DEEP COVID

Predicting COVID-19 From Chest X-Ray Images Using Deep Transfer Learning
https://arxiv.org/abs/2004.09363

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INTRODUCTION

- The COVID-19 pandemic is causing a major outbreak in more than 150 countries
- Early diagnosis is of real importance
- There are specific abnormalities in the chest radiographs of patients infected with COVID-19
    - Ground glass
    - Mixed attenuation
- Abnormalities can only be interpreted by expert radiologists
- Considering huge rate of suspected people and limited number of trained radiologists
    - Diagnosing takes several hours or even days
    - AI/machine learning solutions are potentially powerful tools to assist radiologists

HOW RADIOLOGISTS DETECT DISEASE

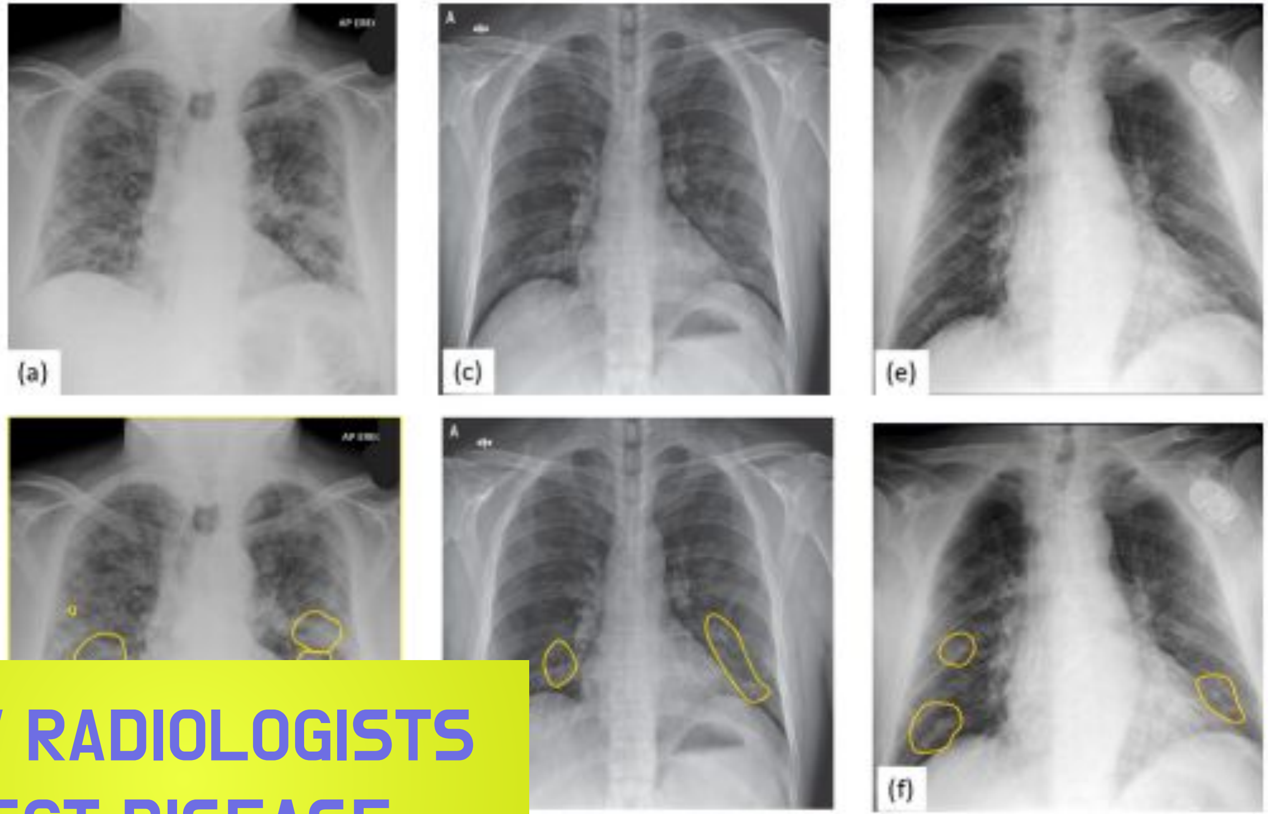


Fig. 1. Three sample COVID-19 images, and the corresponding marked areas by our radiologist.

DATASET

- COVID-Xray-5k Dataset
  - Covid-Chestxray Dataset
  - Chexpert Dataset
- Covid-Chestxray is an small dataset
  - Augmentation

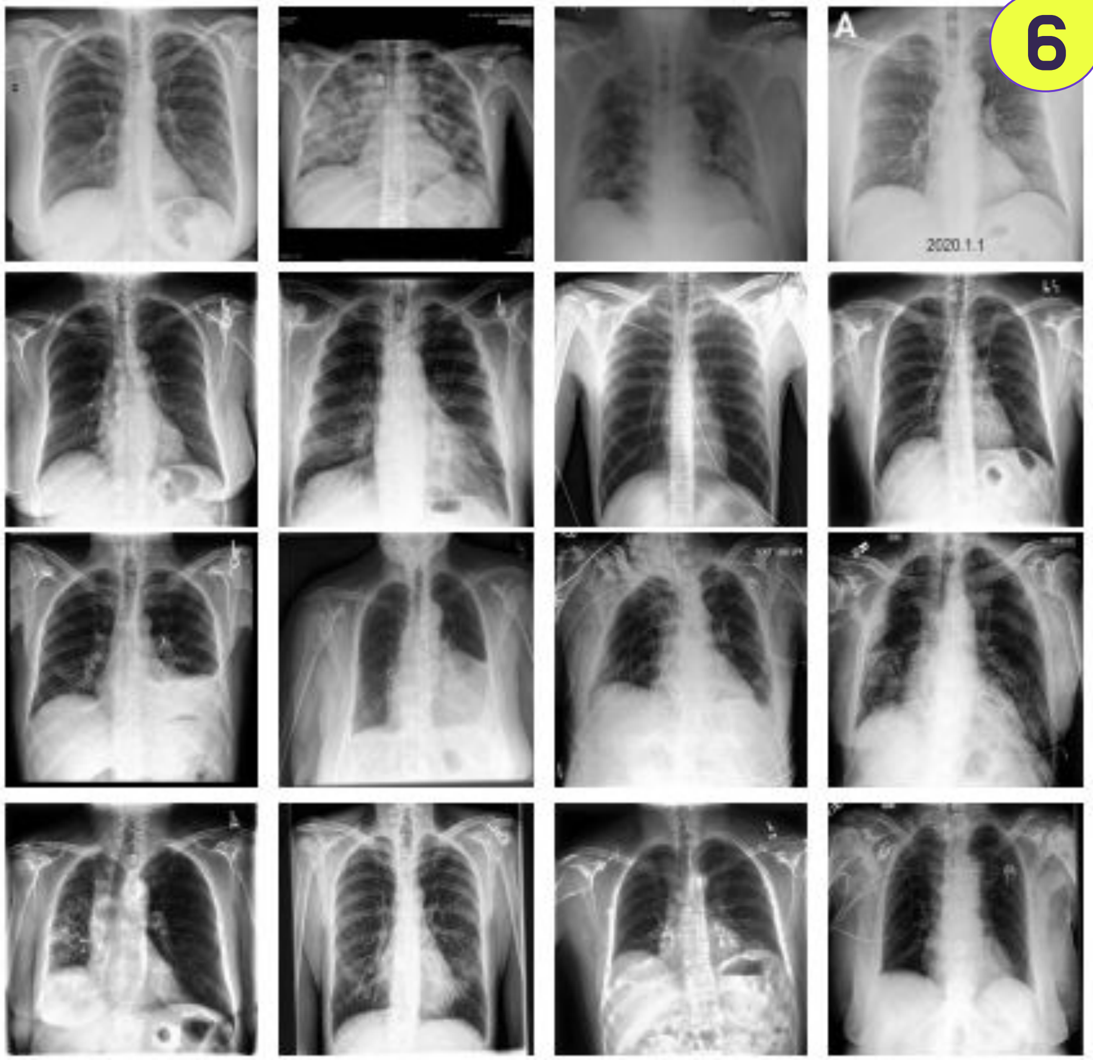
COVID-Xray-5k Dataset

SPLIT	COVID-19	NON-COVID
Training Set	84 → 420	2000
Test Set	100	3000

COVID-19

NO DISEASE

OTHER DISEASE



FRAMEWORK

- Transfer learning approach
  - Model repurposed
  - Suitable for small datasets
  - Two ways
    - As feature extractor
    - Whole network get tuned
- We use both on ImageNet dataset
  - Fine-tuning last layer
  - Extracting feature

Used Convolutional Models

ResNet

The core idea of ResNet is introducing a so-called identity shortcut connection that skips one or more layers.

SqueezeNet

They alternate a 1x1 layer that "squeezes" the incoming data in the vertical dimension followed by two parallel 1x1 and 3x3 convolutional layers that "expand" the depth of the data again.

DenseNet

Each layer obtains additional inputs from all preceding layers and passes on its own feature-maps to all subsequent layers.

RESULTS

- Model Hyper-parameters
  - 100 epochs
  - 20 batch size
  - ADAM optimizer
  - 0.0001 learning rate
  - Images are down-sampled to 224x224
- Evaluation metrics are as shown below

$$\textbf{Sensitivity} = \frac{\text{\#Images correctly predicted as COVID-19}}{\text{\#Total COVID-19 Images}},$$

$$\textbf{Specificity} = \frac{\text{\#Images correctly predicted as Non-COVID}}{\text{\#Total Non-COVID Images}}.$$

Table 2. Sensitivity and specificity rates of ResNet18 model, for different threshold values.

Threshold	Sensitivity	Specificity
0.1	100%	72.4%
0.17	98%	90.7%
0.2	95%	92.4%
0.25	91%	95.8%
0.35	85%	98.3%

Table 3. Sensitivity and specificity rates of ResNet50 model, for different threshold values.

Threshold	Sensitivity	Specificity
0.15	100%	78.2%
0.205	98%	89.6%
0.25	93%	94.2%
0.3	90%	97.3%
0.35	85%	98.4%

Table 5. Sensitivity and specificity rates of DenseNet-121 model, for different threshold values.

Threshold	Sensitivity	Specificity
0.19	98%	75.1%
0.25	95%	88.9%
0.3	90%	94.6%
0.4	79%	98.9%

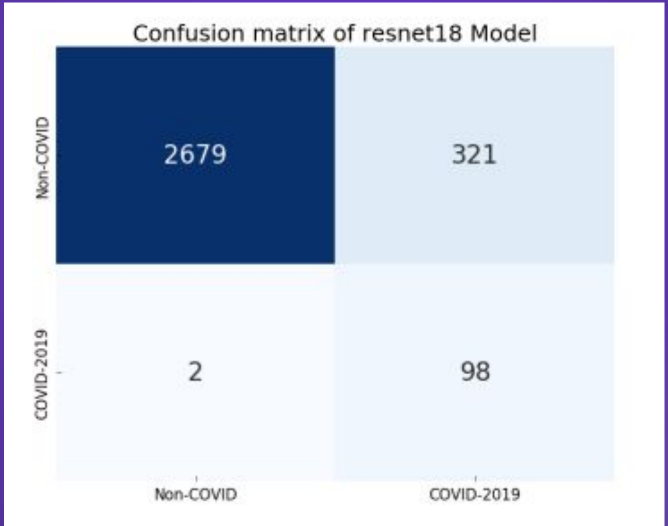
Table 4. Sensitivity and specificity rates of SqueezeNet model, for different threshold values.

Threshold	Sensitivity	Specificity
0.1	100%	89.9%
0.15	98%	92.9%
0.2	96.0%	94.6%
0.4	92%	97.6%
0.5	87%	98.3%

Table 6. Comparison of sensitivity and specificity of four state-of-the-art deep neural networks.

Model	Sensitivity	Specificity
ResNet18	98% ± 2.7%	90.7% ± 1.1%
ResNet50	98% ± 2.7%	89.6% ± 1.1%
SqueezeNet	98% ± 2.7%	92.9% ± 0.9%
Densenet-121	98% ± 2.7%	75.1% ± 1.5%

The Heatmap of Potentially Infected Regions



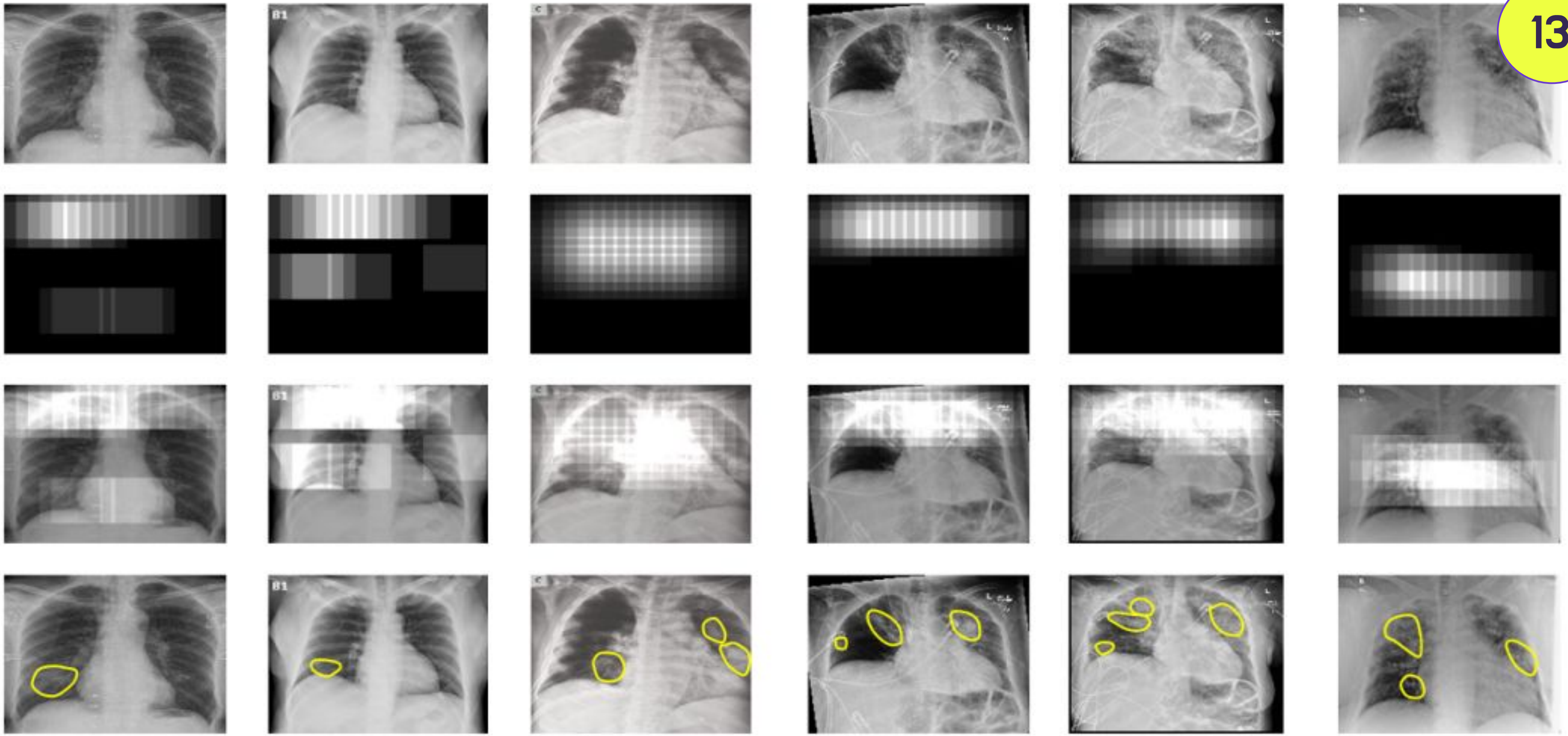


Fig. 14. COVID-19 infected regions detected by our ResNet18 model, in six chest X-ray images from the test set. Vertical sets give the Original images (top row), COVID-19 region heatmap (2^{nd} row), heatmap overlaid on the image (3rd row), and the independent standard of radiologist-marked COVID-19 disease regions (bottom row).

CONCLUSIONS

We performed a detail experimental analysis evaluating the performance of each of these 4 models on the test set of of COVID-Xray-5k Dataset, in terms of sensitivity, specificity. For a sensitivity rate of 98%, these models achieved a specificity rate of around 90% on average. This is really encouraging, as it shows the promise of using X-ray images for COVID-19 diagnostics. This study is

THANKS!

Does anyone have any questions?