Chest Pathology Classification in X-Rays using Deep Learning

Nona Falaki, Junhui Li, Huiqi Yuan, Nicolai Schneider

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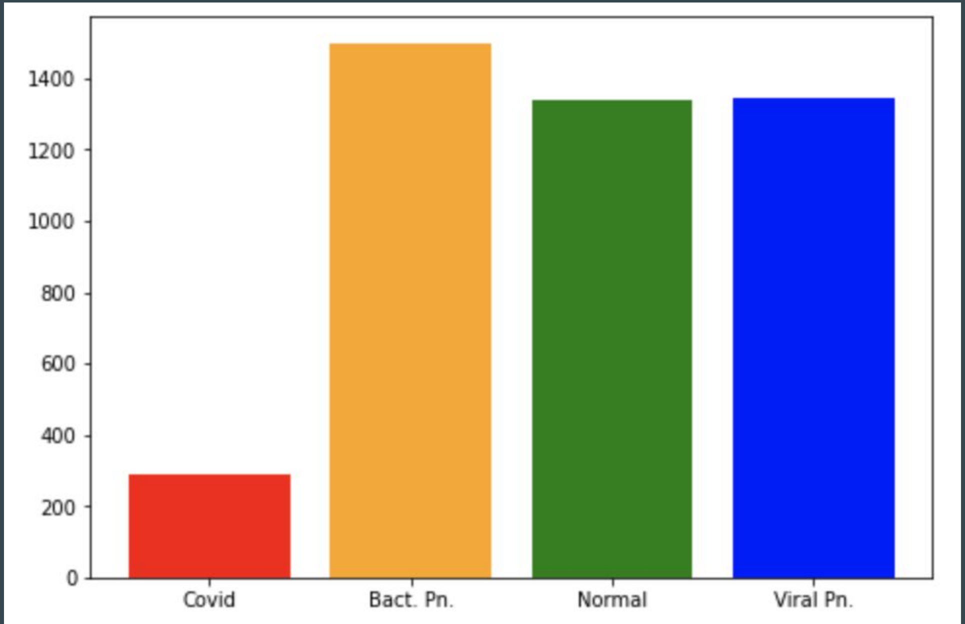
What was our goal?

Training a model to differentiate between the following classes

- COVID-19
- Bacterial Pneumonia
- Viral Pneumonia
- Healthy cases (referred to as 'Normal' throughout the presentation)



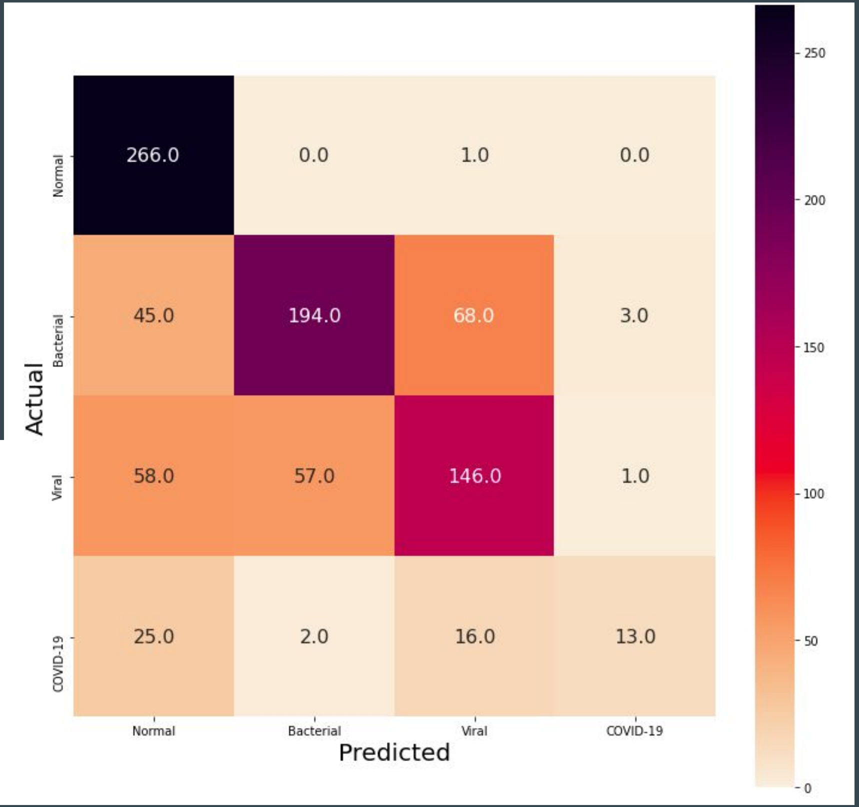
What was our strategy?

- First try with VGG-19 performed poorly

➢ Generate more samples with GAN

[INFO] evaluating network...

	precision	recall	f1-score	support
Normal	0.68	1.00	0.80	267
Bacterial	0.77	0.63	0.69	310
Viral	0.63	0.56	0.59	262
COVID-19	0.76	0.23	0.36	56
accuracy			0.69	895
macro avg	0.71	0.60	0.61	895
weighted avg	0.70	0.69	0.67	895



What was our strategy?

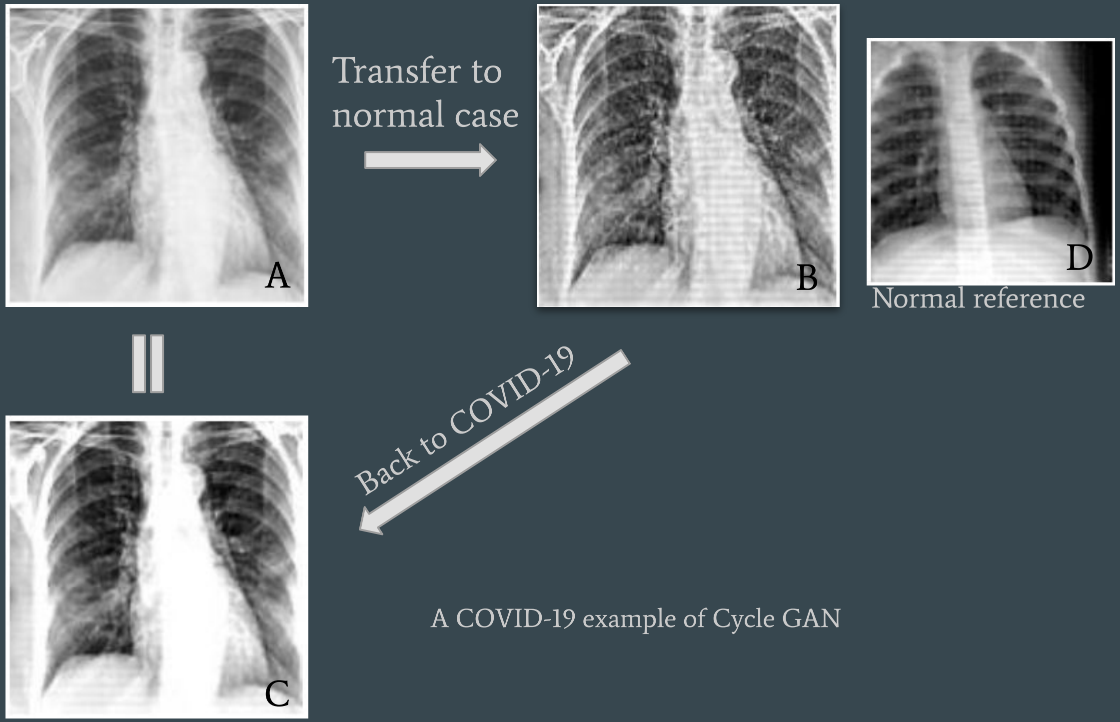
- Implemented GANs
  - Cycle GAN
  - SRGAN in combination with DCGAN
- Classification with multiple architectures
  - DenseNet
  - ResNet
  - VGG-19
- Evaluation of training based on
  - Confusion Matrix and Accuracy Scores (Precision, Recall, F1-score)
  - Saliency Map
  - Grad-CAM

Cycle GAN

A remedy for cycle GAN:

Using the recurrent images at different time steps for Augmentation

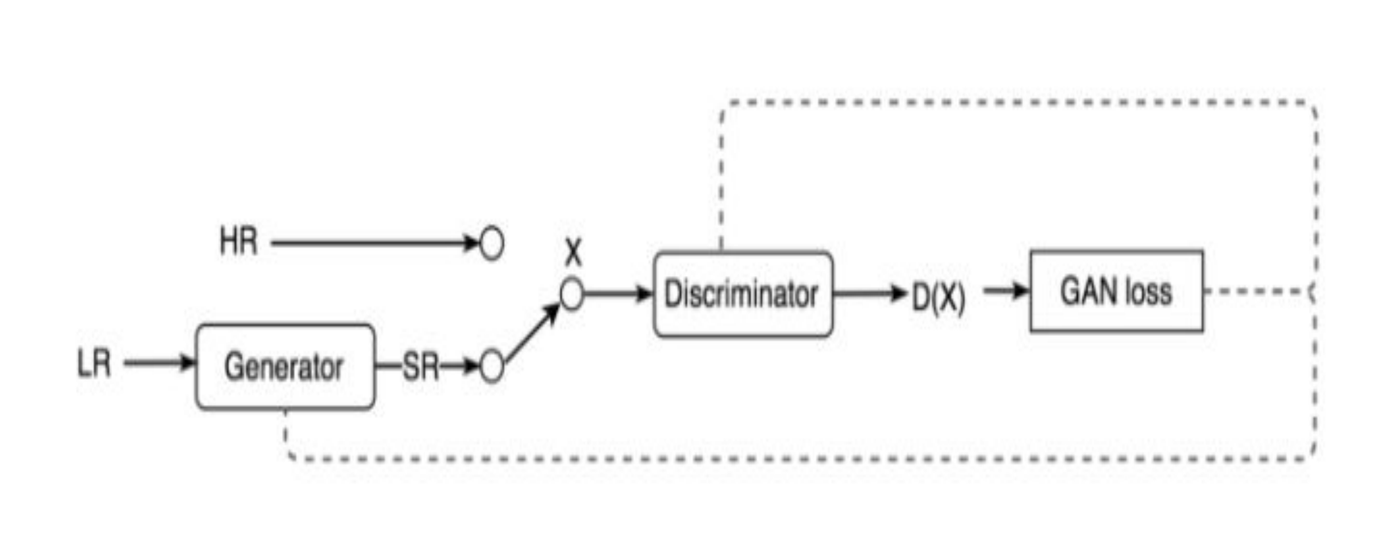
The same trick for Bacterial Pneumonia and Viral Pneumonia cases



A COVID-19 example of Cycle GAN

Super Resolution GAN

- Principle



Principle of SRGAN [1]

SR: Super resolution

LR: Low resolution

HR: High resolution

DCGAN → SRGAN

DCGAN

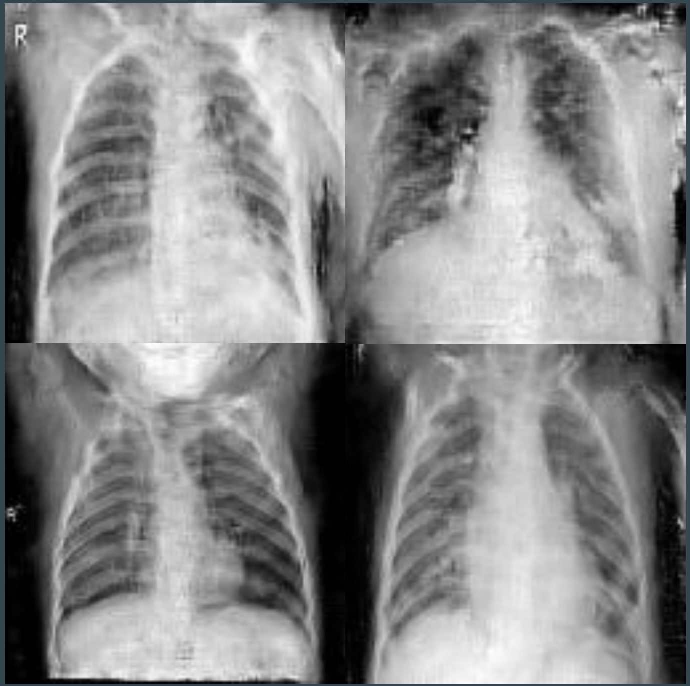
- Relu activation function
- 0.0002 Adam learning rate
- 10000 iterations
- One side label smoothing

SRGAN

- Low resolution picture size: 64*64
- High resolution picture size: 256*256
- 0.0002 Adam learning rate
- 80000 iterations
- Pre-trained model VGG-19

DCGAN

Bacterial Pneumonia Covid-19



Normal Viral Pneumonia

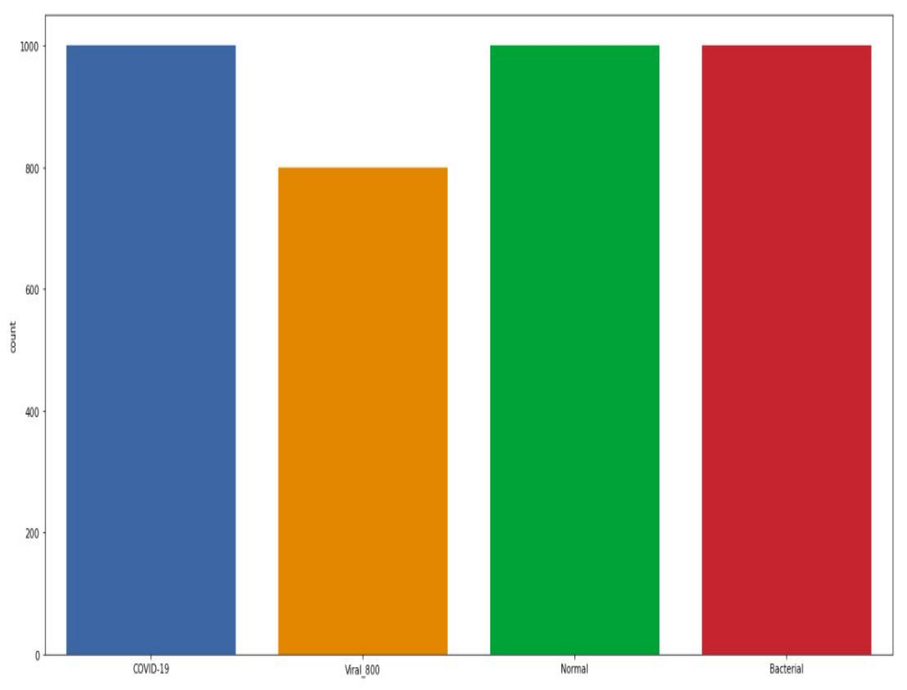
SRGAN

Bacterial Pneumonia Covid-19

Normal Viral Pneumonia

Final Dataset

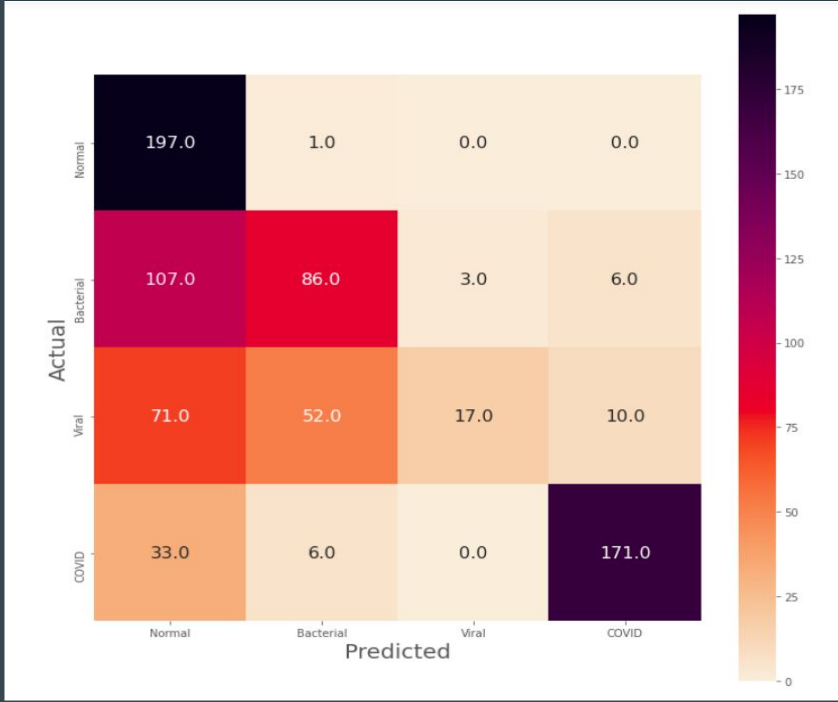
- Almost 500 synthetically generated images per class
- Dataset was split into the following categories:
    - 50 % for training
    - 30 % for validation
    - 20 % for evaluation

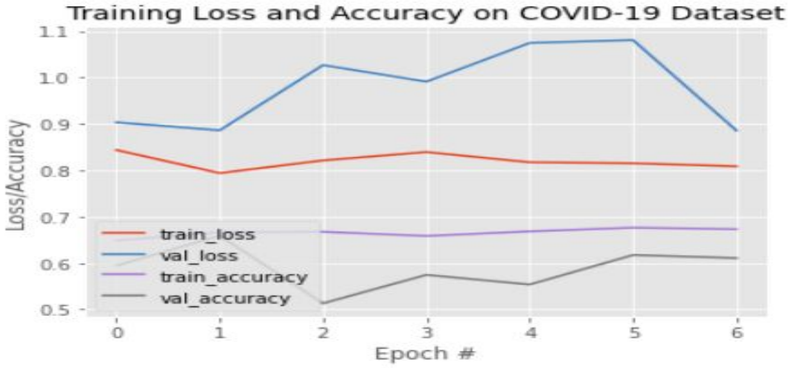


DenseNet 121

- Transfer learning with pre-trained CheXNet weights
- Freeze pre-trained lower layers
- Add Dropout and FC layer
- Learning rate: 0.002
- Early stopping

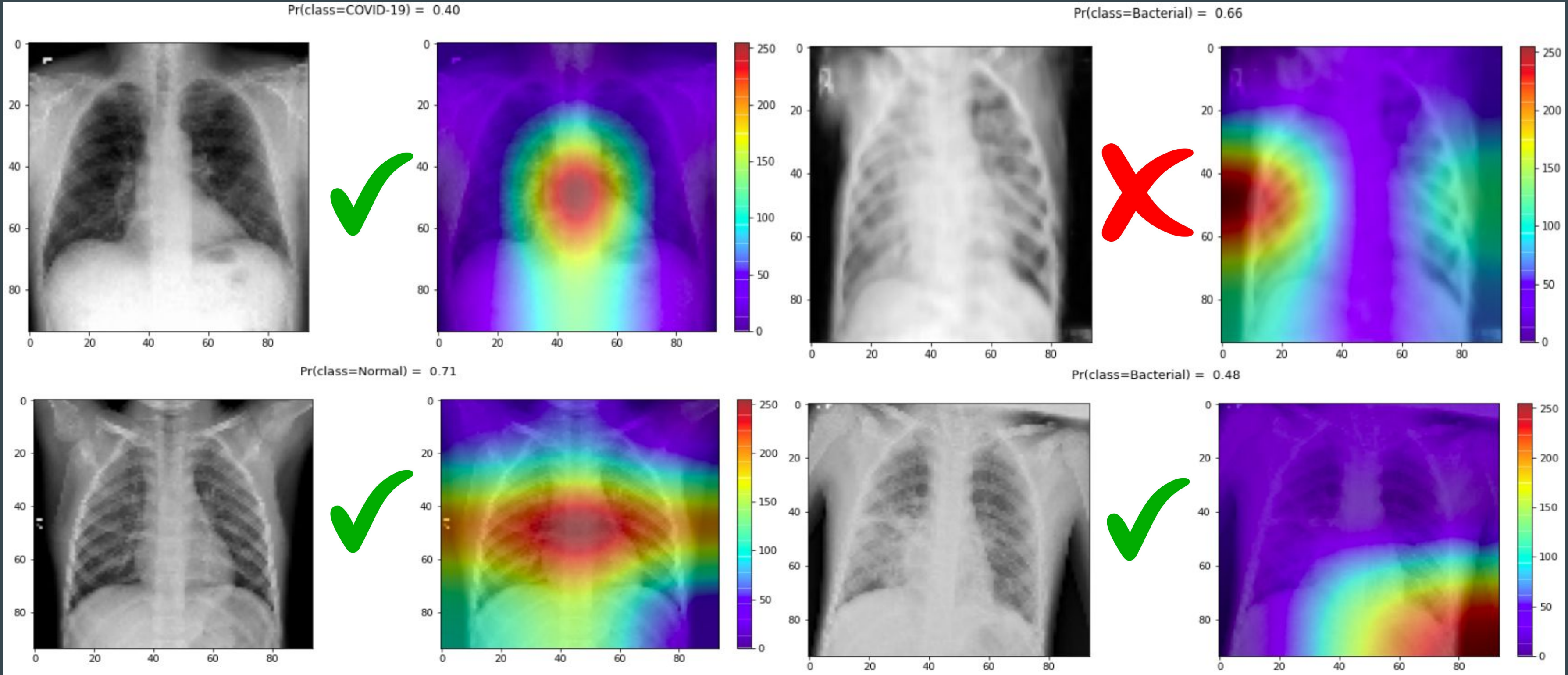
DenseNet 121 - Accuracy



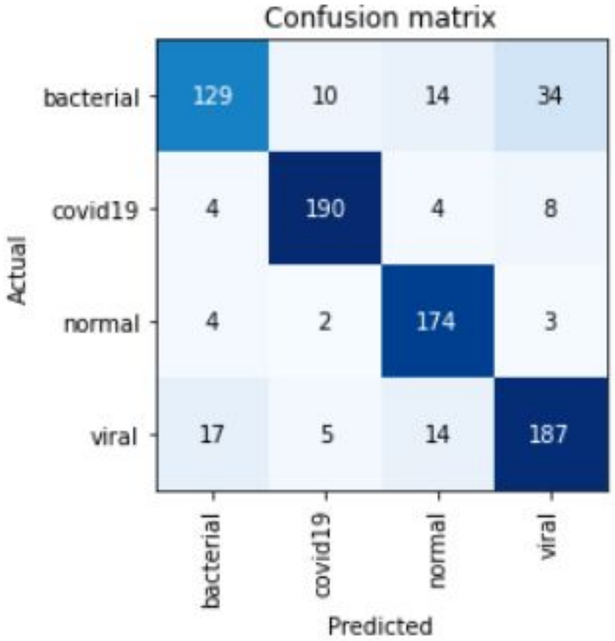


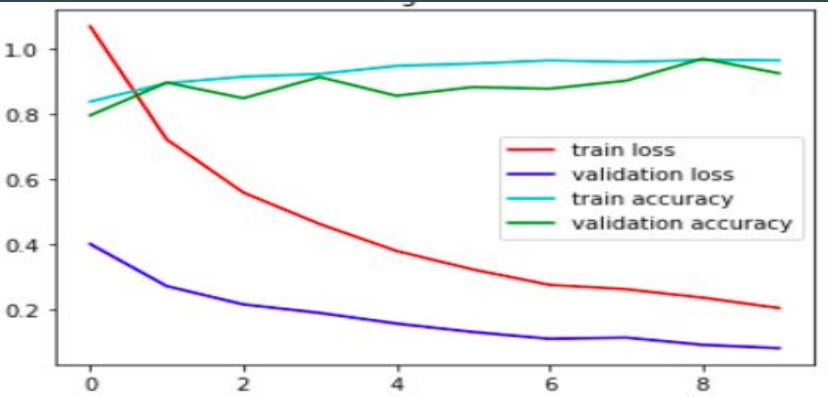
	precision	recall	f1-score	support
Normal	0.48	0.99	0.65	198
Bacterial	0.59	0.43	0.50	202
Viral	0.85	0.11	0.20	150
COVID	0.91	0.81	0.86	210
accuracy			0.62	760
macro avg	0.71	0.59	0.55	760
weighted avg	0.70	0.62	0.58	760

DenseNet 121 - Grad-CAM



Resnet 50 - Accuracy

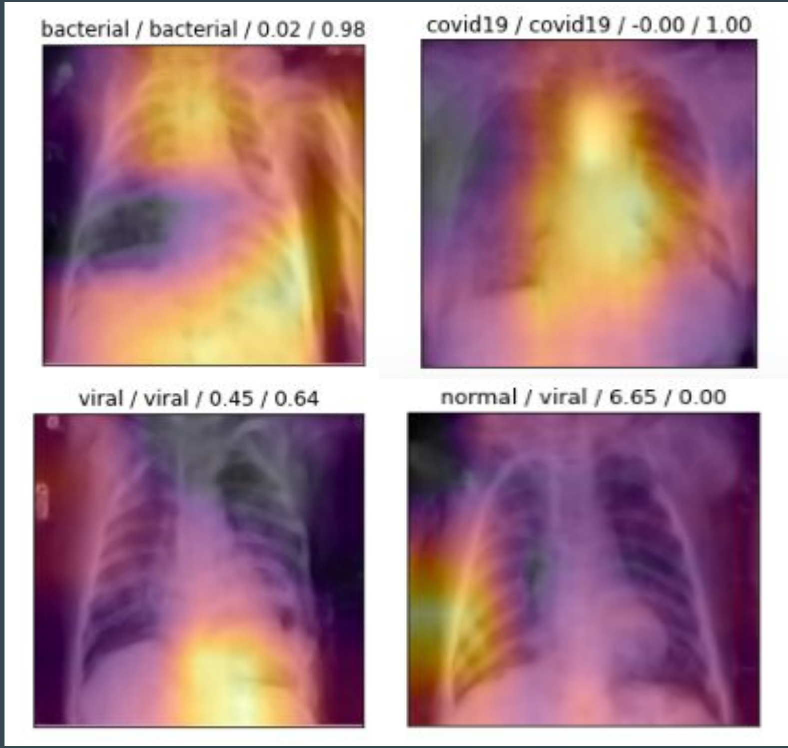




	precision	recall	f1-score	support
bacterial	1.00	0.01	0.02	200
covid19	0.44	0.78	0.56	200
normal	0.93	0.38	0.54	200
viral	0.25	0.96	0.40	200
accuracy			0.38	800
macro avg	0.65	0.53	0.38	800
weighted avg	0.81	0.38	0.34	800

Resnet 50 - Grad-CAM

Predicted/Actual/Loss/Probability



VGG-19

VGG-19: A trained Convolutional Neural Network, from Visual Geometry Group, Department of Engineering Science, University of Oxford[2].

Pre-trained on ImageNet.

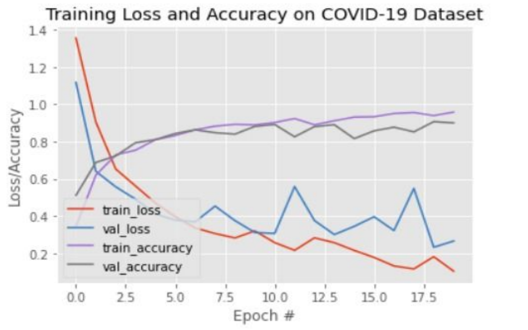
The network takes a RGB image as the input.

16 Convolutional layers plus 3 fully connected layers.

Pre-trained weights are used and transfer learning is applied.

[INFO] evaluating network...

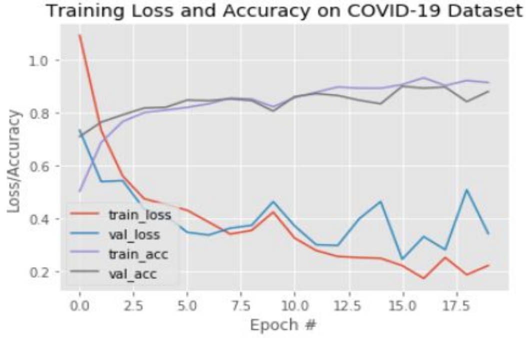
	precision	recall	f1-score	support
Normal	0.96	0.98	0.97	202
Bacterial	0.85	0.89	0.87	214
Viral	0.83	0.78	0.80	147
COVID	0.99	0.97	0.98	197
accuracy			0.91	760
macro avg	0.91	0.91	0.91	760
weighted avg	0.91	0.91	0.91	760



The result based on the dataset of DC-SR-GANs plus original images

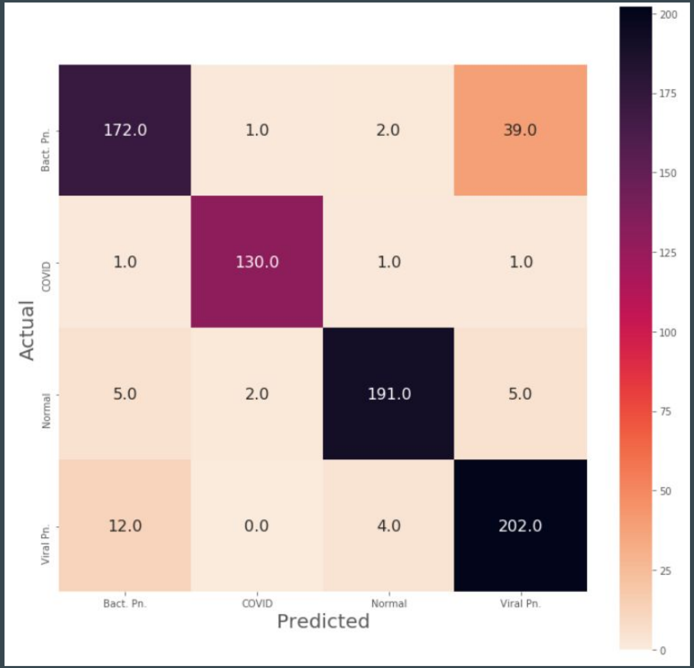
[INFO] evaluating network...

	precision	recall	f1-score	support
Bact. Pn.	0.91	0.80	0.85	214
COVID	0.98	0.98	0.98	133
Normal	0.96	0.94	0.95	203
Viral Pn.	0.82	0.93	0.87	218
accuracy			0.90	768
macro avg	0.92	0.91	0.91	768
weighted avg	0.91	0.90	0.90	768

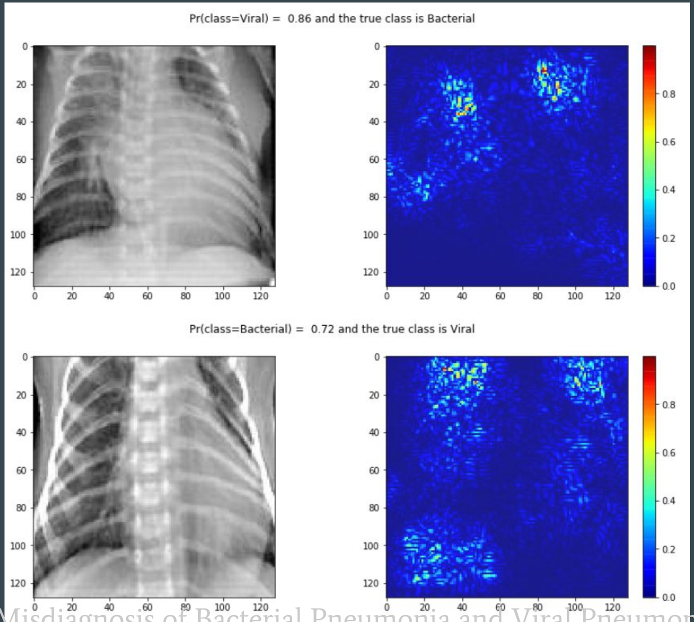


The result based on the dataset of Cycle-GANs plus original images

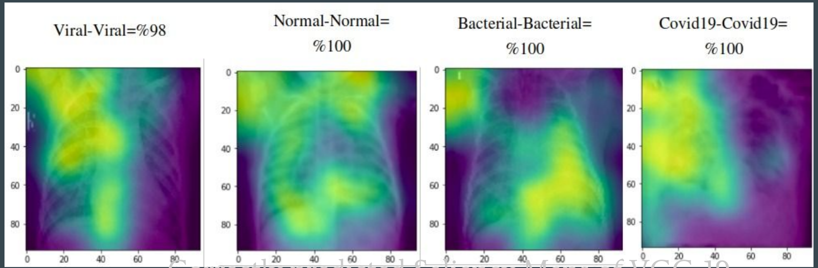
VGG-19 - Saliency Map



Confusion matrix of VGG-19

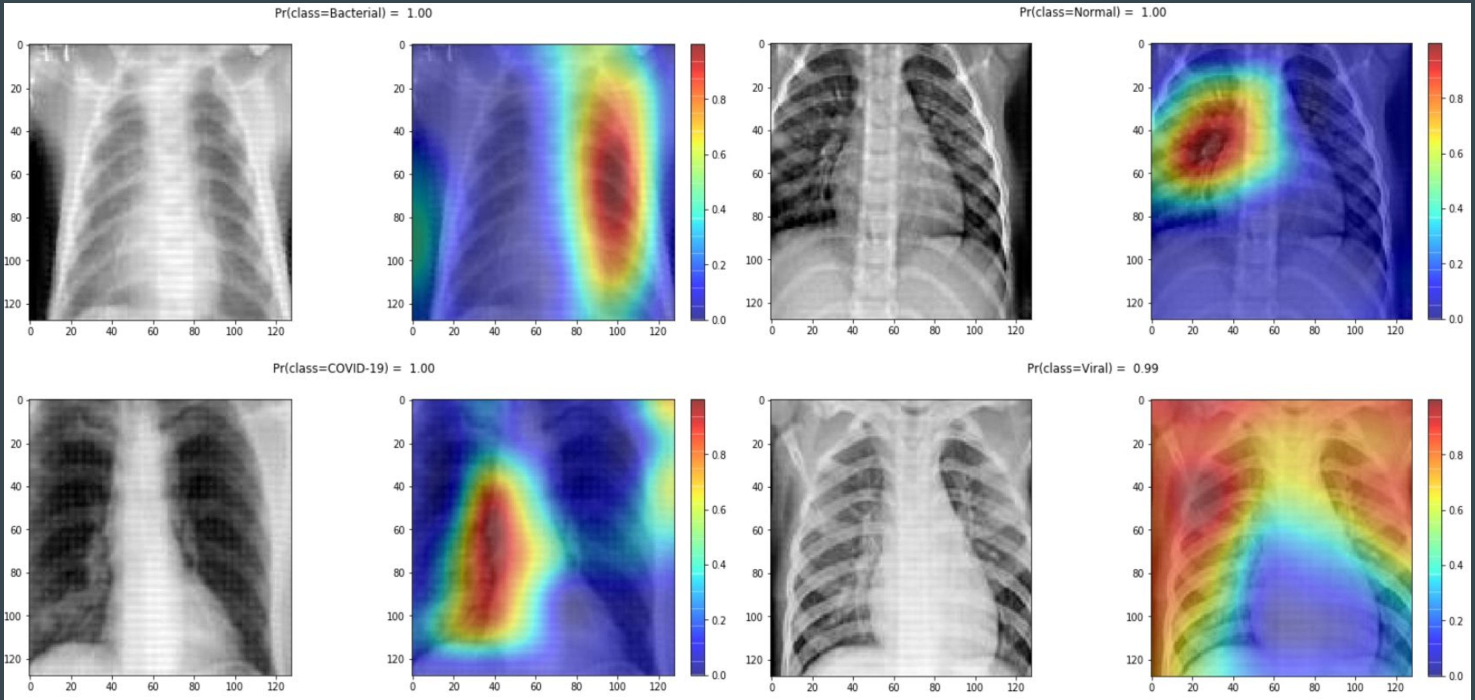


Misdiagnosis of Bacterial Pneumonia and Viral Pneumonia



Correctly predicted Saliency Maps of VGG-19

VGG-19 - Grad-CAM



Grad-CAM of correctly predicted results

Conclusion

- ✔️ Transfer Learning with ImageNet pre-trained weights
- ✔️ Data Augmentation using GAN
- ✔️ Increasing number of COVID-19 instances to train DCGAN
- ✔️ Applying SRGAN to improve DCGAN-generated samples
- ❌ Applying the Keras Data Generator
- ❌ Increasing the number of samples for Bacterial and Viral Pneumonia
- ❌ Utilize complex models

Future Work

- K-Fold Cross Validation
- Ensemble Learning Method
- Active Deep Learning

Sources

Literature:

1. Jonathan Hui, GAN — Super Resolution GAN (SRGAN)
2. Karen Simonyan, Andrew Zisserman : very deep convolutional networks for large-scale image recognition arXiv:1409.1556v6

Datasets:

- COVID-19 samples: https://github.com/ieee8023/covid-chestxray-dataset
- Bacterial Pneumonia: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia
- Viral Pneumonia and Normal (Healthy): https://www.kaggle.com/tawsifurrahman/covid19-radiography-database/data