Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 11, 209-221

Deep Learning Classification Models For Detection Of Covid Patients

[1]Divya Shree , [2]Chander Kant (Corresponding Author)

[1]Assistant professor, CSE department, UIET MDU, Rohtak
[2]Professor, Deptt. Of Computer Sc. & Applications, K.U. Kurukshetra
[1]divspanghal@gmail.com, [2]ckverma@rediffmail.com

Abstract:

This study demonstrates how to evaluate deep Transfer Learning effectiveness in developing a classifier for identifying COVID-19-positive patients using CT scan images. The study found that deep learning (DL) effectively finds COVID-19 cases. A COVID-19 detection technique with high sensitivity and effectiveness is needed to stop it from spreading. This article offered a hybrid approach of image regrouping using ResNet and Densenet using the COVID-19 chest X-ray pictures as the basis for its research. The principal chest X-ray pictures were used to segment the lung area and split it into small portions. The very small components of the lung region were then randomly reconstructed into a normal image. In addition, the regrouped pictures were sent to a deep residual encoder block in order to have their features extracted. In order to prevent the model from becoming too specific and to improve its capacity for generalisation, the training dataset is improved by using a data augmentation technique. We looked at a set of pre-trained TL models DenseNet and ResNet for Convolutional Neural Networks, which improved performance, after pre-processing the data with Contrast Stretching, Histogram Equalization, and Log Transformation.

Keywords: Transfer Learning (TL), Log, Transformation, COVID-19, X-ray.

1 Introduction

There has been a dramatic increase in the amount and variety of data being used in the modern world. In the field of automated modern diagnostics, the use of vast amounts of data has resulted in significant improvements. Medical images must be analysed in order to accurately diagnose and treat diseases. As a medical diagnostics tool the range of imaging procedures used in the medical field is extensive, including CT, MRIs, PET scans and ultrasound scans, among others. Devices are required for each one of these procedures. "CT scans, for example, are produced by CT scanners, which use a rotating X-ray tube to collect measurements from various angles and a computer to transform the information into CT scans"[1]. It's no surprise that CT scans produced by multiple manufacturers (e.g. Siemens, Fujifilm, GE Healthcare) tend to be inconsistent. The problem is exacerbated even further by the use of various scanning protocols. Figure 1.1 clearly shows the differences between vendors. This change may take some time to get used to even for an experienced radiologist who has been trained for it in the past.

The (COVID-19)[1] Illness has spread over the globe, affecting virtually every element of human life. COVID-19 is identified utilising a variety of laboratory techniques, including (RT-PCR)[2] and isothermal amplification of nucleic acids COVID-19 is presently the most widely utilised method of detection. Because of sample contamination, damage, or virus alterations in the COVID-19 genome, there is a high rate of false alarms[3].

The disease-causing virus 19 COVID (SARS-CoV-2)[4] has had a significant impact on people and healthcare worldwide. To detect COVID-19-infected patients and provide early quarantine and therapy, advanced screening technology is required. RT-PCR is the most commonly used coronavirus screening technology, and it can detect SARS-CoV2 in upper respiratory tract mucus samples[5]. Although COVID-19 screening is a highly specialised procedure, its sensitivity varies depending on the method sampled and the period from the beginning of illness. However, only a select few studies have found that the sensitivity of COVID-19 is low [6]. Additionally, since “RT-PCR testing” is a time-consuming procedure that is wanted, it is possible that test results may be delayed shown in figure 1.

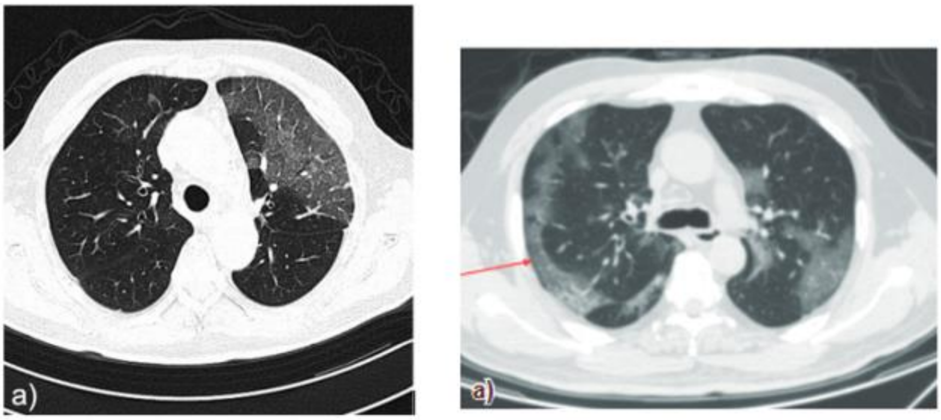

Figure 1: CT scans produced by different vendors can differ in quality. CT scan on the leftSiemens on COVID-19 and the right CT scan from a recent publicationDevice made by Shimadzu Corporation.

As a result of their high sensitivity, chest scans have been considered as a potential replacement for RT-PCR testing as a screening tool for COVID-19 infection[7]. As the COVID-19 pandemic first began to spread, CT scans became standard procedure. Due to financial and logistical constraints, the use of repeat CT scans for COVID-19 detection is restricted [8].

The number of papers every week describing in recent years, there has been an explosion in the use of machine learning techniques for solving categorization issues. Automated image classification in the medical field is not an exception. “In the field of machine learning, deep neural networks (DNNs) are used for a variety of purposes, including the classification of CT scans for respiratory disease diagnosis” [9]. Accurate diagnosis relies on the use of reliable training data. Consequently, the issue of data variance, which was previously raised, now poses a significant challenge. This is of utmost significance in an industry where the choice of a neural network might have a direct impact on a person's life. Since the classification process cannot tolerate any misclassification, homogeneous training data is essential.

At the year's end, a new coronavirus virus (COVID-19) appeared and had far-reaching consequences. As of April 8th, 2021, the fast spreading virus has infected over 150 million individuals and killed over 3 million. It continues to be a problem for us even now. There has been a lot of work done by deep learning researchers analysing chest CT and X-ray pictures to learn about COVID-19 [6]. "real-time reverse transcription polymerase chain reaction (RT-PCR)" [4] is used by labs all over the globe to diagnose COVID-19. Inadequate quality and quantity of nucleic acids are isolated using this approach, which is a limitation [5]. This may lead to a false negative. The need of human labour and knowledge is another limitation. Given this, an alternative to the RT-PCR test that can automate, aid, or even replace it might have a major impact. A wide variety of deep learning architectures have been used extensively for the correct diagnosis of COVID-19 using a variety of publically accessible datasets.

However, detecting coronavirus fast with high classification accuracy with minimal data remains problematic. When developing a detection algorithm, the amount of labelled data for training and the superiority of the data are two critical elements to consider. The number of chest CT images obtained for the studies from a publicly accessible dataset is restricted. Due to the restricted number of data samples, TL is considered an appropriate categorization strategy. The key to achieving the best efficiency in a limited dataset is to use TL, which entails shifting trained features from a source to a target task. The findings of TL are promising, demonstrating the efficacy of DL networks in binary classification. We did a number of experiments to see how accurate the information was[10].

2 Literature Review

The increasing applicability of image classification in medical settings captures the interest of a great number of academics, who then go on to do more study on the principles underlying convolutional neural networks.

As the COVID-19 virus continues to spread throughout the globe, governments are adopting preventative measures. A very sensitive and effective way of detecting COVID-19 is needed to put a halt to its proliferation. Based on the COVID-19 breast X-ray images, this research offered a combination technique for picture regrouping utilising ResNet-SVM. The method effectively decreased the incidence of false positives . After the lung area in the source chest X-ray pictures was segmented and divided into minute portions, those little parts of the lung region were then randomly reassembled into a normal image. In addition to being delivered into the deep residue encoder block, the regrouped pictures were also submitted for feature extraction. At the end of the process, the gathered features were put through a recognition support vector machine. The visibility was achieved by the use of a one-of-a-kind technology that zeroed down on the characteristics of the COVID-19 without diverting attention to its shapes, ribs, or other sounds as CHANGJIAN ZHOU et al. (2022) says**.** The results of the experiments showed that the proposed method beats the current COVID-19 recognition models by obtaining an accuracy of 93 percent without requiring a significant quantity of training data.

After training and evaluating the proposed model using the provided dataset, it was found that the accuracy rate for the two class classification (COVID 19 versus Healthy) was 95%, with both the precision and recall rates being 95% as well. The recommended model's performance is quite encouraging, and it has the potential to be a very valuable tool for radiologists and clinical practitioners in the identification and classification of COVID 19. Additionally, this work compares the proposed method to ELM, which will be useful for future studies in Tatiana Chakravorti et al. (2022).

A 94% accuracy rate was attained across three classes while using the proposed model to classify Chest X-Ray pictures. This model was developed with the goal of speeding up computations by using fewer layers and more hyper parameter manipulation. Previous models are compared to the recommended model, which are simpler in nature but required more time to train and 94% percent accuracy has been reached on the test dataset. In the year 2020, the world has already begun to feel the effects of a pandemic that was caused by the rapid spread of the unique coronal virus COVID-19. Due to the fact that testing for corona viruses was first done by hand, the ever-increasing amount of COVID-19 was able to be managed in an appropriate manner presented in Shamik Tiwari et al. (2021). In addition, the corona virus may go through three different stages, each of which has its own unique effects on the lungs. In order to address this problem, researchers have attempted to identify the corona virus by using chest X-ray pictures and chest CT scan images together with artificial intelligence technologies. Artificial intelligence may assist in the prediction of corona virus cases by analysing the structure of the virus. Chest X-ray and CT scan pictures can be used to assist in the prediction of corona virus stags. As a consequence of this body of work, a CNN model has been developed that employs three types of pictures: those with positive COVID-19, regular photos, and images with viral pneumonia. These photographs were used to train the machine learning algorithm, which ultimately obtained a 94 percent accuracy rate on the training data and a 96 percent accuracy rate on the validation dataset.

Different segmentation strategies have been thoroughly validated, with Sobel demonstrating an accurate result that is not only efficient in recognising edges but also in reducing noise from the image. In light of the fact that radiography modalities provide the possibility of rapid illness diagnosis, the purpose of this work was to demonstrate an automated detection based on images of the lung. Kavya Garlapati (2021) in this work, we trained a deep learning model using 2000 publicly accessible X-ray images. Important parts of the X-ray images were extracted for model building before accurate segmentation was applied. Due to noise and spatial aliasing, the border in X-ray images is often blurry, making precise image segmentation essential. Furthermore, the preprocessed image is given to a SVM network, which achieved "99.17 percent classification accuracy, as well as precision, recall, and F1 score of 99.24 percent, 98.13 percent, and 98.68 percent" in predicting COVID-19 vs other lung disorders. Taking advantage of the model, medical personnel might use it as an early screening tool for individuals.

3 SIMULATION TOOL

- **PYTHON**

4 METHODOLOGY

Contrast Stretching (CS)

Researchers developed a model based on CNN that was used to make the diagnosis of COVID-19. The proposed model consists of 27 layers and has been validated using X-ray, CT, and MRI scans of the human body. Seventy percent of the data was utilised for training, while the remaining thirty percent was used for testing against the other dataset in the trials. The recommended model has weighted average accuracies of 94 percent, 85 percent, and 86 percent, respectively, for X-ray, CT, and MRI scans. The relevance of the model is shown by a multitude of tests in comparison to other studies that are considered cutting edge.

Stretching variable colour values to boost the values of the grey levels existing in the processed image is an image enhancement method. This modifies the pixel value of each image at the same time, improving the visualisation of layout in both dark and light areas of the image. The difference between the maximum and minimum pixel intensity is referred to as picture contrast. This manages a uniform scale function of picture pixel values, similar to equalisation of the histogram.

$$s = T(r) = \frac{1}{1+(m/r)^E}$$

....................(1)

Where r signifies the intensities of the input image, s denotes the equivalent intensity values of the output image, and E denotes the function's slope.

Histogram Equalization (HE)

The dark stages are addressed by an image histogram. A histogram can be used to determine whether an image is light or clear, has a low difference, or has a high separation colour. Histogram The image is equalised by using a histogram. It's utilised to improve the visual appeal of a photograph. This entails breaking up photos into parts. The picture has dim levels or power in the range of 0 to 255, and the histogram is linked to measuring pixel values for the darker levels[25].

To get an enhanced image, HE is employed to find the power values and render them uniform pixel appropriation. The HE technique is used in this way to increase the pixel dynamic range for the image's existence. Histogram equalisation simple equation –

$$E(l) = \max(o, round\left(\left(\frac{L}{N*M}\right) * t(l)\right) - 1)$$

.... (2)

Where,

E (l) - equalized function

Max- maximum dynamic range

L- no. of grey levels

N*M- the size of the image

T (l) - accumulated frequencies

Log Transformation

The term "log transformation" refers to a method for transforming data that involves substituting a log value for each variable x. (x). In most cases, the aims of the statistical modelling will decide the logarithm basis that will be used in the study. The nature log is denoted by the letter ln in the abbreviation. We may log convert the data when it does not match the bell curve in order to make it as "normal" as is practically possible, which will increase the validity of the findings of the statistical study. In other words, the log transformation reduces or removes the amount of distortion that was there in our initial data. The most important criteria is that the initial data must either have a log-normal distribution or be very near to having such a distribution. If this does not occur, the log transformation will not be successful [26]. The formula for the log transformation can be found here.-

$$s = c\log(r + 1)$$

(3)

The output and input images' pixel values are s and r, respectively, while c is a constant. Because the image has a pixel intensity of o and log (o) equals infinity, the value 1 is added to each pixel value in the input image. As a result, the minimum number is increased by one to make it at least one.

Transfer Learning

TL is the process of training a pre-trained neural net to match multiple datasets or circumstances[27]. Fine-tuning from the a pre-trained system may aid with deep network adoption when there's not enough training data. We only have a few photographs to work with in this project, especially for the COVID-19 class. TL is therefore required.

Transferring learning is a well-studied method for training convolutional neural networks. The network is pre-trained in this manner using ImageNet, a large database. This stage leads to the formation of the layers' weights, which reduces the vanishing gradient problem, by importing such weights before installing the network in the existing design. This is an important benefit of TL since it improves goal convergence. Another benefit of this type of learning is the ability to extract relevant visual aspects such as forms and edges. As a result, by constraining computations to the last layers of the training phase, the computational time is minimised.

The network that has managed to survive In terms of accuracy and computational complexity, ResNet is a powerful deep learning technique that outperforms a variety of other dense networks. This is why, using TL, we were able to distinguish the coronavirus from other viral pneumonia infections.

ResNet

In compared to standard CNN architectures, the residual neural network was introduced with a new architecture,. It has gated units that allow connections to be skipped. Batch normalisation is one of its key responsibilities[34]. As a result, the ResNet-20 is capable of training NN with up to 152 layers[28].

DenseNet

One of the well-known neural networks for visual object detection is DenseNet. Its architecture is similar to ResNet's, although there are a few notable differences. This architecture enables maximum information flow throughout the network's levels, making it easier to extract the most important properties. The authors created a Densely Connected Neural Network by matching feature map sizes across the network (DenseNet). As a result, they were able to connect all of the layers directly to their subsequent levels. DenseNet improved the data flow across layers by incorporating a variety of network architectures. Unlike many other networks, such as ResNet, DenseNets mix rather than sum the layer's output feature maps with the incoming feature maps[33].

5 Experimental Analysis

5.1Dataset Collection- The trial yielded SARS-CoV-2 CT-scan data, with a total of 2482 CT scans. The data was acquired from hospitals in the Brazilian city of Sao Paulo. The images in this dataset are digitally scanned copies of printed CT scans with no specified image size. We used the COVID 19 x-ray image dataset with COVID and NON-COVID classifications, having 1252 images in the covid class and 1229 images in the non-covid class.

5.2Data pre-processing- Pre-processing techniques can aid in the reduction of undesired noise, the identification of key areas of the image, and even the DL training stage. A picture's height and width must be scaled to fit the current aspect ratio. The pre-processing method of image filtering minimises the size of all input images. First, we execute three different techniques for preprocessing. -

a. Histogram Equalization
b. Contrast Stretching
c. Log transformation

Each programme pre-processes the source photos in its own way. After that, ResNet and DenseNet models were used to train the pre-processed photos. The original image, as well as its histogram, are shown in Figure 2 and 3 show the pre-processed sample image and the image's histogram after contrast stretching, figure 4 shows the pre-processed sample image and the image's histogram after log transformation, and figure 5 shows the pre-processed sample image and the image's histogram after histogram equalisation.

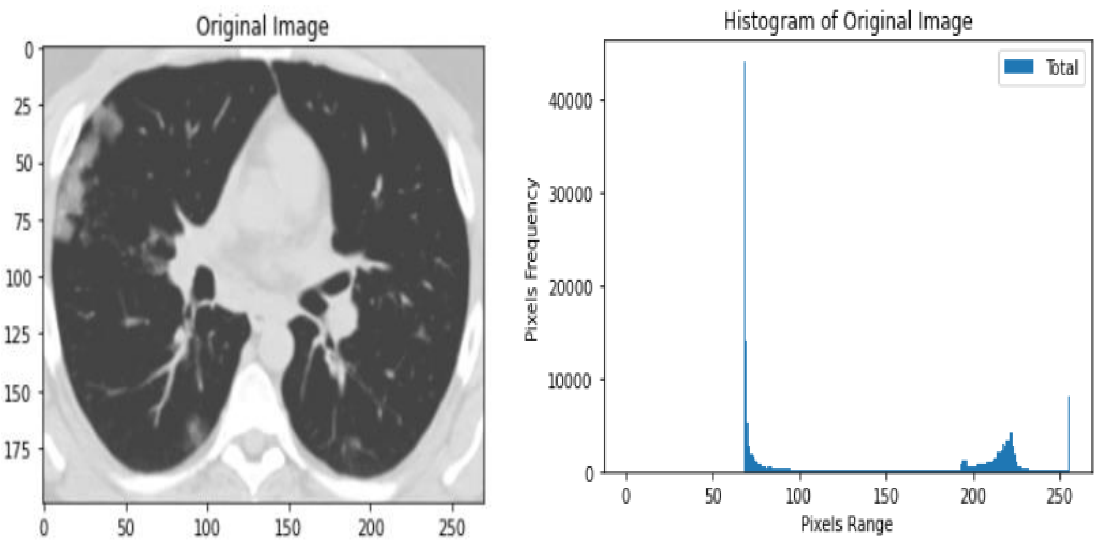

Figure 2- The figure shows the original image and the histogram of the original image.

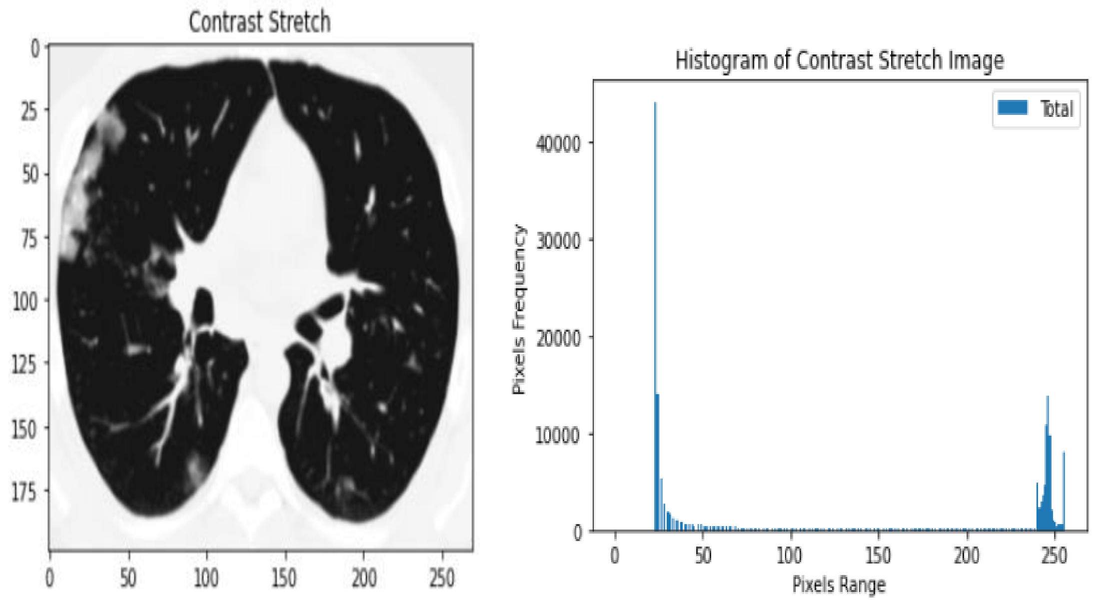

Figure 3- The figure shows the CS image and the histogram of the CS image.

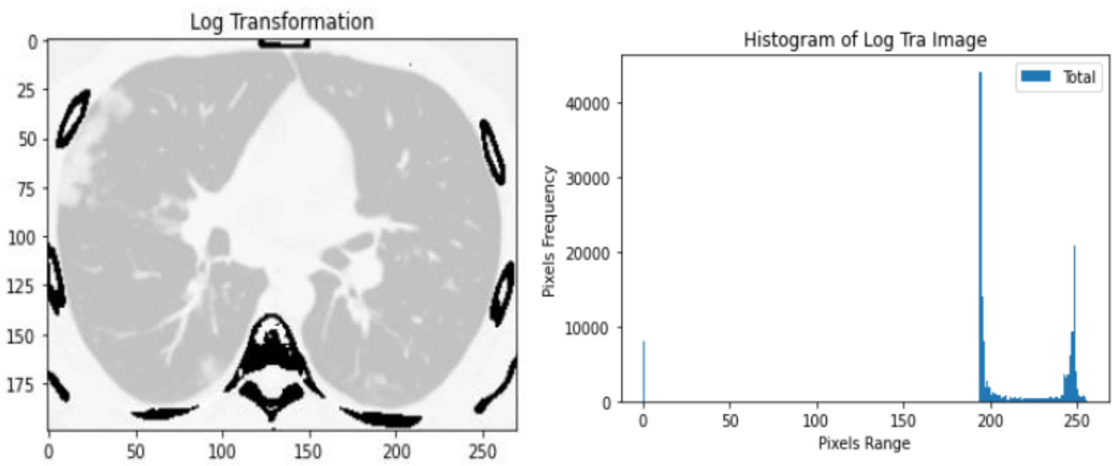

Figure 4- The figure shows the LT image and the histogram of LT image.

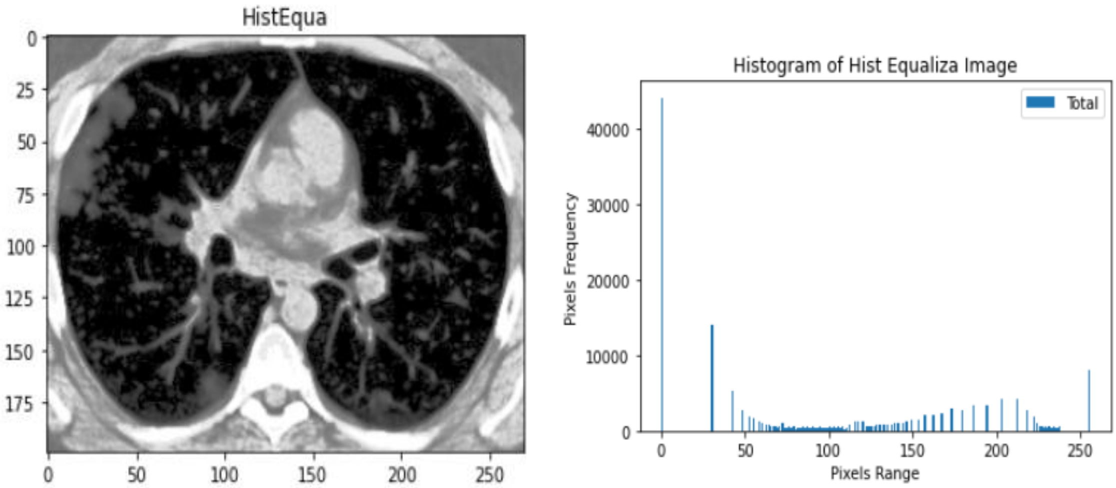

Figure 5- The figure shows the HE image and the histogram of the HE image.

After pre-processing with various methods, get the resulting dataset ready for training with ResNet and DenseNet models. We create a data frame for every class and generate random paths for each photo. For the analysis of each class, the frequency histogram of each class is plotted in the figure.

5.3Data Augmentation-It is a method for obtaining fresh data from an existing dataset. In this case, it creates jumbled copies of the existing photos. The main objective is to strengthen the neural network by incorporating different diversities, creating a network that can differentiate between significant and irrelevant dataset elements. There are several options for improving images. Augmentation strategies are successfully used when data availability and quality permit them. Because they didn't fit the training, a number of the images had to be rejected[79]. Image Data Generator, a novel method to create more data from existing data, was used for batch picture loading and labelling with rotation range = 360, zoom range = 0.2, width shift range = 0.2, and height shift range = 0.2. 128*128 picture size, horizontal flip="True," and vertical flip="True."

Photos should be resized and reorganised to a height and width of 128*128 pixels for training and testing. To prepare data for training, normalise images using the pixel division method (./255), then transform them into categorical labels. Following the use of the augmentation technique, the entire set of images is trained and validated. We created training classes using 80% of the dataset as a training set and 20% as a testing set.

Data that has been pre-processed with Log Transformation, Histogram Equalization, and Contrast Stretching is modelled using DenseNet121 and ResNet101. the ImageNet weight with conv2D and dropout layers, global average pooling, and an image size and shape of 128*128*3. After using the Softmax function as the output function and the Relu activation function as the input function, batch normalisation was used. Table 1 contains a list of the models' parameters.

Table 1: A table describing the models used

Model	DenseNet121, ResNet101
Weights	ImageNet

Shape	128*128*3
Layers	Conv2D, Dropout
Pooling	Global Average Pooling
Normalization	Batch normalization
Activation	Relu
Output Function	Softmax
Optimizer	ADAM
Learning rate	0.002
Loss	Categorical cross-entropy
Matrics	Accuracy

5.4 Performance Metrics-

Precision and accuracy

Accuracy is the degree to which a measured value is close to its true value. Precision is the degree to which all of the measured values are closely connected. To put it another way, accuracy refers to the percentage of right categories among all classifications[39]. We also include the F1-score, which is a statistic that provides a better indication of cases that have been incorrectly classified, when a model's accuracy is greater than 90%. This is calculated using the harmonic mean of precision and recall[40].

Table 2 shows the results of several techniques after training with the ResNet101 and DenseNet121 models. The training accuracy for the ResNet 101 model is 89.80, with testing accuracy of 90.91, while the training accuracy for the Densenet 121 model is 93.72, with testing accuracy of 92.69, as shown in table 2..

Table 2- Evaluation of results for Log Transformation.

Model	**Train Accuracy**	**Test Accuracy**	**Loss**	**Precision**	**Recall**	**F1 Score**
ResNet101	89.80	90.91	24.50	89	94	91
DenseNet121	93.72	92.69	15.61	94	91	93

The greatest testing accuracy for the DenseNet121 model for Log Transformation approach is 92.69 percent, with precision of 94 percent and recall of 91 percent. According to the results, the ResNet model for Log Transformation approach has the maximum testing accuracy of 90.91 percent, with precision of 89 percent and recall of 94 percent.

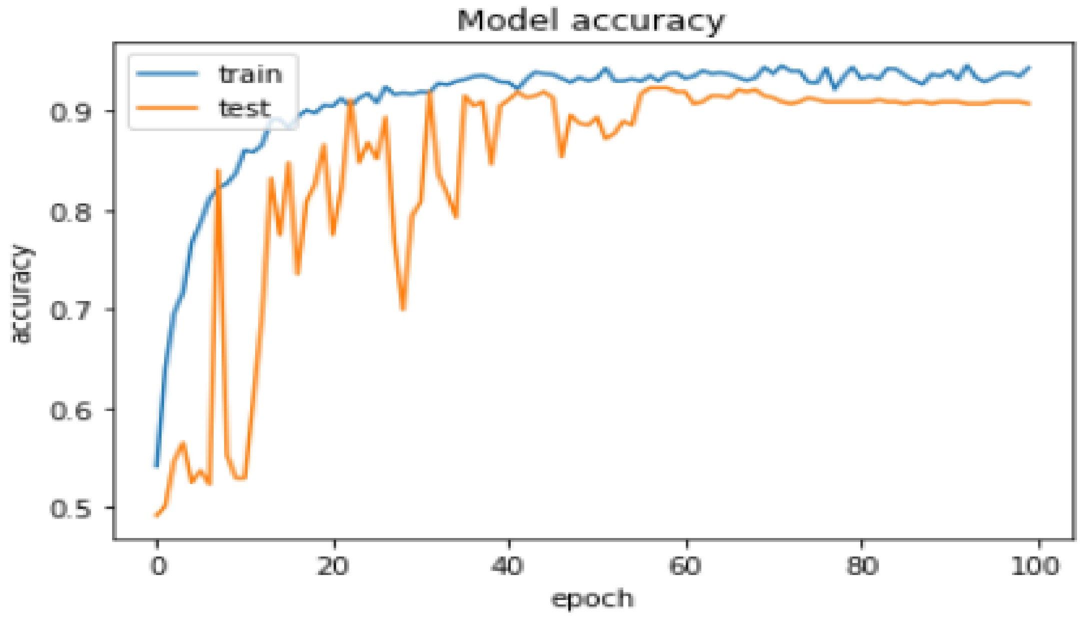

Figure 6- Figure shows the model accuracy graph of outcomes.

Deep learning algorithms to automate the process of examining CT scan images and determining whether or not an individual is COVID positive. The findings of this study are encouraging, but there are two cautions. Because of issues about patient confidentiality, there are no lung image CT-scan datasets that are easily available. This has a huge effect on the research and development of new AI algorithms, which ultimately leads to more accurate outcomes. During the training phase, DL techniques need large datasets since they are required to meet the clinical demand for results. Given the current state of affairs, it looks unlikely that medical workers will be able to collect and interpret crucial CT scan data while delivering patient care. Second, because these programmes aren't transferable, the results of one hospital's trained model may not be applicable to another.

6 Conclusion

The COVID-19 is still being conducted worldwide. More novel DL-based classification and prediction models have been developed, and there are also more publicly accessible datasets now. In this paper, DL techniques for COVID-19 detection in the human respiratory system are presented. The COVID-19 and normal conditions of patients are classified using these patterns. In the study, COVID-19 disease was evaluated and diagnosed using CT scans. These images were used to train and test novel DenseNet and ResNet-based classification models, which were graded on their training and testing accuracy. One of the most important tasks in computer vision is the identification and classification of objects in images. This area of pattern recognition and machine learning research is very active. For service providers and clients alike, forming and probing for products takes time. The time spent sorting and labelling the products is considerable. Training on a sizable dataset takes some time and computing power. An essential part of image processing for ML that can be completed at any stage without human involvement is picture recognition. In this study, we examine the use of an imaging backend in image classification. For our learning model, we split a small number of thousand fashion photos into two categories: training dataset and test dataset. The study's findings demonstrate that the photographs are correctly identified even when similar images are scrambled in different sizes, clipped, or rotated to create a whole original image for the input. This proves the algorithm's effectiveness. The TL method has advanced significantly in terms of training and analysing classification strategies. We used a hybrid Transfer Learning method combining DenseNet121 and Resnet101.

REFERENCE

[1] C. 19, "Coronavirus disease (COVID-19)," World Health Organization, 2020. .

[2] RT PCR, "Reverse transcription polymerase chain reaction," WIKIPEDIA, 2022. .

[3] Y. Qiblawey et al., "Detection and severity classification of COVID-19 in CT images using deep learning," Diagnostics, vol. 11, no. 5, 2021, doi: 10.3390/diagnostics11050893.

[4] SARA-COV-2, "No Title," National Cancer Institute, 2022. .

[5] W. et al. Wang, "Detection of SARS-CoV-2 in Different Types of Clinical Specimens," Jama Netw., 2020.

[6] Y. Yang et al., "Evaluating the accuracy of different respiratory specimens in the laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections," medRxiv, 2020, doi: 10.1101/2020.02.11.20021493.

[7] T. Ai et al., "Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases," Radiology, vol. 296, no. 2, pp. E32–E40, 2020, doi: 10.1148/radiol.2020200642.

[8] H. Gunraj, L. Wang, and A. Wong, "COVIDNet-CT: A Tailored Deep Convolutional Neural Network Design for Detection of COVID-19 Cases From Chest CT Images," Front. Med., vol. 7, no. December, pp. 1–11, 2020, doi: 10.3389/fmed.2020.608525.

[10] R. Sarki, K. Ahmed, H. Wang, Y. Zhang, and K. Wang, "Automated detection of COVID-19 through convolutional neural network using chest x-ray images," PLoS One, vol. 17, no. 1 January, pp. 1–26, 2022, doi: 10.1371/journal.pone.0262052.

[11] R. Devesh, J. Jha, R. Jayaswal, M. Gwalior, and M. Pradesh, "Retrieval of Monuments Images Through ACO Optimization Approach," Int. Res. J. Eng. Technol., vol. 4, no. 7, pp. 279–285, 2017.

[12] M. M. Krishna, M. Neelima, M. Harshali, and M. V. G. Rao, "Image classification using Deep learning," Int. J. Eng. Technol., vol. 7, no. August, pp. 614–617, 2018, doi: 10.14419/ijet.v7i2.7.10892.

[13] J. Jha and S. S. Bhaduaria, "A novel approach for retrieval of historical monuments images using visual contents and unsupervised machine learning," Int. J. Adv. Trends Comput. Sci. Eng., vol. 9, no. 3, pp. 3563–3569, 2020, doi: 10.30534/ijatcse/2020/162932020.

[14] R. Jayaswal, J. Jha, and M. Dixit, "Mining of Images by K-Medoid Clustering Using Content Based Descriptors," Int. J. Signal Process. Image Process. Pattern Recognit., vol. 10, no. 8, pp. 135–144, 2017, doi: 10.14257/ijsip.2017.10.8.12.

[15] M. J. Jha, "Review of Various Shape Measures for Image Content Based Retrieval," vol. 3, no. 6, 2015.

[16] T. Kang, "Using Neural Networks for Image Classification," 2015.

[17] T. Jain, "Basics of Image Classification Techniques in Machine Learning," Opengenus, 2020. .

[18] N. Sharma, V. Jain, and A. Mishra, "An Analysis of Convolutional Neural

Networks for Image Classification," Procedia Comput. Sci., vol. 132, no. Iccids, pp. 377–384, 2018, doi: 10.1016/j.procs.2018.05.198.

[19] P. Wang, E. Fan, and P. Wang, "Comparative analysis of image classification algorithms based on traditional machine learning and deep learning," Pattern Recognit. Lett., vol. 141, pp. 61–67, 2021, doi: 10.1016/j.patrec.2020.07.042.

[20] A. Anand, "Unit 13 Image Classification," Tutor. Process. Classif. Remote. Sensed Images, no. May, pp. 41–58, 2018.

[21] V. Aggarwal and G. Kaur, "A review:deep learning technique for image classification," Accent. Trans. Image Process. Comput. Vis., vol. 4, no. 11, pp. 21–25, 2018, doi: 10.19101/tipcv.2018.411003.

[25] D. Wagh and S. Mahajan, "Product image classification techniques," Int. J. Innov. Technol. Explor. Eng., vol. 8, no. 6, pp. 389–393, 2019.

[26] "North Dakota State University," no. July, 2020.

[27] I. A. Khalid, "TLfor Image Classification using Tensorflow," towards data science, 2020. .

[28] L. Zhu and P. Spachos, "Towards Image Classification with Machine Learning Methodologies for Smartphones," Mach. Learn. Knowl. Extr., vol. 1, no. 4, pp. 1039–1057, 2019, doi: 10.3390/make1040059.

[29] S. Sexana, "The Architecture of Lenet," Analytics Vidhya, 2021. .

[30] Jerry wei, "AlexNet: The Architecture that Challenged CNNs," towards data science, 2019. .

[31] Abhay Parashar, "Vgg 16 Architecture, Implementation and Practical Use," Medium, 2020. .

[32] S. Abdul, "Build ResNet from Scratch With Python," Analytics Vidhya, 2021. .

[33] L. Zhang, D. Li, and Q. Guo, "Deep Learning from Spatio-Temporal Data Using Orthogonal Regularizaion Residual CNN for Air Prediction," IEEE Access, vol. 8, pp. 66037–66047, 2020, doi: 10.1109/ACCESS.2020.2985657.

[34] S. Kiranyaz, O. Avci, O. Abdeljaber, T. Ince, M. Gabbouj, and D. J. Inman, "1D convolutional neural networks and applications: A survey," Mech. Syst. Signal Process., vol. 151, pp. 1–20, 2021, doi: 10.1016/j.ymssp.2020.107398.

[35] D. Li, L. Deng, and Z. Cai, "Research on image classification method based on convolutional neural network," Neural Comput. Appl., vol. 7, 2020, doi: 10.1007/s00521-020-04930-7.

[36] Ed Burns, "What is a neural network? Explanation and examples," searchenterprise. .

[37] O. Harrison, "No Title," towardsdatascience, 2018. .

[38] B. Huo and F. Yin, "Research on novel image classification algorithm based on multi-feature extraction and modified SVM classifier," Int. J. Smart Home, vol. 9, no. 9, pp. 103–112, 2015, doi: 10.14257/ijsh.2015.9.9.11.

[39] ML, "Classification: Precision and Recall," machine learning crash course, 2020. .

[40] R, "ROC Curves," machine learning crash course, 2020. .

[41] S. Narkhede, "Understanding Confusion matrix," towardsdatascience, 2018. .

[42] C. C. Ho, K. Baharim, A. Abdulsalam, and M. Shafiq, "Deep Neural Networks for Text: A Review," Deep Neural Networks Text A Rev., no. May, 2017.

[43] C. Zhou, J. Song, S. Zhou, Z. Zhang, and J. Xing, "COVID-19 Detection based on Image Regrouping and ResNet-SVM using Chest X-ray Images," IEEE Access, vol. 9, 2021, doi: 10.1109/ACCESS.2021.3086229.

[44] T. Chakravorti, V. K. Addala, and J. S. Verma, "Detection and Classification of COVID 19 using Convolutional Neural Network from Chest X-ray Images," 2021 6th Int. Conf. Converg. Technol. I2CT 2021, pp. 2–7, 2021, doi: 10.1109/I2CT51068.2021.9418221.

[45] S. Sharma and S. Tiwari, "COVID-19 Diagnosis using X-Ray Images and Deep learning," Proc. - Int. Conf. Artif. Intell. Smart Syst. ICAIS 2021, pp. 344–349, 2021, doi: 10.1109/ICAIS50930.2021.9395851.