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Automated Recognition Of COVID-19 Cases From Chest X-Ray Images Using Multi-Image Augmented Deep Learning Model

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Abstract. Looking at the global pandemic that had a huge impact on human lives since the last several months where people are losing their lives, people are losing their jobs and it is having a devastating effect on human life. There are frontline health Care community workers for identifying various solutions to minimize this impact. On the other hand there is a different set of people in the data science community who are looking at various different technology related solutions to assist the frontline healthcare community with their solutions. The recognition of covid-19 positive belongings at the early stage in order to preclude the blowout is most crucial. The RT-PCR is a technique to analyse the occurrence of covid-19 by taking and nasal or throat swab from the patients which perceives the capacity of antibodies which are formed by the resistant system. This is the unintended technique of analysis the presence of virus and the antibodies can display amid 7 to 28 days afterward the contagion. But the radiologists proved that the presence of covid-19 virus can be detected by using the changes that has been occurred in chest X-ray images. Due to the limited number of radiologist present across the world there is a challenge for determination of covid-19 using x-ray images. This work aims to represent a framework in order to automatically diagnose covid-19 in x-ray images using multi image augmented deep learning model. The filtered images from the CNN produces discontinuity in their information which can be resolved using multi image augmentation technique thereby accumulative the amount of images for preparation of the CNN model. This simulation has been done through to the databases which are available publicly and the proposed technique provides higher accuracy, sensitivity and specificity.

Keywords: covid-19 chest x ray image, multi-image augmentation, convolutional neural network.

1. INTRODUCTION

Covid-19 concealed by 2019 is accountable for a worldwide contagion and it is instigated by illness called SARS-COV-2 (severe acute respiratory syndrome coronavirus-2) which is hereditarily alike to a virus called SARS, an outbreak in 2002[1]. Coronavirus is circulating among the human which is typically benign because of common cold illnesses[2]. World-

wide as of eight months outbreak there where about 20 million confirmed cases and 681 thousand
deaths[3]. The fatality rate has been increased to 4 % because of the undiagnosed covid-19 cases at the early stage. The solitary method to resist the banquet of this disease is to diagnose the disease at the early stage. The health care specialist needs diagnostic tools to investigate cases, potentially covid-19 that need to be sensitive and specific diagnostic tools[4]. The customary for analysis of covid-19 is RT-PCR which is also known as reverse transcription polymerase chain reaction[5]. Due to the unavailability of resources and less sensitivity determined in PCR tests, the radiologists originate a distinctive chest x-ray arrival is extremely precise of 95.8% and obligates a from top to bottom optimistic extrapolative assessment of 85.2% for SARS-CoV-2 contagion in the venue of a epidemic. The occurrence of occasional and merging, band like ground glass opaqueness or amalgamation in an outlying and mid to lower lung region dissemination on a chest X-Ray is extremely evocative of SARS-CoV-2 contamination and must be cast-off in combination with scientific verdict to brand and analyze[6].
The analyse of covid-19 can be done with the chest x ray images by radiologist even in the early stage[7]. But the main disadvantage is that there are only a few radiologists available for the analysis of covid-19 or pneumonia[8]. So a convolutional neural network has been used in order to automatically detect the presence of covid-19 in the chest X-ray images[9]. The entire process of covid-19 diagnostic report generation is represented in the figure 1. Initially the obtained x-ray images are preprocessed using medical image acquisition and pre filtering[10]. After preprocessing the images they are transmitted into the direction module in which image enhancement image segmentation is performed and localization of suspicious regions are identified. In analyse module feature extraction and feature selection is done by using some optimization techniques and finally the presence of covid-19 is classified using classification algorithms. Compared to the conventional diagnostic analysis X-ray imaging has several advantages to detect the presence of covid-19.
The X-ray imaging is cost effective when compared with the conventional diagnostic analysis and tattoos much more wide spread almost in all parts of the country. Transferring the samples from one path to another path takes much more time and it is quite complicated but the transfer of X-Ray images is very easy because any transport facility is not required from the point of sample collection to the point of sample analysis. Also the portable X-ray machines enable testing even in all parts of the country.
As the available number of samples for training is low, we use a data augmentation technique which is more commonly used in deep learning approaches in order to increase the amount of obtainable models. So a data augmentation technique through numerous preprocessing techniques can be performed in order to train the CNN network. The learning capacity while using data augmentation is enhanced and it provides and well-organized method to thwart the model over fitting by snowballing the quantity of working out information using the statistics provided in the preparation process.

2. RELATED WORK

Various data scientists across the world are working on the detection of covid-19 using x-ray images. The literature shows that there are many architectures in CNN for the recognition of covid-19 using chest x ray images. (Tuncer, Dogan, and Ozyurt 2020) Proposed a hybrid method in which Residual Exemplar Local Binary Pattern (ResExLBP) is cast-off for feature extraction and IRF is used for selecting the most discriminating features which were classi

fied by five different classifiers, 10 fold CV and holdout endorsement method. The input x-ray image can be converted into gray scale image in the preprocessing stage and ResExLBP divides the image into 128*128 sized exemplars and the features can be extracted by using LBP. The designated topographies are exploited as involvement of the classifiers by means of consent one out cross validation, 10 fold cross validation and hold out validation.

(I
slam, Islam, and Asraf 2020) has developed a collective deep CNN-LSTM network to spontaneously diagnose the presence of Covid-19 in early stage with the assistance of chest X-ray images. This network has 12 convolutional layers, 5 pooling layers, 1 fully connected layer, 1 LSTM layer and 1 output layer with softmax function. After the analysis of chest X-ray images through these layers the presence of covid-19 can be easily detected. (Minaee et al. 2020) has proposed a data augmentation technique to generate transformed variety of COVID-19 images to escalate the amount of samples by a factor of 5. As an alternative of working out these mockups from beginning, the last layer is fine-tuned from the pre-trained variety of these mockups on Ima-genet and this prototypical can be skilled with a smaller amount of labeled samples from each class.

(Xu et al. 2020) has proposed a 3D segmentation process which was performed using pixel-level segmentation operation as the edge amongst a vigorous area and the emphasis of contamination is usually unclear and indistinct, it was enormously problematic to tag pixel smooth disguises for laceration areas. The adjustable 3D structures of the laceration regions are determined by the segmentation operation which performs object-detection algorithm. (Shibly et al. 2020) has developed a Faster Region Convolutional Neural Network which is additionally dependable therefore it can be exploited as a instantaneous taxation device and is capable of categorizing upper body X-Ray descriptions deprived of consuming physical feature extraction.

(Alia et al. 2020) have demonstrated significant improvement in performance over COVID-Net in which the primary step provides DenseNet's backbone weights that are unmoving and only the concluding fully connected layer is trained. In the succeeding stage, the network weights are adjusted from above, but the entire network is trained endwise using the same hyper- parameters. (Makris, Kontopoulos, and Tserpes 2020) has introduced Bayesian Deep Learning classifier thatcould have accomplished by transfer learning technique on a pre-educated ResNet50V2 technique by utlizing COVID-19 X-Ray images to guesstimate model indecision. The consequences established a robust relationship among the assessed hesitation in prediction and classification accuracy, thus empowering incorrect divination credentials.

(Toraman, Alakus, and Turkoglu 2020) has projected a Convolutional CapsNet for the recognition of COVID-19 illness by means of chest X-ray descriptions with capsule nets which deliver debauched and precise identification for COVID-19 sicknesses with binary cataloging and multi-class cataloguing for distinguishing COVID-19, Non Findings, and Pneumonia. (Ahuja et al. 2020) has proposed a three-tier recognition model inorder to improve the detection accuracy in which tier1 represents data augmentation by means of stationary wavelets, tier2 represents COVID-19 finding by means of pre qualified CNN model and tier3 characterizes the irregularity localization in X-ray pictures using well known pre qualified architectures, such as ResNet18, ResNet50, ResNet101, and SqueezeNet for the investigational assessment.

(Yaşar and Ceylan 2020) has proposed a Local Binary Pattern (LBP) as a primary operation and by means of Dual Tree Complex Wavelet Transform (DT-CWT) as a ancillary operation, and the results of automatic classification were calculated separately. A new classification approach, which involves performing the experiments in together and combining the results

through a result generation algorithm, has been proposed and tested. (Novitasari et al. 2020) has proposed an amalgamation of kernel by means of linear kernel of SVM method and PCA method as a feature selection. Support vector machine method purposes as an organization technique and finds the greatest outcomes on resnet50 with superior accurateness.

3. THE PROPOSED FRAMEWORK

In this paper, we propose an architecture for intelligent analysis of covid-19 from chest X-ray images automatically and assist the doctors to prevent the spread by early analyse.

3.1OVID-19 radiology database

Many studies in the literature have jagged the upper body x ray metaphors can be a vigorous assessment by means of diagnosing covid-19 infections. The data set are obtained from web-site processes a mixture of covid-19 chest x ray images and non-finding of covid-19 chest x ray images.

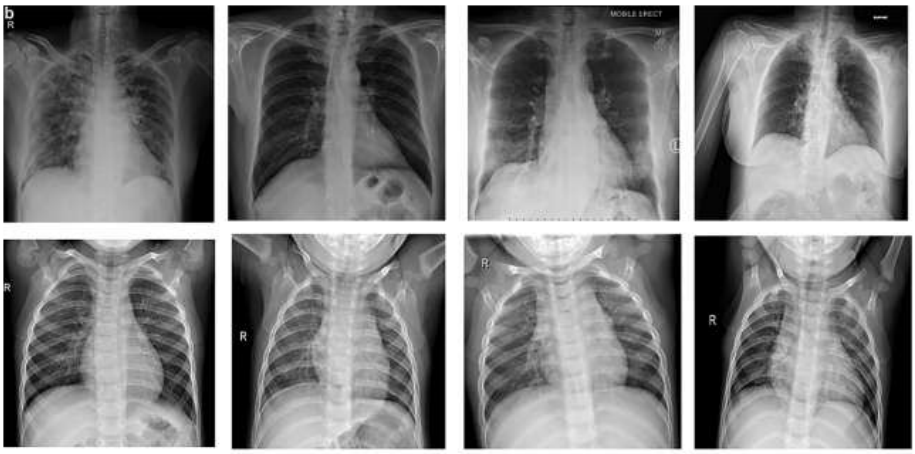

Fig. 1 Representation of chest X-ray images for covid-19 and non covid-19 patients

These x-ray images also contain the information of patient such as sex and age. We have taken this data set for determining the covid-19 patients[11]. From the literature it is clearly understood that the lateral images cannot be chosen for estimating covid-19. Therefore it is necessary to produce cleanly labelled data set in which the anterior posterior view and lateral images should be separated from the interior exterior x-ray images[12]. From this totally available data set only 284 images are selected that provides anterior posterior images and out of these images only 160 images are included in the assessment set and the residual images are included in the training set. Figure 1 represents the sample images that are taken on the data set which represents the covid-19 as well as non covid-19 images.

3.2 Multi-image Data Augmentation

In order to make CNN model to learn, more number of X-Ray images is required but the data set provides only a few images for training[13]. To avoid this limitation a multi-image data augmentation technique can be used to increase the number of samples and the assort
ment of obtainable physiognomies within the X-ray images. It is also essential to sort the X-ray images well-matched with the pre learned transfer training based model. To obtain this the input image should be modified, the images should be resized and import images should be normalized. Multi image augmentation technique by snowballing the number of samples

is performed by converting the input image into a gray scale and in order to precise the dissimilarity of the input gray scale image histogram equalization can be applied. First order and second order edge detection operations can be used to achieve the better quality representation of input image.

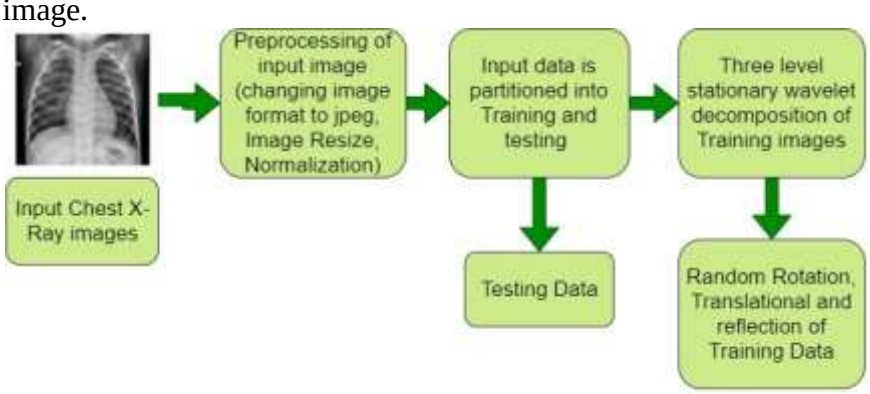

Fig 2. Preprocessing of input X-Ray image

In order to achieve this, the input x-ray images obtained from the data set it is converted into a JPEG format and resized as 256*256*3. These images are then converted into a grayscale images and edge detection is performed in order to determine the boundaries and shape of the lungs. By using edge detection the unwanted information in the images can be removed and the image can be resized. After preprocessing the input chest X-ray images the input data is divided into two parts in which 90% of images are separated for training data and 10 % of the images are separated for testing the data.

Before the training process the preprocessed chest x ray images undergo three level stationary wavelet decomposition. Generally the wavelet transform are suitable for extracting the actual content the data from huge data set. In stage 1 of wavelet transform the normalized input image will be passed over a set of low pass filter and high pass filter and then the obtained image will be down sampled by a factor of 2. This gives the output of stage 1 in wavelet transform. This process will be repeated in the decomposition of images in stage 2 and 3 of wavelet transform. The size of the images remains same before and after decomposition of wavelet transform. To augment the training data this wavelet disintegrated descriptions undergo a shear process in the interior the assortment, arbitrary revolution of working out data amongst the assortment and haphazard translation of pixel assortment.

3.3 Training and classification of CNN based deep learning model

To accomplish working out and cataloging with a multi-image augmented CNN model the rudimentary construction of ResNet18 model is browbeaten. The pre trained model in the CNN can be deployed with two approaches in which the first approach denotes the feature extractor as the pre trained model in words the interior masses of the pretrained technique are not modified to the novel assignment all the classification can be done by training it on the top layer. The second approach CNN network can be fine-tuned on a new task.

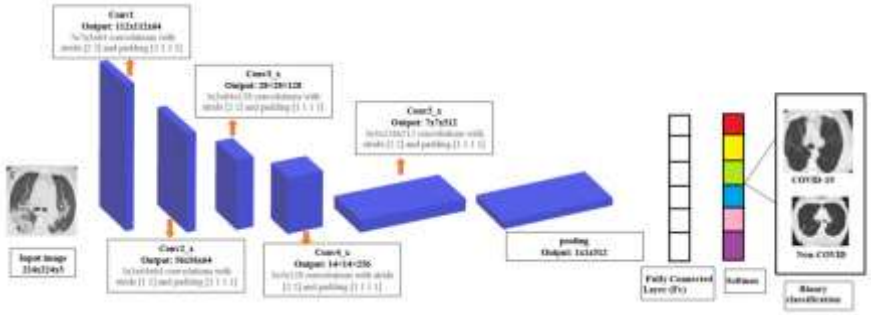

Fig 3. ResNet18 architecture for detection of covid-19 from x-ray images

Since the number of chest X- ray images provided in the data set is very low the last layer of the CNN is fine-tuned and we use this pre-trained model as a feature extractor. Resnet-18 model is used in our work for pre training the chest x ray images which is preprocessed. The architecture of the ResNet18 model is shown in figure 3 provides identity shortcut connection that gives one or more layers. Due to the skipping of layers in the architecture, the direct path can be established between the layers in the network which makes the gradient update for those layers much easier.

The different types of convolutional layer present in the Resnet-18 architecture provide a filter in each layer which scans the whole preprocessed x ray images. These convolutional layers can forecast the period of likelihoods by creating the feature map. The function of the first convolutional layer is to deliver stumpy side by side topographies like hue, boundaries and gradient operations whereas the functions of the next convolutional layers delivers from top to bottom level topographies like the abnormal it is which is provided in the chest x ray images. The pooling layer which is provided after the convolutional layer can reduce the spatial size of the convolution. Max pooling, average pooling and global pooling are the different types of pooling layers which provides positional invariance and rotational function. The fully connected layer which is present next to the pooling layer acts as a feed forward network in which the output from the pooling layer is just pass to the next network. The soft Max layer is responsible for limiting the output range and predicts the possibility of input vector. The CNN based ResNet models are executed through bouncing of the layers with non-linearity's (ReLU) and supplementary weight matrix are cast-off to acquire the skip weights.

Two activation functions are used in this model in which ReLU functions are utilized after the convolutional layer and sigmoid functions are utilized for the classification of test chest x ray images into covid-19 findings and non-findings. The images for down sampled and uses Bayesian optimization technique with the batch size of 32 and binary cross entropy based loss function. The learning rate is set to 0.01 which is linearly leakage and supreme epochs are set to 30. In order to determine the efficiency of the proposed technique random sub sampling or holdout technique can be utilized in which the enter input chest x ray images from the data set which contains both the positive as well as negative samples are splatted up into 2 different ratios such as 90:30, 80:20, 70:30 and 60:40. To overcome the overfitting problem in the proposed technique the multi-image data augmentation is capable of generating large number of samples which carries discontinuity of information.

4. RESULTS AND DISCUSSIONS

This augmented deep learning model with ResNet is implemented by means of Tensor Flow. In order to estimate the context in a forceful and operative way, assessment metrics such a classification accuracy, loss, area under ROC curve, precision, sensitivity, specificity and F1 score have been used. The standards of all this metrics was obtained from various altered ratios of training and test samples in view of the layers present in deep model. This technique adapted is able to classify the chest X-Ray phantasmagorias of COVID-19 belongings from non-COVID-19 belongings. The assessment procedure use the holdout technique where the entire dataset encompassing COVID positive and negative samples are separated into a number of ratios like 90:10, 80:20, 70:30, and 60:40 as training and test samples. Throughout the testing process, the layers are can be altered in the multi-image augmented based deep learning model to comprehend the reliability of the technique.

	Original	Augmented	Original	Augmented	Original	Augmented	Original	Augmented
Train-Test	60%-40%		70%-30%		80%-20%		90%-10%	
Accuracy	99.25	98.88	100	99.44	99.25	99.16	100	100
Loss	2.59	8.92	2.22	1.91	3.84	4.87	1.08	3.66
AUC	100	99.7	100	100	100	99.8	100	100
Precision	1	0.99	1	1	0.99	0.99	1	1
Sensitivity	98.51	99.06	100	99.07	100	99.44	100	100
Specificity	100	98.7	100	99.81	98.51	98.89	100	100
F1-Score	0.99	0.99	1	0.99	0.99	0.99	1	1

Fig 4. Performance of the technique having different train and test values

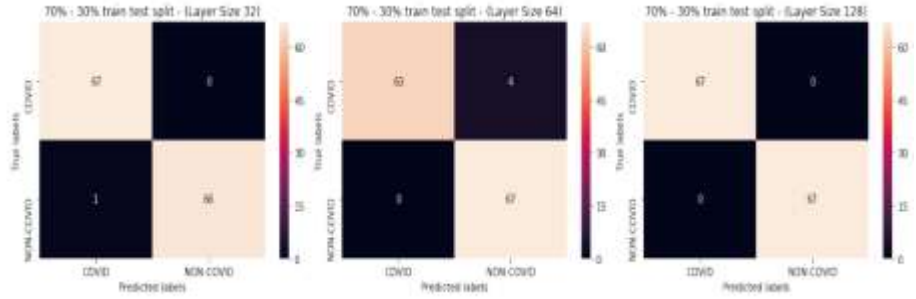

Fig 5. Confusion Matrix of images without multi-image augmentation when train and test ratio is 70:30

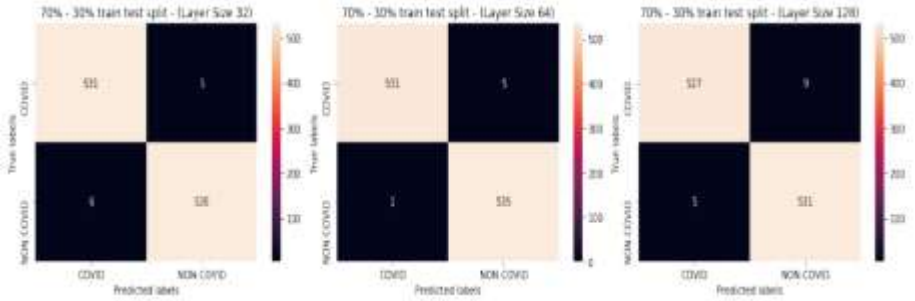

Fig 6. Confusion Matrix of images with multi-image augmentation when train and test ratio is 70:30

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he above figure represents screening analysis of the proposed model in which the accuracy is

increased with different set of train-test values. The two major part such as width and depth of the neural network decide the complexity of the algorithm, but the proposed residual network model decreases the training error and increase the network performance when compared to to all the other traditional CNN models. The figure above represents the different accuracy levels for a normal algorithm as well as our proposed multi-image augmentation based CNN algorithms for different train and test ratios. figure 6 and 7 represents the confusion matrix of images with and without multi image augmentation techniques when the train and test ratio is 70:30.

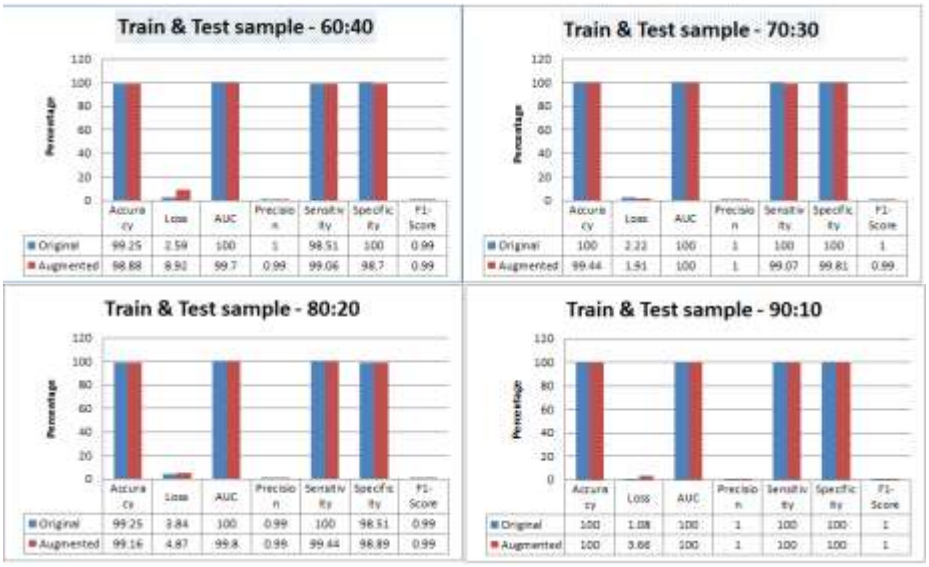

Fig 7. screening accuracy, Loss, AUC, Precision, Sensitivity, Specificity, F1-Score 90:10, 80:20, 70:30, and 60:40 as training and test samples

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he important parameters to evaluate the performance of the CNN network would be e accuracy, loss, precision, sensitivity, specificity and F1 score. Figure 8 represents the various parameters in terms of screening accuracy when the training and test samples is 60:40, 70:30, 80:20, 90:10. This determines various losses of each and every training test ratios. When the training and test samples ratio or increased the accuracy is also increased which produces very small losses and the region of convergence is 100 percentage, precision is the maximum the sensitivity and specificity are maximum with the F1-score to be maximized.

5. CONCLUSION

This work represents an innovative procedure to detect the presence of covid-19 from chest X-ray images. Multi-image augmented convolutional neural network has been adapted in this work in order to upsurge the quantity of models of the input x-ray images because of very few data set available in the data Bank. The proposed technique detects the occurrence of covid-19 automatically from the chest X-ray images and the feature extraction involved in CNN is automated with end-to-end structure. When CNN is trained with the obtained preprocessed augmented images it provides an accuracy of 95 percentages in an average for chest x

ray images. The obtained results from the proposed model are very useful for the radiologist to detect the presence of covid-19 by using chest X-ray.

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