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Artificial Intelligence (AI) for Covid-19 Disease Detection Using Lung X-Ray Images

[1]M Gopi Krishna, [2]Dr.Jaideep G

[1]PG Scholar, Department of AI & DS, ST. Marys Group of Institutions Guntur, AP, India

[2]Associate professor, Department of AI& DS, ST. Marys Group of Institutions Guntur, AP, India

ABSTRACT: The word has faced unprecedented difficulties with COVID-19 outbreak. Millions of peoples across the globe died due to the Corona virus that caused the disease. It has also resulted in economic losses and health issues. The disease affects lungs and the victims suffer from reduction of oxygen levels in the body leading severe health problems and even death. With technological innovations in ArtificialIntelligence (AI), it is possible to solve many real world problems with computer vision applications. With Lung X-ray of COVID-19 suspected people, it is possible to detect the disease. Generally, doctors in healthcare units see the X-rays and diagnose patients. However, it is better to have a Clinical Decision Support System (CDSS) that aids doctors with AI for automatic detection of presence of absence of COVID-19. In this paper, we proposed an AI enabled framework which exploits advanced Convolutional Neural Network (CNN) model based InceptionV3with modified configurations for automatic detection of the disease. It has provision for feature selection and learn from training samples to gain actionable knowledge. With such knowledge, the model can work on test samples and predict class labels. Publicly available COVID-19 lung X-ray dataset is used for the empirical study. The results showed that the proposed deep learning based model has outperformed baseline models such as CNN and Recurrent Neural Network (RNN). The proposed model achieved 92% accuracy which is highest when compared with existing models.

KEYWORDS: COVID-19 detection, Advanced CNN model, CNN, RNN

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I. INTRODUCTION

SARS-CoV-2, denoted as novel coronavirus, and commonly known as COVID-19 pandemic has caused widespread causalities across the globe. It mainly causes respiratory illness leading to reduction of oxygen levels in the human body. The severity differs from person to person due to many factors. There is risk of organ failure and death as well. The disease causes respiratory tract illness initially and gradually the illness progresses into multi-organ failure or death. The pandemic has witnessed unprecedented social and economic situations forcing people to undergo many difficulties. It also led to other health issues such as cardiovascular problems. A great deal of research went on to prevent COVID-19 disease. Researcher's explored machine learning (ML) and deep learning (DL) models that come under AI for possible automatic detection of disease using lung X-ray and CT scans. In this paper we focused on the disease prediction using X-ray images.

Many existing approaches are found using AI in the literature. Daniel *et al*. [7] investigated on AI based models used for COVID-19 detection and their current limitations. Shi *et al*. [8] focused on AI enabled methods that are used in data acquisition, image processing and segmentation for the disease diagnosis. Minaee *et al*. [9] proposed a framework known as Deep-COVID for automatic detection of the disease. They incorporated transfer learning method as part of the framework. Mishra *et al*. [10] on the other hand proposed an AI system for detection of the disease early and discriminate it from other related diseases. Vasal *et al*. [11] proposed a system using AI methods for diagnosis of the disease. It could help as an automated system for disease diagnosis. Haritha *et al*. [16] and Abdullahi *et al*. [17] used deep learning models that use X-ray images for supervised learning based approach in the detection of the disease. Bekhet *et al*. [18] proposed AI based model with underlying ML models for diagnosis of the disease. Jain *et al*. [19] used data analytics supported by deep learning for detection of the disease using X-ray images. Agarwal *et al*. [20] proposed a technique known as bock imaging with nine AI models to find disease, its severity and characterization.From the literature it is ascertained that the CNN and other deep learning models that are under AI domain are widely used for computer vision applications. The CNN baseline model has its limitations unless it is

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empirically evaluated and configured with layers appropriately. In this paper, we proposed amodified InceptionV3, a variant of CNN, model with modified configurations to achieve better prediction performance. Our contributions in this paper are as follows.

1. We proposed an AI based framework with modified InceptionV3 model for leveraging COVID-19 prediction performance using X-ray imagery.
2. We proposed an algorithm known as AI Enabled Automatic COVID-19 Detection (AI-ACD) which exploits training samples and data augmentation for automatic detection of COVID-19 using X-ray images.
3. We built a prototype for empirical study to evaluate the proposed model.

The remainder of the paper is structured as follows. Section 2 review literature on different methods used for COVID-19 detection covering AI methods as well. Section 3 presents the proposed methodology and the underlying algorithm. Section 4 presents experimental results and evaluation of the proposed AI model. Section 5 concludes our work and gives scope for future work.

II. RELATED WORK

This section reviews important literature on AI based prediction models to detect COVID-19 disease from given data. Huang *et al*. [1] proposed a machine learning model that takes features of patients as input and makes its prediction. It throws light on the clinically useful features of patients. Chen *et al*. [2] explored clinical characteristics and epidemiological features of coronavirus cases with descriptive study. It provides the details of different characteristics collected from 99 cases. Wang *et al*. [3] used data of 138 patients who were hospitalized due to COVID-19 infection severity. It is a descriptive study that examines the characteristics of 138 patients. Liu *et al*. [4] also investigated on different characteristics of COVID-19 cases in tertiary hospitals to ascertain the possibilities to help citizens in controlling spread of the disease. Dhiman *et al*. [5] proposed an AI based tool known as ADOPT for automatic detection of COVID-19 from X-ray images. They used deep learning and optimization procedures to improve prediction performance. Togacar *et al*. [6] used deep learning models along with Social Mimic Optimization using X-ray images for COVID-19 detection. It has stacking and fuzzy colour models as part of their methodology. Daniel *et al*. [7] investigated on AI based models used for COVID-19 detection and their current limitations. Shi *et al*. [8] focused on AI enabled methods that are used in data acquisition, image processing and segmentation for the disease diagnosis. Minaee *et al*. [9] proposed a framework known as Deep-COVID for automatic detection of the disease. They incorporated transfer learning method as part of the framework. Mishra *et al*. [10] on the other hand proposed an AI system for detection of the disease early and discriminate it from other related diseases. Vasal *et al*. [11] proposed a system using AI methods for diagnosis of the disease. It could help as an automated system for disease diagnosis.

Harithaet *al*. [12] used CNN model for detection of COVID-19. This model is used to have improved approach in feature selection and learning process. Julian *et al*. [13] focused on AI applied to the detection of the disease from X-ray imagery. Ozturk *et al*. [14] and Altan *et al* [15] used deep learning models with X-ray images for the prediction of the disease. However, in [15] they used 2D curvelet transform for modelling singularities and edges of input images. Haritha *et al*. [16] and Abdullahi *et al*. [17] used deep learning models that use X-ray images for supervised learning based approach in the detection of the disease. Bekhet *et al*. [18] proposed AI based model with underlying ML models for diagnosis of the disease. Jain *et al*. [19] used data analytics supported by deep learning for detection of the disease using X-ray images. Agarwal *et al*. [20] proposed a technique known as bock imaging with nine AI models to find disease, its severity and characterization. From the literature it is ascertained that the CNN and other deep learning models that are under AI domain are widely used for computer vision applications. The CNN baseline model has its limitations unless it is empirically evaluated and configured with layers appropriately. In this paper, we proposed a modified InceptionV3, a variant of CNN, model with modified configurations to achieve better prediction performance.

III. PROPOSED SYSTEM

The proposed system is an advanced CNN based model known as InceptionV3 with altered configurations to have better prediction performance. It exploits pre-trained model with reuse of knowledge for improving performance. With its pre-trained model, it has knowledge that helps in making automatic prediction of COVID-19 from chest X-ray

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imagery. The proposed model has different layers configured with empirical study to achieve better prediction accuracy. The framework shown in Figure 1 is the configured model which is essentially a variant of CNN model with more useful and relevant configurations. Since CNN is the best model for computer vision applications, it is preferred in this research. Inception V3 is a CNN variant best used for image processing or image classification. It is an improved model originally introduced by Google. It has optimizations in the network and adaptation of the model for higher efficiency. It has improved network model without compromising its speed. It is relatively less expensive in terms of resources as well. It makes use of regularizers and auxiliary classifiers.

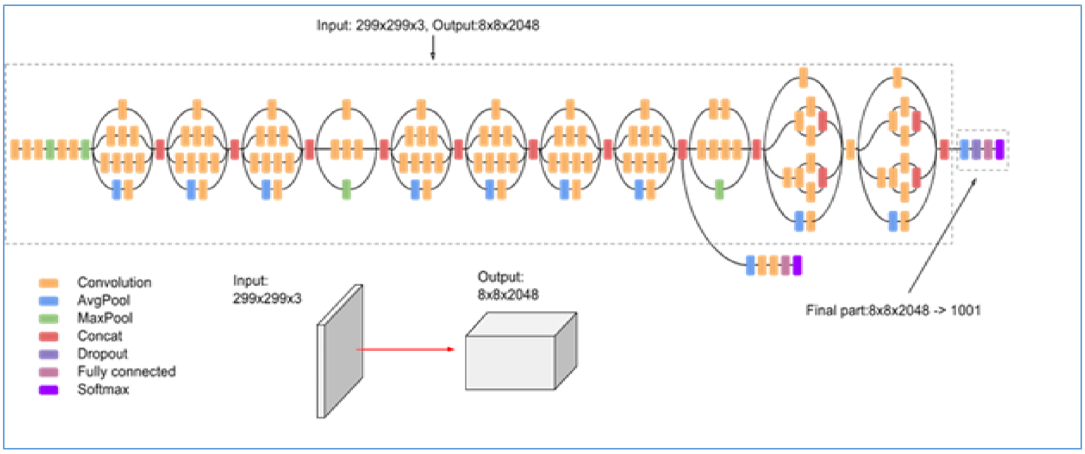

Figure 1: Proposed AI enabled framework with modified InceptionV3 model

As presented in Figure 1, the model is configured with empirical study. It has different layers such as convolution layers, average pooling layers, max pooling layers, concatenations, dropouts, fully connected layers and softmax for final discrimination and classification. These layers are provided appropriately in order to achieve better learning and discrimination provisions. Convolution layers are best used to learn features from the image data. This will help in supervised learning process. The max pooling and avg pooling layers on the other hand help in subsampling and reduce in the dimensions for improving quality of the data. Appropirate dropouts help in dealing with data properly without unnecessary content. Fully connected layer helps in getting the classification done while softmax actually shows final results of classification that is nothing but diagnosis into COVID-19 and NON COVID-19 samples.

Algorithm:AI Enabled Automatic COVID-19 Detection (AI-ACD)
Inputs: Training data T1, Test data T2
Output: Detection results R

1. Start
2. Add convolution layers
3. Add avg pool layers
4. Add max pool layers
5. Add concats
6. Add dropouts
7. Add fully connected layer
8. Add softmax layer
9. Create the AI model M
10. For each epoch e in E
11.   For each batch n in N
12.   Update M with T1
13. End For
14. End For
15. R←Predict(M,T2)
16. Return R

Algorithm 1:AI Enabled Automatic COVID-19 Detection (AI-ACD) algorithm

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As presented in Algorithm 1, it takes training data and test data as inputs. It produces prediction results in supervised learning approach. It used training data T1 to learn features from training images. This will help the algorithm to gain knowledge from the data. This knowledge is used while performing prediction using T2 that is test data. The test data is classified into COVID-19 and NON COVID-19 samples. The algorithm also generates confusion matrix from which the performance metrics are derived.

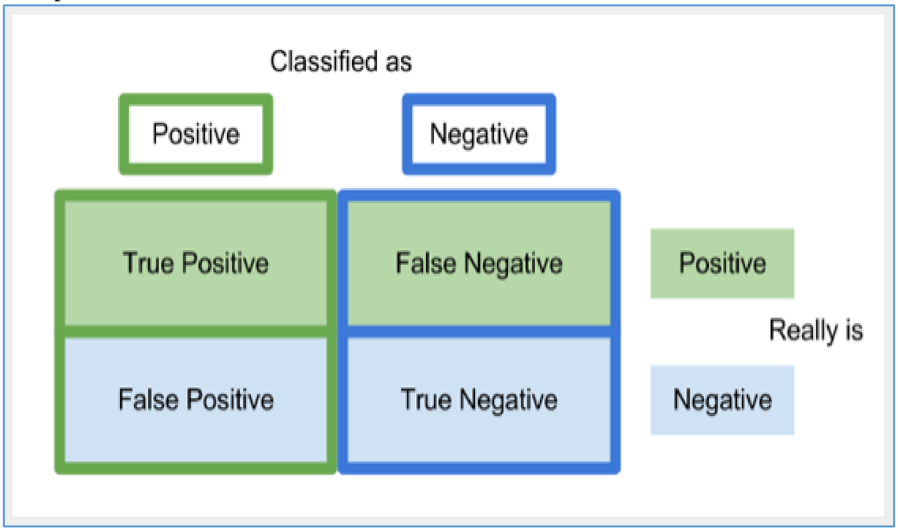

Figure 2: Confusion matrix

Based on the confusion matrix presented in Figure 2, the confusion matrix shows the measures like true positive (TP), false positive (FP), false negative (FN) and true negative (TN). These are determined by comparing result of ML algorithm when compared with the ground truth.

Metric	Formula	Value range	Best Value
Accuracy	$\frac{TP+TN}{TP+TN+FP+FN}$	[0; 1]	1
Precision (p)	$\frac{TP}{TP+FP}$	[0; 1]	1
Recall (r)	$\frac{TP}{TP+FN}$	[0; 1]	1
F1-Score	$2*\frac{(p*r)}{(p+r)}$	[0; 1]	1

Table 1: Performance metrics used for evaluation

Precision refers to positive predictive value while the recall refers to true positive rate. F1-score is the harmonic mean of both precision and recall which is used to have a measure without showing imbalance while accuracy measure may show imbalance.

IV. EXPERIMENTAL RESULTS

The proposed system is evaluated using a prototype application. Different observations are made in terms of detection results. Confusion matrix is visualized in order to know the performance of the proposed modified InceptionV3 model.

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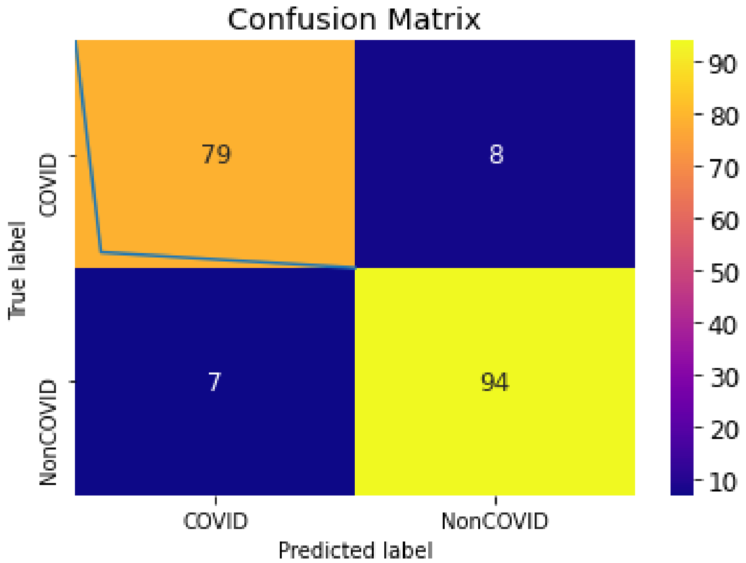

Figure 3: Confusion matrix

As presented in Figure 3, it shows the number of true positives, number of true negatives, false positives and false negatives. These values are used to compute the performance metrics as given in Eq. 1, Eq. 2, Eq. 3 and Eq. 4. Then the results are evaluated and compared with the state of the art AI models.

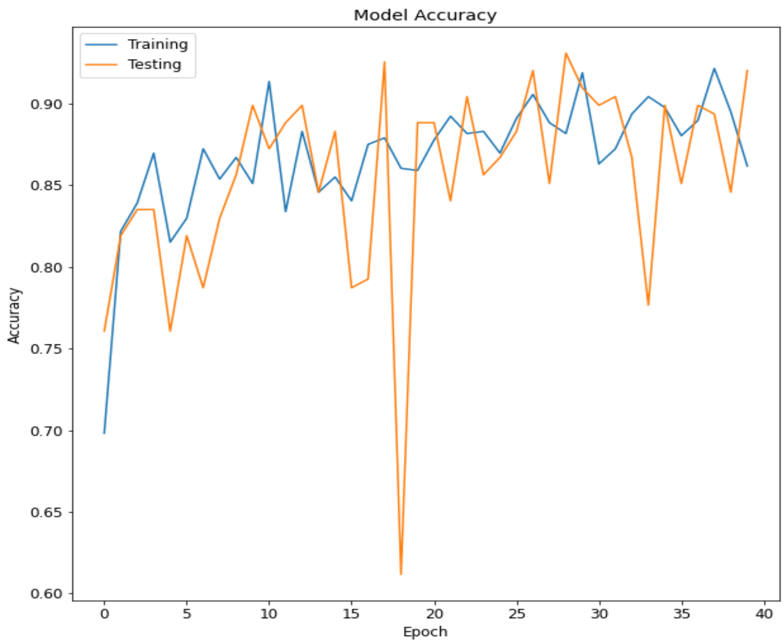

Figure 4: Results of modified InceptionV3 with training accuracy and testing accuracy against different epochs

As presented in Figure 4, the observations are given for 40 epochs provided in horizontal axis and the performance in terms of training accuracy and testing accuracy is provided in vertical axis. The results revealed that as the number of epochs increased there is increase in the accuracy of the model except in few epochs.

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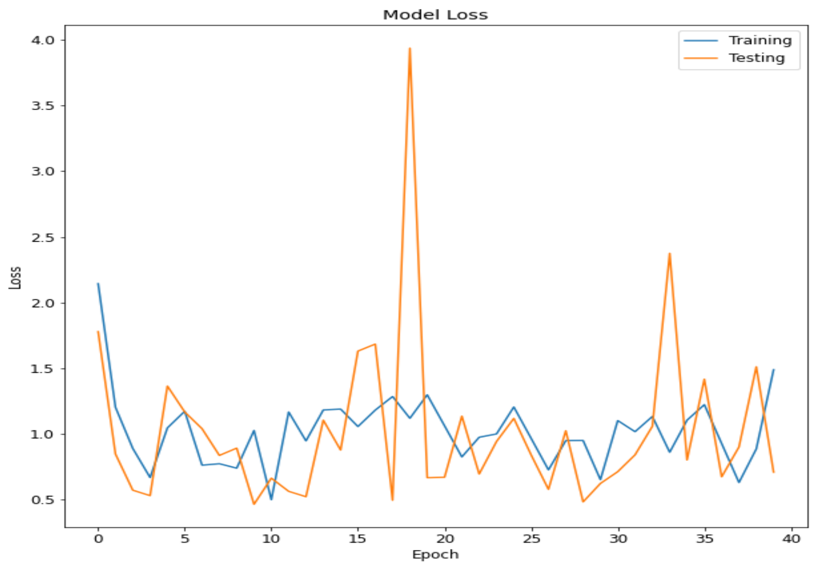

Figure5: Results of modified InceptionV3 with training loss and validation accuracy against different epochs

As presented in Figure 5, the observations are given for 40 epochs provided in horizontal axis and the performance in terms of training loss and testing loss is provided in vertical axis. The results revealed that as the number of epochs increased there is decrease in the loss value of the model except in few epochs.

Model	**Performance (%)**			
	Precision	**Recall**	**F1-Score**	**Accuracy**
InceptionV3	0.92	0.91	0.91	0.92
CNN	0.88	0.98	0.93	0.89
RNN	0.9	0.91	0.9	0.87

Table 2: Performance comparison between the proposed modified InceptionV3 and existing AI models

As presented in Table 2, the performance of three deep learning models is provided in terms of precision, recall and accuracy.

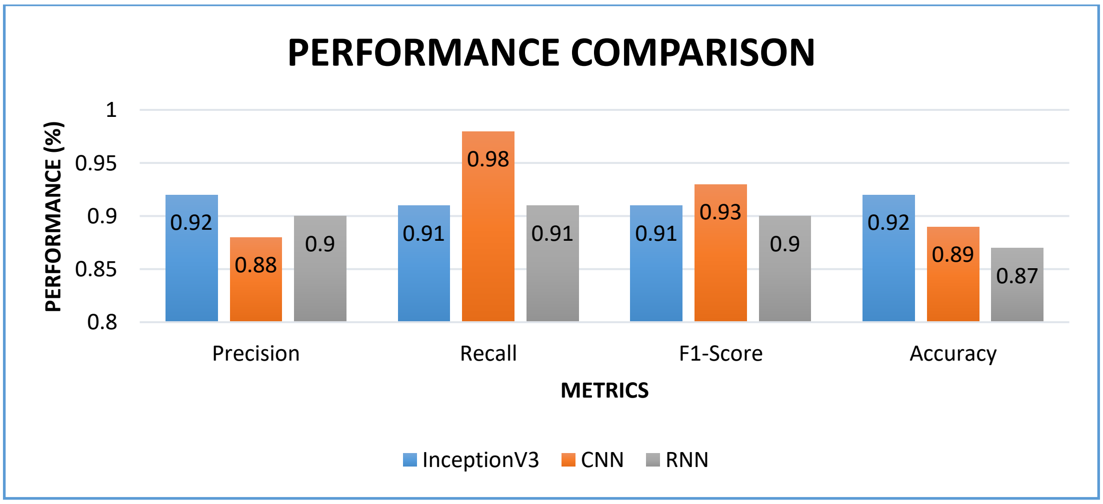

Figure 6: Shows performance of different AI models used in the empirical study

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As presented in Figure 6, the performance of the proposed modified InceptionV3 is compared against existing models such as CNN and RNN. It is observed that each model has shown different performance statistics. The reason behind this is that each model has its own number of layers and configurations. When compared with the baseline CNN and RNN models, the modified Inception V3 showed better performance due to its appropriate configurations to deal with X-ray images to detect COVID-19. The accuracy of RNN is 87% while CNN showed 89%. Highest accuracy is exhibited by the proposed modified Inception V3 model with 92% accuracy.

V. CONCLUSION AND FUTURE WORK

In this paper, we proposed an AI enabled framework which exploits advanced Convolutional Neural Network (CNN) model based InceptionV3 with modified configurations for automatic detection of the disease. It has provision for feature selection and learn from training samples to gain actionable knowledge. With such knowledge, the model can work on test samples and predict class labels. Publicly available COVID-19 lung X-ray dataset is used for the empirical study. The results showed that the proposed deep learning based model has outperformed baseline models such as CNN and Recurrent Neural Network (RNN). When compared with the baseline CNN and RNN models, the modified Inception V3 showed better performance due to its appropriate configurations to deal with X-ray images to detect COVID-19. The accuracy of RNN is 87% while CNN showed 89%. Highest accuracy is exhibited by the proposed modified Inception V3 model with 92% accuracy. In future we intend to modify and use the proposed model with lung CT scan images for automatic COVID-19 detection.

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