Detection of COVID-19 from Chest X-Ray Images using CNN and ANN Approach

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***Abstract*—The occurrence of coronavirus (COVID-19), which causes respiratory illnesses, is higher than in 2003. (SARS). COVID-19 and SARS are both spreading over regions and infecting living beings, with more than 73,435 deaths and more than 2000 deaths documented as of August 12, 2020. In contrast, SARS killed 774 lives in 2003, whereas COVID-19 claimed more in the shortest amount of time. However, the fundamental difference between them is that, after 17 years of SARS, a powerful new tool has developed that could be utilized to combat the virus and keep it within reasonable boundaries. One of these tools is machine learning (ML). Recently, machine learning (ML) has caused a paradigm shift in the healthcare industry, and its use in the COVID-19 outbreak could be profitable, especially in forecasting the location of the next outbreak. The use of AI in COVID-19 diagnosis and monitoring can be accelerated, reducing the time and cost of these processes. As a result, this study uses ANN and CNN techniques to detect COVID-19 from chest x-ray pictures, with 95% and 75% accuracy, respectively. Machine learning has greatly enhanced monitoring, diagnosis, monitoring, analysis, forecasting, touch tracking, and medication/vaccine production processes for the Covid-19 disease outbreak, reducing human involvement in nursing treatment.**

Keywords*—Machine learning; COVID-19; ANN; CNN; X-ray images

I. Introduction

Throughout history, there has been widespread of infectious disease among our places of residence. This has caused deterioration of every aspect of our economics and well-being as a whole. This effect has caused solutions being found through the use of machine learning as a division of artificial intelligence. Over the years there has been the existence some pandemics such as the Athenian plague [1], Ebola pandemic [2], HIV pandemic [3], Zika virus [4], black death [5], etc. Coronavirus which is a happening contactable epidemic that is all over the spheres of the world is a virus belonging to the family Coronaviridae [6].

In fighting covid-19 there has been many solutions being proffered through the use of different machine learning techniques [7]. It has also aided in various studies, including the ensemble of machine learning for the simulation of covid19 deaths [8], as well as identifying who is prone to being the next victim, diagnosing suspected individuals, developing medicine vastly, and being able to predict the next occurrence of such a remerging virus.

Some computer scientists have used machine learning to test coronavirus presence such as [9] who worked on automated detection of Coronavirus disease-2019 (COVID-19) from X-ray images and used YOLO (You only look once) machine learning technique. However, his model misdiagnosed COVID-19 patients as pneumonia and predicted incorrectly in low production of X-ray images and patients with other diseases. Research uses Convolutional Neural Network (CNN) and the deep learning approach to detect multi-class brain disease using MRI images. There was no feature extraction, collection, or classification in this process because it was fully automated [10]. A system created from machine learning techniques was also created to diagnose coronavirus [11].

Artificial intelligence (AI)-based models have effectively used current noticeable data to learn the cause of current therapies on humans, provided their unique characteristics. All this will help in detecting various diseases based on each individual's characteristics. Recent advancements in machine learning models optimized for making research through noticeable information setting can be used to learn customized treatment outcomes.

However, although these models can produce correct diagnosis and predict other ailments and infectious diseases. Furthermore, regardless of how accurate most machine learning models relating to covid19 prediction appear to be, they appear to be difficult to interpret. The difficulty in detecting Covid19 infection at an early stage is also attributed to the high similarity of its symptoms to those of pneumonia. As a result, distinguishing cases of coronavirus from pneumonia is easy, which could save a patient's life.

This research uses chest X-ray images to classify Coronavirus disease using machine learning classifiers (convolutional neural networks) implemented in Python, as well as rectified linear units (ReLU) to help overcome image non-linearity (in this case chest x-ray images). This research, on the other hand, suggests using a Convolutional neural network (CNN) and Artificial Neural Network (ANN) method to develop a model to detect coronavirus disease.

II. Reviews of Related Work

With the support of imaging and image-based classification methods, machine learning is now a highly important and flexible technique for detecting terminal diseases in recent years.

Research that used machine learning was proposed [12] to classify skin cancer at the dermatologist stage (CNNs). The use of a single CNN qualified end-to-end from photographs directly, with only pixels and disease labels as inputs, to classify skin lesions.

An epilepsy detection system based on this technique is proposed [13]. The proposed method has an accuracy of 100% for all of the tested signals when it was used to identify electroencephalogram (ECG) recordings using ECG signals into epileptic and non-epileptic.

A deep convolutional neural network was developed with long-term ECG signals to create a system for detecting arrhythmia [14]. Instead of the hand-crafted feature extraction and selection used in conventional approaches, a full end-to-end structure was developed. Their key achievement is the development of a new 2D-convolutional neural model that can recognize 17 cardiac arrhythmia disorders with a high level of accuracy.

Deep neural networks with chest visuals were used [9] to automate the prediction of coronavirus disease instances. He proposed a model called "DarkCovidNet model," and the model does not involve any handcrafted feature extraction techniques, and it was accurate and fast. However, the model misdiagnosed COVID-19 patients as pneumonia and predicted incorrectly in bad-quality X-ray images and predicting of wrong diseases not aimed at.

A study using CNN and the deep learning approach to identify multi-class brain disease using Magnetic resonance imaging (MRI) images was proposed [15]. There was no feature extraction, collection, or classification in this process because it was fully automated.

The deep learning model was created [16] using 224 verified COVID-19 images. Their model had success rates of 98.75% and 93.48% in two and three grades, respectively.

Using chest X-ray images and the ResNet50 model, [17] achieved a COVID-19 detection accuracy of 98%.

Using X-ray images, [18] categorized features obtained from various convolutional neural network (CNN) models with the aid of a support vector machine (SVM) classifier.

A deep learning approach was proposed to detect Pneumonia in chest X-ray images efficiently [10]; transfer learning is used to fine-tune the deep learning models to achieve higher training and validation accuracy; however, large datasets for chest X-rays were not usable, and the results of the deep learning models could not be clarified properly. The final prediction of the model must also be properly explained, which is one of the disadvantages of deep learning-based models.

A study used whole-slide images and deep transfer learning to detect invasive ductal carcinoma. COVID-Net, a deep model for COVID-19 detection proposed [19], correctly identified normal, non-COVID pneumonia, and COVID-19 cases with 92.4 % accuracy.

A deep learning model for detecting covid19 in CT-scan images was proposed [20]. The Python programming language was used to carry out this research. Python Deep Learning libraries such as Keras and TensorFlow 2.0 were used to develop and train the Convolution Neural Network (CNN) model. The open-access archive of COVID-19 chest computed tomography (CT) images was used as the dataset.

A model was developed for automated voice-based detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [21] that could help with COVID19 screening. However, the cough dataset was not included in any of his input datasets because the transformer was built on speech data and was intended to improve non-speech input efficiency.

A model to efficiently classify the COVID-19 infected patients and normally based on chest X-ray radiography using Machine Learning techniques was proposed [22]. The proposed system involves pre-processing, feature extraction, and classification. The results show that among the four classifiers, SVM has the highest accuracy of 96 % (K-Nearest Neighbors and Random Forest had 92% accuracy, Nave Bayes had 90 % accuracy, and Decision Tree had 82 % accuracy).

A study involving the use of machine learning detects COVID-19 infection from regular blood tests [23]. His model had a sensitivity of 92 to 95 % and an accuracy of 82 %. However, the study had two major limitations: the study had a small number of cases considered, and the accuracy of his test could be harmed by issues such as insufficient procedures for collecting, handling, transporting, and storing swabs, sample contamination, and the presence of interfering substances.

A deep learning model for improving the characterization of covid19 from chest X-ray images using CNN was developed [24], but their limitations include improving the proposed deep learning model's design and, most importantly, testing the model's robustness on some large-scale datasets. In addition, his qualified CNN-based deep learning model has been deployed to both web and Android applications for clinical use.

A study was proposed using used transfer learning and a convolutional neural network to detect covid19 from x-ray images automatically [25]. However, they were unable to differentiate mild symptoms from pneumonia symptoms, even though these symptoms may not be visible on x-rays or may not be visible at all.

For covid19 detection based on x-ray images, [26] proposed a concatenation technique in convolutional neural networks. The model, however, was not tested on a large number of datasets and was ineffective in medical diagnosis.

A study that used deep learning to classify covid19 in chest x-ray images was developed [27]. The accuracy of this study's classification was 99.5 %, but the dataset was too limited.

III. Material and Methods

A. Data Description

This study makes use of dataset retrieved from the Kaggle repository (https://www.kaggle.com/praveengovi/coronahack-chest-xraydataset).

Kaggle is an online data science platform for developers and techies, with a variety of crowdsourced datasets and frameworks. The dataset was found by searching for the

"corona chest x-ray dataset" on Google. It contains a corona chest x-ray dataset with 6 features and 5935 samples, as well as attributes such as the image name of the x-ray, a label that indicates x-ray (normal or healthy, and person affected with pneumonia), dataset type, and another label called label 2 that holds information about the person affected with pneumonia. This dataset of chest x-rays will be used to analyze my data with CNN and ANN to achieve the following performance metrics sensitivity, time, and speed.

The suggested model below focuses on using a convolutional neural network to implement a model. The dataset, which consists of chest x-ray (pneumonia cases included) images obtained from Kaggle, will be fed into a trained CNN model and also a trained ANN model to predict which of the model will give better accuracy results. The analysis will be evaluated using the following performance metrics: accuracies, precision, and recall.

B. Convolutional Neural Network

Convolutional Neural Networks, often known as ConvNet, are a type of deep learning used to assess visuals [28]. The employment of the layered arithmetic operations by the system is referred to as a CNN. Convolution is a unique sort of linear operation. CNN's concealed structures consist convolutional layers that convolve using multiplication and perhaps other dot multiplication. Backpropagation is done in this algorithm and it gives a better result in terms of accuracy. The Convolution layer employs small filters (e.g., $3 * 3\ or\ 5 * 5$), a stride of S=1, and, most significantly, padding the input volume with zeros in such a way that the convolutional layer does not alter or modify the input's spatial dimensions. That is, if F=3, using P=1 would keep the input at its original size. P=2 when $F = 5. P = (F - 1)/2$ holds the input size for a general F. It is only natural to see this on the first convolutional layer that is looking at the input image while using larger filter sizes (such as $7x7$). Convolution is a numerical method for calculating the integration of the combination of two functions while one of the indicators is flipped (also known as signals). After one of two functions g and f is passed over the other, it specifies the sum of their overlap. It is a device that combines two components into one. To begin, rotate the signal g 180 degrees horizontally, then slide the flipped g across f, multiplying and maintaining all of its values.

C. Artificial Neural Network

This deals according to the neurons present in the brain of human and these neurons are arranged in layers. It makes use of similar pattern recognition that solves the problem fed to it. This algorithm mimics the operation of a human brain.

ANNs are used to predict a variety of processes. Numerous disciplines of mathematics, engineering, medicine, economics, neurology, and many others have successfully used ANNs. They can handle noisy and incomplete data, which are typical of most renewable energy data, among their many other benefits. They can handle a vast array of data and are adaptable in handling changes in parameters. They can also correlate the hidden data in a large pile, which may significantly influence the model. Once an artificial neural network (ANN) has figured out the pattern, it can carry out complicated tasks like prediction, modeling, identification, optimization, forecasting, and control. Although this has been discussed by a number of researchers, most biomass models do not use random selection of hidden nodes, which can lead to overfitting and underfitting. The majority of biomass prediction models have been created through trial and error. An artificial neural network (ANN) is a complex network made up of interconnected neurons, which are simple processing units. Three elements—Structure, Learning Algorithm, and Activation Functions—can be used to define ANN. The input and output parameters are connected to a complex stratum of neurons in the hidden layers. A connection that is inbound has two values attached to it: an input value and a weight. The added value influences the unit's output. To learn the pattern, ANNs are trained using data sets. Once trained, they might be shown fresh patterns for prediction or classification. Whether it is a non-linear regression, classification, or optimization task, the network architecture is determined by the way in which neurons are connected to one another. The majority of modeling research up until the year 2000 were primarily based on the linear regression method, according to a summary of the studies on prediction models for the heating value of various biomass-based materials employing proximate analysis components. However, there is a nonlinear relationship between several proximate analysis biomass components and their High Heating Value, HHV. As a result, the prediction of models based on linear regression may not be accurate enough, especially when the models are tested on several data [29].

D. Development and Evaluation of Model

A variety of techniques will be used to incorporate various aspects and functionalities of the system during the implementation process. The model, which is the engine that runs the app/system, will be built/developed using the Python programming language, Kaggle, and Tensorflow software. This includes libraries such as the Keras library, Numpy, Sklearn, and Mataplotlib, among others This research will be carried out on a Windows 10 computer with a Python programming language running on an Intel Pentium Core i3 2GHz processor and 4GB RAM (64bit).

IV. Result and Discussion

The covid-19 dataset was gotten from the Kaggle repository (https://www.kaggle.com/praveengovi/coronahack-chest-xraydataset) and was implemented using goggle colaboratory, thereafter classification techniques were performed. Specifically, this chapter shows the result of the studies for the proposed model. This study implements a coronavirus disease detection from chest x-ray images using a convolutional neural network and artificial neural network. The data contains corona chest x-ray dataset with 6 features and 5910 samples, as well as attributes such as the image name of the x-ray, label that indicates x-ray (normal or healthy, and person affected with pneumonia), dataset type, and another label called label 2 that holds information about the person affected with pneumonia. The "!pip install'' keyword was used to import libraries that are not in collab by default. Different libraries were imported such as; Keras, Tensorflow, NumPy, glob, shuttle, sklearn, imutils, matplotlib, argparse.

Because of the large size dataset, the kaggle Application Programming Interface (!mkdir-p~/.kaggle/ && mv

kaggle.json ~/.kaggle/ &&chmod 600 ~/.kaggle/kaggle.json) was used in importing the dataset.

The data used was categorized into “Normal” which refers to chest x-ray images with coronavirus symptoms and “Pneumonia”. Due to the close resemblance of COVID-19 infection to Pneumonia hence a need to distinguish between them in other to have a high level of accuracy and precision as earlier discussed in the aims and objectives of this study. The COVID-19 dataset is then being passed into the ReLU activation function which is a non-linear function that solves problem of vanishing gradient associated with the use of CNN thereby giving better and faster results and known to be better than the use of sigmoid activation function. Data augmentation simply means creating prototypes of data in other to add to the quantity of the training set and to also regularize the network, classification of the images into “normal” or “COVID” is also being done.

The model is then trained with the train images and by the number of epochs which was 25 and batch size which was 32 provided. During the training, the model tries to learn and recognize patterns of a particular disease for better accuracy. During this training much is taken into consideration to avoid inaccuracy of the model as this can result in inaccurate predictions.

Fig. 1 and Fig. 2 depict the confusion matrix of the CNN trained model which is 74% respectively. For each chop, it explores the correlation among clinical specificity and sensitivity. A confusion matrix is a table that shows how well a classification model (or "classifier") performs on a number of test data for which the true data have been collected.

In this experiment coronavirus chest x-ray dataset was used to experiment with the detection of COVID-19 through chest x-ray images using CNN approach. However, it was shown that ANN outperforms CNN in terms of 95% accuracy. Table I shows the performance evaluation measures for the study.

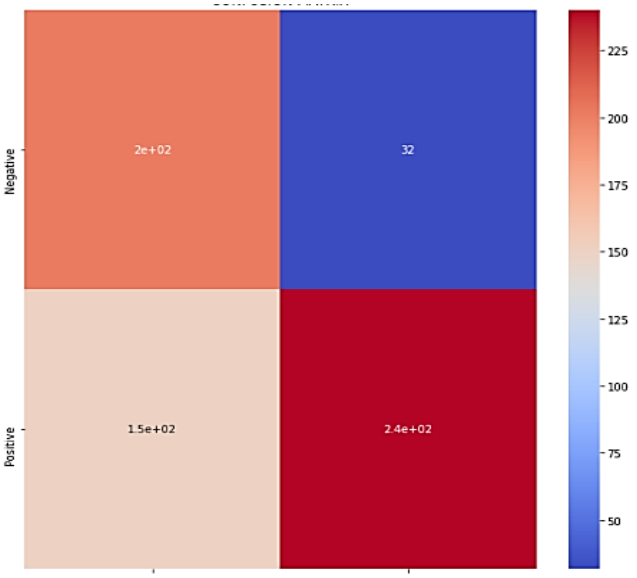

Fig. 1. Confusion Matrix for the COVID-19 Dataset using CNN (TP=32 ; TN=240 ; FP=202 ; FN=150).

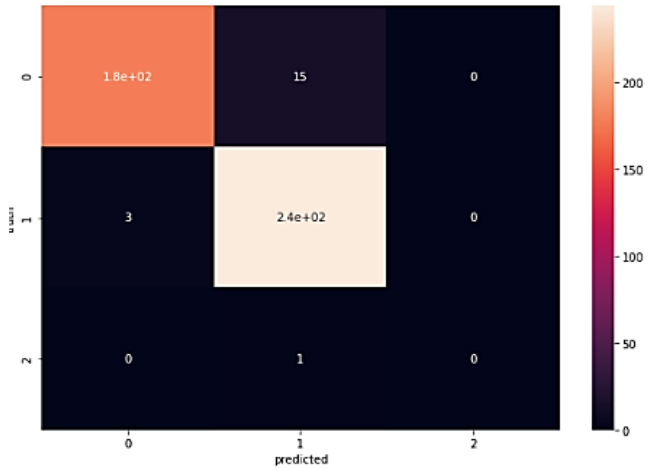

Fig. 2. Confusion Matrix of the ANN Trained Model (TP=178; TN=244; FP=16; FN=3).

TABLE I. PERFORMANCE EVALUATION OF STUDY

Performance Measures (%)	COVID-19 Data + CNN	COVID-9 Data+ ANN	Formula
Accuracy	70.83	95.69	ACC = (TP + TN) / (P + N)
Sensitivity	57.39	98.34	TPR = TP / (TP + FN)
Specificity	88.24	93.85	SPC = TN / (FP + TN)
Precision	86.32	91.75	PPV = TP / (TP + FP)
Negative Predictive Value	61.54	98.79	NPV = TN / (TN + FN)
False Positive Rate	11.76	6.15	FPR = FP / (FP + TN)
False Discovery Rate	13.68	8.25	FDR = FP / (FP + TP)
False Negative Rate	42.61	1.66	FNR = FN / (FN + TP)
F1-Score	68.94	94.93	F1 = 2TP / (2TP + FP + FN)
Matthew’s Correlation Coefficient	46.73	91.36	TP*TN-FP*FN/ Sqrt((TP+FP) * (TP+FN) * (TN+FP) * (TN+FN))

The significance of this study for medical professionals and researchers is critical. The identification of coronavirus with the help of this study will enable human radiologists to make more informed decisions about coronavirus prevention and treatment. Furthermore, since this research focuses on having a higher degree of accuracy, it will support both patients and medical professionals, as well as researchers working on further research and prediction for coronavirus care. It is life-saving for both patients and physicians, and it is much more important in countries where laboratory kits for testing are unavailable. Since there is no need for touch until diagnosing COVID-19, the protection of both uninfected individuals and medical practitioners is guaranteed. Table II compares this study with the state-of-the-art.

TABLE II. COMPARATIVE EVALUATION

Authors	Algorithm/Method	Results
Nusra Rouf et al, 2020	Logistic regression and Multinomial Naive Bayes	80% Accuracy
Wang and Wong, 2020	CovidNet from CXR images	93.3% Accuracy
Shuai Wang, 2020	Modified transfer learning technique	89.5% Accuracy
Ioannis,2020	Transfer learning and CNN	96.78% Accuracy
Chuansheng Zheng, 2020	Weak label	90% Accuracy

V. CONCLUSION

The ability to recognize COVID-19 from chest X-ray pictures is critical for both physicians and patients in order to cut testing expense. Artificial intelligence. and deep learning can recognize pictures for the tasks that have been learned. Numerous tests were carried out in this paper to identify COVID-19 in chest X-ray pictures with extreme accuracy using a CNN. The classification was divided into three categories: COVID-19/Normal, COVID-19/Pneumonia, and COVID-19/Pneumonia/Normal. In this research, both CNN and ANN were employed to detect COVID-19, and the artificial neural network's accuracy was determined to be 95% greater than the convolutional neural network. To combat the challenges of vanishing gradient regarding the usage of CNN, the COVID-19 sample was fed into the rectified linear unit. Furthermore, the next system design, ANN, which has the highest accuracy, can detect COVID-19 in two classes, COVID-19/Pneumonia/Normal pictures, with a 95% accuracy. As a result, clinicians may find that using Artificial intelligence operating systems solutions can help them diagnose COVID-19. Ongoing research based on the result of this research would further to our understanding of the use of CNN architectures with COVID-19 chest X-ray images and improve the study's findings. People may also consider employing real-world data and wider samples in the long term, as well as developing new algorithms such as enhancing DCNN and RNN. A wider sample should be examined, as should the usage of other machine learning algorithms, with the goal of improving accuracy in the long term. Activation maps can be used in conjunction with the intended machine learning technique to make the findings and framework more readable.

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