IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol. 10, Issue.5, May 2022 E-ISSN: 2347-2693

Automated Covid-19 Detection System with CNN using Chest X-Ray and CT-Scans

Bibek Ranjan Ghosh[1]*, Siddhartha Banerjee[2], Ayush Nandi[3], Arya Panja[4], Pritam Mondal[5], Arunava Das[6]

[1,2,3,4,5,6]Department of Computer Science, Ramakrishna Mission Residential College, Narendrapur, Kolakta-700103

**Corresponding author: bibekghosh2019@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v10i5.4752 | Available online at: www.ijcseonline.org

Received: 25/Apr/2022, Accepted: 10/May/2022, Published: 31/May/2022

Abstract: Covid19 is the menace of this century. World Health Organization (WHO) declared it pandemic in February, 2020. This RNA virus has catastrophic impact of the entire human civilization since it was initially reported to have been erupted from Wuhan, a city in Hubei province of China in late December 2019. In the first wave millions of people died in many countries. Even the developed countries like USA, France, Italy, United Kingdom etc. were in shock and could not prevent loss of human lives with their well-established medical infrastructure. Strict lockdown, quarantines were imposed. The hospitals were outnumbered by the severely ill patients who needed ventilation support. Many died without treatment, dead bodies were on the streets and mass graves became a practice. Developing and under-developed countries faced even more disastrous situations. Since then the virus is mutating and giving new challenges to human society in developing a cure. Until now RTPCR and other test are carried out to detect the disease. But they take somewhat longer time. So researchers are using artificial intelligence based techniques especially deep learning methods to develop new models using the CT scans (CTS) and chest X-ray (CXR) images of the patients to detect the disease in real time. This work focuses on the methods developed so far for detecting Covid-19 using convolutional neural network and compare their performances.

Keywords*:* Covid-19, CT scan, Pneumonia, Chest X-ray, CNN.

I. INTRODUCTION

Covid-19 or 2019-nCOV or Corona Virus Disease 19 as the name was coined by WHO in February 2020 is the disaster of the century. The RNA virus that was confirmed later by genome sequencing to be 79.6% similar to severe acute respiratory syndrome coronavirus 2 or SARS-COV2, one of the seven variants of human coronavirus, was first reported Wuhan, China in late 2019 as epidemic. Soon, it engulfed the entire world and it was announced pandemic by WHO on 12th March 2020[1-3]. The human civilization paid havoc since then and come to a complete standstill. The security measures like quarantine, home isolation, lockdown were imposed by the government to arrest the spread of the disease. Gradually the economic activities suffered, public healthcare system collapsed, thousands of human lives lost. The variants of concern (VOC) of this virus as defined by WHO are Alpha, Beta, Gamma, Delta and Omicron [4]. This rapid mutation is making it difficult to find a cure in the form of a vaccine or other. All these variants spread initially through droplet to human respiratory track and later damage lung causing acute pneumonia [5]. The symptoms are mild to severe and many infected patients are asymptomatic and become silent epicenter. Some common symptoms of it are cough, fever and shortness of breath. For pneumonic patients mottling and ground-glass opacity are seen in chest X-rays [1]. Gastronomical symptoms like vomiting, diarrhea etc. are also reported. The blood pathology observation shows drop in eosinophil and lymphocyte count; lesser hemoglobin; increase in WBC, AST, ALT etc.[6]. It can damage many vital organs like kidney, heart, liver etc. though it mainly is attack lungs [7]. Artificial intelligence may be used to analyze huge patient data, improve decision making and patient management [8]. Among various artificial intelligence based techniques deep learning based solution are employed in many cases. There are mainly three distinct methods available for Covid-19 detection namely RTPCR (Reverse Transcription Polymerase Chain Reaction), CXR and CT (Computed Tomography) scan. RTPCR test is accurate but very time consuming. Whereas, the CXR and CTS images detect faster and are used to analyze the after effect of the disease [9]. Another similar disease, pneumonia has similar symptoms and severity if not treated on time. So these two diseases need distinctive detection. The deep learning models like stacked Auto-Encoders (SAE), Deep Belief Network (DBN),Deep Boltzmann Machine (DBM), etc. takes input as vector. In medical imaging this vectorization of image input destroys the structural information like correlation of pixels. Hence, the convolutional neural network (CNN) proved to be a suitable model for medical image analysis [10].CNN takes input an image. Then it has one or more convolutional (Conv) layer where it performs convolution operation on the input image using multiple filters to generate feature map. Activation function Rectified Linear Unit (ReLU) is used to cut-off negative values generated by Conv layer, followed by one or more pooling layers for down-sampling the huge features generated. Thereafter a flatten layer is used to generate one dimensional features which is fed to one or more fully connected layer and ultimately one output layer used for classification result. Sometimes one or more dropout layer is used to avoid over-fitting the model during training. CNN mimic human brain where the hierarchy of layers are used to learn macro features from the features learnt from previous layer. The model parameters like filter weights in Conv layers are learnt during training but this needs a huge amount of data to train. So pre-trained models are often used for transfer learning. This paper focuses on the work that has been done to detect Covid-19 using CNN models from CXR or CTS and compare their performances. Section-II studies the relevant works, Section-III observe there relative performances and Section-IV draws a conclusion and gives future research direction.

II. RELATED WORK

In this section we study the work that had been done in the literature regarding the use of CNN in Covid-19 detection during these three years. A.M. Ismael et al. used resized 224 x 224 X-ray images of patient for Covid-19 detection [11]. A transfer learning approach is used by utilizing five pre trained models of CNN namely VGG(16/19) and ResNet(18/50/101) for feature extraction and fine tuning. The features extracted from pre-trained networks are fed to SVM (Support Vector Machine) with linear, quadratic, cubic, and Gaussian kernels. The SVM achieved average accuracy (in percent) of 87.4, 92.6, 89.5, 89.8 and 88.1 for features extracted using ResNet18/50/101 and VGG16/19 respectively. Cubic kernel give best average accuracy of 90.3 percent. A total of 180 and 200 Covid-19 and healthy chest X-ray images (labeling conducted by specialist doctors) were used for experiment. After fine tuning all five pre-trained models ResNet50 gives best accuracy of 92.63 percent. Finally a 21 layered CNN model having 1 input, 5 convolutional, 5 ReLU, 5 batch normalization, 2 pooling, 1 fully connected, 1 softmax and 1 output layers are trained. Stochastic Gradient Descent Optimizer with Momentum (SGDM) is used with an strating learning rate of 0.001. Obtained training accuracy is 91.58% after 11400 epochs. So the results show that the pre-trained CNN exhibits better accuracy as they are trained on huge number of images. Additionally for comparison purpose eight image texture features are considered namely LBP (Local Binary Pattern), Frequency Decoded LBP, Binary Gabor Pattern (BGP), Quarternionic Local Ranking Binary Pattern (QLRBP), Binarized Statistical Image Features (BSIF), Local Phase Quantization (LPQ), CENsus Transform histogram (CENTRIST), and Pyramid Histogram of Oriented Gradient (PHOG) of the X-ray images are fed to SVM for classification with 4 kernels mentioned earlier and average accuracy (in percent) of 85.1,84.1,82.2 and 84.5 are recorded. BSIF produced best accuracy of 90.5 percent in all kernels except Gaussian. In many cases CNN performed better e.g. ResNet+SVM produced 94.7 percent accuracy. H. Panwar et al. used grad-CAM based color visualization strategy with CNN for Covid-19 detection [12]. The proposed model is a 27 layer CNN having 19 Convolutional-ReLU-MaxPooling layers. To explain the CNN, Selvaraju et al. introduced Gradient Weighted Activation Class Mapping (Grad_CAM) [13]. After predicting the label, Grad_CAM is applied at last convolutional layer to visualize the output. The proposed algorithm does a binary classification. Initially VGG19 trained on 14,197,122 images of ImageNet [14] is selected as base model for transfer learning and proposed model is applied the pre-trained weights. Three different classification experiments are done (a) Covid_19 vs. Normal patients from CXR (b) Covid19 vs. Pneumonia from CXR (c) Covid19 vs. Non_Covid19 on CTS dataset. Three datasets are used a) Covid CXR dataset with 285 images b) SARS-COV-2 CTS with 1252 CTS of Covid19 +Ve patients and 1230 CTS for Covid -Ve patients. c) CXR Images (Pneumonia) with 5856 images of healthy and Pneumonia. For experiment (a) 206 Covid19 CXR of dataset (a) and 364 normal images of dataset(c) are used. The accuracy, sensitivity and specificity are (in percent) 89.47, 76.19 and 97.22 respectively. For experiment (b) 206 Covid19 CXR of dataset (a) and 364 pneumonia images of dataset(c) are used. The accuracy, sensitivity, specificity in percent are 96.55, 96.55, and 95.29 for the +ve cases of Covid-19. In experiment (c) 800 images of Covid-19 and Non-Covid19 CTS of dataset (b) are used. The accuracy, sensitivity, specificity in percent are 94.04, 94.04, and 95.86 for the positive Covid-19. E. Hussain et al. proposed a 22 layered CNN for Covid-19 detection using CXR and CTS images [15]. The proposed CNN model “CoroDet” can diagnose (a) Normal or Covid19 (b) Normal, Covid19, Non_Covid Pneumonia and (c)Normal, Covid19, Bacterial Pneumonia, Viral Pneumonia. The model used 18 (Convolutional + Maxpooling) layer, 2 dense, 1 flatten and 1 leaky ReLU layer. Batch size of 10 and 50 epoch are used for training with learning Rate (LR) of 0.0001. The dataset is assembled from eight different standard datasets containing CXR and CTS images. A total of 2843 Covid19 images, 3108 healthy images and 1439 images with viral or bacterial pneumonia are used for their experiment. The training data is again undergone 5-fold cross validation. The accuracies achieved are in percent 99.1, 94.2 and 91.2 for 2, 3 and 4 class cases respectively. F1-score,Recall and Precision for each class in each classification problem are evaluated and found in the range 86.15 to 97.51 percent S. Chakraborty et al. proposed a 46 layered CNN to detect COVID-19 with patient CXR[16]. The proposed model has 14,23,4,2,2,2 and 1 convolution, hidden, max-pooling, polling, dropout and softmax layers respectively. It can distinguish among Covid19, Pneumonia or Normal CXR. The region of interest i.e. lung region of CXR image is obtained using pulmonary contour mask and FC-DenseNet103 segmentation algorithm. Transfer learning is used by using the trained weight values of ResNet18 in the proposed model. Skipping is used to solve vanishing gradient problem. The dataset consists of a collection 2143, 3674 and 4223 CXR images having size 224x224 of Covid19, Pneumonia and Normal patients. . To increase the dataset images are flipped, magnified and rotated and dataset is increased from 10400 to 16574 images. The training is executed with 13251 images, batch size of 50 and 200 epochs using SGD optimizer. 96.43 percent accuracy was achieved. The AUC computed are 0.99, 0.97 and 0.98 for covid, pneumonia and normal images respectively. V. Madaan et al. implemented a CNN model for detection of covid19 using CXR images [17]. The proposed model consists of 4 conv layers with 32, 64, 64 and 128 filters respectively; 3 max pooling layers and one ReLU layer. 196 Covid19 and 196 non-Covid CXR frontal images are used for the experiment. To reduce noise rescaling, shearing, zooming and horizontal flip is used and CXRs were resized to 224x224x3.The training used learning rate of 0.001, Adam optimizer, 50 epochs and batch size of 32. Three variations of the CNN are tested with two MaxPooling size and stride values. The train test split is also varied and best accuracy achieved is 98.44 percent with 75-25 percent split. R. Tawsifur et al. used image enhancement along with segmentation to explore their effect on the detection accuracy of COVID-19 using CXR [18]. The original dataset consisted of 18479 CXR images with 8851 healthy, 3616 Covid-19 and 6012 non-Covid images. Five image enhancement algorithms namely histogram equalization (HE), complement, contrast limited adaptive HE, balanced contrast enhancement and gamma correction were applied to images and detection performance was analyzed. CNN based U-Net segmentation network which works best for medical image segmentation, was used for lung segmentation to create a new database of segmented CXR images. Experimental values observed in percent for segmentation accuracy, Jacquard Index and F1-score were 98.63, 94.3, and 96.94 respectively. Seven pre trained CNN models namely ResNet18/50/101, InceptionV3, DenseNet201, ChexNet and shallow CNN were used to evaluate classification performance on normal, enhanced, segmented and enhanced segmented CXR dataset. The best classification accuracy was 95.11 percent for segmented image with DenseNet201 using gamma correction and 93.22 percent without any enhancement with ChexNet. The model performed better with accuracy of 96.29 percent with ChexNet and gamma correction for un-segmented images and 93.45 percent accuracy with InceptionV3 for normal un-segmented images. Score-CAM visualization was used for detection of Region of Interest. T. Ozturk et al. established a method for detection of Covid-19 with deep neural networks using CXR [19]. The model had the capacity for binary & multi-class classification where the former classify Covid-19 and Non-Covid CXR whereas the latter had the ability to classify among Covid, Non-Covid and Pneumonia. Two separate image databases namely Cohen JP[20] and Wang et al.[21]are combined with Covid and Pneumonia CXR. The proposed model was inspired from the Darknet19 model and used 17 layers. Original DarkNet-19 had 19 convolutional and 5 MaxPooling layers with Leaky ReLU activation function, to classify for object detection system YOLO (You Only look Once). Each Dark Net (DN) layer has three sub layers of convolution, batch normalization (BN) and leaky RELU whereas each 3XConv layer has 3 DN sub-layers. Batch-normalization standardize input, reduce training time and increase model stability whereas Leaky ReLU produce very small value of derivative in negative part unlike sigmoid and ReLU which produce zero value. Fivefold cross validation with 100 epochs were used from training and accuracies achieved were 98.08 and 87.02 in percent for binary and multi-class respectively. Grad-CAM is used for visualization. B.Nigam et al. used transfer learning using CNN to detect Covid19[22]. VGG16, DenseNet121, Xception, NASNet, and EfficientNet were used to classify covid19,normal and non-covid patients. The accuracies achieved in percent were 79.01, 89.96, 88.03, 85.03 and 93.48 respectively. The dataset consisted of 5634 covid, 6000 normal and 5000 other patients CXR images from Maharastra and Indore hospitals. The images were cropped by R-CNN to delete text information from CXR. 100 epochs with batch size 32 were used for training. Md. I. Khattak et al. used a Multilayer-spatial CNN to detect Covid19 from patient CXR and CTS [23]. 723 CXR images containing 195 and 528 covid-19 and non-covid images respectively were used for experiment. The CTS database includes total 3228 images with 1601 covid and 1627 non-covid images.The achieved accuracies in percent were 93.63 and 91.44 for CXR and CTS respectively. The model was inspired from VGG-11 with 5 (Convolution, ReLU, MaxPooling) layers, one dense layer of 512 neurons. For training 0.01 learning rate, SGD optimizer and loss function binary cross entropy were used. G. Gilanie et al. devised a CNN based model and experimented with public and local CXR and CTS databases (Victoria Hospital Bahawalpur, Pakisthan) [24]. The dataset consisted of 7021 normal/pneumonia and 1066 covid images. The model which can classify healthy, pneumonia and covid used 14 layers having 8 convolutional layers. The model achieved 96.68 percent accuracy.

III. OBSERVATIONS AND COMPARISON OF MODELS

In this section we discuss our observation and compare the design and performance aspect of the methods found in the literature that are discussed in previous section. At the onset we observe that, all the methods are following the basic architecture of convolutional network. So the convolution steps that are performed in the CNN to identify the feature maps which actually are the responses of the filter patterns with input image are prevalent in all the models. They unanimously also used max-pooling steps to downsize the huge feature generated in convolution steps. The activation function used by them are mainly ReLU but some models used leaky ReLU as well to prevent the zero value of the derivative. It is observed that as the dataset were not very huge, hence there were chances of poor training. To avoid this many models like [11, 12, 16, 18, and 22] used pre-trained models and hence used weights of trained models to populate their own model and hence avoid the hazard of training the model from scratch. Again to increase the dataset many models used different kind of boosting process like in [17] shearing, zooming etc. were used. Some of the models used explainable artificial intelligence for better visualization of output e.g. [11] used Grad-CAM technique. Some literature used image processing like segmentation e.g. [18] to observe its impact on accuracy. We discuss the strengths and weakness of the models depending on the criteria listed as follows. a) CNN architecture: The basic CNN design followed b) Pre-trained models used: The list of any pre-trained models used c) Classification type: The classification output i.e. whether it is binary or multiclass and class captions d) Dataset used: The volume and making of the dataset used e) Training parameters: The basic training parameter values like learning rate, batch size, number of epochs, split size, optimizers etc. f)Others: Additional relevant information found in the literature that are useful for the method e.g. visualization tools used, any other variation of the models for comparisons etc.

Table-1: Comparison of Different methods

	CNN Architecture	**Pre-Trained Model Used**	**Classification Types**	**Dataset Used**	**Training Parameters**	**Accuracy (%)**	**Others**
[11]	21 layers with(5Conv,5ReLU, 5 BN layers)	VGG16, VGG19, ResNet18, ResNet50, ResNet101 and SVM with 4 different kernels	Covid/ Non-Covid	180 Covid19 and 200 healthy CXR images	Learning Rate(LR)=0.001,epoch=11400	91.58	Grad-CAM
[12]	27 layers with (19Conv,ReLU, Maxpool layers)	VGG19	a) Covid/ Normal b) Covid/Pneumonia c) Covid /Non-Covid	a) 206 Covid and 364 normal CXR b) 206 Covid and 364 pneumonia CXR c) 800 CT scan images for each type	80-20 split epochs=29,21, 47	89.47, 96.55, 94.04	Grad-CAM
[15]	22 layers with (18Conv,Max Pool layers)	NA	a) Covid /Normal b) Normal / Covid/Pneumonia c) Normal Covid / Bact or Viral Pneumonia	2843 Covid19 , 3108 healthy and 1439 CXR with viral or bacterial pneumonia	LR=0.0001, Batch Size (BS)=10, epoch= 50 ,5fold CV	99.1, 94.2 91.2	12, 16, 18,20 layer CNN tested inferior result. Doctor opinion
[16]	46 layers with(14 Conv layers)	FCDenseNet103 is for segmentation and ResNet18 for model template	Covid19, / Pneumonia /Normal	2143, 3674 and 4223 CXR images of Covid19, Pneumonia and Normal patients	BS=50 and 200 epoch	96.43	AUC =0.99, 0.97, 0.98 for Covid, Pneumonia and normal
[17]	7 Conv-Maxpool layers	NA	Covid/ Non-Covid	392 CXR	LR= 0.001, Optimizer=Adam, epochs=50,BS=32.	98.44	3 models with 4 sample splits are used.
[18]	Pre-trained models with 5 Enhancement & U-net Segmentation network	(ResNet18, ResNet101, ResNet50, DenseNet201 InceptionV3, , and Chex Net, a shallow CNN)	Covid/ Normal /Non-covid	18479 CXR images with 8851 healthy, 3616 Covid-19 and 6012 non-Covid images.	NA	Best= 95.11 Dense Net201,Gamma Correction &segmentation	Score-CAM
[19]	17 layers	DarkNet-19	a)Covid/ Noncovid b)Covid/Noncovid/Pneumonia	Cohen JP[20] and Wang et al.[21] combined	100 epochs	98.08 87.0	Grad_CAM
[22]	5 Pre-trained models	VGG16, DenseNet121,Xception, NASNet, and EfficientNet	Covid19/Normal/Non-Covid	5634 Covid, 6000 normal and 5000 other patients CXR	100 epochs, BS=32	79.01, 89.96, 88.03, 85.03, 93.48	Preprocessing

[23]	16 layer model	VGG-11 is an inspiration	Covid/Non-Covid	723 CXR & 3228 CT scan images	LR=0.01, SGD optimizer	93.63 (CXR) 91.44 (CTS)	ReLU, Leaky ReLU comparison
[24]	14 layers	NA	Normal/ Pneumonia/ Covid	8087 CXR & CTS images of normal, pneumonic & covid	epoch=25 LR=0.0002 BS=128	96.68	Intensity Normalization preprocessing

IV. Conclusion and Future scope

In the previous sections various methods are studied to detect Covid-19 using the CNN. The study shows that CNN is very suitable for image analysis and outperforms other machine learning models. Transfer learning with pre trained CNN is often adopted by researchers as the dataset is not very huge. Some observation also emphasizes image enhancement and dataset boosting and balancing is very effective. The tweaking of the pre-trained models and trial and error with model architecture can be clearly seen from this observation. But the final model accuracy and classification parameters observed is very promising. The future research scope includes - a) What are the logical or mathematical model selection methodology rather using trial and error? b) What is the optimum database size? c) Are the findings explainable with respect to the input feature? d) Contribution ratio of the model with respect to experts (doctor /pathologists / radiologist) once the model is built.

Acknowledgment

The authors thank the members of faculty and staff of the Department of Computer Science, Ramakrishna Mission Residential College Narendrapur, Kolkata, West Bengal, India for their immense support and assistance in carrying out this research work.

Author contributions

Every author have contributed to the work equally and constantly researching on the context by critically studying relevant works and implementation of the models used so far.

Funding statement

This work is not funded by any institute,agency or individual and authors take responsibility in this respect.

Declaration of Conflict of Interest

All authors hereby declare that they don't have any conflicting financial interests or personal relationships that have appeared here to influence this work.

ReferenceS

[1] M. Ciotti, M. Ciccozzi, A.Terrinoni, W. Jiang, C. Wang, S. Bernardini,"The COVID-19 Pandemic", Critical Reviews in Clinical Laboratory Sciences", Vol.**57**, Issue. **6**, pp.**365-388, 2020**.

[2] P. Zhou, X. Yang, X. Wang, B. Hu, L. Zhang,W Zhang ,S. HR, Y. Zhu, B. Li, C. Huang, H. Chen, J Chen, Y. Luo ,H Guo, R. Jiang, M. Liu, Y Chen, X. Shen, X Wang,X. Zheng, K. Zhao, Q. Chen,F. Deng, L. Liu, B. Yan, F. Zhan, Y. Wang, G. Xiao, Z. Shi, "A Pneumonia Outbreak Associated with a New Coronavirus of Probable Bat Origin", Nature. Vol.**579**, Issue.**7798**, pp.**270-273,2020.**

[3] F. Wu, S. Zhao,B. Yu, Y. Chen,W. Wang, Z. Song,Y. Hu ,Z. Tao, J. Tian, Y. Pei, M. Yuan, Y. Zhang, F. Dai, Y Liu, Q. Wang, J. Zheng, L. Xu, E. Holmes, Y. Zhang, "A New Coronavirus Associated With Human Respiratory Disease In China", Nature. Vol.**579**, Issue.**7798,** pp. **265-269**, **2020.**

[4] J. Tregoning, K. Flight, S. Higham, Z. Wang, B. Pierce, "Progress of The COVID-19 Vaccine Effort: Viruses, Vaccines and Variants Versus Efficacy, Effectiveness And Escape", Nature Reviews Immunology, Vol. **21**,pp.**626–636**,**2021.**

[5] F. Almazán, I. Sola, S. Zuñiga, S. Marquez-Jurado, L. Morales, M. Becares, L. Enjuanes, "Coronavirus Reverse Genetic Systems: Infectious Clones and Replicons", Virus Research, Vol.**189**,pp.**262-270**, **2014**.

[6] G. Lippi, M. Plebani, "The Critical Role of Laboratory Medicine during Coronavirus Disease 2019 (COVID-19) And Other Viral Outbreaks", Clinical Chemistry and Laboratory Medicine (CCLM), Vol.**58**, Issue.**7**, pp.**1063-1069, 2020.**

[7] K.Renu, P.L. Prasanna, A.V. Gopalakrishnan. "Coronaviruses Pathogenesis, Comorbidities and Multi-Organ Damage - A Review", Life sciences Vol.**255**, pp**. 117839, 2020.**

[8] T.P. Mashamba-Thompson, E.D. Crayton, "Block chain and Artificial Intelligence Technology for Novel Coronavirus Disease 2019 Self-Testing", Diagnostics Vol.**10**, Issue.**4**, Issue.**198**,pp. **1-4**,**2020.**

[9] Q. Hu, H. Guan, Z. Sun, L.Huang, C. Chen, T. Ai, Y. Pan, L. Xia, "Early CT Features and Temporal Lung Changes in COVID-19 Pneumonia in Wuhan, China", European Journal of Radiology, Vol. **128**,pp.**109017,2020**.

[10] D. Shen, G. Wu, H.I. Suk. "Deep learning in medical image analysis". Annual Review of Biomedical Engineering, Vol. 19, pp. 221-248, 2017.

[11] A.M. Ismael, A. Sengür, "Deep Learning Approaches for COVID-19 Detection Based on Chest X-Ray Images". Expert Systems with Applications Vol.**164**. Issue. **110054** pp.**1-11**, **2021**.

[12] .H. Panwar, P.K. Gupta, M.K. Siddiqui, R. Morales-Menendez, P. Bhardwaj, V. Singh, "A Deep Learning And Grad-CAM Based Color Visualization Approach For Fast Detection Of COVID-19 Cases Using Chest X-Ray And CT-Scan Images", Chaos, Solitons & Fractals, Nonlinear Science, and Nonequilibrium and Complex Phenomena, Vol.**140**, Issue.**110190, pp. 1-12,2020**.

[13] R. R. Selvaraju, M. Cogswell, A. Das, R. Vedantam, D. Parikh,D. Batra, "Grad-CAM: Visual Explanations from Deep Networks via Gradient-Based Localization", In the Proceedings of the IEEE International Conference on Computer Vision (ICCV),Venice, **Italy**, pp. **618-626**,**2017**.

[14] J. Deng, W. Dong, R. Socher, L.J. Li, K. Li, F.F.Li "Imagenet: A Large-Scale Hierarchical Image Database". In the Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR2009), IEEE,Miami, **USA,** pp. **248–255, 2019.**

[15] E. Hussain , M. Hasan, Md. A.Rahman ,I. Lee, T. Tamanna ,Md. Z. Parvez , " Corodet: A Deep Learning Based

Classification for COVID-19 Detection Using Chest X-Ray Images", Chaos, Solitons and Fractals Nonlinear Science, and Nonequilibrium and Complex Phenomena, Vol.**142**, Issue.**110495, pp. 1-12,2021**.

[16] S. Chakraborty, B. Murali, A.K. Mitra, "An Efficient Deep Learning Model to Detect COVID-19 Using Chest X-ray Images", International Journal of Environmental Research and Public Health, Vol.**19**, Issue.**4,** pp.**1-12, 2013**.

[17] V. Madaan, A. Roy, C. Gupta, P. Agarwal, A. Sharma, C. Bologa, R. Prodan, "XCOVNet: Chest X-ray Image Classification for COVID-19 Early Detection Using Convolutional Neural Networks", New Generation Computing Vol.**39**, pp.**583–597,2021.**

[18] T. Rahman, A. Khandakar, Y. Qiblawey, A.Tahir, S. Kiranyaz, S.B.A. Kashem, Md.T. Islam, S.A. Madeed, S.M. Zughaier, Md. S. Khan, Md. E.H. Chowdhury, "Exploring the Effect of Image Enhancement Techniques on COVID-19 Detection Using Chest X-Ray Images", Computers in Biology and Medicine, Vol.**132,** Issue.**104319, pp. 1-16, 2021.**

[19] T. Ozturk, Md. Talo, E.A. Yildirim, U.B. Baloglu, O. Yildirim, U. R. Acharya, "Automated Detection Of COVID-19 Cases Using Deep Neural Networks With X-Ray Images", Computers in Biology and Medicine, Vol. **121** ,Issue. **103792**, pp.**1-11, 2020**.

[20] J.P. Cohen, P. Morrison, L. Dao, "COVID-19 Image Data Collection", **2020**. DOI.**10.48550/arXiv.2003.11597.**

[21] X. Wang, Y. Peng, L. Lu, Z. Lu, M. Bagheri, R.M. Summers, "Chestx-Ray8: Hospital Scale Chest X-Ray Database And Benchmarks On Weakly-Supervised Classification And Localization Of Common Thorax Diseases", In the Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition(CVPR2017),Honolulu, **USA** , pp. **3462-3471,2017.**

[22] B.Nigam, A.Nigam, R. Jain, S.Dodia, N.Arora, B. Annapa, "COVID-19: Automatic Detection From X-Ray Images By Utilizing Deep Learning Methods", Expert Systems With Applications, Vol. **176**, Issue.**114883**, pp.**1-11, 2021.**

[23] Md. I. Khattak, M. Al-Hasan, A. Jan, N. Saleem, E. Verdu, N. Khurshid, "Automated Detection of COVID-19 using ChestX-Ray Images and CT Scans through Multilayer Spatial Convolutional Neural Networks", International Journal of Interactive Multimedia and Artificial Intelligence, Vol.**6,** Issue.**6,** pp.**15-24,2021.**

[24] G. Gilanie, U.I. Bajwa, M.M. Waraich, M.M. Asghar, R. Kousar, A. Kashif, R.S. Aslam, M.M. Qasim, H. Rafique, "Coronavirus (COVID-19) Detection from Chest Radiology Images using Convolutional Neural Networks", Biomedical Signal Processing and Control,Vol. **66**, Issue.**102490,** pp**. 1-6,2021.**

AUTHORS PROFILE

Bibek Ranjan Ghosh (MCA), University of North Bengal, is actively teaching as Assistant Professor, in the Department of Computer Science (CS), Ramakrishna Mission Residential College, (RKMRC), Narendrapur Kolkata, India since 2008. He has published and presented many research articles in national and international journal and conferences including Scopus index journals. His research areas are computer vision, steganography &data science.

Dr. Siddhartha Banerjee, M.Tech (Calcutta University) Ph.D (Jadavpur University), Assistant professor, currently working as HOD in the Department CS in RKMRC Narendrapur, Kolkata since 2008. He has published and presented many research articles in national and international journal and conferences including Scopus, SCI & WoS index journals. His research area are image processing, cryptography, VLSI & AI

Ayush Nandi is an under graduate student of B.Sc. Honours Programme of 6th semester, in the Department of CS, RKMRC Narendrapur, Kolkata. His area of interest are image processing and computer vision

Arya Panja is an under graduate student of B.Sc. Honours Programme of 6th semester, in the Department of CS, RKMRC Narendrapur, Kolkata. His area of study are Data science and Computer Vision

Pritam Mondal is an under graduate student of B.Sc. Honours Programme of 6th semester, in the Department of CS, RKMRC Narendrapur, Kolkata. His area of interest are DBMS and Data science.

Arunava Das is an under graduate student of B.Sc. Honours Programme of 6th semester, in the Department of CS, RKMRC Narendrapur, Kolkata. His area of interest are DBMS and Computer Vision.

