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LM-DNN: pre-trained DNN with LSTM and cross Fold validation for detecting viral pneumonia from chest CT

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ABSTRACT

Some of the viruses may cause lung parenchyma and airway involvement. Usually, viral pneumonia causes ground-glass opacities, bilateral peripheral distribution, consolidation, vascular thickening, and reticular opacity. These features are common in COVID-19 rather than Non-Covid-19 viral pneumonia. However, in advanced cases, COVID-19 viral pneumonia may cause organising pneumonia and fibrosis of the lung. Atypical findings of Non-Covid-19 pneumonia have included central peripheral distribution, pleural effusion, lymphadenopathy, nodules, tree-in-bud opacities, and pneumothorax. Therefore, differentiating Non-Covid-19 pneumonia from COVID-19 pneumonia at chest computed tomography (CT) is necessary. In that case, CT scans of the thorax are one of the essential tools for early identification and future prognosis of viral pneumonia. We have proposed a Computer-Aided Diagnostic (CAD) system that can detect features of chest CT using a Deep Neural Network (DNN) with Long Short-Term Memory (LSTM). Transfer learning using pre-trained DNN models (ResNet50, VGG19, InceptionV3, Xception, DenseNet121, and VGG16) is applied to retain both high-level and low-level features effectively. The deep features are passed to the LSTM layer. The LSTM is utilised as a classifier and detects long short-term dependencies. The proposed method employs a hybrid DNN-LSTM network for automatic detection to take advantage of the uniqueness of the two models. The proposed models are trained with common and different features present in the chest CT of COVID-19 and Non-Covid-19 viral pneumonia. The 5-fold cross-validation (CV) method validated and tested the proposed model. The proposed DNN model's performance is quite improved with LSTM and CV. As a result, the proposed LM-DNN (VGG16+LSTM+CV) model has achieved the classification test accuracy of 91.58% and specificity of 93.86%, which offers superior performance with state-of-the-art. Also, the DenseNet121+LSTM+CV model has reached the classification test accuracy of 90.1% and sensitivity of 92%.

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1. Introduction

Viruses are important causes of pneumonia. Viral pneumonia remains a severe concern for various chronic co-morbidity conditions. Respiratory syncytial, adeno virus, influenza, parainfluenza, and varicella cause pneumonia (Mason et al. 2015) in adults and children. Atypical viruses continue to appear in the epidemic of severe pneumonitis (Mason et al. 2015; Lin et al. 2020), including influenza A virus, influenza (H1N1), hanta virus, and corona virus (SARS, MERS, COVID-19). The SARS-CoV-2 virus is the source of the novel COVID-19 (SARS-Cov 2022). There may be a high rate of mobility and mortality for immune-compromised patients rather than immune-competent patients. The World Health Organization (WHO) (World Health Organization 2021) reported around 623 million mobility cases and more than 6.55 million mortality cases of COVID-19 worldwide as of 19 October 2022. Millions of COVID-19 patients were affected in the lungs and suffered from viral pneumonia in all age groups. Many COVID-19 survivors (Malik et al. 2021) suffer from lung-related complications though they do not have any history of pulmonary issues. Physicians suggested that (Malik et al. 2021) there may be a possibility of pulmonary fibrosis in the lungs that causes shortness of breath due to past COVID-19 pneumonia patients. Therefore, diagnosis of pulmonary viral pneumonia is crucial and life-saving. The CT findings (Bai et al. 2020) between Non-Covid-19 pneumonia and COVID-19 pneumonia are more likely to have ground-glass opacities (68% vs. 91%), bilateral peripheral distribution (57% vs. 80%), vascular thickening (22% vs. 59%), and fine reticular opacity (22% vs. 56%). However, the CT findings between Non-Covid-19 pneumonia and COVID-19 pneumonia are less likely to have lymphadenopathy (10% vs. 3%), central peripheral distribution (35% vs. 14%), and pleural effusion (39% vs. 4%). Computed Tomography (Mason et al. 2015) of the chest is the best tool to diagnose suspicious patients more accurately. For each patient during scans, several slices of a CT image are created. These create a high workload for radiologists to detect the type of diseases and classify patients manually.

To increase the accuracy of computer-assisted diagnosis systems and boost disease prediction efficiency in the healthcare sector, DNN models have brought about revolutionary change. Most scientists and researchers have focused on developing deep-learning models to create automated CAD-based disease detection systems (Ghosal et al. 2019, 2021; Agarwala et al. 2020; Kumar et al. 2020, 2022; Chakraborty et al. 2021).

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