Performance Comparison of Bins Approach With Deep Learning Models for Image Based Detection And Classification Of Covid-19

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***Abstract*—The COVID-19 pandemic, also known as coronavirus 2019, is an ongoing respiratory infectious disease. It first appeared in Hubei province (in China), more specifically in the city of Wuhan, in November 2019, and then spread around the globe. As the number of cases grows at an exponential rate, certain regions of the world are running out of resources and testing. Faced with this challenge, specialist, physicists, and engineers, including Artificial Intelligence (AI) experts, have promoted the construction of Deep Learning model to assist healthcare professionals in detecting COVID-19 from chest X-ray images and determining the immensity of the infection in a very short time at a low cost. In this paper, we put forward two different approaches one is image histogram-based feature engineering technique called bins approach using linear grouping and one approach from machine learning domain i.e. Deep Convolutional Neural Network (CNN) a Res-Net-50 model to categorize COVID-19 disease from ordinary and other pneumonia infection using chest X-ray images. Proposed algorithms are trained on a COVID-19 Radiography dataset. This dataset contains approximately 3000 Chest X-Ray scans and are classified as Normal, Viral Pneumonia, and COVID-19. Our objective is to create an image classification model that can accurately identify Chest X-Ray scans into one of three groups. The experimental results show that our proposed model represents a promising classification performance on a small dataset which can be further achieved with better results with more training data. Bins approach achieves dimensionality reduction and also simplifies the processing with clear insights of features engineering that can be improved further for getting better results. Overall, our model has the ability to be a useful method for radiologists in the diagnosis and early identification of COVID-19 cases.**

***Index Terms*—Covid-19, cnn, deep learning model, bins, chest x-rays, artificial intelligence, resnet, chexnet.**

I. Introduction

The sudden outbreak of the COVID-19 virus has put an unusual load over healthcare systems across the world. In many countries, the healthcare systems have already been under a lot of pressure. The limited availability of testing kits for diagnosis, limited hospital beds for admission of such patients has made us to find an efficient solution for detection of patients as it is highly contagious. The coronavirus pandemic has led to 9.35 million cases and around 135k deaths till date in India itself. Although the researchers have produced plausible solutions for covid-19 detection, the re- verse transcription-polymerase chain reaction (RT-PCR) tests are expensive and they take roughly around 6-9 hours to deliver results. Because of its low sensitivity, RT-PCR produces a large number of false-negative outcomes which can lead to faster spread on the virus. To accelerate the process of recognition of covid-19 in infected patients we propose techniques such as chest X-rays and computed tomography (CT scans) which belong to radiological imaging. We prefer x-rays over CT scans as x-rays are cheaper and faster to get. Also the radiation ionizing spread in chest x-rays is much less compared to CT scans. As a response to the fight against the virus through Artificial intelligence. There are several deep learning strategies that we have investigated in order to address various problems related to various aspects of the virus, such as diagnosis, infection transmission, and estimate of cardiac involvement elicited by the virus and drug recommendation. For image based detection the usage of Deep learning technologies, such as convolutional neural networks CNN have proved to be the right option in the medical domain. This is because this form of network is highly capable of nonlinear simulation and has a wide range of applications in medical image analysis and diagnostic processes. The Image based approach is ideal by a reason that it has taken a leap in the medical domain over the past years. Primarily in anatomical/cell structure detection, tissue segmentation, computer-aided disease diagnosis or prognosis, and so on. With the enhancements of artificial intelligence (AI), we have developed a web application that uses image recognition strategies to diagnose positive covid cases using images of the lungs. Our aim is to attain better accuracy than the present models and make it cost and time efficient. We also want to identify the severity of the patient based on the regions of the lungs affected by things like Ground-Glass opacities (GGO), Traction bronchiectasis, Air space consolidation and other pertinent features that are important to analyze. For this we have compared three algorithms on their efficiency and concluded using the same. This will help us decide the final output of our project using deep learning techniques.

II. Related Work

Because of the rapid increase in COVID-19 Cases, many scientists have proposed deep learning models especially convolutional neural networks to detect cases infected with COVID-19 or pneumonia using chest x-ray radiological imaging. [25] Where a deep Convolutional neural network is used for detecting covid-19 from chest-xray imaging dataset. The dataset is publicly available.The dataset consists of chest radiography images that contain four classes including COVID-19 infection, Pneumonia Viral, Pneumonia bacterial and normal (non-COVID19 infection). The COVID-Net model had a comprehensive accuracy of 83.5accuracy of 92.4 [7] Introduced a deep learning algorithm, termed COVIDX-Net to aid radiologists to exigently detect COVID-19 in chest x-ray images. This structure is positioned using seven different deep architectures viz. ResnetV2, InceptionResnetV2, Xception, DenseNet201, MobileNetV2, VGG19 and InceptionV3. This abstraction acknowledges that the VGG19 and the DenseNet models have analogous administration of programmed COVID-19 detection with f1-scores of 0.91 and 0.89 for COVID-19 and normal, reciprocally, while the InceptionV3 model had a poor outcome with f1-scores of 0.00 for COVID-19 and 0.67 for normal cases. Additionally, it is substantiated on 50 X-rays compassing 25 cases of COVID-19 and 25 cases without any contagion. [22] Prospective of a system established on a deep convolutional neural network that is solely matured for detecting the contagion of COVID-19 using chest X-ray imaging. This model is trained on a dataset taken away from Github, Open-I repository and Kaggle and it managed an accuracy of 95.38. Ozturk et al [20] Prospective of a system established on a deep convolutional neural network that is solely matured for detecting the contagion of COVID-19 using chest X-ray imaging. This model is trained on a dataset taken away from Github, Open-I repository and Kaggle and it managed an accuracy of 95.38. Ozturk et al. [20] conferred a deep CNN based on the DarkNet model, viz. DarkCovidNet for automatic COVID-19 recognition using chest x-ray radiology imaging. It proffered to accommodate accurate diagnostics for achieving multiclass apportionment ie. COVID vs. Pneumonia vs. Normal and also binary classification ie. COVID vs. Normal, achieving an apportioned accuracy of 87.02.% classes. [2]Trained discrepant pre-trained deep learning models on dichotomic datasets. The initial is an assemblage of 1426 x-ray images comprehending 504 images of normal cases, 700 images with proved bacterial pneumonia and 224 images with covid-19 cases. The further is a dataset inclusive of 504 images of normal cases, 714 images with proved viral pneumonia and bacterial and 224 images with covid-19 cases. The model accomplished an accuracy of 98.75.% and 93.48.% for two and three classes [14]Contemplated CoroNet, a CNN to recognize COVID-19 by applying X-ray images as well as CT scans for detection. The empirical results display that the pretrained network accommodates a comprehensive accuracy of 89.6.% and 95.% for 4 classes viz. Pneumonia viral vs. pneumonia bacterial vs. COVID-19 vs. normal and for 3 classes viz. Normal vs. COVID-19 vs. pneumonia [26] established an early screening model to differentiate COVID-19 from Influenza-A viral pneumonia and healthy cases using 618 pulmonary CT samples (i.e., 175 healthy persons, 224 patients with Influenza-A, and 219 patients with COVID-19). This model achieves a total accuracy of 86.7%. S. Wang et al. proposed a deep CNN model to classify COVID-19 from viral pneumonia using 99 Chest CT images (i.e., 55 viral pneumonia and 44 COVID-19). The results of testing dataset show an overall accuracy of 73.1%, along with a sensitivity of 74.0 % and a specificity of 67.0 %. L. Li et al. [17] Proposed COVNet, A ResNet50 model to characterize COVID-19 from pneumonia and normal using a dataset comprising of 4356 chest and CT scan imagery.The results from the foreknown model suggest a specificity of 96.%, a sensitivity of 90 and AUC of 0.96 in characterizing COVID-19. [23] Produced DeepPneumonia, a system based deep learning, which analyzes patients having COVID-19 from bacterial pneumonia and healthy patients using Chest CT Scan images. The model gives an accuracy of 94.0 for COVID-19 vs. healthy classification and 86.0 for COVID-19 vs. bacterial pneumonia classification. [5] trained a Bayesian Deep Learning classifier using transfer learning method to estimate model uncertainty using COVID-19 X-Ray images.All these approaches reviewed for COVID- 19 detection and classification are from deep learning domain.However the main focus is on the features being extracted for Covid – X-ray images. Looking at the contribution of bins approach in content-based image retrieval we could identify that its feature engineering process is taking minute image details into consideration. This helps in uniquely identifying the images of different classes with quite good accuracy in terms of various parameters [11], [12], [13]. Variations of this bins approach is being applied in other medical domain applications like alzheimers, skin cancer and malaria parasite detection and classification and found to be very effective [1], [24].

III. CHALLENGES IDENTIFIED

Although past innovations in this domain have produced plausible solutions in classifying covid19 , the methods used have certain drawbacks in terms of inefficiency. The drawbacks are as shown below:

A. *Database used was limited*

The size of the publicly available data-set is small, so the accuracy of the results may vary for different data-sets.The experimental results of the model of paper are promising but with a small data-set, further better results with more training data will achieve the same is unclear.

B. *Classification accuracy of Pneumonia and COVID19*

Since the accessible Chest X-ray images are limited, we created a CNN model that could be accurate and robust even though the CNN training data was small. The suggested approach involved transfer learning, in which CNN models pre-trained on a large dataset are used to increase accuracy and robustness. System have been created using this approach with good accuracy to identify viral pneumonia, so we had aim to achieve same accuracy for covid19 detection.

IV. WORKFLOW OF THE PROPOSED SYSTEM

Our primary focus in this work is to prepare an automated system of detecting Covid19 using effective image processing and classifying them using machine learning techniques. The fundamental aim of this system is to detect the white spot in the x-ray. This system will help to detect Covid19 and Pneumonia using chest x-ray. The workflow of our system is shown

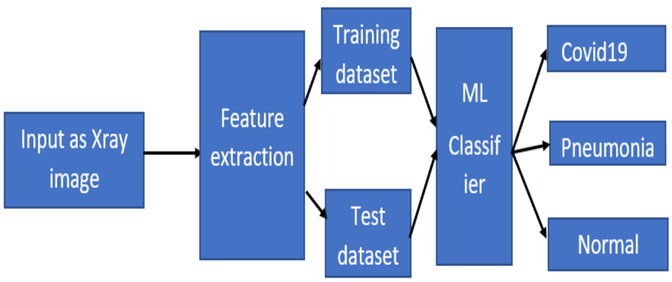

Fig. 1. Architecture of the proposed Covid19 detection and classification of system [16]

in Fig. 1 that illustrates the process of image acquisition, image pre-processing, feature extraction, and classification. The system has been designed and implemented using two different approaches. One of the machine learning techniques used is CNN. [3] The second method applied is the novel Bins Technique [8], [10], focusing on color contents of the image to improve the quality of features with the hope of improving the accuracy in detection of the Covid19.

V. ALGORITHMIC VIEW WITH IMPLEMENTATION DETAILS

We have experimented with our proposed system with three different methods, as mentioned in Section IV. They have been explained in detail:

A. Classification of Covid19 using CheXnet Approach

CheXNet is a deep convolutional neural network consisting of 121 layers. This network produces a heatmap that restricts the areas in which disease symptoms are highly in the image along with the probability prediction.For our model, we used a DenseNet121 pretrianed model to create a CheXNet model. It has five convolution layers and employs average pooling. We loaded the weights from the pretrained from the pre-trained model into our model using the weights file. Because this ChexNet model was trained on chest x-ray images itself as opposed to other models.First, we load the dataset that contains 6432 images with 3 classes for binary classification. As the DenseNet takes input images of size 224x224, resize the images in our dataset to 224x224.Then take the DenseNet network with pretrained weights of CheXNet without including the full connected (FC) layer as head. This model is built with five conv layes and its trained with pretrained weights.We also used feature maps in our ChexNet model to see how much each layer of the proposed ChexNet model handles the given input chest x-rays. This gives insights about the internal representation of feedback and evaluation. This feature maps, also known as activation maps, provide the preferential regions of the image that are used by convolutional neural networks to characterise covid chest x-rays and bacterial pneumonia x-rays with regular chest x-rays. [18]

B. Classification of Covid19 using resnet

B. Proferred in 2015 by the researchers back at Microsoft Research, Classification of Covid19 using ResNet, a new architecture termed Residual Network. In traditional trained neural networks, a degradation problem is found, which is that the more depth is increased in the network, accuracy starts saturating. Resnet helps in reducing this problem using skip connections., wherein gradients can flow directly through the identity function from later layers to the earlier ones [19] A 34-layer plain network architecture is used by the model which is influenced greatly by VGG19 wherein the shortcut skip connection is joined. These connections in turn novice the architecture into a residual network.

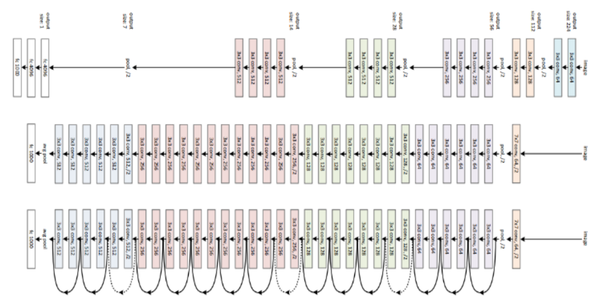

Fig. 2. Resnet50 architecture [6]

C. Classification of Covid19 using Bins Approach:

Inorder to Bins Approach is a novel technique that can extract essential image contents and represent in the form of simple feature vectors with a significant reduction in the feature dimensions. It is one of the Content-Based Image Retrieval (CBIR) processes that attempts at retrieving appropriate features from large digital image databases [24]. It has proved its best performance in the CBIR domain. In order to check its performance in the medical field, we are proposing to apply the same for our covid19 detection and classification system. Here we are proposing the simple histogram based bins approach with linear grouping to reduce the size of feature vector and further computations of statiscal properties of these bins contents in order to analyze the texture of Covid-X-ray images. In this Proposed work we have worked out one more variation with bins based feature extraction by enhancing the image contents using the polynomial transformation. Both variations are applied to all of data base of Covid19 X-ray images converted into grayscale. Simple bins approach and its variation with polynomial transform is discussed as follows:

1. Feature Extraction

Step 1: read and convert the image into gray scale image and Compute histogram for each Image.

Step 2: Perform linear grouping at interval of 32 to reduce the no of bins from 256 to 8 bins for each image.

Step 3: Compute the first four statistical moments i.e. mean, standard deviation, skewness, and kurtosis for the intensities segregated into these 8 bins.

Bins with Polynomial Function: Linear grouping based 8 bins formation is preceded by the application of Polynomial transform over entire image. Polynomial transformation is given by in equation (1) [9].

$$y = 2x - x^2 \tag{1}$$

This gives the enhanced image contents into 8 bins for which, further four moments are computed in order to improve the texture analysis with the hope of improving the feature vector quality to improve the detection accuracy.

2. Application of machine learning classifiers

After applying above steps we prepared two Feature vector databases for above two variations of bins approach. First is bins with four moments and another variation is Bins with four moments preceded by polynomial transformation over image contents. These features now to be forwarded to the classifiers for final detection and classification of infected and non-infected images based on based feature vectors. We have planned to use three classifiers for the same. Brief details about the same are given below.

i) SVM performs several data transformations and computes an ideal boundary between the classifying outputs using a property known as a kernel trick [24].

ii)Random Forest classifier is used for classification and behaves similarly to a decision tree. The random forest algorithm is trained using the bootstrap aggregation technique. The ultimate forecast can be made by averaging the projections of all the individual regression trees [15].

iii)Logistic regression predicts the class based on its association with the label. The algorithm that classifies the data by taking the result variables at the extreme ends and attempting to draw a logarithmic line that differentiate between them [4].

VI. Performance evaluation parameters

he various performance evaluation parameters that need to be considered while evaluating a covid19 classification system are as follows:

1) Accuracy: Accuracy determines how often the classifier shows this correct output. The accuracy of a system must be higher. This is shown in Equation (2).

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{2}$$

2) Precision: Precision is defined as the ratio of the number of accurate positive results generated to the total positive results predicted by the classifier. A higher precision denotes that the results are more relevant than the irrelevant ones. This is shown in Equation (3).

$$Precision = \frac{TP}{TP + FP} \tag{3}$$

3) Recall: Recall is the ratio of the correct positive results generated by the classifier to the number of all relevant samples. A higher recall denotes that the classifier returns more actual results. This is shown in Equation (4).

$$Recall = \frac{TP}{TP + FP} \tag{4}$$

4) F1 measure: F1-measure is the harmonic mean between precision and recall. It tells how accurate and robust the classifier is. This is shown in Equation (5).

$$F1measure = frac2 * recall * precisionrecall + precision \tag{5}$$

VII. Experimental setup

Proposed System of bins approach along with its variation and the deep learning models resnet and cheXnet are experimented with following dataset Dataset: on Chest X-ray dataset, the dataset have been obtained from the kaggle repository . [21].This repository holds 6432 chest x-ray images if patients with Covid19, pneumonia and normal chest x-ray images and this dataset is divided into two sets that is test data and train data.We have used 1288 images for test set which comprises of 116 COVID19 chest X-ray images, 317 for normal images and 855 for pneumonia images, and 4144 images for training set which comprises of 460 chest X-ray images for COVID19, 1266 for normal images and 3418 images containing pneumonia chest X-ray. All the sets of results are evaluated using same set of performance evaluation parameters

VIII. Result and Discussion

We have assessed and compared the approaches using following parameters Accuracy, Precision, Recall, and F1-score,and we have correspondingly found the results of the outputs are: From above Table, we can observe that Resnet50 works as considerably as good as CheXnet and bins approach,with accuracy scaling at 96% a result, we can infer that Resnet50 works fairly well with our classification strategy, but slightly lesser than CheXnet approach. The above table also describe that Resnet50 is the best classifier for this approach, with an accuracy of 96%, which is significantly higher than the other methods cited so far (the results are highlighted in yellow). Furthermore,the SVM classifier has the lowest accuracy. It should be observed that in Table, we although models such as CheXnet achieved high precision, there are a few disadvantages to using this approach. For starters, it take a long time to train the model. We trained the model on basic Windows 10 PC for about 60 to 100 minutes during the process. Although processing times may vary between PCs, loading even a simple model and performing the required computations is more costly.The derived results are summarized in

TABLE I: COMPARING DEEP LEARNING MODEL

Approach Parameter	CheXnet	Resnet50
Accuracy	93 %	**96** %
Precision	92 %	**96** %
Recall	93 %	**96** %
F1- score	92 %	**93** %

below Tables:
From table 1, Comparing the deep learning models we can clearly see that the accuracy of Resnet50 is more than CheXnet in terms of all parameters.

TABLE II: COMPARING PERFORMANCE OF DIFFERENT CLASSIFIERS FOR PLANE- BINS APPROACH

Approach Parameter	Bins with logistic regression	Bins with svm	Bins with Random forest
Accuracy	69 %	**79** %	82 %
Precision	68 %	**79** %	82 %
Recall	70 %	**76** %	81 %
F1- score	67 %	**78** %	81 %

We can see from the below table 2 and 3 that results obtained by linear grouping-based bins approach getting highest accuracy i.e. 82% for random forest classifier. So we further try to implement to bins using polynomial function in order to improve the image contents with the hope of getting better results.

TABLE III: COMPARING PERFORMANCE OF DIFFERENT CLASSIFIERS FOR BINS APPROACH WITH POLYNOMIAL FUNCTION.

Approach Parameter	Bins with logistic regression	Bins with svm	Bins with Random forest
Accuracy	70 %	**76** %	81 %
Precision	69 %	**76** %	80 %
Recall	70 %	**76** %	81 %
F1- score	67 %	**76** %	80 %

We can observe in table 3 that even after enhancing the contents using polynomial function, we could not achieve much improvement in the results. It is nearly same for both the variations.

TABLE IV: RESULT OBTAINED FROM DEEP LEARNING MODEL AND BINS APPROACH WITH ML CLASSIFIERS.

Approach Parameter	CheXnet	Resnet50	Bins with svm	Bins with random forest	Bins with logistic regression
Accuracy	93 %	**96** %	79 %	82.21 %	72 %
Precision	92 %	**96** %	79 %	82 %	71 %
Recall	93 %	**96** %	79 %	82 %	72 %
F1- score	92 %	**93** %	78 %	81 %	70 %

Table 4 shows the overall comparison of bins approach with existing approaches i.e deep learning models. These results are clearly showing that CheXnet and Resnet are giving much better accuracy (93%, 96% respectively) as compared to bins approach with random forest classifier (82%) for Covid 19 detection and classification. In bins approach, converting the original image into grey image must be losing some useful image information which is impacting the feature vector formation and in turn in the classification accuracy. However if we analyse the feature engineering process of bins approach its it is a simplified approach and also computationally less complex. Feature vector dimensions have been reduced to great extent by simply performing the linear grouping of the histogram bins.

IX. Conclusion

In the course of our research, we have studied the various approaches contributing to the medical field of diseases, especially highlighting the repercussions of false detection of Covid-19 that can lead to more spread of the virus and early prediction of COVID-19 patients is vital to avoid spreading the sickness to totally different individuals. during this study, we proposed a deep transfer learning-based approach the utilization of chest X-ray pictures obtained from COVID-19 patients, normal and virus infection for automatic detection of COVID-19 pneumonia. Among all the possible ways to detect and diagnose the virus, we have chosen the image processing techniques to facilitate the doctors with a second opinion on the currently present testing mechanisms and also determine the severity of the patient. We have thoroughly read research papers related to present work in image-based classification of images and various optimal techniques used for it, and we have also shortlisted the ones to be implemented so as to fulfil the technical specifications and requirements. We have also successfully implemented the proposed system with deep learning models along with proposing the application of bins approach in this medical domain.
AI mainly uses computer techniques to perform clinical diagnoses and suggest treatments. We have proved the same by executing the three models, the first one is Resnet50, second one is CheXnet and last one is the proposed use of bins approach. Based on result and discussion we can recommend that deep learning models are proving their best as AI has the capability of detecting meaningful relationships in a data set and has been widely used in many clinical situations to diagnose, treat, and predict the results. Bins approach can further be improved by focusing more on original image contents rather than converting it into grey and processing the same for feature engineering can be extended as future work.

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