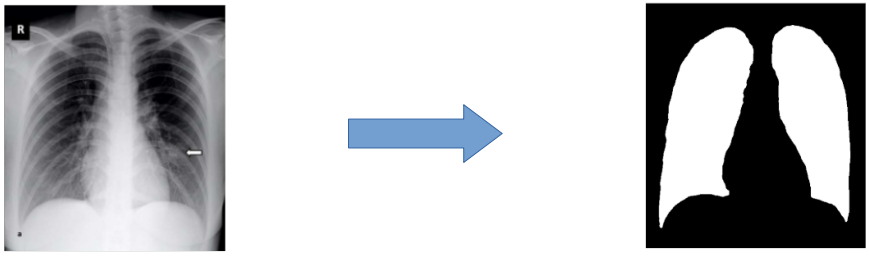
# Lung segmentation from chest X-ray images



DAO THI TRUC LOAN

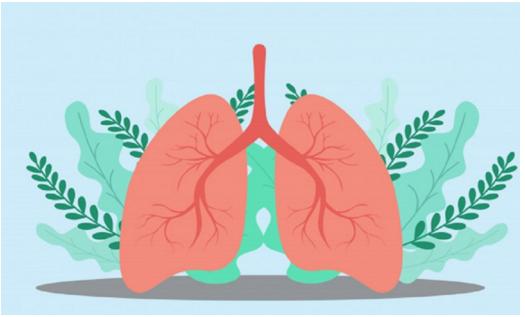
TUESDAY, APRIL 5, 2022

# Outline

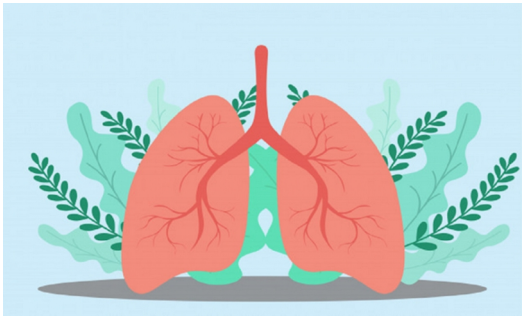
1. Introduction
2. Datasets
3. Pre-processing
4. Model
5. Post-processing
6. Results
7. Conclusion

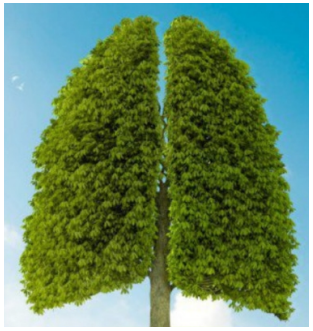
# 1. Introduction

# 1. Introduction



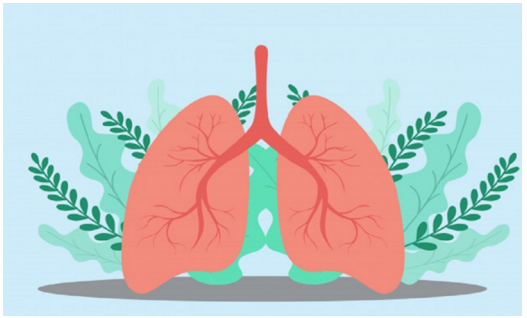
# 1. Introduction

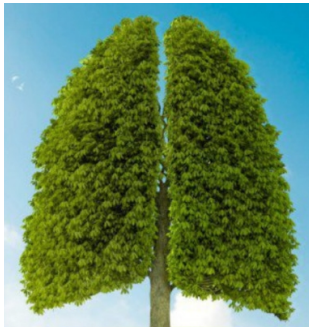




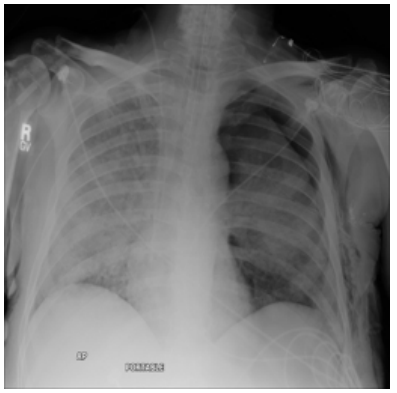
Normal

# 1. Introduction



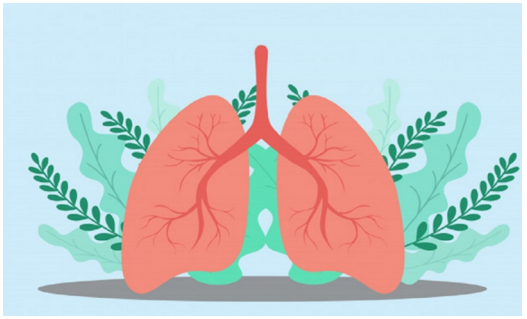


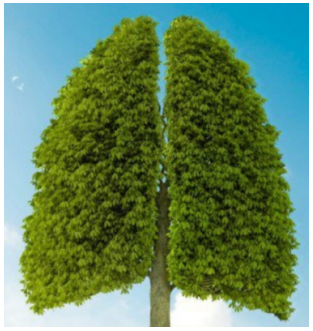
Normal

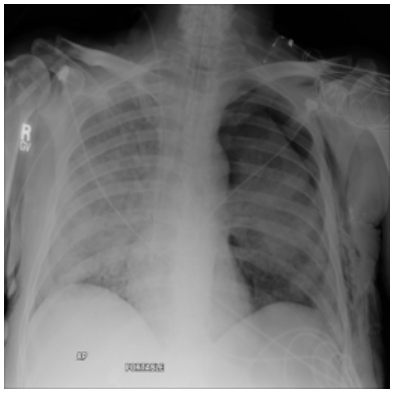


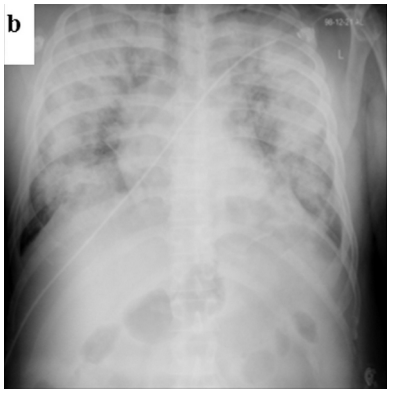
Non-COVID pneumonia

# 1. Introduction







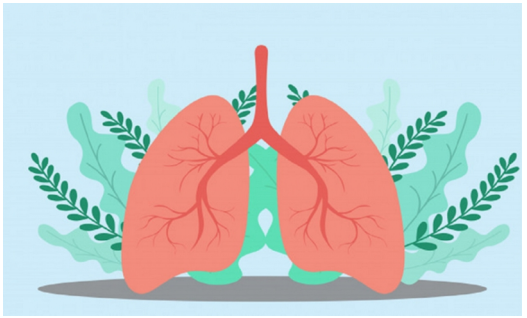


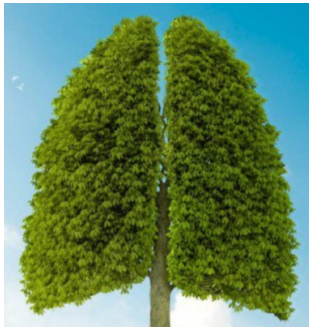

Normal

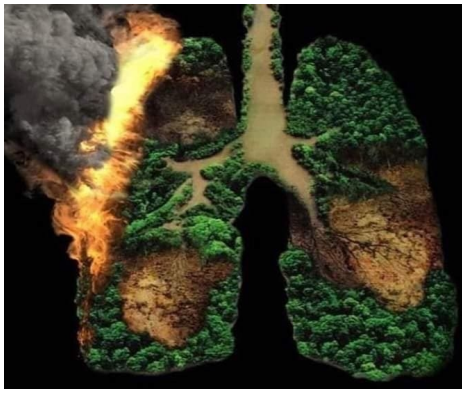
Non-COVID pneumonia

COVID-19

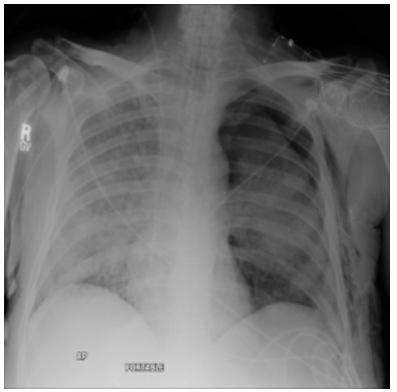
# 1. Introduction



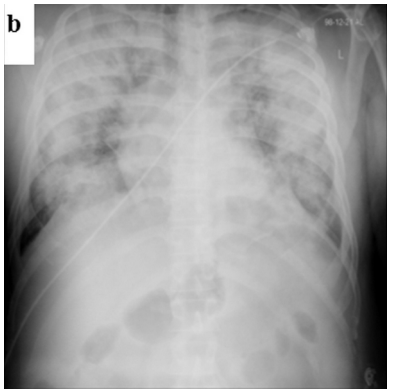




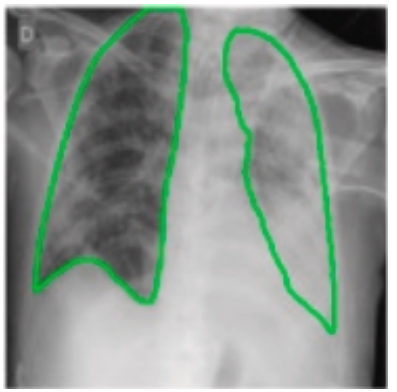
Normal



Non-COVID pneumonia




COVID-19



Lung Segmentation

# 1. Introduction

Is this a dog?

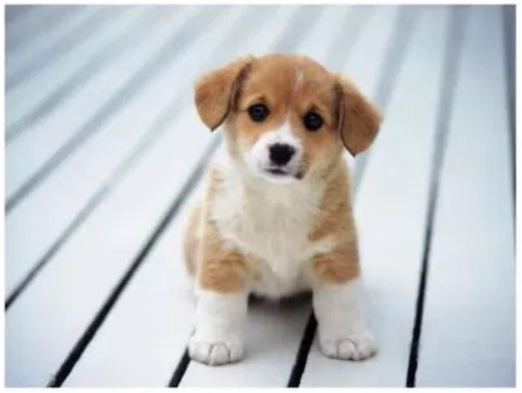
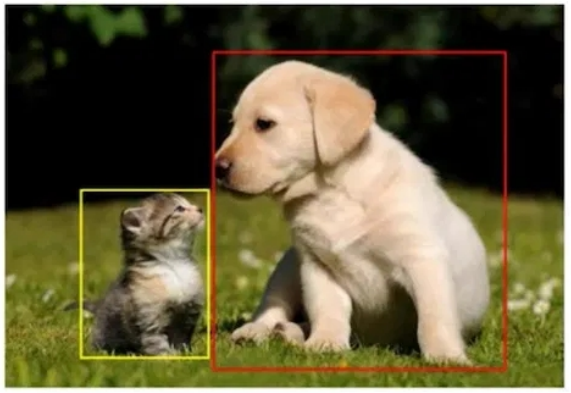


Image Classification

What is there in image and where?



Object Detection

Which pixels belong to which object?

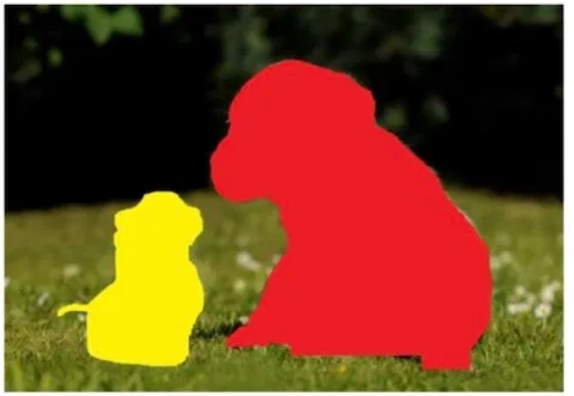
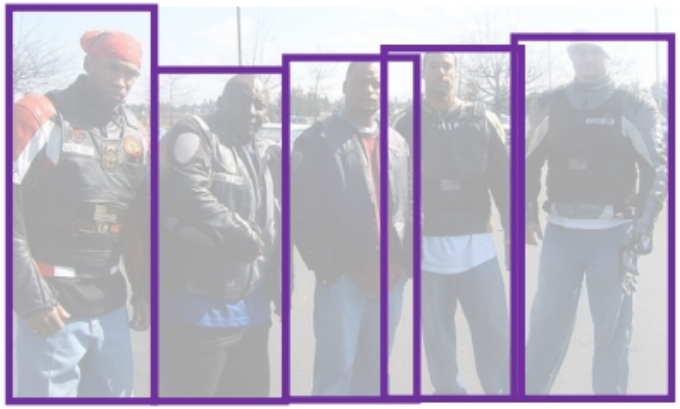


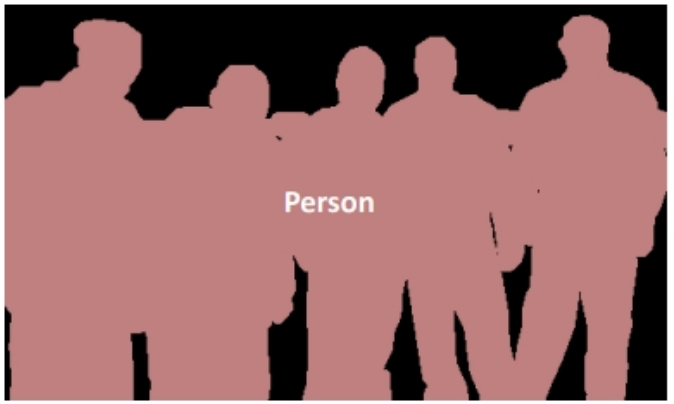
Image Segmentation

https://venturebeat.com/2021/05/14/new-deep-learning-model-brings-image-segmentation-to-edge-devices/

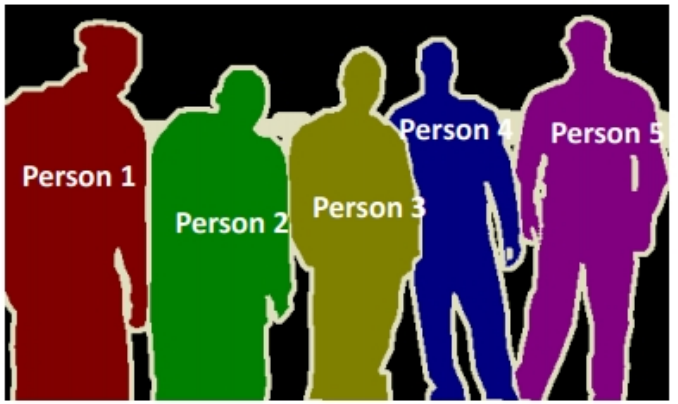
# 1. Introduction



Object Detection




Semantic Segmentation




**Instance Segmentation**

https://towardsdatascience.com/understanding-semantic-segmentation-with-unet-6be4f42d4b47

# 2. Datasets

**Train/ Validation:**

800 images (406 tuberculosis + 394 normal) (*704 labeled*) from Shenzhen and Montgomery [1]

**Test:**

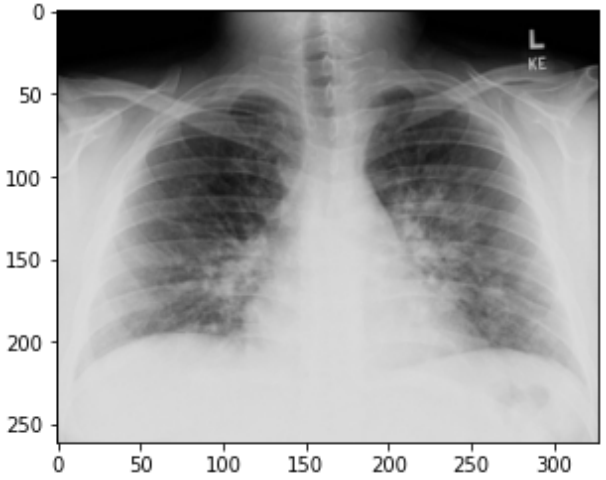
930 images (584 covid) (*206 labeles*) [2]

**Inferred:**

30482 images (16490 covid) (13992 non-covid) [3]

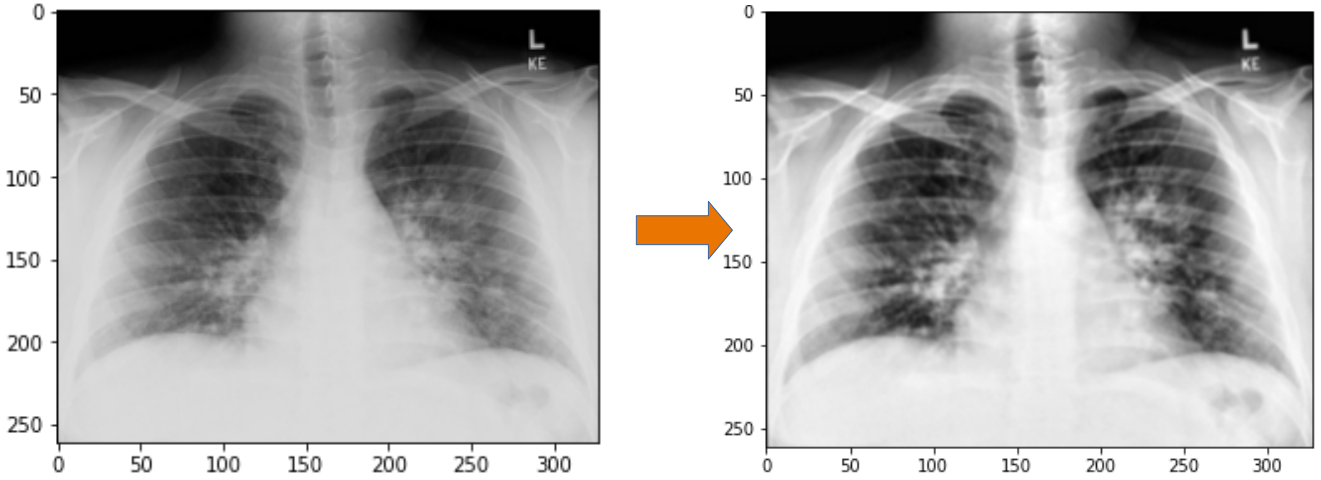
[1]: https://www.kaggle.com/datasets/kmader/pulmonary-chest-xray-abnormalities
[2]: https://github.com/ieee8023/covid-chestxray-dataset
[3]: https://www.kaggle.com/andyczhao/covidx-cxr2?select=train.txt

# 3. Pre-processing




Original

# 3. Pre-processing

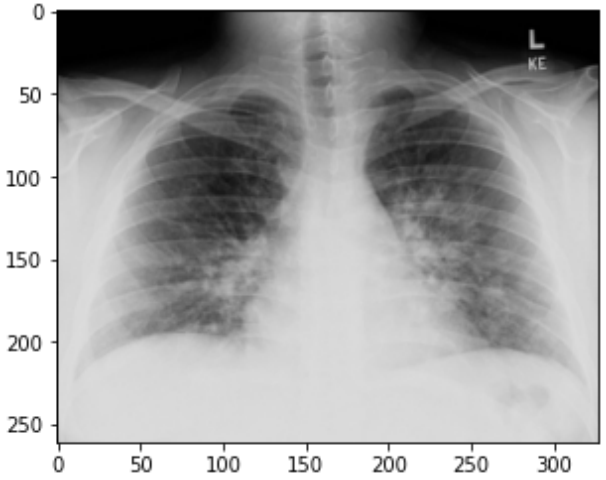



Original

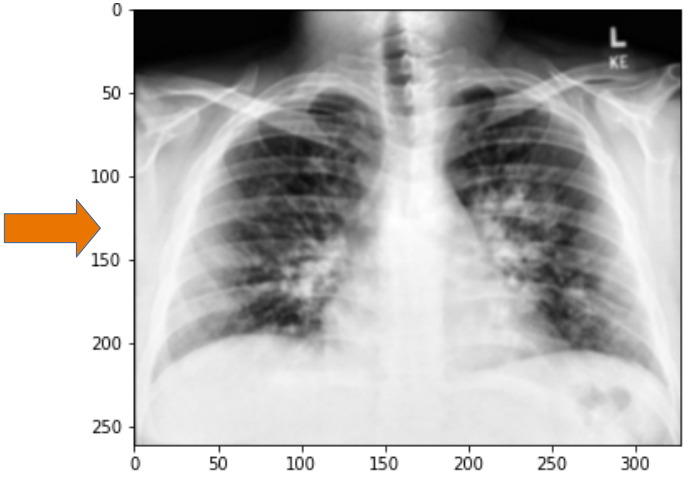



GaussianBlur

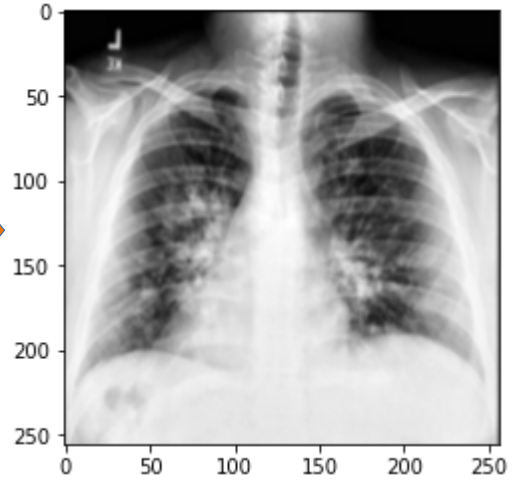
# 3. Pre-processing



Original

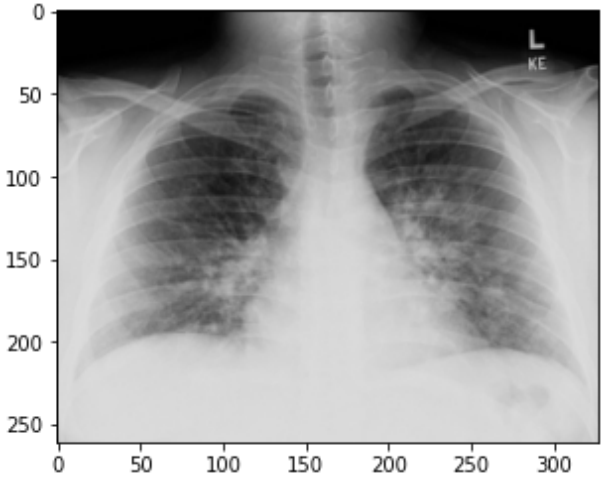


GaussianBlur

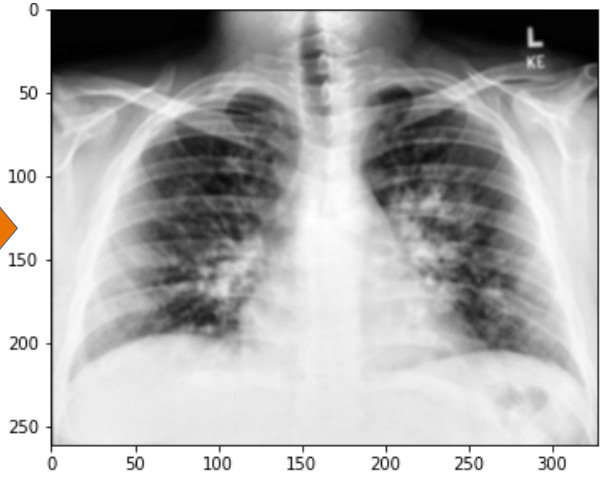


Resize+HorizontalFlip

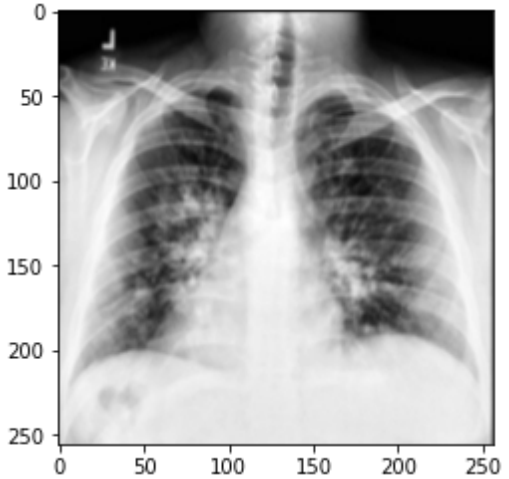
# 3. Pre-processing



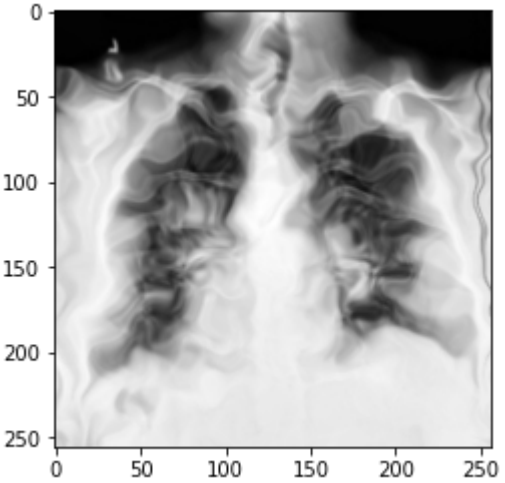
Original



GaussianBlur

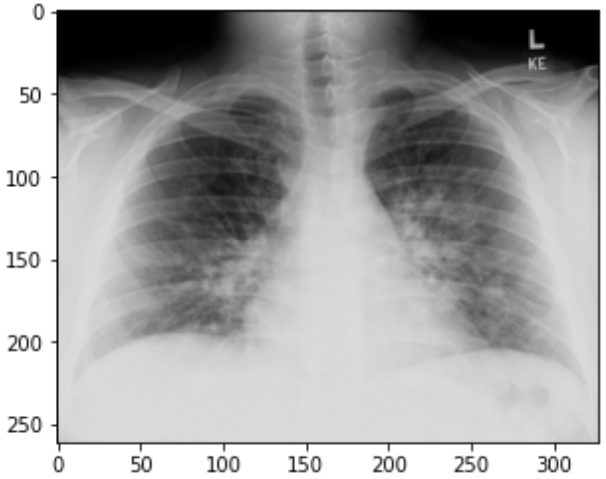


Resize+HorizontalFlip

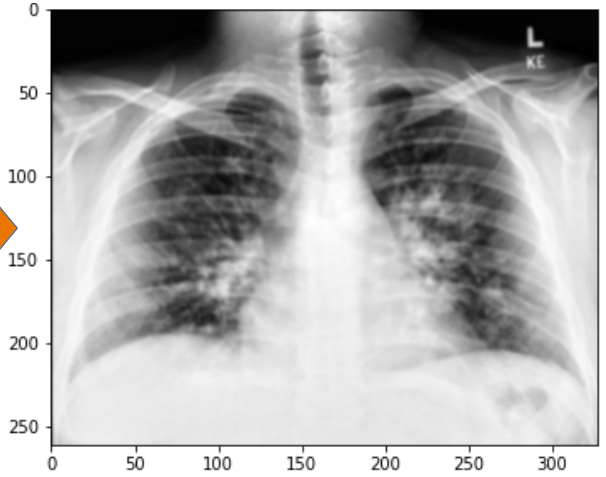


ElasticTransform

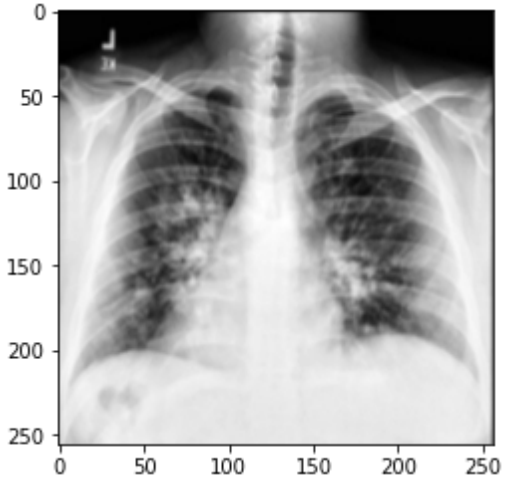
# 3. Pre-processing



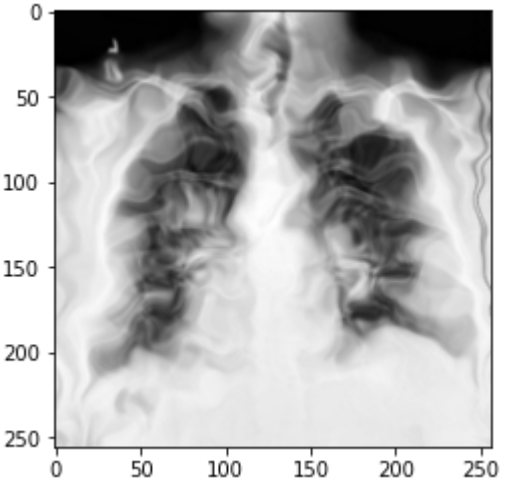
Original



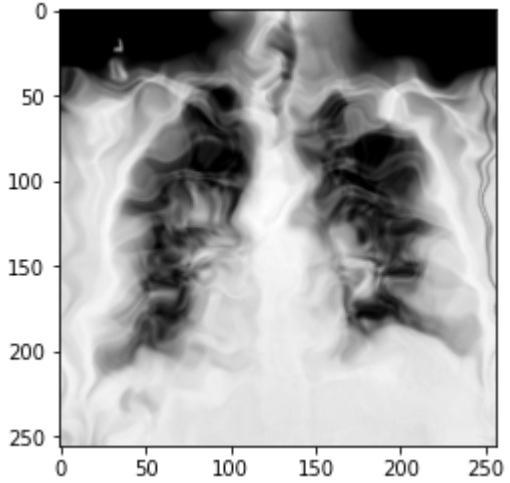
GaussianBlur



Resize+HorizontalFlip

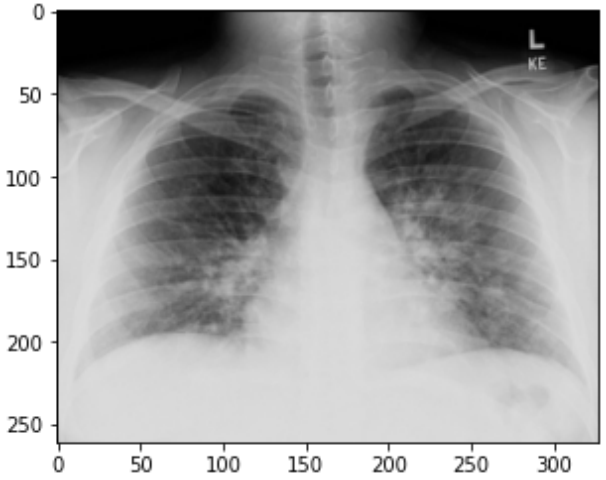


ElasticTransform

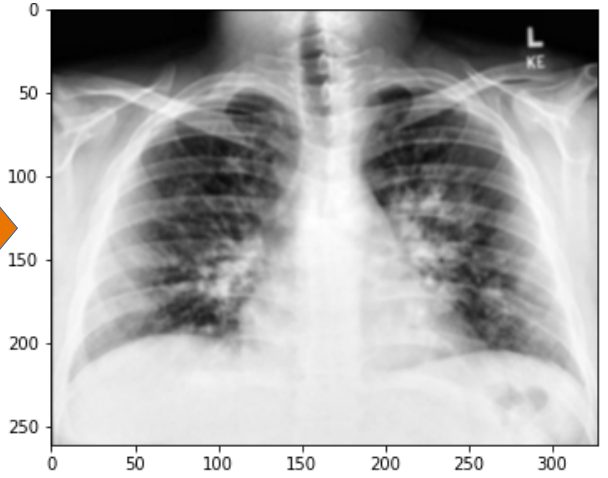


RandomBrightnessContrast

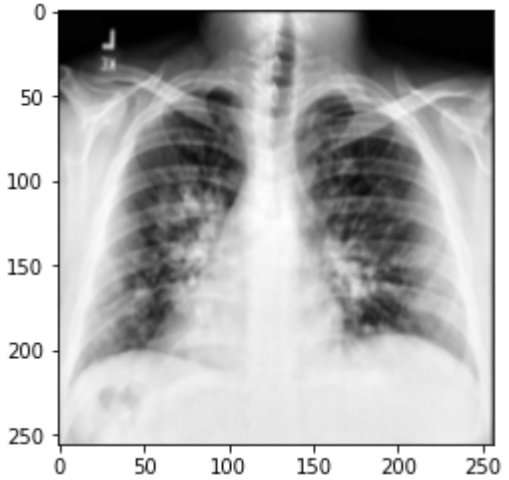
# 3. Pre-processing



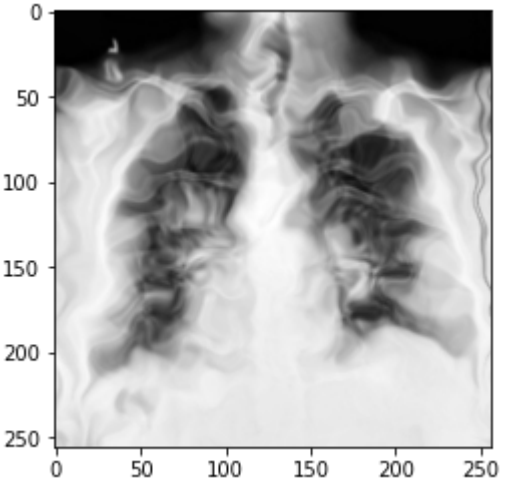
Original



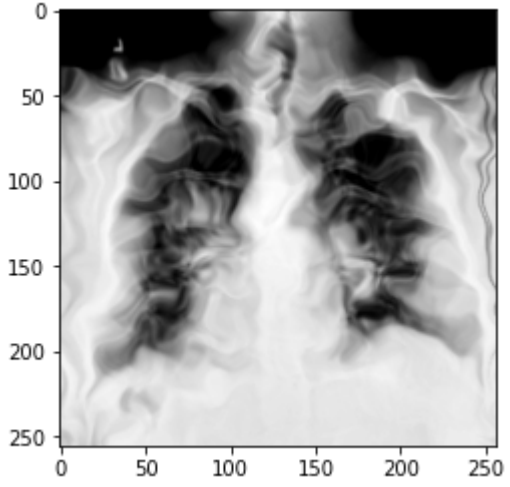
GaussianBlur



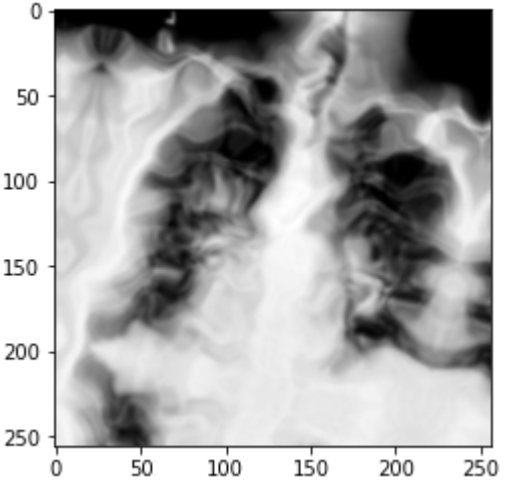
Resize+HorizontalFlip



ElasticTransform



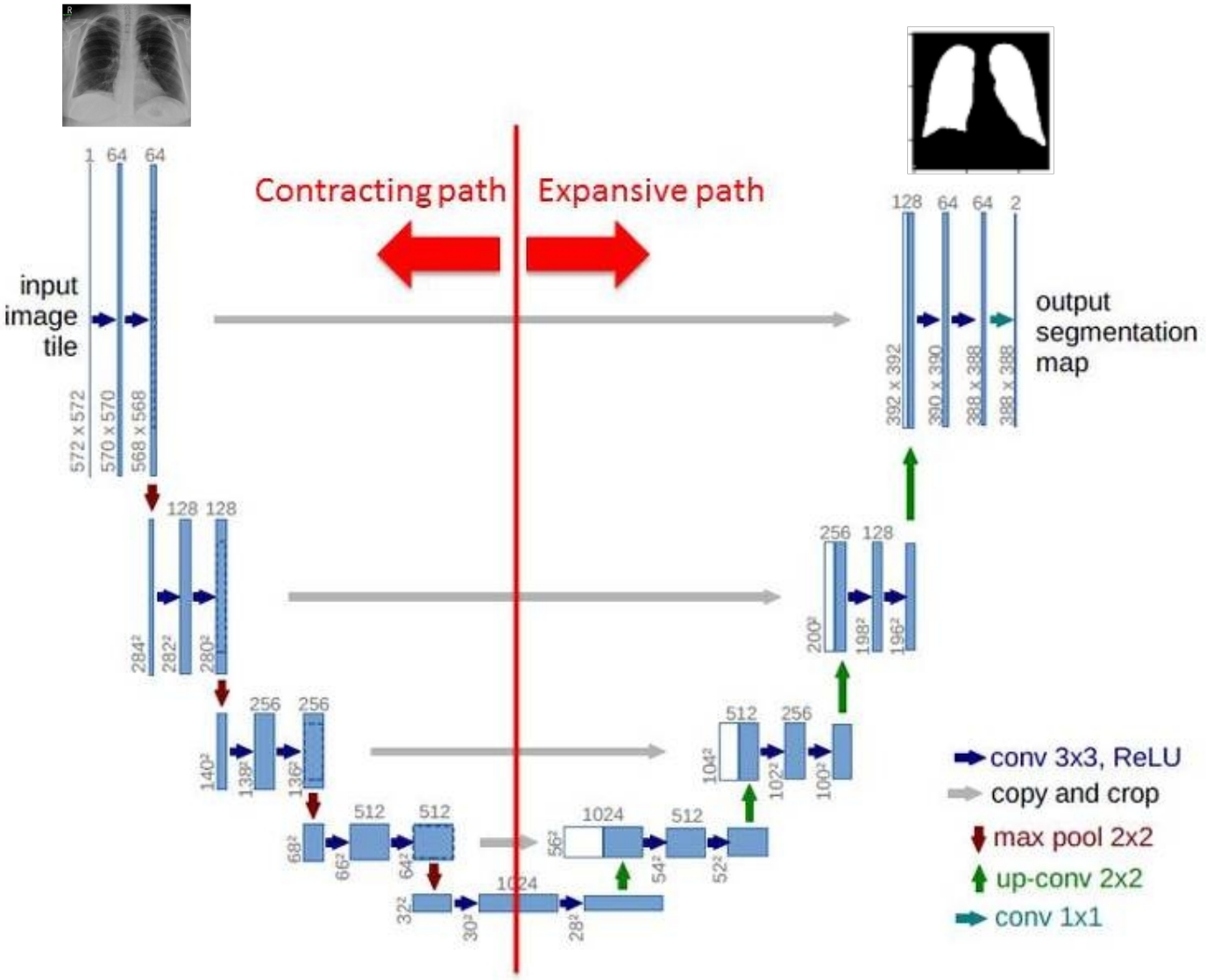
RandomBrightnessContrast



ShiftScaleRotate

# 4. Model

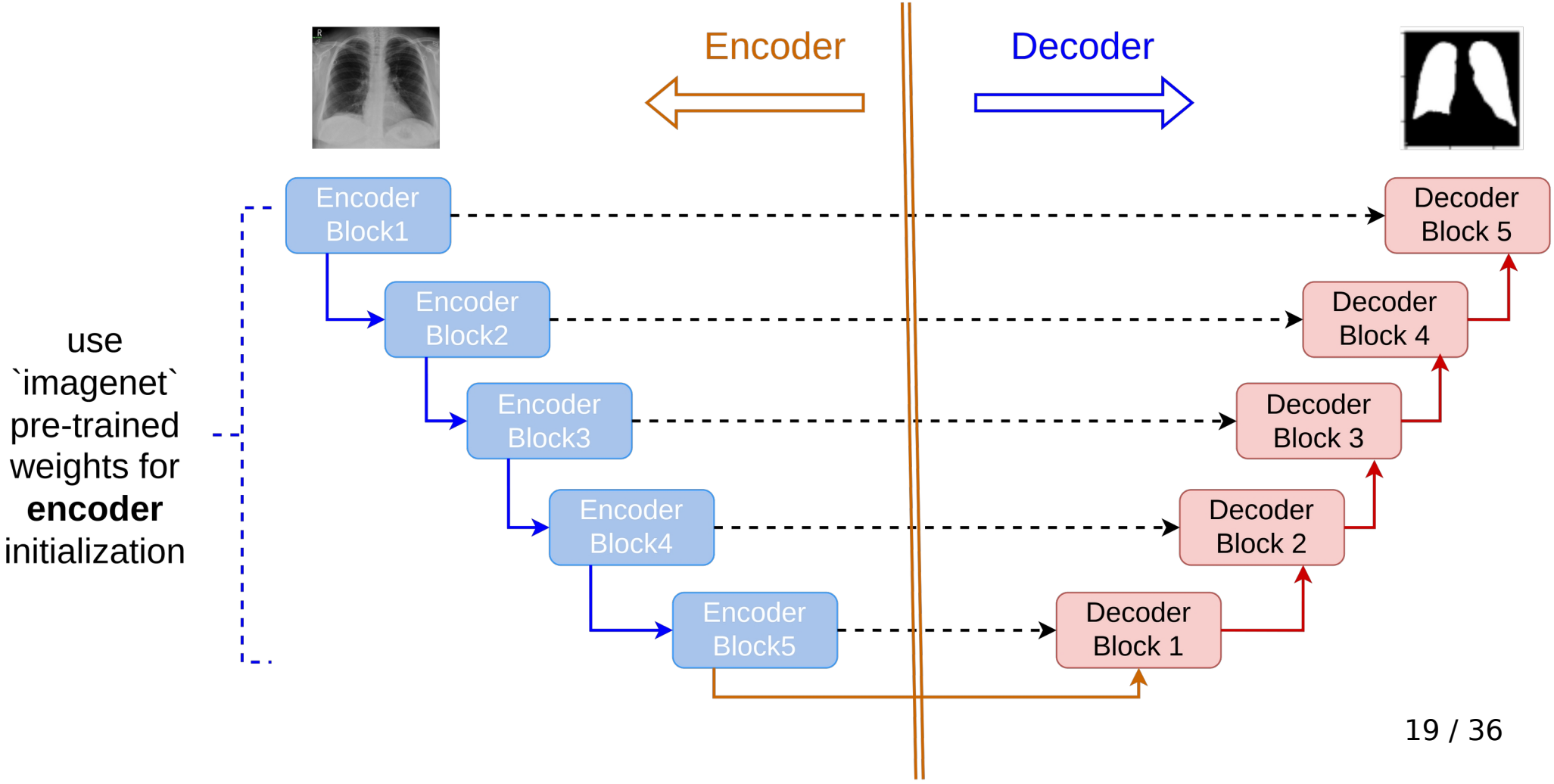
## UNet Architecture




https://towardsdatascience.com/u-nets-with-resnet-encoders-and-cross-connections-d8ba94125a2c

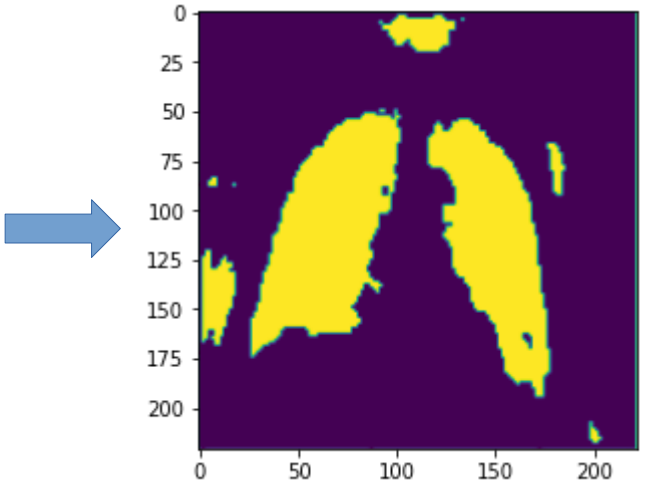
# 4. Model

## Unet (Encoder pretrained) Architecture



# 5. Post-processing

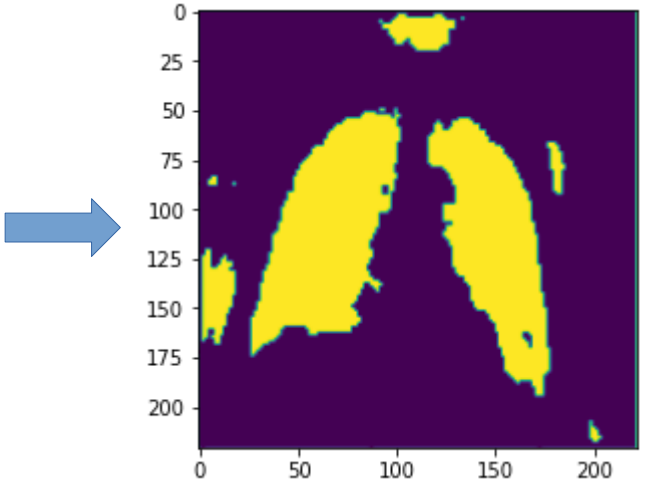
Original



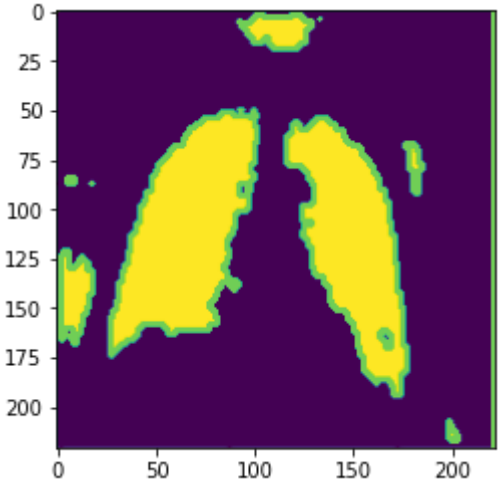

Segmentation

# 5. Post-processing

Original



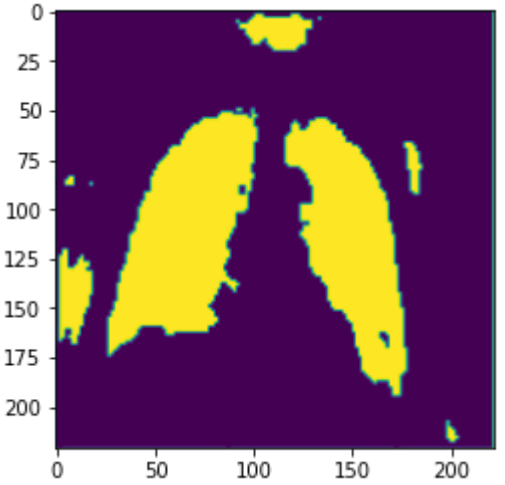

Segmentation



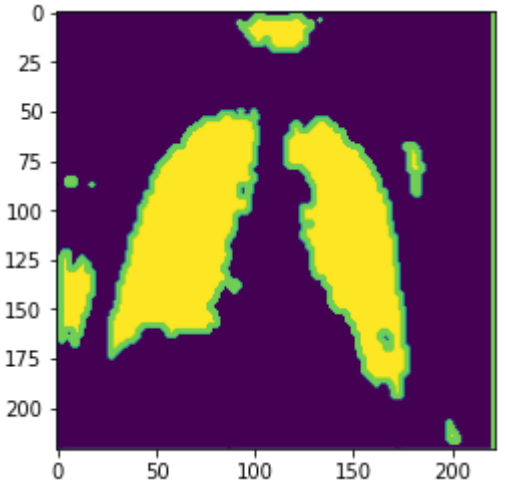

Number of Contours found = 14

# 5. Post-processing

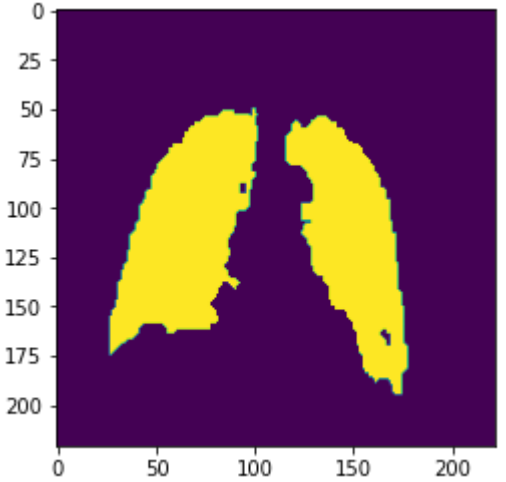
Original




Segmentation



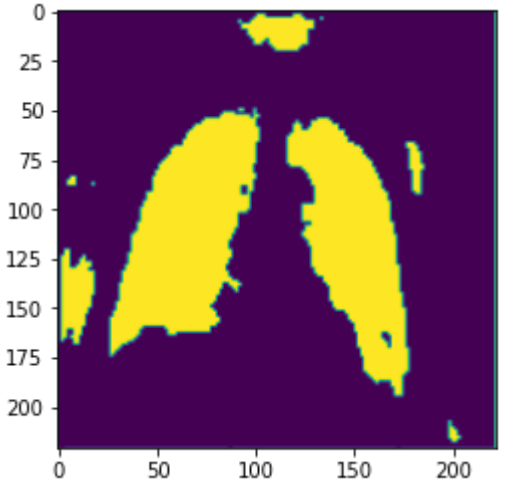

Number of Contours found = 14



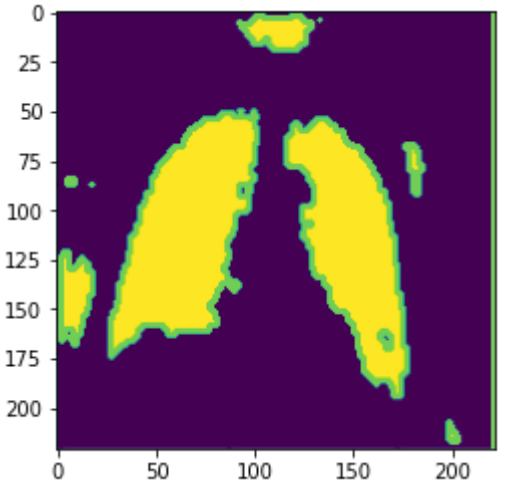

Remove small objects

# 5. Post-processing

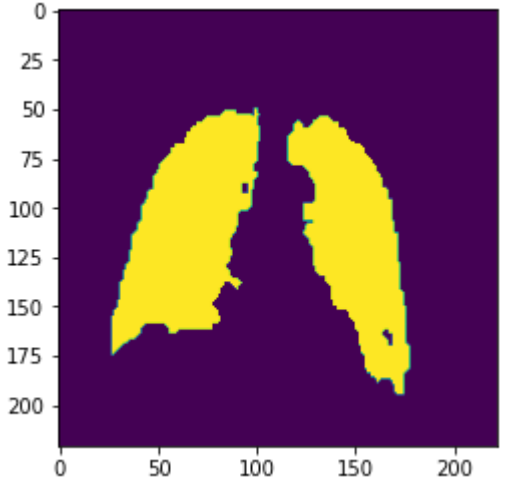
Original



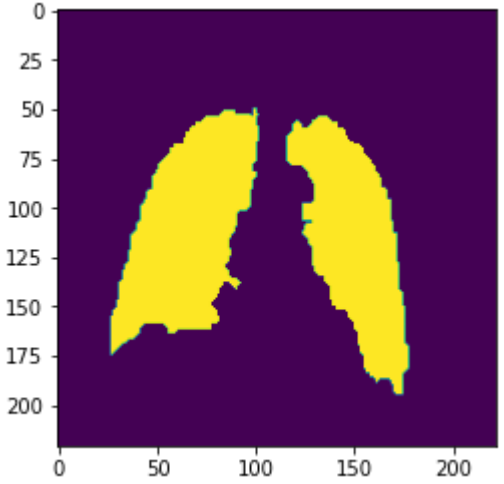

Segmentation




Number of Contours found = 14




Remove small objects



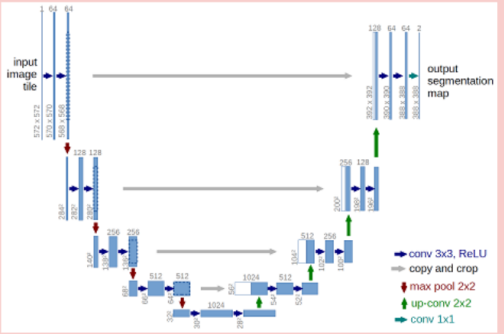

Remove small holes

# Pipeline Lung Segmentation

## Train/Validation phase

**Dataset** k-fold (k=5)
(800 imgs, 704 masks)

**PreProcessing**:
GaussBlur
+ Augmentation




**UNet** (Encoder: VGG11_bn, pretrain on ImageNet)
**Loss:** Dice + BCE + Focal
**Optimizer:** Adam

Acc 97.48 %

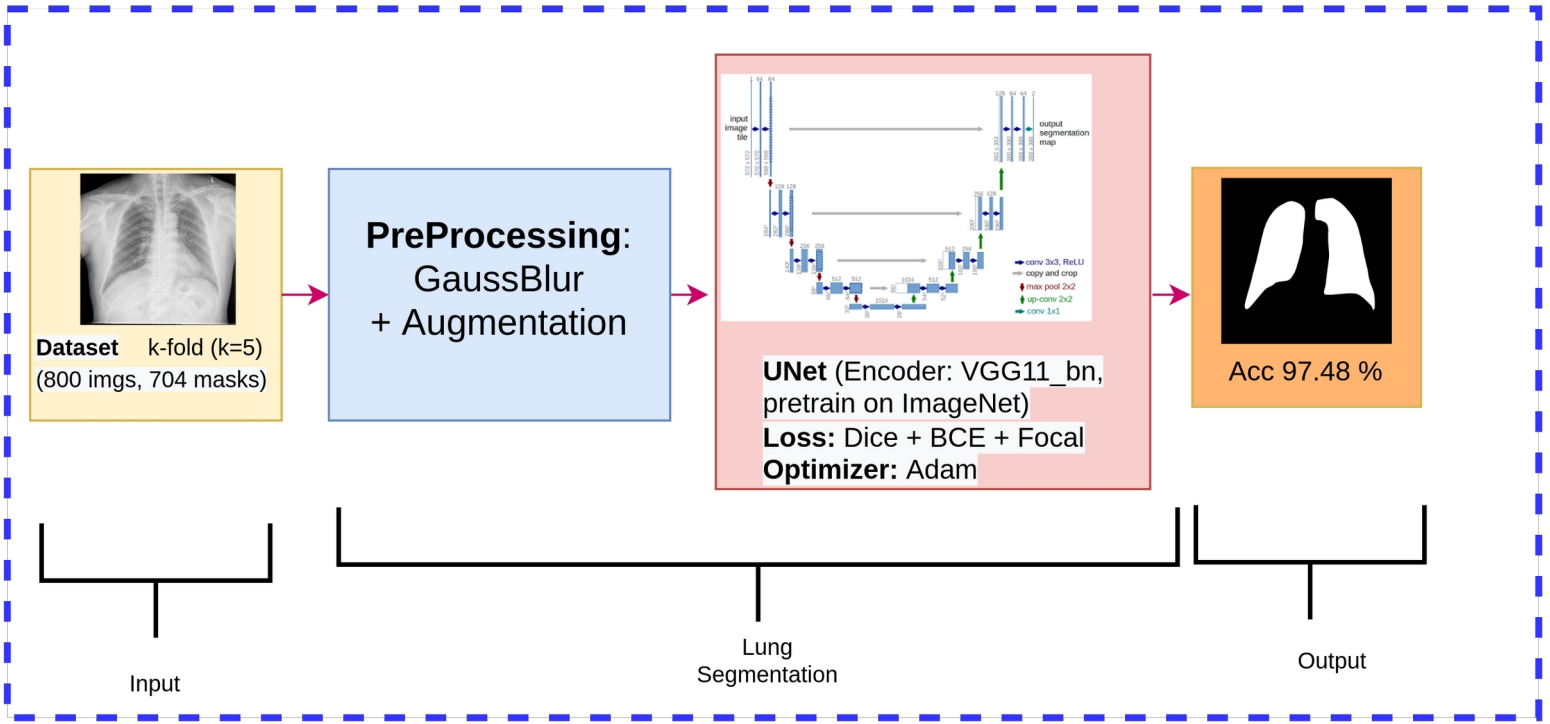
Input

Lung Segmentation

Output

# Pipeline Lung Segmentation

## Train/Validation phase




Fold 0: 97.15 %

Fold 1: 97.57 %

Fold 2: 97.45 %

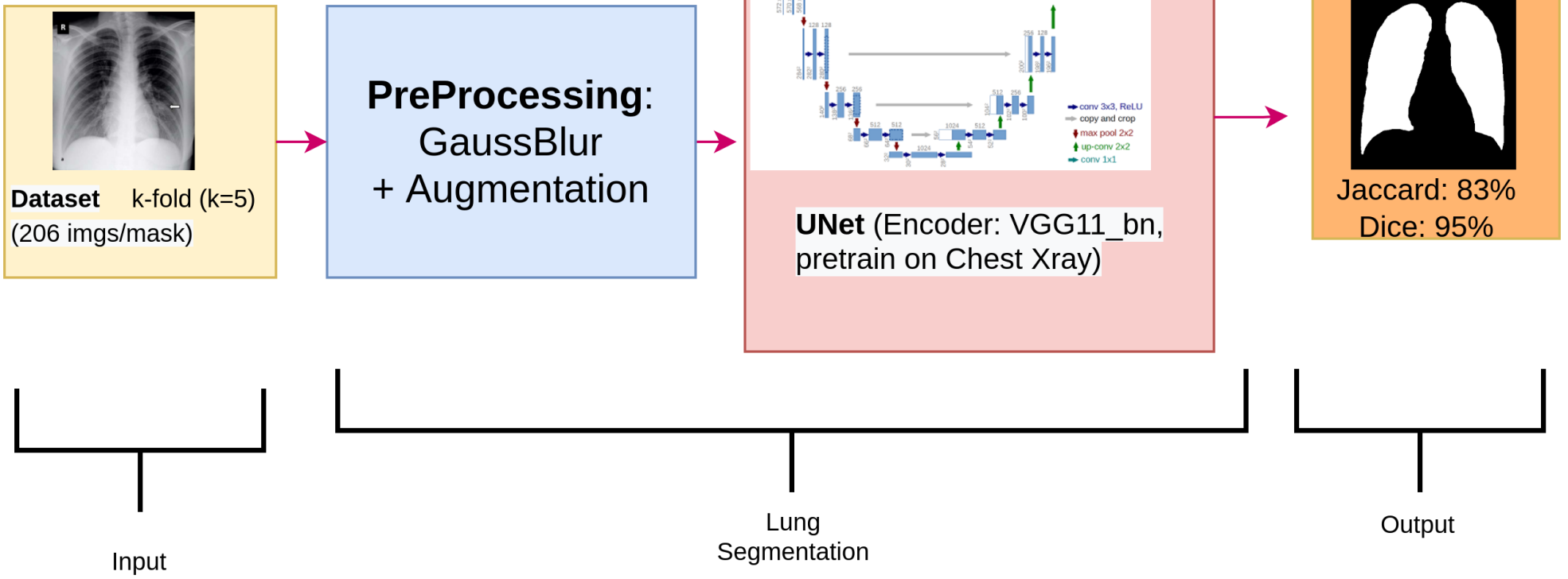
Fold 3: 97.60 %

Fold 4: 97.60 %

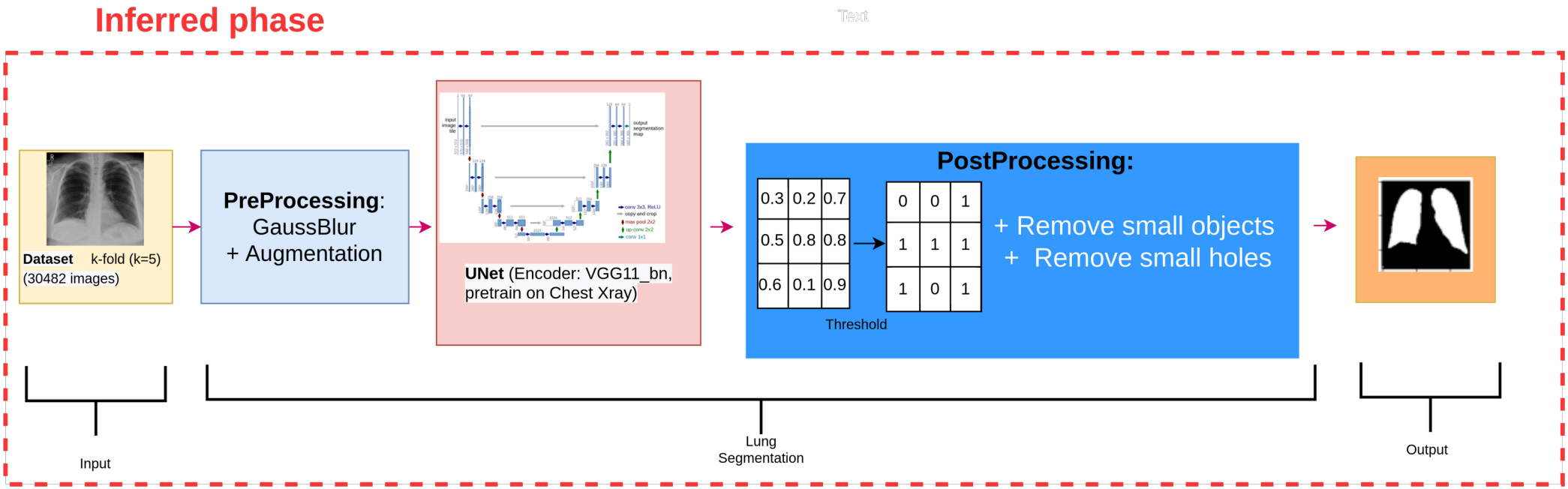
Average: 97.48 %

# Pipeline Lung Segmentation

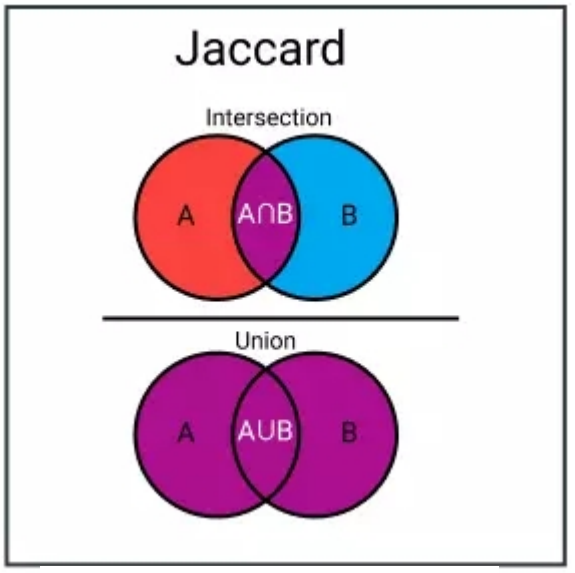
## Test phase

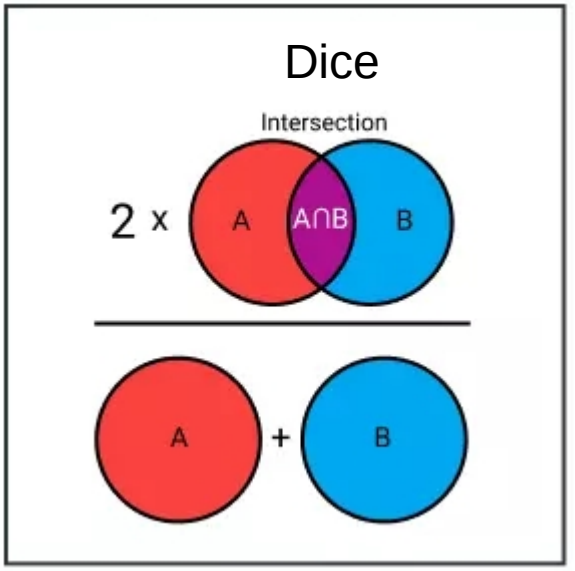


# Pipeline Lung Segmentation



# Segmentation evaluation metrics




$$IOU(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

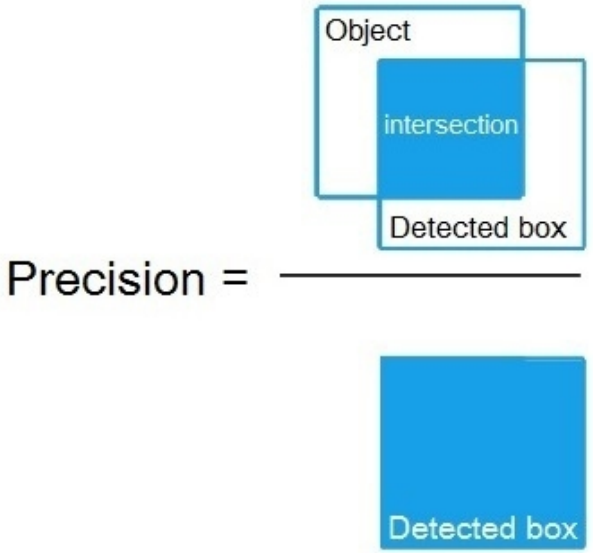
$$dice(A,B) = \frac{2|A \cap B|}{|A| + |B|}$$

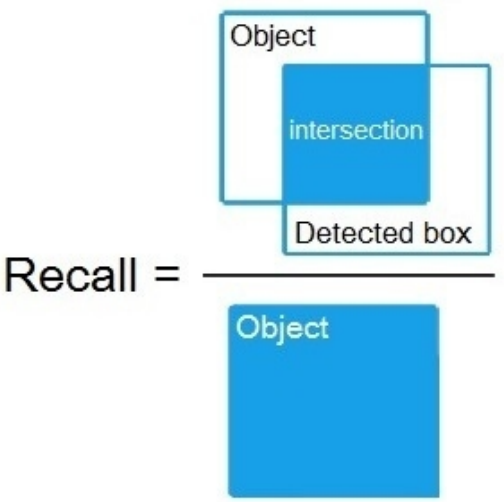
$$IOU = \frac{dice}{2 - dice}$$

https://viblo.asia/p/distance-measure-trong-machine-learning-ByEZkopYZQ0#_8-jaccard-index-8

https://www.programmersought.com/article/47276704061/

# Segmentation evaluation metrics




$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

# 6. Result

**Comparison performance results computed over test (unseen) set with seven encoder architectures**

| | Encoder | Jaccard | Dice | Recall | Precision | Accuracy |
|---|---|---|---|---|---|---|
| Train from the scratch | Unet (original) | 0.70618 | 0.90654 | 0.82168 | 0.74054 | 0.9382 |
| | UNet_BN | 0.81286 | 0.94134 | 0.8934 | 0.8439 | 0.95724 |
| Encoder Pre-Trained on ImageNet | **ResNet18** | 0.82866 | 0.94666 | 0.90466 | 0.8568 | 0.9624 |
| | ResNet34 | 0.81586 | 0.89630 | 0.84028 | 0.9666 | 0.94302 |
| | ResNet152 | 0.79358 | 0.93648 | 0.88114 | 0.82436 | 0.95704 |
| | DenseNet121 | 0.79778 | 0.93664 | 0.88458 | 0.82572 | 0.9595 |
| | VGG11_bn | **0.83392** | **0.94766** | **0.90754** | **0.87396** | **0.94872** |

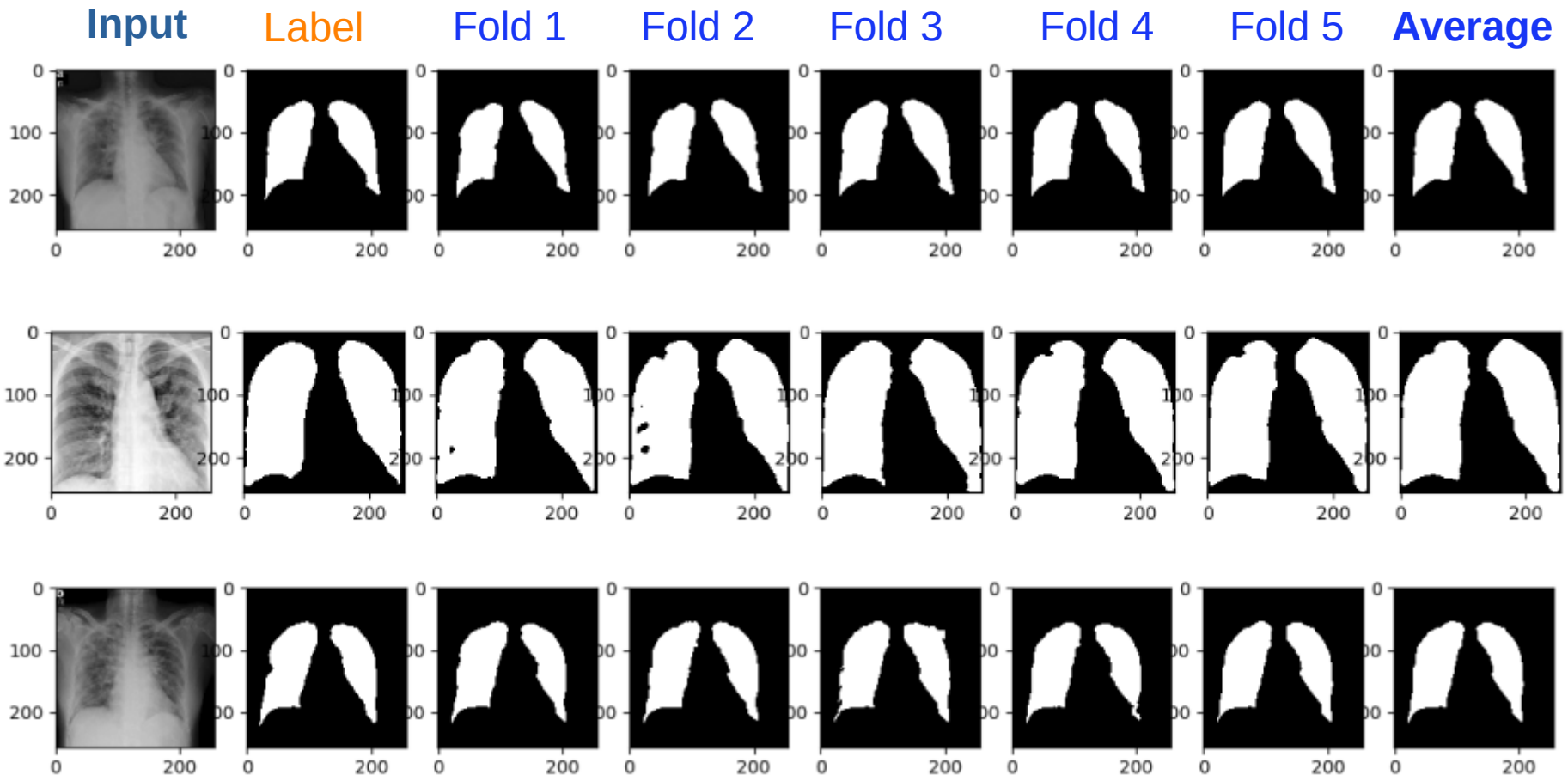
# 6. Result

## The number of trainable parameters of the models

| | Encoder | Trainable params |
|---|---|---|
| Train from the scratch | Unet (original) | 7,78 M |
| | UNet_BN | 21,99 M |
| Encoder Pre-Trained on ImageNet | ResNet18 | 14,32 M |
| | ResNet34 | 24,43 M |
| | ResNet152 | 67,15 M |
| | DenseNet121 | 13,60 M |
| | VGG11_bn | **18,26 M** |

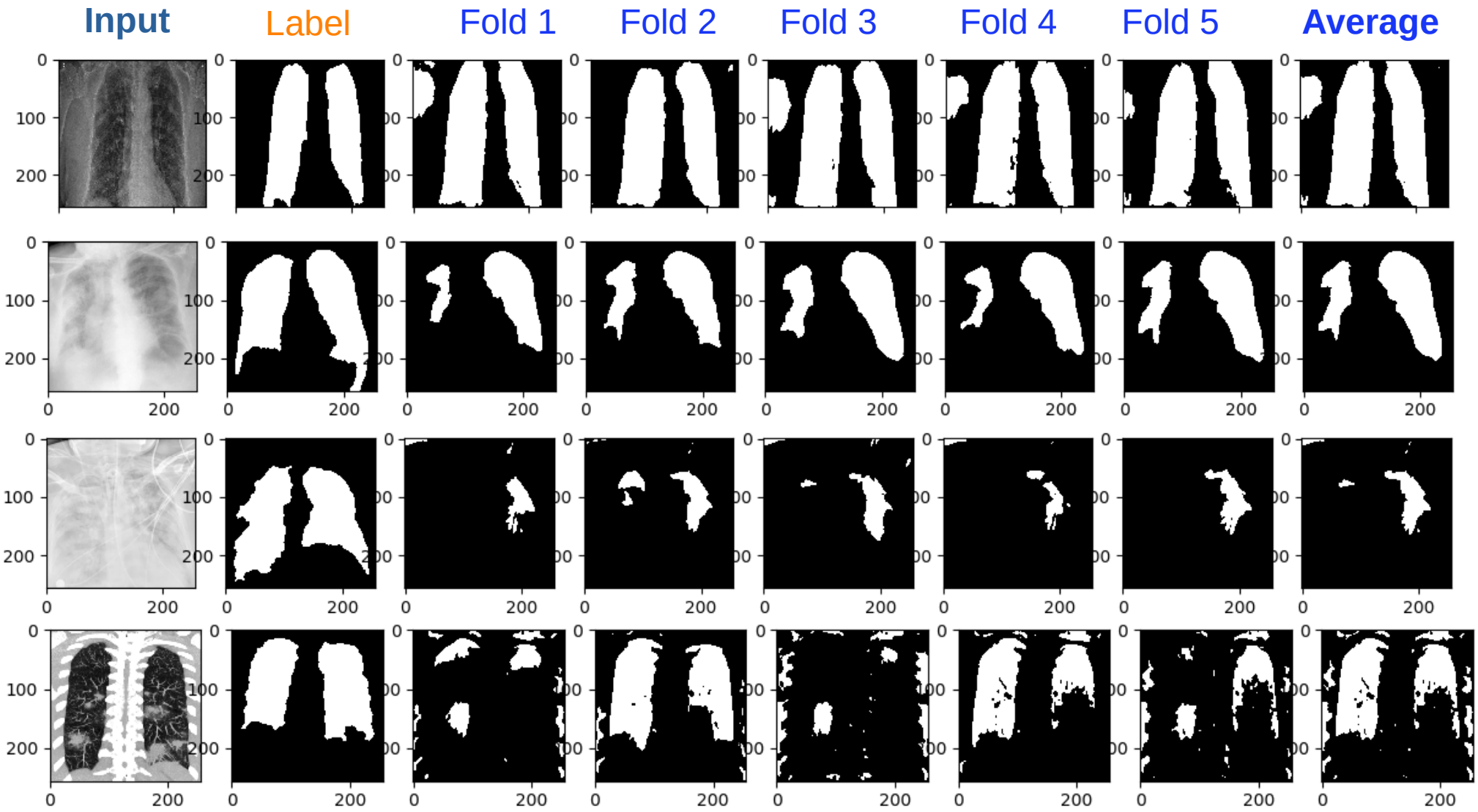
# 6. Result

Test results (Good cases)

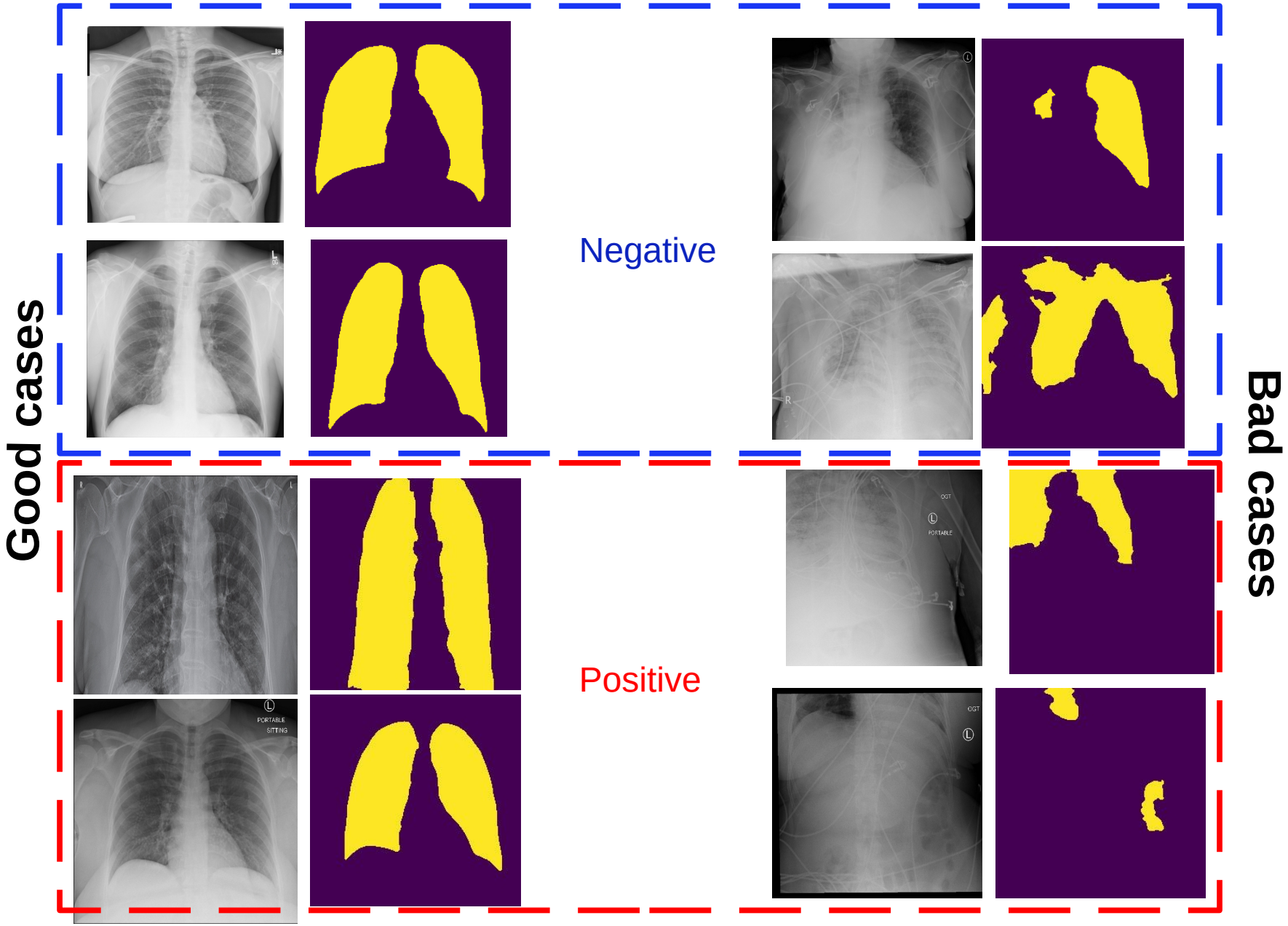


# 6. Result

Test results (Bad cases)



# 6. Result (inference)



# 7. Conclusion

- Constructed ground-truth lung segmentation masks for COVIDx CXR-2 dataset (30482 images)
- Future works
  - Find ways to improve performance
  - Carry out the covid-19 classification

# THANK YOU
# FOR LISTENING