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UTILIZING CONVOLUTIONAL NEURAL NETWORK FOR EARLY COVID-19 DETECTION THROUGH CHEST X-RAYS

[1]Himanshu Agarwal, [2]Shweta Agarwal, [3]Sanpreet Kaur
[1]Assistant Professor,[2] Assistant Professor,[3]UG Scholar
[1]Department of Computer Science and Engineering,
[1]Moradabad Institute of Technology, Moradabad, U.P.-India

Abstract: The worldwide state of health is continuing to be severely impacted by the Covid-19 pandemic. Covid-19 has affected the human race in all aspects of life whether it be mentally, physically, socially, or economically. Diagnosing Covid-19 is a critical task, especially when there is a shortage of resources. Moreover, the present tests and techniques lack solutions to problems such as ease of accessibility, the requirement of rapid response, the cost of testing, the accuracy of results, etc. The most modern Machine Learning (ML) algorithms could be employed to develop a solution that allows for rapid testing and more accurate findings. The model prepared will be a more efficient imaging method to diagnose lungs related problems. Recognizing conceivable corona virus diseases using X-ray of chest will potentially be helpful to isolate patients lies in danger zone. X-ray machines are currently available in most healthcare systems also there is no transportation time needed for the models by a similar token. The timely detection of Severe Acute Respiratory Syndrome CoV-2 (SARS CoV-2), which is the main reason for Wuhan virus, utilizing chest X-ray pictures will prove to be life-saving for both patients and specialists [1]. In the present work, our aim to develop a system that detect of Covid-19 using X-ray images of the chest with the help of the Convolutional Neural Network (CNN) based ML technique. On performing comparative analysis with other models we found CNN to be the appropriate one for our work.

Index Terms - Covid-19, Deep Learning, Machine Learning, CNN, SARS CoV-2, Parallel 2D Convolutional Layer

I. INTRODUCTION

The healthcare systems in many nations are already overburdened. There are limited diagnostic tools, constrained hospital beds for the admission of such patients, restricted personal protective equipment (PPE) for medical staff, and limited ventilators [2]. In this work, we employed chest X-rays to check for the potential of Covid-19 since SARI (severe acute respiratory infections) symptoms and signs were present in the patients. The use of X-Ray has numerous blessings over traditional diagnostic procedures and CT scans:

1. X-ray imaging is far more common and affordable than traditional diagnostic procedures.
2. The diagnostic process is incredibly speedy because to the fact that transferring virtual X-ray photographs from the point of acquisition to the point of analysis no longer requires any transportation.
3. In contrast to CT scans, portable X-ray devices also allow imaging within an isolation ward, reducing the need for additional Personal Protective Equipment (PPE), a very rare and valuable help in this situation.
4. Chest X-ray imaging enables quick triaging of Covid-19 patients and should be possible with minimal human contact (which reduces effort) to help reduce the high patient volumes, especially in the most influenced regions where they have reached their capacity, or even independently when viral testing isn't an alternative (low supplies) [3].

II. MOTIVATION AND CONTRIBUTION

While examining a few research papers and information regarding Covid-19 we found an urge for building such a system that could fasten the testing process with great accuracy. The CT experiment and X-ray scans, each uses invisible stages of the electromagnetic spectrum to come across any form of incongruity, used for timely detection and feature excessive scientific relevance. The version organized can be a powerful imaging approach for diagnosing lungs associated problems. Possible Covid-19 infections found on chest X-rays may also help confine extremely dangerous patients while test results are awaiting [4]. Most healthcare facilities already have X-ray machines, and since most modern X-ray facilities are already digital, there is also no need to worry about sample transit time.

It could additionally assist in figuring out sufferers with an excessive chance of Covid-19 with a fake terrible RT-PCR which could want repeat trying out. So, we endorse using present-day ML strategies to come across the Covid-19 sufferers the use of X-Ray photographs in an automatic manner, mainly in settings in which radiologists aren't to be had and assist make the proposed trying out era scalable. Furthermore, a few have recommended that because the Covid-19 pandemic spreads, there should be more reliance on portable CXR due to the benefits indicated above and have shown that portable CXR is especially valuable for very ill Covid-19 patients. As a result, computer-aided diagnostic tools that can assist radiologists in more quickly and correctly interpreting radiography photos to find Covid-19 cases are highly wanted. Furthermore, most radiologists won't be familiar with all of the details of the contamination because the virus is still relatively new, and they may lack the knowledge necessary to make an accurate diagnosis. As a result, people leading this analysis can use this automated programme as a guide.

A significant contribution of this research is the proposal of a CNN based model which accurately identify the Covid-19 infection using patient chest X-ray images [5]. The authors would like to re-emphasize that the authors aren't featuring using the proposed version as an opportunity to the traditional diagnostic checks for Covid-19 infection, however as a triage device to decide the suitability of an affected person with SARI to go through the check for Covid-19 infection.

III. Related Work

We have studied many documents related to other medical diagnosis reports, CNN, transfer learning, etc. According to them, we found the similarity between various disease detection such as cancer detection, pneumonia detection, diabetes, Covid-19 detection, etc. The most relevant similarities were found between lung diseases and Covid-19. In a research done by B. Sekeroglu and I. Ozsahin [6] of slas technology done few experiments in the field of transfer learning and succeed to build efficient models for the same, but their model was limited to the small dataset. On a large dataset, it's not working so efficiently. Another research that was done by Linda et al. [7] have divided the work into two parts i.e. Covid-Net (for Covid network architecture) and Covid-X (for dataset) and built a model using it, though their work was quite helpful for our research still lags many things and its accuracy is not as satisfactory as it should be.

A 3-dimensional deep mastering version for the Covid-19 prognosis was suggested by Dadário et al. [8]. 4356 numbers of chest CT images were utilised to validate the effectiveness of the suggested strategy. Satisfactory sensitivity and good specificity for the detection of Covid-19 infection have been demonstrated by the experimental results. A set of rules is advanced for the type of clinical pictures. It has applied switch mastering and its overall performance has been as compared with numerous present structures primarily based totally on CNN. Few more pieces of research were studied and explored, most of them worked similarly by dividing data and model in two (Covid-Net and Covid-X). Finally, we decided to build a model using CNN by improving the accuracy of the model and building a model that can work on large datasets and also on real-time Chest X-Rays.

IV. Proposed Method

In view of the fact that the current surge of Covid-19 infections worldwide, many opportunity screening methods had been advanced to pick out possible instances of Covid-19 [9,10]. Though the data of chest X-rays for the detection of corona virus is limited but the COVID-Network is the simplest technique having an open-supply and actively maintained device that may become aware of the opportunity of detecting Covid-19. COVID-Network uses a machine-driven format exploration to take a look at the shape format starting from the initial format prototype and requirements. The current ML strategies may be embedded to expand an answer for speedy trying out and getting outcomes with better accuracy. So, we've used Machine getting to know technology as our base generation [11] and a few concepts of Deep Learning (DL) too [12]. It takes a X-Ray image of chest as input and predict the output as one of the two classes: 0 i.e. COVID negative and 1 i.e. COVID positive. We deal with this version as our baseline, evaluating our outcomes with it.

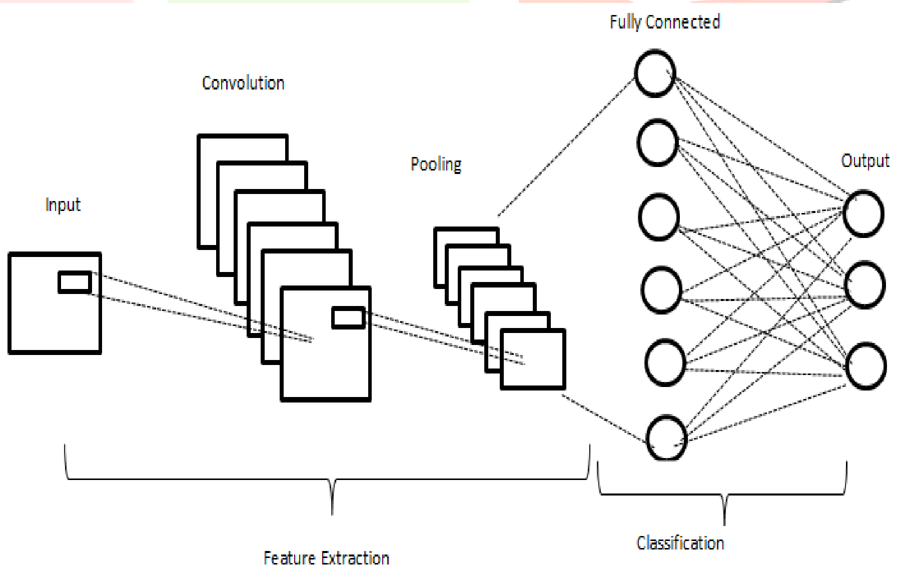


Fig. 1. CNN model with Parallel 2D Convolutional Layer

The proposed work uses CNN with Parallel 2D convolutional layer. Fig. 1 explains the main architecture. The 128 X 128 pixels images are taken as input and then passed through neural network for further processing. The model after processing, gives the results in two layers, one depicting Covid Positive and the other Covid Negative.

V. DATA SET OF THE STUDY

For the experiments, several sources of X-rays were researched and finally, one was chosen for the proposed work. The dataset as shown in Fig.2 for this study was obtained from the popular repository Kaggle which includes different chest X-ray images of patients infected with Covid-19 as well as healthy individuals [14]. The total number of chest X-ray pictures in the gathered dataset is around 2500. This data set is further divided into training (i.e., 2000) and validation (i.e.,500) set of normal, Covid. In the training set, 1000 is normal, 1000 are Covid. In the validation phase, 250 samples of a normal case, 250 Covid were considered for this analysis. To assist with the quick training of our model, the scans were reduced to 128 X 128 pixels.

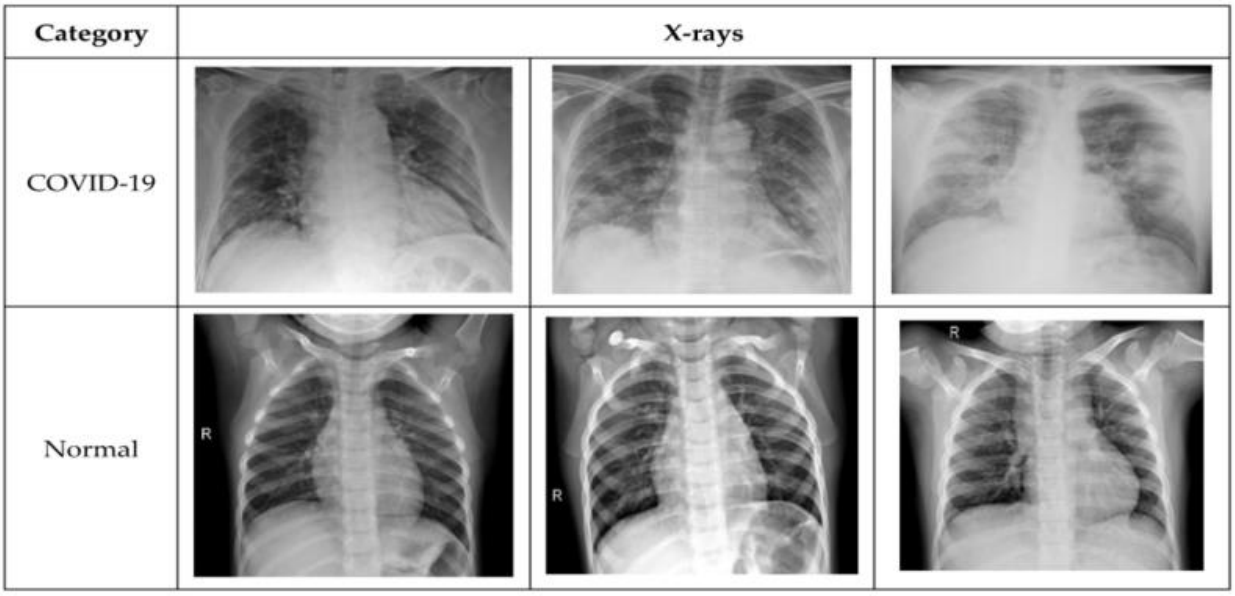


Fig. 2. X-Ray Images of Covid-19 Infected Patients and Healthy Individuals

VI. IMPLEMENTATION

starting with the implementation of the research work, as we are using Python as our programming language we need some pre-requisites, that is importing of Libraries. The used Libraries for the proposed research work are Numpy, Pandas, Matplotlib, Keras, Tensor Flow os,cv2,tqdm.

In this paper, the authors have taken the PA view of chest x-ray of Covid-19 patients and healthy patients. Once all the pre-requisites requirements were satisfied then for the implementation purpose dataset is loaded first. Pre-processing such as reducing the image size, maintaining a consistent orientation and for cropping, data augmentation is used to counter the lack of a large data set initially. The procedure is followed by model training and testing on the dataset. Quantitative analysis such as checking the accuracy, sensitivity, specificity of the model, will also be considered in the meantime. At last, for effective presentation the user interface was developed which will allow users to upload their x-rays and get a prediction with reasonable accuracy.

The proposed work the authors collected chest X-ray (i.e., radiography) of different test subjects which included both Covid Positive as well as Covid Negative patients from various age groups and gender. To create a dataset the dataset files and read and saved its path and then divided them into categories. After setting the dataset the authors worked on images mainly resizing and gray scaling. Images have a high number of pixels For e.g., a 480 x 480 image has 2,30,400 pixels. Using a high number of pixels will need a longer time to train a deeper network to achieve good results. So, a much smaller image can even give a good accuracy but with a fraction of resources and training time, so in this work we resize the image to 64 x 64 pixels. The reason for consider 64 x 64 pixels image is that it gave the most accurate results in terms of accuracy and validation loss. It gave the least validation loss and there is very little difference in validation accuracy and training accuracy. Other models such as 32 X 32 pixels, 100 X 100 pixels, and 128 X 128 pixels were performing well for validation accuracy but they could not provide a satisfactory result for training accuracy. Also few of them were giving very high validation loss. So, we chose to resize the image to 64 X 64 pixels.

After that all the images were normalized by dividing them from 255. So all the images range between 0-1 because they are grey scaled images then we reshaped the images so that the number of images is100,101,…… which is required for a neural network since the authors can give like a 4D array to train the neural network [15].

For the training, a convolutional neural network is used as our base. We took the input images of 64 X 64 pixels which will go through a convolutional neural network(shown in fig 3) and finally it will be a classification type neural network where we got 2 neurons at the output layer and they are given like Covid-19 negative and Covid-19 positive. This is giving us the probability of Covid-19 positive and Covid-19 negative. The popular Keras API is used to implement this neural network architecture and Tensor Flow is used as a backend. In Fig.4 we have 128, 3x3 kernels and 128,5x5 kernels and 128, 7x7 kernels that much of parallel convolution layers. The proposed solution consider every kernel and later appending those layers into one layer(kernel). Finally created the sequential layer, the first layer is the parallel layer and then concatenated all these layers, and we have a general convolutional layer of 16 3x3 kernels and another general 2D convolution layer of kernel size 32 3x3 kernel, moving to flatten layer. Finally, we reach neurons with32 dense layers, then 64 neurons dense layer towards the output layer where we have two neurons Covid-19 positive and Covid-19 negative.

Drop-out layers have also been employed by us to reduce the neural network's over fitting. Since we needed to determine the likelihood that Covid-19 would be positive or negative, we also utilized softmax as the output activation. In order to solve loss classification difficulties, we employed category cross entropy. Then we have calculated the validation loss.

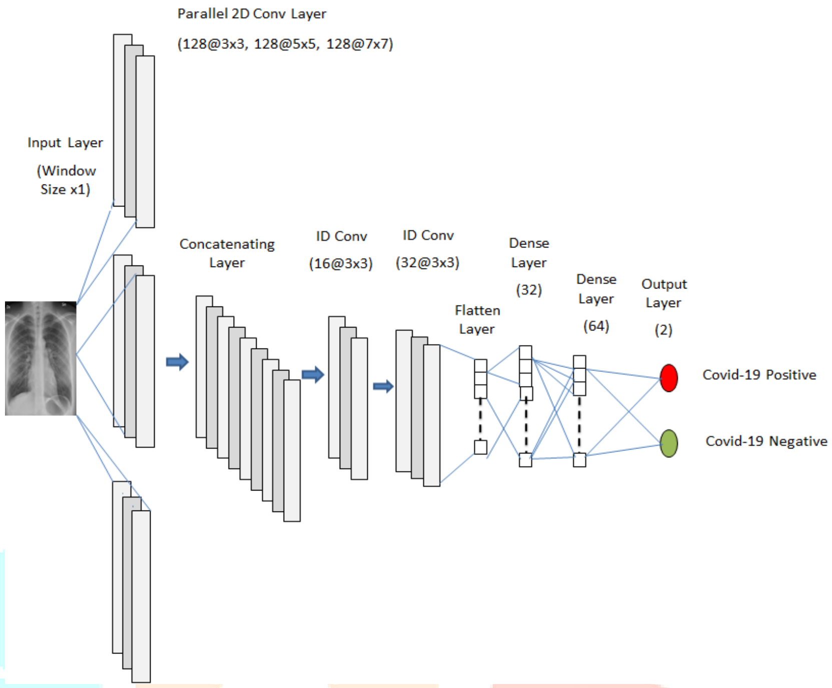


Fig. 3. Process of Covid-19 Detection

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
model (Functional)           (None, 64, 64, 384)       11008
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 62, 62, 16)        55312
_________________________________________________________________
activation (Activation)      (None, 62, 62, 16)        0
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 31, 31, 16)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 29, 29, 32)        4640
_________________________________________________________________
activation_1 (Activation)    (None, 29, 29, 32)        0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
flatten (Flatten)            (None, 6272)              0
_________________________________________________________________
dropout (Dropout)            (None, 6272)              0
_________________________________________________________________
dense (Dense)                (None, 32)                200736
_________________________________________________________________
dropout_1 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_1 (Dense)              (None, 64)                2112
_________________________________________________________________
dropout_2 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 130
=================================================================
Total params: 273,938
Trainable params: 273,938
Non-trainable params: 0
_________________________________________________________________
```

Fig. 4. Model Summary

VII. QUANTITATIVE ANALYSIS

After training of the model, the obtained the curves between loss and epochs as shown in Fig. 5 which shows that as the training is proceeding the loss is decreased and also that the training loss is always greater than the validation loss which is an indication of a good ML model. The further continuation of training we obtained the curves between accuracy and epochs as given in Fig. 6, which shows that accuracy is increasing. Validation and Training accuracy is almost equal, indicating a good model.

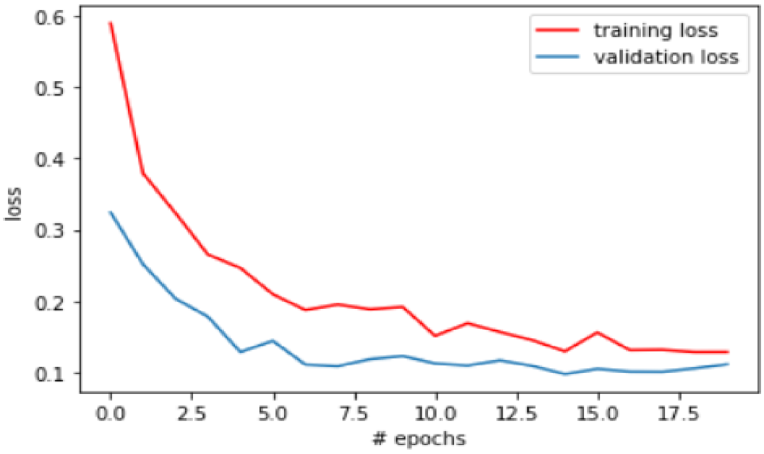


Fig. 5. Curves Between Loss and Epochs

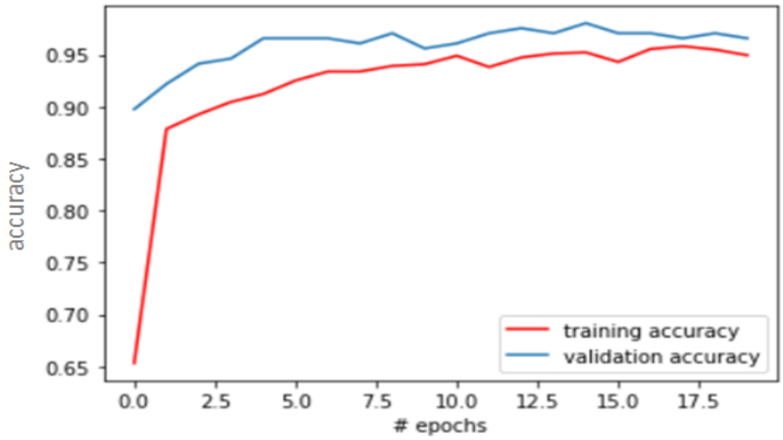
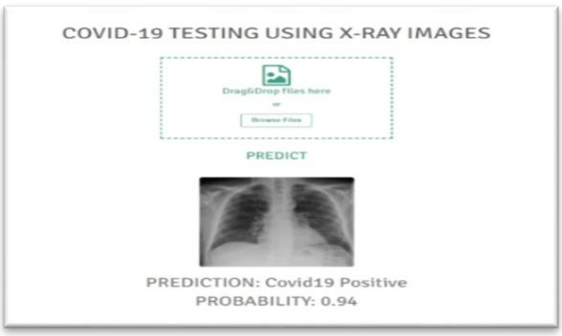
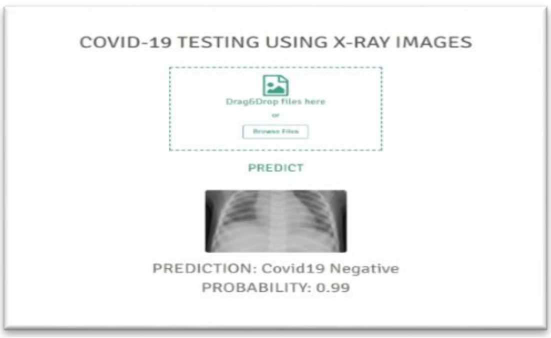


Fig. 6. Curves Between Accuracy and Epochs

VIII. RESULTS

To stop the disease from spreading and maintain control over it, quick and fast discovery of COVID +ve patients is required. The goal of this research project was to develop a quick and low-cost method for identifying COVID +ve patients from chest X-ray pictures. Three cutting-edge deep learning models have been adopted and combined in the work that is being offered in this study. The sensitivity for COVID +ve cases is about 95%, meaning that out of 100 COVID +ve patients, more than 95 can be identified accurately using our suggested model. This, in our opinion, will considerably advance the medical industry. After the evaluation, our model indicated an accuracy of 95.17 % with a validation loss of 13% which is a great success for our model. Fig 6 represents the final output of our model.





IX. Conclusions and Future Work

In this study, we used the COVID dataset from Kaggle that is comprised of 2500 CXR images. We desire we can get better-promising outcomes, and these studies will result in be leveraged and increase for destiny researchers and to boost up the improvement of extraordinarily correct but realistic deep studying answers for detecting COVID-19 instances from CXR snapshots and boost up the remedy of folks that want it the most. Future guidelines consist of persevering with to enhance sensitivity and PPV to COVID-19 infections as new statistics are collected, in addition, to make bigger the proposed COVID-Net to hazard stratification for survival analysis, predicting hazard fame of patients, and predicting hospitalization length which could be beneficial for triaging, affected person populace management, and individualized care planning.

The model and this paper, however, only serve to summarise our present understanding of this quickly developing situation, and that too with relatively few data. In this work, we tried our best for producing accurate and précised results. This work could lead towards future researches and enhance knowledge towards technology and its uses in medical science. In the future, a constraint can be added in uploading images, as in present we had no constraint so sometimes, which may create a problem in detecting results.

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