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Deep learning approaches for COVID -19detection based on chest X-ray images

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ABSTRACT: Safety and cost play the most important role in Today's world. COVID-19 hascaused great loss in all over the world. There are many people who died because of thisvirus, in that few died without treatment because they were not able to afford for thetreatment. Due to the expensive test kits many people are avoiding to check whether theyare corona positive or negative. So, in this project the model would predict whether corona is present or not in a person using binary classification. This model would easily predict and its affordable compared to the test kits. This model would predict correctdecision. The deep-learning-based approaches would be used in this model. Deeplearning technique like CNN is used in the project additionally traditional machinelearning algorithm such as SVM . The data set has been fetched from Kaggle,Githuband it would be divided into training and testing images. The images which are usedwould be classified as normal or COVID-19. We are comparing the accuracy resultsobtained by the classification model.

KEYWORDS- Deep learning, Artificial Intelligence, Chest X-ray image, Machine learning ,Image preprocessing, COVID-19, Convolutional netural network.

I. INTRODUCTION

COVID-19 is a disease which manifests as an upper respiratory tract and lung infection, was first investigated in the Wuhan province of China in late 2019, and is mostly seen to affectthe airway and consequently the lungs. COVID-19 can be severe, and some cases have caused death. It isa disease which can spread from person to person. researchers have identified that the new coronavirusis spread through droplets released into the air when an infected person coughs or sneezes.

SARS stands for severe acute respiratory syndrome. In 2003, an outbreak of SARS started in China andspread to other countries before ending in 2004. The virus that causes COVID-19 is similar to the onethat caused the 2003 SARS outbreak: both are types of Coronaviruses, but COVID-19 seems to spreadfaster than the 2003 SARS and also may cause less severe illness.So COVID-19 is identified using chest X-ray image as input for the Deep learning model. Since Chest X-rayimages are known to have potential in the monitoring and examination of various lung diseases such astuberculosis, infiltration, atelectasis, pneumonia, and hernia and the virus has since spread rapidly tobecome a global pandemic with numbers of cases. Chest X-ray images have shown to be useful infollowing-up on the effects that COVID-19 causes to lung tissue.

The major motivation of the project is to facilitate the people an efficient andaffordable way for predicting whether they are having corona or not. Since the corona testkits are costly and many people cannot afford for it. So, this project is to help the doctorsas well as public to identify corona positive or corona negative patients in a cost-effectiveway. Sometimes the test kit predicts the corona negative patient as positive or vice-versawhereas this model would be trained in an efficient way for predicting the correct results.Sometimes there might be a shortage of test kits in such cases our model would be anefficient way for detecting corona positive or negative. This model can be used even inthe remote areas for detecting corona positive or negative. This model can be used in theareas where there is shortage of test kits. It can be used in the remote areas where the public can't afford for the expensive test kits.So we are creating a model using deep learning techniques. In our paper we would be detailing what isdeep learning and how it is used for COVID-19 prediction. So before going to deep learning we shouldknow deep learning is a part of Artificial Intelligence(AI).

Artificial intelligence (Artificial intelligence (AI) refers to the simulation of human intelligence inmachines that are programmed to

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think like humans and mimic their actions. The termmay also be applied to any machine which exhibits traits associated with a human mindsuch as learning and solving problems. AI covers everything related to making machinessmarter.ML refers to an AI system that can self-learn based on the algorithm and it’s thesystems that get smarter and smarter over time without human intervention. DeepLearning (DL) is machine learning (ML) applied to large data sets. Deep Learning is asubset of machine learning (AI) refers to the simulation of human intelligence inmachines that are programmed to think like humans and mimic their actions. The termmay also be applied to any machine which exhibits traits associated with a human mindsuch as learning and solving problems. AI covers everything related to making machinessmarter.ML refers to an AI system that can self-learn based on the algorithm and it’s thesystems that get smarter over time without human intervention.

DeepLearning (DL) is a subset of machine learning (ML) that can be applied to large data sets.As discussed above Machine learning is an application of artificial intelligencethat provides systems the ability to automatically learn and improve from their ownexperience without being explicitly programmed. Machine learning focuses on thedevelopment of computer programs that can access data and use it to learn for themselves.Machine learning involves computers discovering how they can perform tasks without being explicitly programmed. It involves computers learning from the data which is provided so that they carry out certain tasks. For simple tasks assigned to computers, it is possible to program algorithms and telling the machine how to execute all steps requiredto solve the problem on the computer's part, no learning is needed in such cases. But whena more advanced task is given, it can be challenging for a human to manually create theneeded algorithms and provide them to the machine to help the machine in execution. Itwould be more effective to help the machine develop its own algorithm, rather than havinghuman programmers specify each and every needed step. Therefore, the discipline ofmachine learning employs various approaches to teach computers to accomplish taskswhere no fully satisfactory algorithm is available.

Machine learning approaches are divided into following category:
1.Supervised learning
2.Unsupervised learning
3.Reinforcement learning
4.Deep learning
5.Deep Reinforcement learning

Deep Learning

Deep learning is also called Deep Structured Learning and it is part of the MachineLearning method. The major difference between deep learning and machine learning isthat in machine learning feature extraction is to be done manually whereas in deeplearning we do not need to manually extract features from the image. The network learnsto extract features while training. We just need to feed the image to the network.

Deep learning is generally a class of machine learning techniques that exploitmany layers of non-linear information processing for supervised or unsupervised featureextraction and transformation, for pattern analysis and classification. It consists of manyhierarchical layers to process the information in a non-linear manner, where some lower-the level concept helps to define the higher-level concepts. It offers human-like multi-layeredprocessing in comparison with the shallow architecture. The basic idea of deep learningis to employ hierarchical processing using many layers of architecture. The architecturelayers are arranged hierarchically. After several pre-training, each layer’s input goes to itsadjacent layer. Many times, such pre-training of a selected layer executed in anunsupervised way. Deep Learning comes under Supervised Learning. SupervisedLearning is a concept of the Machine Learning technique where the function maps the inputto output based on the input-output pairs. Supervised Learning learns from the trainingdataset and provides output based on the training dataset. By increasing the number oftraining datasets, we can get better accuracy and performance.

Deep learning architectures such as deep neural networks,recurrent neural networks and convolutional neural networks can be used in differentfields such as computer vision, speech recognition, natural language processing, audiorecognition, social network filtering, machine translation, bioinformatics, drug design,medical image analysis, material inspection, and board game programs, where they haveproduced results comparable to and in some cases surpassing human expert performance.In Deep Learning each level learns to transform its input data into a slightly moreabstract and composite representation. In an image recognition application, the raw inputmay be a matrix of pixels; the first representational layer may abstract the pixels andencode edges; the second layer may compose and encode arrangements of edges; the thirdlayer may encode a

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nose and eyes, and the fourth layer may recognize that the imagemcontains a face. Importantly, a deep learning process can learn which features to optimallyplace in which level on its own.

We have various deep learning model. They are:
1.Autoencoder
2.Deep Belief Net
3.Recurrent Neural Network
4.Convolutional Neural Network

Convolutional Neural Network:

A convolutional neural network (CNN) is another variant of the feedforwardmultilayer perceptron. It is a type of feedforward neural network, where the individualneurons are ordered in a way that they respond to all overlapping regions in the visualarea.

Deep CNN works by consecutively modelling small pieces of information andcombining them deeper in the network. One way to understand them is that the first layerwill try to identify edges and form templates for edge detection. Then, the subsequentlayers will try to combine them into simpler shapes and eventually into templates ofdifferent object positions, illumination, scales, etc. The final layers will match an inputimage with all the templates, and the final prediction is like a weighted sum of all of them.So, deep CNNs can model complex variations and behavior, giving highly accuratepredictions. Such a network follows the visual mechanism of living organisms. The cellsin the visual cortex are sensitive to small subregions of the visual field, called a receptivefield. The subregions are arranged to cover the entire visual area, and the cells act as localfilters over the input space. The backpropagation algorithm is used to train the parametersof each convolution kernel. Further, each kernel is replicated over the entire image withthe same parameters. There are convolutional operators which extract unique features ofthe input. Besides the convolutional layer, the network contains a rectified linear unitlayer, pooling layers to compute the max or average value of a feature over a region ofthe image, and a loss layer consisting of application-specific loss functions. Imagerecognition and video analysis and natural language processing are major applications ofsuch a neural network.

The area of computer vision has witnessed frequent progresses in the past fewyears. One of the most stated advancements is CNNs. Now, deep CNNs form the core ofmost sophisticated fancy computer vision applications, such as self-driving cars, gesturerecognition, auto-tagging of friends in our Facebook pictures andautomatic number plate recognition, facial security features.

Image Processing

Image processing is a method to perform some operations on an image, in orderto get an enhanced image or to extract some useful information from it. It is a type ofsignal processing in which input is an image and output may be image orcharacteristics/features associated with that image.Image processing -> Optimization problemMachine Learning->Effective tool to solve Optimization problem.

II. LITERATURE SURVEY

COVID-19 detection from chest X-Ray images using Deep Learning and CNN Antonios Makris, Ioannis Kontopoulos, Konstantinos TserpesA dataset was created as a mix of publicly available X-ray images from patientswith confirmed COVID-19 disease, common bacterial pneumonia and healthyindividuals. To mitigate the small number of samples, they employed transfer learning,which transfers knowledge extracted by pre-trained models to the model to be trained.The experimental results demonstrated that the classification performance can reach anaccuracy of 95%.

Classification of COVID-19 in chest X-ray images using DeTraC deep CNNAsmaa Abbas, Mohammed M. AbdelsameaTransfer learning is an effective mechanism that can provide a solution bytransferring knowledge from generic object recognition tasks to domain-specific tasks.

In this paper a deep CNN called Decompose, Transfer, and Compose (DeTraC), for the classification of COVID-19 chest X-ray images. DeTraC can deal with any irregularities in the image dataset by investigating its class boundaries using a class decompositionmechanism. High accuracy of 93.1% was achieved.

Automatic detection of COVID-19 infection using chest X-ray imagesthrough transfer learningElene Firmeza Ohata, Gabriel Maia Bezerra, Joao Victor Souza das ChagasTransfer learning method is used. The different architectures of convolutionalneural networks (CNNs) trained on ImageNet and adapt them to behave as featureextractors for the X-ray images. Then the CNNs are combined with consolidated machinelearning methods such as k-Nearest Neighbor, Bayes, Random Forest, multilayer perceptron (MLP) , and support vector machine (SVM) .The results show that, for oneof the datasets, the extractor-classifier pair with the best performance is the Mobile Netarchitecture with the

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SVM classifier using a linear kernel, which achieves an accuracyand an F1-Score of 98.5%. For the other dataset, the best pair is DenseNet201 with MLP,achieving an accuracy and an F1-Score of 95.6%.

Deep Learning-Based Decision-Tree Classifier for COVID-19 Diagnosis froChest X-ray ImaginSeung Hoon Yoo, Hui Geng, Tin Lok Chui

The proposed classifier comprises three binary decision trees, each trained by adeep learning model with convolution neural network based on the PyTorch frame. Thefirst decision tree classifies the CXR images as normal or abnormal. The second treeidentifies the abnormal images that contain signs of tuberculosis, whereas the third does the same for COVID-19. The accuracies of the first and second decision trees are 98 and 80%, respectively, whereasthe average accuracy of the third decision tree is 95%.

COVID-19 Detection from Chest X-Ray Images Using CNNs ModelsMohamed Samir BoudriouaFurther Evidence from Deep Transfer Learning -Deep transfer learning is used.They fine-tune three pre-trained deep convolutional neural networks (CNNs) models ona training dataset; Dense Net 121, NASNetLarge and NASNetMobile. The evaluation ofour models on a test dataset shows that these models achieve a sensitivity rate of around99.45 % on average, and a specificity rate of around 99.5 % on average.

III. EXISTING SYSTEM

The existing system consist of Deep learning technique like Convolutional Neural Network (CNN) andMachine learning algorithm Support Vector Machine (SVM) is used. In CNN they have used many modellike ResNet-18,ResNe-t50,ResNet-101,VGG-16,VGG-19 for getting higher accuracy.

IV. PROPOSED METHOD

In the proposed method we have used Resnet-18,ResNet-34,ResNet-50,ResNet-101,VGG-16,VGG-19.Wehave included the ResNet-34 so that the system will be strong and accuracy rate will be increased as weare increasing the layers.

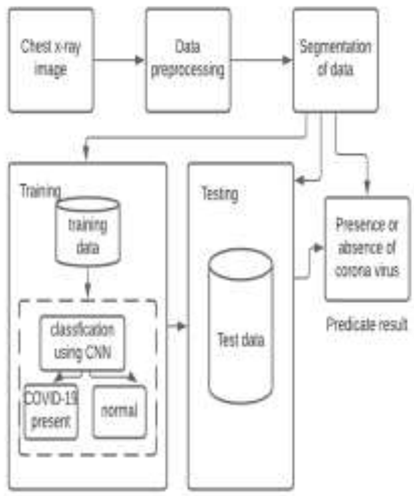

Fig 1: Block diagram

V. WORKING PRINCIPLE

ResNet

ResNet, short for Residual Network is a specific type of neural network that wasintroduced in 2015 by Kaiming He, Xiangyu Zhang, Shaoqing Ren and Jian Sunin their paper "Deep Residual Learning for Image Recognition".Resnet modelsare extremely successful models .Generally they are used in order to solve a complex problem, we use some additional layers in the Deep Neural Networks which gives higher accuracy and Performance. The main aim behind adding more layers is that these layerprogressively learn more complex features.We have different ResNet modelthey are ResNet-18,ResNet-34,ResNet-50,ResNet-101,ResNet-110.In our model we have used ResNet-18,ResNet-34,ResNet-50,ResNet-101.

ResNet-18: It is a Convolutional neural network with 18 layers deep.

ResNet-34: It is a Convolutional neural network with 34 layers deep.

ResNet-50: It is a Convolutional neural network with 50 layers deep.

ResNet-101: It is a Convolutional neural network with 101 layers deep.

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layer name	output size	18-layer	34-layer	50-layer	101-layer	152-layer
conv1	112×112	7×7, 64, stride 2				
conv2_x	56×56	3×3 max pool, stride 2				
		[3×3, 64; 3×3, 64] ×2	[3×3, 64; 3×3, 64] ×3	[1×1, 64; 3×3, 64; 1×1, 256] ×3	[1×1, 64; 3×3, 64; 1×1, 256] ×3	[1×1, 64; 3×3, 64; 1×1, 256] ×3
conv3_x	28×28	[3×3, 128; 3×3, 128] ×2	[3×3, 128; 3×3, 128] ×4	[1×1, 128; 3×3, 128; 1×1, 512] ×4	[1×1, 128; 3×3, 128; 1×1, 512] ×4	[1×1, 128; 3×3, 128; 1×1, 512] ×8
conv4_x	14×14	[3×3, 256; 3×3, 256] ×2	[3×3, 256; 3×3, 256] ×6	[1×1, 256; 3×3, 256; 1×1, 1024] ×6	[1×1, 256; 3×3, 256; 1×1, 1024] ×23	[1×1, 256; 3×3, 256; 1×1, 1024] ×36
conv5_x	7×7	[3×3, 512; 3×3, 512] ×2	[3×3, 512; 3×3, 512] ×3	[1×1, 512; 3×3, 512; 1×1, 2048] ×3	[1×1, 512; 3×3, 512; 1×1, 2048] ×3	[1×1, 512; 3×3, 512; 1×1, 2048] ×3
	1×1	average pool, 1000-d fc, softmax				
FLOPs		1.8×10^9	3.6×10^9	3.8×10^9	7.6×10^9	11.3×10^9

ures for ImageNet. Building blocks are shown in brackets (see also Fig. 5), with the numbers of block

Fig 2: ResNet

VGG

VGG is a convolutional neural network model proposed by K. Simonyan and AZisserman from the University of Oxford in the paper "Very Deep ConvolutionalNetworks for Large-Scale Image Recognition" . The model achieves 92.7% top-5 testaccuracy in ImageNet. VGG is an innovative object-recognition model that supports up to 19layers. Built as a deep CNN, VGG also outperforms baselines on many tasks and datasetsoutside of ImageNet. VGG is now still one of the most used image-recognition architectures.In VGG we have VGG-16 and VGG-19. VGG-16 is a CNN that is 16 layers deep and VGG-19is a CNN with 19 layers deep.

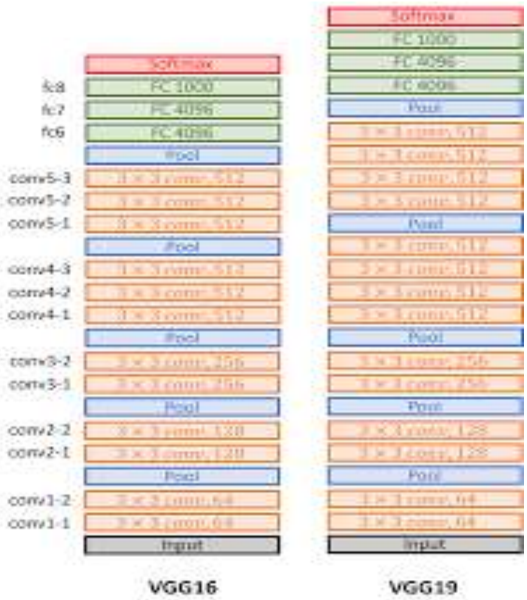

Fig 3: VGG16 and VGG19

VI. IMPLEMENTATION

Setting Up the EnvironmentThe environment required for the implementation has to be set up before building the model. Thisincludes importing and installing all the necessary packages and libraries.Colaboratory or 'Colab' for short, allows you to write and execute Python in yourbrowser, with Zero configuration required, Free access to GPUs, Easy sharing,interactive environment that lets you write and execute code. Colab notebooks allow us tocombine executable code and rich text in a single document, alongwith images, HTML, LaTeX and more. When we create our own Colab notebooks, they arestored in your Google Drive account. We can easily share our Colab notebooks with co-workersor friends, allowing them to comment on our notebooks or even edit them. With Colab we canharness the full power of popular Python libraries to analyse and visualise data. The code celluses numpy to generate some random data, and uses matplotlib to visualise it.

Collection and import of DatasetData collection is the first and foremost step. In this phase wehave collected various Chest X-ray images. The images are mixture of Covid-19 and NormalChest X-ray image.These datasets are collected from Git-hub,Kaggle.Once the datasets arecollected it is grouped together and given as input to the pre-processing phase which isdiscussed in the next topic.

Total of 253 images are collected with and without Corona.Out of 253 165 images has Corona and 98 images do not have Corona.These 253 images areour datasets.Data collected will be in the form of unstructured data. It should be convertedto structured format for further processing.Dataset should be imported for the further process.

Fig 4: Importing the Dataset

Importing the Dataset

Data Pre-processing

In any Machine Learning process, Data Preprocessing is that step in which the data gets transformed, or Encoded, to bring it to such a state that now the machinecan easily parse it. In other

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words, the features of the data can now be easilyinterpreted by the algorithm. We have to prepare the Dataset for Preprocessing.

Fig 5: Data Pre-processing

Preparing the dataset

Data preprocessing plays an important role in our project. In datapreprocessing the features of the image gets changed by doing some operations suchas Scaling, Rotation, Translation, etc.The following are the steps involved in the data preprocessing in our project

Image Conversion

In image conversion, the conversion of Chest X-ray image from RGB toGrayscale image occurs. The image is converted to Grayscale because withgrayscale images we can easily detect and remove the noises present in the image.
So we are converting the RGB image to Grayscale image.

Removal of Noise

Removing noise from the image is one of the important steps in imageprocessing. When there is a presence of less noise we can get better accuracy. In ourproject we remove noise using

- Gaussian blur
- Erosion
- Dilation

Gaussian Blur

Gaussian blur is the processing of blurring the image using the Gaussianfunction. It is a widely used effect in graphics software, typically to reduce imagenoise and reduce detail. Some of the noises that are left by Gussian blur are removedby the Erosion and Dilation process.

Erosion

In the Erosion process the foreground of the grayscale image width isdecreased i.e., size of the object in the white area gets decreased by eroding theforeground of grayscale image. The kernel slides through the image so all the pixels near the boundary will be discarded depending upon the size of the kernel. Thismakes the foreground object width smaller in the image.

Dilation

In the Dilation process the foreground of the grayscale image width isincreased i.e., size of the object in the white area increases. As the erosion processremoves the noise by decreasing the foreground, the original image gets changed, toretain the original image we do the dilation process. It is also useful in joiningbroken parts of an object and the removed noise won’t come back.

Edge Removal

After the noise removal step we have removed noise from the images, but theimage has unwanted area in it i.e., the edges present in the Chest X-ray image. Weneed to remove those edges. We can remove those areas by finding the extremepoints in the image and crop the image based on the extreme points and setting the default dimension of 224X224.

Fig 6: Image Transformation

Splitting of Data

Splitting of data in this we are going to split the image in the dataset based onour requirements. Here the dataset is split into two different categories. They are

- Training of data
- Testing of data

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Fig 7: Preparing the Data for Training and Testing

Training

After building the model we need to train the model to provide betteraccuracy. The model has to be trained through multiple iterations (called Epochs inML). Epochs are nothing but the rounds of optimization applied during the modeltraining. Thus, through more rounds of optimizations i.e. epochs, the error in thetraining data will be highly reduced. An epoch usually consists of one full processing throughthe entire training dataset. It is basically a full iteration over the provided samples. Thishappens in the form of multiple steps.

In our model we are using :
1. ResNet-18
2. ResNet-34
3. ResNet-50
4. ResNet-101
5. VGG-16
6. VGG-19
We have to create and train the above models.

Fig 8: Create the model

Fig 8: Train the model

Testing

Testing the model is done to evaluate the working of convolutional neural network models. They provide the accuracy and loss rate for testing the datasets.

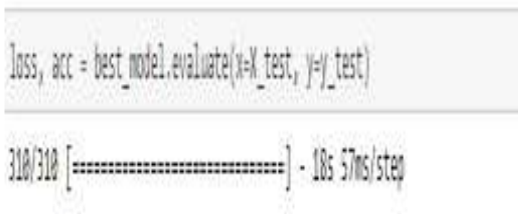

Fig 9: Testing

Linear SVM is tested and it provides accuracy and loss for testing datasets.

Model Performance
Algorithm 1 (Convolutional Neural Network)

Two important metrics define the performance of a model i.e. Model
Accuracy and Model Loss.

Model Accuracy: This is the primary metric used to evaluate classification models.

Accuracy =Number of Correct Predictions / Total Number of predictions

Accuracy gets better while Loss gets worse and vice-versa.

Model Loss: A machine learning algorithm can be optimized by using a Lossfunction. In fact, the machine learns through this loss function. If the predictions deviate too much from the actual results, the loss function willproduce a very high number.

VII. CONCLUSION

Various methods have been proposed for detecting corona virus but in majority,they have used CNN for predicting corona virus is present or not.In our project we have presented deep learning method specifically CNN becauseit has proven its highest accuracy for image classification. In this project we are creatinga model which can predict presence or absence of corona virus using CNN (ConvolutionalNeural Network) algorithm and Linear Kernel SVM. Our main focus is to develop a model that is easy and
cost efficient and plays a vital role in the safety of the people.

VIII. FUTURE WORK

In future we are planning to include the multi-class classification,that is we would be training our modelto predict Covid-19 and other lung disease if present in a patient. So that our model can be used forpredicting normal lung diseases as well.

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