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Original Research Article

USE OF DEEP NEURAL NETWORKS WITH RADIOGRAPHIC IMAGES FOR AUTOMATED COVID-19 DETECTION

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Abstract: *The prospective study was conducted in CH & ICH Multan from January 2021 to January 2022 to assess the significance of the proposed deep learning model that automatically uses X-rays to detect COVID-19. The development of the model proposed in the current study is based on the Darknet-19 model. When two classes are used, the proposed models detect COVID-19 infection. If three classes are used, the model classifies x-ray images as No finding, pneumonia, or COVID-19. First, the proposed model was used to classify X-ray images into Pneumonia, COVID-19, and No finding. Second, the model has been trained to detect two classes: No finding and COVID-19 categories. Our model achieved 87.06% and 97.88% accuracy for multiclass and binary tasks, respectively. Thus, it can be concluded that DarkCovidNet Deep Learning Model can be used for automated COVID-19 detection through X-ray images.*

Keywords: Deep neural network, COVID-19, automated detection, chest x-ray

Introduction

Polymerase chain reaction (PCR) is commonly used to diagnose COVID-19. Chest radiology, including X-ray and computed tomography, is significant for early disease diagnosis (Zu et al., 2020). Because of the low sensitivity of PCR, radiological images can be used to confirm the diagnosis in suspected cases. CT has significant sensitivity for detecting COVID-19 and can be a screening tool (Lee et al., 2020). Radiographic images and laboratory results can provide useful information about disease status. Studies have highlighted COVID-19-specific radiographic findings such as right infra hilar airspace opacities, nodular opacity, ground glass opacity, consolidation, vascular dilation, air bronchogram sign and interlobular septal thickening (Li and Xia, 2020; Yoon et al., 2020; Zhao et al., 2020).
Recently, machine learning methods have been increasingly used for automatic disease diagnosis (Litjens et al., 2017). Deep learning is a field of artificial intelligence; it has been successfully used for arrhythmia detection, lung segmentation, pneumonia detection, brain disease classification, and breast cancer detection (Ozturk et al., 2020). The rapid rise of COVID-19 has necessitated development in AI-based automated detection. Simple and accurate AI models can be applied to cover the limited number of expert clinicians and radiologists. The use of AI in the field of radiology can help obtain accurate diagnoses (Caobelli, 2020). Recently, deep learning models have been used to diagnose COVID-19 through X-ray images. A study showed 92% accuracy in classifying COVID-19, non-COVID pneumonia, and normal cases (Wang et al., 2020). In another study, the deep learning model had 98% accuracy for COVID-19 detection through X-ray images and the ResNet50 model (Narin et al., 2021). Different studies have been conducted on deep learning models using CT images of COVID-19 detection. However, there is a lack of local data on this topic, thus in the current study assessed.

Methodology

The prospective study was conducted in CH & ICH Multan from January 2021 to January 2022. In this study, a total of 1020 images (450 No-Findings, 450 Pneumonia, and 120 COVID-19 positive) were used for developing our model. Informed consent of the participants was taken. The ethical board of the hospital approved the study. The model proposed in the current study is based on the Darknet-19 model (Redmon and Farhadi, 2017). The DarkCovi dNet architecture was designed based on the DarkNet architecture. Fewer filters and layers than the original DrakNet model were used in this study. Filters were

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gradually increased to 8, 16, and 32. To better understand the proposed model, it is important to explain the Darknet-19, which has 5 pooling layers and 19 convolutional layers. These are conventional CNN (Convolutional Neural Network) layers having different stride values, numbers, and sizes of filters. The flow of input data through these layers is shown in Figure 1. Softmax layers and Avgpool layers produce the output.

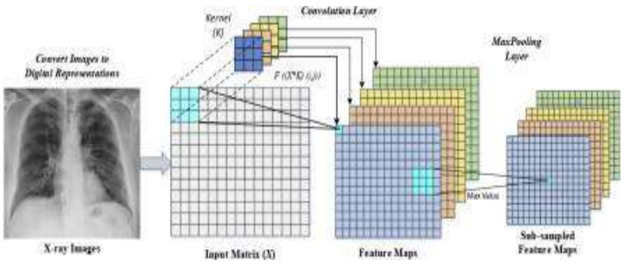

Figure I Flow of data from convolution and maxpool layer

The current study had a problem regarding the classification of subtle images. For such classification, models like ResNext or ResNets (He et al., 2016), which can capture minor details, should be used. The model proposed in this study has seventeen convolution layers. Each DN layer has LeakyReLU and BatchNorm operations after one convolutional layer. Inputs are standardized through batch normalization operation. LeakyReLU is used for keeping neurons alive. Like the Darknet-19 model, all pooling operations use the Maxpool method. Input is downsized by maxpool. When two classes are used, the models detect COVID-19. If three classes are used, the model classifies X-ray images as No finding, pneumonia, or COVID-19.

Results

Two different experiments were done to detect and classify COVID-19 through X-ray images. First, the proposed model was used to classify X-ray images into Pneumonia, COVID-19, and No finding. Second, the model was trained to detect classes: No finding and COVID-19 categories. A 5-fold cross-validation procedure was used to evaluate the model's performance. The model's classification performance was evaluated for all folds, and average performance was calculated. The mean classification accuracy of the model was 87.06%. The accuracy, F1 score, precision, specificity, and sensitivity of the classification model are shown in Table I. The proposed model is better in classifying COVID-19 compared to classes of No finding and pneumonia. The results of the binary classification problem showed that the proposed model had 97.88% accuracy in detecting COVID-19. Its F1 score, precision, specificity, and sensitivity for detecting classes are shown in Table II.

Table I Diagnostic value of the model for classification problem

Folds	Precision (%)	Accuracy (%)	Sensitivity (%)	Specificity (%)	F 1 score (%)
Fold 1	90.67	89.34	88.16	93.65	89.45
Fold 2	89.83	84.98	84.56	90.62	86.65
Fold 3	89.97	85.77	84.12	91.14	86.55
Fold 4	90.62	87.12	83.67	92.39	86.43
Fold 5	89.73	88.11	85.73	92.57	87.56
Average	90.16	87.06	86.04	92.07	87.32

Table II Diagnostic value of the model for COVID-19 detection

Folds	Accuracy (%)	Precision (%)	Sensitivity (%)	Specificity (%)	F 1 score (%)
Fold 1	100	100	100	100	100
Fold 2	97.61	94.53	96.43	96.54	95.53
Fold 3	96.81	98.12	90.46	90.46	93.78
Fold 4	97.51	98.56	93.76	93.76	95.94
Fold 5	97.51	98.57	93.19	93.19	95.51
Average	97.88	97.9	94.76	94.19	96.15

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Discussion

The current study proposed the DarkCovidNet deep learning model for COVID-19 detection. A total of 1020 images (450 No-Findings, 450 Pneumonia, and 120 COVID-19 positive) were used for developing our model. We achieved 87.06% accuracy for three classes and 97.88% for binary tasks. It can effectively help experts in making diagnoses. The model also focused on localizing significant regions on the X-ray image, which can provide an added benefit. Unlike our study, in which the model design was based on the DarkNet model, in previous research, techniques like ResNet and VGG are commonly used. A previous study proposed COVIDX-Net for diagnosing COVID-19 through X-ray images; their model's accuracy was 90% (Hemdan et al., 2020). Wang and Wong proposed COVID-Net for detecting COVID-19; it was a deep learning-based model and obtained a 92.5% success rate in disease detection through radiological images (Hemdan et al., 2020). Another study used a transfer learning model; they used normal, pneumonia, and COVID-9 radiology images and reported 98.7% accuracy for 2 classes and 93.5% for 3 class performances (Apostolopoulos and Mpesiana, 2020). Different studies have proposed different models and methodologies.

In a previous study, CNN mode was used for extracting image features, and the SVM classifier was used for classifying them. They reported 95.3% accuracy using a combination of SVM and ResNet50 (Islam et al., 2020). Song et al. proposed a deep model called DRE-Net and obtained 86% accuracy using CT images (Song et al., 2021). Similarly, a deep inception deep model was used in a study, and 83% classification accuracy was reported by using CT images. A three-dimensional deep learning model was proposed by Pathak et al., it reported 91% accuracy for COVID-19 detection using CT images). Another study used ResNet and detected 87% accuracy in detecting COVID-19 from CT images (Bai et al., 2020; Pathak et al., 2022).

The model proposed in this study can be used for COVID-19 diagnosis from X-ray images. X-ray is preferred due to its easy accessibility. X-rays are widely used for disease diagnosis during the pandemic. The proposed model was able to detect COVID-19 in seconds. CT images were not used as these are comparatively costly and not readily available in remote areas.

Moreover, in CT imaging, the patient is more exposed to radiation hazards compared to x rays. COVID-positive patients detected by the model can then be treated without delay. Moreover, unnecessary PCR tests can be avoided in COVID-19 patients. This will reduce the load on the healthcare system. The limitation of this study is that we used a limited number of chest X-ray images. A more robust study is recommended for detailed analysis.

Conclusion

Our model achieved 87.06% and 97.88% accuracy for multiclass and binary tasks, respectively. It is an automated model and can be used in remote areas to overcome staff shortages. Thus, it can be concluded that DarkCovidNet Deep Learning Model can be used for automated COVID-19 detection through X-ray images.

Conflict of interest

The authors declared absence of conflict of interest.

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