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COVID-19 Detection From CHEST X-Ray Images Using Convolutional Neural Network & MATLAB

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***Abstract*— This is a proposal for an automated detection and remote monitoring system based on CNN, Mobile-Net and MATLAB software. This network will be deployed to monitor a population settling in a target area (cities, region, country, etc.). The goal of this system is the detection and early diagnosis of the disease in people infected with the COVID-19 virus, using a device (such as a bracelet or a chest strap). This device collects in real time all the necessary biomedical measurements of a person, including their location, freeing them from any hospitalization or use of complex and expensive equipment. These information are then transmitted, via a wireless connection, to a regional or national control center which takes care of its storage in a specialized database. This center executes a decision-making algorithm using artificial intelligence and fuzzy inference engine to detect accurately each possible abnormal change in the supervised biomedical signs reflecting risk factor or indicating the appearance of symptoms characterizing COVID-19 disease. In the positive case, the control system triggers a warning alarm concerning this infected person and requests intervention of the competent authorities to take the necessary measures and actions. Computer simulations with Matlab software tool have been conducted to evaluate the performance of the proposed system. Study findings show that the designed device is suitable for application in COVID-19 patient monitoring.**

***Keywords*—COVID-19, Pneumonia, X-Ray, Convolutional Neural Networks, Coronavirus**

I. INTRODUCTION

At the end of 2019, humankind was faced with an epidemic—severe acute respiratory syndrome coronavirus 2 (SARS CoV-2)–related pneumonia, referred to as coronavirus disease 2019 (COVID-19)—that people did not expect to encounter in the current era of technology. While the COVID-19 outbreak started in Wuhan, China, the significant spread of the epidemic around the world has meant that the amount of equipment available to doctors fighting the disease is insufficient. At the time of writing (September 8, 2020), there have been more than 27,000,000 confirmed cases and more than 875,000 confirmed deaths worldwide.1 Considering the time required for diagnosis and the financial costs of the laboratory kits used for diagnosis, artificial intelligence (AI) and deep learning research and applications have been initiated to support doctors who aim to treat patients and fight the illness.2 Although rapid point-of-care COVID-19 tests are expected to be used in clinical settings at some point, for now, turnaround times for COVID-19 test results range from 3 to more than 48 hours, and probably not all countries will have access to those test kits that give results rapidly. According to a recently published multinational consensus statement by the Fleischner Society, one of the main recommendations is to use chest radiography for patients with COVID-19 in a resource-constrained environment when access to computed tomography (CT) is limited.3 The financial costs of the laboratory kits used for diagnosis, especially for developing and underdeveloped countries, are a significant issue when fighting the illness. Using X-ray images for the automated detection of COVID-19 might be helpful in particular for countries and hospitals that are unable to purchase a laboratory kit for tests or that do not have a CT scanner. This is significant because, currently, no effective treatment option has been found, and therefore effective diagnosis is critical.

II. LITERATURE REVIEW

Manoj, Mk, et al. "An Incentive Based Approach for COVID-19 planning using Blockchain Technology".

2020 IEEE Globecom Workshops (GC Wkshps. IEEE, 2020 [1].The current situation of COVID-19 requires new solutions to improve health services and economic growth. A comprehensive solution that can help government and individuals to maintain their normal way of life and develop their economy is important. By bringing to the picture a unique approach based on motivation, the form of government and the people can be greatly reduced. By providing motivation for actions such as voluntary testing, segregation, etc., the government can better plan strategies to combat the situation while people in need benefit from the encouragement provided. This idea of combining strength to fight the virus could open up new opportunities that could give a higher hand in this battle. As the unpredictable future develops, sharing and maintaining COVID-related data for every user can be a necessary start-up for the economy and the blockchain paves the way for this solution through data separation and consistency. As the unpredictable future develops, sharing and maintaining COVID related data of every user could be the needed trigger to kick start the economy and blockchain paves the way for this solution with decentralization and immutability of data.

Zhang Weishan, et al. "Integrated study based on Dynamic fusion for COVID-19." IEEE Internet of Things Journal 2021 [2]. Diagnostic imaging of a medical diagnosis (e.g., CT scan or X-Ray) using machine learning is an effective and accurate way to diagnose COVID-19 infections. However, sharing of diagnostic images at all medical facilities is generally not permitted due to patient privacy concerns. This causes the problem of insufficient data sets to train the image classification model. Integrated learning is an emerging privacy learning machine paradigm that produces a global impartial model based on customer-generated location model updates without the exchange of customer location data. However, the automatic configuration of shared reading introduces significant communication costs for transmitting model updates and cannot guarantee model performance if there is a strong diversity of clients. In order to improve communication efficiency and performance of models, in this article, we propose a flexible novel-based organization-based learning approach to the analysis of clinical diagnostic images for the diagnosis of COVID-19. First, we design the architecture of integrated fusion-based study programs to analyze medical diagnostic images. In addition, we introduce a flexible integration approach to strongly determine participating clients based on the performance of their local model and plan model integration based on the training time of participating clients. In addition, we summarize the category of data sets for clinical diagnostic images of COVID-19 detection, which can be used by the machine learning community for image analysis. The results of the experiments indicate that the proposed method is feasible and more efficient than the default set of integrated learning about model performance, communication efficiency, and error tolerance.

Liu, Boyi, et al."Combined study study of covid-19 chest x-ray images." IEEE conference on computer vision and pattern recognition, 2020 [4],
AI plays a key role in the identification of COVID-19. Computerized visualization and in-depth study methods can help determine COVID-19 infection with Chest X-ray Images. However, in order to protect and respect the privacy of patients, certain hospital-related medical data did not allow for leaks and sharing without permission. Gathering such training details was a major challenge. To some extent, this has resulted in a lack of sufficient data samples when in-depth study methods were developed for COVID-19. Federated Learning is an available way to deal with this issue. It can effectively deal with the issue of data silo and detect shared model without access to location data. In practice, we propose the use of integrated learning in COVID-19 data training and use tests to ensure efficiency. We also compare the performance of four popular models (MobileNet, ResNet18, MoblieNet, and COVIDNet) with an integrated learning framework and without framework. This work aims to encourage further research into organizational learning about COVID-19.

Otoom Mwaffaq, et al. ” IoT-based framework for early detection and monitoring of COVID-19 cases ”. International Conference on Biomedical Signal Processing and Control 62 IEEE with a computer vision 2020 [7], The world has been facing the challenge of COVID-19 since the end of 2019. It is expected that the world will need to fight the COVID-19 epidemic with precautionary measures, until an effective vaccine is developed. This paper proposes a real-time detection and monitoring system for COVID-19. The proposed system will use the Internet of Things (IoTs) framework to collect real-time symptomatic information for users to quickly identify suspected cases of coronavirus, monitor the treatment response of those already infected, and understand the nature of the virus. virus by collecting and analyzing relevant data. The framework consists of five main components: Symbol and Loading Data Collection (using wearable sensors), Separation / Separation Center, Data Analysis Center (using machine learning algorithms), Health Physicians, and Cloud Infrastructure. To quickly identify potential coronavirus conditions in this real-time signal data, this function proposes eight machine learning algorithms, namely Support Vector Machine (SVM), Neural Network, Naïve Bayes, K-Nearest Neighbor (K-NN), Decision Table , Decision Stump, OneR, and ZeroR. A test was performed to test these eight algorithms on the COVID-19 signaling database, after selecting the appropriate signals. The results show that five of the eight algorithms achieved more than 90% accuracy. Based on these results we believe that real-time signal data will allow these five algorithms to provide effective and accurate identification of potential COVID-19 cases, as well as the framework.

III.PROBLEM IDENTIFICATION

Covid-19 is a rapidly spreading viral disease that infects not only humans, but animals are also infected because of

this disease. The daily life of human beings, their health, and the economy of a country are affected due to this deadly viral disease. Covid-19 is a common spreading disease, and till now, not a single country can prepare a vaccine for COVID-19. A clinical study of COVID-19 infected patients has shown that these types of patients are mostly infected from a lung infection after coming in contact with this disease. Chest x-ray (i.e., radiography) and chest CT are a more effective imaging technique for diagnosing lunge related problems. Still, a substantial chest x-ray is a lower cost process in comparison to chest CT. Deep learning is the most successful technique of machine learning, which provides useful analysis to study a large amount of chest x-ray images that can critically impact on screening of Covid-19. In this work, we have taken the PA view of chest x-ray scans for covid-19 affected patients as well as healthy patients. After cleaning up the images and applying data augmentation, we have used deep learning-based CNN models and compared their performance. We have compared Inception V3, Xception, and ResNeXt models and examined their accuracy.

The paper presents an alternative modeling framework based on Convolutional Neural Networks, referred to as the CNN, being capable of handling small datasets, which is of significant importance due to sudden and rapid emergence of COVID-19. Our results based on a dataset of X-ray images show that ResNet-50 has advantage over previous CNN-based models. ResNet-50 achieved an Accuracy of 95.7%, Sensitivity of 90%, Specificity of 95.8%, and Area Under the Curve (AUC) of 0.97, while having far less number of trainable parameters in comparison to its counterparts. To potentially and further improve diagnosis capabilities of the ResNet-50, pre-training and transfer learning are utilized based on a new dataset constructed from an external dataset of X-ray images. This is in contrary to existing works on COVID-19 detection where pre-training is performed based on natural images. Pre-training with a dataset of similar nature further improved accuracy to 98.3% and specificity to 98.6%.

There are still various problems with automatic Covid-19 Detection systems. The most common challenge they image is the non-uniformity of Covid-19 Detection models for different cities and countries. Their length may also vary. That's why the software must be customized to the place it's being used in.

3.1 METHODOLOGY

Covid-19 The various deep learning methods use data to train neural network algorithms to do a variety of machine learning tasks, such as the classification of different classes of objects. Convolutional neural networks are deep learning algorithms that are very powerful for the analysis of images. This article will explain to you how to construct, train and evaluate convolutional neural networks. You will also learn how to improve their ability to learn from data, and how to interpret the results of the training. Deep Learning has various applications like image processing, natural language processing, etc. It is also used in Medical Science, Media & Entertainment, Autonomous Cars, etc.

CNN is a powerful algorithm for image processing. These algorithms are currently the best algorithms we have for the automated processing of images. Many companies use these algorithms to do things like identifying the objects in an image.

Images contain data of RGB combination. Matplotlib can be used to import an image into memory from a file. The computer doesn't see an image, all it sees is an array of numbers. Color images are stored in 3-dimensional arrays. The first two dimensions correspond to the height and width of the image (the number of pixels). The last dimension corresponds to the red, green, and blue colors present in each pixel.

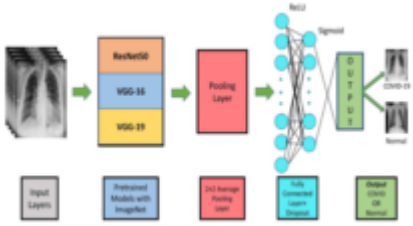


Fig. 1 Flow of Covid-19 Detection By CNN

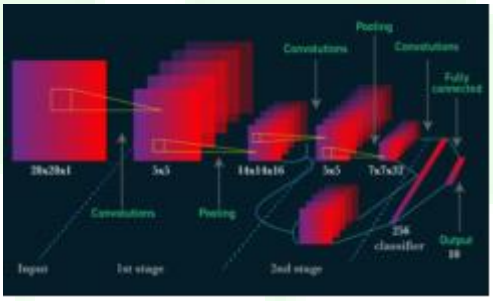


Fig. 2 Architecture of CNN Technique

The dataset of this work has been collected from Kaggle repository , which contains Chest X-Ray scans of Covid-19 affected, normal and pneumonia. This collected dataset is not meant to claim the diagnostic ability of any Deep Learning model but to research about various possible ways of efficiently detecting Coronavirus infections using computer vision techniques. The collected dataset consists of 6432 total chest X-ray images. This data set is further divided into training (i.e., 5467) and validation (i.e., 965) set of normal, covid, and pneumonia. In the training set, 1345 is normal, 490 are covid, and 3632 is pneumonia. In the validation phase, 238 samples of a normal case, 86 covid, and 641 of pneumonia were considered for this analysis.

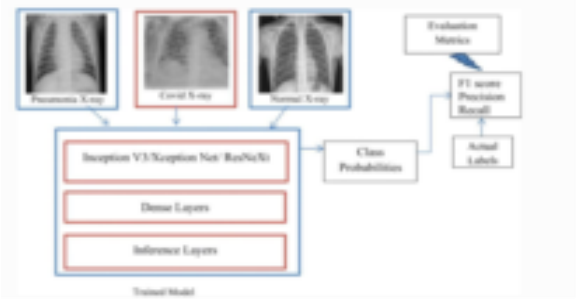


Fig. 3 Proposed model for chest X-ray dataset evaluation

IV. IMPLEMENTATION WORK

It is the largest category for an RNA virus. In most cases, it is difficult to detect if coronavirus or a different cold-causing virus is causing you fever. Known as "COVID-19", the newly identified coronavirus can cause pneumonia, and like other respiratory infections, it has an incubation of between 1 and 14 days. There are different types of model for features extraction for Covid-19: There are various technique used to detect Covid-19.

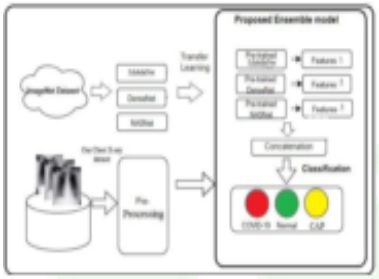


Fig. 4 Schematic illustration of our model

4.1 DenseNet: Introduced in the year 2018 by Huang et. al. [17], densely connected Covolutional Network connects each layer in a network to every other layer in a feed-forward style. This revolutionary work made possible to design more deeper and more accurate Convolutional Neural Network.

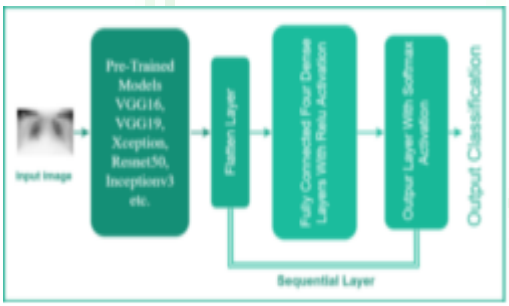


Fig. 5 Structure of X-Ray classification CNN

4.2 Data pre-processing

For pre-processing Zero mean normalization is used to get rid of uneven lighting condition and also to make all input pixels values between 0 and 1 and thus speeding up the convergence of the training model .

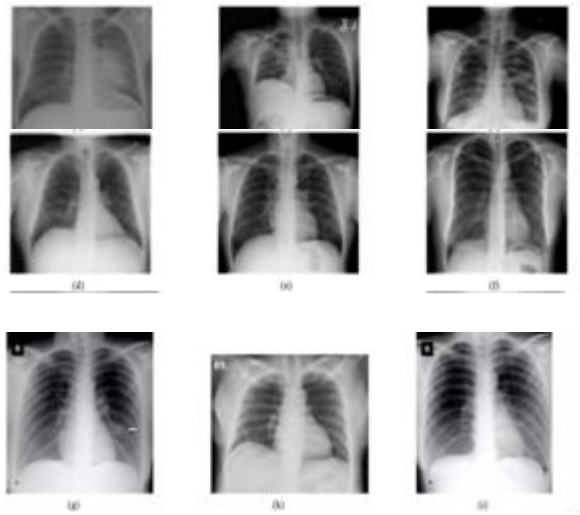


Fig. 6 : Example of Chest X-Ray images as given in Cohen et. al. first row shows CAP, second row shows the normal and the third row shows the COVID-19 cases

4.3 How Deep Learning is different from Machine Learning :-

Deep learning is a part of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised. In deep learning, a computer model learns to perform classification tasks directly from images, texts, or numeric data. MATLAB provides you an app to select the best algorithm for your data. It is called classification app learner for classification and regression app learner for regression, in the case of machine learning.

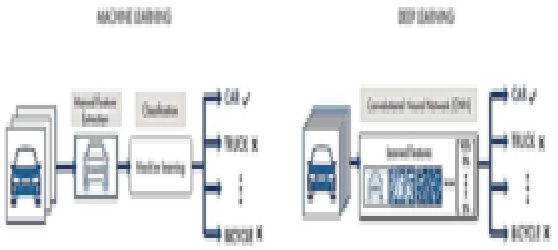


Fig. 7 Machine Learning and deep Learning

In the case of machine learning, if I have to detect different kinds of vehicles, then first I will extract features of the vehicles and these features will be input for my machine learning algorithm. In the case of deep learning there are hidden layers, which will extract features from different kinds of vehicles automatically and based on these features it will learn about types of cars.

4.4 Workflow

We will follow the workflow below for a deep learning model on COVID-19.

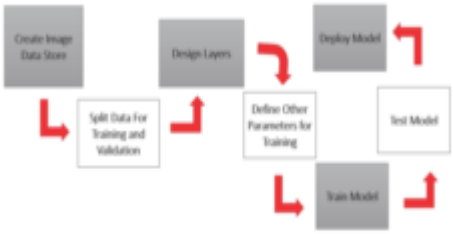


Fig. 8 Workflow

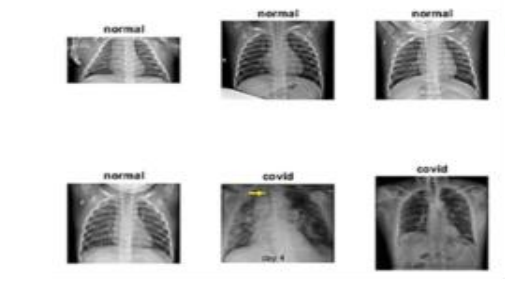
First we will create an image data store. We will save images in two different sub-folders by class name. In covid sub-folder infected X-ray images will be saved and in normal sub-folder uninfected X-ray images will be saved. We will split data for training and testing. To get the accuracy, testing is important. Next we will modify ResNet-50 network according to our data. Because in ResNet-50 millions of images are trained with 1000 of classes. In our case we have 798 images with 2 classes. Next step is to define training parameters, like what will be initial learning rate, maximum number of epochs and batch size etc. Further we will train our model and optimize hyper parameters if it is required. When the model is trained we will test the model on testing dataset to check its accuracy.

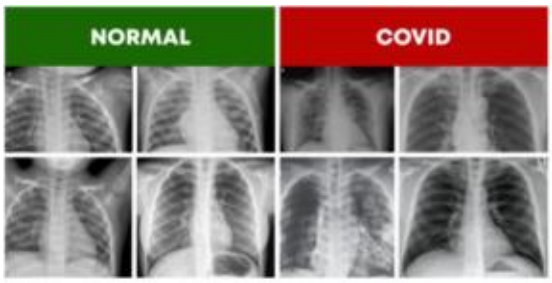
If everything works fine you can further deploy your model on a hardware for real time application.

V. SIMULATION RESULT

5.1 Simulation Result

5.1.1 Normal and Covid-19 X-ray images





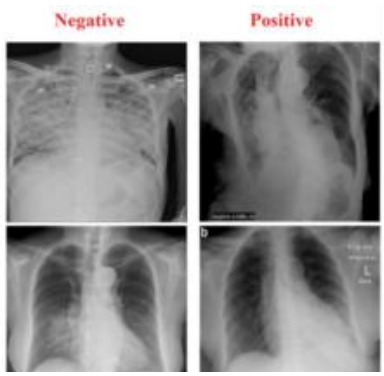


Fig. 9 Positive and Negative Covid-19 X- ray images

5.2 Our COVID-19 patient X-ray image dataset

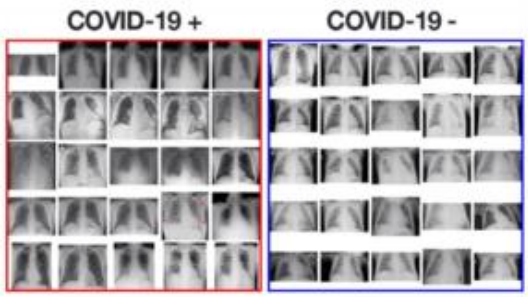


Fig. 10 Positive and negative Covid-19 X- ray images

A. DATASET USED: 1000 Chest X-ray images were collected from publicly available COVID Chest X-ray dataset.

Fig. 11 Sample Chest X-ray from dataset

B. EXPERIMENTAL SETUP: INTEL CORE i7 8th Gen Processor with 8GB RAM and 4GB NVIDIA GPU. PyTorch was used for training and testing the model with all the necessary packages mainly FastAI v2.

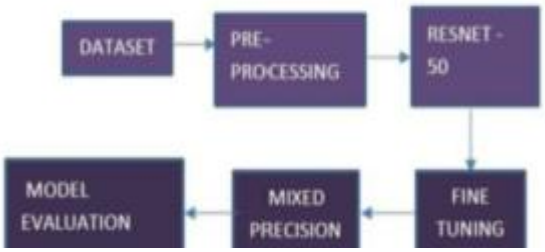


Fig. 12 PROPOSED METHODOLOGY

Pre-Processing includes resizing image to 100*100 with splitting 80% of samples from dataset for training and rest for testing. Data augmentation methods like rotation, zoom, cropping were used in order to create more complexity in image block. This will help the model to learn more features from the data.

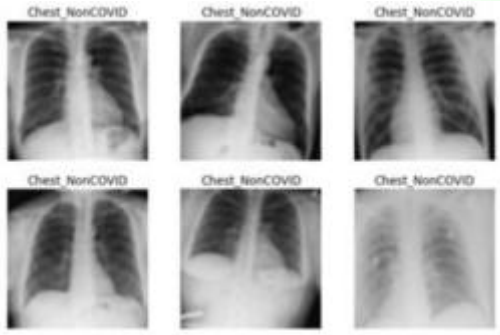


Fig . 13 Data Block Visualization

RESNET 50 – RESNET uses residual blocks that mainly includes skip connections which is a shortcut path for gradient flow. This reduces issues like vanishing gradient even if the network is too deep. Element-wise addition of gradient is carried out in residual blocks .

VI. CONCLUSION

Early prediction of COVID-19 patients is vital to prevent the spread of the disease to other people. In this study, we proposed a deep transfer learning-based approach using chest X-ray images obtained from normal, COVID-19, bacterial and viral pneumonia patients to predict COVID-19 patients automatically. Performance results show that ResNet50 pre-trained model yielded the highest accuracy among five models for used three different datasets (Dataset-1: 96.1%, Dataset-2: 99.5% and Dataset-3: 99.7%). In the light of our findings, it is believed that it will help radiologists to make decisions in clinical practice due to the higher performance. In order to detect COVID-19 at an early stage, this study gives insight on how deep transfer learning methods can be used. In subsequent studies, the classification performance of different CNN models can be tested by increasing the number of COVID-19 chest X-ray images in the dataset. This work focused on the working principle of transfer learning and explored the use of Pretrained model Resnet-50 on chest X-rays. This study shows how use of these concepts in medical image processing and AI will help in fast and reliable detection of COVID-19 with extreme accuracy. So, it is believed that this will contribute in overcoming the current diagnosing and screening problems for COVID-19 detection as it seems like the pandemic is not stopping soon. The proposed model obtained best results with 96 % accuracy and it proved to be very sensitive and specific to the dataset.

The framework presented in this manuscript uses an ensemble of three most common and up-to-date DCNN structures for detection and classification of Chest X-Ray images. The combination of features extracted from the three DCNN structures namely NASNet, MobileNet and DenseNet leads to a better generalization performance than single classifier as counterparts. The results obtained by our framework not only outperformed the individual DCNN architectures but also some of the state-of-the-art models presented in the literature.

And most importantly the ensemble model takes a little over one second to classify the input test images, whereas each of the individual models takes less than a second. But this little delay can be afforded when accuracy of the model is our priority.With the increasing number of cases, it is also important to ensure that no single COVID-19 patient goes undetected. The proposed method can assist the radiologists to have a deeper understanding of the critical aspects related to COVID-19. We strongly believe that once more training data becomes available, the accuracy will go up.

This research deals with the problem of COVID-19 disease detection and monitoring. An intelligent algorithm for its accurate diagnosis has been studied to avoid this issue. The proposed solution approach is based on different technologies. Effectively, the suggested diagnosis approach correctly treats the problem with satisfactory performance. In addition, the proposed system constitutes an effort toward the design of an intelligent, flexible and integrated fuzzy logic based home healthcare system. Simulation results proves the COVID-19 detection accuracy and the knowledge extraction feasibility.

6.1 FUTURE SCOPE

Covid-19 pandemic is a growing manifold daily. With the ever-increasing number of cases, bulk testing of cases swiftly may be required. In this work, we experimented with multiple CNN models in an attempt to classify the Covid-19 affected patients using their chest X-ray scans. Further, we concluded that out of these three models, the X Ceptionnet has the best performance and is suited to be used. We have successfully classified covid-19 scans, and it depicts the possible scope of applying such techniques in the near future to automate diagnosis tasks. The high accuracy obtained may be a cause of concern since it may be a result of overfitting. This can be verified by testing it against new data that is made public shortly. In the future, the large dataset for chest X-rays can be considered to validate our proposed model on it. It is also advised to consult medical professionals for any practical use case of this project. We

do not intend to develop a perfect detection mechanism but only research about possible economically feasible ways to combat this disease. Such methods may be pursued for further research to prove their real case implementation. Furthermore, it is concluded from the obtained outcomes that the proposed remote diagnosis task has been accomplished successfully in real-time. This promotes the experimental validation and evaluation of the system of the performance in a university hospital center with COVID-19 patients. As perspectives, we proposed to extend this work to establish a comparative study towards other types of fuzzy inference engine : Tsukamoto, Takagi-Sugeno and ANFIS for an accurate diagnosis of COVID-19. At present health of the individuals in the entire world is getting affected at an alarming rate. It is very difficult to test a large number in a short time to curb the spread of the disease. Major points to worry for the governments are with false- negative results. Here suggested proposed methodology proved to best for classification of covid-19 patients which used convolution neural network and Mobile Net with maximum F1 score. Future work suggests the development of the architecture for large amounts of datasets too.

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