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COVID-19 detection on chest x-ray using an enhanced neural network model: Impact of data network complexity, data augmentation, and transfer learning

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Statement of the Problem: 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 small datasets and are prone to over fitting. To optimize such a model, we assessed the performance impact of network complexity, data augmentation, and transfer learning on model performance.

Methodology & Theoretical Orientation: A DCNN model was developed using the COVID open access dataset of 16,352 CXR images associated with known COVID-19 status by RT-PCR. Performance characteristics of pre-trained CNNs, 24 models in all, with various enhancement features were compared.

Findings: Among 5 pertained DCNNs, low complexity ResNet18 architecture performed best. Increasing complexity correlated with validation loss. Adding data augmentation using horizontal flip (HF), Gaussian blurs (GB), and cut out (CO) improved ResNet18 performance—with the ResNet18-CO/GB model performing best at 1,000 iterations. Transfer learning using a tuberculosis (TB) detection model enhanced the performance of ResNet18-HF and ResNet18-CO/HF/GB models, while transfer learning using a pneumonia dataset for pertaining did not improve model performance. At 10,000 iterations, the best model for COVID-19 detection was ResNet18-GB/CO, with a sensitivity of 82.0%, specificity 96.5%, positive predictive value 81.8%, negative predictive value 95.0%, F-score 81.5%, and accuracy 94.5%. Validation loss was low overall at 0.18, but mild over fitting was observed with validation-training loss difference of 0.06. This robust final COVID-19 CXR detection model meets the World Health Organization standards for COVID-19 antigen tests (sensitivity>80%, specificity>97% and exceeds the <50% sensitivity and <80% specificity achieved by unassisted radiologists. Transfer learning models did not perform as well as the data augmented DCNNs.

Conclusion & Significance: Our findings suggest there is clinical utility for automated COVID-19 detection by CXR, particularly if data augmentation is heavily incorporated into such models.

Recent Publications:

1. Himal Bamzai-Wokhlu. COVID-19 Detection on chest x-ray using an enhanced neural network model: Impact of network complexity, data augmentation and transfer learning. AJCSIT. 2022; 10(1): 113.

Biography

Himal Bamzai-Wokhlu is a student at Buchholz High School in Gainesville, FL. She developed this model under the mentorship of Dr. Parsa Akbari at University of Oxford at Cambridge.

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