Mansoura University
Faculty of Engineering
Mansoura Engineering Journal

Medical Image Recognition Method for Respiratory System Viruses Diagnosis based on a Proposed Combined Neural Network System

Mazhar B. Tayel and Ahmed M. Fahmy*

KEYWORDS:

Biomedical imaging, image classification, Covid-19, Probabilistic Neural Network (PNN), Convolutional Neural Network (CNN), Computed Tomography (CT scan), Artificial Intelligence (AL), Deep Learning (DL), and Machine Learning (DL).

Abstract— ***Respiratory viral detection is a confusing and time-consuming task of constantly looking at clinical pictures of patients. So, there is a need to develop and improve the respiratory case prediction model as soon as possible to control the spread of Respiratory viruses. Today advanced machine learning methods diagnose viruses such as Corona viruses that can be effectively classified. This paper proposes a scanning model based on using a combination of CNN (Convolutional Neural Network) and PNN (Probabilistic Neural Network) to classify images of Corona viruses. The proposed combined network, (PCN) system. The images used are resized, and the light was adjusted in a way that reflects the size of the Plaque damage and highlighted by converting the image to Hue Saturation Value (HSV). Essential distance information in an image is filtered, leaving important features of the image information. The PCN system uses the Convolutional Neural Network to calculate the dependent factors and passes the results to the Probabilistic Neural Network, and link the features of intermediate stages with the combined network to predict segmentation. As a result, PCN system achieves 100% accuracy.***

I. INTRODUCTION

RESPIRATORY viruses such as Corona viruses (Covid) leading to a major cause of illness and death worldwide. About one-fourth of all deaths worldwide are associated with respiratory infections. Corona-virus is currently a highly contagious disease worldwide. On January 3, 2020, the World Health Organization (WHO) announced that Corona viruses to be an International Emergency Medical Concern (PHEIC). [1] Coughing, ageusia, anosmia, respiratory distress, and fever and fatigue. Research efforts are carried out on various aspects of Corona viruses including treatment research, antiretroviral therapy and diagnostic tools to determine who is infected early. In this study, high-accuracy access to imaging categories was assessed on Corona Viruses Computed Tomography (CT Scan) images.

Machine learning methods can anticipate risk of death by successfully analyzing previous and present patient data and can contribute to fight against the virus by diagnosing people, information, classification, medical assistance and recommendations related to disease control. Deep Learning (DL) is a category of AI sites that contain a few algorithms such as deep neural network and convolutional neural network. providing clever models to identify or integrate specific tasks. Lately in various activities. Also DL played a vital role in image classification activities. Interestingly, researches that are working in the medical, technical, and military fields have successfully introduced advanced AI-based methods of DL in the Corona virus war shortly after the COVID-19 explosion and

Received: (26 July, 2022) - Revised: (20 September, 2022) - Accepted: (24 September, 2022)

Mazhar B. Tayel is with the Alexandria University, Alexandria, Egypt. He is now a professor in Electrical Engineering department (e-mail: profbasyouni@gmail.com).

***Corresponding Author:** Ahmed M. Fahmy is a PhD student in Alexandria University, Alexandria, Egypt. (e-mail: eng.ahmed.fahmy07@gmail.com).*

(Ser. NO. BFEMU-2207-1292)

made significant progress. In addition, to a large extent, COVID-19 case data DL models learn to create diagnostic models that accurately predict outbreaks. DL is also widely used in epidemic protection and community surveillance, such as airport security, patient tracking, and epidemic detection. [3]

II. CHEST CT SCAN IMAGE

CT scan pictures are two-dimensional (2D) pictures representing three-dimensional objects [4]. Corona viruses diagnoses senstivity is found to be appreciably higher as it has smart resolution and occurs before a positive infectious agent research laboratory take a look at. Chest CT-scan image plays a vital role within the estimation of COVID-19 patients with rigorousmetabolic process symptoms and has potential to see how defectively are lungs compromised and the way the illness of individual progresses, that is effective in creating medical choices[5]. DL helps to analyze the CT scan pictures in less than ten seconds. Figure (1) shows a chest CT scan image.

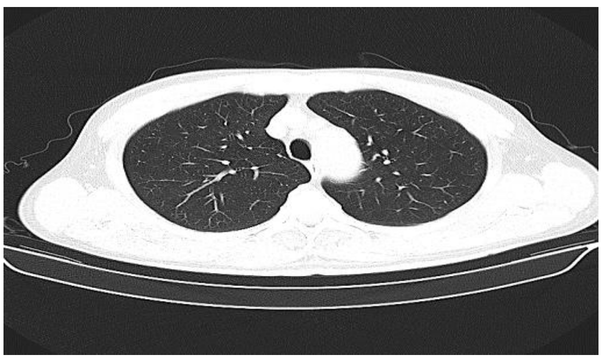


Fig.1. Chest CT-Scan Image [6]

III. NEURAL NETWORK (NN)

A. Convolutional Neural Network (CNN)

The convolutional neural network is a type of deep learning that collects pictures and data items and builds an artificial neural network (ANN) by weighting them. At present, the preferred choice of all data scientists to manage image or video processing data. The architecture of the CNN is shown in Figure (2). [7]

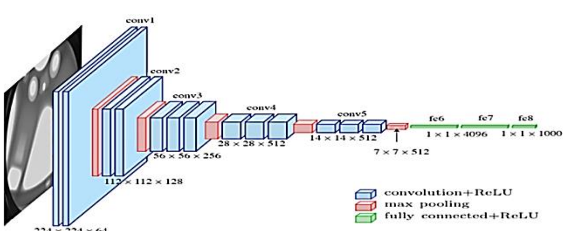


Fig.2. Architecture of CNN **[7].**

B. Probabilistic Neural Network (PNN)

A probabilistic neural network is a spoke and hub network well suited for classification problems. It uses the Bayesian classification technique for decision making, as well as the Pazen window, which uses training data to calculate the probability density function (PDF) for each category. [8]

The architecture of this model is a multilayer feed-forward network as shown in Figure (3). An input layer, a pattern layer, a sum layer and an output layer form the four layers.

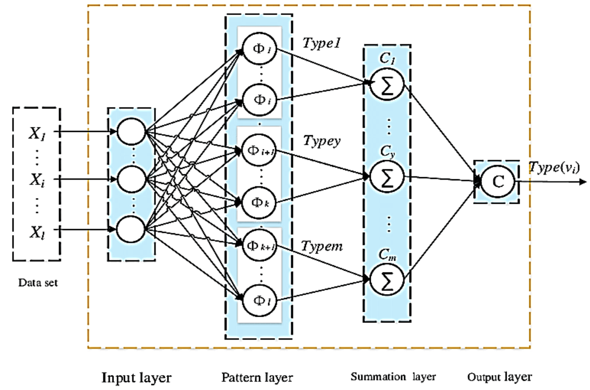


Fig.3. Probabilistic Neural Network Architecture [8].

IV. THE PROPOSED COMBINED NETWORK (PCN)

The PCN system include recognition and classification of patients suffering from COVID-19 via two deep learning methods named Convolutional Neural networks and Probabilistic Neural Network.

The PCN system uses data set gathered and found at Kaggle images depository and this data set needs pre-processing before passing it to the CNN to extort the acquired features then using the PNN for recognition and classification process. The PCN system components are shown Figure (4).

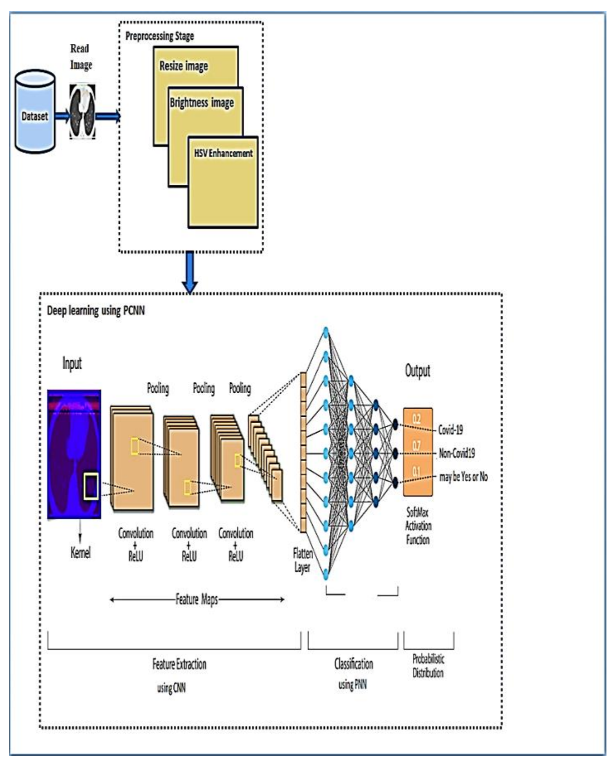


Fig.4. The PCN of Corona virus detection.

A. Image Acquisition

Images can be captured using a variety of methods, including cameras and scanners and acquired. Nearly 50% of cases distributed to COVID and NON-COVID. The dataset was divided as 500 training images, and 246 test images. Figure (5) shows one of the CT- scan images used from the dataset.

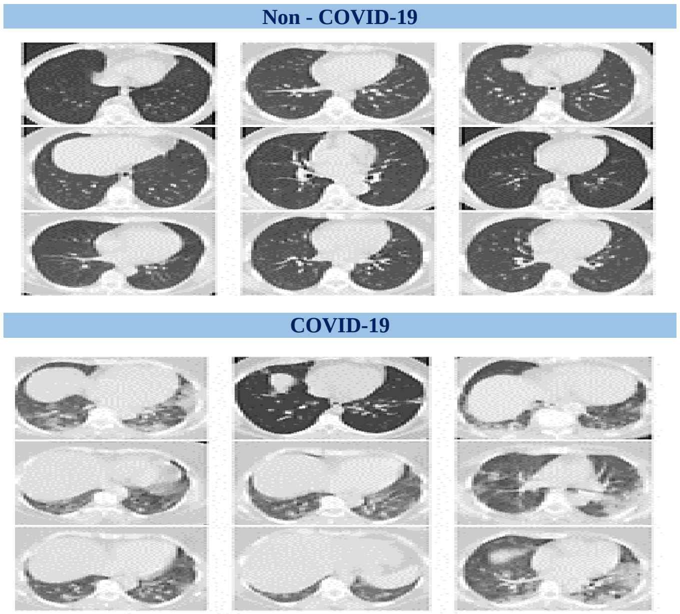


Fig.6. Sample of CT scan datasets [6].

B. Preprocessing Stage

Although CT images are rarely noisy, the dataset acquisition process can reduce image detail, requiring us to process the images. There was lighting that affected it, it is needed to improve the lighting. In addition, the image needs to be highlighted in Covid 19 by transforming the image and using HSV.

The images were resized to 256x256 for covid19 as there was an image that differs in size present in the dataset used. The PCN technique is used to pre-process the image brightness enhancement method in order to display image details well. The brightness enhancement is to be increased between 0 and 255 to prevent any noise or light distortion. Choosing a source images with similar characteristics is a must to line up the image for better coloring results and, if images are incorrectly chosen, this will result in (YCbCr) with various pixels from 2x2 and 3x3 to 10x10 and poor coloring.

C. Feature Extraction

Feature extraction from dataset like COVID19 CT- scan images is an enormous phase in classifying whether a person is infected with Covid 19 or not using the CNN.

1. Input layer

The image dimensions are 28x28x1, maintain the same dimensions of border, width and height with three color channels.

2. Convolution Layer

The feature extraction layer applies a weight sliding mask to the source image and makes a dot-product multiplication to create the feature map. The weight is randomly generated and then cycled through the batch normalization (BN), pooling, and ReLU layers for several rounds. The weight reflects the characteristics after finding out the optimal weight for that image.

3. Batch Normalization Layer (BN)

BN layer hustles the training process and eliminates sensitivity in network initialization through reducing the number of channels. The activation of each channel is normalized by first subtracting the minimum batch deviation and dividing by the mini standard batch deviation, after which the shift input is compensated and finally scaled by the factor. This layer is combined with the ReLU and convolution layers.

4. ReLU layer

The max pooling layer was used here to eliminate unwanted features and then returning a vital feature by sliding a mask of known dimension over the feature map created by the previous convolutional layer but the maximum is empty, so the result is the highest value found under that mask at in each step.

5. Fully Connected Layer

This layer is a vector of features that consists of the most essential information for the input; It gathers all the features extracted from the previous convolution layers during training and then used for classification. In other words, a hidden layer can be trained to predict the probability of each class.

6. Softmax layer

This layer produces a probability number between 0 and 1and for each class it has got its own probability, such as e.g. (0.021, 0.007).

7. Loss function level

The loss function level is used to calculate the error {loss} in each iteration held; it's also a key component for back-propagation weight updates, as it shows the difference between the intended output and the actual label.

V. EXPERIMENTAL RESULTS

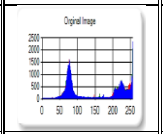
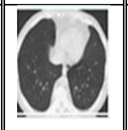
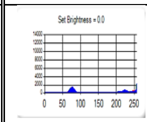
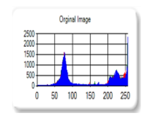
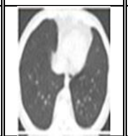
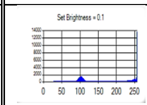
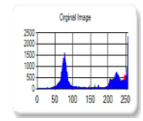
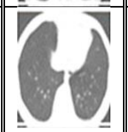
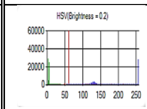
The results of obtaining and recognition of COVID image is shown in this section as a series of classification steps.

A. Pre-Processing Stage

Image brightness:

A CT-scan image of a Covid-19 image is a applied to an optimization processing phase, showing off the histograms before and after optimization pre-treatment. The best parameter is 0.1 as shown in Table (I) as of selection a range of parameters to manage the preferred brightness in this stage of image pre-processing.

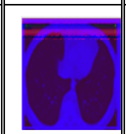
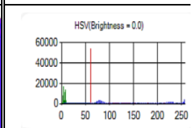
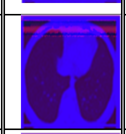
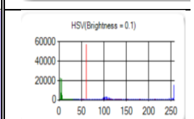
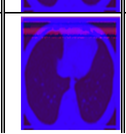
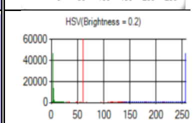
TABLE I
BRIGHTNESS OF CT SCAN COVID IMAGE.

Original Image	Histo-gram	parameter	Brightness Image	Histogram
		**0.0**		
		**0.1**		
		**0.2**		

HSV augmentation:

The H, S, and V parameters were flexible in the arrangement needed to obtain the desired HSV image from the results of CT-scan image of Covid-19. Superlative parameters for HSV are H {0 – 60}, S {61—180}, V {181—255} as given, Table (II).

TABLE II
HSV CT SCAN COVID IMAGE.

Original image	Parameter			HSV	Histogram
	H [From, To]	S [From, To]	V [From, To]		
	[0 – 60]	[61-180]	[181-255]		
	[0-30]	[30-130]	[131-255]		
	[0-80]	[81-150]	[151-255]		

B. Feature Extraction Using The CNN

At this step, the characteristics that will be extract through the convolutional neural network through the eight layers as described below and utilized as shown in the tables below each stage accomplished.

Convolution layer:

The padding of an image here is the same in this layer which consists of eight filters with each filter size of 3x3. As the kernel is 1 px. Reason of using these numbers of filters to extract individual features to recognize if the original image contains particular patterns in every iteration of the convolutional layer as shown in Table (III).

TABLE III
ITERATIONS OF THE CONVOLUTIONAL LAYER.

Iteration	Activation	Pyramid Level
1	12.183	1
2	18.384	1
3	28.258	1
4	68.894	1
5	128.593	1
6	134.125	1
7	166.603	1
8	186.746	1
9	243.594	1
10	255.901	1

Batch Normalization:

Regulates the inputs to mini-batch of the layer which helps to alleviate the learning process and minimizing the training iterations epochs required to improve DNN, Table (IV).

TABLE IV
ITERATIONS OF BATCH NORMALIZATION.

Iteration	Activation	Pyramid Level
1	0.001	1
2	0.456	1
3	0.764	1
4	0.922	1
5	0.987	1
6	1. 445	1
7	1. 095	1
8	1.134	1
9	1.156	1
10	1.178	1

ReLU layer:

The output of the corrected linear activation (ReLU) function is directly equal to the value of the input; else, it is zero. The iterations activation of ReLU layer is shown in Table (V).

TABLE V
ITERATIONS OF RELU.

Iteration	Activation	Pyramid Level
1	0.661	1
2	0.647	1
3	0.926	1
4	1.046	1
5	1.056	1
6	1.067	1
7	1.088	1
8	1.119	1
9	1.119	1
10	1.11 9	1

Max Pooling

The pooling layer's purpose is letting activation maps as minor as feasible, that's why additional filters may utilize. Max pooling is used to conserve the maximum values within each window however erasing feature matrix) to minimize the size of the matrix, Table (VI).

TABLE VI
ITERATIONS OF MAX POOLING.

Iteration	Activation	Pyramid Level
1	0.846	1
2	1.370	1
3	1.551	1
4	1.548	1
5	1.693	1
6	1.667	1
7	1.891	1
8	1.843	1
9	1.876	1

Fully Connected Layers:

Neurons in this network layer are all fully linked up to all neurons in the preceding layer, Table (VII).

TABLE VII
ITERATIONS OF FULLY CONNECTED LAYERS.

Iteration	Activation	Pyramid Level
1	0.35	1
2	2.25	1
3	3.69	1
4	5.08	1
5	6.18	1
6	7.32	1
7	8.92	1
8	9.29	1
9	9.80	1
10	10.13	1

Soft max layer:

Softmax function is used here to summarize a set of K real numbers, which take a set of K real values and add one to it. It converts zero, positive, negative, or many input values to values between 0 and 1, to let the values be recognized as probabilities., Table (VIII).

TABLE VIII
ITERATIONS OF SOFTMAX LAYER.

Iteration	Activation	Pyramid Level
1	0.20	1
2	0.76	1
3	0.85	1
4	0.96	1
5	0.98	1
6	1	1
7	1	1
8	1	1
9	1	1
10	1	1

The training accuracy (TA) and validation accuracy (VA) acquired by CNN of the PCN approach on testing the dataset is illustrated in Fig. 7. To be specific the TA is lower than the VA. Training loss (TL) and validation loss (VL) achieved on test dataset are accomplished in Fig. 8. The experimental outcome represented CNN of the PCN has established minimal values of TL and VL.

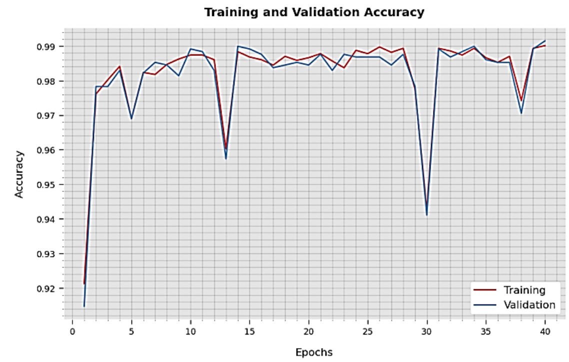


Fig.7 The TA and VA

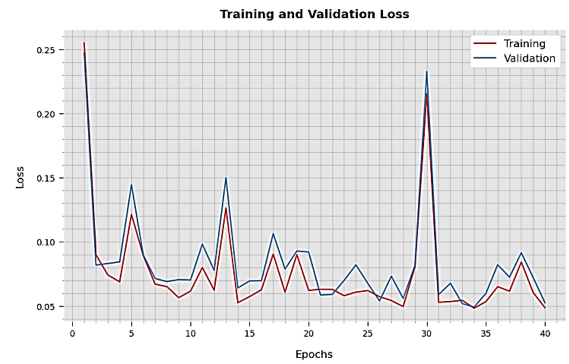


Fig.8. The TL and VL of the CNN.

VI. CLASSIFICTION USING THE PCN

Following up the process of features extraction from the CNN through a series of layers, the number of features is reduced because they differ from one image to the next by calculating the mean and standard deviation, and the features are then entered in the layers of PNN and summation calculation of the characteristics to classify whether or not a person is infected with Covid, Table (IX). Fig. 9 & 10 shows the Precision-recall curve analysis and ROC curve analysis of PCN system respectively.

TABLE IX
CHARACTERISTICS TO CLASSIFY WHETHER OR NOT A PERSON IS INFECTED WITH COVID.

Feature Normalization		Sumation		PNN
Feature	**Value**	**Class**	**Sum**	**Class = Positive COVID-19 Sum**=0.2850
F(0)	130.0567	1	0.2356	
F(1)	150.2563	2	0.2850	
F(2)	0.078463	3	0.2619	
F(3)	16.01987	4	0.2619	
F(4)	7.51229	5	0.0622	
F(5)	64.0659	6	0.0784	
F(6)	34.0563	7	0.0321	
F(7)	0.16202	8	0.0962	
F(8)	5.146365	9	0.0345	
F(9)	1.51979	10	0.0915	
F(10)	3.62023	11	0.1200	
F(11)	12.6641	12	0.0721	
F(12)	-0.0040	13	0.0643	
F(13)	1.18152	14	0.0954	
F(14)	0.524876	15	0.0341	
F(15)	55.91278	16	0.3451	
F(16)	164.5747	17	0.1102	
F(17)	0.13420	18	0.2019	
F(18)	18.3671	19	0.1567	
F(19)	8.78339			

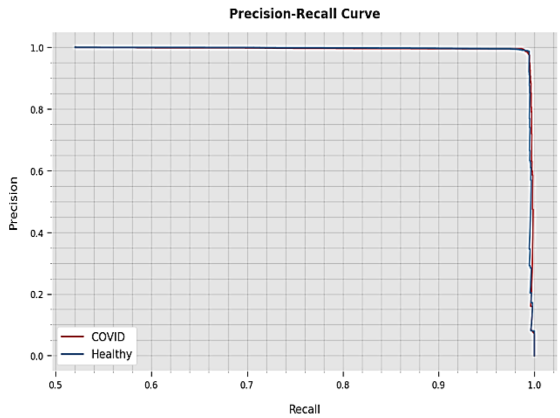


Fig.9. Precision-recall curve analysis the PCN system.

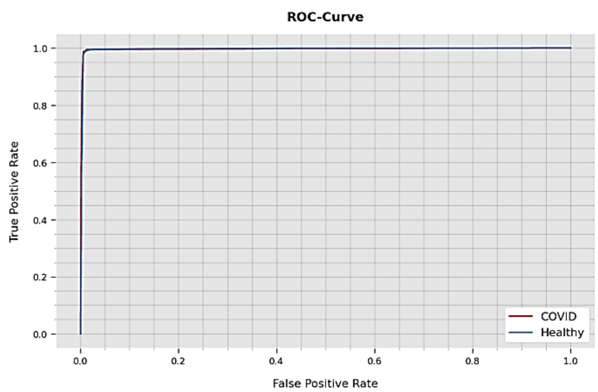


Fig.10.ROC curve analysis of the PCN system.

VII. EVALUATION OF THE PCN.

The standard metrics used to measure the performance and evaluation of the PCN. How rapidly network parameters are changed is determined by the learning rate through hyper parameters. Due to the low rate of learning, the learning process slows down, but it eventually converges. It is frequently suggested that the learning rate be slowed down. During training, the number of periods refers to the total of the full training data presented to the network. The stated micro-batch accuracy at the specified iteration corresponds with the micro-batch accuracy recorded during training. The approach divides the entire data set into several tiny groups during random gradient descent with momentum training (SGDM). The calculation of network gradients for each small batch is known as iteration. Every potential modest push corresponds to a different period. The model is updated only after all training examples and error calculations have been reviewed. The circumstances of training the model may affect the accuracy and loss in the validation of the data model. Val's loss shrinks, while Value accuracy grows. It is beneficial since it shows that the model has a superior performance and good learning rate. In the PCN system, Covid detection is 100 percent accurate, Table (X).

TABLE X
ACCURACY OF THE CNN.

#	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:01	15 %	60%	4.0718	1.7120	100%
2	10	00:00:03	98%	98%	0.0721	0.0609	100%
3	20	00:00:07	100%	99%	0.0077	0.0183	100%
4	30	00:00:09	100%	100%	0.0096	0.0084	100%
5	40	00:00:13	100%	100%	0.0056	0.0065	100%
7	50	00:00:14	100 %	100 %	0.0044	0.0049	100%
8	60	00:00:15	100 %	100%	0.0082	0.0037	100%
9	70	00:00:16	100%	100.00%	0.0018	0.0026	100%

Table of Comparison against similar research work between the proposed system model accuracy and other research work presented before, Table (XI).

TABLE XI
COMPARISON BETWEEN OTHER SYSTEMS CLASSIFIERS ACCURACY

Classifier	Accuracy	Reference
Logistic Regression	66%	[9]
Random forest	70%	[10]
SVM	82%	[9]
CNN(detection presence of)	97%	[11]
MFCC features of the audio signal for Covid coughs	70.58%	[12]
Proposed Combined Network System	100%	The Proposed System.

VIII. Conclusion

The PCN has achieved a superior performance metrics and can be used and applied on other certain CT-scan images and MRI in the biomedical field. The system dataset was divided into 50% COVID-19 and Non- COVID images and each of the two subdivisions where splitted into 70% trained and 30% tested, indicating that the system's accuracy achieved 100% accuracy and also declaring that it is not vulnerable to faults.

REFERENCES

[1.] G. Jain, D. Mittal, D. Thakur and M. K. Mittal, “A deep learning approach to detect Covid-19 coronavirus with X-Ray images,” Biocybernetics and Biomedical Engineering, vol. 40, no. 4, pp. 1391–1405, 2020.

[2.] A. Rehman, T. Saba, U. Tariq and N. Ayesha, “Deep learning-based covid-19 detection using ct and x-ray images: current analytics and comparisons,” IT Professional, vol. 23, no. 3, pp. 63–68, 2021.

[3.] D. Brinati, A. Campagner, D. Ferrari, M. Locatelli, G. Banfiet al.“Detection of covid-19 infection from routine blood exams with machine learning: a feasibility study,” Journal of Medical Systems, vol. 44, no. 8, pp. 135, 2020.

[4.] A. Rehman, M. A. Iqbal, H. Xing and I. Ahmed, “COVID-19 detection empowered with machine learning and deep learning techniques: a systematic review,” Applied Sciences, vol. 11, no. 8, pp. 3414, 2021.

[5.] M. Roberts, D. Driggs, M. Thorpe, J. Gilbey, M. Yeunget al. “Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans,” Nature Machine Intelligence, vol. 3, no. 3, pp. 199-217, 2021.

[6.] www.kaggle.com/ [accessed February 2022]

[7.] J. I. Z. Chen, “Design of accurate classification of covid-19 disease in x-ray images using deep learning approach,” Journal of ISMAC, vol. 2, no. 2, pp. 132–148, 2021.

[8.] Donald F. Specht, Probabilistic neural networks, Neural Networks, Volume 3, Issue 1, 1990, Pages 109-118 ISSN 0893-6080, https://doi.org/10.1016/0893-6080(90)90049-Q.

[9.] E. Y. Boateng, J. Otoo, D. A. Abaye, E. Y. Boateng, J. Otoo, and D. A. Abaye, “Basic Tenets of Classification Algorithms K-Nearest-Neighbor, Support Vector Machine, Random Forest and Neural Network: A Review,” J. Data Anal. Inf. Process., vol. 8, no. 4, pp. 341–357, Sep. 2020, doi: 10.4236/JDAIP.2020.84020. [3] C. H. Chen and C. Te Chu, “High performance iris recognition based on 1-D circular feature extraction and PSO-PNN classifier,” Expert Syst. Appl., vol. 36, no. 7, pp. 10351–10356, Sep. 2009, doi: 10.1016/J.ESWA.2009.01.033.

[10.] A, Imran, I. Posokhova,and et al. AI4COVID-19: AI Enabled Preliminary Diagnosis for COVID-19 from Cough Samples via an App. Informatics in Medicine Unlocked, page 100378, apr 2020.

[11.] Vipin Bansal; Gaurav Pahwa; Nirmal Kannan" Cough Classification for COVID-19 based on audio mfcc features using Convolutional Neural Networks "

[12.] Negin Melek Manshouri "Identifying COVID-19 by using spectral analysis of cough recordings: a distinctive study'.

Title Arabic:

طريقة التعرف على الصور الطبية لتشخيص فيروسات الجهاز التنفسي بناءً على نظام الشبكة العصبية المشترك المقترح.

Arabic Abstract:

تعد التهابات الجهاز التنفسي مهمة مربكة وتستغرق وقتًا طويلاً للنظر باستمرار في الصور الطبية للمرضى. لذا هناك حاجة لتطوير وتحسين نموذج التنبؤ بالحالة التنفسية بأسرع ما يمكن للسيطرة على انتشار فيروسات الجهاز التنفسي. اليوم ، تقوم طرق التعلم الآلي المتقدمة بتشخيص الفيروسات مثل فيروسات كورونا التي يمكن تصنيفها بشكل فعال. تقترح هذه الورقة نموذج مسح يعتمد على استخدام مزيج من CNN (الشبكة العصبية التلافيفية) و PNN (الشبكة العصبية الاحتمالية) لتصنيف صور فيروسات كورونا. نظام الشبكة المدمجة (PCN) المقترح. تم تغيير حجم الصور المستخدمة ، وتم ضبط الضوء بطريقة تعكس حجم تلف البلاك وتمييزه عن طريق تحويل الصورة إلى Hue Saturation Value (HSV).

تتم تصفية معلومات المسافة الأساسية في الصورة ، مع ترك ميزات مهمة لمعلومات الصورة. يستخدم نظام PCN شبكة CNN لحساب العوامل التابعة والمخرجات المستمرة للطبقة المركزية لنموذج PNN ، وربط ميزات هذه المستويات الوسيطة بشبكة كاملة للتنبؤ بالتجزئة. يحقق نظام PCN دقة بنسبة ١٠٠٪