

Detection of COVID-19 from Chest CT Images Using CNN with MLP Hybrid Model

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Abstract. COVID-19 when left undetected can lead to a hazardous infection spread, leading to an unfortunate loss of life. It's of utmost importance to diagnose COVID-19 in Infected patients at the earliest, to avoid further complications. RT-PCR, the gold standard method is routinely used for the diagnosis of COVID-19 infection. Yet, this method comes along with few limitations such as its time-consuming nature, a scarcity of trained manpower, sophisticated laboratory equipment and the possibility of false positive and negative results. Physicians and global health care centers use CT scan as an alternate for the diagnosis of COVID-19. But this process of detection too, might demand more manual work, effort and time. Thus, automating the detection of COVID-19 using an intelligent system has been a recent research topic, in the view of pandemic. This will also help in saving the physician's time for carrying out further treatment. In this paper, a hybrid learning model has been proposed to identify the COVID-19 infection using CT scan images. The Convolutional Neural Network (CNN) was used for feature extraction and Multilayer Perceptron was used for classification. This hybrid learning model's results were also compared with traditional CNN and MLP models in terms of Accuracy, F1-Score, Precision and Recall. This Hybrid CNN-MLP model showed an Accuracy of 94.89% when compared with CNN and MLP giving 86.95% and 80.77% respectively.

Keywords. COVID-19, CNN, Classification, Deep Learning, Multilayer Perceptron

1. Introduction

Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2) which causes the Corona Virus Disease 2019 (COVID-19) was identified in China in late 2019. In March 2020, the World Health Organization (WHO) labelled the disease a pandemic. As of 22nd July 2021, around 191 million COVID-19 cases and 4 million deaths due to COVID-19 have been reported [1]. The most predominant manifestation of COVID-19 is pneumonia, which affects the lungs, and presents with symptoms like high temperature, cough and dyspnea [2]. CT scan examination for abnormalities is by far the most rapid way to evaluate the patients.

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Over the last decade, deep learning and Artificial Neural Networks (ANNs) have had an accelerating study focus. On a number of important benchmarks, deep ANNs have surpassed other conventional models. As a result, ANNs have shown to be the state-of-the-art technology in a variety of application domains, including speech recognition, image processing, biological sciences, and Natural Language Processing (NLP), as well as academic fields. The development of ANNs for smart healthcare advancement, particularly in medical predictive analytics, diagnosis through medical image processing and analysis, has enormous promise [3,4,5]. As has been witnessed recently, several sections of the world are experiencing a healthcare shortage, both in relation to the required number of healthcare personnel and electronic components. In this study, CNN was used to create an automatic diagnosis method that uses CT scan image results to determine if a person has acquired the COVID-19 infection or not. This study's initial findings in terms of reliability and other quality metrics to evaluate the condition in a cost-effective and time-efficient manner have showed encouraging outcomes. The accuracy of COVID-19 CT scan image categorization was improved in this work by combining CNN and MLP. The CNN architecture in neural networks is specifically designed to deliver two-dimensional image operations.

2. Proposed Work

In this section, the proposed model has been discussed elaborately. The architecture of the proposed hybrid model is shown in Figure. 1. Here, CNN is used for feature extraction by the removal of the fully connected layers from the CNN model and MLP is used for classification.

2.1. Convolutional Neural Network (CNN)

Convolutional Neural Network is comprised of an input layer, hidden layers, and an output layer. Input CT scan images are fed as input to the CNN model through the input layer. The hidden layers of a CNN include convolutional layers and pooling layers. The ReLU activation function is used in this model, and it is typically the Frobenius inner product. The convolution operation is performed by sliding the convolutional kernel over the input matrix of the CT scan images, thereby the feature map is generated, which then imparts to the input of the succeeding layers. Other subsequent layers such as pooling layers performs the dimensionality reduction, fully connected layers perform the classification task, and the normalization components are also stacked with this model. The convolutional filter of size $3 \times 3 \times 4$ is being used for first convolutional layer followed by convolutional operation with size $2 \times 2 \times 8$. The max pooling layer of size 2×2 is being used to reduce the dimensions. 8 neurons are being used as dense layer followed by dropout of 0.25 is being constructed. ReLu is used as activation function for the convolutional and max pooling layers. SoftMax is used as an activation function for dense layers.

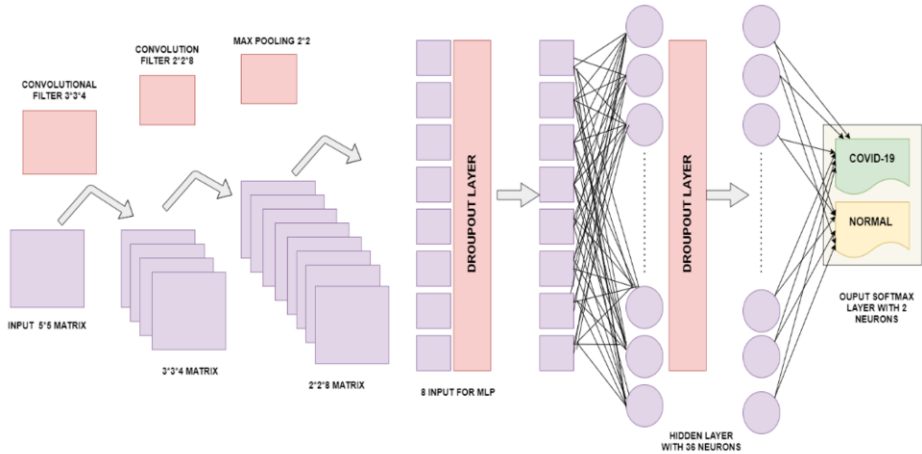


Figure 1. Architecture of the proposed CNN-MLP model

2.2. Multilayer Perceptron (MLP)

Multilayer Perceptron model is one of the widely used supervised learning model in real time applications. It is comprised of input layer, followed by multiple hidden layers with an output layer. It has two phases; one is forward phase and other is the backward phase. Forward phase is used for classification and the backward phase is used for error propagation in the backward direction for the learning process. Any nonlinear activation function will be used in the hidden and the output layers to solve any real time nonlinear problems.

3. Experimental Results

The dataset required for carrying out the experiment has been gathered from GitHub [6] and Kaggle’s TPU machine was utilized to run the models. The models were constructed using TensorFlow and Keras provided by Python programming language. The training images and testing images for both classes (COVID-19 and normal CT scan images) were separated in 80:20 ratio with number of images in each class being 1200 (960 for training and 240 for testing). The metrics used for comparing the performance includes accuracy, precision, recall, F1-Score and specificity. The confusion matrix and the performance measures of the CNN, MLP and the proposed Hybrid Model is given in Table 1. From the results, the proposed Hybrid model showcases a better performance compared to the CNN and the MLP models.

Table 1. Confusion Matrix and Classification Report for the models

Models	Category	COVID-19	Normal	Total	Category	Precision	Recall	F1 Score	Specificity
CNN-MLP	COVID-19	114	6	120	COVID-19	0.95	0.93	0.94	0.95
	Normal	9	111	120	Normal	0.92	0.95	0.94	0.95
	Total	123	117	240	Average	0.94	0.94	0.94	0.95
CNN	COVID-19	102	18	120	COVID-19	0.85	0.86	0.86	0.86
	Normal	16	104	120	Normal	0.86	0.85	0.86	0.86
	Total	118	122	240	Average	0.86	0.86	0.86	0.86
MLP	COVID-19	96	24	120	COVID-19	0.80	0.82	0.81	0.80
	Normal	21	99	120	Normal	0.80	0.80	0.80	0.80
	Total	117	123	240	Average	0.80	0.81	0.81	0.80

Conclusion

In conclusion, our research revealed the viability of using trained hybrid model to help clinicians determine whether or not a patient is infected with COVID-19. The proposed hybrid model could enable rapid identification. With the deployment of the proposed model in patient care, clinicians could make more trustworthy decisions by attaining good performance on diagnoses.

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References

- [1] WHO, Coronavirus Disease 2019 (COVID-19) <https://covid19.who.int/> , World Health Organization, Accessed on 22nd July 2021.
- [2] Shi H, Han X, Jiang N, Cao Y, Alwalid O, Gu J, Fan Y, Zheng C. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. *The Lancet infectious diseases*. 2020 Apr 1;20(4):425-34.
- [3] Xie X, Zhong Z, Zhao W, Zheng C, Wang F, Liu J. Chest CT for typical coronavirus disease 2019 (COVID-19) pneumonia: relationship to negative RT-PCR testing. *Radiology*. 2020 Aug;296(2):E41-5.
- [4] Zhu Z, Xingming Z, Tao G, Dan T, Li J, Chen X, Li Y, Zhou Z, Zhang X, Zhou J, Chen D. Classification of COVID-19 by compressed chest CT image through deep learning on a large patients cohort. *Interdisciplinary Sciences: Computational Life Sciences*. 2021 Mar;13(1):73-82.
- [5] Shah V, Keniya R, Shridharani A, Punjabi M, Shah J, Mehendale N. Diagnosis of COVID-19 using CT scan images and deep learning techniques. *Emergency radiology*. 2021 Jun;28(3):497-505.
- [6] Mohammad Rahimzadeh, Abolfazl Attar, Seyed Mohammad Sakhaei, A fully automated deep learning-based network for detecting COVID-19 from a new and large lung CT scan dataset, *Biomedical Signal Processing and Control*, Volume 68, 2021, 102588, ISSN 1746-8094, <https://doi.org/10.1016/j.bspc.2021.102588> .