COVID-19 Detection From Chest X-ray Images Using Imprinted Weights Approach

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Introduction

- The COVID-19 pandemic had devastating effects on the well-being of the global population.
- Computer-assisted diagnosis (CAD) is playing a key role in detecting COVID-19 using Chest radiography as an effective screening method [1].
- A big challenge in training CAD models to diagnose COVID-19 is limited training data, especially at the onset of the pandemic when data is scarce but rapid development of diagnosis tools is critical.
- The use of low-shot imprinted weights approach in CAD models improves their classification performance on COVID-19 X-ray images by leveraging the abundance of samples from known illnesses like pneumonia to boost novel class performance with low-shots.

Methods

CAD Model

- The model consists of a 256 neuron fully connected embedding layer, and a softmax classification layer.
- The embedding extractor uses ResNet-50 pre-trained on the ImageNet data set.
- For comparison, a 3-class joint model is built as a baseline model. This model shares the number of neurons in the fully connected layer and the softmax classification layer but does not use the embedded weights approach.
- Input images are resized to 256x256, cropped to 224x224 and normalized.

Implementation Details

Parameter	Setting
Learning Rate	10^{-3}
Learning Rate Reduction Method	Exponential Step Decay with 4 Steps, and Decay Factor of 0.94.
Optimizer	SGD with Momentum of 0.9 and 10^{-4} Weight Decay.
Number of Epochs	40

COVIDx-CXR Database

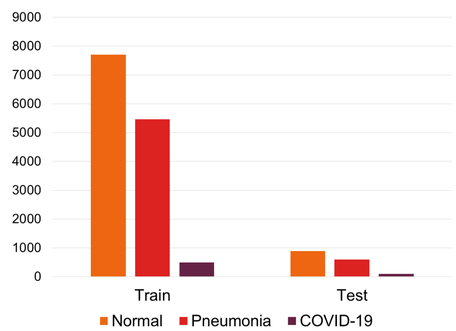

Figure 1. The train/test split of COVIDx-CXR database [2].

- Normal and pneumonia categories are used to train a base classifier.
- COVID-19 images are used for inference to the base classifier to generate averaged embedding vectors used in the imprinting step.

Imprinting Architecture

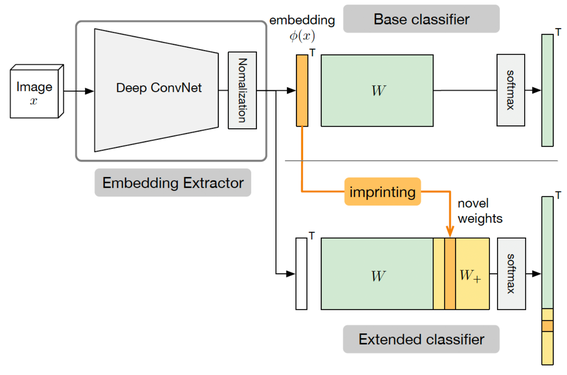

Figure 2. Low-shot learning with imprinted weights [3]

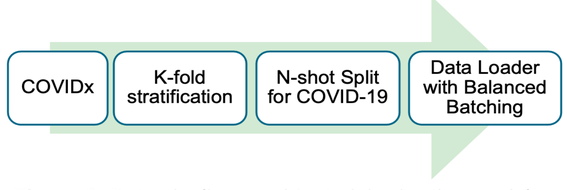

Figure 3. Data pipeline used for training/testing models

Results

To evaluate the generalization performance of the models, 10-fold stratified cross validations are performed.

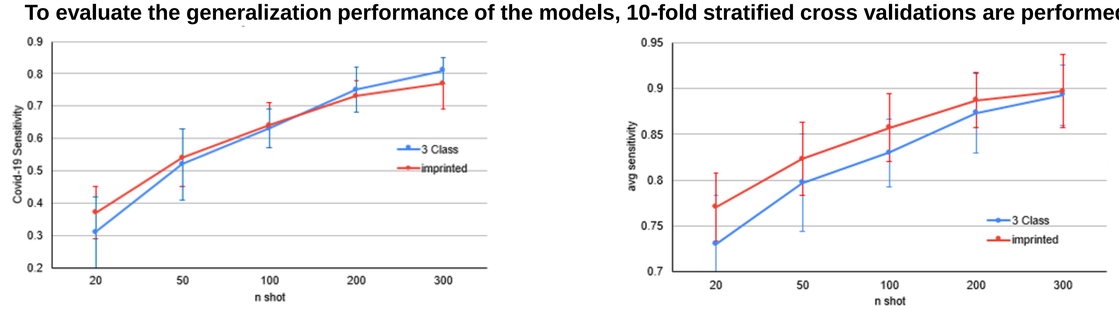

Figure 4. (a) COVID-19 sensitivities for Imprinted Weights and 3-class joint models as they change with increasing number of COVID-19 samples used. (b) Overall (averaged between all 3 classes) sensitivity comparison of the two models. Both (a) and (b) have their standard deviation across the folds as the error bars.

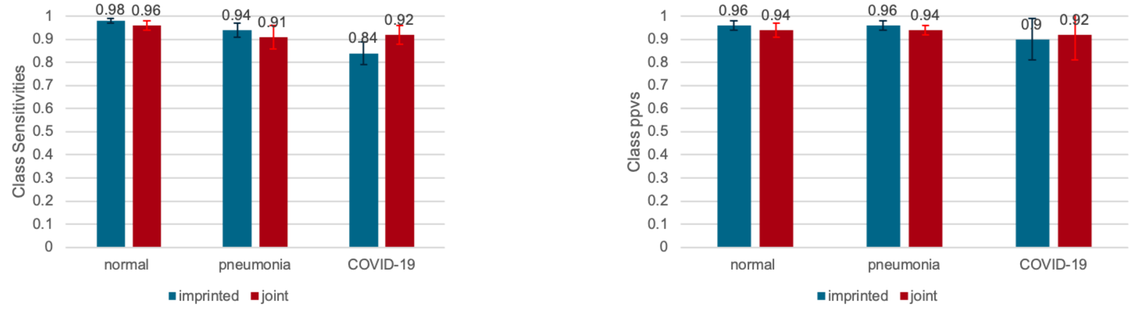

Figure 5. (a) Class sensitivities for Imprinted Weights and 3-class joint models. (b) Class positive predictive value (PPV) for Imprinted Weights and 3-class joint models. Both (a) and (b) have their standard deviation across the 10 folds as the error bars.

Conclusion

- The effectiveness of the imprinted weights approach for COVIDx dataset was evaluated with 10-fold stratified cross validation, focusing on the metrics of the COVID-19 class.
- Sensitivity of COVID-19 at low shots were significantly better with the imprinted weights architecture compared to 3 classes. This advantage diminishes as the number of shots increased. The imprinted weights approach also provided smoother and faster convergence during training.
- The imprinted weights architecture can be used to rapidly develop diagnosis models at the onset of a pandemic, performing better than its traditional CAD counterparts when data is scarce.

References

[1] Alexander Wong, et al. Covidnet-s: Towards computer-aided severity assessment via training and validation of deep neural networks for geographic extent and opacity extent scoring of chest x-rays for sars-cov-2 lung disease severity. arXiv e-prints, pp. arXiv–2005, 2020.

[2] Wang, L., Lin, Z.Q. & Wong, A. COVID-Net: a tailored deep convolutional neural network design for detection of COVID-19 cases from chest X-ray images. *Sci Rep* **10,** 19549 (2020).

[3] Hang Qi, Matthew Brown, and David G Lowe. Low-shot learning with imprinted weights. In Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 5822–5830, 2018.