Chapter 37
P2P-COVID-GAN: Classification and Segmentation of COVID-19 Lung Infections From CT Images Using GAN

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ABSTRACT

Early and automatic segmentation of lung infections from computed tomography images of COVID-19 patients is crucial for timely quarantine and effective treatment. However, automating the segmentation of lung infection from CT slices is challenging due to a lack of contrast between the normal and infected tissues. A CNN and GAN-based framework are presented to classify and then segment the lung infections automatically from COVID-19 lung CT slices. In this work, the authors propose a novel method named P2P-COVID-SEG to automatically classify COVID-19 and normal CT images and then segment COVID-19 lung infections from CT images using GAN. The proposed model outperformed the existing classification models with an accuracy of 98.10%. The segmentation results outperformed existing methods and achieved infection segmentation with accurate boundaries. The Dice coefficient achieved using GAN segmentation is 81.11%. The segmentation results demonstrate that the proposed model outperforms the existing models and achieves state-of-the-art performance.

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INTRODUCTION

The COVID-19 pandemic has become a serious health crisis globally since December 2019 (Zhu et al., 2020; Benvenuto et al., 2020; Wang et al., 2020; Ugail et al., 2021) The symptoms of COVID-19 are fever, dry cough, tiredness, diarrhea, headache, loss of taste and smell. The serious symptoms include shortness of breath as well as an inability to walk or stay awake and may require emergency medical care (Huang et al., 2020; Ng et al., 2020). The exponentially increasing COVID-19 positive cases have limited the accurate and early detection of disease in patients due to a shortage of testing kits. One of the methods of diagnosing the disease is by segmenting the infections in the lung CT scan. CT images play a crucial role in detecting COVID-19 by segmenting the lesions from the images (Lei et al., 2020; Li et al., 2020). Manual segmentation is laborious and time-consuming and is also subjected to variations in annotations by different radiologists. These challenges can be alleviated by automating the process of infection segmentation from the CT scans (shan et al., 2020). Deep learning techniques have been frequently used in the medical field in recent times and these techniques have proved to be successful (Wu et al., 2020; Huang et al., 2020; Jha et al., 2020; Patro et al., 2020; Khan et al., 2020; Nandhini Abirami et al., 2021). Deep learning techniques can be adopted to accurately identify and segment the infections from the CT images (Khan et al., 2021; Rauf et al., 2021).

Infection segmentation from CT scans is difficult due to irregularity in the shapes of the lesion and low contrast between normal and infected lesions. Ground glass opacities were observed in the early stages of infection, while pulmonary consolidation was observed in the later stages (Ye et al., 2020; Akbari et al., 2020). In recent times, deep learning models have frequently been used for accelerating the diagnosis of COVID-19 via chest X-ray images and CT scans (Mangal et al., 2020; Shi et al., 2020; Ma et al., 2020). The performance of the best CNN models in classifying COVID-19 is evaluated in (Apostolopoulos et al., 2020). For distinguishing between people with infected and normal lungs, a deep learning model was employed in (Toğaçar et al., 2020). A multi-objective differential evolution (MODE) and CNN were used to classify COVID-19 infections using chest CT images (Singh et al., 2020). A semi-supervised deep learning model was presented in (Zheng et al., 2020) to detect COVID-19 from CT images (Zheng et al., 2020). An anomaly detection model was proposed to differentiate among pneumonia classes using COVID-19 chest X-ray images (Zhang et al., 2020).

Classic lung CT segmentation techniques are computationally expensive, fail to handle attenuation variation, and fail to segment regions with high levels of abnormality (Roy et al., 2020). Also, the segmentation of infections from lung CT images is challenging, and its performance is affected by (i) lung inhomogeneity, (ii) image acquisition protocol, (iii) scanner type, and (iv) GGO (Ground Glass Opacity) nodules. Segmenting GGO nodules is challenging because of subtle boundaries that are hard to delineate. Also, the variations in the position and size of the infections in the CT images poses challenges in segmenting the lesions from CT slices.

To mitigate these challenges, an automatic COVID-19 lung infection segmentation model is proposed. But, automating the process of segmenting the lung infection faces several challenges which includes varitions in infection characteristics and the contrast between the normal and infectious tissues is low. Several studies have been proposed for detecting COVID-19, but there are no works related to the segmentation of infected lesions from CT slices using a Generative Adversarial Network. Also, the existing works to automatically segment the lung infections from CT slices did not perform well exhibiting very low dice co-efficient. This work aims at segmenting the infected lesions from CT images using Pix2Pix