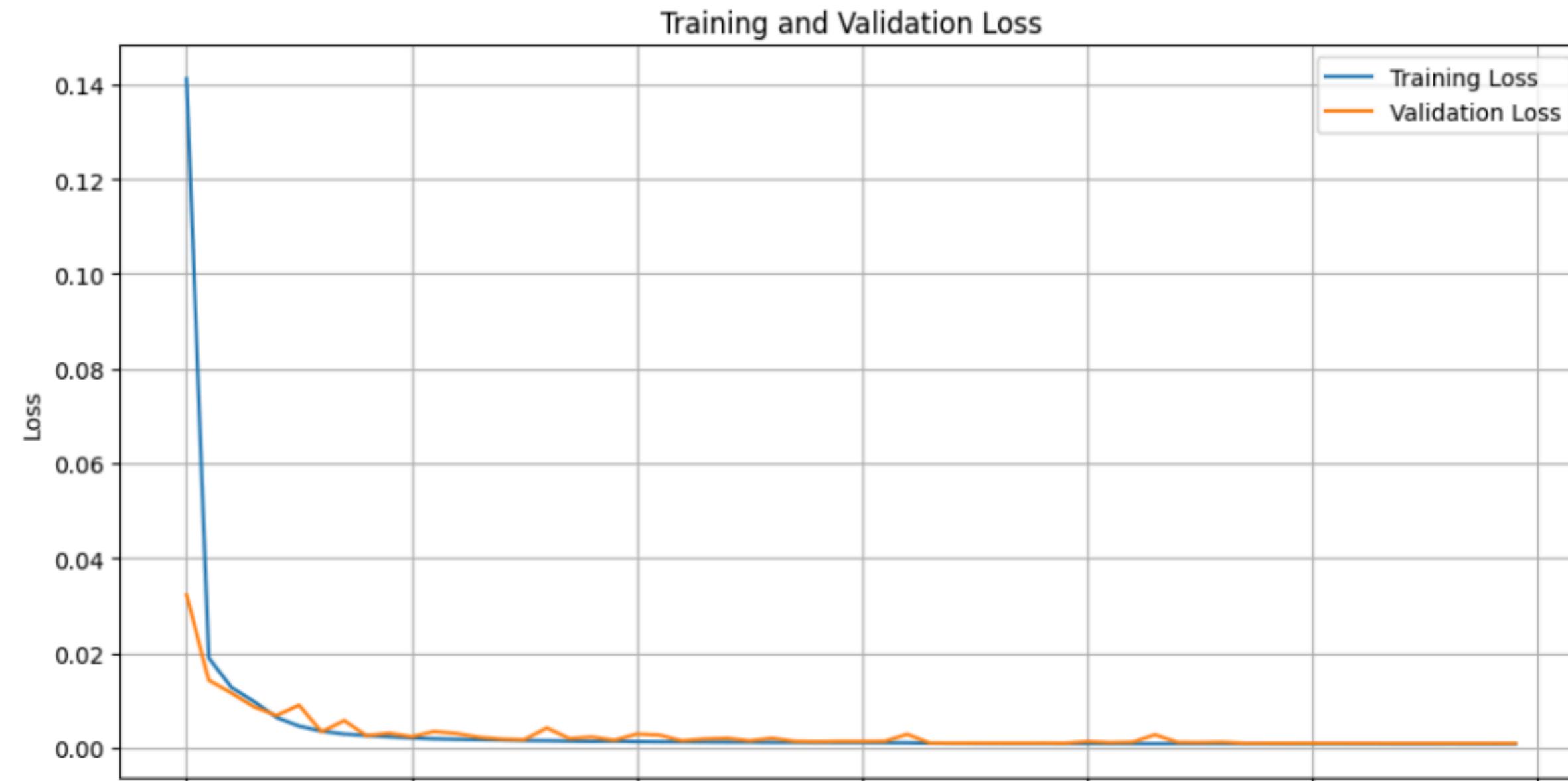
# TRAINING

# TRAINING RESULTS



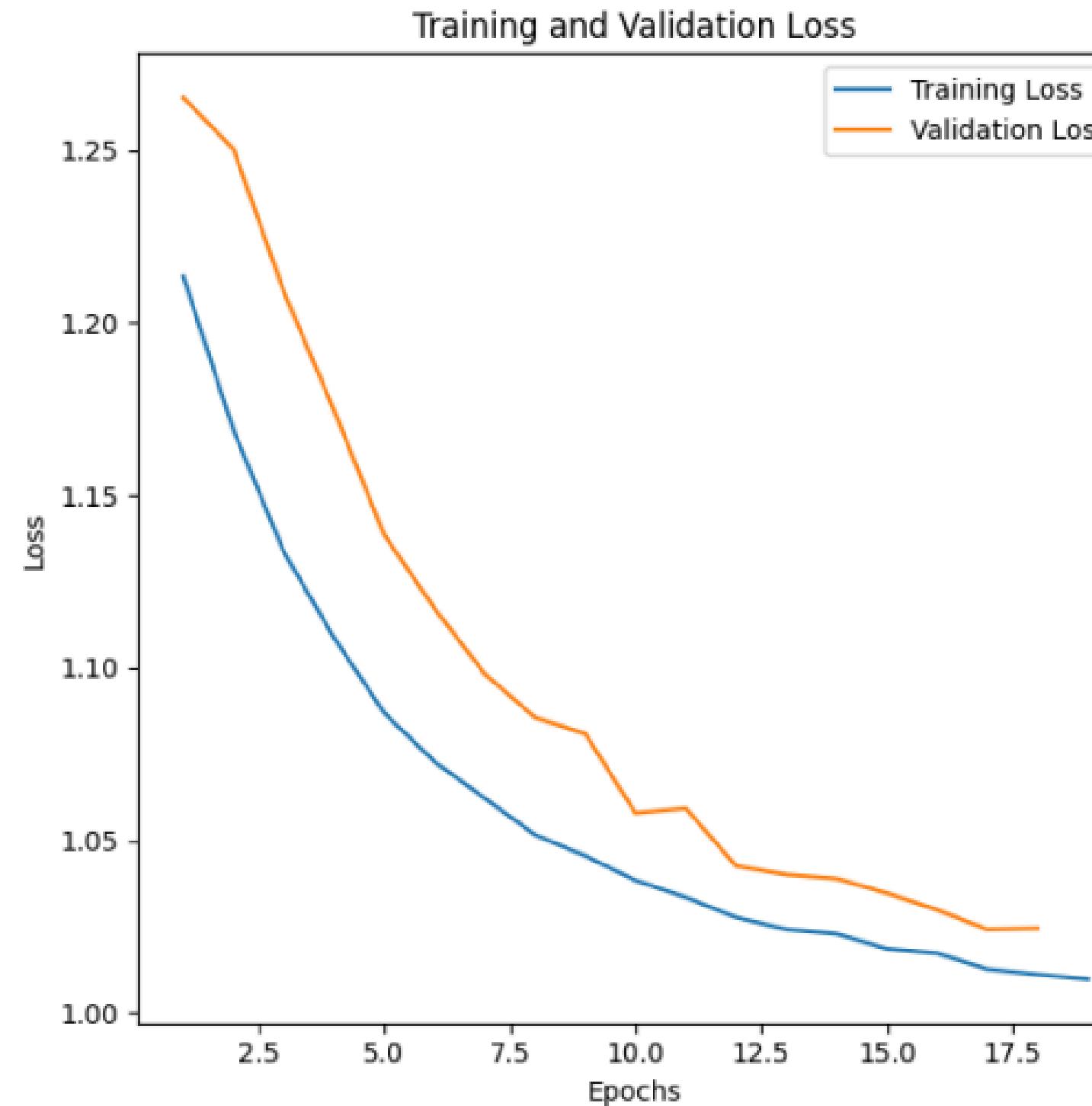
2D Unet training

# TRAINING RESULTS

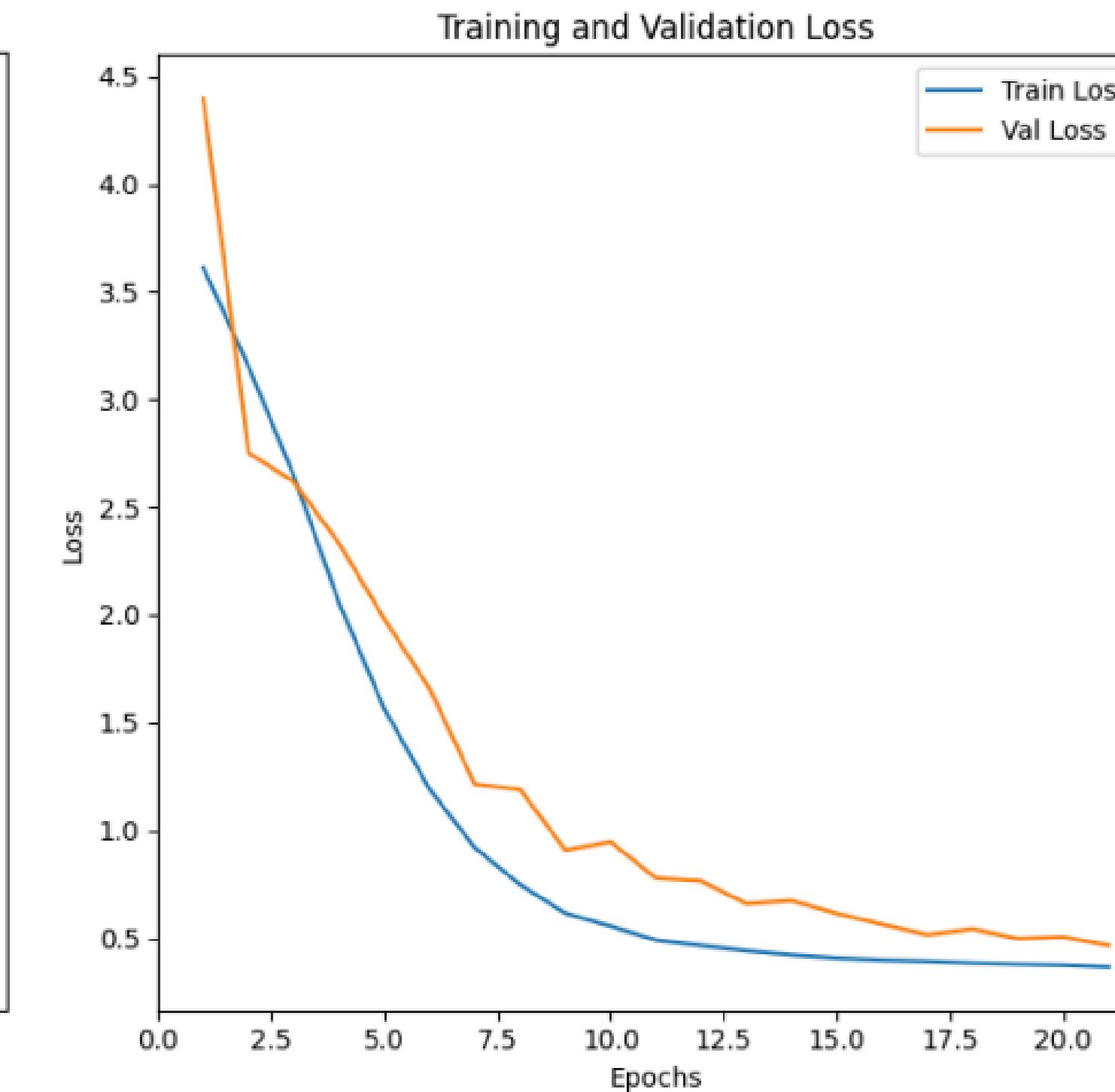


2D Unet loss graph

# TRAINING RESULTS



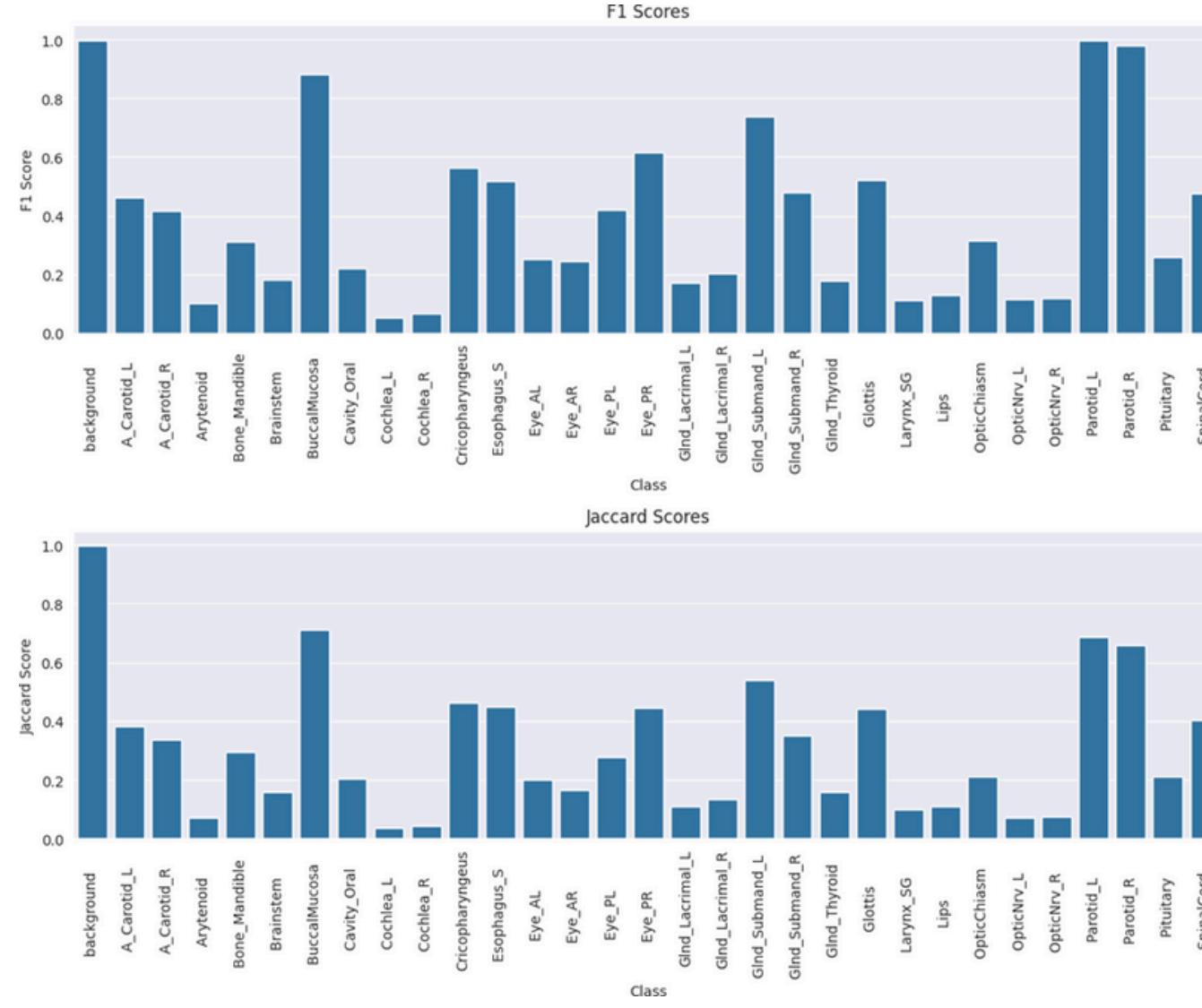
3d training with 64 patches



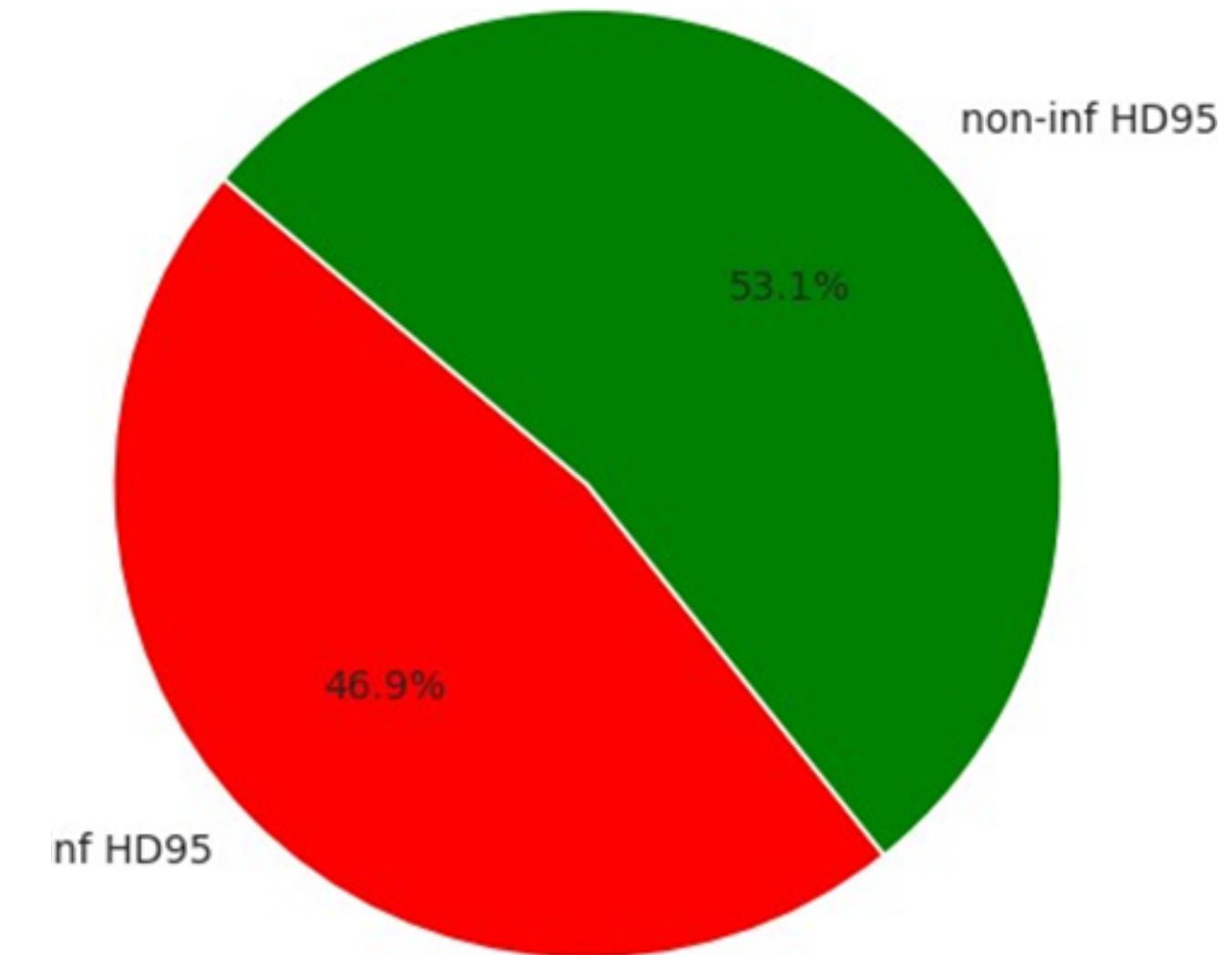
3d training with 128 patches

# EVALUATION

# MODEL SCORES

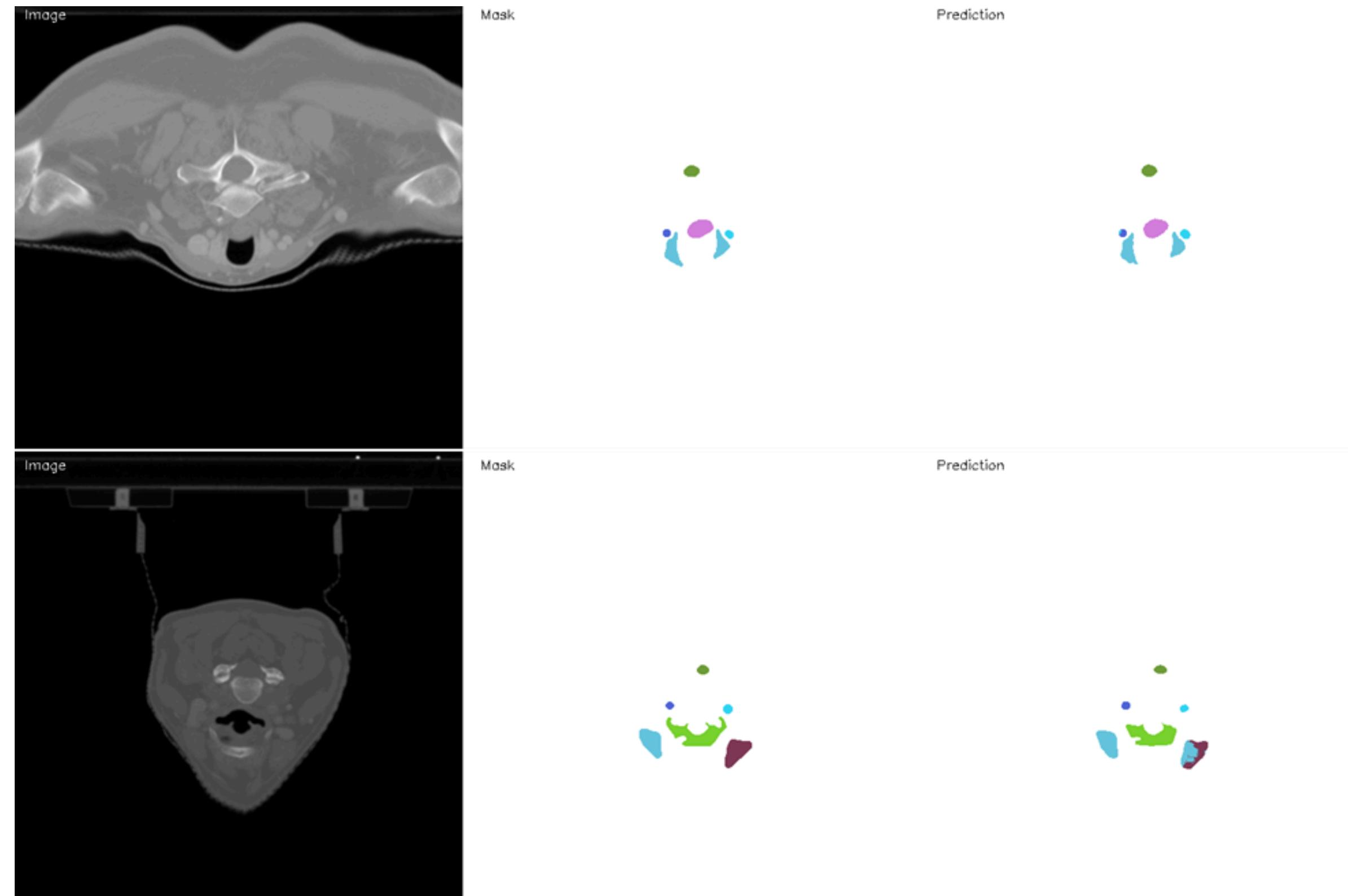


**F1 score and Jaccard index**



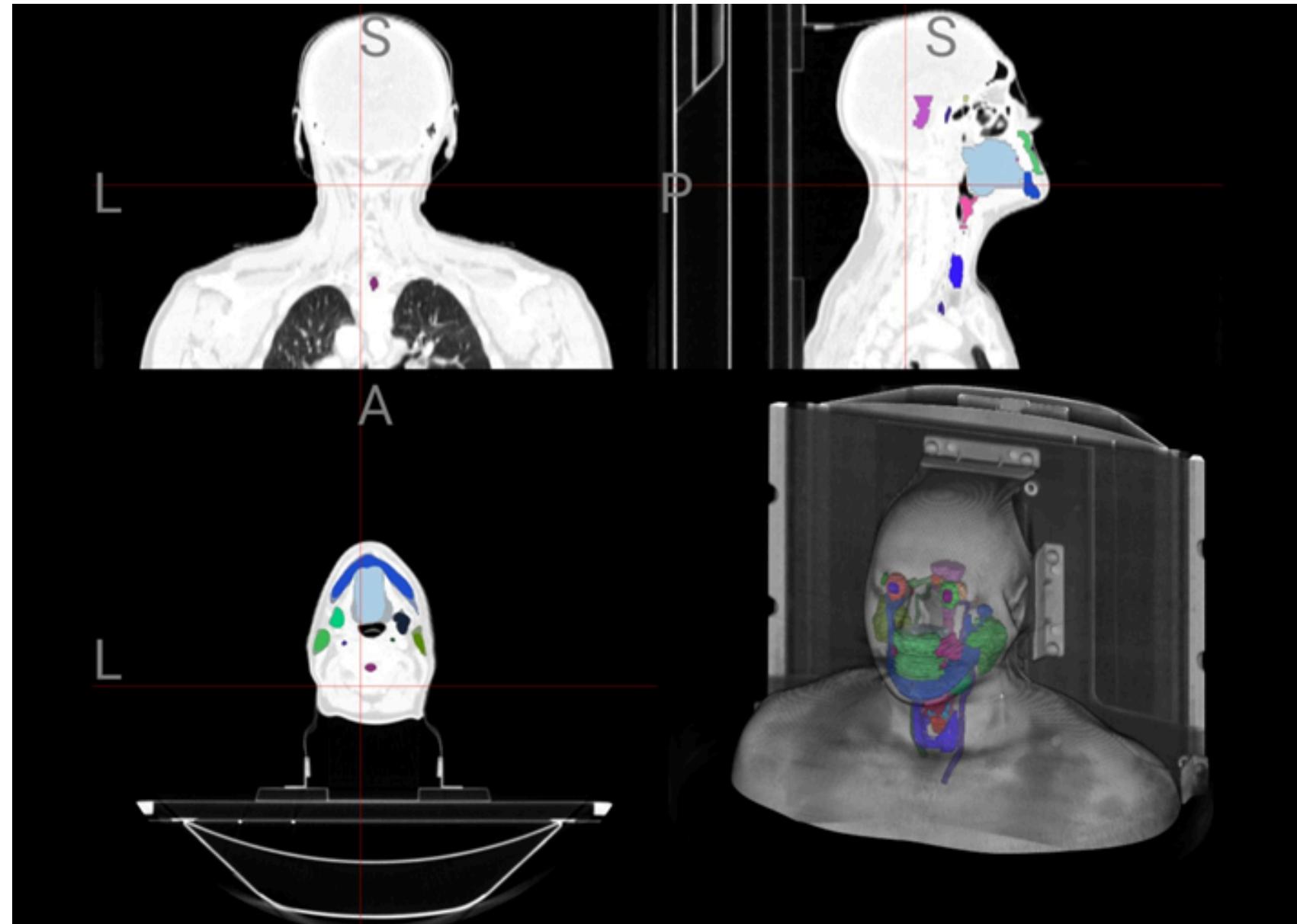
**Percentage of classes based on Hausdorff distance metric**

# MODEL PREDICTION



Model performance on 2D images

# CASE PREDICTION



# **EXPERIMENTATION AND RESULTS**

The background features a dark blue gradient with various abstract, translucent blue shapes resembling organic molecules or cellular structures. A central rectangular area is left white to contain the main title text.

# Work environment

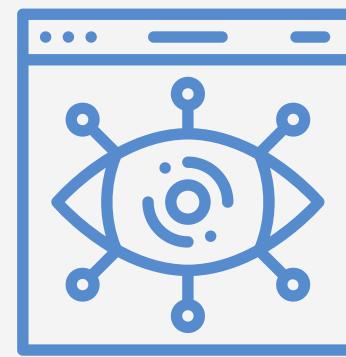
- Brand: DELL
- RAM: 32.0 GB
- Processor: 13th generation Intel Core i7
- GPU: NVIDIA RTX 4060
- Operating System: Windows 11



git



# Deployment process



01

Initial  
Deployment

02

Performance  
Optimization

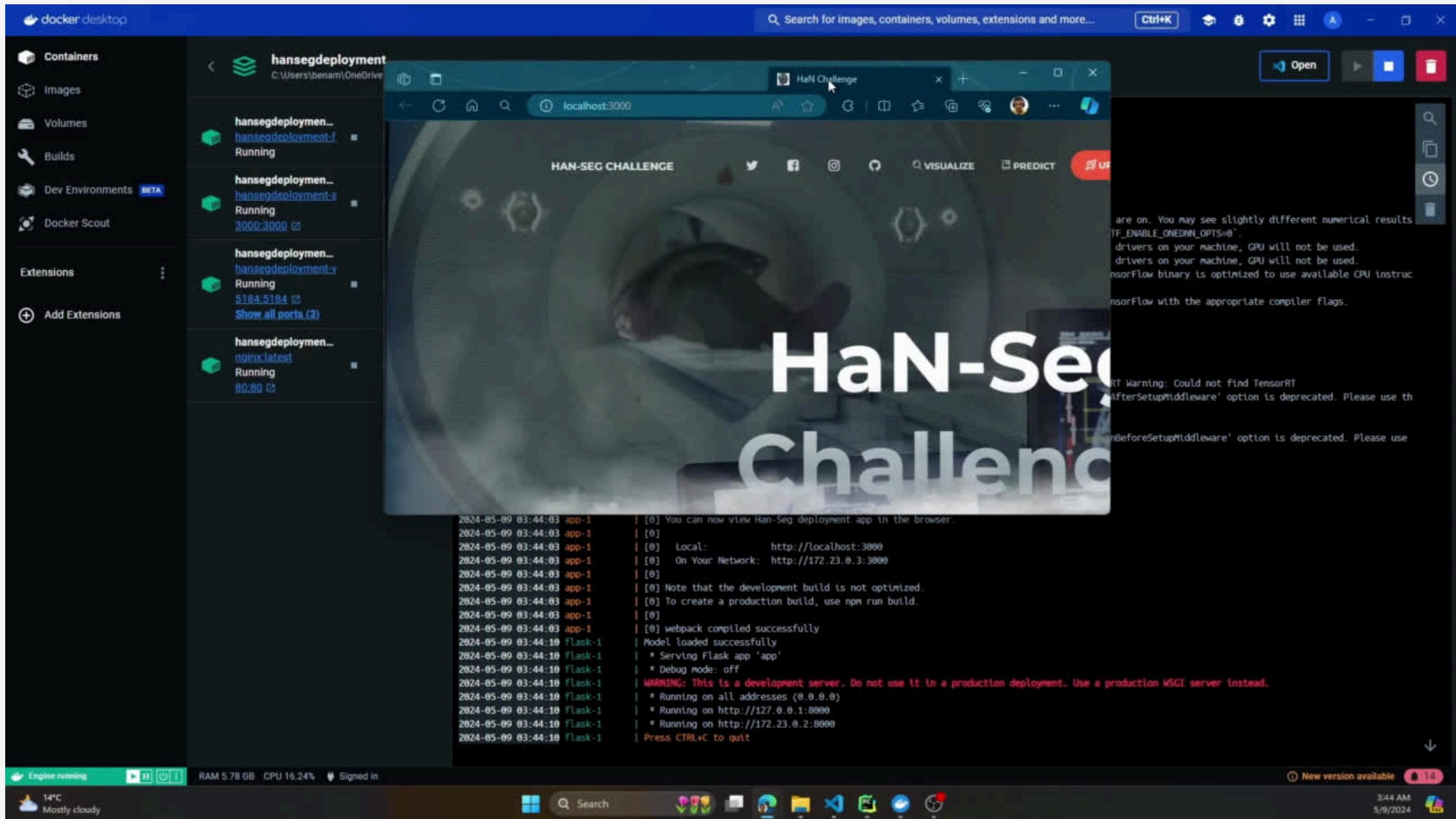
03

Visualization  
Integration

04

React-based  
Application

# DEMONSTRATION



# CONCLUSION AND PERSPECTIVES

# Conclusion & Perspectives

**Our research underscores the critical role of segmentation methods in refining head and neck cancer diagnosis and treatment.**

**Transitioning from a 3D to a 2D approach demonstrates the adaptability necessary to address computational challenges effectively.**

**Looking ahead, the integration of innovative segmentation techniques into user-friendly applications promises a transformative era in medical imaging.**

**Enhanced precision and accessibility offered by these advancements benefit both clinicians and patients alike.**



**THANKS FOR YOUR  
ATTENTION**