Deep Features for COVID-19 Screening and Decision-Making

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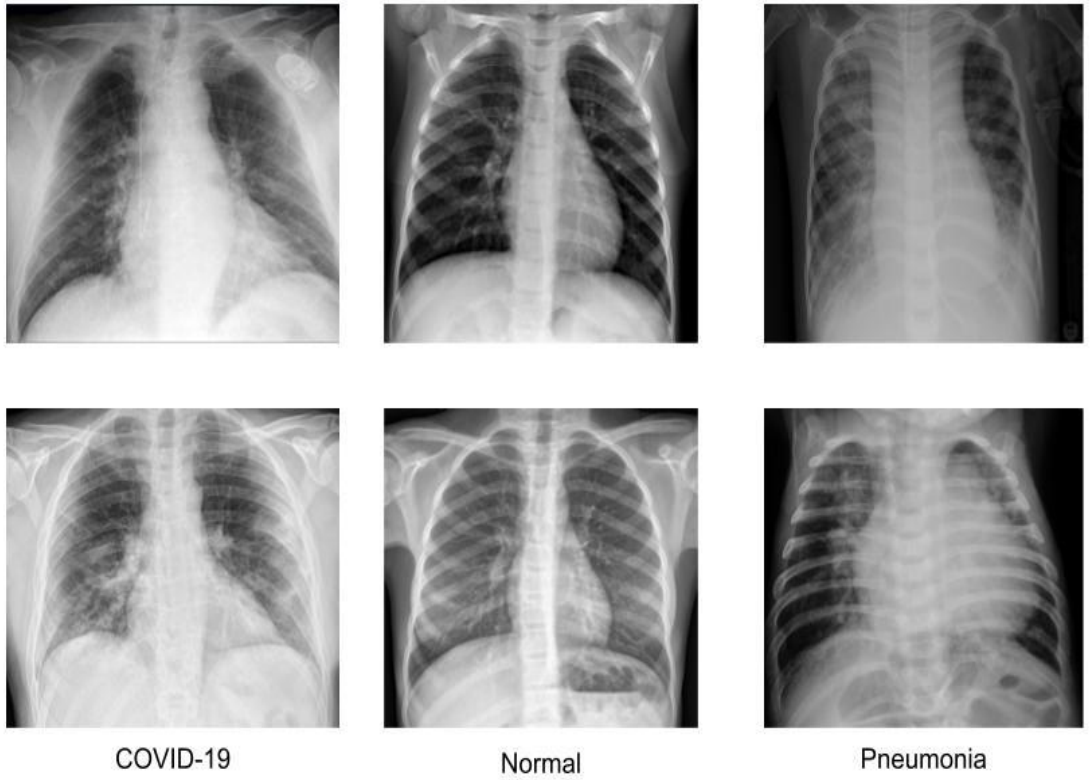
Overview

Chest X-ray images could facilitate greatly in mass COVID-19 screening.

In this study, we build deep learning models to detect COVID-19 positive cases using chest X-ray image.

We leverage DNN models such as DenseNet, ResNet, VGG to build automated COVID-19 screening.

Early results (based on deep features) show performance improvement and further possibilities.



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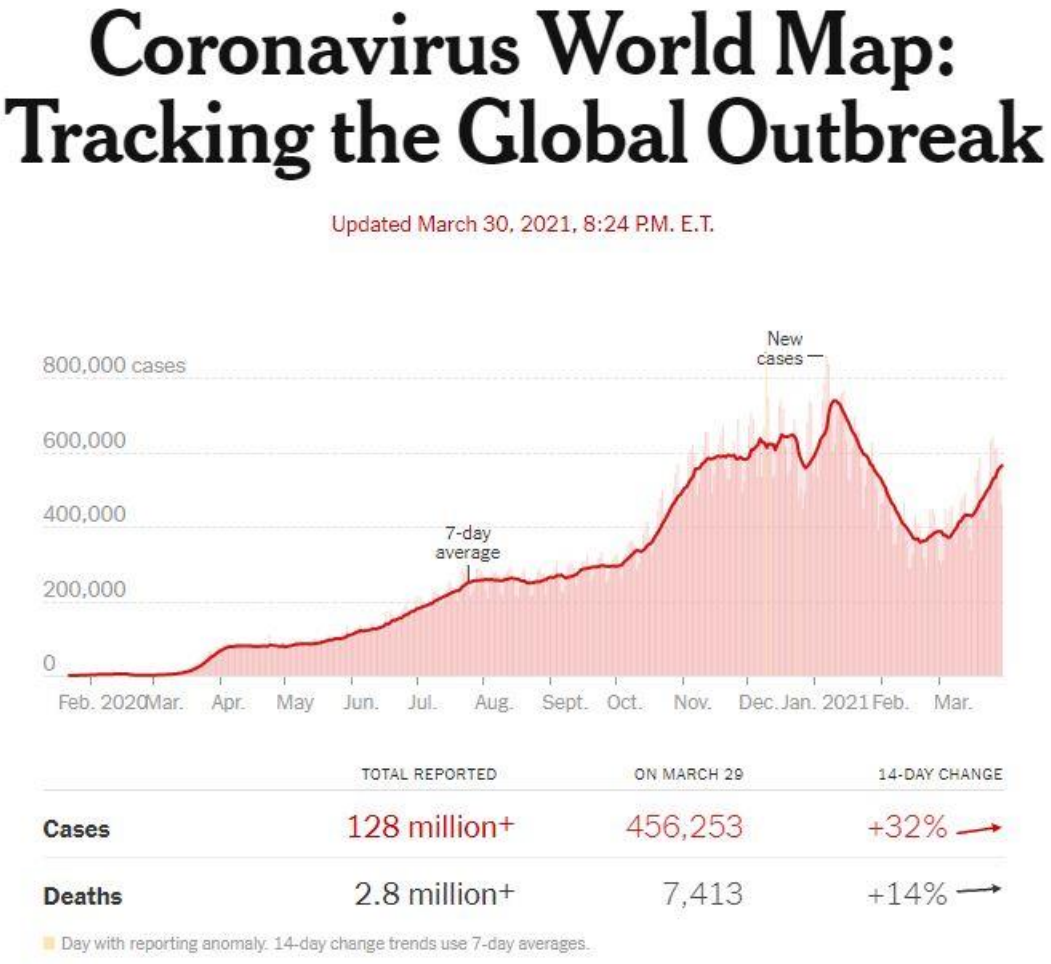
Motivation

- Since December 2019, the infection rate of COVID-19 cases has been very high.
- In such infectious disease, early detection tools would help largely to mitigate the spread and save lives.
- Current COVID-19 screening are expensive and time-consuming.
- Chest X-ray imaging is available and accessible in many clinical sites as it is considered standard equipment in most healthcare systems.



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Related Work

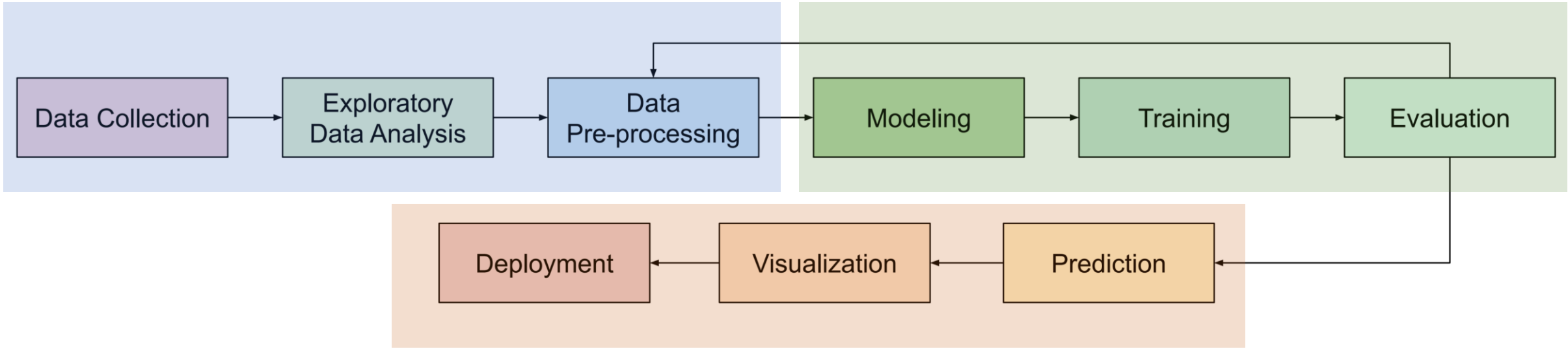
- A number of AI-driven tools have been used to help predict, screen, and diagnose COVID-19 positive cases.
  - Santosh, K.C. AI-Driven Tools for Coronavirus Outbreak: Need of Active Learning and Cross-Population Train/Test. Models on Multimudinal/Multimodal Data. J Med Syst 44, 94 (2020). https://doi.org/10.1007/s10916-020-01562-1

- A Convolutional Neural Network (CNN) –tailored Deep Neural Network (DNN) has been proposed that can collectively train/test both CT scans and Chest X-rays.
  - Mukherjee, H., Ghosh, S., Dhar, A., Santosh, K.C. et al. Deep neural network to detect COVID-19: one architecture for both CT Scans and Chest X-rays. Appl Intell (2020). https://doi.org/10.1007/s10489-020-01943-6

- However, the performance was not up to the mark because at that time there were not available data. Now we are using state-of-the art for better performance.

Methodology

- The stages of the Deep learning pipeline that we followed



Data Collection

- We have collected 6432 Chest X-Ray images from the source below.

- Source:
  - https://github.com/lindawangg/COVID-Net
  - They collected and validated data.
  - They created the platform to receive COVID-19 Chest X-ray image upload from around the world.

- We will include further release of COVID-19 Chest X-ray data.

Chest X-Ray Image	**Collections**
Normal Chest X-Ray	1583
COVID-19 Chest X-Ray	576
Pneumonia Chest X-Ray	4273
Total Chest X-Ray	**6432**

Data Pre-processing

Data Augmentation

- Shifting width and height
- Shear angle

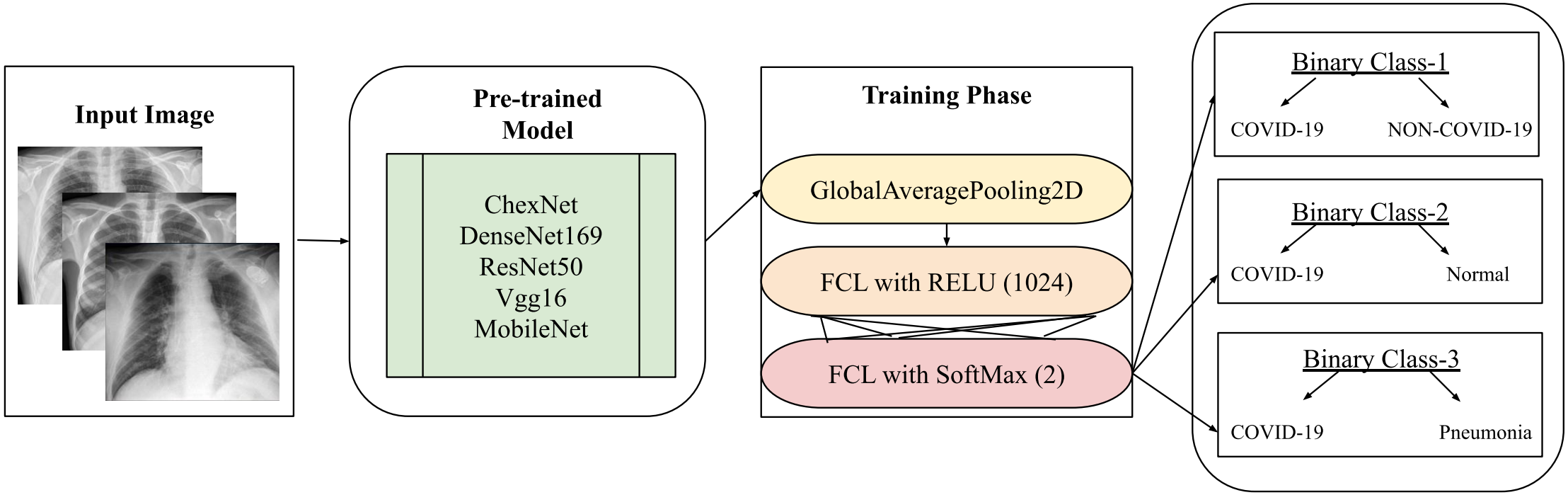
These allowed us to make the model more robust and work on different set of data.

Data Standardization

- Samplewise centering
- Samplewise standard normalization

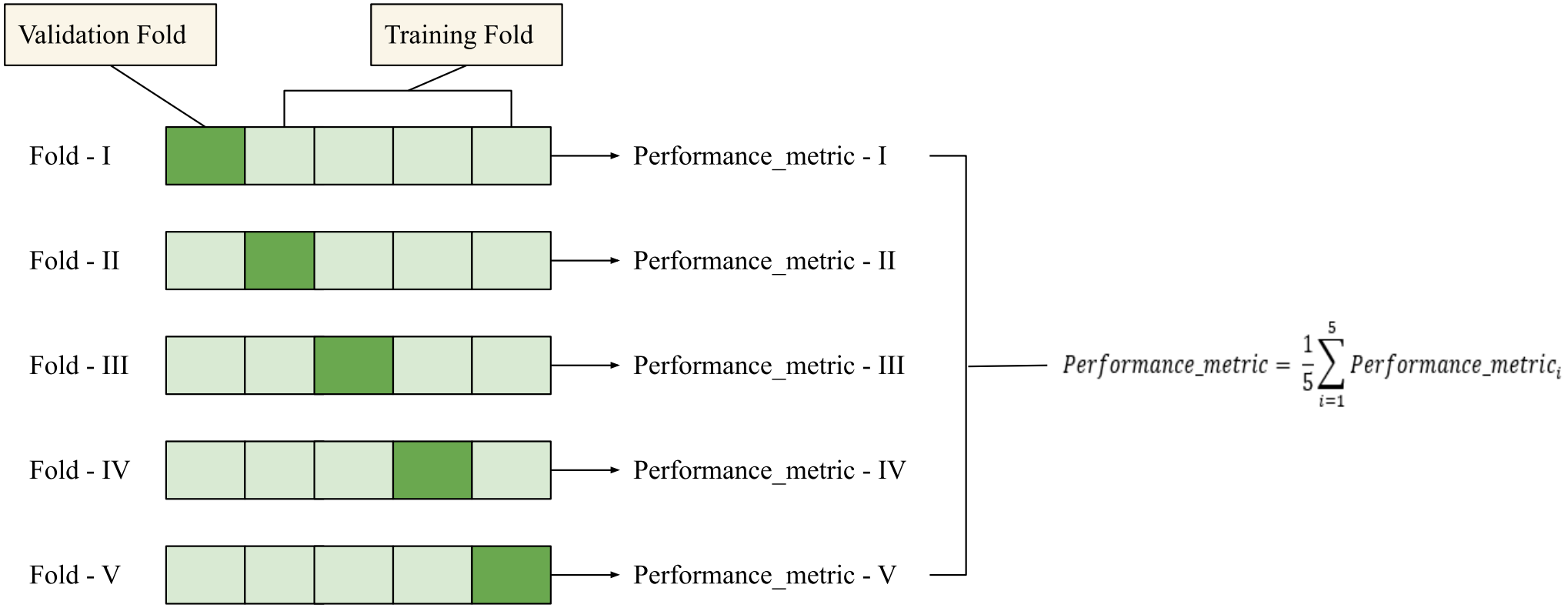
These helped us to avoid overfitting and dependence on specific set of data or features.

Modeling



Model architecture for the prediction of COVID-19, NON-COVID-19, Normal and Pneumonia patients

Training



- Schematic representation of cross validation
- We are using k-fold cross validation to make model more robust.

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Results

Evaluation Metric	DenseNet169 Model	ChexNet Model
Accuracy	99.84%	99.98%
AUC (Area Under Curve)	0.99	0.99
Sensitivity	0.99	0.99
Specificity	1.0	1.0
Precision	0.99	1.0
F1-Score	1.0	1.0

Result of Binary Class – 1 (COVID-19 vs NON-COVID-19)

The accuracy and precision are very promising.

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Conclusion

Chest X-ray imaging enables rapid screening of patients to suspect of COVID-19 virus.

Because of Chest X-ray's availability and accessibility, early detection is possible to reduce the infection rate, specially in mass populated area.

Chest X-ray images of COVID-19 patients could compare with other abnormalities like Pneumonia, Tuberculosis, Lung Cancer, etc.

Future Work

- Based on the results, we would improve the model architecture to explore more features.
- We would be able to use our model in consumption with other models that work on diseases like Pneumonia, Tuberculosis x-ray images.
- The model would be deployed in real world scenarios for screening and prediction.

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References

[1] Santosh, K.C. AI-Driven Tools for Coronavirus Outbreak: Need of Active Learning and Cross-Population Train/Test. Models on Multimudinal/Multimodal Data. J Med Syst 44, 94 (2020). https://doi.org/10.1007/s10916-020-01562-1

[2] Mukherjee, H., Ghosh, S., Dhar, A., Santosh, K.C. et al. Deep neural network to detect COVID-19: one architecture for both CT Scans and Chest X-rays. Appl Intell (2020). https://doi.org/10.1007/s10489-020-01943-6

[3] Mukherjee, H., Ghosh, S., Dhar, A., Santosh, K.C. *et al.* Shallow Convolutional Neural Network for COVID-19 Outbreak Screening Using Chest X-rays. *Cogn Comput* (2021). https://doi.org/10.1007/s12559-020-09775-9

[4] Das, D., Santosh, K.C. & Pal, U. Truncated inception net: COVID-19 outbreak screening using chest X-rays. *Phys Eng Sci Med* **43,** 915–925 (2020). https://doi.org/10.1007/s13246-020-00888-x

[5] https://www.nytimes.com/interactive/2020/world/coronavirus-maps.html

[6] https://github.com/lindawangg/COVID-Net

[7] https://github.com/ieee8023/covid-chestxray-dataset

[8] Kermany, Daniel, Kang Zhang, and Michael Goldbaum. "Labeled optical coherence tomography (OCT) and Chest X-Ray images for classication." Mendeley data 2.2 (2018), https://doi.org/:10.17632/rscbjbr9sj.2

[9] https://data.mendeley.com/datasets/rscbjbr9sj/2

Thank you

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