Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 05, 2023

Deep Learning Model for Detection of Covid-19 and Pneumonia from Chest X-Ray Images

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Abstract

Over the decades, a typical imaging test that has been used is an X-ray. It allows doctors to see into the body without an incision. As a result, an X-ray can aid in diagnosing, monitoring, and treating a variety of medical disorders by detecting diseases beforehand. Among the diseases, pneumonia got major heed because of its intensity. As the lungs are the most vulnerable part of the body when it comes to pneumonia, doctors rely on chest X-ray to diagnose the disease. In this research, we have worked on the X-ray images to discern pneumonia using our proposed deep learning convolutional neural network (DLCNN) model and different types of transfer learning models and manifested a comparison of those methods in terms of their ability to detect the disease. This is one major reason for its severity and rapid spread. Therefore, this work is focused on implementation of chest x ray image analysis network (CXRIA-Net) for identification of COVID-19 and pneumonia related 21 diseases. The CXRIA-Net utilizes the DLCNN model for training and testing. Finally, the simulations revealed that the proposed CXRIA-Net resulted in superior performance as compared to existing models.

Keywords: Chest X-ray imaging, Covid-19, Pneumonia, deep learning convolutional neural network.

1. Introduction

COVID-19 is an infectious and contagious disease pandemic that spread over 200 countries in the past year. Meanwhile, COVID-19 has become a serious health threat for the entire world that causes respiratory problems, heart infections, and even death. This virus first reported in a human being in December 2019 in Wuhan, China rapidly crossed the continent borders due to intensive travelling among countries COVID-19 has had an adverse impact on the world economy too. Research studies found out that the COVID-19 virus badly affects the lungs and promptly mutates before the patient receives any diagnosis led medication. The situation becomes more severe when the symptoms match the normal flu, as in the Southeast and Central Asia cases. Experts found out that the incubation period of COVID-19 virus is approximately 1 week. This observation is crucial because the infected patient acts as a virus carrier during this period and unintentionally transmits it. Due to its rapid contagious nature, its spread is much faster than its detection. Machine learning methods are very popular in healthcare applications. There are various methods used to detect the presence of a COVID-19 virus in patients, such as RTPCR test, X-ray imaging, computed tomography (CT) scan, rapid antigen, serological test.

Rest of the paper is organized as follows: Section 2 details about literature survey, section 3 details about the proposed methodology, section 4 details about the results with discussion, and section 5 concludes article with references.

2. Literature Survey

Ieracitano, Cosimo, et al. (2022) [11] proposed a fuzzy logic based deep learning (DL) approach to differentiate between CXR images of patients with Covid-19 pneumonia and with interstitial pneumonias not related to Covid-19. Khan, A. I., Shah, et al. (2020) [12] proposed CoroNet, a Deep Convolutional Neural Network model to automatically detect COVID-19 infection from chest X-ray images. The proposed model was based on Xception architecture pre-trained on ImageNet dataset and trained end-to-end on a dataset prepared by collecting COVID-19 and other chest pneumonia X-ray images from two different publicaly available databases. Ravi, Vinayakumar, et al. (2022) [13] proposed a large-scale learning with stacked ensemble meta-classifier and deep learning-based feature fusion approach for COVID-19 classification. Next, a feature fusion approach was employed to merge the features of various extracted features. Finally, a stacked ensemble meta-classifier-based approach was used for classification. Sharifrazi, Danial, et al. (2021) [14] proposed to detect COVID-19 using X-ray images. A new X-ray image dataset was collected and subjected to high pass filter using a Sobel filter to obtain the edges of the images. Then these images were fed to CNN deep learning model followed by SVM classifier with ten-fold cross validation strategy. Eljamassi, Duaa F., et al. (2020) [15] proposed a classification model that detect the infected condition through the chest X-ray images. A dataset containing chest x-ray images of normal people, people with pneumonia such as SARS, streptococcus and pneumococcus and other patients with COVID-19 were collected. Histogram of oriented gradients (HOG) was used for image features extraction.

Hemalatha, Murugan et al. (2022) [16] proposed EfficientNet by streamlining the mobile inverted bottleneck convolution (MBConv) module, introducing the efficient channel attention (ECA) module and coordinate attention (CA) module, and transfer learning. The accuracy of GECM-EfficientNet reaches 94.54% and 94.23% on the self-built household waste dataset and TrashNet dataset, with parameters of only 1.23 M. Ahmed, M. A., et al. (2021) [17] proposed system based on the convolution neural network (CNN) architecture and can automatically expose discriminative features on chest X-ray images due to its convolution with rich filter families and weight-sharing characteristics. As a deep feature extractor, the CNN model SqueezeNet was used. The extracted deep discriminative features were fed machine Decision Tree, Random Forest, Neural Network (NN), Naive Bayes, Logistic Regression, and k-nearest neighbor learning algorithms. Mostafiz, Rafid, et al. (2022) [18] proposed an intelligent approach to detect Covid-19 from the chest X-ray image using the hybridization of deep convolutional neural network (CNN) and discrete wavelet transform (DWT) features. At first, the X-ray image was enhanced and segmented through preprocessing tasks, and then deep CNN and DWT features were extracted. The optimum features were extracted from these hybridized features through minimum redundancy and maximum relevance (mRMR) along with recursive feature elimination (RFE). Kumar, Rahul, et al. (2020) [19] proposed the machine learning-based classification of the extracted deep feature using ResNet152 with COVID-19 and Pneumonia patients on chest X-ray images. SMOTE was used for balancing the imbalanced data points of COVID-19 and Normal patients. This non-invasive and early prediction of novel coronavirus (COVID-19) by analysing chest X-rays can further be used to predict the spread of the virus in asymptomatic patients. Gupta, Siddharth, et al. (2021) [20] proposed useful analysis to study a large amount of chest x-ray images that can critically impact on screening of Covid-19. In this work, we had taken the PA view of chest x-ray scans for covid-19 affected patients as well as healthy patients. After cleaning up the images and applying data augmentation, we had used deep learning-based CNN models and compared their performance. We had compared Inception V3, Xception, and ResNeXt models and examined their accuracy.

3. Proposed Methodology

This section describes CXRIA-Net method consisting of two phases, illustrated in Fig. 1:

(i) data engineering and

(ii) model training and validation.

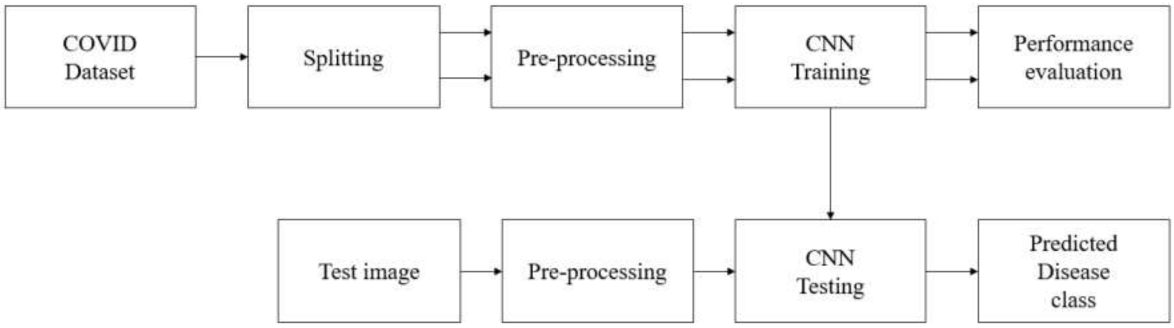

Figure 1. Proposed CXRIA-Net model phases

Dataset: We use two chest X-ray image datasets in our method, summarized. Dataset-1 [36] contains total of 950 X-ray images3 labeled with more than ffteen types of disease fndings such as: pneumocystis, streptococcus, klebsiella, legionella, SARS, lipoid, varicella, mycoplasma, infuenza, herpes, aspergillosis, nocardia, COVID-19, tuberculosis, and others. This image dataset contains anteroposterior (front to back), front postero-anterior (back to front) and lateral (side) X-ray image views. Front postero-anterior images give clear lung representations, therefore we selected 196 COVID+ pre-processed chest X-ray images labelled with front view for our experiments and removed the rest.

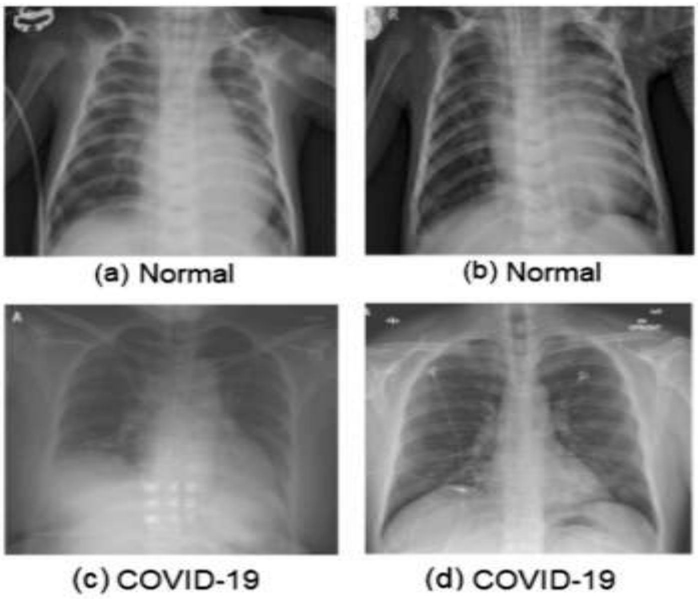

Figure 2. X-ray image samples of COVID-19-infected and healthy (i.e., normal) patients

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 05, 2023

Table 2 Dataset description

X-ray image type	X-ray front posteroanterior view	Dataset-1 image count [36]	Dataset-2 image count [37]
COVID-19 positive	✓	196	–
	×	388	–
COVID-19 negative	✓	–	1583
	×	–	–
Other disease	–	366	4273

Dataset-2 contains total 5856 chest X-ray images labelled in three categories: normal, viral pneumonia, and bacterial pneumonia. All X-ray images have a front posteroanterior view. We randomly selected 196 X-ray images of normal category and labelled them as COVID− image type. The reason for this selection was to keep the data unbiased and balanced by keeping COVID+ and COVID− data size equal. We performed four image pre-processing steps to reduce the noise: (i) rescaling, (ii) shearing, (iii) zooming, and (iv) horizontal fip. Finally, we reduced the pre-processed image size to 224 × 224 × 3 and made them uniform before applying model training (Fig. 2)

CXRIA-Net CNN architecture

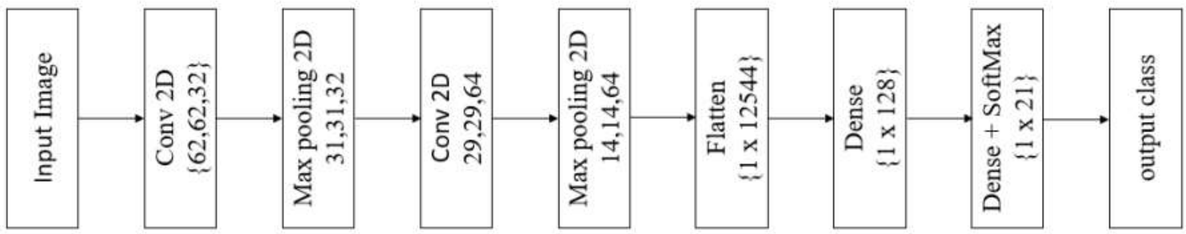

Figure 3. CXRIA-Net CNN architecture

We used a layered sequential model architecture for X-ray image classification with four convolutional layers displayed in Fig. 3. The first convolutional layer has 32 filters, the second layer has 64 filters, the third layer has 64 filters, and the last layer has 128 filters. The number of filters corresponds to number of features the network can extract at each layer. We gradually increased the number of filters in the proposed network because the lower layers detect features in a very small part of the image and learn a hidden pattern during the network training. The receptive field of the CNN layer architecture increases with its depth in the network. This means that by increasing the number of layers, the network extracts the features from the larger part of the original picture, as the deeper layers in the network will detect higher level features. We fixed the default kernel size to 3 × 3 at the convolutional layer and applied a non-linear ReLU activation function.

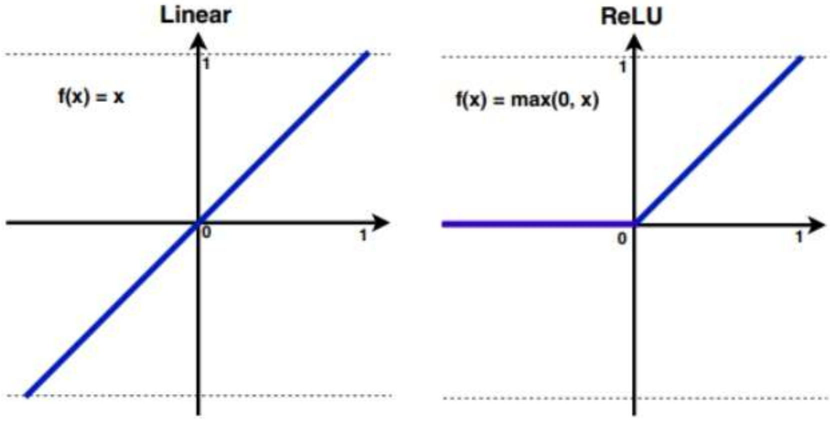

Figure 4. Linear and ReLU activation function

Figure 4 clearly shows that the ReLU curve is half rectified, unlike the linear activation function. This means that ReLU returns zero as output value for all negative input values and represented. If the value of y is less than 0 then value of f(y) will be zero otherwise output will be y. Similarly, we used three max-pooling layers and kernel window of size 2 × 2 with the increased number of filters in each layer to contain the more complex image patterns in training network. Table 3 summarizes the proposed CNN model parameters, used to classify the chest X-ray dataset. We implemented proposed CNN model on the selected datasets with 196 positive and 196 negative COVID-19 images. We trained the model and tuned it using different learning parameters and training and testing dataset distributions. We experimented with three CNN architectures: 1. CNN model-1 with a maximum pool size of 2 × 2 and one stride; 2. CNN model-2 with a maximum pool size of 2 × 2 and two strides; 3. CNN model-3 with a maximum pool size of 3 × 3 and three strides.

Table 1. CNN model parameters for chest X-ray image dataset

Layer Name	No. of filters	Feature size	parameters
Conv 2D	32	62 x 62	896
Max pooling 2D	32	31 x 31	0
Conv 2D	64	29 x 29	18496
Max pooling 2D	64	14 x 14	0
Flatten	-	1 x 12544	0
Dense	-	1 x 128	1605760
Dense	-	1 x 21	2709

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 05, 2023

4. Result and Discussion

This section gives the detailed analysis of simulation results implemented using "python environment". Further, the performance of proposed method is compared with existing methods using same dataset. Figure 5 and Figure 6 shows the predicted outcomes using proposed method. Table 2 compares the performance of proposed method with existing methods. Here, Proposed CXRIA-Net resulted in superior Accuracy, Precision, Recall, and F1-SCORE as compared to existing CNN. The graphical representation of table 1 is presented in figure 7.

Figure 5. Disease predicted as: pneumonia viral COVID-19.

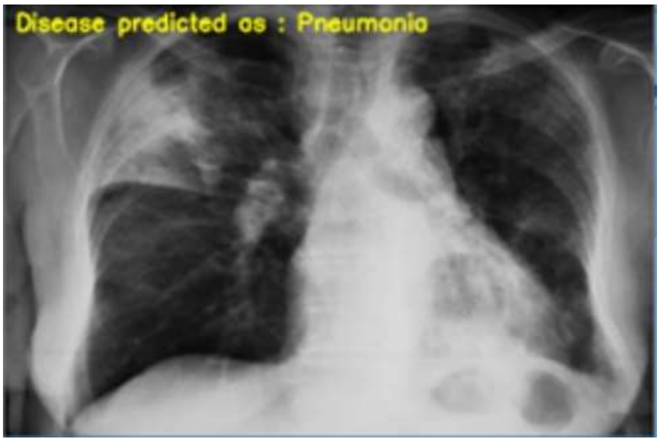

Figure 6. Disease predicted as: Pneumonia.

Table. 2. Performance comparison.

Method	NB	RF	SVM	Proposed
Accuracy (%)	67.37	77.48	78.37	99.5

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 05, 2023

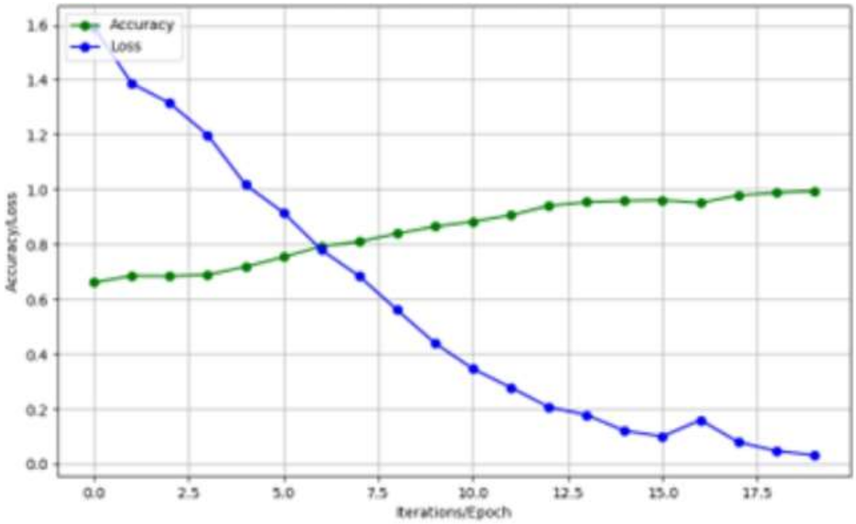

Figure 7. Accuracy and loss graph.

5. Conclusion

We developed in this work a model to detect the COVID-19, pneumonia infection using chest X-ray images. For this purpose, we used a publicly available dataset of 392 positive COVID+ and negative COVID− X-ray patient images. We fixed each input image size to 224 × 224 × 3 and performed CNN training for a accurate classification. We implemented three convolutional layer-based models with a kernel size of 3 × 3. we still face a serious need to find out the severity level of the infection too. In the future, we intend to perform experiments on chest CT scan image data for COVID-19 detection and combine both the models to identify the severity level. Voice recognition based early COVID19 infection detection using intelligent methods is also part of our future plans.

References

[1] Saiz, Fátima, and Iñigo Barandiaran. "COVID-19 detection in chest X-ray images using a deep learning approach." (2020).

[2] Hasan, Md Jahid, Md Shahin Alom, and Md Shikhar Ali. "Deep learning based detection and segmentation of COVID-19 & pneumonia on chest X-ray image." 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD). IEEE, 2021.

[3] Zargari Khuzani, Abolfazl, Morteza Heidari, and S. Ali Shariati. "COVID-Classifier: An automated machine learning model to assist in the diagnosis of COVID-19 infection in chest x-ray images." Scientific Reports 11.1 (2021): 9887.

[4] Maghdid, Halgurd S., et al. "Diagnosing COVID-19 pneumonia from X-ray and CT images using deep learning and transfer learning algorithms." Multimodal image exploitation and learning 2021. Vol. 11734. SPIE, 2021.

[5] Aggarwal, Sonam, et al. "Automated COVID□19 detection in chest X□ray images using fine□ tuned deep learning architectures." Expert Systems 39.3 (2022): e12749.

[6] Widodo, Chomsin S., et al. "UBNet: Deep learning-based approach for automatic X-ray image detection of pneumonia and COVID-19 patients." Journal of X-Ray Science and Technology 30.1 (2022): 57-71.

[7] Ouchicha, Chaimae, Ouafae Ammor, and Mohammed Meknassi. "CVDNet: A novel deep learning architecture for detection of coronavirus (Covid-19) from chest x-ray images." Chaos, Solitons & Fractals 140 (2020): 110245.
[8] Cohen, Joseph Paul, et al. "Predicting covid-19 pneumonia severity on chest x-ray with deep learning." Cureus 12.7 (2020).
[9] Hammoudi, Karim, et al. "Deep learning on chest X-ray images to detect and evaluate pneumonia cases at the era of COVID-19." Journal of medical systems 45.7 (2021): 75.
[10] Ibrahim, Abdullahi Umar, et al. "Pneumonia classification using deep learning from chest X-ray images during COVID-19." Cognitive Computation (2021): 1-13.
[11] Ieracitano, Cosimo, et al. "A fuzzy-enhanced deep learning approach for early detection of Covid-19 pneumonia from portable chest X-ray images." Neurocomputing 481 (2022): 202-215.
[12] Khan, A. I., Shah, J. L., & Bhat, M. M. (2020). CoroNet: A deep neural network for detection and diagnosis of COVID-19 from chest x-ray images. Computer methods and programs in biomedicine, 196, 105581.
[13] Ravi, Vinayakumar, et al. "Deep learning-based meta-classifier approach for COVID-19 classification using CT scan and chest X-ray images." Multimedia systems 28.4 (2022): 1401-1415.
[14] Sharifrazi, Danial, et al. "Fusion of convolution neural network, support vector machine and Sobel filter for accurate detection of COVID-19 patients using X-ray images." Biomedical Signal Processing and Control 68 (2021): 102622.
[15] Eljamassi, Duaa F., and Ashraf Yunis Maghari. "COVID-19 detection from chest X-ray scans using machine learning." 2020 International Conference on Promising Electronic Technologies (ICPET). IEEE, 2020.
[16] Hemalatha, Murugan. "A hybrid random forest deep learning classifier empowered edge cloud architecture for COVID-19 and pneumonia detection." Expert Systems with Applications 210 (2022): 118227.
[17] Ahmed, M. A., et al. "Automatic COVID-19 pneumonia diagnosis from x-ray lung image: A Deep Feature and Machine Learning Solution." Journal of Physics: Conference Series. Vol. 1963. No. 1. IOP Publishing, 2021.
[18] Mostafiz, Rafid, et al. "Covid-19 detection in chest X-ray through random forest classifier using a hybridization of deep CNN and DWT optimized features." Journal of King Saud University-Computer and Information Sciences 34.6 (2022): 3226-3235.
[19] Kumar, Rahul, et al. "Accurate prediction of COVID-19 using chest X-ray images through deep feature learning model with SMOTE and machine learning classifiers." MedRxiv (2020): 2020-04.
[20] Gupta, Siddharth, et al. "Automatic Diagnosis of Covid-19 Using Chest X-ray Images Through Deep Learning Models." Machine Vision and Augmented Intelligence—Theory and Applications: Select Proceedings of MAI 2021. Springer Singapore, 2021.