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CNN-based Automated COVID-19 Detection from Chest X-ray Images

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ABSTRACT

The introduction of COVID-19 has negatively impacted both global health and human health. The main tactic to limit the spread of this virus is the early and accurate identification of the viral infection. Real-Time Polymerase Chain Reaction is the most commonly used method for determining Covid-19 (RT-PCR). However, RT-PCR tests take a long time and may produce false results. Therefore, radiology imaging techniques (like X-ray & CT scan pictures) can aid in determining Covid-19 since

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these images provide essential information about the sickness caused by the Covid-19 virus. But, reviewing each report requires a lot of time and multiple radiology experts, which is a challenging task during the pandemic. So, a model that can automatically detect Covid-19 both X-ray and CT scan photographs of the chest is developed using a Convolutional Neural Network (CNN) based encounter. The primary goal of this automated detection is to deliver faster and more accurate results. However, a chest X-ray is used in this paper instead of CT scan. This is due to the fact that most hospitals have X-ray equipment. Even, the X-ray machine is less expensive than a CT scanner. And when compared to CT scans, X-rays expose people to less ionizing radiation. The model is tested against random samples to get the results. Finally, various performance metrics will be used to evaluate the model's performance.

Keywords: Convolutional Neural Network (CNN), radiology imaging techniques, performance metrics.

1. INTRODUCTION

Since December 2019, the World Health Organization has classified the new coronavirus (COVID-19) as a pandemic. This serious health issue has been the focus of media attention. From Wuhan to other regions of China, this new virus spread in just 30 days. The COVID epidemic was first deemed a The World Health Organization declared it a Pandemic on March 11, 2020, after declaring it a Public Health Emergency of International Concern on January 30, 2020. According to the World Health Organization, more than 6.9 million people are diagnosed globally to date, and there have been over 61 lakh confirmed cases of mortality (WHO). Respiratory discomfort, fever, cough, and cold are the major symptoms that indicate a possible infection. In cases of more virulent infections, the virus may potentially result in pneumonia. In addition to pneumonia, the infection can result in septic shock, multi-organ failure, pulmonary syndrome with extreme acuteness, and, eventually, death. Coronavirus 2 which causes severe acute respiratory syndrome is the source of COVID-19 (SARS-CoV-2). As a result, it is categorized as a respiratory disease. The infected person may take up to 14 days to experience all of the symptoms.

The most widely utilized technique for diagnosing COVID-19 is referred to as Reverse Transcription-Polymerase Chain Reaction (RT-PCR). A various kind of technologies are already in place to identify COVID:

Swab Test - Your nose or throat is sampled using a specific swab.

Nasal aspirate: After injecting saline solution into your nose, a small amount of air is gently suctioned out to collect a sample.

Blood test - A blood sample is collected throughout this case from an arm vein.

Finding genetic material from a specific organism, such as a virus, is the test's goal. Due to sample contamination and damage from COVID-19 virus mutations, RT-PCR arrays have a high rate of false alarms. To confirm infection in the patient, RT-PCR kits must be purchased and take 6 to 9 hours to complete. The RT-PCR method has a low sensitivity and frequently produces false-negative results. To solve this problem, COVID-19 is identified and diagnosed using radiological imaging techniques such computed tomography (CT) scans and chest X-rays.

With the global development of new technology, virus tests are becoming faster and faster. A chest scan is used to diagnose COVID-19 infections in order to confirm the patient's lung state, and if the patient has pneumonia on the scans, a COVID-19 infection is assumed to be present. With the use of this technique, authorities can quickly and effectively isolate and treat infected people. It is straightforward to recognise certain COVID-19 radiological signals using chest X-rays. Radiologists must examine these signals for this reason. It takes a lot of time and is prone to mistakes. Therefore, it is necessary to simplify the evaluation of chest X-rays.

Some of the most difficult problems in computer science, such as the real-time processing and comprehension of visual data, are helped by computer vision. One of the effective methods for fixing difficulties in the present is deep learning. In computer vision, deep learning algorithms are used to learn, detect, and categorize the domains of images and videos. Neural networks in computer vision search by dissecting images into pixels that are assigned labels or tags. It performs convolutions and uses labels to make predictions. In order to recognise COVID-19 using X-rays, the basic aspects of deep learning have really been suggested in this research.

Samira Lafraxo et al. proposed CoviNet is a supervised learning method that uses CNN, histogram equalization, and an anisotropic diffusion filter to find the existence of covid-19 in chest X-ray images. Kanaka Prabha et al. used activation functions and ReLU which helps in pixel data is taken from visuals and passed to the following layer. Jenita Manokaran et al. generated by removing DenseNet201's last classification layer. Regarding overall efficiency, sensibility, and specificity, our model was able to surpass competing techniques. In this paper Ezz El-Din hemdan et al. uses 7 various CNN models' architectures are used like as DenseNet, VGG19(Visual Geometry Group) network & second version of google MobileNet. In order to categorise the Covid-19 patient phases, they additionally examine the normalized intensities of the X-ray picture. The publishers proposed five pretrained CNN based models are used in this paper to detect pneumonia and covid19 from the chest X-ray radiography and implemented 3 different binary classification by using five-fold cross validation. In this research paper they use different machine learning algorithms and supports SVM and Random Forest (RF) to in optimization methods, extract the graphical characteristics implementation from chest X-ray images. Asma

Abbas et al. validate, and deep CNN called Detrac used for classification of covid-19 from chest X-ray radiography and attained an accuracy of 93.1. CheXNet algorithm developed by making small changes to diagnosis 14 pathological conditions and chest X-ray images are collected from Kaggle website. In this study, a technique to recognize COVID-19 using supervised learning to assemble medical photographs was suggested. The study's accuracy rate for assessing COVID-19 is 91.67%, which is a promising result. With the help of radiography photographs of the human chest, this study will attempt to identify the condition. Their deep learning approach employs convolutional neural network principles and operates on a freely available dataset. This model produced categorization results with an accuracy of 87%.

This proposed study introduces a convolutional neural network-based method for recognizing COVID-19 through the analysis of patient X-rays and the search for visual cues in COVID-19 patients' chest radiography imaging. Recently, many medical imaging tasks using deep learning, a subset of machine learning in artificial intelligence, were found to be superior to those using traditional AI methodologies (handcrafted methods). It has been applied in numerous issues like segmentation, identification, and classification. With no human feature extraction techniques used, to do this, we recommend a deep learning algorithm built on to a final convolutional neural network (CNN) design.

2. METHODOLOGY

The block diagram of proposed system architecture includes dataset collection, data preprocessing, building the CNN model, traininig and testing the CNN model and finally the trained model's performance is evaluated using some performance metrics.

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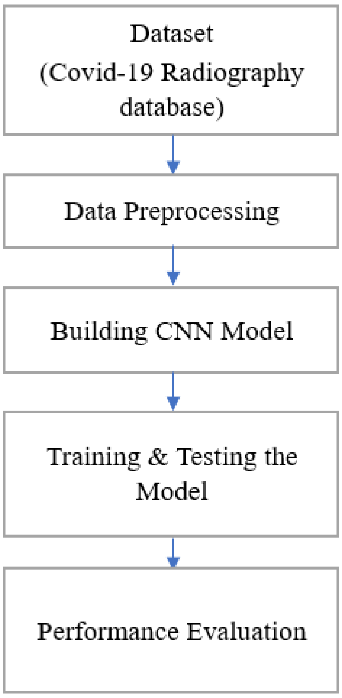

Fig. 1. Block Diagram of the proposed methodology

A. Dataset Description

We have collected the dataset (COVID-19 DATABASE RADIOGRAPHY) from website named Kaggle. The gathered data was awarded as the COVID-19 Dataset Award winner by the Kaggle neighborhood. In cooperation with medical professionals a collection of chest X-ray pictures for COVID-19 positive patients as well as photos of normal and viral pneumonitis has been created by a team of researchers from Qatar University in Doha, Qatar, the University of Dhaka in Bangladesh, and their collaborators from Pakistan and Malaysia. The collected dataset includes X-Ray images of 3616 Normal cases and 3616 COVID-19 positive cases and 1345 Viral Pneumonia cases. All of the images are 299*299 pixels in size and are stored in the Portable Network Graphics (PNG) file format. With the help of chest X-ray A CNN architecture is created to create 3 levels from the visuals. that can be used to distinguish between normal, covid infected, and viral pneumonia-infected lungs. Table 1 displays the dataset details.

Table 1. Dataset Description

Dataset	No. of Images
COVID 19	3616
Normal	3616
Viral Pneumonia	1345

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Fig 2. displays the samples of each of these three types of chest X-ray problems.

Fig. 2. Normal, COVID 19, Viral Peumonia

B. Data Preprocessing

The data set is split into 3 categories: training data (80%), testing data (10%), and validation data (10%). Fig 3. shows the no. of images used for training, validation and testing the model. After splitting the dataset, all the images are resized to 70*70 pixels.

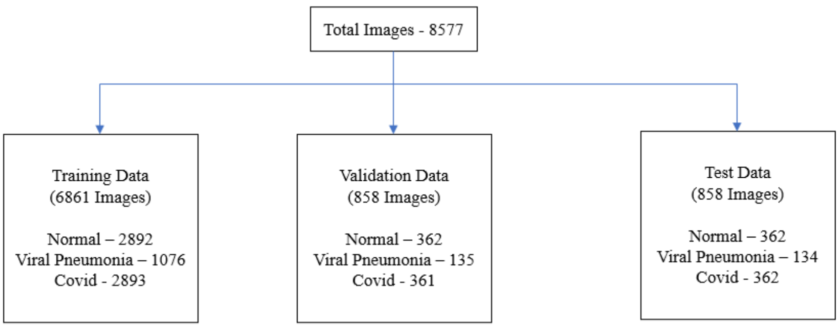

Fig. 3. Dataset Splitting

C. Proposed CNN Model

Convolutional Neural Networks (CNN) are indeed a type of deep neural network primarily utilized for evaluation and image classification in the field of artificial intelligence.

Each image can be broken up into many layers, including the Convolution, Max-Pooling, and Fully Connected layers. ReLu and Softmax, which are utilised in the Convolution layer and Fully Connected layer, respectively, are the two most often used activation functions. The very first step in performing the convolution layer

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functions are to extract the image features and perform filtering operations. ReLu is mostly used to adjust the output of neural networks so that it falls between zero and one. And randomly chosen neurons are discarded during training using the technique dropout layer. The dimensionality of the image is decreased using the Max-Pooling layer. The image's two-dimensional vector is finally flattened to create a single-dimensional vector.

The deep learning architecture is composed of the input neurons, deep learning stages, and output neurons. The three CNN layers used to illustrate the deep learning layers in Fig. 4 are Max-Pooling, Fully connected, and a convolutional layer that appears just after input layer. The 3x3 kernels in the convolution layer will produce 32, 64, and 128 channels in consecutive rounds, as shown in Fig. 4.

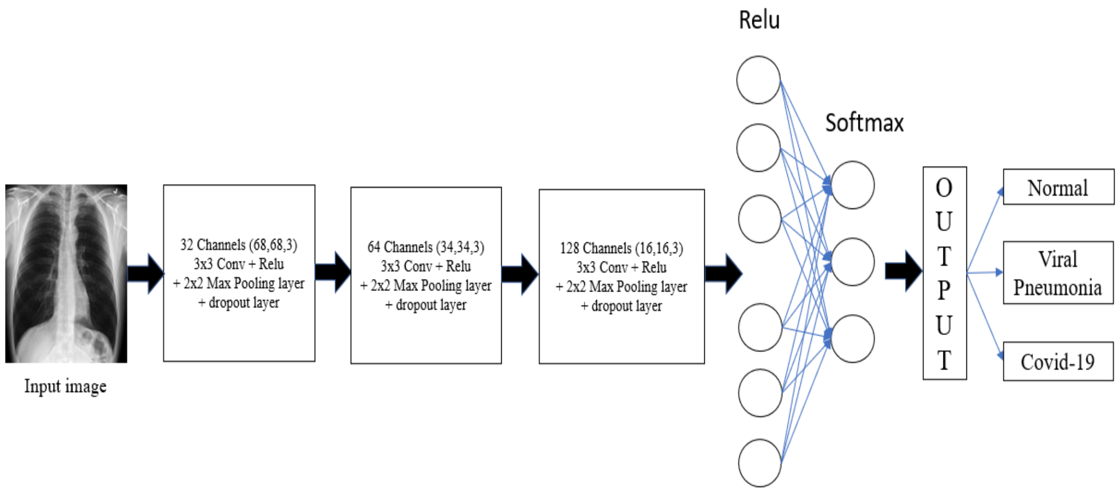

Fig. 4. Proposed CNN Architecture

The first lap is almost never very large. As a result, the photos' small size can be detected much more clearly. The width of the kernel is typically (3,3). The size of the displayed image is estimated as (70,70,3). The remaining layers are drop out layers, Max-Pooling layers with a 2x2 kernel size, and convolution layers. The image will be classified as one of the following 3 classes: Normal, Viral Pneumonia and Covid.

Figure 5 displays the summary of the proposed model in which the output shape of the first 32-filter neural layer with such a 3-by-3-kernel length is (68,68,32).

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```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 68, 68, 32)        896

 max_pooling2d (MaxPooling2D  (None, 34, 34, 32)       0
 )

 dropout (Dropout)           (None, 34, 34, 32)        0

 conv2d_1 (Conv2D)           (None, 32, 32, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 16, 16, 64)       0
 2D)

 dropout_1 (Dropout)         (None, 16, 16, 64)        0

 conv2d_2 (Conv2D)           (None, 14, 14, 128)       73856

 max_pooling2d_2 (MaxPooling  (None, 7, 7, 128)        0
 2D)

 dropout_2 (Dropout)         (None, 7, 7, 128)         0

 flatten (Flatten)           (None, 6272)              0

 dense (Dense)               (None, 64)                401472

 dropout_3 (Dropout)         (None, 64)                0

 dense_1 (Dense)             (None, 3)                 195

=================================================================
Total params: 494,915
Trainable params: 494,915
Non-trainable params: 0
_________________________________________________________________
```

Fig. 5. Summary of proposed CNN model

D. Training and Testing the model

The models are trained and tested using Google Collaboratory, also known as Colab. A training dataset of 6861 images and a validation dataset of 858 images were used to

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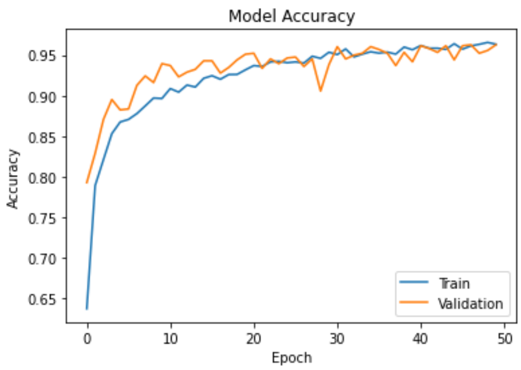
train the suggested CNN model. With a batch size of 16, the model is trained over 50 epochs. The Adam optimizer is employed because its results are typically superior to those of all other optimization algorithms, it computes more quickly, and it needs fewer tuning parameters. A validation data of 858 photos is used to evaluate the system once it has been developed.

3. RESULTS AND DISCUSSION

The experimental findings and a discussion of the effectiveness of our proposed methodology are presented in this section. The model's accuracy and loss graphs are shown in figures 6a. and 6b. respectively. These plots show a little overlap between the training and validation accuracy curves as well as the loss curve. Because of dropout regularisation, the model fits well and overfitting is therefore prevented.



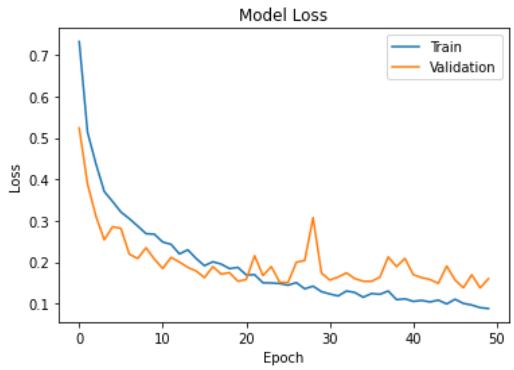


Fig. 6 (a). Model accuracy graph **Fig. 6 (b). Model loss graph**

The performance of the classifer on test data is evaluated using the confusion matrix. It is a tabular form with instances of the represented classes from test data that are real and those that were predicted. The confusion matrix on testing data is shown in Fig. 7. Other characteristics that can be determined using it include F1-score, recall , precision, and classification accuracy. A few terms are necessary to specify in order to calculate these parameters from the confusion matrix, such as

(a) True Positive (TP),

(b) True Negative (TN),

(c) False Negative (FN),

(d) False Positive (FP).

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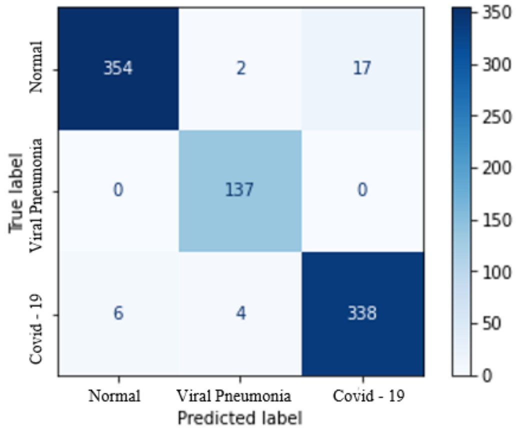

Fig. 7. Confusion Matrix on Testing Dataset

Precision (P) and recall (R) for the three-class classification are determined separately for each class based on one-vs.-rest, and the average of P and R is then used to determine the F1 score. F1 rating is the P and R's weighted harmonic means. The equations for calculating the above mentioned parameters are:

$$Accuracy = (\mathrm{TP} + \mathrm{TN})/(\mathrm{TP} + \mathrm{TN} + \mathrm{FP} + \mathrm{FN})$$

$$Sensitivity = Recall = R = \mathrm{TP}/(\mathrm{TP} + \mathrm{FN})$$

$$Precision = P = \mathrm{TP}/(\mathrm{TP} + \mathrm{FP})$$

$$F1 - Score = F1 = \frac{2 \times P \times R}{P + R}$$

Three class classification results for the calsses Normal, Viral Pneummonia and Covid - 19 are presented in the table 2. And overall training accuracy of 99.46% is obtained on the proposed model.

Table 2. Classification Report for 3 class classification

	precision	recall	f1-score	support
Normal	0.96	0.95	0.96	373
Viral Pneumonia	0.97	0.98	0.97	137
Covid - 19	0.95	0.96	0.96	348
accuracy			0.96	858
macro avg	0.96	0.96	0.96	858
weighted avg	0.96	0.96	0.96	858

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4. CONCLUSION

The planned study used X-Ray pictures to determine lung disease types: normal, COVID19-infected, and pneumonia-infected. The CNN model is employed to distinguish between healthy and infectious individuals, including those with COVID-19 or those infected with pneumonia. The suggested model's accuracy is 96.62%. We can conclude from this outcome that our suggested strategy is highly suitable for COVID-19 CXR image categorization. One of the important conclusions of this article is that data fusion models may additionally improve performance in prediction and diagnosis by utilizing more public sources with Multi classification which our model used. The other is that by employing our models, virologists might more accurately diagnose COVID-19, and radiologists might use them to combat the COVID-19 pandemic by diagnosing critically ill patients in a short amount of time, which could be crucial for their treatment. We think that by using this study as an initial screening, healthcare providers will be able to better diagnose and treat COVID patients. It offers a non-contact automatic testing technology that is both affordable and helpful in lowering the risk of COVID infection among medical professionals.

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