Detection and Severity Identification of Covid-19 in Chest X-ray Images Using Deep Learning

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ABSTRACT- COVID-19 pandemic is causing a significant flare-up, seriously affecting the wellbeing and life of many individuals all around the world. One of the significant stages in battling COVID-19 is the capacity to recognize the tainted patients early and put them under exceptional consideration. In the proposed model we used deep learning-based exception Net under transfer learning paradigm. We trained the proposed model using chest-X rays collected from the open-source dataset (COVID -19 Dataset) using K10 cross-validation. We further calculated the severity in the covid classified images by the model using radiologist ground truth. We achieved an accuracy of 96.1% in the classification, and we are able to calculate the severity of the COVID -19 within the range of 75-100 % risk. Our proposed model successfully classified the COVID chest x-rays with severity measure.

Keywords: COVID-19, Machine Learning, Xecption, CNN, RT-PCR, VGG19, ResNet and Inception.

1. INTRODUCTION

Covid-19, also known as Coronavirus, is a contagious illness that causes disease in people's respiratory systems. The term Coronavirus is an abbreviation for "Novel Covid Illness 2019." Covid has had an impact on our daily lives. This pandemic has affected many social classes, with many people becoming ill or dying as a result of the disease's spread. Covid-19 was first recognized in December 2019 in the Chinese city of Wuhan. In 2020, the World Wellbeing Association (WHO) announced the Covid episode a pandemic [1]. There is a gigantic acceleration of infection inside a brief timeframe. Many individuals who got affected have associations with the live animal's food market. This made the analysts believe that the spread happens because of association with live food market [2]. On additional examination, Coronavirus cases were coming up which had no association with live food market, like voyaging and exportation of merchandise.

There are three principle ways that Coronavirus can spread:
1. By taking in air conveying drops or spray particles that contain the SARS-CoV-2 infection when near a tainted individual or in ineffectively ventilated spaces with contaminated people.

2. By having drops and particles that contain the SARS-CoV-2 infection land on the eyes, nose, or mouth - particularly through sprinkles and splashes like a hack or wheeze.
3. By contacting the eyes, nose, or mouth with hands that have the SARS-CoV-2 infection particles on them.

Symptoms: A wide scope of effects for Coronavirus have been reported. These effects include:

Fever or chills, Hack, Muscle or body throbs, Anorexia, Sore throat, Nasal blockage or runny nose, Migraine, The runs, Queasiness, Windedness or trouble relaxing, Loss of smell or taste. The assessed incubation time frame is somewhere in the range of 2 and 14 days with a middle of 5 days. It is vital to take note of that certain individuals become tainted and foster no side effects or feel sick. Coronavirus is a moderately new illness; accordingly, extra gamble factors for serious Coronavirus might keep on being distinguished [3]. Sometimes, individuals who get Coronavirus can foster serious entanglements, including trouble breathing, causing a requirement for hospitalization and escalated care. These serious complexities regularly lead to no end [4]. The gamble of extreme infection increments consistently as individuals age. Also, those of any age with fundamental ailments, including yet not restricted to coronary illness, diabetes or lung sickness, are at higher gamble to create extreme Coronavirus contrasted with those without these conditions. Those at higher gamble for serious disease ought to be focused on for vaccination [6].

Coronavirus testing has progressed significantly since Spring. From nasal swabs to spit tubes, there are countless various ways of getting tried for the infection [7-8]. They all have their legitimacy in various ways, the PCR is the most dependable test. The antigen tests can be a major advantage since they're fast, however you compromise a great deal of that exactness for speed, which is an issue.

PCR TEST: PCR tests, or polymerase chain response tests, search for the hereditary material of the infection. The examples gathered for the test come from the nose and mouth. Assuming that you test positive, it implies the infection is right now dynamic in your body [9-10].

The primary COVD-19 PCR test we were acquainted with was the nasopharyngeal swab, which included what feels a piece like a Q-tip scouring against your mind. It's truly awkward for the individual that is having the test done. These tests were at first so intrusive in light of the fact that there wasn't an adequate number of information showing whether exact outcomes could be accomplished from a swab lower in the nasal depression [5]. Presently, there are substantially more mediocre choices. We presently have tests where you can simply utilize [a Q-tip] in your nose, so basically cleaning your own nose with a Q-Tip- it's not any more intrusive than that. There is likewise a salivation test where everything you do is spit in a cylindrical tube. And each of the three of those [tests] are comparable as far as the outcomes they get and how exact they are. However this is the most dependable method for testing for Coronavirus, it's not 100% precise. Indeed, even with the PCR, we know 20% or 30% of the time, you can get a bogus negative. That is particularly evident assuming you test too soon. So on the off chance that I'm uncovered and I get tired the following day, distinguishing anything too soon. Regardless of whether the infection is there, the test wouldn't get it [11].

Antibody Test: Neutralizer tests have a totally different capacity that PCR tests, says Dr. Labus. To be tried for antibodies, you must have blood drawn in light of the fact that that is the place where antibodies course in your body. The PCR searches for the presence of the infection in your body at the time of the test. The immunizer test searches for your safe framework's reaction to the infection already being there," he says. So you should be correct now crippled with the disease or defiled with the contamination to be positive on a PCR test, yet you could be positive on an immunizer test for a seriously significant time-frame after you were corrupted [12].

Neutralizer tests are done on blood since that is the place where antibodies flow in your body. PCR test, regardless of whether it's an alternate brand, it's done in the very same way. With the immune response test, various organizations are fostering those units and they're not indistinguishable, as that is the reason there is anything but a set [accuracy rate] for the counter acting agent test. It truly relies upon which one you use. The equivalent is valid with neutralizer tests we use for anything. Take flu neutralizer tests, for instance. "There are counter acting agent tests that can show assuming you were tainted or immunized,

and their capacity to identify the infection truly differs relying upon the maker [13]. Since it's at this point unclear what level of insusceptibility the people who have recuperated from Coronavirus have against getting it once more (there have been a few instances of reinfection), neutralizer tests are more compelling for analysts noticing designs than people settling on choices about their wellbeing.

Antigen Test: The possibility of an antigen test is you're searching for the outside of the virus. The PCR test is searching for the hereditary material, the antigen test is searching for the proteins, essentially the construction of that infection. By and large, antigen tests will quite often be less precise than PCR tests, however they're significantly quicker to run. Consider the fast influenza tests you can get in a specialist's office. You can take a specimen and after 15 minutes, the specialist will have a response. The issue, however, is you can obtain a ton of bogus outcomes on those tests since they're only not quite as exact as PCR [14].

Furthermore, to guarantee results from an antigen test are precise, you need to run multiple. In any case, you can't gather examples for those tests at a time. Those examples are taken under a similar condition. So on the off chance that the infection isn't perfectly located brilliantly, you will miss it on those tests. For the most part, on the off chance that we will rehash an antigen test, we'll have you returned a few days straight so we can take a gander at it in an unexpected way. With that antigen test, essentially you're compromising exactness and speed [15].

2. RELATED WORK

VGG-16: Visual Geometry Group from Oxford was exceptionally basic and had a more noteworthy profundity than Alex Net. The paper had two models with 16 and 19 layers profundity. All the CNN layers were utilizing 3 by 3 channels with step and a stack of size 1 and a maximum pooling size of 2 with step 2. The contribution to the first convolutional layer is a proper size of 224 x 224 RGB picture. Convolution layers map the heap of 3X3 utilized convolved future extraction channel is one of the design. The image is gone through a pile of convolutional layers, where the channels were used with a small open field: 3×3. In one of the plans, it similarly utilizes 1×1 convolution channels, which ought to be apparent as a straight difference in the data channels [16]. The convolution step is fixed to 1 pixel; the spatial cushioning of convolutional layer input is such a lot of that the spatial goal is defended after convolution. Spatial pooling is done by five max-pooling layers, which follow a piece of the convolutional layers. Max-pooling is performed over a 2×2 pixel window, with stage 2.
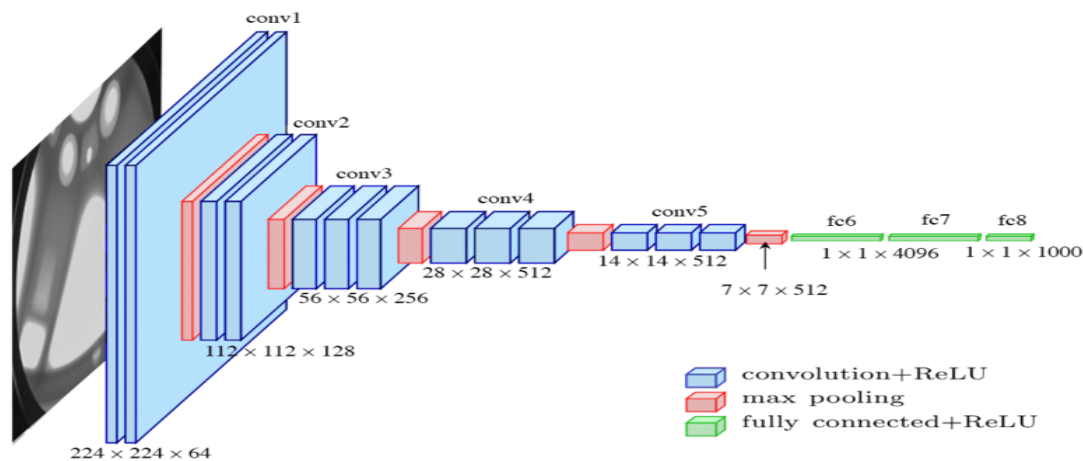
Figure 1: Convolution network evolution

Three Fully-Connected layers can follow convolution heap with 2 different initial 4096 channels each, the third performs a 1000-way ILSVRC arrangement along, hence contains 1000 channels. The last layer is the delicate max layer. The design of the completely associated layers is something very similar in all organizations [17]. All the layers are outfitted with the correction (ReLU) non-linearity. It is likewise noticed that none of the organizations contain Local Response Normalization (LRN), such standardization doesn't work on the presentation on the ILSVRC dataset, however it prompts expanded memory utilization and calculation time.

Formula:

$$f(x)=fL(\ldots f2(f1(x;w1);w2)\ldots),wL) \qquad (1)$$
$$w=(w1,\ldots,wL)w=(w1,\ldots,wL) \qquad (2)$$

RESNET: The full form of RESTNET is Residual Networks. It is also known as "Highway networks". It is a convolutional neural network which overcomes the vanishing gradient problem. Generally, this deep learning neural network has 56 CNN layers. It uses skip connectors or shortcuts to jump over a few layers. These skip connectors are used to solve the vanishing gradient problem. This will help to reduce the time for the output to be displayed. This gives faster predictions. ResNet models are carried out with twofold or triple-layer avoids that contain nonlinearities (ReLU) and bunch in the middle between. There are two primary motivations to add skip associations: to stay away from the issue of disappearing slopes, or to alleviate the Degradation (exactness immersion) issue; where adding more layers to a reasonably profound model prompts higher preparation blunder [18]. The main ResNet design ,the Resnet-34, which associate inclusion of another way associations in transforming a simple org into its leftover association partner The plain group was enlivened for this situation by VGG brain associations VGG-16 & VGG-19 with convolutional networks with 33 channels. In any case, ResNets have fewer channels and are less comprehensive than VGGNets. The 34-layer ResNet achieves an exhibition of 3.6 billion FLOPs, as contrasted to the 1.8 billion FLOPs of more modest 18-layer ResNets.
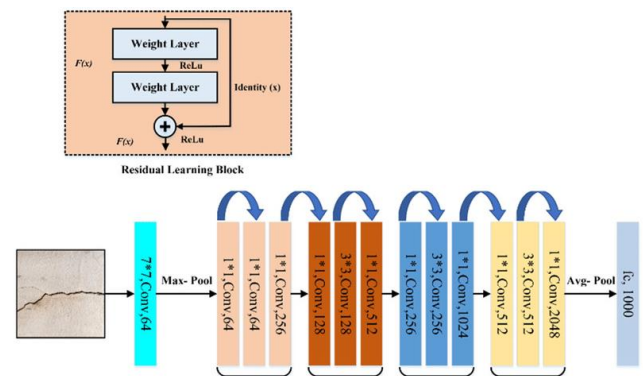

Figure 2: ResNet Network convolution with FLOPs

It likewise observed two straightforward plan guidelines - the layers had a similar number of channels for a similar result including map size, and the quantity of channels multiplied in the event that the component map size was split to protect the time intricacy per layer. It comprised 34 weighted layers.

Formula:

$$F(x):= H(x) - x \text{ which gives } H(x):= F(x) + x. \qquad (3)$$

INCEPTION NEURAL NETWORK: This model's layers go up to 27 layers deep. It consists of 3 convolutional filters:1x1,3x3 and 5x5.This Image recognition model is proven to attain greater than 78.1% accuracy on the ImageNet dataset.
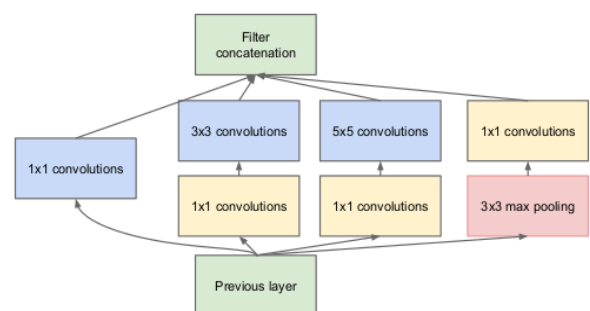

Figure 3: Inception Network filter concatenation

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The purpose of 1x1 convolution is to decrease or reducing the dimensions of data passing through the network, and also gives benefits of increasing the width and depth of the network. It is also known as Network in Network. A 1x1 convolution takes the component-wise result of all pixels upsides of a picture [20]. The inception model consists of Input layer, 1x1 convolution layer, 3x3 convolution layer, 5x5 convolution layer, Max pooling layer, Concatenation layer. Usually, when inception model is used, the 1x1 convolution is added before 3x3 and 5x5. This is because to reduce the dimensions of the input passed to the 3x3 or 5x5 layer. When doing a max pooling to the input, we give 1x1 convolution after the pooling so the dimensions are reduced. They are used to decrease the computational cost [18].

XCEPTION NEURAL NETWORK: The Xception Model was presented by Francois Chollet,a Google scientist. Xception is an expansion of the origin Architecture which replaces the standard Inception modules with profundity wise Separable Convolutions. Firstly, input moves into entry flow, then after that it. goes through the middle flow and repeating itself 8 times in this middle flow, and finally exiting through the exit flow *Figure 4*.

An Xception Neural Network is a CNN that is capable of advancing till 71 layers deep. It stands for Extreme-Xception. The Inception Neural Network uses 1x1 convolution to reduce or compress the input and then those input spaces will be used by 3x3 and 5x5 convolutions. In Xcpetion Neural Network, the step is reversed. It first applies the filters on the input then it uses 1x1 convolution to compress or reduce the input. Another contrast in the Inception and Xception Neural Network, that is, Inception Neural Network has the property of non-linearity whereas Xception Neural Network does not have non-linearity features. Also, Inception can parameterize nearly 23.6 million while Xception has 22.8 million parameters. Generally, Xception Neural Network gives better accuracy than other models as the layers are deeper [19].
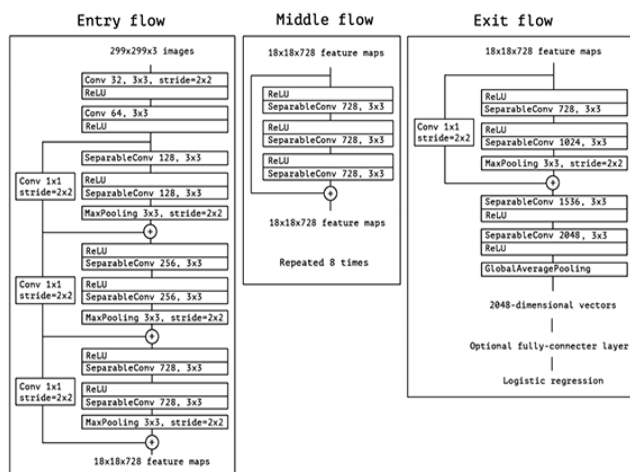
Figure 4: Xception Network model existing flow

Network trained on more than a million images from the ImageNet database can be loaded while using this Xception neural network. The pretrained network can classify images into 1000 object categories, such as animals, flowers, feet, and clothes.
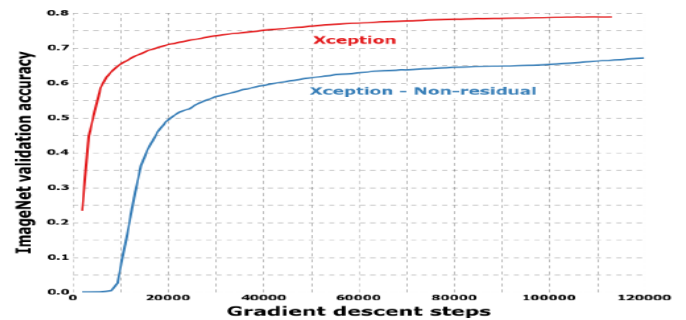
Figure 5: ImageNet validation accuracy

Table 1: Results of various Deeplearing Model with best accuracy

|		Top-1 accuracy	Top-5 accuracy
VGGNet-1st Runner up in ILSVRC 2014	VGG-16	0.715	0.901
ResNet-Winner in ILSVRC 2014	ResNet-152	0.77	0.933
Inception-V3-1st Runner up in ILSVRC 2014	Inception V3	0.782	0.941

The best four models surpassed the CheXpert baseline of 0.828 (ResNet-34 0.840, ResNet-152 0.836, DenseNet-161 0.834, ResNet-50 0.832) [20]. For congestion, the highest AUROC was achieved using ResNet-152 (0.933), Inception V3(0.941), and Xecption (0.96).

3. PROPOSED FRAME WORK

ALGORITHM
1. Connect to dataset and import all dependencies
2. Define few parameters, Fetch images and class labels from the files
3. Visualize first 40 images from the dataset
4. Normalization-Model takes pictures as exhibit of pixels, hence convert into cluster and normalize.
5. Train Test split, Visualize a few images from test and train sets
6. Building and visualizing the model, Image Augmentation
7. Training the model, Making predictions
8. Visualizing some predictions
9. Plot ROC curve, Confusion matrix, Classification report.
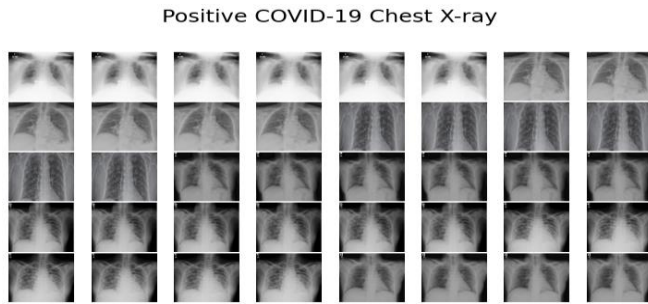
Negative COVID-19 Chest X-ray
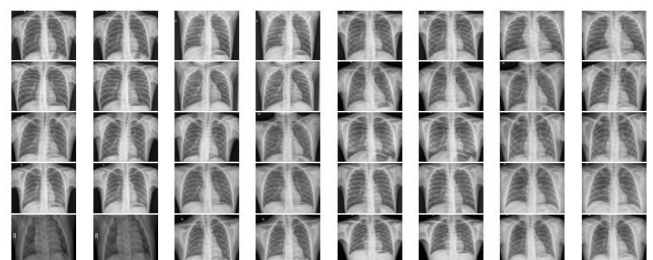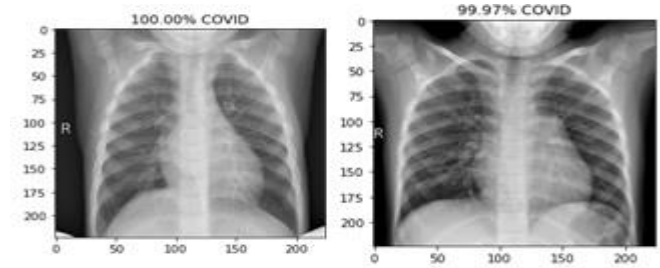
Figure 6: Covid-19 Negative and Positive chest X-ray

4. RESULTS AND DISCUSSION
Proposed algorithm implementation

Prediction with image sizes and Flip-flops and rotation

Prediction set

For loop to iterate on prediction set

If probability>0.5,

To show the probability of severity, we plot with floating point of a data type probability = ((no. of epochs * total true possibilities)-1)/100

Formula
severity=probability * 100

Else severity=(1-probability) * 100
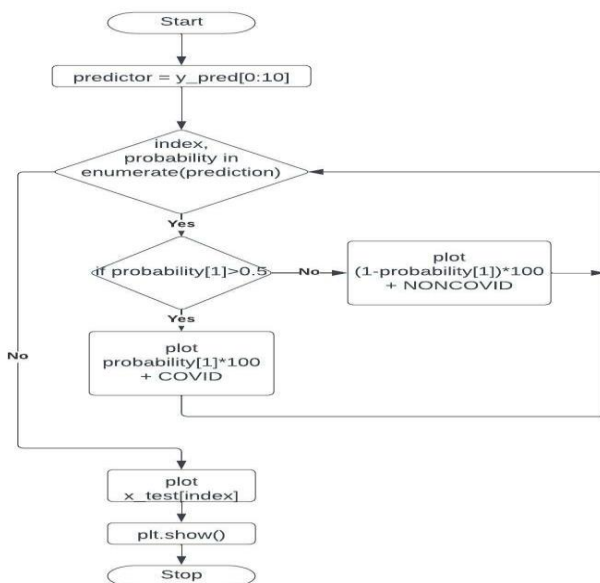
Indexing the data

Stopping the prediction

Stop for loop.

Figure 7: Flow chart diagram of proposed model working process

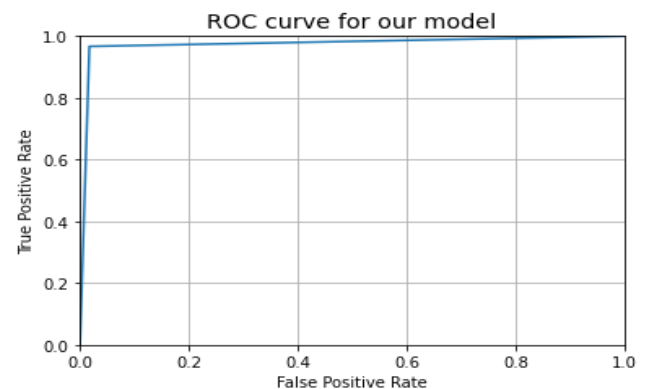**Figure 8**: Covid-19 positive with severity in percentage

Figure 9: ROC curve for our model

Here we are classify the severity in 3 types with ground truth values given by radiology norms in lesions in chest x-ray it can 0 to 2 regions in that 1st level will calculate 0 is Normal with below 25% and 0.5 to 1 is mild with below 35% and 2nd level is above 1 region is severe with 2 category severe and high severe.
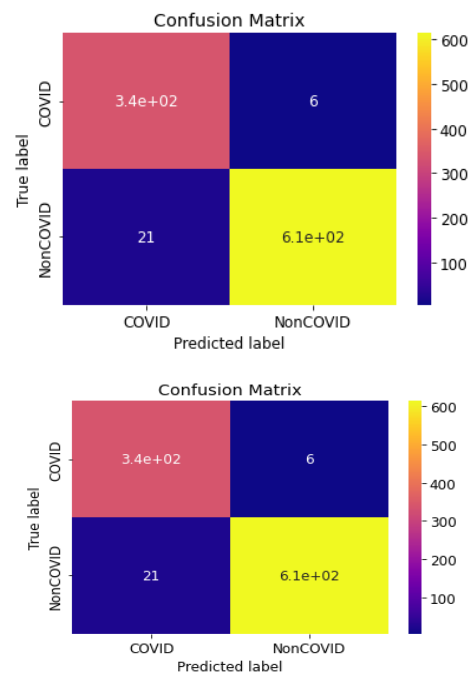

Figure 10: Confusion Matrix without Normalization

5. CONCLUSION

The infection which has taken all around the globe and have made pandemic in the 2020's has shown simple movement after the immunization. Yet, before immunization was created it has left devastation universally. The repercussion due to Coronavirus might have been limited on the off chance that the determination of each and every patient is finished during the clinical help is given to them. The distinguishing proof of the seriousness of the infection inside the patient, would give every one of the clinical groups open ways to help the extreme patients foremost. a strategized technique for going to patients as per the seriousness would have given less level of ailing all through the world. Distinguishing seriousness utilizing chest x-beams is one methodology which gives fast outcomes. The stakeholders of this created device would significantly include doctors, medical groups, and patients. Alongside foreseeing the seriousness of illness utilizing chest x-beam. This could assist the presence of wellbeing with caring execution to save an opportunity to distinguish which level of infection is harming the organ. And more endeavors ought to be made to explain the full range of COVID-19 seriousness. The model created goes about as an apparatus that detects the presence of Coronavirus infection which gives the seriousness rate. Later on, the model can be sent in the web application that can be utilized by any stakeholder who approaches chest x-beams. Further this proposed method can be applicable to detecting the pneumonia and its severity.

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