International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

Deep Learning Framework for Covid-19 Detection and Severity Classification towards Clinical Decision Support System

Mr. Shaik Khasim Saheb[1*], Dr B. Narayanan[2], Dr.Thota Venkat Narayana Rao[3]
[1]Research Scholar, Department of CSE,
Annamalai University, Annamalainagar, Chidambaram,
Tamil Nadu,India
[*]shaikkhasims@sreenidhi.edu.in
[2]Assistant Professor, Computer Science and Engineering,
FEAT, Annamalai Univerisity, Annamalainagar,
Chidambaram, India
[3]Professor, Department of Computer Science and Engineering and HOD-CSE (IoT),
Sreenidhi Institute of Science and Technology, Yamnampet, Ghatkesar,
Hyderabad,Telangana, India.

Abstract—Chest CT scans are widely used for COVID-19 diagnosis. Existing methods focused more on the detection of the disease. However, there is need for detection of severity towards making decisions for suitable course of action. Towards this end, we proposed a deep learning framework for automatic COVID-19 diagnosis and severity detection. Our framework is based on enhanced Convolutional Neural Network (CNN) model which is found efficient for medical image analysis. We proposed two algorithms to realize the framework. The first algorithm is known as Deep Learning based Automatic COVID-19 Diagnosis (DL-ACD). This algorithm is meant for diagnosis of COVID-19 with learning based phenomena. The second algorithm is known as Automatic COVID-19 Severity Detection (ACSD). It is designed to know severity of the disease which helps in making treatment appropriate. Our framework is evaluated against existing deep learning models and found to have superior performance over the existing models.

Keywords-COVID-19 Diagnosis, COVID-19 Severity Detection, Deep Learning, Artificial Neural Network.

I. INTRODUCTION

SARS-COV-2 of Covid-19 pandemic has caused havoc across the globe. People died of it due to the fact that the Corona virus affects lungs and kills in short span of time. As there was no established treatment, healthcare units treated Covid-19 patients with symptoms based approach for long time. Later on Covid-19 vaccines were invented by scientists in different countries. Due to vaccines, the disease is largely under control now. However, variants of Corona virus continued to emerge and causes waves of rapid spreading in different countries. As part of Covid-19 treatment chest X-Ray images and CT scans are widely used for diagnosis and severity detection by doctors. With AI innovations, deep learning techniques are found suitable for automatic detection of Covid-19 [1]. Parallel to the efforts of healthcare units, researchers across the globe came up with AI based approaches for Covid-19 diagnosis.

Deep learning techniques based on chest X-Rays are explored in [1], [6], [13], [15] and [19]. Verma et al. [1] focused on automatic detection of Covid-19 using chest X-ray images. Their methodology is based on deep learning and Wavelet technique. Sekeroglu and Ozsahin [6] defined a CNN based methodology for detection of Covid-19 by using chest X-ray images. Alghamdi et al. [13] used chest X-ray images for Covid-19 detection. Towards this end they explored different existing methods to know their efficacy in disease detection process. Chattopadhyay [15] used chest X-ray images for Covid-19 detection. Their methodology includes Dynamic Radial Basis Function Network which has potential to discriminate Covid-19 positive samples from negative ones. Shah et al. [19] combined Gated Recurrent Unit (GRU) and CNN to form an architecture for automatic Covid-19 detection. CT imagery is another imaging technology widely used in the research as explored in [2], [5], [8] and [10]. These researches are based on deep learning focusing on Covid-19 diagnosis. However, it is found that severity detection is important to know the proper course of action by physicians. Our contributions are as follows.

We proposed a deep learning framework for automatic COVID-19 diagnosis and severity detection. Our framework is based on enhanced Constitutional NeuralNetwork (CNN) model which is found efficient for medical image analysis.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

We proposed two algorithms to realize the framework. The first algorithm is known asDeep Learning based Automatic COVID-19 Diagnosis (DL-ACD). This algorithm is meant for diagnosis of COVID-19 with learning based phenomena. The second algorithm is known as Automatic COVID-19 Severity Detection (ACSD). It isdesigned to know severity of the disease which helps in making treatment appropriate.We built an application that is user-friendly to detect Covid-19 automatically besides determining severity based our proposed algorithms. The remainder of the paper is structured as follows. Section 2 reviews literature on existing deep learning models used for Covid-19 research. Section 3 presents the proposed system including framework and algorithms. Section 4 presents results of our experiments while Section 5 concludes the paper.

II. RELATED WORK

This section reviews literature on existing Covid-19 detection models based on deep learning. Verma et al. [1] focused on automatic detection of Covid-19 using chest X-ray images. Their methodology is based on deep learning and Wavelet technique. Turkoglu et al. [2] proposed a methodology for automatic detection of Covid-19 using chest CT images collected from infected patients. They used Deep Neural Network and Extreme Learning Machine (ELM) in their method. They combined those two models with multiple kernels in order to achieve high accuracy in Covid-19 detection. Then intended to improve their system with mobile-web interface to help radiologists. Ahuja et al. [3] exploited pre-trained CNN based models along with transfer learning for Covid-19 detection. Their detection model has three phases such as data augmentation, Covid-19 detection and localization of abnormality using lung CT scans. With transfer learning in their method, they could achieve faster convergence, reduce complexity and limit pre-processing. Their model is found suitable for small dataset and they intended to evaluate it with larger dataset in future. Geng et al. [4] proposed a novel method for Covid-19 diagnosis using molecular immune pathogenesis. Fung et al. [5] proposed a two-stage deep learning system for automatic Covid-19 diagnosis. It was a self-supervised approach considering putative causal relationship between the disease and age. They incorporated an improved feature engineering process for leveraging prediction process. Sekeroglu and Ozsahin [6] defined a CNN based methodology for detection of Covid-19 by using chest X-ray images. They opined to improve their model further with advanced CNN architectures towards improving performance. Rezaeijo et al. [7] proposed a hybrid approach with ML and deep learning models in order to achieve Covid-19 diagnosis. With deep transfer learning they realized better performance in prediction process. They made global average pooling with ML models such as SVM. Back propagation is used in order to achieve desired results.

Li et al. [8] proposed a deep learning based system with three phases in the methodology for Covid-19 detection. In the first phase, training process is completed. In the second phase data augmentation is carried out along with further training with transfer learning. In third phase actual diagnosis of Covid-19 is carried out. In future, then intend to improve their system to have generalizable capability in disease detection. Ibrahim et al. [9] focused on SARS-COV-2 detection automatically using deep learning. It performs both detection of abnormality using CT scans and also detection of severity. It combines traditional approaches and deep learning technique. It has three phases such as pre-processing, feature engineering and classification. In future, they intend to incorporate unsupervised techniques into their methodology. Cifci et al. [10] proposed a deep learning architecture based on AlexNet for detection of Covid-19 from CT imagery. They incorporated image processing techniques such as Gaussian blur, Otsu threshold, image splitting and histogram feature extraction.

Irmak [11] proposed a CNN based model for severity detection of Covid-19 using Chest X-ray images. They used CNN with hyper parameter optimization. Rahman et al. [12] explored ECG trace images using deep learning technique known as CNN. It has methodology to detect Covid-19 and also any other Cardiovascular diseases. Alghamdi et al. [13] used chest X-ray images for Covid-19 detection. Towards this end they explored different existing methods to know their efficacy in disease detection process. They found that Generative Adversarial Network (GAN) based approaches have potential to leverage detection performance in future. Akgun et al. [14] explored different pre-trained deep learning models such as RestNet50 and VGG19 towards diagnosis of Covid-19 using audio data. They found that audio of Covid-19 patients differs from normal patients. In future, they intend to use more pre-trained models along with transfer learning. Chattopadhyay [15] used chest X-ray images for Covid-19 detection. Their methodology includes Dynamic Radial Basis Function Network which has potential to discriminate Covid-19 positive samples from negative ones. They intend to improve their method to fit into a multi-class problem in future.

Mohammad-H and Tayarani-N [16] explored the role of AI in building solutions for automatic detection of Covid-19 disease. They studied different ML and deep learning models that are used with chest X-ray and chest CT scan images of Covid-19 patients. They opined that AI is a promising solution towards disease diagnosis. Vasal et al. [17] explored many pre-trained deep models for Covid-19 diagnosis. Their method also includes data augmentation in order to improve training

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

quality. Among their studied models Densenet121 could achieve highest accuracy in disease diagnosis. Bouchareb et al. [18] used radiological images for Covid-19 diagnosis. They made use of CT scans and X-ray images for empirical study. They explored AI based radiology workflow towards automatic detection of Covid-19. Their research found that it is important to correlate AI based methods with the machinery being used in healthcare units. Shah et al. [19] combined Gated Recurrent Unit (GRU) and CNN to form an architecture for automatic Covid-19 detection. Chest X-ray images are used in their experiments. They performed multi-class classification resulting in three class labels such as Pneumonia, Covid-19 and normal. In future, they intend to use GAN and data augmentation for further improvement. Park et al. [20] explored a phenomenon known as task-agnostic training for Covid-19 detection from chest X-ray images. Their methodology is based on federated split vision transformer which is one of the latest deep learning architecture. In future they intend to improve their system to preserve privacy of patients. From the literature, it is understood that most of the deep learning models used for Covid-19 detection are based on CNN. However, there is need for improving accuracy in detection process by leveraging architecture of CNN models. Moreover, there is need for severity detection of Covid-19 which helps physicians to prescribe appropriate course of action, medication besides clinical care.

III. PROPOSED SYSTEM

We proposed a deep learning based framework for automatic detection of Covid-19 and Covid-19 severity detection. The framework is presented in Figure 1. It is a two-stage architecture which takes care of Covid-19 diagnosis and also severity detection. It is designed to use lung CT scan images which helps physicians to diagnose and also find severity level towards proper course of action and medication to patient. The given dataset is subjected to pre-processing which does many things. First, it performs Region of Interest (ROI) detection and discards CT scans that do not have ROI. From candidate ROI, dark pixel counting is carried out with an iterative process to identify and discard unwanted samples. Second, for the remaining scans, it performs splitting of data into training set and test set. In the training phase, a pre-trained model DenseNet169 is used along with the proposed deep learning architecture illustrated in Figure 2. Transfer learning is employed in order to speed up the process of learning. Transfer learning is an important ML technique which enables a model to reuse previously trained knowledge instead of learning from the scratch. Thus DenseNet169 model with pre-trained knowhow is reused to leverage speedup or convergence of the proposed deep network architecture.

After the model is trained by exploiting pre-trained DenseNet169 model using transfer learning, a knowledge model is built which is known as Covid-19 diagnosis model. This model takes test data in order to perform actual diagnosis resulting in two classes such as Covid-19 +ve and Covid-19 –ve. This process comes under stage 1 in the proposed framework. In stage 2, the Covid-19 +ve samples are

used to perform feature extraction using DenseNet169 model. Then all the feature maps extracted are subjected to fusion. These features are subjected to severity detection process which classifies the given Covid-19 +ve samples into different levels of severity such as low, medium and high.

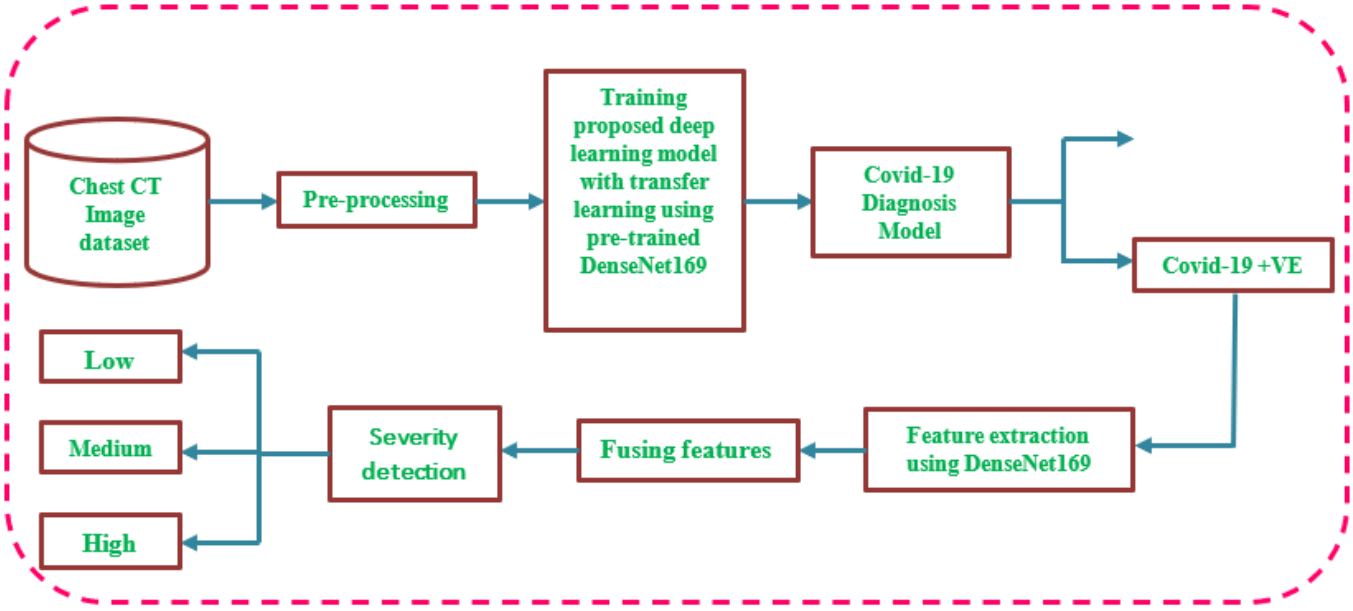


Figure 1. Proposed framework for Covid-19 detection severity classification

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

After the model is trained by exploiting pre-trained DenseNet169 model using transfer learning, a knowledge model is built which is known as Covid-19 diagnosis model. Thismodel takes test data in order to perform actual diagnosis resulting in two classes such as Covid-19 +ve and Covid-19 – ve. This process comes under stage 1 in the proposed framework. In stage 2, the Covid-19 +ve samples are used to perform feature extraction using DenseNet169 model. Then all the feature maps extracted are subjected to fusion. These features are subjected to severity detection process which classifies the given Covid-19 +ve samples into different levels of severity such as low, medium and high.

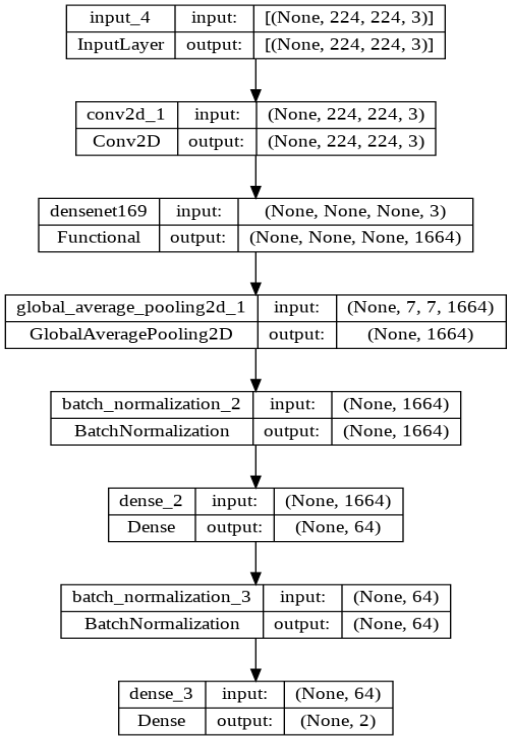


Figure 2. Proposed deep learning model architecture with transfer learning

A. Severity Detection

The severity detection is the phase in which Covid-19 diagnosed CT samples are taken as input. Figure 3 illustrates the process involved in the severity detection process. The data is subjected to data augmentation in order to improve number of samples. It is found with empirical study DenseNet19 is the pre-trained model which could improve prediction performance. Therefore, this pre-trained model is used to obtain features from training sets and validation sets. The architecture of DenseNet169, each layer is linked to other layer in feed-forward fashion. Hence it is named as DenseNet. Different layers generate feature maps. Such feature maps of all previous layers are given as input to the next layer. Thus each layer obtains a collective knowledge from its preceding layer. Moreover, DenseNet169 takes care of vanishing problem as it could reduce the issue due to accumulated knowledge from preceding layers. It improves the process of feature propagation with reduced number of parameters. From each image it acquires around 2000 features. Therefore, it is indispensable to reduce number of features. Thus we implemented Principal Component Analysis (PCA) method for reducing features. After reducing feature set, it is fed to feed-forward network in order to enable it in classification of Covid-19 +ve sample into one of the severity levels. It makes use of 10 neurons in hidden layer and Sigmoid is the activation function. As the weights are attuned towards steepest descent way, there is no guarantee that back propagation yields faster convergence. In order to overcome this issue, we scaled it to realize a conjugate gradient back propagation.As searching is made towards conjugate directions, faster convergence is made possible.

B. Algorithm Design

We proposed two algorithms to realize the framework. The first algorithm is known as Deep Learning based Automatic COVID-19 Diagnosis (DL-ACD). This algorithm is meant for diagnosis of COVID-19 with learning based phenomena. The second algorithm is known as Automatic COVID-19 Severity Detection (ACSD). It is designed to know severity of the disease which helps in making treatment appropriate.

Algorithm 1: Deep Learning based Automatic COVID-19 Diagnosis

As presented in Algorithm 1, the given Chest CT scans are subjected to verification. This is because some CT scans might not have Region of Interest (ROI) which is essential for Covid-19 detection. All CT scans that do not have ROI are discarded. Once this pre-processing is done, the resultant dataset is subject

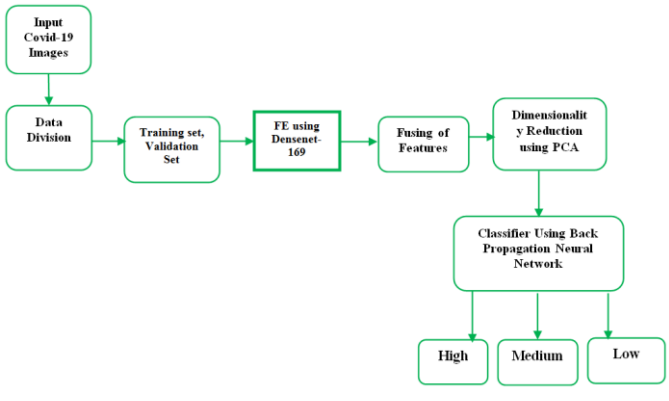


Figure 3. Architecture for the COVID-19 severity detection system

to splitting into 80% training and 20% testing. Then DenseNet169 model is trained along with transfer learning. Then the saved model is reused with test data towards completion of diagnosis process.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
Article Received: 28 April 2023 Revised: 22 June 2023 Accepted: 05 July 2023

Algorithm: Automatic COVID-19 Severity Detection (ACSD)
Input: Training Dataset T1 (Chest CT scans), Test Dataset T2 (Covid +ve diagnosed samples returned by DL-ACD algorithm)
Output: Severity classification results R

1. Begin
2. T1'←Augmentation(T1)
3. F←FeatureExtractionUsingDenseNet169(T1')
4. F'←PCA(F) //dimensionality reduction
5. M←TrainBPNN(F')
6. F←FeatureExtractionUsingDenseNet169(T2)
7. F'←PCA(F) //dimensionality reduction
8. R←DetectSeverity(M, F')
9. Display R
10. End

Algorithm 2: Automatic COVID-19 Severity Detection

As presented in Algorithm 2, the given training set is subjected to data augmentation for quality in the training process. Then DenseNet169 is used to extract features from the resultant training set. Afterwards PCA is applied to reduce dimensionality towards further improvement in quality of training. Such reduced feature set is used to train BPNN which results in a knowledge model. Afterwards, the algorithm extracts features from test set using DenseNet169. Then the features are subjected to PCA. The final feature set is given to the model to classify severity level of each test sample.

IV.EXPERIMENTAL RESULTS

Experiments are made with publicly available Covid-19 CT scan dataset [21] which consists of 1252 Covid-19 +ve samples and 1230 Covid-19 –ve samples for training purpose. The observations with respect to Covid-19 diagnosis and severity detection are presented in this section.

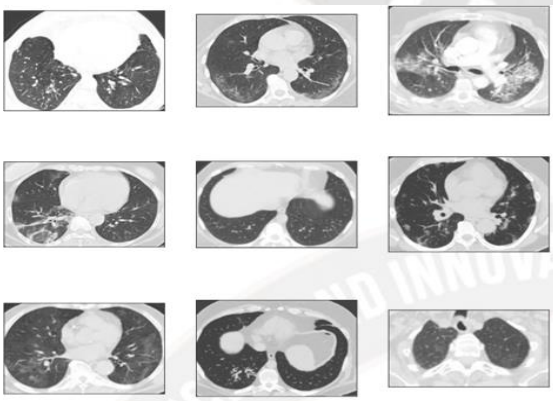


Figure 4. Covid-19 CT scan samples

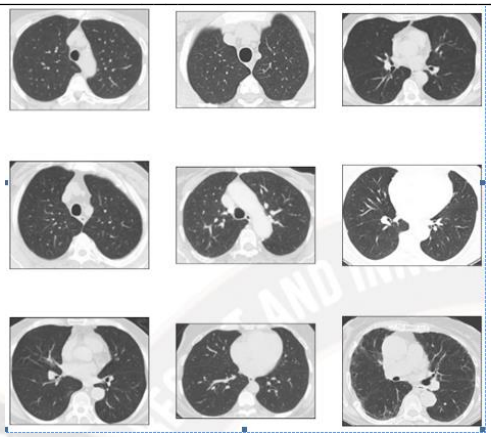


Figure 5. Non Covid-19 CT scan samples

As presented in Figure 4 and Figure 5, both Covid-19 and non Covid-19 samples are provided. They are excerpts from the dataset collected from [21].

A. Results of Covid-19 Diagnosis

This sub section presents automatic Covid-19 detection results observed through the proposed framework and underlying algorithm.

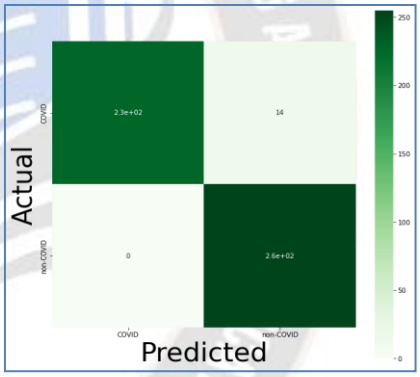


Figure 6. Confusion matrix reflecting Covid-19 detection statistics

As presented in Figure 6, confusion matrix shows the predicted and actual results for correct and wrong predictions of Covid-19 +ve and Covid-19 –ve samples.

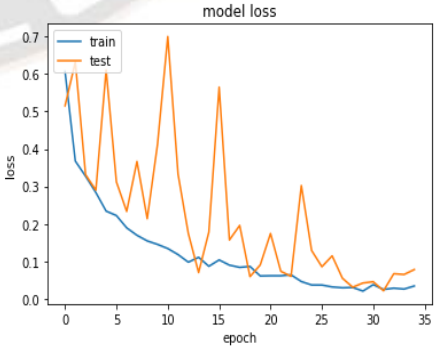


Figure 7. Model loss for training and testing against number of epochs

As presented in Figure 7, the number of epochs used in the empirical study is 35. As the number of epochs is increased,

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

there is reduction in the training loss. However, the test loss is not steady though there is decreasing trend against increase in the number of epochs. Less model loss reflects high in performance.

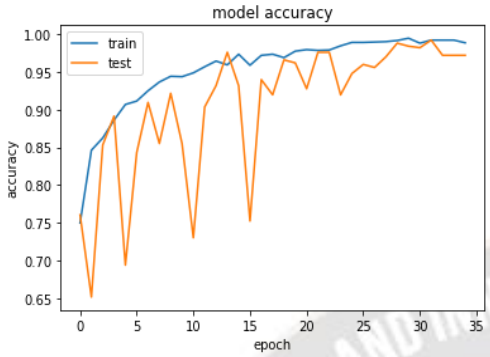


Figure 8. Model accuracy for training and testing against number of epochs

As presented in Figure 8, the number of epochs used in the empirical study is 35. As the number of epochs is increased, there is increase in the training accuracy. However, the test accuracy is not steady though there is increasing trend against increase in the number of epochs. Higher in model accuracy reflects higher in performance.

TABLE I. EXPERIMENTAL RESULTS OF DIFFERENT COVID-19 DETECTION MODELS

Covid-19 Diagnosis Model	Accuracy (%)
AlexNet	93.71
VGG-16	94.62
VGG-19	93.56
Proposed Model	97.18

As presented in Table 1, different Covid-19 detection models based on deep learning are provided along with their performance in terms of accuracy.

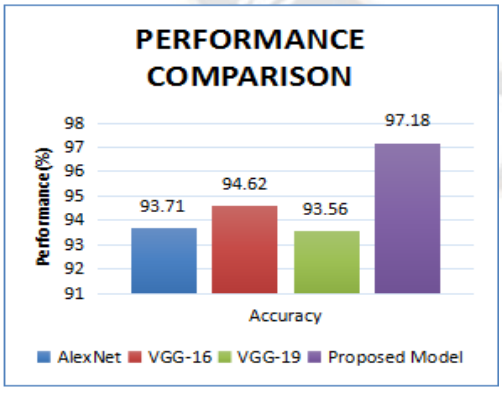
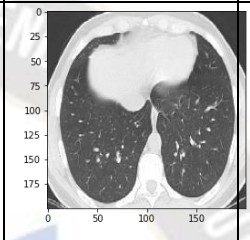
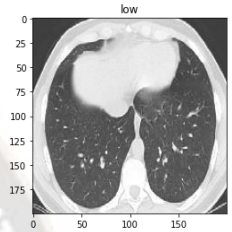
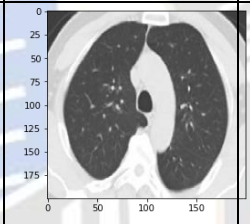
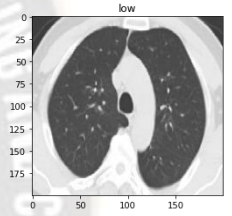
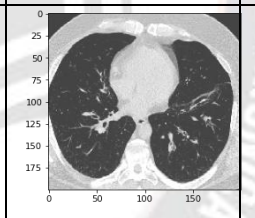
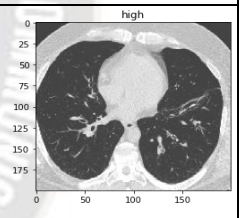
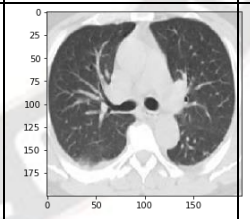
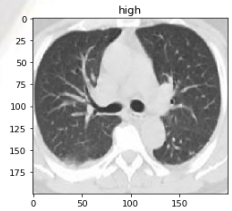
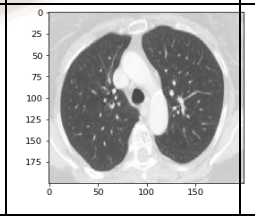
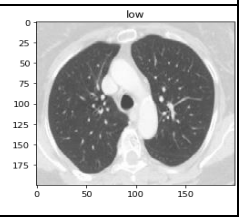


Figure 9. Performance comparison of different deep learning models for automatic Covid-19 detection

As presented in Figure 9, experimental results on Covid-19 diagnosis are provided in terms of accuracy. There are four deep learning methods for which results are provided. One of the models is the proposed one based on DenseNet169. Other three models include VGG-16, VGG-19 and AlexNet. The performance of these models is observed with CT scan images in terms of Covid-19 diagnosis. Each model is found to have different performance due to their internal architecture. AlexNet could achieve 93.71% accuracy, VGG-16 93.71%, VGG-19 93.56% while the proposed model achieved 97.18% which is highest among all prediction models.

A. Covid-19 Severity Detection

This sub section presents experimental results pertaining to severity detection of Covid-19 among the diagnosed samples.

S.No	Original image	Severity Predicted Image
1		
2		
3		
4		
5		

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 7
DOI: https://doi.org/10.17762/ijritcc.v11i7.7843
***Article Received**: 28 April 2023 **Revised**: 22 June 2023 **Accepted**: 05 July 2023*

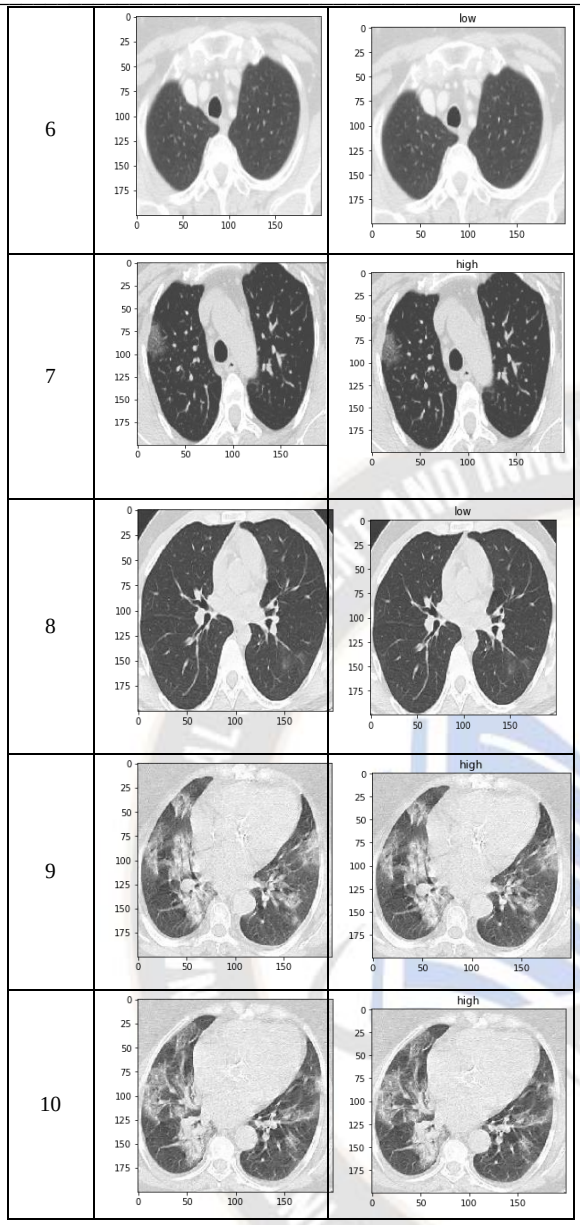


Figure 10. Results of severity classification

As presented in Figure 10, severity classification results are provided for 10 Covid-19 +ve samples. For each given sample corresponding CT scan image along with label reflecting severity is provided. Thus the proposed framework is capable of Covid-19 diagnosis automatically besides severity prediction. Therefore, the proposed framework has merits to have integration with healthcare units to reap benefits of Artificial Intelligence (AI) based diagnosis of Covid-19 and severity detection. Such CDSS can help physicians without the need for using their knowledge even when there are mild Covid-19 cases.

V.CONCLUSION AND FUTURE WORK

We proposed a deep learning framework for automatic COVID-19 diagnosis and severity detection. Our framework is based on enhanced Convolutional Neural Network (CNN) model which is found efficient for medical image analysis. We proposed two algorithms to realize the framework. The first algorithm is known as Deep Learning based Automatic COVID-19 Diagnosis (DL-ACD). This algorithm is meant for diagnosis of COVID-19 with learning based phenomena. The second algorithm is known as Automatic COVID-19 Severity Detection (ACSD). It is designed to know severity of the disease which helps in making treatment appropriate. Our framework is evaluated and compared against state of the art deep learning models and found to have superior performance over the existing models. AlexNet could achieve 93.71% accuracy, VGG-16 93.71%, VGG-19 93.56% while the proposed model achieved 97.18% which is highest among all prediction models.

REFERENCES

[1] Amar Kumar Verma;Inturi Vamsi;Prerna Saurabh;Radhika Sudha;Sabareesh G.R.;Rajkumar S.; (2021). Wavelet and deep learning-based detection of SARS-nCoV from thoracic X-ray images for rapid and efficient testing . Expert Systems with Applications, p1-16.

[2] M. Turkoglu; (2021). COVID-19 Detection System Using Chest CT Images and Multiple Kernels-Extreme Learning Machine Based on Deep Neural Network . IRBM, p1-8.

[3] Ahuja, Sakshi; Panigrahi, Bijaya Ketan; Dey, Nilanjan; Rajinikanth, Venkatesan; Gandhi, Tapan Kumar (2020). Deep transfer learning-based automated detection of COVID-19 from lung CT scan slices. Applied Intelligence, p1-15.

[4] Li X, Geng M, Peng Y, Meng L, Lu S. Molecular immune pathogenesis and diag- nosis of COVID-19. J Pharm Anal 2020.

[5] Daryl L. X. Fung;Qian Liu;Judah Zammit;Carson Kai-Sang Leung;Pingzhao Hu; (2021). Self-supervised deep learning model for COVID-19 lung CT image segmentation highlighting putative causal relationship among age, underlying disease and COVID-19 . Journal of Translational Medicine, p1-18.

[6] Sekeroglu, Boran; Ozsahin, Ilker (2020). Detection of COVID-19 from Chest X-Ray Images Using Convolutional Neural Networks. SLAS TECHNOLOGY:Translating Life Sciences Innovation, p1-13.

[7] Seyed Masoud Rezaeijo;Mohammadreza Ghorvei;Razzagh Abedi-Firouzjah;Hesam Mojtahedi;Hossein Entezari Zarch; (2021). Detecting COVID-19 in chest images based on deep transfer learning and machine learning algorithms . Egyptian Journal of Radiology and Nuclear Medicine, p1-12.

[8] Yarong Li1,a , Yizhang Jiang1, 2,b, Yi Gu1, 2,c, and Pengjiang Qian1. (2022). An Automatic Detection Method for COVID-19 in CT Images. Journal of Physics: Conference Series, p1-9.

[9] Mohamed Ramzy Ibrahim;Sherin M. Youssef;Karma M. Fathalla; (2021). Abnormality detection and intelligent severity assessment of human chest computed tomography scans using deep learning: a case study on SARS-COV-2 assessment . Journal of Ambient Intelligence and Humanized Computing, p1-24.

[10] Mehmet Akif Cifc. (2020). Deep Learning Model for Diagnosis of Corona Virus Disease from CT Images. International Journal of Scientific & Engineering Research. 11 (4), p1-6.

[11] Paul Garcia, Ian Martin, Laura López, Sigurðsson Ólafur, Matti Virtanen. Automated Grading Systems: Advancements and Challenges. Kuwait Journal of Machine Learning, 2(1). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/165

[12] Simmi Bagga, Anil Sharma. (2023). Transformation from CIM to PIM for Querying Multi-Paradigm Databases. International Journal of Intelligent Systems and Applications in Engineering, 11(2s), 354–359. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2717

[13] Emrah Irmak. (2021). COVID-19 disease severity assessment using CNN model. IET Image Processing, p1-11.

[14] Tawsifur Rahman1 , Alex Akinbi2* , Muhammad E. H. Chowdhury1 , Tarik A. Rashid3 , Abdulkadir Şengür4 , Amith Khandakar1 , Khandaker Reajul Islam1 and Aras M. Ismael5. (2022). COV-ECGNET: COVID-19 detection using ECG trace images with deep convolutional neural network. Health Information Science and Systems, p1-16.

[15] HANAN S. ALGHAMDI 1 , GHADA AMOUDI1 , SALMA ELHAG1 , KAWTHER SAEEDI 1 , AND JOMANAH NASSER2. (2020). Deep Learning for Automated Recognition of Covid-19 from Chest X-ray Images. IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY SECTION. 9, p1-20.

[16] DEVRİM AKGÜN ABDULLAH TALHA KABAKUŞ ZEHRA KARAPINAR ŞENTÜRK ARAFAT ŞENTÜRK ENVER KÜÇÜKKÜLAHLI . (2021). A transfer learning-based deep learning approach for automated COVID-19diagnosis with audio data . Turkish Journal of Electrical Engineering & Computer Sciences. 29 (8), p 2807 – 2823.

[17] Subhagata Chattopadhyay. (2021). Towards Grading Chest X-rays of COVID-19 Patients Using A Dynamic Radial Basis Function Network Classifier . Artificial Intelligence Evolution. 2 (2), p1-15.

[18] Tayarani-N., Mohammad-H. (2020). Applications of Artificial Intelligence in Battling Against Covid-19: A Literature Review. Chaos, Solitons & Fractals, p1-62.

[19] Mrs. Ritika Dhabliya. (2020). Obstacle Detection and Text Recognition for Visually Impaired Person Based on Raspberry Pi. International Journal of New Practices in Management and Engineering, 9(02), 01 - 07. https://doi.org/10.17762/ijnpme.v9i02.83

[20] Somil Vasal, Sourabh Kumar Jain and Ashok Verma. (2020). COVID-AI: An Artificial Intelligence System to Diagnose COVID-19 Disease. International Journal of Engineering Research & Technology (IJERT). 9 (8), p62-67.

[21] Yassine Bouchareb, Pegah Moradi Khaniabadi, Faiza Al Kindi, Humoud Al Dhuhli, Isaac Shiri, Habib Zaidi and Arman Rahmim. (2021). Artificial intelligence-driven assessment of radiological images for COVID-19 . Computers in Biology and Medicine . 136, p1-18.

[22] Mohammad Hassan, Machine Learning Techniques for Credit Scoring in Financial Institutions , Machine Learning Applications Conference Proceedings, Vol 3 2023.

[23] PIR MASOOM SHAH1,6, FAIZAN ULLAH1 , DILAWAR SHAH1 , ABDULLAH GANI (SENIOR MEMBER, IEEE)2,3, CARSTEN MAPLE (MEMBER, IEEE)4,5, YULIN WANG6 , SHAHID1 , MOHAMMAD ABRAR7 , SAIF UL ISLAM. (2021). Deep GRU-CNN model for COVID-19 detection from chest X-rays data. IEEE. 9, p1-13.

[24] Sangjoon Park, Gwanghyun Kim, Jeongso Kim, Boah Kim and Jong Chul Ye. (2021). Federated Split Vision Transformer for COVID-19 CXR Diagnosis using Task-Agnostic Training. Conference on Neural Information Processing Systems, p1-14.

[25] SARS-COV-2 Ct-Scan Dataset. A large dataset of CT scans for SARS-CoV-2 (COVID-19) identification. Retrieved from https://www.kaggle.com/datasets/plameneduardo/sarscov2-ctscan-dataset