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Machine learning screening of COVID-19 patients based on X-ray images for unbalanced classes

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ABSTRACT

Background: COVID-19 is a pandemic that had already infected more than forty-six million people and caused more than a million deaths by 1st of November 2020. The virus pandemic appears to have had a catastrophic effect on the global population's safety. Therefore, efficient detection of infected patients is a key phase in the battle against COVID-19. One of the main screening methods is radiological testing. The goal of this study is using chest X-ray images to detect COVID-19 pneumonia patients while optimizing detection efficiency.

Methods: As shown in Figure 1, we combined three methods to detect COVID-19 namely: convolutional neural network, transfer learning, and the focal loss[1] function which are used for unbalanced classes, to build three binary classifiers which are COVID-19 versus normal, COVID-19 versus pneumonia, and COVID-19 versus normal pneumonia (normal and pneumonia). The database used[2] includes a mixture of 400 COVID-19, 1,340 viral pneumonia, 2,560 bacterial pneumonia, and 1,340 normal chest X-ray images for training, validation, and testing of four pre-trained deep convolutional neural networks. Then, the pre-trained model that gives the best results was chosen to improve its performances by two enhancement techniques which are image augmentation, allowing us to reach approximately 2,500 images per class, and the adjustment of focal loss hyperparameters.

Results: A comparative study was conducted of our proposed classifiers with well-known classifiers and obtained much better results in terms of accuracy, specificity, sensitivity and precision, as illustrated in Table 1.

Conclusion: The high performance of this computer-aided diagnostic technique may greatly increase the screening speed and reliability of COVID-19 diagnostic cases. Particularly, at the crowded emergency services, it will be particularly helpful in this pandemic when the risk of infection and the necessity for prevention initiatives run contrary to the available resources.

Keywords: COVID-19, chest x-ray images, convolutional neural network, transfer learning, focal loss function

Page 2 of 2

Mrad et al. Machine learning screening of COVID-19 patients based on X-ray images for unbalanced classes 2021:38
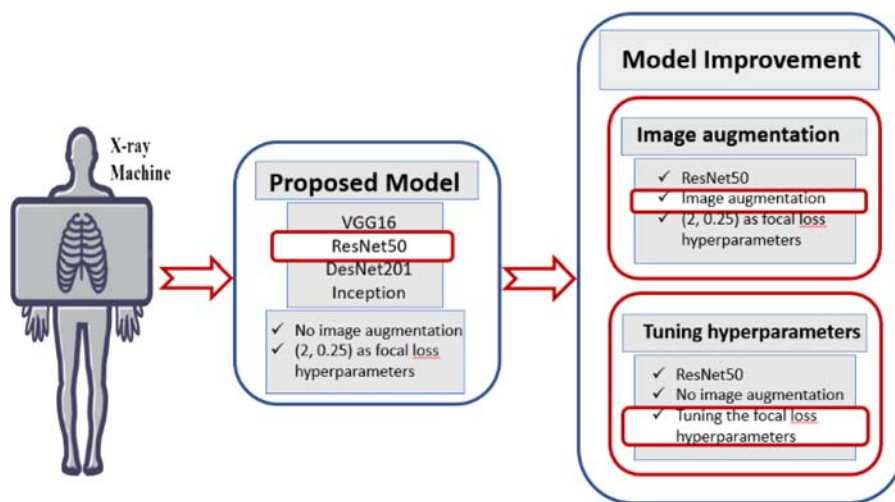
Figure 1. Adopted system model.

Table 1. Classification performance for different data setups for the proposed techniques

Task	Improvement Technique	Pretrained Model	Accuracy	Specificty	Sensitivity	Preceision	F1 score
COVID-19 vs Normal	Tuning the FL hyperparameters	ResNet50	99.92%	0.99	1.0	0.99	0.99
COVID-19 vs Pneumonia	Image augmentation	ResNet50	99.51%	0.99	0.97	0.97	0.97
COVID-19 vs Normal & Pneumonia	Tuning the FL hyperparameters	ResNet50	99.94%	0.99	1.0	0.99	0.99

Ethical approval/IRB statement: N/A

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[2]   The following datasets were used to create our dataset, which are available from: https://www.kaggle.com/tawsi-furrahman/covid19-radiography-database; https://github.com/ieee8023/covid-chestxray-dataset; https://threadrea-derapp.com/thread/1243928581983670272.html; https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia