CT Scan Segmentation for COVID-19 Infected Lungs

BENG 280A

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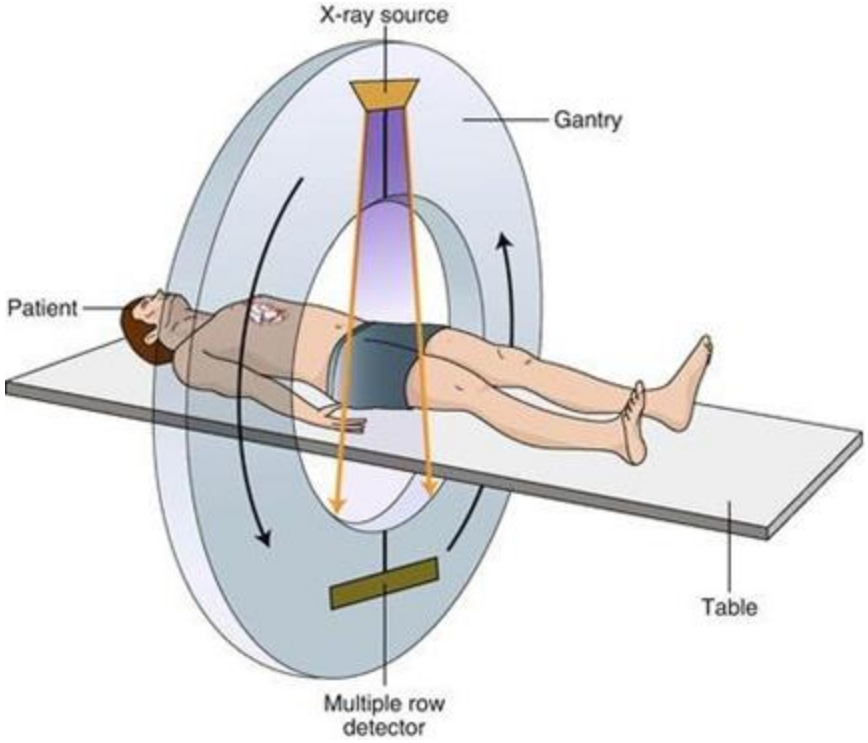
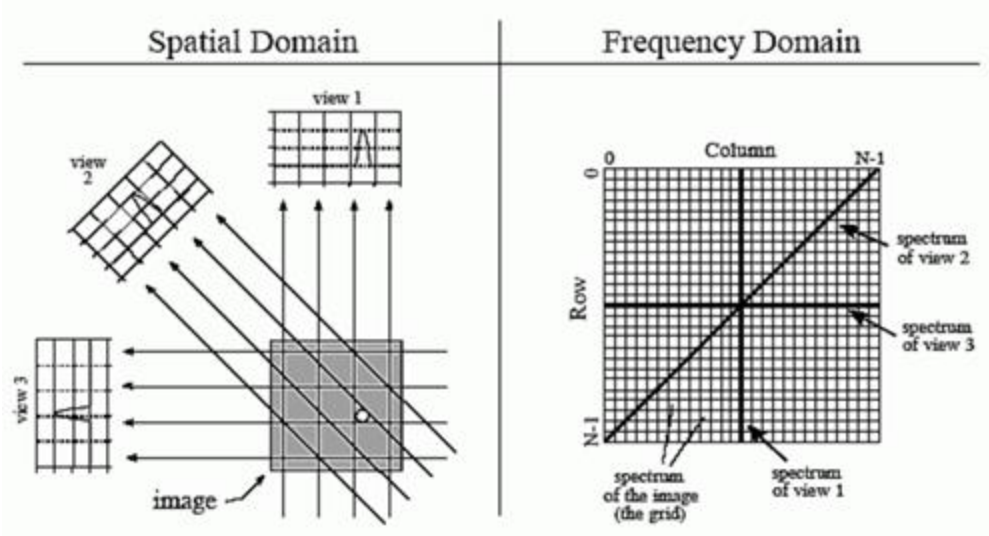
Introduction

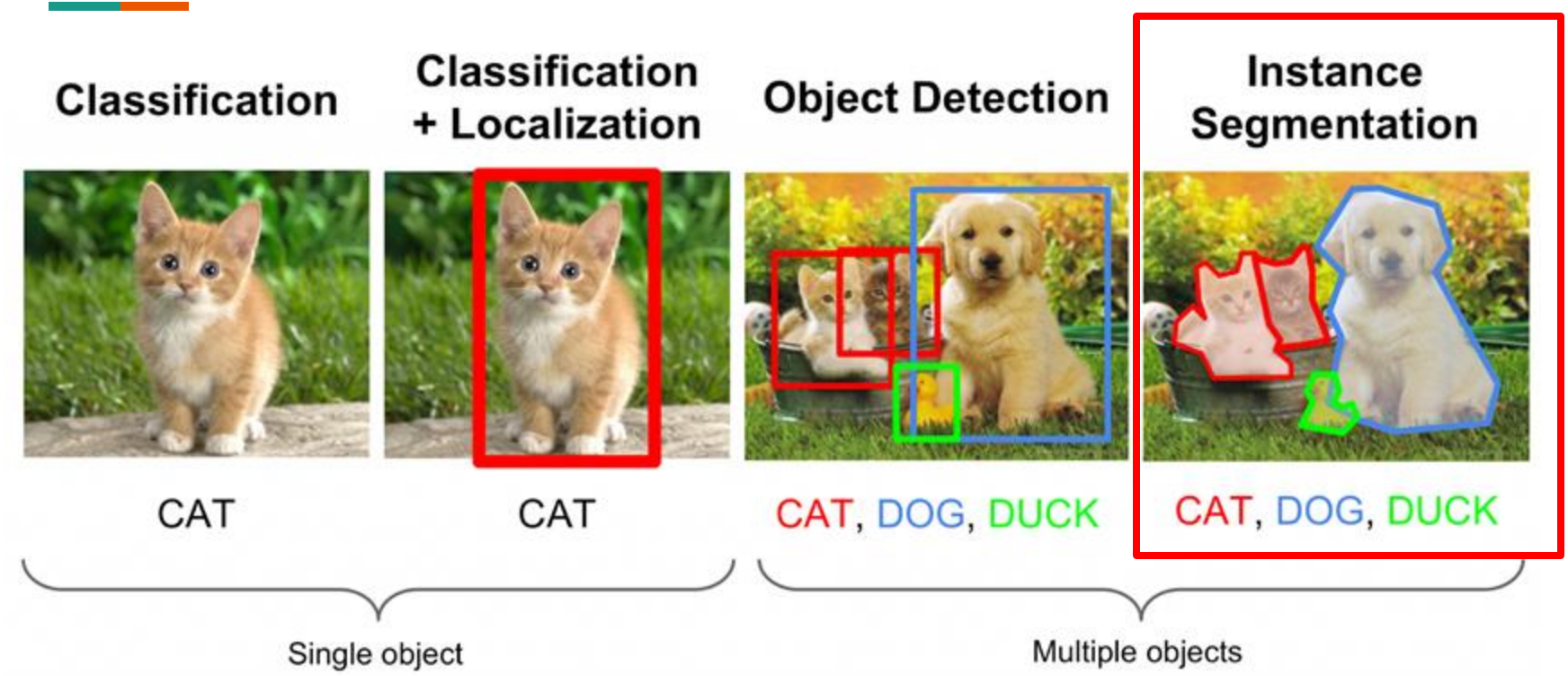
Computed Tomography





Introduction

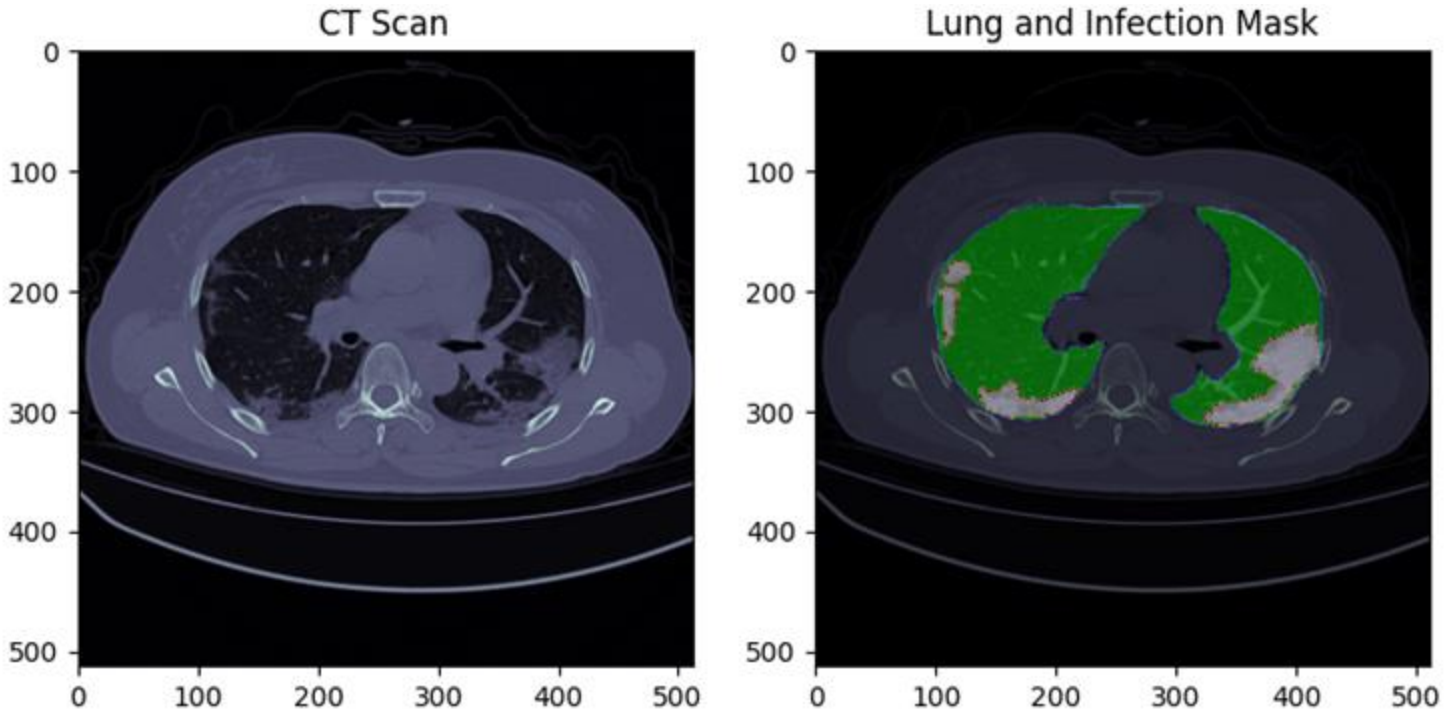
Instance Segmentation



Introduction

https://www.kaggle.com/datasets/andrewmvd/covid19-ct-scans

COVID-19 Infected Lung CT Scans Segmentation Task and Dataset

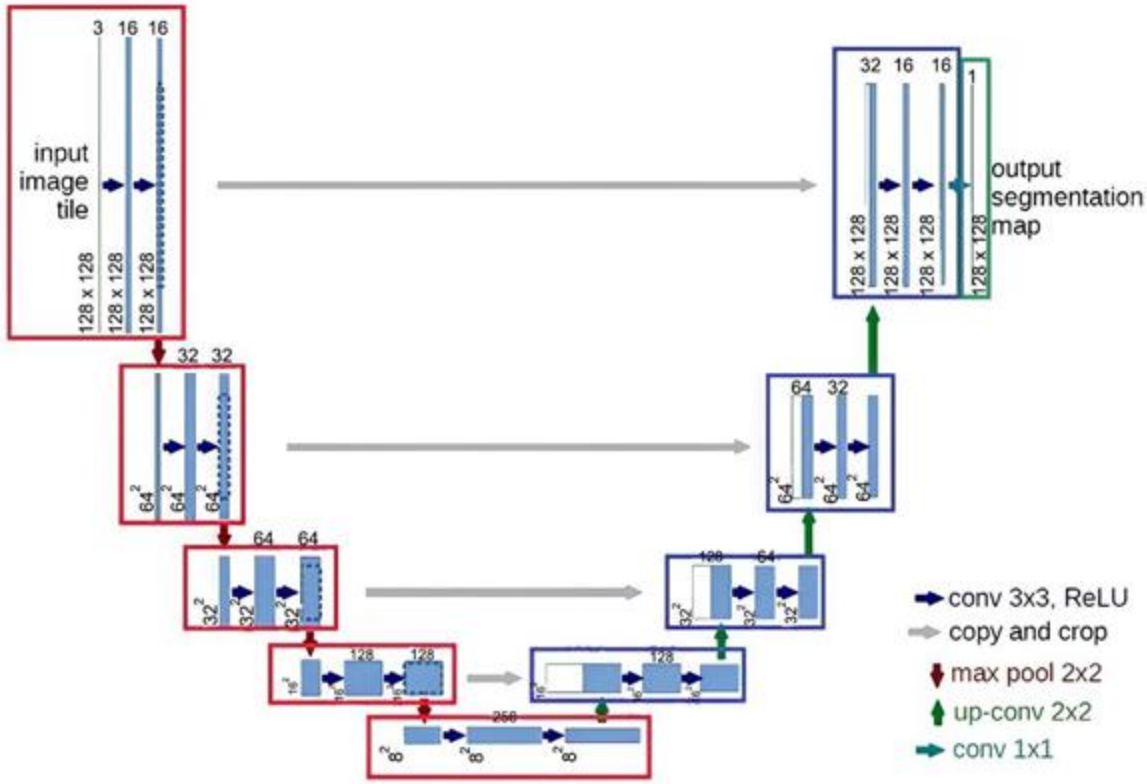


20 CT scans with multiple slices (512*512), in total 3,520 slices.
Three classes: (1) Infectious area; (2) Lung (healthy part); (3) Background
Train: 65% Validation: 13% Test: 22%

Methods

(Long et al., 2015)

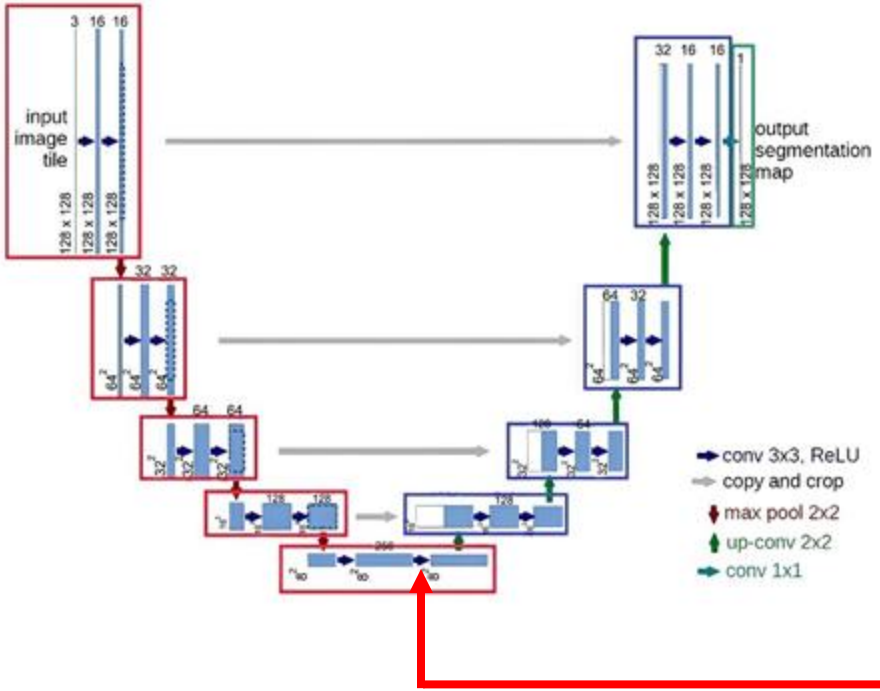
Network 1: UNet

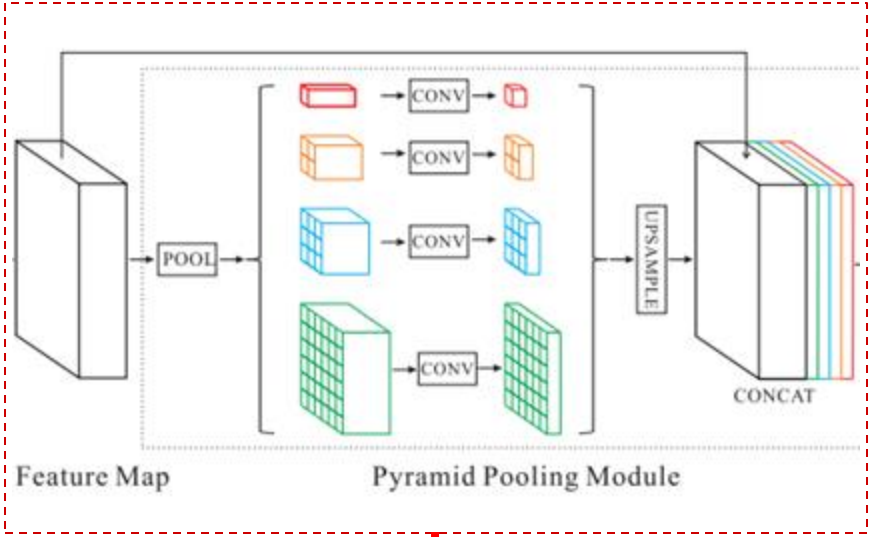


Methods

(Zhao et al. 2017)

Network 2: Pyramid Scene Parsing Network (PSPNet)

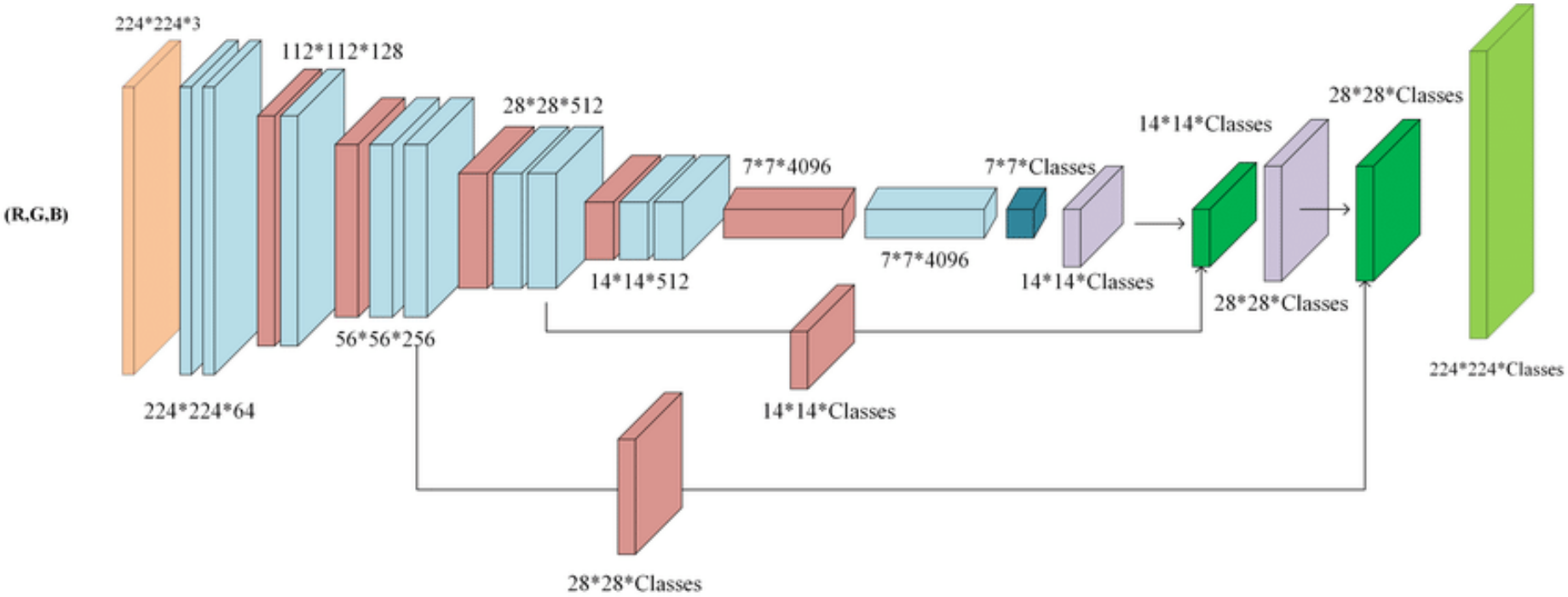




Methods

(Ronneberger et al., 2015)

Network 3: Fully Convolutional Network (FCN)



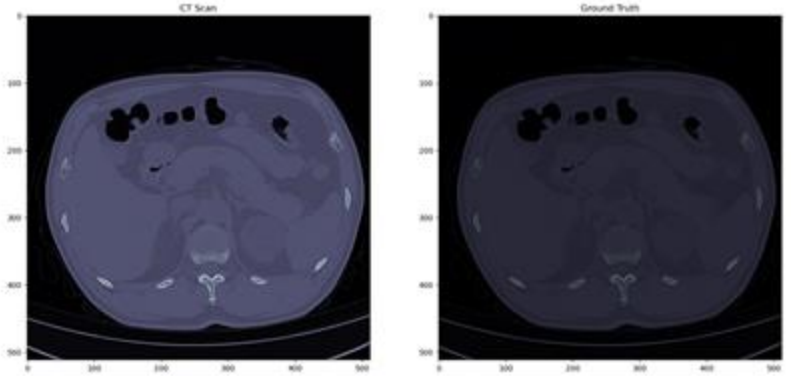
Training

- **Data Screening**: Select the middle one third of the slices of each scan.
- **Loss Function:** Binary cross entropy with logits
- **Optimizer:** Adam
- **Hyperparameters:**

  Learning Rate: 1e-4

  Weight Decay: 1e-5

  Number of Epochs: 40



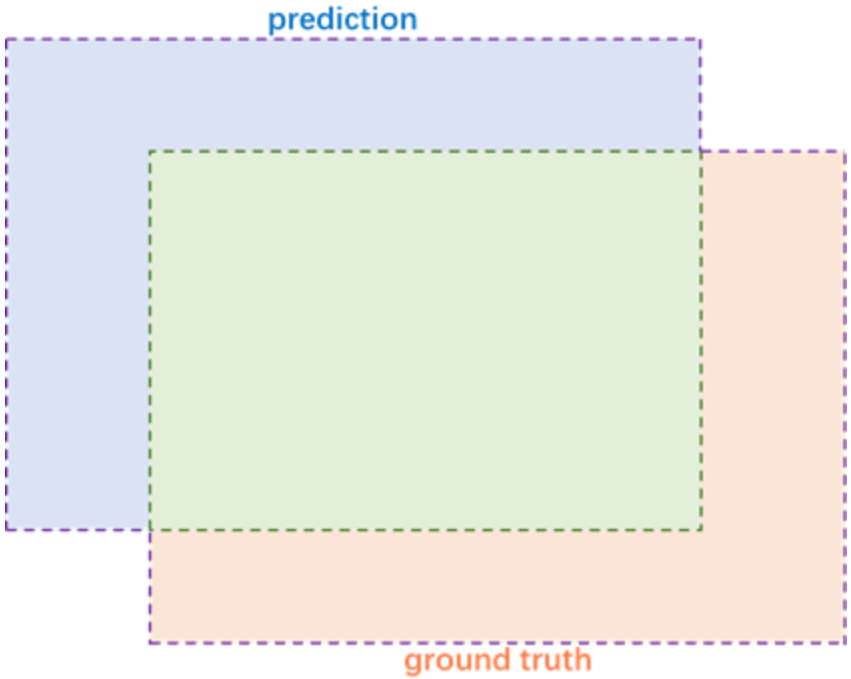
Experiment and Evaluation

Metrics

- Pixel-wise Accuracy

$$acc. = \frac{\#correctly\ classified\ pixels}{\#total\ pixels}$$

- Intersection over Union (IoU)

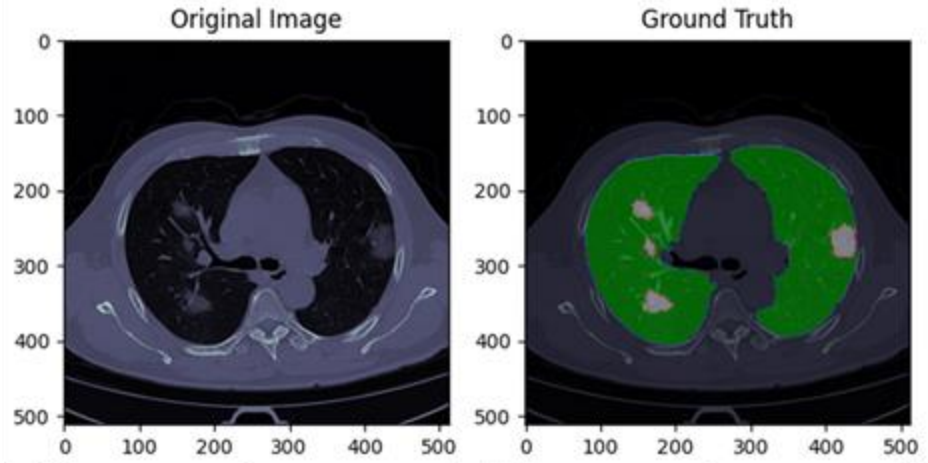


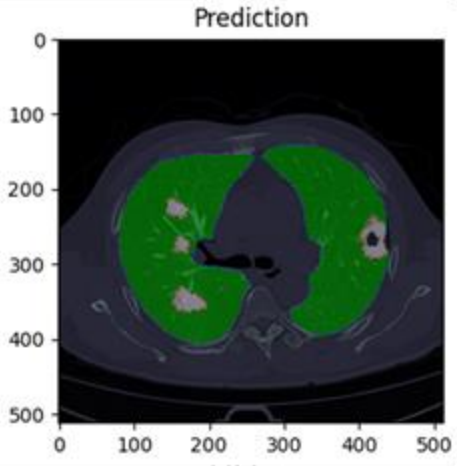
$$intersection = preditction \cap truth$$

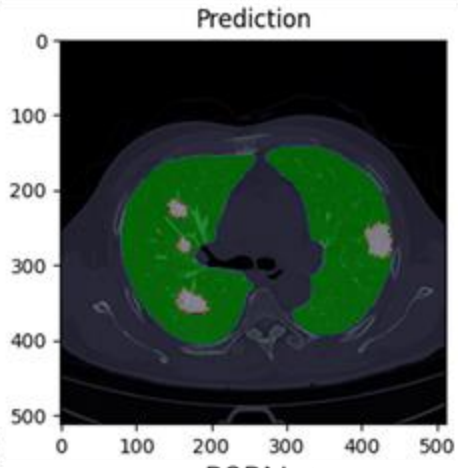
$$union = preditction \cup truth$$

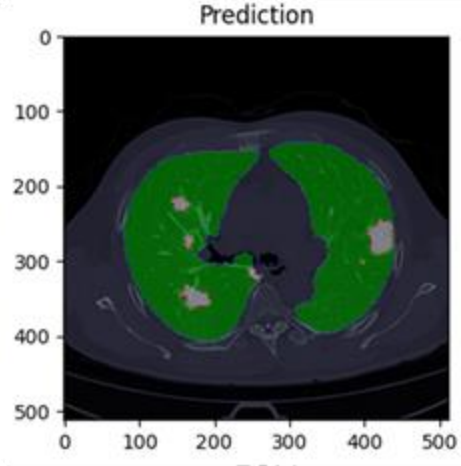
$$IoU = \frac{intersection}{union}$$

Qualitative Results - Easier Example

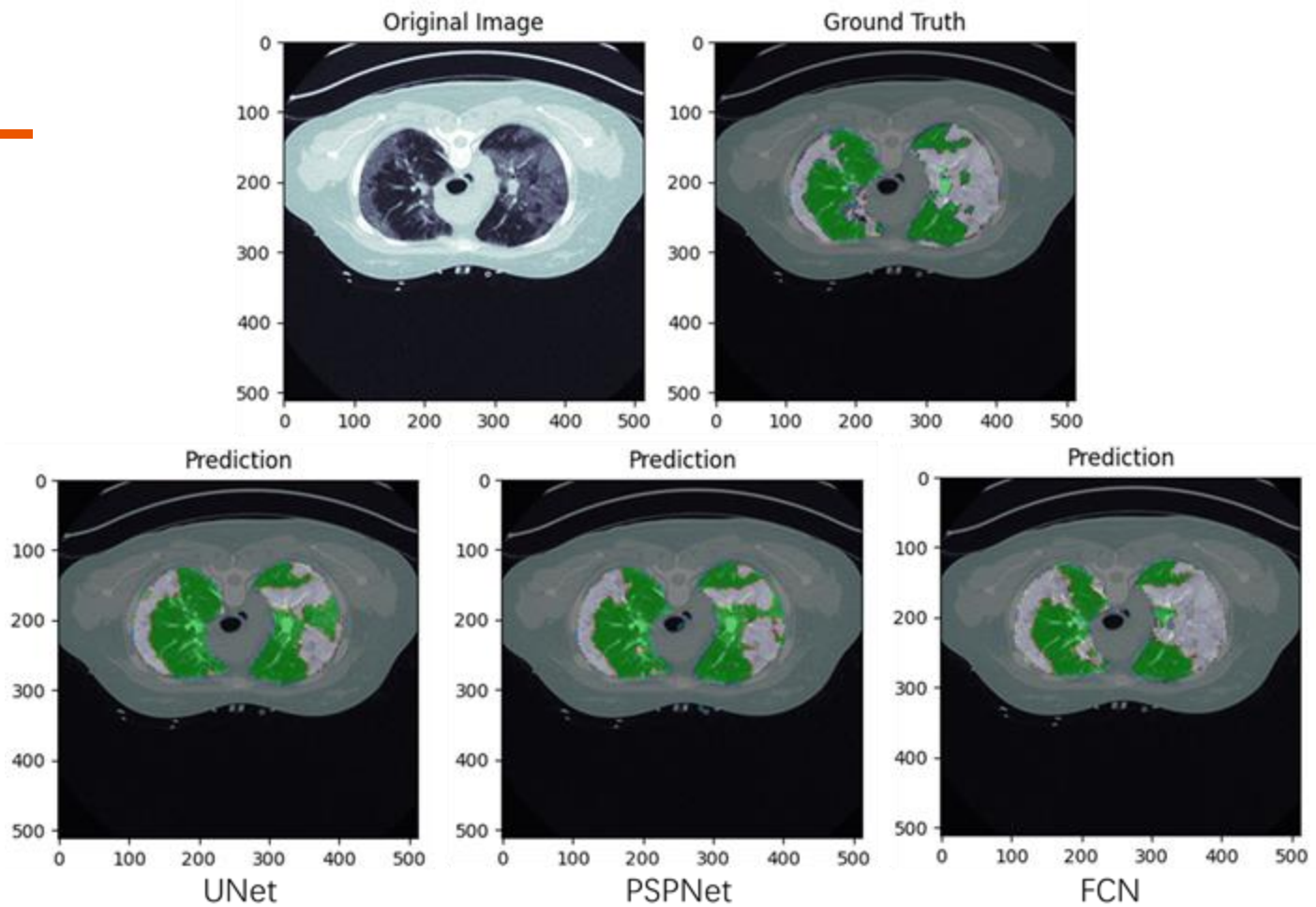








Qualitative Results - Harder Example



Numerical Results

Metrics/ Network	Acc. (%)	mIoU (%)			
		Background	Lung	Infection	Average
UNet	98.6	99.1	89.8	39.4	76.1
PSPNet	**98.8**	**99.3**	**90.6**	54.6	81.5
FCN	98.7	99.0	89.5	**60.4**	**83.0**

Ablation Study

Histogram Equalization

Infection mIoU	**FCN**
Without Histogram Equalization	60.4
With Histogram Equalization	29.2

Data Augmentation

Infection mIoU	**FCN**
Without Data Augmentation	60.4
With Data Augmentation	54.8

Loss Function

Infection mIoU	**FCN**
BCE Loss	60.4
Focal Loss	53.6

Conclusion

- A vision-based solution of automatic COVID-19 lung infection localization and area estimation
- Comparison between different CNNs and screen out the optimal one.

Sources

“14.11. Fully Convolutional Networks¶ Colab [Pytorch] Open the Notebook in Colab Colab [Mxnet] Open the Notebook in Colab Colab [Tensorflow] Open the Notebook in Colab Sagemaker Studio Lab Open the Notebook in SageMaker Studio Lab.” *14.11. Fully Convolutional Networks - Dive into Deep Learning 1.0.0-alpha1.post0 Documentation*, https://d2l.ai/chapter_computer-vision/fcn.html.

“Basic Principles in Computed Tomography (CT).” *Thoracic Key*, 10 July 2016, https://thoracickey.com/basic-principles-in-computed-tomography-ct/.

Cai, Lei, et al. “A Review of the Application of Deep Learning in Medical Image Classification and Segmentation.” *Annals of Translational Medicine*, AME Publishing Company, June 2020, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7327346/.

Hermena, Shady, and Michael Young. “CT-Scan Image Production Procedures.” *National Center for Biotechnology Information*, U.S. National Library of Medicine, 8 Aug. 2022, https://www.ncbi.nlm.nih.gov/books.

Lamba, Harshall. “Understanding Semantic Segmentation with UNET.” *Towards Data Science*, 17 Feb. 2019, https://towardsdatascience.com/understanding-semantic-segmentation-with-unet-6be4f42d4b47.

Naushad, Raoof. “UNET for Semantic Segmentation — Implementation from Scratch - Medium.” *Medium*, 14 July 2021, https://medium.datadriveninvestor.com/unet-for-semantic-segmentation-implementation-from-scratch-26e043fdcffa.

Saood, Adnan, and Iyad Hatem. “Covid-19 Lung CT Image Segmentation Using Deep Learning Methods: U-Net versus SEGNET - BMC Medical Imaging.” *BioMed Central*, BioMed Central, 9 Feb. 2021, https://bmcmedimaging.biomedcentral.com/articles/10.1186/s12880-020-00529-5.

Smith, Steven W. “The Scientist and Engineer's Guide Todigital Signal Processing.” *Computed Tomography*, 2011, https://www.dspguide.com/ch25/5.htm.

Turečková, Alžběta, et al. “Improving CT Image Tumor Segmentation through Deep Supervision and Attentional Gates.” *Frontiers*, Frontiers, 1 Jan. 2021, https://www.frontiersin.org/articles/10.3389/frobt.2020.00106/full.

Yang, Ruixin, and Yingyan Yu. “Artificial Convolutional Neural Network in Object Detection and Semantic Segmentation for Medical Imaging Analysis.” *Frontiers*, Frontiers, 1 Jan. 2021, https://www.frontiersin.org/articles/10.3389/fonc.2021.638182/full.