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DETECTING COVID-19 BASED ON CHEST X-RAY IMAGES USING WAVELET SCATTERING AND CONVOLUTION NEURAL NETWORKS

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Abstract
This paper demonstrates a new technique for detecting covid-19 cases in chest X-ray images. The virus Covid-19 began to spread widely around the world, killing an increasing number of people. The Wavelet scattering network is used to find distinguishing features in X-ray images, and the convolution neural network (CNN) is used to classify the extracted features. The images were divided into three categories: 500 x-ray images for pneumonia, 400 covid-19 images, and 500 normal images. The proposed system produced x-ray images with a precision of 98.37 percent.
Keywords -covid-19, deep learning, chest X-ray, convolution Neural network, Wavelet scattering network

抽象的
本文展示了一种在胸部 X 射线图像中检测 covid-19 病例的新技术。 Covid-19 病毒开始在世界范围内广泛传播，造成越来越多的人死亡。 小波散射网络用于寻找 X 射线图像中的区别特征，卷积神经网络 (CNN) 用于对提取的特征进行分类。 这些图像分为三类：500 张肺炎 X 射线图像、400 张 covid-19 图像和 500 张正常图像。 所提出的系统产生的 X 射线图像的精度为 98.37%。
关键词 -covid-19、深度学习、胸部 X 光片、卷积神经网络、小波散射网络

1. INTRODUCTION

The coronavirus disease (covid), also known as the covid-19 epidemic, was discovered in Wuhan, China, in late 2019. The World Health Organization (WHO) declared the epidemic a Public Health Emergency in February 2019 and March. As of October 2021, over 243 million COVID-19 cases had been reported in over 223 countries, resulting in over 4,000,000 deaths [1]. The virus is primarily transmitted through tiny droplets formed by proximity talking, coughing, and sneezing. Instead of landing on the surface or the ground, the droplets do not travel in long detachments in the air [2]. Table 1 shows the world effect of covid-19 in numbers

Table (1): world result of covid-19[1]

Country	Number of Infections	Number of Deaths
USA	46,174,547	753,747

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India	34,143,236	453,037
Brazil	21,647,236	604,764
Uk	8,641,221	139,146
Russia	8,131,164	227,389
Turkey	7,772,604	68,472
France	7,108,206	117,411
Iran	5,833,525	124,763
Argentina	5,227,525	115,796
Spain	4,995,176	87,102

There was no proof of airborne transmission in a sample of thousands of cases in China. By touching a contaminated surface or object and then touching their face, a person can become infected. Even if there are no symptoms, the virus can spread[3]. For the first three days after the onset of symptoms, however, the infection is most infectious. CXRs at different time frames for comparison and proper diagnosis radiograph of the chest named a chest X-Ray (CXR) is a chest prediction radiograph used to detect chest symptoms. Like all, the chest x-ray has been exposed to reduce the number of inaccurate diagnoses and be especially useful in teaching hospitals. The characteristics of minimal pattern and features of low-variance from real-valued time series have been implemented with wavelet scattering framework; this gives power featuring image [4-5]. One of the Deep Learning (DL) architectures is the convolutional neural network (CNN) that is used in this work [6]. CNN has been usually used in medicinal turf because of powerful feature extraction illustration. CNN techniques' accurate recognition and classification are the most successful technology in medical applications [7].

2. Related work

In this section, you'll learn about some of the greatest recent involuntary covid-19 detection techniques. wang et al. [8] supported covid-19 detection using a method of deep learning called covid-net, which correctly classified normal, pneumonia, and COVID-19 classes 92.4 percent of the time. Gourisaria et al. [9] The accuracy of a machine learning-based binary classification task using several CNN configurations on a dataset of CXR, which depicts unaffected and affected pneumonia cases, was 95 percent. sethy et al. [10] used svm to categorize features in X-ray images produced by different convolutional neural network models. According to the researchers, the res-net 50 models with an SVM classifier provided 95.38 percent accuracy. A wavelet scattering model was proposed by Zaben et al. [11]. Their model was 97 percent accurate for a two-class. Narin et al. [12] used the ResNet50 model to achieve a 98 percent recognition accuracy in chest X-ray images.

3. WAVELET SCATTERING TRANSFORM

Wavelet Scattering's mathematical foundation[13] It's well-maintained, and unlike deep networks, it only uses a few parameters. The wavelet scattering transform data is currently being

processed in steps. When the production of the first step develops Feedback for the next step, as shown in Figure 1, the callous of a three-stage wavelet scattering transform is recognized. The term "zeroth-order" refers to something that isn't. Scattering coefficients are determined by averaging the data [14-15]

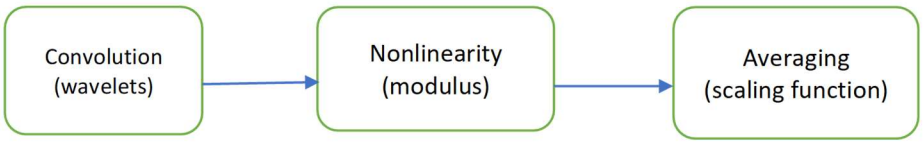

fIGURE (1): Wavelet scattering stages[13]

The wavelet scattering structure used a tree algorithm, as shown in Figur

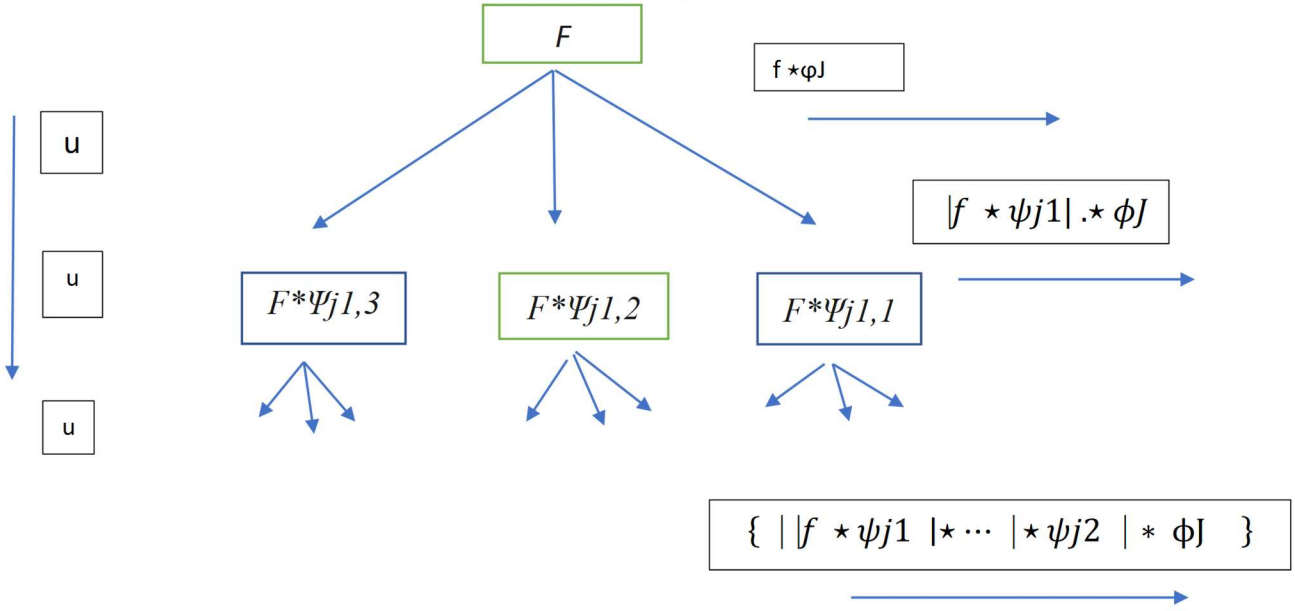

Figure (2): the tree of wavelet scattering[15]

Wavelets j, k are waves, J is the function's amount, then f is a data entry in the image data, with several rotations specified for both j, k. The sequence of edges will form a path from the root to the node[16]. The coefficients of the graph enfolded with the scale function ϕ J are the dispersion coefficients. A set of dispersion coefficients represents Low-contrast features extracted from data. They are wrapping with the scaling function results in low-pass filtering, which causes data loss. However, when measuring transactions in the next step[17], information is retrieved. To build and configure the framework, use wavelet scattering (for time sequence) or wavelet scattering (for continuous data) to extract features from the data (for image data)

This parameter controls the size of the parameter measure, the number of candidate banks, and the sum of waves per response in each candidate bank. Also, specify the number of revolutions per wavelet

in wavelet scattering [18]. To set the number of processes for each wavelet in wavelet scattering. Using the wave scattering object's functions to remove features from time series. The transform, or matrix property. To extract features from image data, use the wavelet Scattering function of the scattering Transform object or feature matrix. On-time, the transformation produces features. First, transform the data into S [0], the zero-order coefficients, using the function f J. After that, take the following steps:

1. With each wave filter in the first candidate bank, take the input data waveform.
2. There is a parameter for each of the filter's outputs. The nodes in the scalogram are U [1].
3. Regular all of the units using the filter size. The first-order coefficients, S [1,], are the results.
Replication of the procedure for each node. The scattering Transform function returns the scaling and scattering coefficients. The Feature Matrix function is a helpful tool. Dispersion features are replaced by. Learning algorithms allow for easy consumption of all outputs[19].

4. convolution Neural Network

CNN's are a type of Deep Neural Network commonly used in computer vision and visual imaging examination. CNN is a kind of artificial neural network (ANN) that analyzes image contributions and has learnable weights to headquarters used for multiple image sections and distinguish [20].

The mathematical convolution attitude is a linear operation extensively used in many fields, including image processing, statistics, and physics [21]. Convolutional is the name of this network because it employs convolutional layers, which follow the mathematical convolution principle.

The states of CNN are organized into a spatial grid structure at each layer. Each feature value is founded on a small limited spatial section in the previous layer, and these spatial relations are passed down since one layer to the next. As the convolution operation and the conversion to the next layer are both dependent on them, maintaining these spatial relations among the grid cells is critical [22].

This deep network has a classified structure when it comes to its interior data. It similarly keeps track of multi-scale hierarchical learning behavior (training). The CNN's layers are three-dimensional grid structures with height, width, and depth. The processes in CNN's layers are spatially prearranged through sparse, carefully constructed connections among layers, similar to a standard feed-forward neural network[23]. In Figure 3, the main layers of CNN are depicted. The four types of layers found primarily within CNN are as follows: taken convolution neural network steps shown in below description work architected (CNN), The following are the five types of layers found primarily within CNN:

1- **input layer**: X-Ray images are included in The image dimensions (512*512) are used as parameters.

2-Convolutional layers: During the increased operation, a set of weights is applied to the input, one on each side of the chain, and the result is nothing but linearity. It's designed for the input of two-dimensional data. This is the same as multiplying the weighting and volume data volume values of the filters.

3-Pooling Layers: a technique for downsampling feature plots by highlighting the presence of features in patches.

4- **ReLU layers:** For the individually convolutional layer, four were used.

5- Fully connected layers: Take an easy vector as input and produce an odd vector as output. In this model, there is only one inner-product layer. The most recent, with SoftMax activation, is a fully connected output layer.

Images are fed into CNNs, filtering them using convolutional operations to produce a final vector that summarizes the image's most exciting features. After that, the vector will be fed into a series of Fully Connected Layers to create the final product. Do some sorting on it. A layer of ten 3x3x3 filters only parameters and this number. It will remain constant as the input image size grows, allowing for more profound and extensive training networks**.**

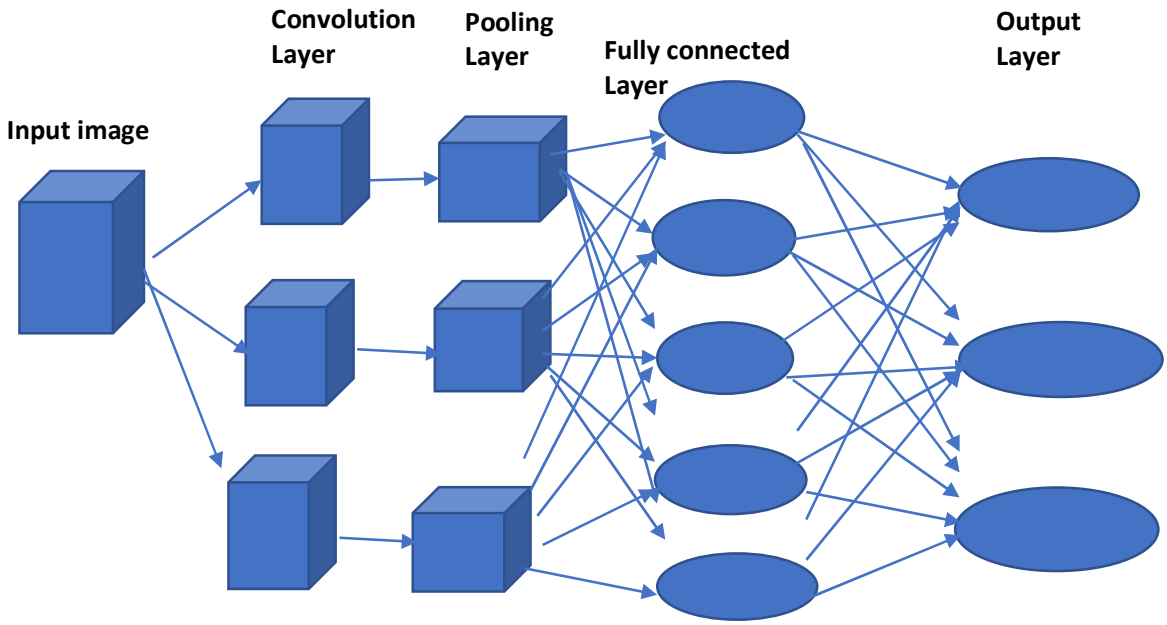

Figure 2: diagram CNN[23]

5 . Proposed system

The proposed system aims to classify chest X-ray images that are normal, pneumonia, or Covid-19, based on several stages as shown in the diagram below Figure 3

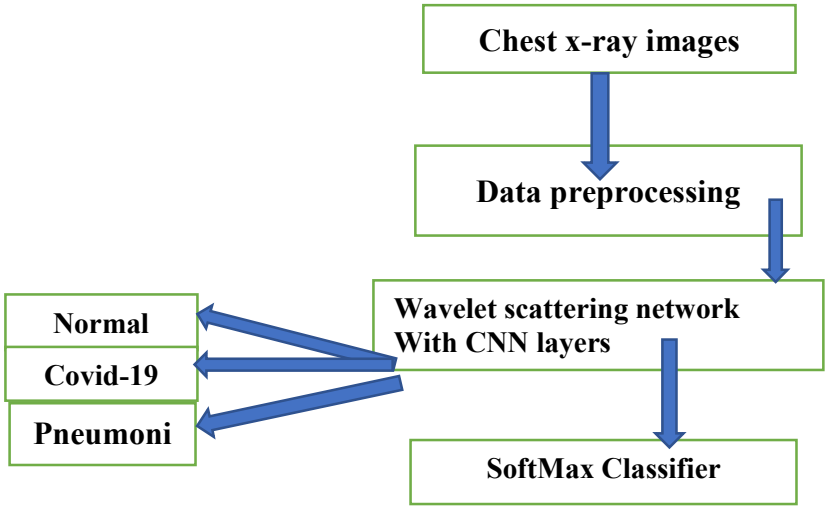

FIGURE 3. Block Diagram of the proposed system

5.1. Dataset

The database is supported in this work Has been published by cohen / Covid-19 X-Ray_ detection[24]. The Dataset 1400 images Have two type images (500 normal and 500 pneumonia, covid-19 400) and size images 512*512 and as shown in figure 4

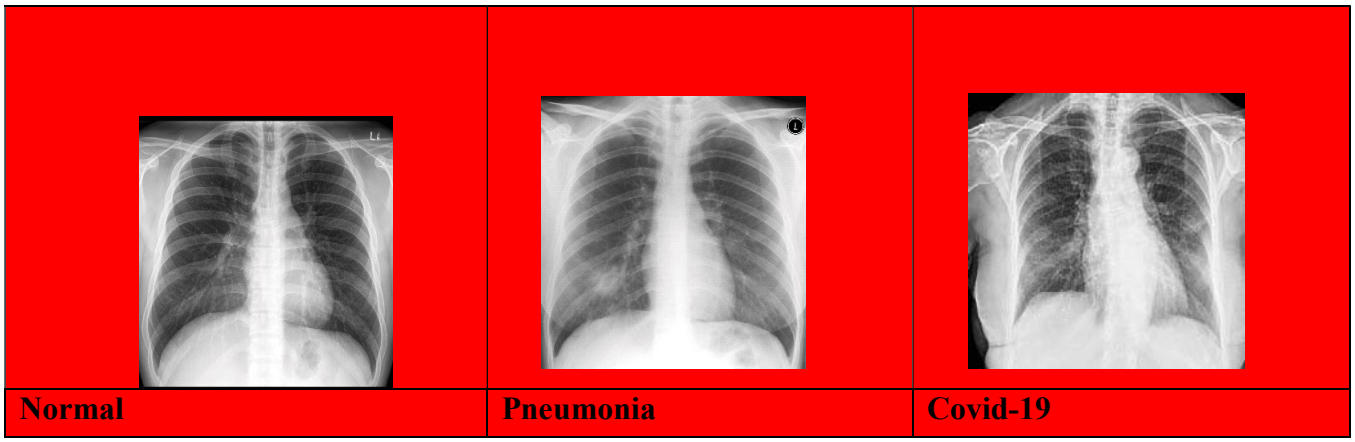

FIGURE 4: chest x-ray image

The Dataset total of 1400 images will be divided into two groups according to training and testing . as shown in the following Table (2)

Table 2. division dataset

Type	Number of images
Training	910
Testing	490

Total	1400

5.2. Data preprocessing

These two conversions and resizing processes are required to work with this Dataset. Still, they are fundamental to overall model improvement because they are involved in converting and re-and-the data. Converting the image to grayscale will expand the work from 3-band to 1-band, meaning it converts from 24-bit pixels per channel to 1 bit per channel. For enlarging, reduce step for reducing To make the images ready for the wavelet scattering network, the images will be expanded from 1024 by a factor of two and then shifted from 0 to 255 times their original resolution.

5.3. wavelet scattering Network

A used input image is 128*128*1 wavelet scattering network takes place between each set of two stages where the original images are passed on to the wavelet layer where three filters of the first level act as a group and eight nodes each, with each set of the subsequent one used as a group in a layer, and it gets them expanded to another group of filters of the second level where two features are constructed from each set of original images and each level act class to types according to normal, pneumonia and covid-19. Happen through add scatter2D. As shown in figure(3).

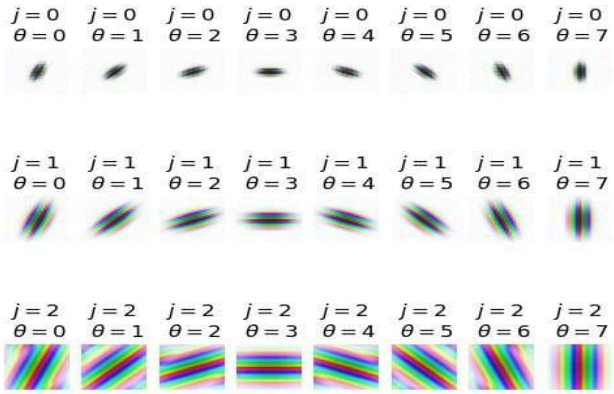

Figure3 : The Wavelet Scattering filters (L=3, N=8).

5.4 Convolution Neural Network (CNN)

Ccomprises four linked Convolutional and Max pooling layers, with a total volume of 128*128*1 for the input image and 8*8*256 for the output feature map for classification. As a fully connected layer,

it is made up of 4096 neurons. Due to the need to make the proposed CNN scheme work for three different types of COVID-19 cases (COVID- 19, Pneumonia, Normal)., the X-ray image volume must be 128x128x1. The primary two layers are 32 then 64 convolution filters, correspondingly, by identical window volumes of 3* 3, tracked by 128 and 256 convolution filters, respectively, with similar window volumes of 3*3, for the following two layers used, the 2x2 max Pooling layers that occur after respectively four convolution layers, and one fully connected concealed layer. The suggested proposer's trainable structure will distinguish the test of covid-19 cases slightly after various epochs. Figure (5) shows the proposed schema to CNN, and Table (5) shows the layers of the suggested schema.

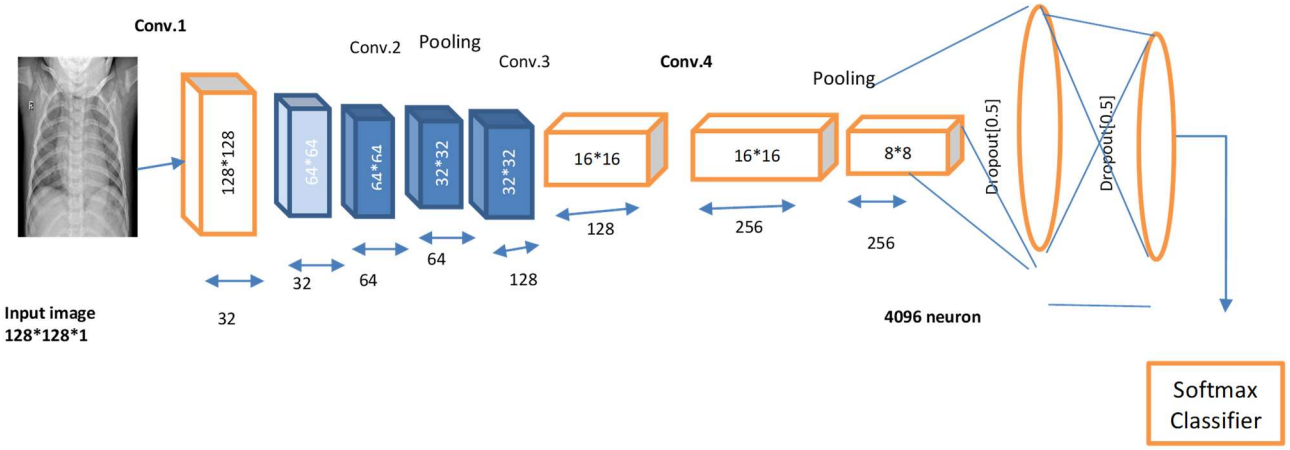

Table (5): layers of the proposed schema

Layer (type)	Output shape (No of filter, No of parameter)	Number of parameters
conv2d (Conv2D)	(None, 126, 126, 32)	896
max_pooling2d (MaxPooling2D)	(None, 63, 63, 32)	0
conv2d_1 (Conv2D)	(None, 61, 61, 64)	18496
max_pooling2d_1 (MaxPooling2)	(None, 30, 30, 64)	0
flatten (Flatten)	(None, 57600)	0
dense (Dense)	(None, 512)	29491712
dropout (Dropout)	(None, 512)	0

dense_1 (Dense)	**(None, 3)**	**1539**

5.5. SoftMax classifier

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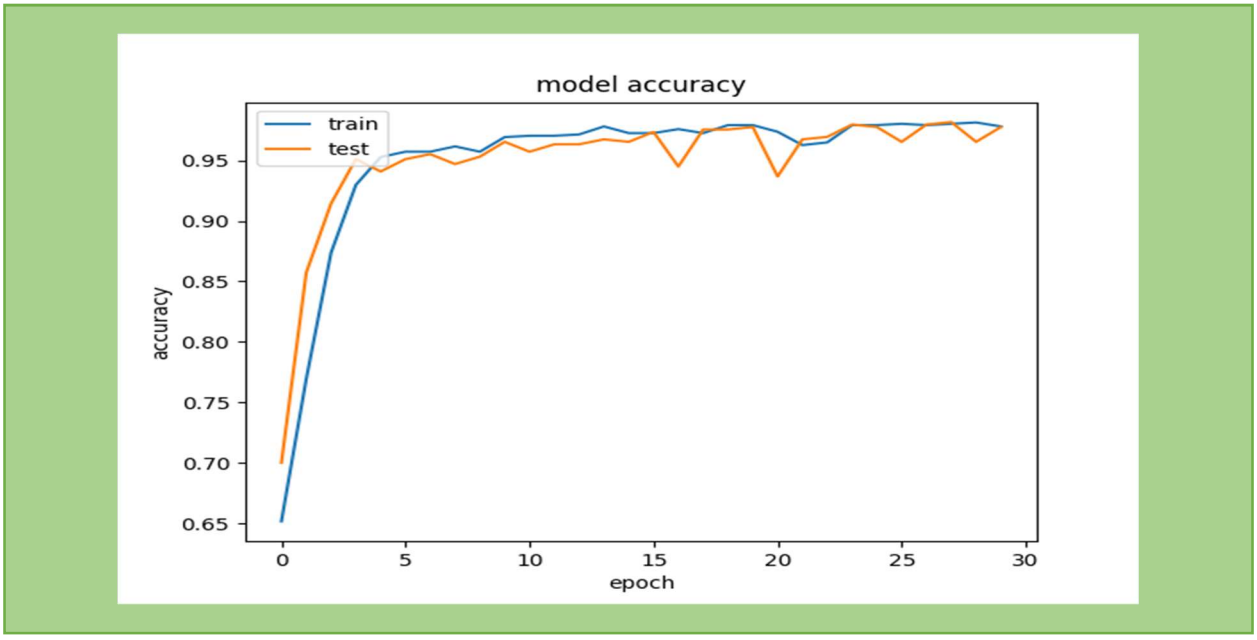
The scattering wavelet network and CNN are trained at this stage, with each class of pneumonia, either normal or covid-19, receiving priority. SoftMax is used to calculate the value-added probabilities for each class (0,1,2). is a mathematical function that converts a set of numbers into a set of probabilities, with probabilities proportional to the vector's size. SoftMax's covid-19 class will take probability. If the image contains a covid-19, we assign it a probability (2). If it isn't, it takes a probability (1), and the image's probability of pneumonia is also probability(0) if the image is normal

VI. Evaluation Results

The suggested schema should be run on a 64-bit operating system with RAMG enabled. Using Python 3.9, Keras, and TensorFlow libraries with Google Tools, we implemented 1400 images of patients under examination with chest X-ray images in the covid-19 Dataset for classifying three classes. The following set of critical metrics were used to evaluate the proposed schema.

A. Accuracy metric: As shown in Figure(5), the correct organization ratio is the proportion of correctly classified cases (0.9837%).



Figure(6).the accuracy curve

B. Loss metric: This is the inverse of the accuracy metric, and it refers to the percentage of cases classified incorrectly (0.0828 percent), as shown in figure (7).

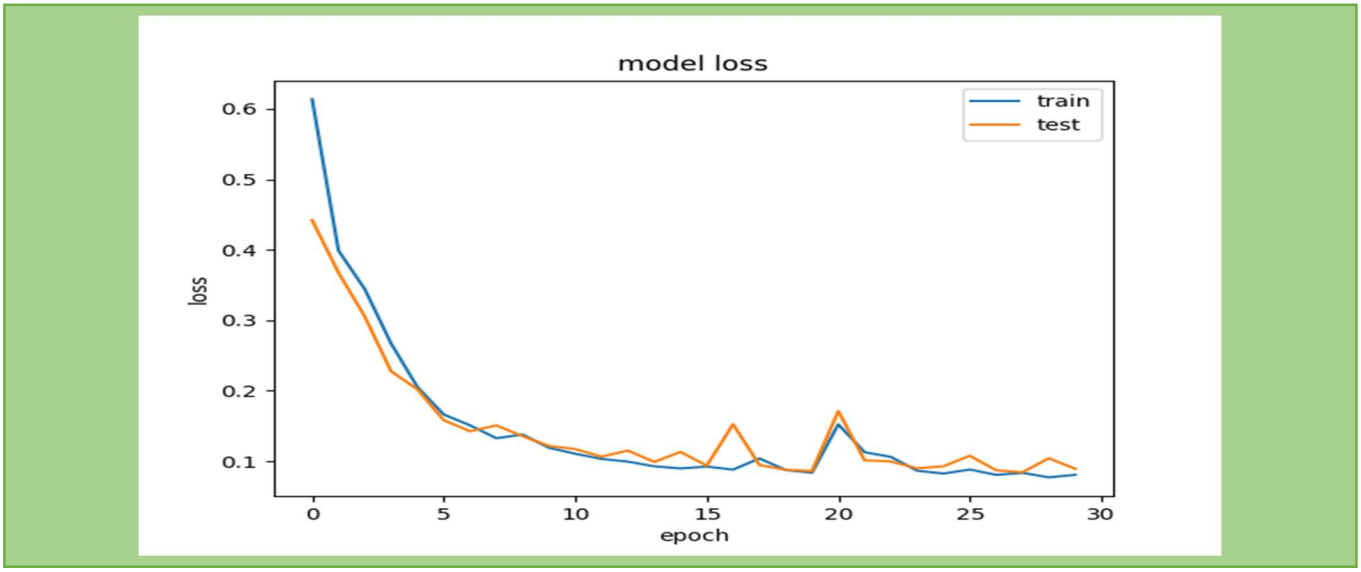


Figure 7:loss curve

Figure (7). Loss curve

C. Confusion matrix: as shown in Table, this matrix depicts how well a suggested scheme performs a set of test data from the covid-19 Dataset (3). It's worth noting that the suggested schema's acquired outputs are promising, and the results of predicting three COVID-19 Dataset classes have no issues.

Table (7): confusion matrix

True Label	**Normal**	**175**	**0**	**0**
	Pneumonia	**0**	**188**	**0**
	Covid-19	**8**	**0**	**119**
		Normal	**Pneumonia**	**Covid-19**

	Predicted label

D . metrics classification: It contains four metrics (Precision and recall, f1-score also macro metrics). shown in table (7)

Table (8). metrics classification

Name of classes	Precision	Recall	F1-score
Normal	**0.96**	**1.0**	**0.98**
Pneumonia	**1.0**	**1.0**	**1.0**
Covid-19	**1.0**	**0.94**	**0.97**
Macro average	**0.99**	**0.98**	**0.99**

Table (9) below compares the previous works referred to with the proposal regarding technology and accuracy.

Table(9): comparison with related work

No	Ref	Technical	Accuracy	Type of classification
1	8	Used Deep learning based on covid-net	92.4%	Normal Covid-19
2	9	Used convolution neural network based on a binary organization	95%	Normal Covid-19
3	10	Used support vector machine with convolution neural network	95.38%	Normal Covid-19

4	11	Used wavelet scattering network	97%	Normal Covid-19
5	12	Used deep convolution neural network based on ResNet50	98%	Normal Covid-19
6		Proposed	98.37%	Normal Pneumonia Covid-19

VII.CONCLUSIONS

The suggested structure Used for classifying chest X-ray images from the covid-19 Dataset into three classes (covid-19, pneumonia, and Normal), a wavelet scattering network and CNN are created. The applied outcomes demonstrate the suggested scheme. The wavelet scattering network and The CNN classifier have a 98.37 percent accuracy rate. The proposed Plan of wavelet scattering network and CNN using a large dataset and additional feature synthesis technique is for future work.

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