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Enhanced Deep Learning Based X-Ray Analysis for COVID-19 Identification

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Abstract: The rapid and accurate detection of COVID-19 is critical for mitigating its transmission and ensuring timely medical intervention. This research enhances COVID-19 detection by implementing the Artificial Neural Networks Algorithms. Our research paper embeds the concept of a Convolutional Neural Network for efficient and accurate detection of COVID-19 by taking x-rayed images of the lungs of patients as input. The proposed model development involves systematic steps, including data acquisition, preprocessing, and augmentation, as well as the application of a convolutional neural network to the prepared data. The dataset utilized for this research paper on COVID-19 detection using Artificial Neural Network (ANN) is obtained from the source of the website Kaggle. The dataset consists of three classes: normal, viral, and COVID-19 affected. The visual data of these three classes is utilized to train and test the model. PCR testing is the most used technique for COVID-19 detection, but this technique is pricey for people who belong to middle- or lower-class families, so our research paper overcomes this financial barrier by using X-ray images of the patient to detect whether the patient is infected with COVID-19 or not. Accurate identification of COVID-19 cases is vital for controlling its transmission. Minimizing false negatives ensures timely care for infected individuals, reducing spread. Our proposed model achieves an accuracy of 95% by using multiple layer Convolutional Neural Network.

Keywords: CNN; COVID-19; Artificial Neural Network; Tensor Flow; Keras; Artificial Intelligence

1. Introduction

This research paper on COVID-19 detection is a superlative intersection of AI and health care. The research paper implements the concepts of neural networks. Neural networks are the networks inspired by the Human Brain in terms of functioning. This research paper utilizes the concept of neural networks to analyze the data and then make accurate predictions of COVID-19 .

The COVID-19 detection research paper contributes to health by efficient and reasonable model of COVID-19 detection with the help of X-ray images, which helps further in addressing critical challenges in the health care field. Nowadays, healthcare is a big challenge faced by every country in various ways, and it's very crucial to take appropriate steps regarding thehealthcare sector to improve the overall health conditions of any country. Our research paper aims to contribute to thehealthcare sector by providing a research paper or tool that can help detect COVID-19 easily and efficiently. Our research paper aims to provide a tool that is cost-effective as well. Nowadays, it's very difficult for every individual to afford goodhealthcare treatment, so our research paper promises to provide an easy and cost-effective method. It allows individuals to detect whether they are infected with COVID-19 and tells them if there is any other virus in their lungs by taking x-ray images of their lungs.

This research paper aims at the early detection of COVID-19 with reliable predictions of the presence of disease with high accuracy. Neural Networks are based on deep learning models involving continuous learning, resulting in high accuracy and prediction.

Hussain et al, [1] proposed a CNN model called CoroDet for the automatic selection of COVID-19 using Chest X-ray and CT-Scan images. CoroDet is developed to serve to deal with 2 classes (accuracy 99%), 3 classes (accuracy 94%) and 4 class classifications (accuracy 91%). Recently, a model called C-CovidNet has been developed, a lightweight, CNN-based model that can compete with a heavy transfer learning-based approach [2]. Alazab, M. [3] [4] utilized 1000 images dataset for COVID-19 detection and implemented ANN and achieved an accuracy of 94.80%. He utilized LSTM to predict the number of COVID-19 detections recoveries in the next 7 upcoming days. He also made predictions by relating a patient's age and chances of that person being affected by COVID-19 . Mohammed Qasim et al. [5] have done work on real-time COVID-19 detection. This study utilized the deep learning optimization system that can work with imbalanced datasets, and he applied various techniques to balance and further process them. He implemented a recursive feature elimination algorithm to extract features in his studies and achieved an accuracy of 94.98 %. Walter, J. R., et al. [6] uses artificial intelligence for the cough detection and early detection of COVID-19 . He utilized different sensors for the purpose of detection of COVID-19 . His study highlights the potential value of wearable devices in early disease detection and monitoring. The final performance of the algorithm achieved an F-1 score of 83.3%. Kuvvetli, Y. et al. [7] have made a predictive analytical model for COVID-19 by using ANN. This model deals with the future number of daily patients and deaths with COVID-19 . He achieved an accuracy of 91%. Saha et al. [8] utilized CT scans and CXRs for the detection of COVID-19 . They used GIN based model to detect COVID-19 from CT scans in their working. Shoeibi, A. et al. [9] have worked on COVID-19 detection using real-time reverse transcription–polymerase chain reaction (RT-PCR) tests with a turnaround time of 2–3 days. Zhao, W., W. Jiang, and X. Qiu [10] their study analyzed the pre-trained models of COVID-19 detection using CT images and concluded that training the model on the large number of datasets can tremendously enhance the performance of the model, and their study applies this analysis them. They enhanced the pre-trained models by enhancing the datasets utilized, and they achieved an accuracy of 93%. Hariri et al. [11] have utilized the images and acoustic based techniques for the detection of COVID-19 . In their work they applied the technique of transfer learning and also utilized auto encoder-based models for the detection of COVID-19 , and they achieved an accuracy of 92%.

ANN is an efficient approach for COVID-19 detection, but there is a notable gap in developing ANN models that are precise, highly accurate and generalized as well. Existing research lacks the standardized methodologies for model development and validation, which faces many problems, including biases and disparities.Healthcare areas are very sensitive because they can cost anybody's life. So, the models that should be built or designed for healthcare areas should be highly efficient and precise and work with the highest accuracy as much as possible, but there is an issue, which is that understanding how the ANN works is sometimes difficult, which makes it challenging to use it inhealthcare areas where the cases are sensitive and can cost patients life if a wrong prediction is made by the model, therefore, to overcome this problem we must create large amount of data to train models and get the accurate and precise predictions using ANN.

PCR testing is the most used technique used for COVID-19 detection, but this technique is pricey for people who belong to middle- or lower-class families, our research paper overcomes this financial barrier by using X-ray images of the patient to detect whether patient is infected with COVID-19 or not.

This research will employ the CNN which is a type of ANN for COVID-19 detection. CNN consists of single or multiple convolutional and pooling layers to first analyze and then detect the useful features from the visual data and then conclude efficient results from them. Our research paper aims to enhance the sensitivity and specificity for our detection model, ultimately contributing to more reliable and efficient COVID-19 detection. The CNN model also possesses the capability to learn relevant features from the images, making it the right choice for our problem of COVID-19 detection. Further details regarding the number of convolutional and pooling layers used in our model, as well as the sizes of kernels, are elaborated below in the Model Architecture section of this document.

Accurate identification of COVID-19 cases is vital for controlling its transmission. Minimizing false negatives ensures timely care for infected individuals, reducing spread. However, high false positives can lead to unnecessary quarantines, straininghealthcare systems. Balancing false negatives and positives is crucial for effective disease control and resource management.

The dataset under scrutiny consists of three main classes, namely 'Normal', 'Virus', and 'COVID-19 affected'. The visual data of images in train folder of the dataset is used for the training of the Neural Network, while the data in the test folder is for testing out a model and how well it performs.

2. Literature Review

The research paper on COVID-19 detection is a superlative intersection of Artificial Intelligence and health care. The research paper implements the concepts of neural networks. Neural networks are the networks inspired by the Human Brain in terms of functioning. The research paper utilizes the concept of neural networks to analyze the data and then make accurate predictions of COVID-19 . The COVID-19 detection research paper sights to contribute to the Healthcareby contributing an efficient and reasonable model of COVID-19 detection with the help of X-ray images, which helps further in addressing critical challenges in the health care field. Our research paper utilizes X-ray images of the patient to detect whether the patient is infected with COVID-19 or not. Accurate identification of COVID-19 cases is vital for controlling its transmission. Minimizing false negatives ensures timely care for infected individuals, reducing spread [12] have applied a feed forward neural network for lung cancer detection and achieved an accuracy of almost 94%. Lung cancer is a death-causing disease, and his model is very beneficial in way that it helps in the early detection of such a death-causing disease, which is rewarding for the healthcare industry from various perspectives.[13] U. Rajendra Acharya et al. (2002) have used the 3-layered feed forward neural network for cardiac monitoring. Their model is used for the classification of heart rate based on ECG sampling. They achieved the accuracy in between 85-95%. [7] Kuvvetli Y. et al. have made a predictive analytical model for the pandemic of COVID-19 by using ANN. His model predicts future number of daily patients and deaths with COVID-19 . He achieved an accuracy of 91% in his work by applying the model of ANN. [8] Saha, P., et al. They utilized CT scans and CXRs for the detection of COVID-19 . They used GIN GIN-based model to detect COVID-19 from CT scans in their workings. [14] Muhammad Azeem et al. (2023): They have used the Convolutional Neural Network for the purpose of the COVID-19 detection. Their model uses the multi-layer convolutional Neural Network and has achieved an accuracy of 93%. Further their model can be improved by using more complex datasets and by using additional layers of CNN to enhance the efficiency and accuracy.[15] D. K. Ravish et al. (2014): They worked on monitoring, predicting, and preventing heart attacks. They utilized the back propagation Neural Network alongside the ECG heartbeat categorization. Their study is beneficial for healthcareare industry to monitor, predict and prevent such a life-threatening disease with the help of their model, which has an accuracy of almost 95%.[10] Zhao, W., W. Jiang, and X. Qiu their study analyzed the pre-trained models of COVID-19 detection using CT images, and they concluded that training the model on a large number of datasets can tremendously enhance the performance of the model, and their study applies this analysis of them. They enhanced the pre-trained models by enhancing the datasets utilized, and they achieved an accuracy of 93 %. [4] Alazab, M. utilized a 1000-image dataset for COVID-19 detection and implemented ANN and achieved accuracy of 94.80% in his work. He utilized LSTM to predict the number of COVID-19 detections, recoveries in next 7 upcoming days. He also made predictions by relating the age of a patient and chances of that person being affected with COVID-19 in his studies.

[16] Nasreen Sameer et al. (2018) designed a model with an Artificial Neural Network to predict diabetes. Their model works in a way that predicts whether a patient is diabetic or not. They have made a binary classification model with an accuracy of 87.3%. His work has had a very good impact on the healthcare industry as nowadays it's becoming a common disease and needs to be detected early, easily and efficiently. [11] Hariri, W. and A. Narin have utilized the images and acoustic based techniques for the detection of COVID-19 . In their work, they applied the technique of transfer learning and also utilized auto encoder-based models for COVID-19 detection, and they achieved an accuracy of 92%.

[17] Dipali M. Joshi et al. (2010) used Artificial Neural Networks for brain cancer classification. She utilizes the neuro-fuzzy classifier for the detection of tumors. In addition to overcoming the problems that usually arise from the quality and quantity of dataset,s her model serves as a foundational step in utilizing advanced technologies for the detection of brain cancer. [9] Shoeibi, A. et al. have worked on COVID-19 detection using real-time reverse transcription–polymerase chain reaction (RT-PCR) tests with a turnaround time of 2–3 days. [18] Rahila Parveen et al. (2017): has utilized the Artificial Neural Netwok for the detection of malaria. She achieved accuracy of 85% which showcase that either the dataset utilized is

not sufficient for training the data or either the training of the model is not done properly which results in low accuracy. %. [6] Walter, J.R., et al. uses the artificial intelligence for detecting Covid 19 in early stages. He utilized different sensors for the purpose of detection of cough and COVID-19 in his studies. They achieved an F-1 score of 83.3%. [19] Behrouz Alizadeh et al. (2015): worked on asthma diagnosis using Artificial Neural Networks. He utilizes the concept of back propagation in his research paper for asthma diagnosis and achieved an accuracy of 91.5%. His model facilitates the early and accurate diagnosis of asthma, which nowadays as well is a common disease.[20] Victor Gotliv et al. (2013): has done the diagnosis of thalassemia minor. He applied Feed Forward NN in his model for diagnosis thalassemia. Their study offers new insight into the disease mechanism as well. Their study is helpful for the healthcareindustry for the early detection of thalassemia as well.

Table 1. Literature Review.

Authors	Problem	Dataset	Technique	Accuracy	Limitations
Ibrahim M. et. al, (2019)	Lungs Cancer Detection	Lungs Cancer Detection	Feedforward Neural Network	94.67%	-
U. Rajendra et. al, (2002)	Classification of Heart Rate	Sampling Frequency of ECG	3-Layered Feedforward Neural Network	85-95%	-
Muhammad Azeem et. al, (2023)	Detection of COVID-19	COVID-19	Convolutional Neural Network	93.73%	Complexity and Deficient training data
D. K. Ravish, et. al, (2014)	Monitoring, Prediction and Prevention of Heart Attack	ECG Heartbeat Categorization	Feature selection Back Propagation Neural Network	95%	Cardiologist suggestion more clinical trials tread test (TET)
Nasreen Sameer, et. al, (2018)	Diabetes prediction using ANN	Association of Diabetic city of Urmia	Just Neural Network (JNN) Environment	87.3%	-
Dipali M. Joshi et. al, (2010)	Classification of Brain cancer using ANN	Brain Tumor Detection	Feature Extraction Neuro Fuzzy Classifier	75%	Low quantity dataset Limited detection
Angona Biswa et. al, (2021)	Brain Tumor Types Classification	MRI Brain Tumor Dataset	K-mean clustering Feedforward Neural Network	95.4%	
Rahila Parveen et. al, (2017)	Prediction of Malaria using ANN	Self-collected Data	Feedforward Neural Network	85%	Low training testing data
Behrouz Alizadeh, et. al, (2015)	Diagnosis of Asthma using ANN	Clinical dataset	Back Propagation Neural Network	91.5%	
Victor Gotliv et. al, (2013)	Diagnostic of Thalassemia Minor by ANN	Self-Collected Data	Feedforward Neural Network	93.7%	

3. Materials and Methods

COVID-19 detection model includes a systematic approach. It consists of a series of various steps which includes data acquisition, data preprocessing, training, testing, evaluation, and output. Dataset obtained from KAGGLE which is an open source webiste consist of multiple datasets. The dataset obtained consists of three classes folders namely 'Normal', 'Viral' and 'COVID-19 affected'. After the accession of the data,

data is preprocessed by using different techniques to make it ready for use. The preprocessed data is then fed into the Convolutional Neural Network Model, which is consist of multiple convolutional and pooling layers to extract important features by analyzing the X-ray images to make efficient identification of COVID-19 and then these layers are followed by the flattening of data and then full connected network is created and results are passed to the output layer and then the CNN model is compiled and evaluation is done to validate models performance.

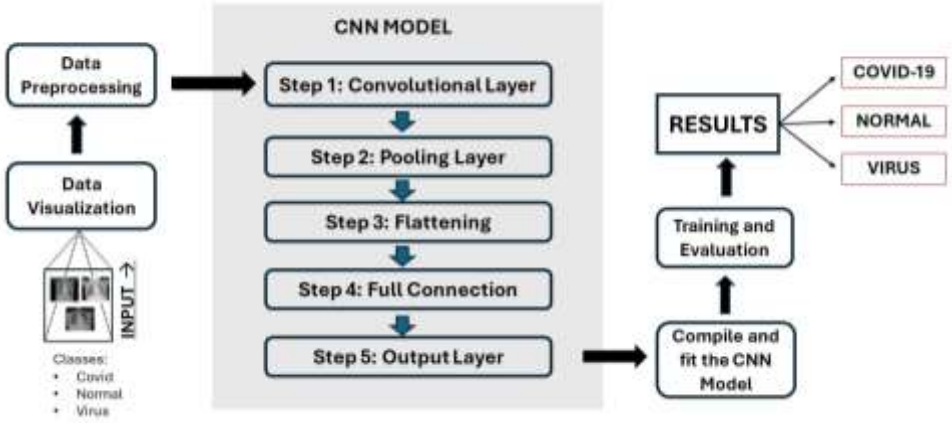

Figure 1. Flow Diagram of Methodology.

3.1. Dataset

The dataset utilized for this research paper of COVID-19 detection using Artificial Neural Network (ANN) is obtained from the source of website of Kaggle. The dataset is consisting of three classes:

- Normal.
- Viral.
- COVID-19 affected patients.

Covid Normal Virus

Figure 2. Covide_Normal_Virus

In total the dataset consists of approximately 1500 images divided into the three classes mentioned above. These three classes are used for the training and testing of our CNN model. Normal class consists of the normal healthy images of chests while viral class consists of images of chests effected with different viruses and class name COVID-19 affected patients contains images of chests affected with disease of COVID-19 . All these three classes are combinedly used for the purpose of training and testing of our model.

3.2. Data Preprocessing

Data preprocessing is a crucial step in machine learning and deep learning tasks. It involves various types of techniques to transform the data into a suitable format for further processing. Our model of COVID-19 detection uses the 'Rescaling' technique of data preprocessing. In this technique every pixel is divided by the maximum pixel value to scale down all pixel values to the range [0,1]. In addition to this during preprocessing stage the data is split into training and testing for the purpose of first training the model by using train data and then testing the model with the rest of the data in test. The color mode is set to 'rgb', so the images are read in RGB format.

3.3. Data Augmentation

Data augmentation incorporates various procedures or techniques to grow dataset by making varieties of existing information to upgrade performance of model. Our model of COVID-19 detection uses various data augmentation techniques including shear range, zoom range, horizontal flip, flow from directory. Shearing distorts the image along a specified axis. Our model uses a range of 0.2 which means images are sheered by maximum angle of 0.2. Horizontal flip is used to flip the images horizontally and add those flipped images to the dataset results in growing the size of dataset. Zoom range is used to zoom in or out the images, our model uses zoom range of 0.2 which means images are zoomed in or out by a factor of 20%.

3.4. Deep Learning Model

Selecting the appropriate model is a very essential part in problem solving. While choosing between different models to use for solving a particular problem make sure to take into consideration very precisely what the actual problem is and what are the expected outcomes. Furthermore, before finalizing the model, it's also very essential to evaluate performance by examining the F1 score, accuracy, Precision and recall of the model output for the desired problem. The problem we are solving is the COVID-19 detection and we aim to classify images as normal and COVID-19 affected, making it a binary classification task.

We aim at classifying the inputs as positive or negative (positive states that the input image is an image of a healthy lungs while negative states that the input image of chest or lungs is affected with the virus COVID-19).

The model which we selected considering our problem and the outputs we expect is Convolutional Neural Network (CNN).

CNN consists of multiple layers that are pooling layers and Convolutional Layer. Convolutional layer include different kernels that are used to capture features. Kernel slides over the whole image to detect features. Multiple kernels are used to detect multiple features which then lead to the formation of feature maps.

Proceeding to the convolutional layer there is an activation layer that consist of activation function. This layer is used to learn complex patterns and features. The most common activation function used in CNN is Rectified Linear Unit (ReLu) activation function.

Moving forward there are pooling layers which are used to extract only useful features. It reduces the spatial dimension of feature maps which results in improving efficiency and accuracy as well.

The CNN model contains fully connected layer after convolutional and pooling layers. In a fully connected layer, each neuron is connected to every neuron in the previous layer. The output generated by the fully connected layer is fed to the softmax function which then performs further classification. CNN model contains the flattening layer which is used to convert the 3-D feature maps to 1-D which after conversion can be fed into the fully connected layer.

3.5. Model Architecture

The model we utilized in our research paper of COVID-19 detection is Convolutional Neural Network (CNN) which uses the x-ray images as input and then predict weather the input image of lungs is affected with COVID-19 , or the lungs are affected with any other virus, or the input image of lungs are healthy.

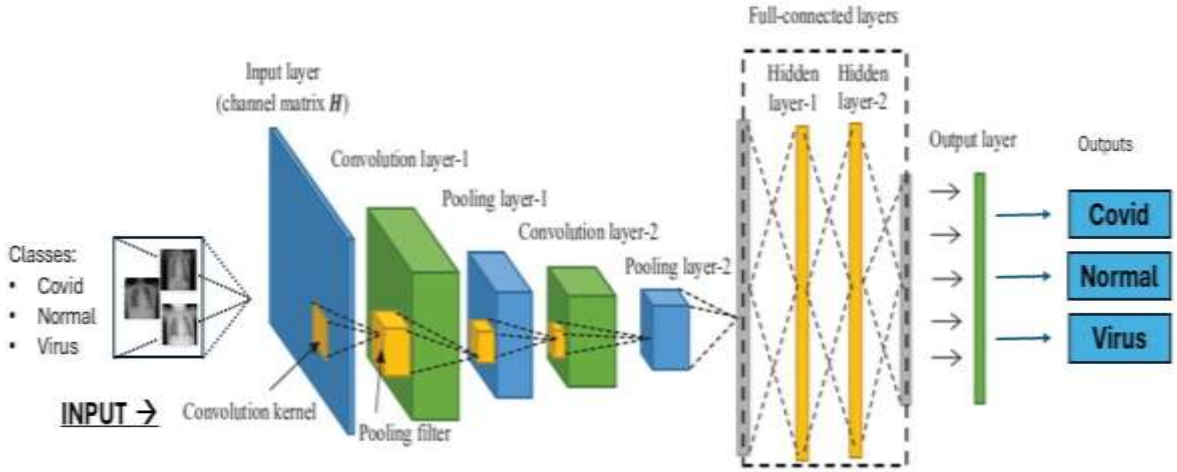

Figure 3. Model Architecture.

Our model processes in such a way that firstly the dataset is loaded, and necessary libraries are imported which will be used further in the model. Then the data is preprocessed to make it ready for use and then it's fed into the CNN.,

Our Convolutional Network consists of 4 layers and each layer contains two layers that are 'Convolutional Layer' to extract features and 'Pooling layer' to spatial down the dimensions of the features maps. Below are the details of these four layers:

In the initial layer the image is given as input for the processing. The kernel which is used in convolutional layer is of size (3,3) to extract features, and the activation function which is used by the convolutional layer is ReLu activation function. Afterwards the convolutional layer there is a max pooling layer in which pooling is done and pool size used for this purpose is (2,2).

Moving towards the second layer, it consists of the convolutional layer which has the kernel of size (3,3) to learn features and then convolutional layer is followed by the max pooling layer which has the pool size of (2,2) and the activation function for this layer was also ReLu like the initial layer.

The third layer also contains the convolutional and pooling layers like the previous two layers and the kernel size and pool size utilized in this layer are also (3,3) and (2,2) with an activation function of ReLu.

Just like the previous three layers the fourth layer performs the same functionality with the same activation function and kernel and pool size as utilized in previously three addressed layers.

Using multiple layers has many advantages like learning the complex features or generalizing well to the new examples or many more.

After the model is trained by using CNN then the model is visualized and examined with the help of confusion matrix, accuracy measures and classification report and in many other ways.

4. Results

Our model achieved accuracy of 95% in detection of COVID-19 with the help of X-ray images by embedding the concepts of convolutional neural network which is a type of Artificial Neural Network. The model underwent excessive training and testing using the dataset obtained from Kaggle.

During the training phase the model showed an excessive accuracy of 95% by learning complex features and patterns from the visual data given to it as input and learning complex features and patterns. As model implements the concept of Convolutional Nural Network so it holds the potential of generalizability as well which makes it more efficient.

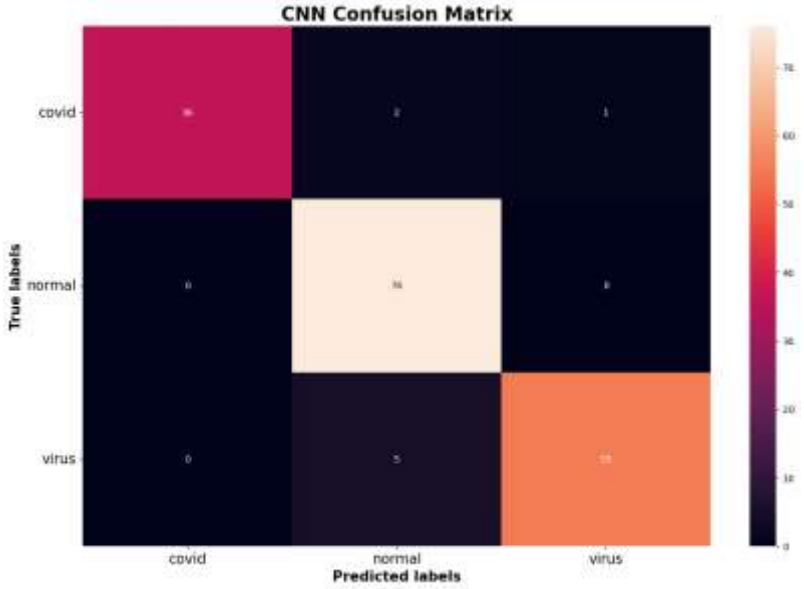

Figure 4. Confusion Matrix of Proposed Model

The confusion metrics of our model show that instances of covid class are predicted correctly by our model.

Table 2. Precision, Recall, F1-Score of Proposed Model.

Class Label	Precision	Recall	F1-Score

Covid	1.00	0.92	0.96
Normal	0.92	1.00	0.96
Virus	0.98	0.92	0.95

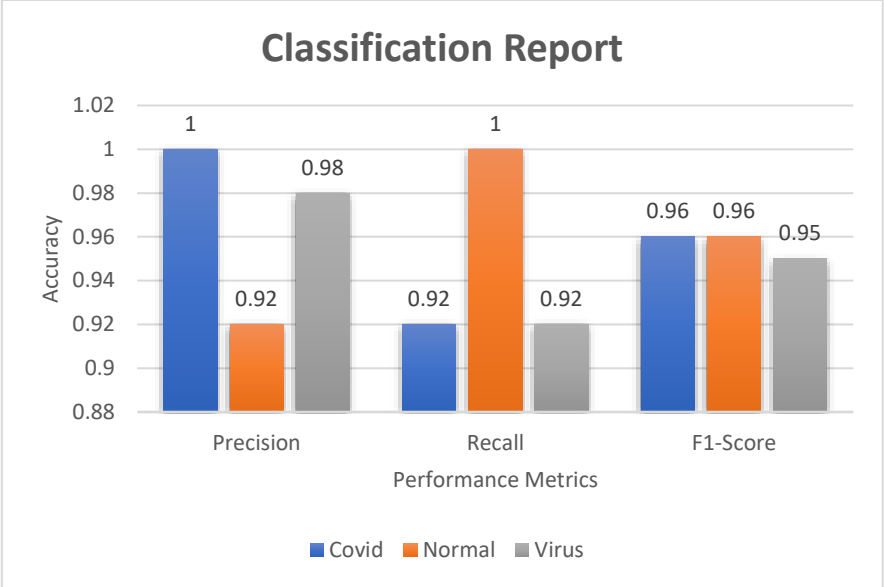

Figure 5. Classification Report of Proposed Model.

Classification report summarized the overall performance of the model. It contains information regarding precision, recall, F1-Score. Our model gives an overall 95% testing accuracy. By using the information generated by the confusion metrics different calculations can be performed to get various values including values of F1 Score, Precision, Recall etc.

The above results show the overall performance of our model. Accuracy tells how well the model performs and how often it makes right predictions. The accuracy of our model tells how often it predicts right weather the lungs image given as input are affected with COVID-19 or not. Precision tells us about that in all positive predictions how much the model has predicted positive right. Recall tells that in all correct items how much model predicted right. It tells how much model is good at doing what it is supposed to do. F1 score is the harmonic means of precision and recall. It combines precision and recall into a single number. Calculating all these values helps to have a comprehensive look at the overall performance of a model. These factors won't only help at looking at the overall model's performance but in addition these factors can help to detect where the model is lacking and where it's performing good.

Furthermore, the testing accuracy of our model matches close to the training accuracy which states that the model has done learning efficiently and can generalize very efficiently and gives precise and accurate outputs.

Table 3. Comparison with other Models.

References	Model Used	Accuracy
Rajavat et al. [2]	Back-Propagation Neural Network	92%
Kuvvetli et al. [7]	Feed Forward Neural Network	91%
Zhao et al. [10]	CNN	93%
Hariri et al. [11]	Transfer Learning and Auto Encoder	92%
Proposed Model	CNN	95%

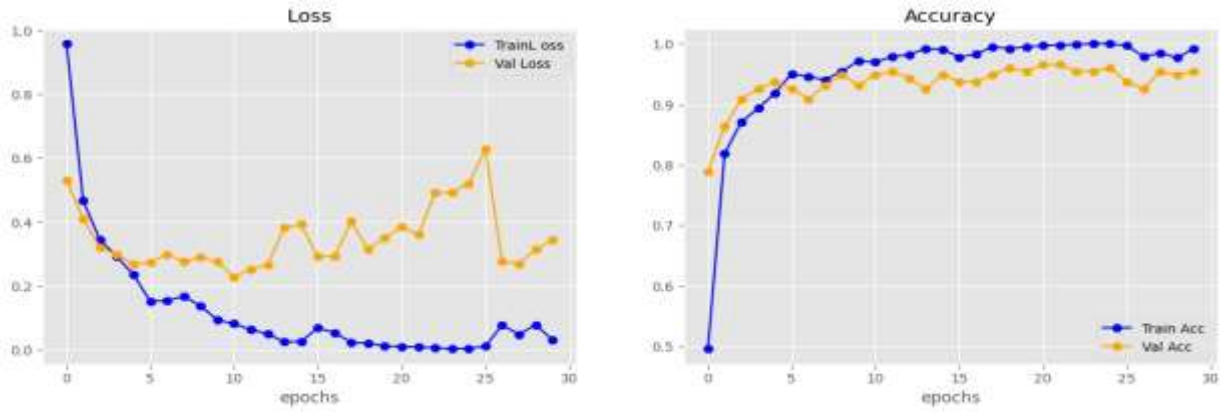

Figure 6. Accuracy and Loss Graph.

Given below is the comparison of our model with the working of others in terms of accuracies.

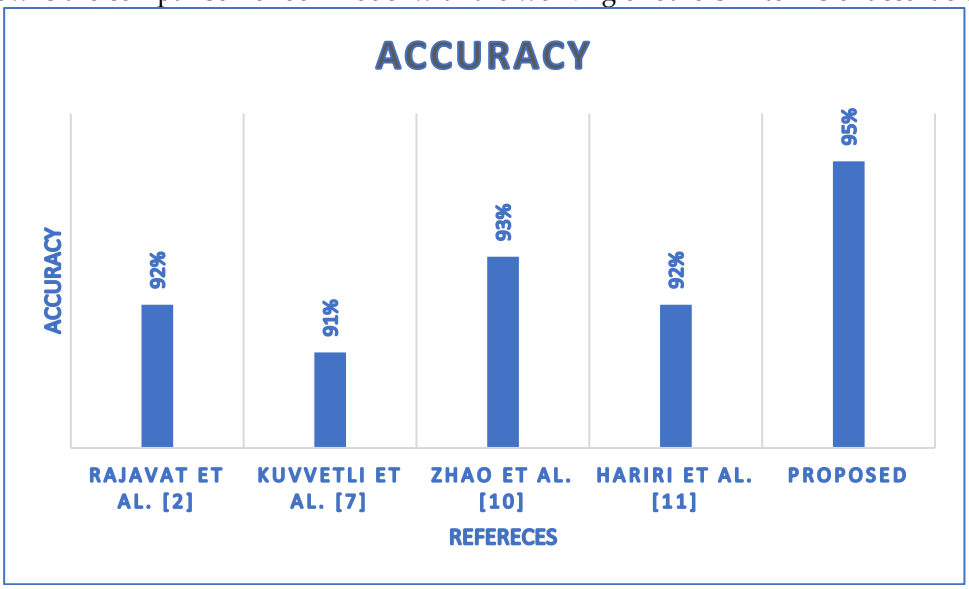

Figure 7. Comparison of Existing Model with Proposed Model.

Rajavat et al. [2], Kuvvetli et al. [7], Zhao et al. [10] and Hariri et al. [11]. Achieved accuracies of 92%, 91%, 93% and 92% respectively. Most of the used double layer architecture of CNN, while our model stood out with accuracy of 95% by adding additional convolutional and pooling layers which improved the accuracy and makes the model more accurate for the COVID-19 detection. Furthermore, the research paperwork can be enhanced by incorporating additional data along with X-ray images. Additional data can include patient symptoms, blood tests and various other elements that can help in the detection of COVID-19. By incorporating the additional data, it will help to make more accurate predictions of COVID-19. The factors which limit our model are complexity and data quality. Understanding how ANN works and makes predictions is a difficult task. Incorrect prediction by the model can lead to many consequences like wrong treatment, it can endanger patients' life etc. Secondly data quality is also one of the limitations of our resrach paper, the precise detection of COVID-19 depends on the quality of input image as well. Poor quality input image may lead to the wrong prediction.

5. Conclusions and Future Work

The ANN research paper on COVID-19 detection demonstrates the application of Artificial Intelligenhealthcarehcare. With the help of advanced methods, the research paper exhibited markable accuracy by introducing additional convolutional and pooling layers. The research paper tends to help hehealthcare detect COVID-19-affected patients very efficiently in a cost-effective way. Utilizing technology in this manner allows the hhealthcareo analyze the patients efficiently by using their X-ray images to predict the possibility of being affected by COVID-19 or not. Accurate identification of COVID-19 cases is vital for controlling its transmission. Minimizing false negatives ensures timely care for infected

individuals, reducing spread. Our research paper achieves an accuracy of 95% by using multiple layers of Convolutional Neural Networks. Furthermore, the future improvements that can be made to this model are to incorporate more diverse and extensive for more precise detection. This can be done by obtaining data from different sources. Another improvement that can be incorporated in this research paper in the future is to utilize CT scan images as well along with the X-ray images for more efficient detection of COVID-19 . Real-time processing can also be imbedded in to provide immediate feedback which will help us to make quick decisions.

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