Preface

Thoracic diseases refer to a group of medical conditions that affect the chest, lungs, and esophagus. Pneumonia is one of the most common thoracic diseases that cause inflammation of the lungs and is considered one of the most frequent and potentially devastating medical complications after infection resulting in hospitalization or death. The most common cause of pneumonia are bacteria, viruses, and fungal infections. Recently, after the COVID-19 invasion, pneumonia-caused deaths have drastically increased. Evaluation of patients with the suspected thoracic disease and pneumonia usually begins with chest radiography. Chest X-rays are also favorable due to their quickness, cost-effectiveness, and availability over other imaging modalities like computed tomography and magnetic resonance imaging. However, certain biochemical tests require detecting exact pneumonia categories for a specific treatment selection and disease management. RT-PCR is a commonly used method for detecting and quantifying the expression of viral genes in diagnostic samples. However, the technique is laborious, time-consuming, and costly, with a significantly high error rate. Additionally, the scarcity of test kits has become a significant challenge during the COVID-19 pandemic. In recent years implementing artificial intelligence and deep learning techniques for medical imaging has revolutionized the healthcare sector by automatically and precisely detecting and classifying lesions in radiological images that may be unnoted by a radiologist. Implementing convolutional neural networks has achieved prodigious success in several image classification, segmentation, and quantification tasks. In this work, multiple deep-learning models have been developed and implemented for the segmentation, classification, and detection of pneumonia, including COVID-19, in chest radiographs. First, seven highly efficient pre-trained convolutional neural networks, namely, VGG16, VGG19, DenseNet201, Xception, InceptionV3, NasNetMobile, and ResNet152, were designed and applied for classification of up to five classes of pneumonia, i.e., COVID-19, viral pneumonia, bacterial pneumonia, tuberculosis, and control. For the first time, binary classification experiments were performed for COVID-19 vs. bacterial pneumonia and COVID-19 vs. tuberculosis disease classes. Our models achieved higher classification accuracy for binary and five-class classification task than any other state-of-the-art

methods. Thereafter, to improve the system's accuracy and preciseness, a segmentation-based classification system was developed. The segmentation experiments were performed employing three different versions of U-series networks: UNet, UNet+, and UNet++ models. Next, eight highly efficient convolutional neural networks, VGG16, VGG19, Xception, InceptionV3, Densenet201, NASNetMobile, Resnet50, and MobileNet, were employed to classify the segmented lung regions up to five classes. The system outperformed state-of-the-art methods in binary, three, and five-class classification experiments. Finally, we designed and implemented three ensemble models. These used four convolutional neural networks, namely, Xception, MobileNet, NasNetMobile, and InceptionResNetV2. These models classified the segmented lungs into five classes. The Ensemble model outperformed previous experiments and state-of-the-art methods and verified its efficacy and superiority for clinician precision in COVID-19 and pneumonia diagnosis using chest X-rays. The visualization capabilities of the networks were also investigated using the Gradient-weighted Class Activation Mapping to view the abnormalities in chest X-rays and discuss them from radiological perspectives. The system's algorithm demonstrated high accuracy and robustness, suggesting that it could be a valuable tool in environments where there's a scarcity of biochemical test facilities and radiological expertise.