

Deep learning based classification algorithm for Covid-19

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Outline

1. Related work
2. Problem Statement
3. Algorithm
4. Experiments
5. Limitations and future work

Related Work

- **Covid-19 Classification**
 - Two kinds of algorithm
 1. **Directly** train CNN backbone on medical image
 2. **Processing** before training network (*e.g. Data augmentation, segmentation*)
 - Difference choice of negative samples
- **Image Classification**
 - *Problem Statement:* Assign labels to images from a given set of categories
 - Two direction
 1. **Deeper** network (*e.g. AlextNet, VGGNet, GoogleNet => ResNet, DenseNet*)
 2. **Lightweight** network (*e.g. ShuffleNet, MobileNet*)

Related Work

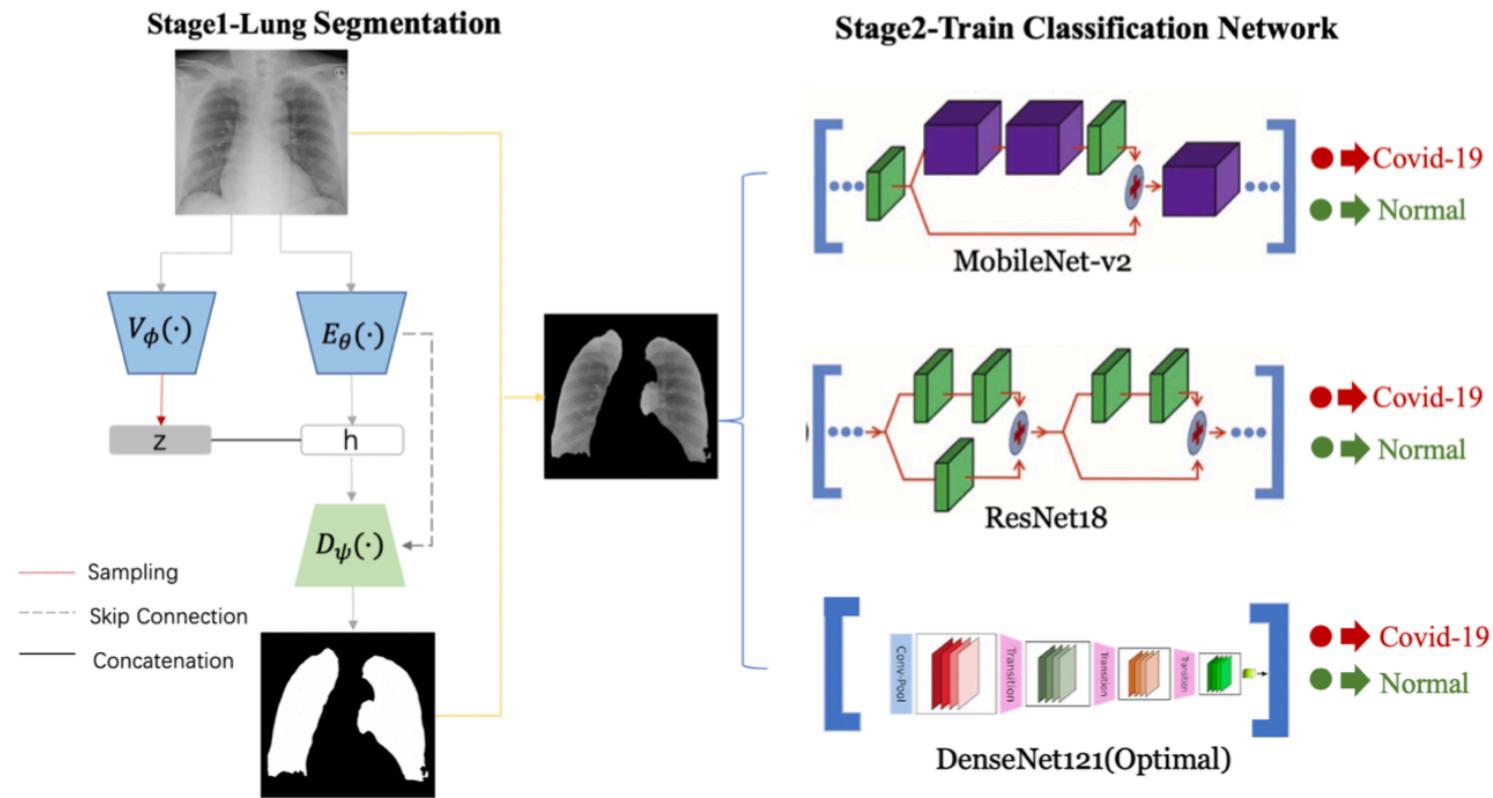
- **Medical Image Segmentation**
 - *Problem Statement: Segment the medical images with some special meanings*
 - Milestones
 1. Fully convolutional network (FCN)
 2. U-Net widely applied in medical image processing

Problem Statement

- **Binary classification** between Covid-19 and Normal
 - The ability to learn features of various lung diseases may be insufficient
- Given dataset $D = \{(x_i, y_i)\}_{i=1}^N$ (x_i is a chest X-ray image, $y_i \in \{0,1\}$)
Learning a mapping function: $f_\theta: x \rightarrow y$
 - Goal: correctly distinguish Covid-19 from normal people

Algorithm

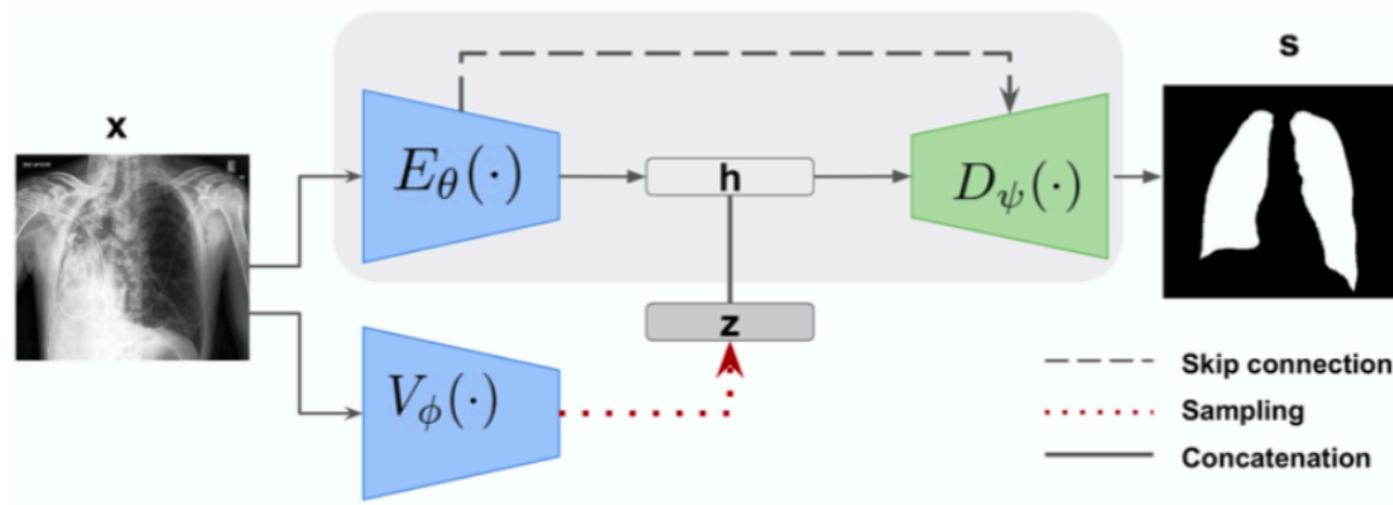
- 2-Stage algorithm



Algorithm

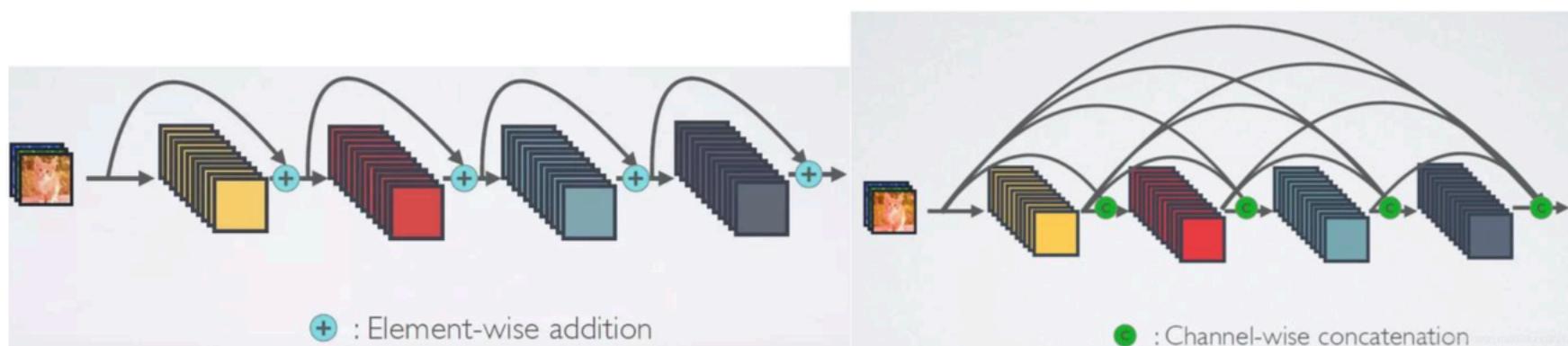
- **Step 1: Lung Segmentation**

- *Use a pre-trained lung segmentation network: LungVAE*
 - A variation of **U-net**, take advantage of variational autoencoder
 - Train large amount of chest X-ray with Dice-overlap 84.0%



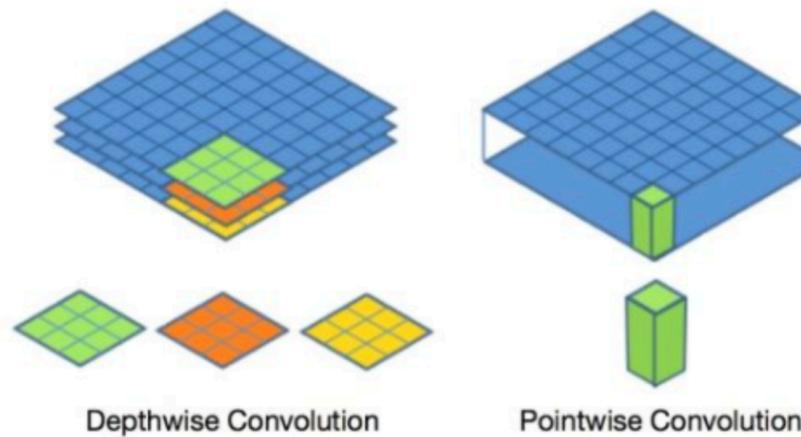
Algorithm

- Step 2: Train classification network
 - ResNet
 - Establish a *short-cut* connection between the front layer and the back layer
 - helpful for back propagation, thus training *a deeper and better* CNN network
 - DenseNet
 - More aggressive *dense connection* : all layers are connected to each other



Algorithm

- Step 2: Train classification network
 - MobileNet
 - A typical *lightweight network* with fewer parameters
 - Trick: Split the convolution operation into *Depthwise* and *Pointwise*



Algorithm

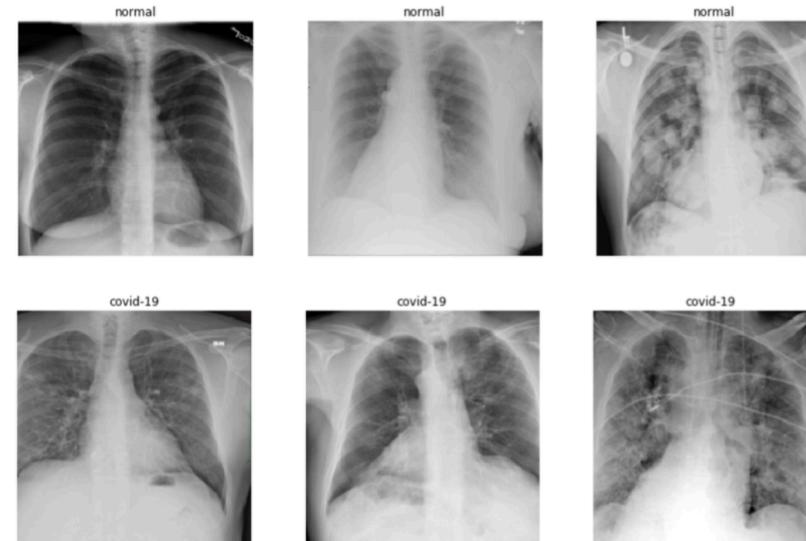
- **Training**

$$L = - \sum_{i=1}^N \{y_i \log \hat{y}_i + (1 - y_i) \log(1 - \hat{y}_i)\}$$

Experiments

- **Dataset**

- *Total: 392 chest X-ray images, half positive and negative samples*
- Split dataset into trainset, testset and validationset with ratio **7:2:1**



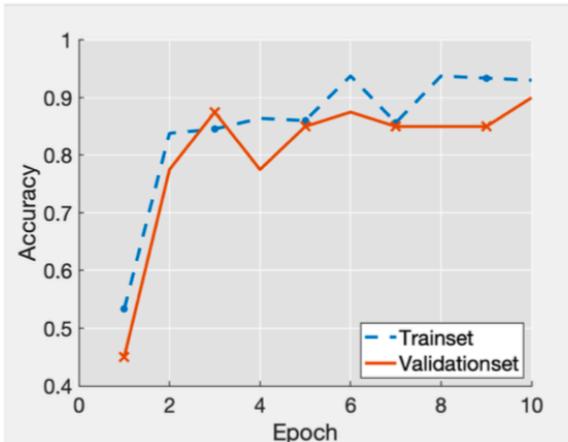
Experiments

- Steps
 1. The pre-trained lung segmentation network was called to get **masks**
 2. The mask is **combined** with original image to obtain segmented image.
 3. Train different classification networks on segmented images

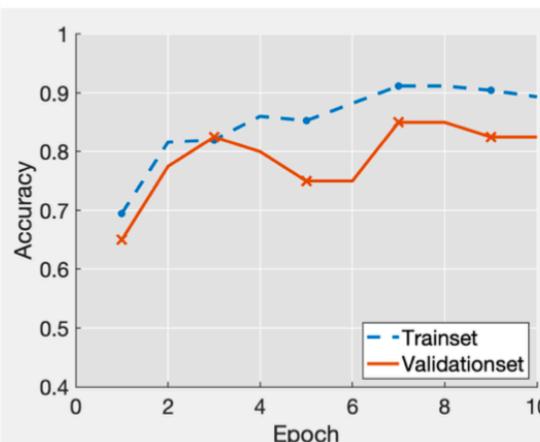


Experiments

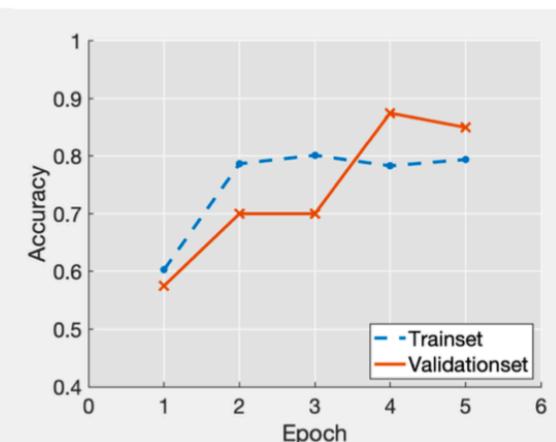
- **Hyperparameters**
 - *Learning rate 0.002 with Adam-optimizer*
- **Results**
 - *DenseNet performs best, with 93% accuracy on trainset and converges faster*
 - *MobilNet encounters heavy overfitting when epoch increases*



(a) DenseNet



(b) ResNet



(c) MobileNet

Experiments

- **Comparison between raw-dataset and segmented dataset**
 - *DenseNet* performs best no matter segmented or non-segmented
 - Segmented dataset achieves higher accuracy, *recall* and *F1-score*

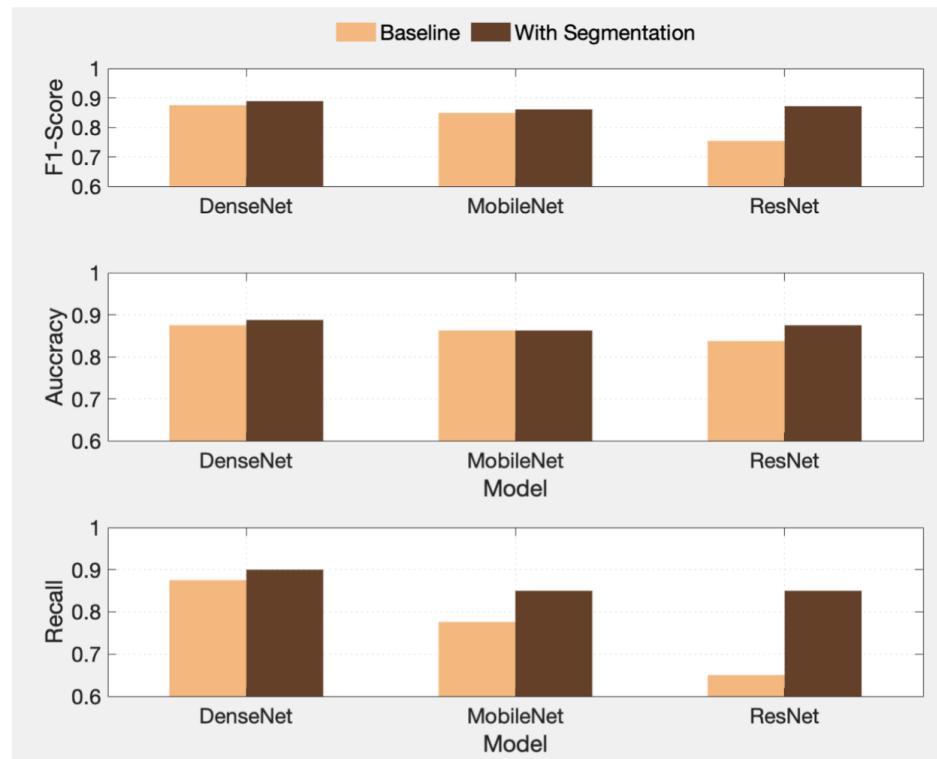
表 1: 三个分类网络作用于原图和经过分割处理后图像的性能比较

Model	Accuracy	Precision	Recall	F1-score
DenseNet	87.50%	87.50%	87.50%	87.50%
MobileNet	86.25%	93.94%	77.50%	84.93%
ResNet	83.75%	89.66%	65.00%	75.36%
Segmentation+DenseNet	88.75%	87.80%	90.00%	88.89%
Segmentation+MobileNet	86.25%	87.18%	85.00%	86.08%
Segmentation+ResNet	87.50%	89.47%	85.00%	87.18%

Experiments

- Comparison between raw-dataset and segmented dataset

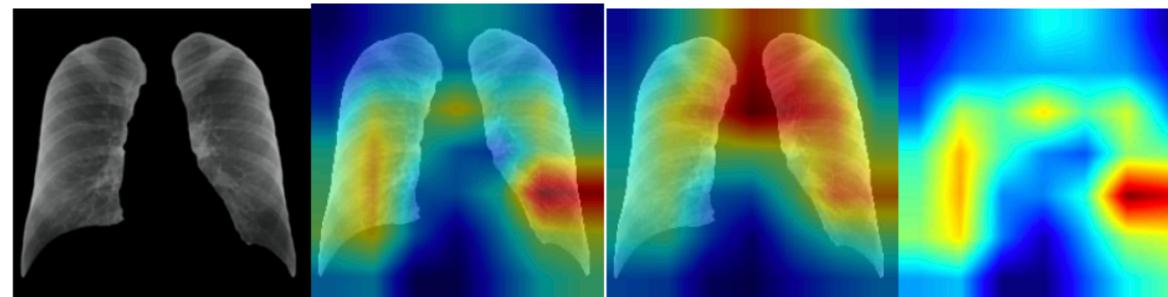
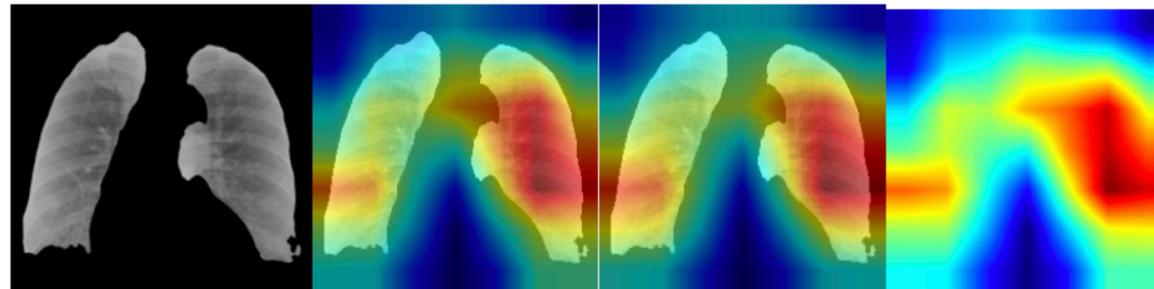
=> Our 2-stage algorithm is **reasonable and efficient**



Experiments

- **Case Study**

Grad-CAM, Grad-CAM++ and heatmap on Covid-19 chest X-ray



Conclusions

- **Construct a reasonable dataset**
 - Binary classification on chest X-ray dataset
- **Propose an efficient 2-stage algorithm**
 - Segmentation + CNN backbone
 - Achieve 88.75% accuracy and 88.89% F1-score
 - Compared with pure CNN, **recall** increased significantly

Limitations & Future work

- **Dataset is so small**
 - insufficient to learn comprehensive features for classification
- **Lack of experiments on other classification network**
 - AlexNet, GoogleNet, etc
 - Attention mechanism
- **Lack comparison between different lung segmentation network**
 - FCN, U-Net, etc

Q&A