COVID-19 Detection on Chest X-Ray Using an Enhanced Neural Network Model: Impact of Network Architecture Complexity, Data Augmentation, and Transfer Learning on Model

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Background: Machine learning (ML) algorithms have potential to rapidly screen COVID-19 from chest x-ray (CXR). Current deep convolutional neural network (DCNN) models for COVID-19 detection are limited by overfitting. Objective: We hypothesized that less network complexity, heavy data augmentation, and the addition of transfer learning would result in the best performing model. Methods: A COVID-19 detection model was developed using a public dataset of 16,352 de-identified CXR images associated with known COVID-19 status. Pre-trained DCNNs with various enhancement features, 24 models in all, were compared using 80% of images for training and 20% for testing. Results: Among 5 pretrained DCNN's, the low complexity but deep ResNet18 architecture performed best. Increasing complexity correlated with validation loss (R=0.86, p=0.03). Data augmentation using horizontal flip (HF), Gaussian blur (GB), and cutout (CO) improved ResNet18 performance- with the ResNet18-CO/GB model performing best at 1,000 iterations. Although transfer learning using an extrinsic pneumonia detection model did not boost performance, transfer learning from tuberculosis (TB) detection models enhanced the performance of ResNet18-HF and ResNet18-CO/HF/GB models. Comparing the top models at 10K iterations, the best model was ResNet18-GB/CO without transfer learning with sensitivity 82.0%, specificity 96.5%, F-score 81.5%, and accuracy 94.5% with minimal overfitting. Conclusion: Our findings suggest clinical utility for automated COVID-19 detection by CXR using DCNN's enhanced by data augmentation more so than transfer learning. This robust final model is comparable to standards for COVID-19 antigen detection tests and exceeds reported performance of radiologists.

Awards Won:
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category