International Journal of Decision Inelligence
Vol 1, Issue 4, Autumn 2024 , 17-22

Using deep convolutional neural network to diagnose covid-19 disease from CT scan images

Rezvaneh Azizi[a, *], hamid abbasi
[a]Department of Computer Engineering, Damghan Branch, Islamic Azad University, Damghan, Iran

Received 10 September 2024; Accepted 29 January 2025

Abstract:

This paper examines the application of soft computing techniques in detecting COVID-19 through CT scan image analysis. Convolutional deep learning models are employed, and their performance in disease detection is evaluated. In this study, we investigate the optimization of feature extraction methods from CT scan images and present the results of our experiments. We focus on designing a COVID-19 detection system using a convolutional neural network model supported by open-source software such as Keras, Python, Google Colab, Kaggle, and Visual Studio. The results of this study indicate that using deep convolutional networks with layered architecture can significantly enhance the accuracy of COVID-19 detection through CT scan images and be effective in faster and more accurate patient diagnosis.

Keywords : CT scan images, convolutional neural network, Covid-19, modeling, deep learning

1. Introduction

With the emergence and global spread of COVID-19, there has been a significant need for rapid, accurate, and non-contact methods for diagnosing this disease. One approach that is increasingly used in the field of viral disease detection is deep learning, particularly Convolutional Neural Networks (CNNs). As a type of deep learning architecture, CNNs have substantial capabilities in image analysis. These networks utilize convolutional layers to extract important features from images, enabling the identification of various diseases, including COVID-19, in medical images. X-ray imaging offers incredible advantages, including minimal cost, reduced time consumption, and more. Therefore, X-ray imaging processing represents a superior option for rapid analytical techniques in the context of a pandemic such as COVID-19. In this paper, we examine the application of Convolutional Neural Networks in detecting COVID-19 through medical imaging. We use CT scan data from COVID-19 patients and healthy individuals collected from the Valiasr Hospital in Damghan and the Imam Hossein Hospital in Shahrud to train a deep CNN model. This model not only assists in disease detection but also extracts various features from the images. We aim to demonstrate how CNNs can be employed to differentiate between healthy lungs and those affected by COVID-19 using these images. The proposed model is designed to provide accurate predictions for binary classification (COVID-19 positive versus negative). Our model achieved a classification accuracy of 96.153% for binary classes. The remainder of the paper will cover the problem statement, literature review, theoretical foundations, implementation of the proposed system, evaluation of results, and conclusions. The problem statement section will detail the research topic, its significance, and objectives. The literature review section will explore previous research and proposed methods. The theoretical foundations section will introduce important terms and concepts necessary for understanding the study. The implementation and results evaluation section will provide a comprehensive description of the modeling and functioning of the proposed system, assess it based on the defined criteria, and conclude with a final evaluation of the proposed model.

2. statement problem

The exponential rise in COVID-19 cases worldwide has severely impacted the healthcare systems of densely populated countries due to the limited number of doctors, testing kits, and other resources, making it essential to identify infected individuals. Given these challenges, the goal of this paper is to develop an accurate, efficient, and time-saving method for detecting COVID-19 positive patients. The novel coronavirus, commonly known as COVID-19, was first identified in Wuhan, Hubei Province, China, in December 2019 and has since spread globally. On February 11, 2020, the World Health Organization named it COVID-19. Coronaviruses (CoV)

are a large family of vulnerable and dangerous viruses. Today, the COVID-19 pandemic has become one of the greatest global health challenges. Given the rapid spread of the virus and its high transmissibility, there is a critical need for precise and swift diagnostic methods. One of the most important and practical tools for diagnosing COVID-19 is medical imaging, such as CT scans. These images provide detailed information that can be crucial for diagnosis, predicting disease progression, and ultimately aiding in effective treatment. However, manual analysis of medical images is time-consuming and may have relative accuracy issues. On the other hand, advancements in deep learning, particularly Convolutional Neural Networks (CNNs), offer the possibility of automatic and precise disease detection through image analysis. Such methods can assist doctors in rapidly and accurately diagnosing COVID-19, thereby enabling timely and effective treatment. In this paper, we address how we can leverage the capabilities of Convolutional Neural Networks to detect COVID-19 through CT scan image analysis. We explore how to train these networks to identify specific features associated with COVID-19 and ultimately develop an automatic and accurate detection system to assist doctors in swiftly identifying patients and providing appropriate treatment. This technical challenge is not only crucial for improving COVID-19 diagnosis but also for managing and controlling the rapid response to disease outbreaks. The objective of this paper is to construct a multi-layer Convolutional Neural Network that is trained using a dataset, with network weights updated to improve performance. This network can then be tested on experimental datasets to analyze and optimize the CNN model for better accuracy.

3. literature review

In numerous studies and research, the diagnosis of COVID-19 through artificial intelligence and various deep learning algorithms has been explored, yielding different results and accuracies. In one study conducted by Ozturk and colleagues, a neural network called DarkCovidNet was designed to diagnose COVID-19 using X-ray images, achieving an accuracy of 87% [2].

Another study by Lin T. Dong and collaborators presented a practical solution for diagnosing COVID-19 from chest X-ray images (LCT) using advanced machine learning techniques. EfficientNet and MixNet, two recently developed deep neural network families, were used as the primary classification engines. This modeling, performed on the ImageNet dataset, achieved an accuracy of approximately 95% [3].

Shimpy Goyal and colleagues used the F-RNN-LSTM method for COVID-19 detection. The use of the f-RNN-LSTM neural network for COVID-19 detection can be a useful approach, though this technology requires suitable data and processing capabilities. However, RNN networks also face challenges, with one of the most significant being the vanishing gradient problem, which can prevent gradients from adequately reaching the input layers and result in inadequate training. The accuracy of this model was reported to be 87% [4].

Ying and colleagues conducted a similar experiment by creating a dataset of chest X-ray images from both COVID-19 and non-COVID-19 patients. The authors used a pre-trained DRE-Net model, achieving an accuracy of 83% for binary classification. However, the number of X-ray images was significantly smaller [5].

Marius Antimopoulos and collaborators used a CNN for classifying ILD patterns. The proposed network consisted of five convolutional layers with 2 kernels and LeakyReLU activation, followed by average pooling with a size equal to the final feature size and three dense layers. They achieved an accuracy of 85% in their study.[6]

4. Theoretical foundations

4.1. Neural Networks

A neural network, or artificial neural network, refers to a collection of neurons connected in a specific architecture to solve a particular problem, where each neuron performs simple computations. The process within an artificial neural network involves neurons receiving data based on their connections to other neurons and passing this data to other connected neurons. The connections between neurons are variable, which allows the network to learn. The primary goal of artificial neural networks is to handle classification and regression tasks [7].

4-2. Convolutional Neural Networks (CNNs)

A neural network, in modern terms, is an artificial neural network consisting of nodes known as artificial neurons. Convolutional Neural Networks (CNNs) are a type of deep learning network particularly suited for image processing. These networks employ convolutions (operations similar to matrix filters) and pooling layers (to reduce image dimensions), enabling the extraction of complex features and various levels of detail from images [6].

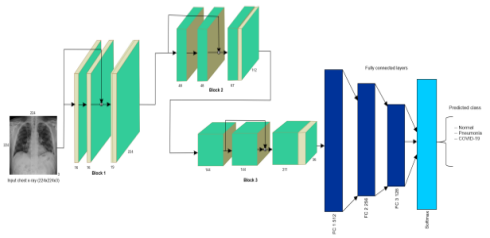

Figure No. 1: Visual presentation of the designed CNN model [8]

4.2. CT Scan images in the diagnosis of diseases:

CT Scan images have become one of the most important tools in the diagnosis of internal diseases due to their high accuracy and ability to display the internal state of the body. These images provide detailed information of the internal structures of the body that can help in diagnosing and predicting diseases.

4.4. Deep learning:
Deep learning is an important area of machine learning that uses deep networks such as CNN [9]. With the help of optimization algorithms and a large number of hidden layers, these methods model more complex features of the data and can detect complex patterns. [10]

5. System implementation and results evaluation

In this section, the evaluation of the proposed covid-19 detection system by deep convolutional neural network has been discussed on the selected data set, which will be discussed in detail in the following cases.

5.1. Introduction to the dataset

In this research, we will use a dataset containing CT Scan images of patients with Covid-19.

These images were collected from Damghan and Imam Hossein Shahroud hospitals and have accurate labels of positive and negative patients for covid-19. In the data preprocessing section, these images are preprocessed before entering the CNN model. This includes resizing images to standard sizes, applying special filters to reduce noise and increase image quality, and normalizing pixel values in the image. During the preprocessing of the dataset of about 562 X-ray images, the dataset was divided into 2 classes for testing and training the proposed CNN. The training dataset consists of 242 positive X-ray images of Covid-19 and 242 normal X-ray images, making a total of 484 training images. Similarly, the test dataset consisted of 39 positive images of Covid-19 and 39 normal images, making a total of 78 images of the test set.

5.2. System implementation

The Process of Creating a Model of Convolutional Neural network by setting the flow of the model as shown in the figure and setting the essential parameters to train the model is known as modeling CNN.

The last CNN model comprises 16 layers out of which 4 are Convolutional, 4 Max_Pooling layers, 4 Dropout layers, 56 bunch standardization layer for the preparation set and 1 flatten layer, and 2 fully connected layers, 6 actuation layers (5 ReLU layers and last one sigmoid layer); input picture state of CNN model is (150, 150, 3). All the Convolutional layers are handled with a 3*3 size filter or kernels, the number of filters been utilized in each convolutional layer is 32, 64, 128, 256 individually. After each con2D layer, the Max-pooling layer with a 2*2 size Max_Pooling has been utilized. The actuation layer is being applied with the ReLU function, and the dropout layer has been utilized with a 25% dropout rate. The result of 65536 neurons of the last Con2D layer is flattened into a column matrix, this flattened layer will be the input for the next 3 dense layers of order 256, 128, 1 respectively. Since only one output node is needed to classify the data to one of 2 classes we make use of Binary classification by giving the output to a sigmoid activation function. The output given by the sigmoid activation function lies between 0 and 1.

5.3. Evaluation of results

The proposed CNN model is capable of classifying or distinguishing CTscan images of Covid-19 and CT scan images of normal lungs. The trained model is presented with the CT scan image of the patient that is provided for prediction.

Our dataset consisted of about 562 X-ray images, for testing and training the proposed CNN, which was divided into 2 classes. The training dataset includes 242 positive X-ray images of Covid-19 and 242 normal X-ray images, which makes a total of 484 training images. The test dataset, similarly, consisted of 39 positive Covid-19 images and 39 normal images, making a total of 78 test set images.

The CNN model performed with an accuracy of 96.69% on the experimental validation data set, during the process of training the model and testing it on the validation data set. Also, at the end of training, step-loss has decreased to

0.127 Figure 3 shows the confusion matrix of the model based on which the CNN model was tested for 78 images, of which 2 images were incorrectly predicted.

But it should be noted that the wrongly diagnosed images are related to healthy people who were wrongly diagnosed as sick.

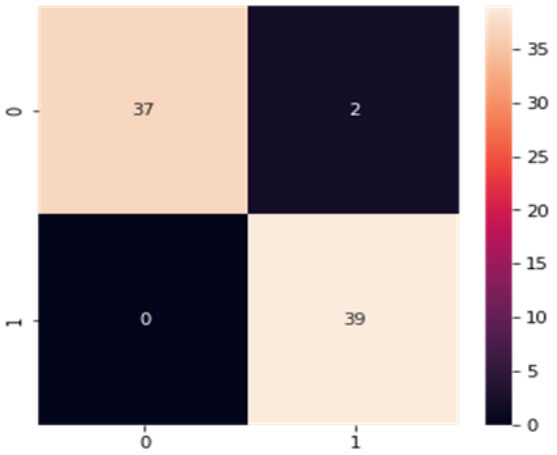

Figure 2: confusion matrix of the proposed model

As mentioned earlier, in the diagnosis of dangerous diseases, it is important that the affected people are diagnosed with certainty or with relatively high accuracy, which is what happened here. Figures 3, 4, 5 and 6, graphical visualization of the accuracy and loss curve for the training and testing data sets and their correlation, we can see how the accuracy of the system increases with each epoch, respectively, as the loss decreases. Also, with an increase in a period, the accuracy also increases in order, after a certain period, the accuracy tends to be saturated, which can be seen in the graphs after 15 epochs.

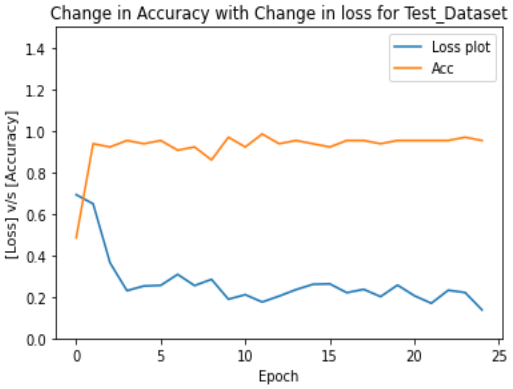

Fig 3:Accuracy V/S Loss Training Dataset

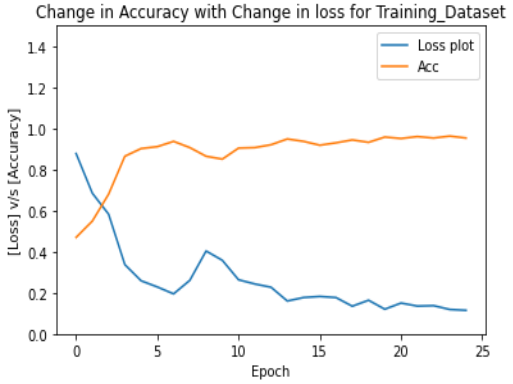

Fig 4 :Accuracy V/S Loss Test Dataset

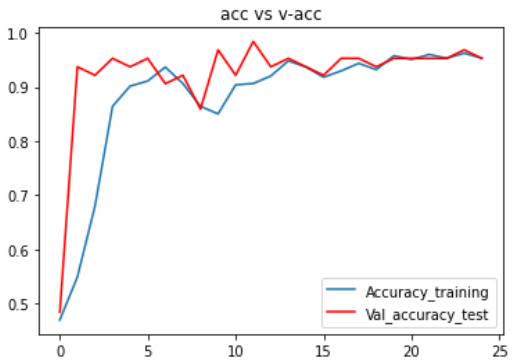

Fig 5:Accuracy of Training dataset V/S Test dataset

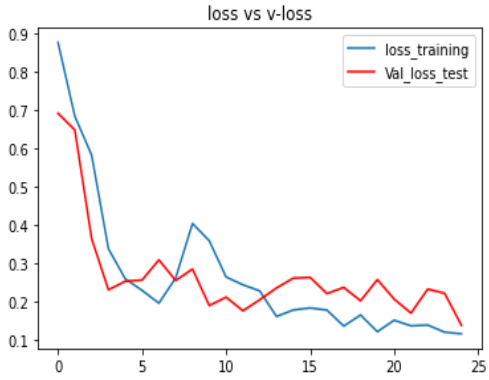

Fig 6: Accuracy of Test dataset V/S Test dataset

The conducted research shows that the model works on a massive dataset of 78 images, of which 39 are positive and 39 are negative. This model can predict positive images of Covid-19 with 100% accuracy, but when it comes to normal negative or negative photos of Covid-19, its accuracy is only 95%. The overall accuracy of the model in the test dataset is about 97%.

Table 1: Performance of the proposed model in the test dataset

	Precision	Recall	F1-scoee	Support
Covid-image-test	100%	95%	97%	39
Normal-image-train	95%	100%	97%	39
Accuracy			97%	78

Next, in table number 2, you can compare the proposed method in this article with other methods and check its model in terms of accuracy and other evaluation values.

Table 2: Review and comparison of other algorithms with our proposed method in this research

precision	Algorithm	Researchers
87%	DarkCovidNet	Ozturk et al
95%	MixNet،EfficientNet	Lin T. Dong et al
87%	F-RNN-LSTM	Shimpi Goyal et al
83%	DRE-Net	Ying et al
85%	CNN	Marius Antimopoulos et al

By examining the mentioned methods and the proposed method in this article, it can be seen that our method in this article has provided higher accuracy in terms of accuracy and has been trained and tested on a larger number of images. Also, in the proposed method in this article, the cases of covid-19 are identified with 100% accuracy, which is very important for us in diagnosing a dangerous disease like covid-19.

6. conclusion

observation In this research, we designed and evaluated a deep CNN model for the diagnosis of Covid-19 through the analysis of CT Scan images. The designed model was able to extract specific features from CT Scan images and diagnose patients with covid-19 with high accuracy.

This method has not only increased the accuracy of diagnosis, but also allows doctors to diagnose patients more quickly and confidently. During this research, we solved various problems and challenges using the designed model. Among these challenges, we can mention the separation of the disease from other diseases with similar symptoms, as well as reducing the possibility of human error in diagnosis.

According to the results obtained in this research, it can be concluded that the use of CNN deep networks with the proposed layering and functions used in this research in the analysis of CT Scan images is effective as an efficient and accurate tool in the diagnosis of Covid-19.

This method can not only help in early diagnosis of patients, but also can be effective in better management of

patients and creation of more effective treatment plans. In this research, we used deep learning technology to improve the accuracy and speed in the diagnosis of the Covid-19 disease, and the results showed that this method can work effectively in this field.

In addition to accurate diagnosis, this model allows doctors to identify patients faster and provide appropriate treatment plans for them. Finally, deep learning technology in the field of disease diagnosis through the analysis of medical images is effective as a powerful tool in the advancement of medicine and can bring significant improvements in the diagnosis and treatment of various diseases. It is suggested to investigate and test new deep network architectures and learning methods such as hybrid networks and collaborative deep learning in the future because it can have important improvements in the accuracy of disease diagnosis. It can also be done in future researches. By creating a multi-purpose data set that includes data from other types of medical images, such as radiographs and clinical information of patients, in addition to CT Scan images, he designed the relevant model.

References

[1] M. Aslan, "CoviDetNet: A new COVID-19 diagnostic system based on deep features of chest x-ray," Electrical-Electronics Engineering, 2022.

[2] T. M. Y. E. B. U. Y. O. A. U. Ozturk T, "Automated detection of COVID-19 cases using deep neural networks with X-ray images.," Computers in Biology and Medicine., 2020.

[3] P. T. N. ,. I. ,. F. Linh T. Duong, "Automatic detection of Covid-19 from chest X-ray and lung computed tomography images using deep neural networks and transfer learning," www.elsevier.com/locate/asoc, 2022.

[4] R. S. Shimpy Goyal, "Detection and classifcation of lung diseases for pneumonia and Covid-19 using machine and deep learning techniques," Journal of Ambient Intelligence and Humanized Computing , 2021.

[5] Z. S. L. L. Z. X. Z. X. H. Z. e. a. Song Y, " Deep learning enables accurate diagnosis of novel coronavirus (COVID-19) with CT images.," IEEE/ACM Transactions on Computational Biology and Bioinformatics., 2021.

[6] S. C. E. Marios Anthimopoulos, "Lung Pattern Classification for Interstitial Lung Diseases Using a Deep," IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 35, NO. 5,, 2016.

[7] M. S. B. Maind, "Research Paper on Basic of Artificial Neural Network," International Journal on Recent and Innovation Trends in Computing and Communication , 2000.

[8] A. A. Khandaker Foysal Haque, "A Deep Learning Approach to Detect COVID-19 Patients from Chest X-ray Images," Proceedings of the 3rd IEEE International Conference on Computing, Electronics & Communications Engineering, University of Essex, Southend Campus, Southend, UK, , 2022.

[9] M. H. Olyaee, H. Abasi, M. Yaghoobi, Using Hierarchical Adaptive Neuro Fuzzy Systems And Design Two New Edge Detectors In Noisy Images, Journal of Soft Computing and Applications,2013, P.1-10.

[10] G. H. Y. B. Yann LeCun, "Deep learning REVIEW," doi:10.1038/nature14539.