MULTI-DEEPNet: A Novel Weakly-Supervised Multi-Task and Multi-View Deep Learning Model for COVID-19 Diagnosis from CT Images

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Since December 2019, a novel coronavirus known as COVID-19 has plagued the world. Currently, Chest CT imaging is used alongside the reverse transcription polymerase chain reaction test (RT-PCR) to perform accurate diagnosis. However, similar imaging features between COVID-19 and other pneumonia makes classification a time-consuming and challenging task. Thus, deep learning models that can classify patients based on input CT volumes have been proposed for faster and more accurate diagnosis. Current methods have relied upon training with large, balanced datasets or pixel-wise lung lesion masks, both of which may not be accessible during a sudden outbreak situation. To consider realistic data constraints under unpredictable scenarios, this study proposes MULTI-DEEPNet, a novel weakly-supervised deep learning model that is trained on a small and imbalanced dataset. Specifically, a multi-task pre-training module is introduced to better extract distinguishing features between similar classes, and a multi-view-oriented classifier is proposed to consider relevant spatial information in the classification process. Our MULTI-DEEPNet achieves an experimental accuracy of 96.20% after training on 180 healthy, 160 COVID-19, and 90 Community-Acquired Pneumonia (CAP) patients, superior to state-of-the-art methods. Clear Grad-CAM visualizations of predicted cases offer reliable and interpretable results for radiologists. Furthermore, our model has been employed in the Shanghai Public Health Clinical Center to assist in the frontline diagnosis of COVID-19 patients, achieving 93.86% clinical accuracy. The methods of this study can be generalized to improve classification performance in other scenarios that require the distinguishing of similar categories given severe data limitations.

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