COVID-CAM: A Method of Detection COVID using Active Map Classification, CNN and Deep Learning

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ABSTRACT
The Novel Corona Virus (COVID'19) spread rapidly around the world and become pandemic.it has caused more than 6.1 million cases (end of May 2020) of corona disease and effect on both people's daily lives, public health, and the main issue of the global economy. It has critical to detect the COVID'19 from the people and give the quick treatment of affected people due to no accurate toolkit available. They see many researcher-made detection methods using CT images this method is time-consuming and also not give that much accuracy therefore for the early detection and accuracy we develop one model of AI system using computer vision and deep learning which can detect CORONA using chest X-ray (CXR) images that is open source and available to the general public. However model divide into the two modules, the first module detects the COVID'19 using Chest X-ray images and the second module with help of active classification map method gives results with high accuracy.

Keywords
Chest X-Ray(CXR),Active Map Classification, Artificial - Intelligence, Convolution Neural Network(CNN),Deep Learning

1. INTRODUCTION
Novel Coronavirus 2019 (COVID'19) which first appeared in Wuhan city of China on 31 December 2019, has rapidly become a pandemic[10-12]. The disease is named COVID'19 and the virus termed Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-COV-2).This new virus spread from Wuhan to all cities of China in just 30 days[13]. On 30 January, India reported its first case of COVID-19 in Kerala, reached over 182,143 by the 31st May 2020[14]. Most coronaviruses affect animals, but they can also be transferred to humans because of their zoonotic nature. Severe acute respiratory syndrome Coronavirus (SARS-CoV) and the Middle East respiratory syndrome Coronavirus (MERS-CoV) has caused severe respiratory disease and cause demise in humans. The symptoms of COVID'19 include fever, cough, sore throat, headache, fatigue, muscle pain, and shortness of breath[9].

Recently we see many researchers develop a method using Computed Tumorous(CT) images detection it is gold standard method but it's time-consuming as well as not give appropriate accuracy, for the COVID'19 early detection and high accuracy we develop one model AI system using computer vision and deep learning. we divide this model into the two phases or we can say two modules the first module contains the detection of COVID'19 using Chest X-Ray images and second phase using artificial intelligence we classify the images for the better accuracy also the first module contain why using Chest X-ray images over CT images and compare COVID'19 with pneumonia and second module contain three classification method of the active map using gradient-based class activation maps (GRAD-CAM) method. we get about 90% accuracy using chest x-ray images from the open-source database generic public https://github.com/ieee8023/covid-chestxray- dataset[15].

In this paper first, we discussed about the relationship between pneumonia and corona then by Chest x- ray images over CT images, and for the second module we use active classification method using gradient-based class activation maps(GRAD-CAM) method[16].

2. COVID CAM MODEL
Here we proposed the COVID CAM method means the COVID Class activation method through this method we detect COVID pattern using Chest X-Ray images. So we divide this model into two module in first we detect corona using Chest X-ray images and second module we make a classification for accuracy.

In the first module, we find the relationship between the corona and pneumonia with the comparison of Chest X- ray images of Corona cases and pneumonia cases also we test one 50 years old COVID-19 patient with pneumonia over a week of Chest X-Ray images(CXR) after that we see pneumonia vaccine avert COVID-19 pneumonia then Computed Tumorous(CT) images and Chest X-Ray Images(CXR).At the end, we elaborate on them why we choose CXR images over CT images[1].

Pneumonia is a lung infarction that causes inflammation in the tiny air sacs inside your lungs. They may fill up with so much fluid and pus that it’s hard to breathe so here we find pneumonia makes what types of relationship with the COVID-19 .

2.1 Relationship Between Pneumonia and Corona
Pneumonia is a serious lung infection. In some people, it can be deadly, especially among the aged and those with ventilatory disorders. COVID-19, the ailment the novel coronavirus causes, can roll out to the lungs, causing pneumonia. While the multitude of people recovers, some spread severe pneumonia that does not respond well to treatment. Here, there are day's wise chest x-ray images of a 50-year-old COVID-19 patient with pneumonia over a week shown in figure 1

A person who grows symptoms in the lungs, COVID-19 may be life-threatening. In China, doctors confidential 81% of COVID-19 cases as mild. These mild infections involve mild cases of pneumonia. The other 19% of the cases were more severe.

The symptoms of pneumonia can many from mild

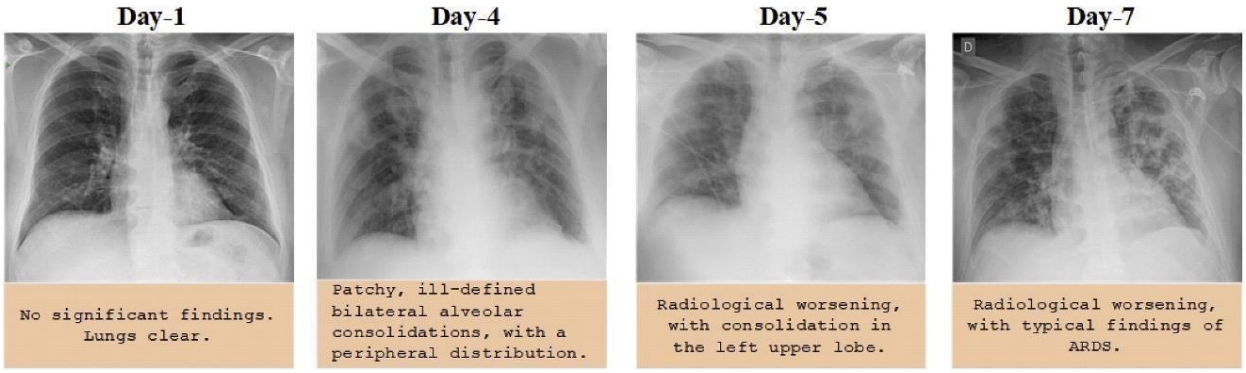

Figure 1. Chest X-ray images of a 50-year-old COVID-19 patient with pneumonia over a

As stated by the Centers For Disease Control And Prevention (CDC), COVID-19 is a respiratory illness. A person acquires a dry cough, fever, muscle aches, and fatigue. First, the virus can proceed through the respiratory tract and into a person's lungs. This gives rise to inflammation and the air sacs, or alveoli, that can charge fluid and push. This continuation then limits a person's capacity to take in oxygen. Many serious cases of pneumonia may have lungs that are reddened, they cannot take in enough oxygen or remove enough carbon dioxide. COVID-19 and Pneumonia patients have some differences in symptoms or identification of their lung damages. In Figure 2, some case images shown of differences observed by the radiologist between some COVID and Pneumonia patients.

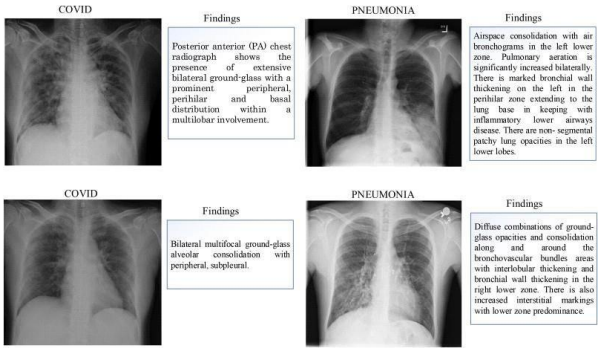

Figure 2. Differences observed by the radiologist between some COVID and pneumonia case image[2].

Constant oxygen deprivation can harm many of the body's parts, causing kidney failure, heart failure, and other terrifying conditions. According to the World Health Organization, the most usual diagnosis for severe pneumonia to severe. Therefore, typical symptoms includes: Coughing, Loss Of Appetite, Nausea, Vomiting, Shortness Of Breath, Fever, Difficulty Breathing Deeply. COVID-19 pneumonia includes: Dry Cough, Tiredness, Fever, Headache, Chest Pain Or Pressure, Difficulty Breathing, Or Shortness Of Breath.

2.2 Does the pneumonia vaccine avert COVID-19 Pneumonia ?

Vaccines for pneumonia only protect certain types of pneumonia, like pneumococcal pneumonia. Although, these boosters may help prevent other serious illnesses, including infections a person may contract while in hospital[21].

As stated by the World Health Organization (WHO), the pneumonia vaccine does not defend against the new coronavirus. Still, there is no vaccine for COVID-19 either[21].

2.3 Chest X-Ray Images

The chest X-ray is the most rapidly performed opinion x-ray examination. A chest x-ray generated images of body's inner parts like, heart, lungs, airways, blood vessels, and the bones of the spine and chest. An x-ray is a non- invasive medical test that helps doctors identify and treat medical conditions. Picturing with x-rays involves let out a part of the body to a little dose of ionizing radiation to produce pictures of the inner of the body.

A chest x-ray utilizes a very small dose of ionizing radiation to generate pictures of the inside of the chest. It is used to assess the lungs, heart and chest wall and may be used to help identify shortness of breath, persistent cough, fever, chest pain, or injury. It also may be used to help identify and observe treatment for a variety of lung conditions such as pneumonia, emphysema, and cancer. Because chest x-ray is fast and easy, it is useful in emergency identification and treatment[22].

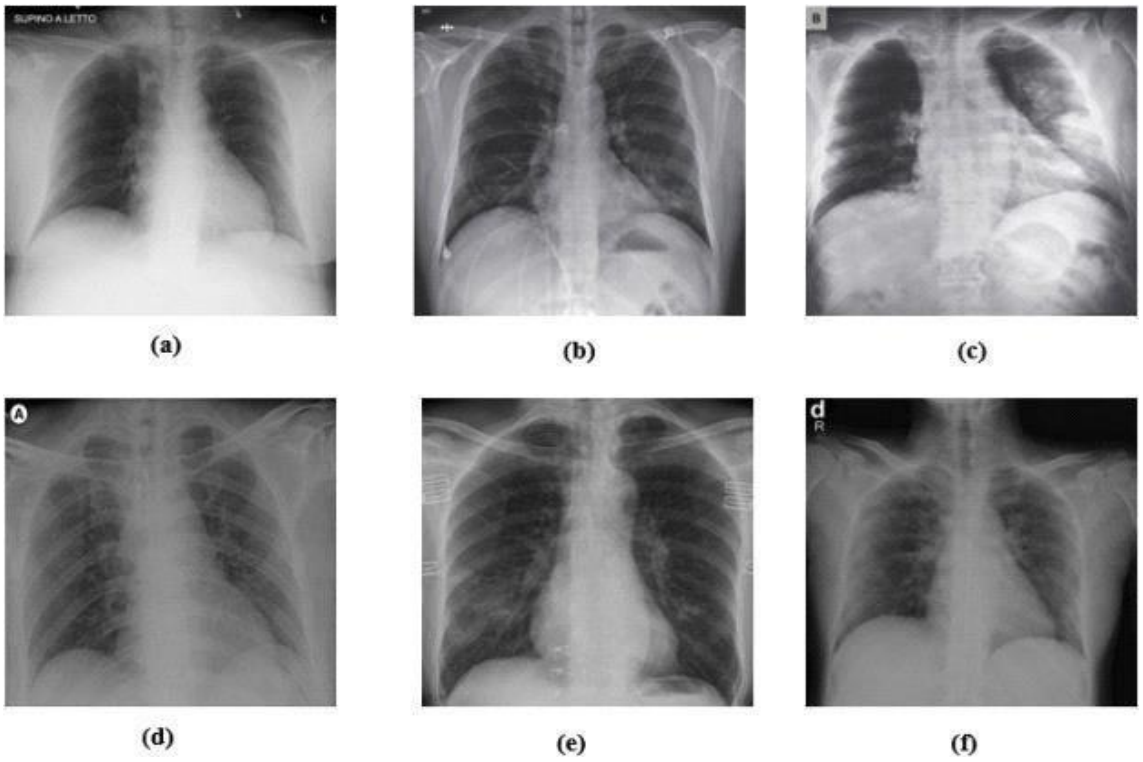

Figure 3. A few COVID-19 cases and findings by dataset: (a) Cardio-vasal shadow within the limits [3], (b) Increasing left basilar opacity is visible, arousing concern about pneumonia [4],

(c) Progressive infiltrate and consolidation [5], (d) Small consolidation in right upper lobe and ground-glass opacities in both lower lobes [6], (e) Infection demonstrates right infrahilar airspace opacities [7], and (f) Progression of prominent bilateral perihilar infiltration and ill- defined patchy opacities at bilateral lungs [8].

2.4 Detection Of COVID-19 Cases Using Deep Convolutional Neural Networks And X-Ray Images

In many areas such as classification, segmentation, and lesion detection of medical and health-related data deep learning models have been used successfully. With the help of deep learning models analysis of image and signal data acquired with medical imaging techniques such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and X-Ray. As an outcome of these analyses, detection and diagnosis of illnesses such as diabetes mellitus, brain tumor, skin cancer, lung cancer, and breast cancer are provided with convenience.

In the study of medical data, one of the considerable trouble faced by researchers is the limited number of available datasets. Deep learning models rapidly need a large amount of data. It is costly and time-consuming by specialists in labeling this data. The biggest lead of using the transfer learning method is that it authorizes the training of data with fewer datasets and requires fewer calculation costs. The information gained by the pre-trained model on a large dataset is hand over to the model to be trained, with the transfer learning method, which is widely used in the field of deep learning[23].

Newly, many radiology images using X- rays have been widely used for COVD-19 detection. Hemdan et al. used deep learning models to identify COVID-19 in X-ray images and proposeda COVIDX-Net model comprising approximately seven CNN models. Wang and Wong presented a deep model for COVID-19 detection (COVID- Net), which obtained 92.4% accuracy in categorizing normal, non-COVID pneumonia, and COVID-19 classes. Ioannis et al evolved the deep learning model using 224 confirmed COVID-19 images. For two and three classes, their model achieved 98.75% and 93.48% success rates. Narin et al obtained a 98% COVID-19 detection correctness using chest X-ray images combined with the ResNet50 model. Sethy and Behera classified the characteristic obtained from different convolutional neural network (CNN) models with a support vector machine (SVM) classifier using X-ray images. From their study we states that the ResNet50 model with the SVM classifier provided the best performance.[9]

In this review, presented an automatic prediction of COVID-19 using a deep convolution neural network-based pre-trained transfer models and chest X-ray images. For this review, we have utilized ResNet50, InceptionV3 and Inception-ResNetV2 pre-trained models to acquire a higher prediction accuracy for small X-ray datasets. The originality of this review is summarized as follows: 1) The proposed model has end-to-end architecture without using any manual feature extraction and selection methods. 2)

We show that ResNet50 is a fruitful pre-trained model among the other two pre-trained models. 3) Chest X-ray images are the finest implement for the detection of COVID-19. 4) The pre-trained models have been shown to submit very high outcomes in the small dataset[23].

In this study, demonstration has been based on a generated dataset with chest X-ray images of 50 normal and 50 COVID-19 patients. In Figure 4 and Figure 5, illustrative chest X-ray images of normal and COVID-19 patients are shown, respectively.

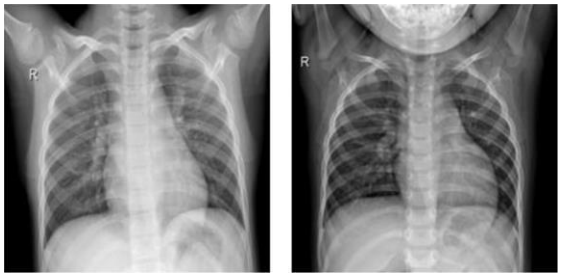

Figure 4. Representative chest X-ray images of normal[23].

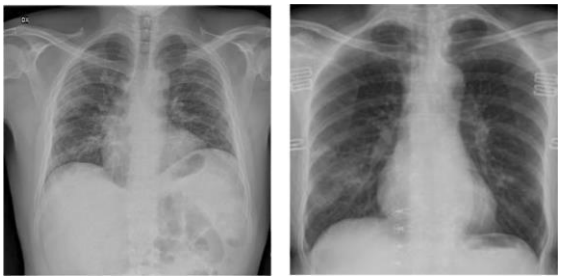

Figure 5. Representative chest X-ray images of COVID-19 patients[23].

2.5 Why Use Chest X-Ray Over Computed Tomography(CT)

X-ray radiographs are advocated because they are readily accessible for disease recognition. They are universally used in health centers worldwide during the pandemic. The model can point out COVID-19 within seconds. Also, when CT is compared to X-ray, the amount of radiation received by the patient is more. Therefore, it is suggested to use a deep learning model with x-ray imagery, as it is more accessible with lower radiation dose as compared to CT[9].

3. ACTIVE MAP CLASSIFICATION

In the first module we detect Covid'19 using Chest X-Ray images and now For the Second Module we have run the Convolution Neural Networks on three Classification problems :

1) Normal Cases vs COVID"19 Cases [Classifying in 2 class problem]
2) Pneumonia Cases vs COVID'19 Cases[Classifying in 2 class problem]
3) Normal Cases vs COVID"19 Cases vs Pneumonia Cases[Classifying in 3 class problem]

We see in some study, people have merged the normal cases and pneumonia cases which is don't find relevant as the model will next make an effort to look the other way the connecting group variance between those two classes and accuracy Hence we obtained won't be an appropriate and relevant measure[17].

We can see that they are presently linearly divisible but if we merge the classes of Normal cases and Pneumonia cases in one main class or we can say in a single class, the divisibility disappear and consequence can be deceiving, therefore if we are merging classes, certain validation acquire to be done. Even so, one might say that predication will keep an eye of that but they won't keep good since we are using Transfer Learning.

Regardless, in this survey the furthermost point is to reduce both false positives and false negatives. In this analysis, we have used Transfer Learning with the VGG-16 model and make small adjustment the last some layers[17].

```
vgg_pretrained_model = VGG16(weights="imagenet", include_top= False,

input_tensor=Input(shape=(224, 224,3)))

new_model = vgg_pretrained_model.output new_model = AveragePooling2D(pool_size=(4,4))(new_model) new_model = Flatten(name="flatten")(new_model) new_model = Dense(64, activation="relu")(new_model) new_model = Dropout(0.4)(new_model)

new_model = Dense(2, activation="softmax")(new_model) model = Model(inputs=vgg_pretrained_model.input, outputs=new_model)
```

The final number of parameters of this model is shown below. The model has been trained using ***Kaggle GPU.[17]***

Total params: 14,747,650

Trainable params: 2,392,770

Non-trainable params: 12,354,880

Case 1: Normal vs COVID-19 classification results[17]

	precision	recall	f1-score	support
covid	1.00	1.00	1.00	16
normal	1.00	1.00	1.00	20
accuracy			1.00	36
macro avg	1.00	1.00	1.00	36
weighted avg	1.00	1.00	1.00	36

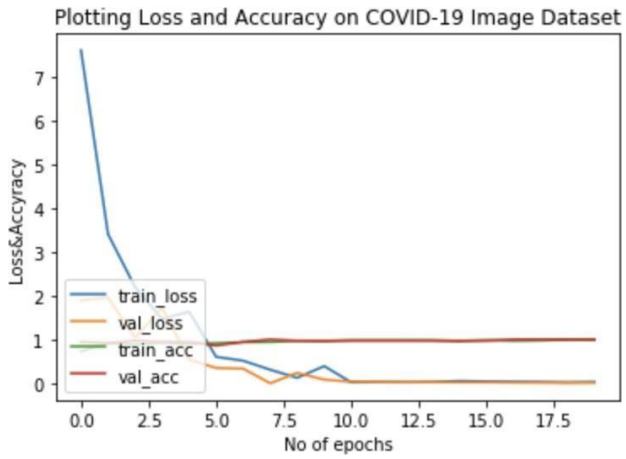

Figure 6. Classification report of the COVID-19 vs Normal model

As we can see distinctly, that the model can give close to 100% accuracy precision and call up differentiate between the two cases. For understanding in the deep, we have used the concept of gradient-based class activation maps to find which is the most significant section of the image that is helping the model to categorize with such accuracy[17].

Now to understand more about how ***gradient-based class activation maps (GRAD-CAM)*** works[16]

$$\alpha_k^c = \overbrace{\frac{1}{Z}\sum_i\sum_j}^{\text{global average pooling}} \underbrace{\frac{\partial y^c}{\partial A_{ij}^k}}_{\text{gradients via backprop}}$$

Figure 7: Gradient-Based Class Activation Maps

The code for plotting the Grad-CAM heatmaps have been given below. Team have done a few modifications in order to have a better view.

```
def get_class_activation_map(ind,path,files) :

img_path = path + files[ind] img = cv2.imread(img_path)

img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB) img = cv2.resize(img, (224, 224))

img = np.expand_dims(img,axis=0)

predict = model.predict(img) target_class = np.argmax(predict[0])

last_conv = model.get_layer('block5_conv3')

grads =K.gradients(model.output[:,target_class],last_conv.output)[0] pooled_grads = K.mean(grads,axis=(0,1,2))

iterate = K.function([model.input],[pooled_grads,last_conv.output[0]]) pooled_grads_value,conv_layer_output = iterate([img])

for i in range(512):

conv_layer_output[:,:,i] *= pooled_grads_value[i] heatmap = np.mean(conv_layer_output,axis=-1) for x in range(heatmap.shape[0]):

for y in range(heatmap.shape[1]):

heatmap[x,y] = np.max(heatmap[x,y],0) heatmap = np.maximum(heatmap,0) heatmap /= np.max(heatmap)

plt.imshow(heatmap)img_gray = cv2.cvtColor(img[0], cv2.COLOR_BGR2GRAY)

upsample = cv2.resize(heatmap, (224,224))

output_path_gradcam = '/kaggle/working/' + files[ind] + 'gradcam.jpeg' plt.imsave(output_path_gradcam,upsample * img_gray)
```

Class activation Map outputs for Normal patients :

So, we can see that the model focusses more on that highlighted section to identify and classify them as normal/healthy patients or we can say negative case of COVID'19.

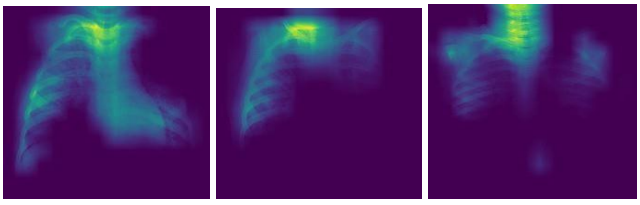

Fig 8: Grad-CAM heatmap for Normal Patients[17]

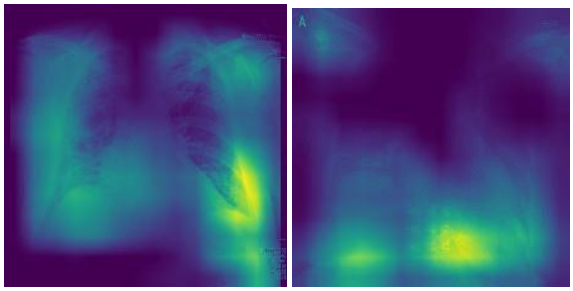

Fig 9: Grad-CAM heatmap for COVID-19 Patients[17]

Similarly, the highlighted part is towards the right-end section of the image which indicates that possible that section is an important feature in determining if the patients have ***COVID-19*** or it can be that ***COVID-19 has affected the patient in section***. This can be validated with the clinical notes[17].

For pneumonia vs COVID-19 classification, we get

0.94 precision of COVID and 0.95 precision of pneumonia this results same for the recall and f-1 score respectively. Support of the COVID is small then pneumonia in terms of number COVID get 16 number where pneumonia get 20 number for the macro average and weighted average we have the same number for precision and recall so in this active map classification of pneumonia and COVID we get quite a different result then the comparison of Normal cases here in the case.2 we can see the results of active map classification that derived from the using GRAD-CAM method[17].

Case 2: Pneumonia vs COVID-19 classification results[17]

	precision	recall	f1-score	support
covid	0.94	0.94	0.94	16
pneum	0.95	0.95	0.95	20
accuracy			0.94	36
macro avg	0.94	0.94	0.94	36
weighted avg	0.94	0.94	0.94	36

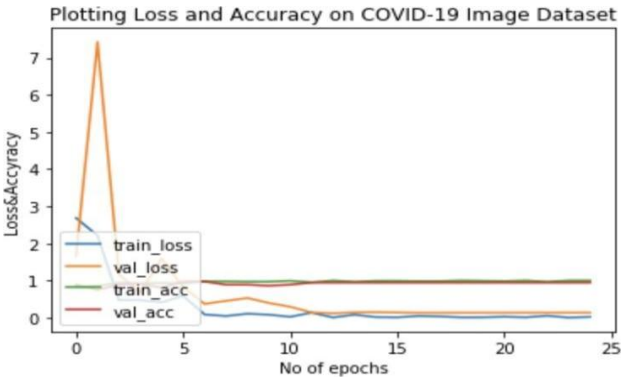

Fig 10: Classification report of the COVID-19 vs Pneumonia model[17]

Case 3: Pneumonia vs COVID-19 vs Normal classification results[17]

	precision	recall	f1-score	support
covid	1.00	0.94	0.97	17
normal	0.84	0.94	0.89	17
pneum	0.90	0.86	0.88	22
accuracy			0.91	56
macro avg	0.92	0.92	0.91	56
weighted avg	0.91	0.91	0.91	56

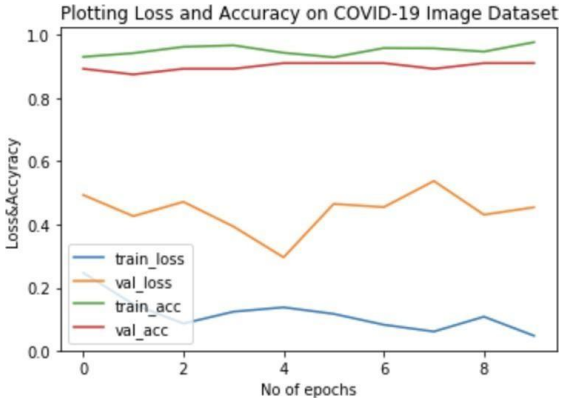

Fig 12: Classification report of the COVID-19 vs Pneumonia vs Normal model[17]

Class activation Map outputs for patients with Pneumonia:

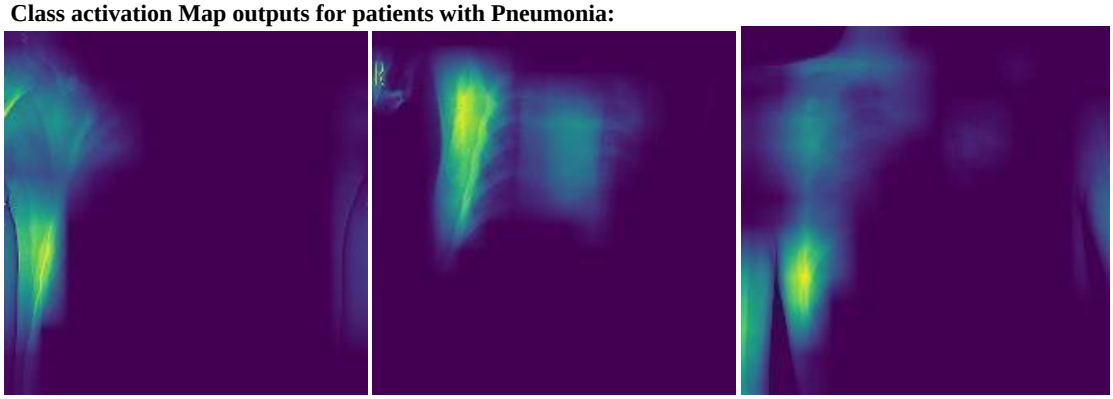

Fig 11: Grad-CAM heatmap for Patients with Pneumonia[17]

For case 2, we
compare pneumonia and COVID classification for the result we get 0.94 precision for CIVD and 0.95 precision for pneumonia also we can see there plotting loss and accuracy data set of COVID-19 after that we can see the classification of the active map in terms of comparison pneumonia and COVID.now we compare all three classification problems: Normal vs pneumonia vs COVID.

In all three cases, the model has performed significantly well even with this small dataset. Moreover, the purpose of building three different models was also to check the **model consistency** with respect to the detection of the ***COVID-19*** cases. In all three cases, both the precision and recall have been significantly high for ***COVID-19*** cases in test data. But, there is a huge potential to this approach and can be an excellent method to have an ***efficient, fast, diagnosis system*** which is the need of the hour[17]. The major advantages have been listed below[15] :

Advantages :

1. Shipping the test or the sample is one of the shortcomings of PCR tests whereas X-ray machines can solve the problem.

2. If a situation comes when the radiologists & doctors get affected, AI can generate preliminary diagnosis to understand if a patient isaffected/not.

The proposed model can be used for the diagnosis of COVID-19 using Chest X-Ray(CXR). We used CXR because it gives results in the seconds and widely used in health centers worldwide during a pandemic.CT is a costly process and not readily accessible as they are usually only the local health centers also it's not given that much accuracy in comparison of CXR images. Here we make some comparison of the method already used by the researches and also compare with the model accuracy

Table.1 Comparison of COVID-19 Method

Study	Types of Images	Method Used	Accuracy (%)
Ying et al[18]	Chest CT	DRE-Net	86
Wang et al.[19]	Chest CT	M-Inception	82.9
Xu et al.[20]	Chest CT	ResNet+Location Attention	86.7
Tulin Ozturk[9]	Chest X-Ray	DarkCovidNet	87.2
Proposed Study	Chest X-Ray	**COVID-CAM**	**90.20**

4. CONCLUSION

In this study, we have proposed an Artificial Intelligence-based model to detect and classify COVID-19 cases from Chest X-Ray Images(CXR). We are able to get about 90% accuracy of our model for the detect COVID-19 also in this paper we make two

modules of our model first model works on the detect COVID-19 using Chest X-ray over Chest CT images and our second module is active map classification for the get accuracy of our model. The limitation of this study is we use the limited number of Chest X-Ray Images and also applied for the local base health centers In the future, there are many new methods invent so that we will get high accuracy in the future and solve the pandemic COVID-19 all over the world. We intend to make our model robust and accurate by using such images from the local health center in the future.

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