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Analysis Of Deep Learning Techniques For Chest X-Ray Classification In Context Of Covid-19

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Abstract

Coronaviruses (COV) are a large family of viruses that cause illness ranging from common cold to more severe disease such as MIDDLE EAST RESPIRATORY SYNDROME (MERS-COV) and SEVERE ACUTE RESPIRATORY SYNDROME (SARS-COV). Common signs of infection include respiratory symptoms, Fever, Cough, Shortness of breath and breathing difficulties. In severe cases, infection can cause pneumonia, severe acute respiratory syndrome, kidney failure and even death.3-Tier strategy is employed by the government to combat this virus i.e., Track, Test and Treat. So, there is a need to increase the testing speed but the main stumbling block is the time RT-PCR takes which is around 2-3 days. In this situation, the recent research using Radiology imaging (such as Xray) techniques can be proven helpful to detect Covid 19. Latest deep learning techniques applied to X Ray scans which rapidly detect the disease and thus reducing the time for testing. Moreover, it is accurate as compared to RT-PCR test where nose and mouth swabs are taken by a lab technician which is prone to error.In this survey paper, ten different DL Techniques are surveyed which performs X Ray classification with different accuracy. Different combinations of Datasets are employed by these algorithms to improve the performance of their proposed model.Our paper evaluates the performance of each algorithm based on two parameters -Accuracy and Sensitivity.

Keywords: Blockchain, privacy preservation, vehicle network.

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1. Introduction

With the advent of Deep learning techniques, clinical analysis can be done with much more accuracy and efficiency.It significantly speeds up the processing of data needed to obtain the information,reponses and recommendation to manage and combat the covid 19 pandemic.Deep learning techniques performs feature extraction automatically rather manually and thus achieves recognition accuracy at higher level than ever before.Deep learning employs Convolutional neural network which perform feature extraction.A CNN convolves learned feature with input data and use 2D convolutional layer,making this architecture suitable for processing 2D images.CNN learned to detect different features of image by using tens or hundreds of hidden layers[1]. The relevant features are not pretrained; they are learned while the network trains on a collection of images [2]. This automated feature extraction makes deep learning models highly accurate for computer vision tasks such as object classification[3]. Every hidden layer increases the complexity of the learned image features[4]. The two most common ways researchers use deep learning to perform object classification are:

1.1 Training from Scratch

Training a deep architecture from scratch, requires a very large labelled data set. A new designed network architecture will learn the features from the dataset and is tested for its performance. This proves beneficial when a new algorithm is used for designing the layered architecture [5]. This is a less common approach because with the large amount of data and rate of learning, these networks typically take days or weeks to train and it is not economical.

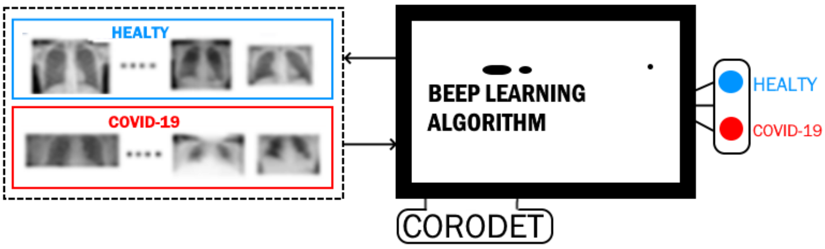

fig 1. Deep Learning Model Using Training From Scratch.

1.2 Transfer Learning

Most deep learning applications use the transfer learning approach.It is a process that involves fine-tuning a pretrained model[6]. In this, a model developed for a particular task is reused as the starting point for a model on a second task, such as AlexNet CNN model is trained on Image net database but by applying TL approach it can be used for other classification problems.Only classification layer needs to be trained according to the problem at hand.This will significantly reduce the time that would have been elapsed if network need to be trained from scratch[7].Transfer learning can be accomplished with three different scenarios a)" Shallow tuning":which adapts only the classification layer to cope with the new task. b)" Deep tuning": which aims to retrain all the parameters of a pretrained network from end-to-end manner. c)"Fine tuning" that aims to gradually train more layers by tuning the learning parameters until the significant performance boost is achieved.Transfer learning via fine tuning mechanism shows outstanding performance in ChestXray classification [8]. Figure below illustrates the application of TL technique in Deep learning architecture in Chest X Ray classification.

Depending upon different types of layered CNN architecture,we have different DL algorithms which give different accuracy[9]. Deep CNN has been successfully applied in many problems such as classification of skin cancer,classification of brain diseases, detection of breast cancer,lung segmentation[10].Beside its superior performance as compared to machine learning,Deep learning comes with drawback:

1. It is a data hungry network so the size of the dataset is small, it may not give optimal performance.

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2. Due to its complexity of multiple layer hidden architecture,it requires expensive GPUs which make it a costly technique.

This paper is organized as follows: In section 2, Ten different CNN architectures are described. Section 3 compares the above-described architectures in terms of Accuracy and Sensitivity [11]. Section 4 discusses the future research opportunities and conclusion followed by References.

2. Research Method

BRIEF DESCRIPTION OF DEEP LEARNING ARCHITECTURES:

2.1 Xception Model

It is a Convolutional neural network architecture based entirely on depth wise separable convolution layers. Xception stands for "Extreme Inception". The Xception architecture [5] has 36 convolutional layers forming the feature extraction base of the network[12]. The 36 convolutional layers are structured into 14 modules, all of which have linear residual connections around them, except for the first and last modules. In short, the Xception architecture is a linear stack of depth wise separable convolution layers with residual connections [13]. This makes the architecture very easy to define and modify.It is a modification of inception net.Its parameter size is similar to Inception net but performs better as compared to Inception net [14].
DATASET:Xception net makes uses of data from Kaggle repository.

MODELS	ACCURACY
XCEPTION NET	**97.97%**
INCEPTION NET	96%
RESNET	93%

2.2 COVID-AID

COVID AID [2]: Covid19 AI detector, a novel deep NN based model to triage patients for appropriate testing[15]. This model contains pretrained CheXnet with 121-layer Densenet. DenseNet is quite similar to ResNet with some differences. ResNet uses an additive method which merges the previous layer (identity) with the future layer, whereas DenseNet concatenates the output of the previous layer with the future layer [16]. An output of the previous layer acts as an input of the second layer by using composite function operation. This composite operation consists of the convolution layer, pooling layer, batch normalization, and non-linear activation layer.These connections mean that the network has L(L+1)/2 direct connections. L is the number of layers in the architecture [17].
Deep CNN backbone followed by fully connected layer. **COVID AID achieves an accuracy of 90.5%**
Two stage training is used:

1. Densenet's backbone weights are frozen and only the final connected layer is trained. Batch size=16, No. of epochs=30 and lowest validation loss is selected for the next stage.
2. In the second step, network weights are initialized from above but the whole network is trained end to end.

DATASET:1) Covid chest Xray images2) Chest Xray pneumonia.

2.3 Detrac Deep Model

DETRAC [17] method of image classification is used which consists of three phases.First phase: Train the pretrained CNN model (Alex net, vgg19, ResNet, google net,squeeze net) to extract deep local features from image. Second phase: Training is accomplished using sophisticated gradient descent optimization method[18].Third phase:Composition layer to refine the final classification layer of images.This method can detect irregularities in the dataset by investigating class boundaries using class decomposition.For decomposition of classes Kmean clustering method is used [19].
DATASET: i)80 samples from Japanese Society of Radiological Technology ii) Covid-19 Image data collection.

MODELS	ACCURACY	SENSITIVITY
ALEXNET	95.66%	97.53%
VGG19	**97.35%**	**98.23%**
RESNET	95.12%	97.91%
GOOGLENET	94.71%	97.88%
SQUEEZENET	94.90%	95.70%

2.4 Instacovnet Model

InstaCovNet-19[13] is a deep convolutional architecture (DCNN) used for the detection of patients with COVID-19 using chest Xray images [20]. Transfer Learning and multiple pre-trained DCNNs are used like Inception v3, MobileNetV2, ResNet101, NASNet and Xception. These models were first imported with their pre-trained weights matrix (on ImageNet). Then these models were fine-tuned for the dataset. The fine-tuned models were then combined using the Integrated Stacking technique, making the stacked model a larger and more robust model. Two image preprocessing techniques are used i) fuzzy color image enhancement ii)stacking.
DATASET: i) COVID19 Radiography database by Kaggleii) ChestXray dataset

MODELS	ACCURACY	SENSITIVITY
COVIDDIAGONSIS NET	98.33%	NA
CORONET	89.6%	NA
RESNET50+DCNN	NA	NA
COVIDNET	93.3%	NA
DARKCOVIDNET	87.02%	NA
MOBILENETV2	94.72%	NA
COVIDAID	92.3%	NA
INSTACOVNET19	**99.08%**	**NA**

2.5 CORODET

CORODET [5] is a Novel CNN model which uses ChestXray images to detect Covid. It's a new 22Layer CNN model [21]. It consists of 9-layer Conv2d followed by Maxpooling2D,9-layer Conv2d followed by Max Pooling and at last Flatten layer followed by Dense layer. Adam optimizer has been used. Training is carried out for 50 epochs with learning rate=.0001.
DATASET: COVID-R dataset has been used which consists of 2843 Covid19 images,3108 Normal images,1439 Pneumonia images.

MODELS	ACCURACY	SENSITIVITY
SETHY AND BEHR	95.38%	NA
HEMDAN	90%	NA
NARIN	98%	NA
WANG	82.9%	NA
ZHANG	90.8%	NA
OZTURK	98.08%	NA
KHAN	99%	NA
CORODET	**99.1%**	**NA**

2.6 CVDNET

CVDNET [1], a deep CNN model is used to classify COVID-19 images from normal and other pneumonia cases using Chest X ray images. It is based on a residual neural network and uses two parallel levels with different kernel size to capture local and global features of input. This architecture is trained on a small dataset but achieves promising results [22]. For the convolution, it employs the concept of residual technique which enhances the performance of this model.
DATASET:Kaggle Covid 19 Radiography database. Total images are 2905.Out of which Normal (1341), Covid19(219), Viral Pneumonia (1345) images are used.

MODELS	ACCURACY	SENSITIVITY
COVIDNET	92.4%	NA

COVIDX-NET	92%	NA
RESNET50+SVM CLASSIFIER	95.38%	NA
DARKCOVIDNET	87.02%	NA
VGG19	93.48%	NA
RESNET+LOCATI ON ATTENTION	86.7%	NA
MINCEPTION	73.1%	74%
COVNET	96%	90%
DEEP PNEUMONIA	86%	NA
DROP WEIGHT BAYESIAN CNN	92.90%	NA
DEEP CNN BACKBONE NETWORK	**96.69%**	**96.84%**
CORONET	89.6%	NA

2.7 DEEP CORONET

Deep coronet [19] is a new approach based on the deep LSTM model. Instead of a transfer-learning approach, the deep LSTM model is designed from scratch. Preprocessing of image is done using sobel gradient and Marker-controlled Watershed segmentation (MCWS) are applied to raw images followed by deep LSTM model which increases classification performance[23].Deep LSTM model consists of sequence data creating block and LSTM network sequence data creating block consists of convolution operation, Batch Normalization, Relulayer. The LSTM model is a modified version of recurrent neural networks[24]. This layer is followed by fully connected layer, Relu and dropout fully connected which give output to SoftMax layer which give probable scores of classes [25].

DATASETS: Covid 19 and Normal CX images are taken from Kaggle repository.

MODELS	ACCURACY	SENSITVITY
DARKCOVIDNET	87.02%	92.18%
COVID DIAGONSIS NET	98.26%	99.13%
PRETRAINED CNNS	93.48%	92.85%
COVIDNET	92.64%	91.37%
DEEP FEATURES RESNET-50, SVM	95.38%	NA
DEEP CNNS	90.0%	100%
DEEP CNN RESNET 50	98%	NA
DRE NET, DEEP CNN	86%	96.4%
DEEPCNN, INCEPTION, TRANSFER LEARNING	89.50%	87%
NCOVNET, TRANSFERLEARNIN G, DEEP CNN	88.10%	97.62%
DEEP CNN, SVM	98.97%	89.39%
PROPOSED METHOD	**100%**	**100%**

2.8 ENSEMBLE DEEP LEARNING-EDL AVID

Ensemble deep learning [16] is a hybrid learning paradigm which is able to produce effective results by combining various machine learning models intelligently[26]. Combined strength of models offset individual model variances and biases and provide composite prediction where the final accuracy is better than accuracy of individual model. In EDLCOVID, instead of taking multiple models for ensembling, multiple model snapshots of a deep learning networkCOVIDNET has been taken.COVIDNEt network is used with its multiple snapshots and cosine annealing learning rate is used to change the learning rate aggressively but systematically to generate different model weights over training epochs by allowing the learning rate to start high and decrease to minimum value zero at relatively rapid speed[27].

COVIDX DATASET:It is a combination of five different datasets: Actual med covid 19 dataset, Covid19 Image data collection, Covid19 radiography database collection,Covid19 CXR dataset Initiative, RSNA pneumonia detection challenge.

MODELS	ACCURACY	SENSITVITY
COVIDNETM1	93.50%	92.2%
COVIDNETM2	94%	93%
COVIDNETM3	92.50%	93.12%
COVIDNETM4	94.50%	94%
COVIDNETM5	94.50%	95%
COVIDNETM6	93.50%	92.3%
EDL COVID	**95%**	**94.9%**

2.9 DENSENET 121

Dense blocks [14] are first proposed by Huang which introduces dense connectivity, means each layer receives signal from all its preceding layers combined by channel wise concatenation resulting into low information bottleneck[28]. Dense net integrates the properties of identity mappings, deep supervision, reduced feature redundancy and diversified depth allowing feature reuse and making it a good feature extractor[29]. Dense net with different depths are Densenet121,169,209,264 are there but Dense net 121 found to be more accurate.The number 121 indicates the number of layers and is calculated as:5+(6+12+24+16)*2=121 where 5 (convolution and pooling layer),3(Transition layer(6,12,24)),1 classification layer(16),2 dense block(1*1 and 3*3conv)

DATASET: Covid19 dataset and pneumonia dataset

MODELS	**ACCURACY**	**SENSITIVITY**
VGG19	94.74%	N.A.
INCEPTIONV3	97.37%	N.A.
RESNET50	94.08%	N.A.
RESNET50V2	94.08%	N.A.
MOBILENET	95.4%	N.A.
MOBILENETV2	95.4%	N.A.
DENSENET121	**98.69%**	**N.A.**
NASNETMOBILE	97.37%	N.A.

A new family of models based on the efficient Net family [8] is explored for detection of chest X ray images. Its baseline architecture consists of Mobile Inverted Bottleneck convolution as a basic component (MBConv). It starts from a high quality yet compact base line model and uniformly scales each of its three dimensions) depthii) width iii) resolution with fixed set of scaling coefficients. Architecture B1 to B7 are derived from B0. Efficient net family has models of high performance and low computational cost. Efficient net B3X model found to most accurately classify chest Xray images. Efficient net employs Batch normalization, Drop out and switch activation function

DATASET:i)RSNA pneumonia detection challenge ii) Covid19 image data collection iii) HCV-UFPR COVID 19

MODELS	ACCURACY	SENSITIVITY	POSITIVE PREDICTION
EFFICIENTNET B0X	90.0%	93.5%	100.0%
EFFICIENTNET B1X	91.8%	87.1%	100.0%
EFFICIENTNET B2X	90.0%	77.4%	100.0%
EFFICIENTNET B3X	**93.9%**	**96.8%**	**100.0%**
EFFICIENTNET B4X	93.0%	90.3%	93.3%
EFFICIENTNET B5X	92.2%	93.5%	90.6%
MOBILENET	90.4%	83.8%	100.0%
MOBILENETV2	90.0%	87.1%	96.4%
RESNET50	83.5%	70.9%	81.4%
VGG16	77.0%	67.7%	63.64%
VGG19	75.3%	77.4%	50%

3. Findings

Comparison Of Above-Described Deep Learning Methodology

Ten different deep learning methodologies are surveyed and their performance are analyzed on the basis of two parameters: Accuracy and Sensitivity.

MODELS	**ACCURACY**	**SENSITIVITY**
XCEPTION MODEL	97.97%	NA
COVID AID	90.5%	100%
DETRAC MODEL	97.35%	98.23%
INSTACOVNET MODEL	99.08%	NA
CORODET	99.1%	NA
CVDNET	96.69%	96.84%
DEEP CORONET	**100%**	**100%**
EDL COVID	95%	95.2%
DENSENET121	98.69%	NA
EFFICIENTB3X	93.9%	96.8%

4. Conclusion

In this paper, ten different approaches of Deep learning are surveyed.However, it cannot be said that methods are completely superior to each other due to different datasets. Deep coronet method reaches 100% accuracy but due to application of MCWS segmentation in its preprocessing stage its computation cost has increased. In the future, more organized datasets can be employed to increase the reliability of these models. Moreover, beside Covid 19 and pneumonia detection, these models can be employed to detect other respiratory diseases [30]. As covid 19 poses a huge challenge which affects the economic prosperity of almost every country, its diagnosis at a rapid rate is of utmost importance. ChestXray scans prove to be an efficient, less time consuming and economical method for its diagnosis. When Chest Xray scans are carried out with an efficient Deep learning algorithm, it will boost the diagnosis rate and hence help in combating the pandemic.

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