Classification and Localization of COVID-19 based on a Pneumonia Radiograph using a Deep Learning Approach

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ABSTRACT

The world is battling the pandemic corona virus disease (COVID-19) now, and even after 2 years of the COVID-19 pandemic, this technology is still not reasonably advanced to tackle the battle against this virus most efficiently. The total number of COVID-19 cases worldwide surpassed 420 million, with 5.8 million deaths. COVID-19 infects a person with various symptoms, and one of the symptoms is pneumonia. A person suffering from pneumonia may or may not be carrying COVID-19. This research article aims to describe an X-radiation (X-ray) of patients with pneumonia and proposes other subjects who also have the corona virus. This system is based on Deep Learning (DL), and the Convolutional Neural Networks (CNN) method is applied. The work is done with additional help from the frameworks Tensorflow and Keras. Firstly, the images are loaded into the compiler, cleaned, and preprocessed accordingly. The next thing to come up with is setting up the Neural Network (NN) layer. The CNN layer is formed, and a particular Activation Function (AF), Rectified Linear Unit (ReLu), is applied. Finally, the model is trained, and a classification is done to determine whether the patient's X-ray is only for pneumonia or pneumonia + COVID-19. The paper's outcome has an accuracy of 96% to 98%.

CCS CONCEPTS

• **Computing methodologies** → Machine learning; Machine learning algorithms.

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KEYWORDS

COVID-19, CNN, Deep learning, X-Rays, Pneumonia, Accuracy, ReLu

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1 INTRODUCTION

Initially, COVID-19 was declared a pandemic by the World Health Organization (WHO) in 2019. The virus was found in Wuhan, China. The virus was then transmitted to the entire world [1]. The virus is contagious and has infected over 420 million people worldwide. The virus mutates with time, causing symptoms in people. Cough, fever, cold, diarrhea, and loss of smell and taste are the minor symptoms. The significant symptoms are pneumonia and lung lesions. This study focuses on Pneumonia symptoms and establishes a proper classification of Pneumonia patients and Pneumonia patients with Corona Virus presence [2].This work deals with pneumonia X-ray reports and classifies the X-rays into COVID-19 patients and regular pneumonia patients. The applications of Deep Learning (DL) is used to train the images in bulk, and the method of Neural Networks (NN), specifically Convolutional Neural Networks (CNN), is applied. CNN is a DL method mainly used to train and work on datasets containing images [3].

Here, the images are in the form of X-rays. With over 1002 images in the dataset, the model is trained accordingly to classify the X-rays. The dataset contains over 575 COVID-19 sample lungs and 427 pneumonia X-ray images [4]. These images are preprocessed and trained to filter the selected images into COVID-19 and non-COVID patients. This model tends to predict thousands of X-rays in just a

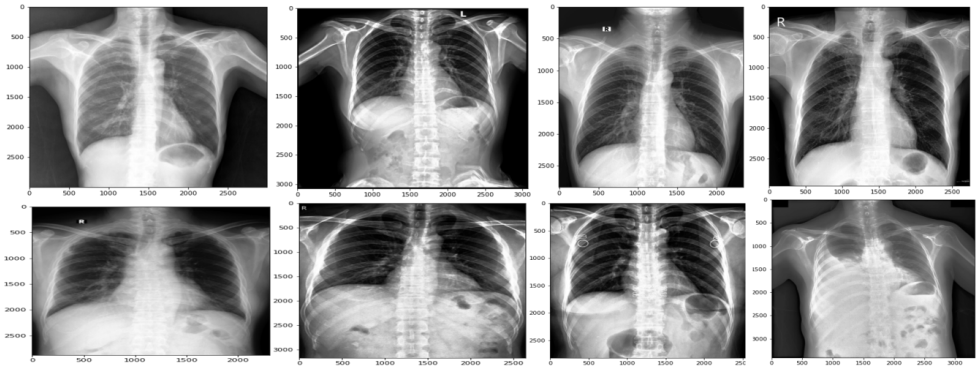


Figure 1: COVID-19 Chest X-Rays [5]

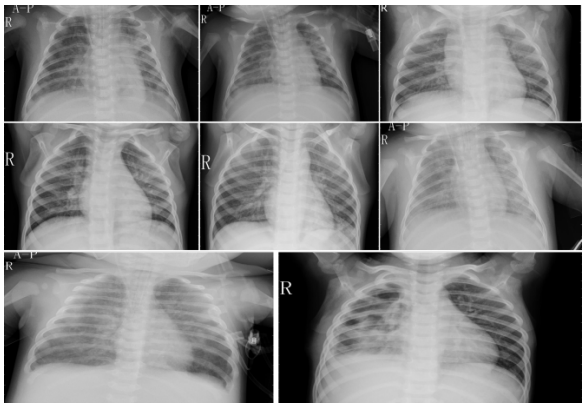


Figure 2: Pneumonia Chest X-Rays [6]

second and helps the doctors and front-line workers save enough time to manually go through the X-rays and filter out the patients (Figure 1).

Figure 2 shows the X-rays for COVID-19-infected lungs with over 575 sample training images [5]. Various inferences are made by looking over the X-rays, which show a cloudy type presence in the lungs, which signifies the prominent presence of COVID-19 in the lungs.

2 LITERATURE SURVEY

2.1 CNN and Deep Learning Basic Inferences

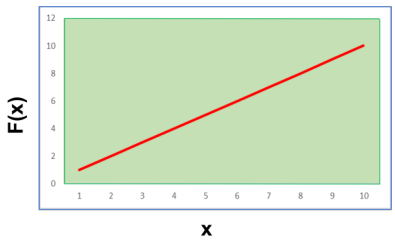


Figure 3: ReLu Function

From a mathematical model, explain how a CNN operates. It has been argued that using vectors and matrices to chain out images is used in the model. The author has also specified the Activation Function (AF) applied to every input element. The rectified linear activation function (ReLu) layer is emphasized below (Figure 3).

2.2 CNN Comprehension

This author explains two main aspects of this work [7] (Figure 4):

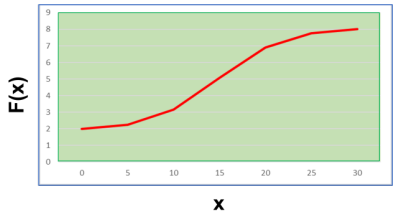


Figure 4: Sigmoid AF

- The significance of a non-linear function at the bottom of a convolutional layer.
- Why is it better to use an II-layer cascade system.

2.3 Object Recognition Evaluation of Pooling Functions in Convolutional Models

It shows how pooling occurs, how images are pixel-wise classified, and how objects are recognized [8]. It shows the architecture of the feature extraction and classification system.

2.4 Data Fusion and Feature Extraction Method for Internet of Things (IoT) Dataset

This research uses data acquisition and fusion techniques to handle Feature Extraction (FE) and classification [9].

2.5 Image Recognition with Deep Residual Learning

The authors explained the layers inside a CNN [10]. It was shown that the models needed several layers inside them to create a well-trained network. Theoretically, it was said that the more effective

the layers, the better the model training would be. This work was proved wrong when a comparison for a particular model was made by creating a 20x56 layer model. The graph showing the error percentage showed that the model with 56 layers showed a significantly higher error percentage than the model with 20 layers. It was creating unnecessary noise through FE and overpopulating it.

2.6 Batch Normalization Reduces Internal Covariate Shift to Accelerate DL Training

The author has shown the importance of batch normalization in training [11]. To reduce computing time, batch trains the images in a more efficient method; here, normalization has shown how it is achieved. Every input distribution changes its state and forms when sent to the next layer, so it carries on. It makes it hard to train models or images with non-linearity. To address this issue, we performed batch normalization on every training batch, and the few images that were difficult to train due to non-linear structure issues were successfully solved. A normalized weight has now been assigned to the model batch.

2.7 CNN with Flattening for Feed-Forward Acceleration

This work describes the importance and the need to convert a two-dimensional (2D) array of computed images into a one-dimensional (1D) array of images [12]. It was shown that the AFs are applied more efficiently, and it also helps remove data redundancy as faster computing time is achieved. This method was tested andit found that the accuracy was not lost; hence, the significance of flattening was justified, which helped in faster computing time. On average, a flattened model provides almost twice the speed of a non-flattened model.

3 PROBLEM STATEMENT

The research aims to train, identify, and classify the X-ray images of pneumonia and COVID-19 patients. COVID-19 patients are in category 1; pneumonia patients are in class 2 [13].

3.1 The Architecture of the Model

Below is a detailed explanation of the proposed model created for this work (Figure 5).

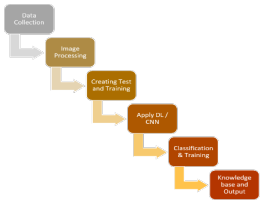


Figure 5: State Diagram

3.1.1 Software Model. The model has considered the basic DL methods for use. TensorFlow. Tensorflow is used to create the CNN, and Keras preprocesses the images accordingly [14]. The backpropagation algorithm is the only algorithm working over the process inside a convolutional network, which is done to adjust the weights when training.

Table 1: Data Set [16]

Dataset	Image Size
COVID-19	575
Pneumonia	427

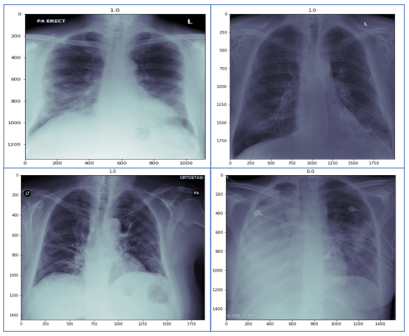


Figure 6: COVID-19 Chest X-Ray

3.1.2 Dataset. A dataset is a key player in any research investigation. An independent author on Kaggle considered the dataset used for the prediction, and the dataset is named "Chest X-ray (COVID-19 and Pneumonia)".

3.1.3 Neural Network Layer. The next step is to set up the convolution layer. And define all the techniques for converting the resultant image into a 2D image array that is input by the machine. It also defines convolution methods like max-pooling and flattening [15]. Finally, the model is fed as a 1D array, followed by a traditional NN with hidden layers to adjust weights and train the model.

3.2 Dataset

The test images from the dataset depict a COVID-19 chest X-ray (Figure 6). The image sources from the dataset depict a pneumonia chest X-ray (Figure 7).

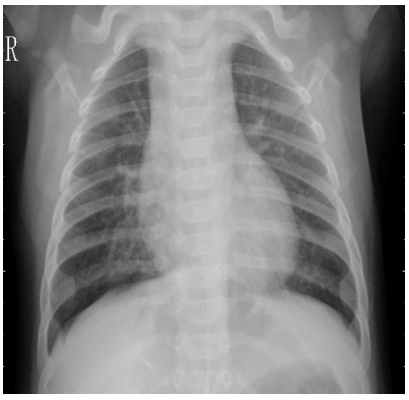


Figure 7: Pneumonia Chest X-Ray

Table 2: Linear and Non-Linear AF

Epoch	Loss	Accuracy (%)
1	0.2297	93.55
2	0.0971	96.70
3	0.0786	97.71
4	0.0670	97.99
5	0.0622	97.96
6	0.0626	98.07
7	0.0568	97.99
8	0.0543	98.19
9	0.0554	97.91
10	0.0644	98.04

Table 3: Linear and Linear AF

Epoch	Loss	Accuracy (%)
1	1.7934	88.14
2	1.8088	88.14
3	1.8088	88.14
4	1.8088	88.14
5	1.8088	88.14
6	1.8088	88.14
7	1.8088	88.14
8	1.8088	88.14
9	1.8088	88.14
10	1.8088	88.14

Table 4: Non-Linear and Non-Linear AF

Epoch	Loss	Accuracy (%)
1	13.5953	11.86
2	13.5953	11.86
3	13.5953	11.86
4	13.5953	11.86
5	13.5953	11.86
6	13.5953	11.86
7	13.5953	11.86
8	13.5953	11.86
9	13.5953	11.86
10	13.5953	11.86

3.2.1 Preprocessing. This paper applied the Keras module from the official website (Figure 8) to preprocessing.

The convolutional layer is shown above in the state diagram.

- Case I: The input image is fed into the network through which the FS is made through detection techniques. The highlighted features are made into a feature map.
- Case II: The feature map is created into several convolutional layers, and an AF is applied to them (ReLu).
- Case III: After the convolutional layer, pooling is done.
- Case IV: To turn the data into a 1-D array, it is fetched in the next layer as "flattening."

4 RESULTS AND DISCUSSION

The DL model used Tensorflow to create the convolutional layer, and Keras was used to preprocess the images. It is followed by training the model. Table 2 shows the AF functions used in the model: the ReLu and Sigmoid functions.

Step 1. Optimizing → Adam
Step 2. Loss → Binary Cross Entropy
Step 3. Metrics → Accuracy
Step 4. Epochs →10

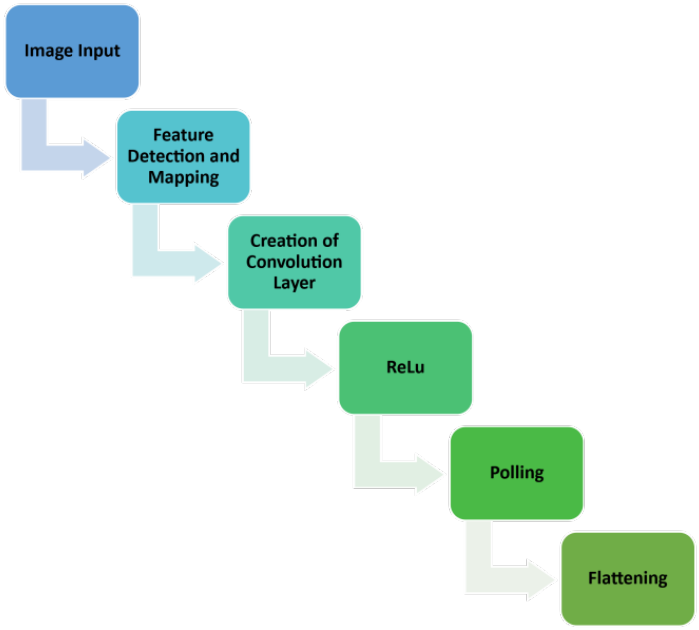


Figure 8: Directed Flow of System

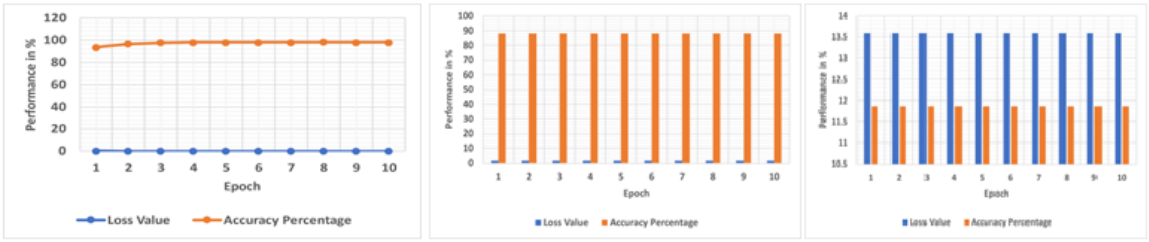


Figure 9: Performance analysis of AF (a) Linear vs. Non-Linear (Left Panel) (b) Linear vs. Linear (Middle Panel) (c) Non-Linear vs. Non-Linear

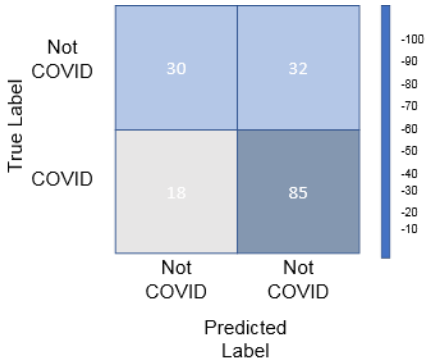


Figure 10: Confusion matrix of pneumonia

The model proved an accuracy of 98.04% when running it on 10 epochs. The following tables are for the system with a linear and non-linear AF and a linear and linear AF (Tables 3 and 4).

From the above table, to refer to the move along the epoch cycle, this model is better trained, and the loss metrics keep decreasing, whereas the accuracy keeps improving. The loss and accuracy show similar data points after every epoch, indicating that the model is trained at its best and that any additional epochs increase the computation time and memory usage. It was noted that this work had linear and non-linear trends. The runtime is around 25 minutes. The classification is based on comparing the input image with trained COVID-19 X-ray features (Figure 8). If the image contains COVID-19 X-ray features, it returns the statement that the patient has COVID-19; otherwise, it returns the statement that the patient only has a Pneumonia confusion matrix (Figure 9).

5 CONCLUSION

This proposed model aims to structure a model that divides patients into COVID-19-infected pneumonia patients and pneumonia-only infected patients. COVID-19 Pneumonia is a severe symptom that has infected many people worldwide in the current scenario. The

model is well-trained and has more than 98% accuracy when tested. Classification is performed at the end, in which the image is looked at, and the DL and CNN layer notes its inference points. The computing time for training is improved with better Graphics Processing Unit (GPU) performance, which depends on the user's system.

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