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Covid-19 Disease Detection using Chest X-Ray Images by Means of CNN

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***Abstract*— Covid is a respiratory disease that ultimately results in death. It is of the utmost importance to determine whether or not a person has covid. Since it first appeared in December 2019, the COVID-19 pandemic has been a problem all across the world. For individuals who may have COVID-19, getting a timely and accurate diagnosis is absolutely necessary in order to receive medical treatment. In order to put a stop to the COVID-19 epidemic, chest X-rays will need to be capable of making an independent diagnosis of the virus using Machine Learning. This study provides evidence that the use of ensemble deep transfer learning for the early diagnosis of COVID-19 patients is both effective and efficient. If you follow these instructions, you will be able to report suspected COVID-19 activity and receive responses as they become available. With the help of medical sensors and the deep ensemble model of a cloud server, chest X-ray modalities can identify the presence of an infection. The authors of this study educated a Convolutional Neural Network system to reliably predict Covid-19 by using chest X-ray images as their training data. The researchers were the ones who developed the CNN algorithm. During the model's creation and training, they encountered difficulties, which they addressed and developed solutions for.**

Keywords: Covid -19, X-Ray Chest Images, CNN – Deep Learning.

I. INTRODUCTION

In China, on December 31, 2019, a novel coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was found. The first cases of pneumonia were discovered in Wuhan, which is located in the Hubei Province [1]. As a result of the rapid global spread that COVID-19 experienced in less than a month, the World Health Organization (WHO) has declared a global public health emergency. The World Health Organization (WHO) confirmed on March 11, 2020 that COVID-19 is currently a worldwide epidemic. As of the 18th of August in the year 2020, around 21 million people were infected with the virus, and more than 750,000 people had died as a direct result of the infection [2]. There is a wealth of information available elsewhere that delves further into the ways in which the global spread of COVID-19 will impact societal, economic, and medical concerns [3].

Before the 21st century, members of the coronavirus family didn't typically contribute to any significant health issues in humans. Nevertheless, outbreaks that have occurred over the course of the previous two decades have brought to light the expanding role that coronaviruses play as worldwide killers. Even while SARS and MERS were less common than COVID-19, it is likely that they were responsible for more fatalities. As a result of recent happenings, it is possible that new diseases could emerge, each of which would have significant repercussions for people's health and for society as a whole [5]. Healthcare practitioners (also known as HCPs) face a number of obstacles when it comes to the management of new viral illnesses, some of which include the need for a prompt diagnosis, prevention, and therapy. We made the decision to focus this study on diagnostic concerns because it took us such a long time to establish diagnostic techniques that were both speedy and reliable for COVID-19. It has previously been established that employing AI in histopathology for the detection of cancer has a number of advantages. In 1956, artificial intelligence was first brought up in a public forum. Artificial intelligence (AI) is a subfield of computer science that focuses on ways to educate machines to learn from their experiences. [6][18] Machine learning is one of the subfields that fall under the umbrella of artificial intelligence (ML). When calculating example datasets for machine learning, mathematical models are put to use. [7] Deep learning is an approach to modern machine learning that makes use of neural network methods. Because of their rapid development, algorithms have reached a point where they are able to recognize patterns and do complex computing tasks more rapidly and accurately than humans

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can. [9–13] The domains of pathology, radiology, dermatology, ophthalmology, and cardiology are already making use of diagnostics and prognoses that are generated by machine learning algorithms. It is anticipated that artificial intelligence will bring about significant change to the future of health care [14].

In the scope of artificial intelligence (AI), the author of this paper investigates the hypothesis that COVID-19 pneumonia can only be detected through the use of chest x-rays (CXR). Microsoft Custom Vision[19], which can be found online at www.customvision.ai, is a platform for machine learning (ML) that can be used right now and is completely automated in order to achieve this goal. It is possible that the use of AI to health screening and the detection of new disorders such as COVID-19 may fundamentally alter our present understanding of medical treatment. We also address the possible value of using a website that is open to the public (interknowlogy-covid-19.azurewebsites.net) as an aid in making a diagnosis of COVID-19 pneumonia using chest radiographs.

Mathematical models for the COVID-19 pandemic, which have been validated by data from China, Italy, and other places, imply that the number of critically ill patients is increasing at a rate that is exceeding the overall capacity of intensive care units (ICUs). This is the case even after accounting for routine critical admissions for things like trauma, stroke, and other emergencies[19].

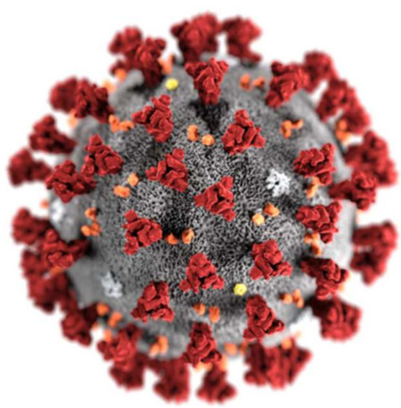

Figure 1. a. Covid-19 Source: Statnews

It is absolutely necessary to have easily available resources for data collecting and artificial intelligence (AI) algorithms in order to speed the process of locating remedies that are both effective and safe for the COVID-19 pandemic[20]. The gradual incorporation of radiomics methods and AI-based solutions into the healthcare ecosystem is causing long-held beliefs across the whole ecosystem to gradually shift. This has become feasible as a result of the gradual but ongoing digitalization of patients' medical records. The first examples of innovation in the health care industry include, in particular, the diagnostic and decision support systems that were developed for medical imaging. With the use of diagnostic apps that have been made feasible by developments in artificial intelligence, it is now able to perform rapid image collection, preprocessing, annotation, and interpretation. In point of fact, rather than serving as a replacement for radiologists' job, this serves more as a "addition" to that work. In particular, the application of artificial intelligence (AI) in medical imaging has made it easier to evaluate and diagnose neurological problems, cancers of the breast and lung, and cardiovascular illnesses.

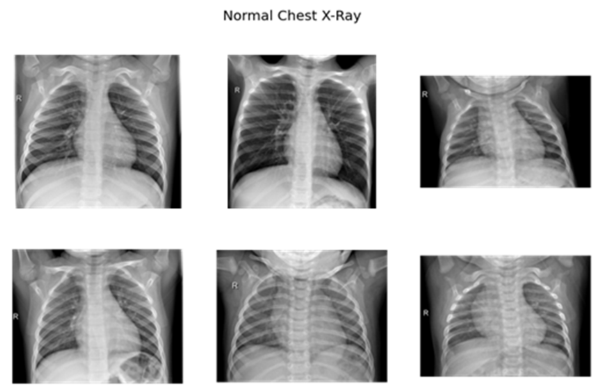

Figure 2. a. Covid-19 Source: Statnews

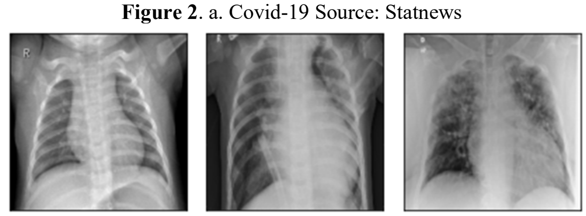

Figure 2. b. Covid-19 Source: Statnews

Figure 2.a. and 2.b. Shows that the scanned X-Ray images of Covid -19 Chest, with the help of this radiologist can more quickly detect infected patients with the assistance of the deep ensemble model.

This paper will be organized as follows, in accordance with the outline: Section 2 discusses literature survey of this research, followed by Section 3 on methodology in general. In Section 4, authors discuss the outcomes of the tests we did to evaluate the system's performance in relation to several alternative methods in 5th and 6th chapter.

II. LITERATURE WORK

The goal of artificial intelligence (AI) approaches such as deep learning (DL) and machine learning (ML) is to develop software that, when exposed to data, can teach itself new things and improve its performance on its own. Machine learning (ML), often known as the study of how computers learn and improve on their own through experimentation and the application of previously acquired knowledge, primarily focuses on the process of automatically upgrading software. ML is a subfield of artificial intelligence. Studying specific examples of data allows machine learning algorithms to acquire the skills necessary to predict future events or form opinions without being specifically trained to do so (known as "training data"). Algorithms that are based on machine learning are utilized in a wide variety of contexts, including some in which it is challenging or perhaps impossible to develop traditional algorithms that are capable of completing the task (such as in medicine, email filtering, speech recognition, or computer vision). The subjects of machine learning and computational statistics, both of which depend on the use of computers to derive conclusions, are not interchangeable, despite the fact that many machine learning approaches are comparable to those employed in computational statistics. The study of mathematical optimization can provide the field of machine learning with useful tools, such as new techniques, new theories, and new fields of application, which are all examples of these types of contributions. Data mining is an allied field of study that places a greater emphasis on self-directed data analysis as opposed to analysis carried out under the direction of an instructor.

Deep learning is a paradigm in the field of machine learning that refers to a set of approaches that extract semantic meaning from raw data via the use of multiple layers of processing. Image processing may have several layers, with the lower levels being able to recognize edges and the higher layers being able to detect human-relevant information such as numbers, characters, and faces. Deep learning architectures such as deep neural networks, deep belief networks, deep reinforcement learning, recurrent neural networks, and convolutional neural networks have been used to achieve results that are on par with or even exceed those of human experts in a variety of fields, including computer vision, speech recognition, natural language processing, machine translation, bioinformatics, drug design, medical image analysis, material inspection, and board game programming, to name a few. These are just some of the areas where these types of architectures have been applied.

Applications of DL and ML that are both useful and successful can be found in a wide variety of fields, including the fields of medical informatics and healthcare. A significant portion of research is being put into understanding and combating COVID-19 utilizing DL and ML. Techniques of deep learning and machine learning that can be used to COVID-19 have been the subject of a significant amount of research and development effort.

On the subject of AI's contribution in COVID-19 investigations, a number of articles that synthesize previous research have been published. Agbehadji et al. [16] presented a succinct explanation of how big data and AI models can be used to identify possible contacts and detect occurrences of COVID-19. Several writers, including Bullock et al. [17], investigated the existing and potential applications of AI in the fight against COVID-19 on a range of stages. These scales included the molecular, medical, and epidemiological levels of analysis. The research conducted by Wu et al. [18] looked into the application of big data in China with the goals of preventing and treating COVID-19. They looked at the most recent ML algorithms in this field and focused on their potential in two primary applications: diagnosing COVID-19 and forecasting mortality risk and severity using simple clinical and laboratory data. Both of these applications are important. They conduct an analysis of the fundamental qualities that were determined to be essential for a variety of applications.

Previous research that made use of imaging data from COVID-19 patients focused mostly on diagnosis rather than prognosis. With the use of prognostic models, one is able to make forecasts regarding mortality, morbidity, and other effects related with the progression of a disease. These models have a wide range of potential applications in the real world, ranging from the identification and classification of sick patients in a consistent manner to the alerting of bed management teams to anticipated demand to the provision of teams caring for individual patients with a clearer picture of the situation and the allocation of resources. In the past, the majority of the diagnostic work for COVID-19 patients was carried out with the use of machine learning. These methods, for the most part, depended on clinical variables2,19 that were gathered on a routine basis, such as vital signs and laboratory tests. These variables have been known for a very long time to be reliable indicators of deterioration20,21. The severity of lung involvement and the rate of advancement can be determined by chest X-rays using grading algorithms that have been created as a result of some research. Deep learning or, more typically, human clinical evaluation are the two methods that are implemented in these systems. There is still a degree of debate regarding whether or not deep learning has a meaningful impact on the prognosis of COVID-19 patients when chest X-ray imaging is utilized. It is also new territory to incorporate both visual data and scientific considerations into a single AI system. We show that each of them has knowledge that is supplementary to the other, which opens the door to a new way of thinking about how to construct AI systems that can predict the path that COVID-19 will take in the future.

III. PROPOSED METHODOLOGY

Figure 3 depicts the architecture of proposed CNN algorithm. This architecture has been put together one layer at a time. The entirety of the system may be broken down into four distinct layers: the application layer, the network layer, the data storage and processing layer, and the perception layer. It is essential to take into account the fact that every one of these levels is in charge of a different function. At the perception layer, medical IoT devices will collect scans, including X-ray, CT, and ultrasound photographs. This use is exactly what the equipment was designed for. After the scans have been finished, the data will be transferred to the data storage layer through the network layer, which is responsible for the transmission of data. It is possible to send the obtained scans via the network layer using the telephone, the Internet, or one of the many other available methods.

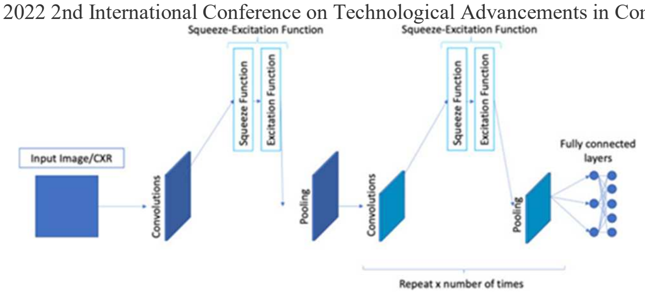

Figure 3. Proposed CNN Architecture Model

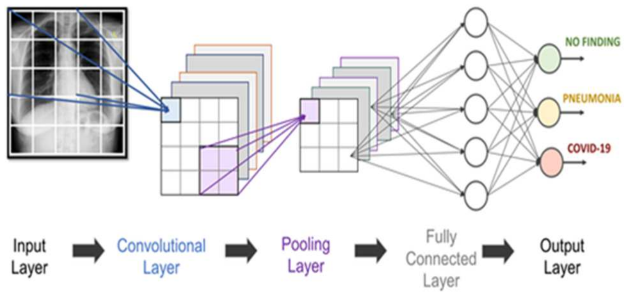

Figure 4. Proposed AI based Deep Learning Model

To identify whether or not a person is infected, this layer of the CNN infrastructure makes use of deep learning models. After then, a record of the findings is created. The findings of the diagnosis can subsequently be used by users on the application layer, such as medical professionals, to initiate additional care for patients. The diagnostic ensemble model for COVID-19 can be seen in the image that can be found below (Figure 3). Because of their high levels of accuracy and variety on the dataset that was freely available, CNN uses Figure 3 depicts the proposed ensemble model that will be used to understand what is going on with COVID-19. This model employs a multi-layered transfer learning model with 64 neurons in the first dense layer and a carefully tuned procedure for feature extraction that is referred to as the ensemble technique. The goal of this procedure is to extract the best features, which will result in an improvement in classification accuracy.

Researchers have demonstrated that employing a collection of models that have already been pre-trained produces superior results to employing a single model. It is possible to employ the ensemble technique to extract the best features in order to increase the accuracy of classification. The proposed ensemble model for diagnosing COVID-19 may be found depicted in Figure 3. In the first dense layer, there are a total of 64 neurons. In order to extract the characteristics, a multi-layered transfer learning model that has been carefully tweaked is used. The SoftMax activation function is utilized in order to provide a successful resolution to the challenge of four-class categorization. It was discovered that the models were developed with epoch 100 and batch size 10 in mind. In order to prevent overfitting during the first phase of the tuning of the characteristics, fully linked layers consisting of 64 neurons and dropouts of 0.3 and 0.2 are utilized. Regularization can also be accomplished by the use of the idea of early halting.

A. Outline of Dataset

The training dataset contains 15264 images with a resolution of 512 by 512 pixels, each of which has been labelled by a radiologist with significant prior experience. The validation set contains 400 photographs that are very similar to one another.

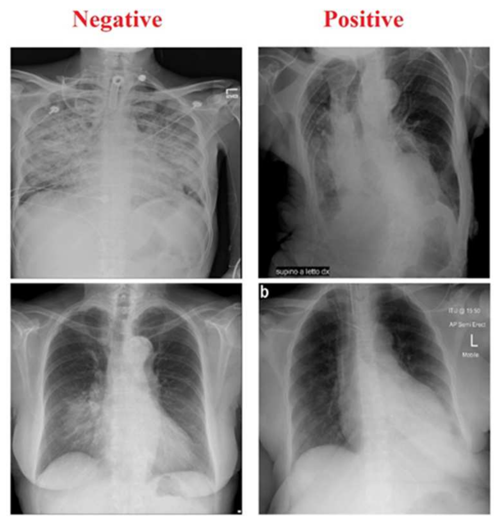

Figure 5.Shows Positive and Negative Chest X-Ray image.

The fact that over 90 percent of the photographs in the training set do not originate from the Covid class is a significant problem. An issue that arises when working with sets that differ greatly from one another is that even the most fundamental learning method, which merely outputs the category of the category that is most prevalent, will be extremely accurate. To put it another way, it will assert that no one has Covid and attain an "accuracy" of 90%, despite the fact that approximately 10% of the total population actually does have it. The authors began with this lopsided training dataset as their point of departure. In observation, the training dataset was not the best possible choice; but one must make do with the resources at their disposal.

B. Image Enhancement (White Balance and CLAHE)

The authors of this study pre-processed the images by adjusting the White Balance and the CLAHE methods in order to locate COVID-19 cases.

1) White Balance: White balance is a processing step that is used in digital photography to ensure that a picture is rendered with the appropriate tonal values. In some areas of the medical image, there was a lack of brightness because the lighting was inadequate, and the imaging equipment that was used to take the image did not have the same level of sensitivity to light that human’s do.

Therefore, editing or correcting an image can be an aid in ensuring that the colours of the final image are accurate representations of the colours that were originally there in the image. This procedure's objective is to improve the image's visibility so that Deep CNNs can more effectively analyse it. The white balance algorithm adjusts the colours of the image's active layers by individually stretching each of the red, green, and blue channels.

In order to accomplish this, the spectrum of colours is broadened, and the final few colours in each of the three channels are removed from consideration because only roughly 0.05% of the image's pixels make use of them.

Because of this, pixels with colours that appear less often near the finish of the channel will no longer have a negative impact on the values of the upper and lower bounds while stretching. In this article, we will demonstrate how to write the code for a white-balance method in Python using the NumPy and OpenCV libraries.

$$M_i = P_{0.05}(C)$$
$$M_a = P_{100-0.02}(C)$$
$$C_{upd} = Clip\left(\frac{(C - M_i) * 255}{M_a - M_i}, 0{,}255\right) \quad (1)$$

The algorithm that determines white balance is made up of a few different parts. The saturation operation known as Clip (min, max) is performed between the channel's minimum and maximum levels, and Pi(C) is the channel's ith percentile. The pixel values of the original channel and the modified channel are each represented by a separate letter, C and Cupd, respectively.

2) CLAHE (Contrast Limited Adaptive Histogram Equalization): It's a great technique for giving an image more contrast and making enhancement. The CLAHE is an improved version of the adaptive histogram equation (AHE).

Histogram equalization is an easy method that may be used to improve the contrast of an image by either expanding the intensity range of the image or increasing the value of its most common intensity. When the intensity values are stretched, the image's natural brightness is changed, and undesirable noise is introduced as a result.

Before the histograms of the incoming image are formed using AHE, it is first cut up into smaller pieces (also known as "tiles"). After that, the histograms that were produced are put to use in order to deduce the function of intensity remapping for each tile. The murky appearance is a direct result of the excessive amplification that had place. The primary difference between CLAHE and AHE is that the former clips the histogram at predetermined values before calculating the cumulative distributive function, whilst the latter does not.

In the portion of the histogram that contains an excessive number of points, a greater amount of shuffling is performed than in other parts of the histogram. An earlier study discovered that CLAHE greatly improved chest CT scans; this finding suggests that it might be beneficial for analyzing other kinds of medical images as well. To determine your CLAHE score, follow these steps:

$$p = (P_{max} - P_{min}) * P(f) + p_{min} \quad (2)$$

Where, p represents pixel value after applying CLAHE, pmax, pmin represents maximum and minimum pixel value of an image respectively and P(f) represents cumulative probability distribution function.

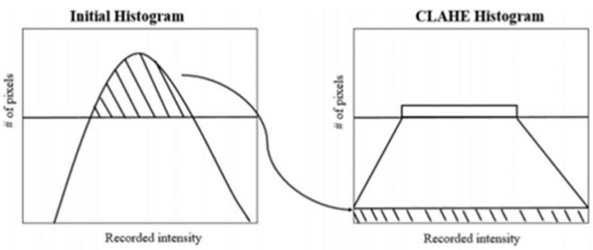

Figure 6. Histogram of CNN

3) Confusion Matrix: The confusion matrix is shown below of the proposed CNN based Covid -19 prediction.

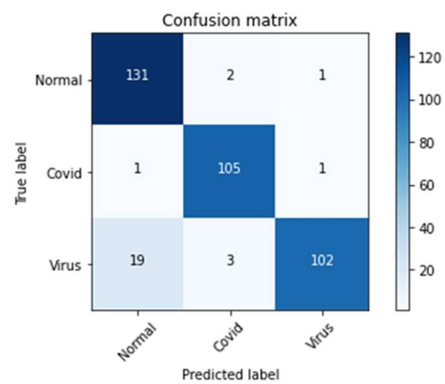

Figure 7. Confusion Matrix of CNN

IV. RESULT AND DISCUSSIONS

In total, the trained model was able to remember 92.9% of what it was shown. Recall and precision were 99.1% and 94.8%, respectively, for COVID-19 using Chest X-Ray. These values were 91.8% and 89%, respectively, for non-COPD pneumonia, and 88.9% and 95.1%, respectively, for normal chest X-Rays. (Figure 2).

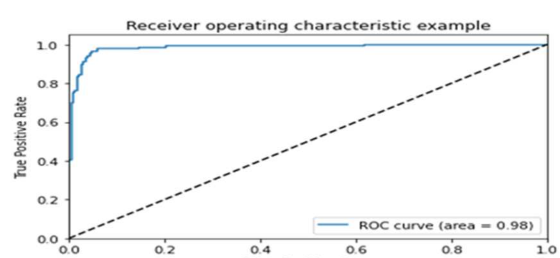

Figure 8. ROC True Positive of CNN

Then, in order to determine whether the training model performed adequately on the VA data, we produced predictions for each of the 30 images that were included in the dataset. Our model was successful, generating an NPV of 100%, NPV-91%, NPV-97%, NPV-91%, NPV-91%, NPV-91%, and NPV-100%, respectively.

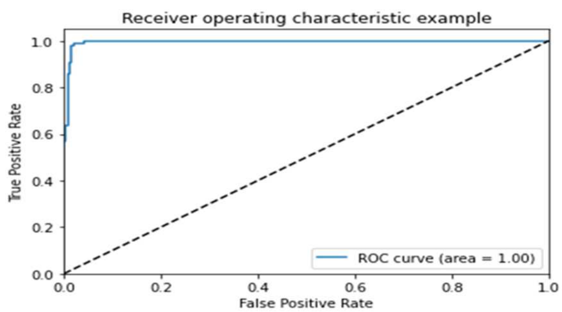

Figure 9. False Positive of CNN

The results of the training and validation processes for the proposed model is summarized in table that can be found below. The findings indicate that the model that is proposed is more resistant to problems caused by overfitting, and it also generates results of a higher quality in terms of training and validation.

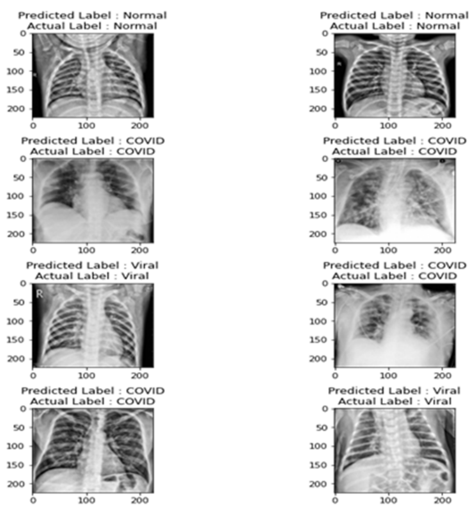

Figure 10. Proposed Output of CNN – Actual and Predicted

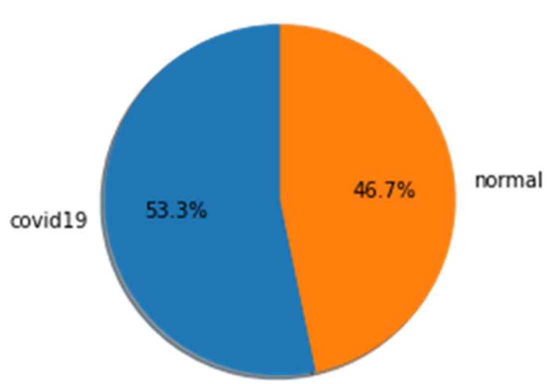

Figure 11. Proposed and Detected Covid -19 and Normal Chest X-Ray of CNN

The COVID-19 group has been rated as accurate 99.6% of the time overall. The CNN model that was proposed has a success rate of 99.2 percent when it comes to correctly classifying normal patients. When it comes to correctly detecting pneumonia subtypes, the deep ensemble model that was proposed has attained an overall accuracy of 99.4 percent. The detection of tuberculosis E is accurate in almost all situations (99 percent). Because it has an accuracy rate of 99.3 percent across the board, the model that was provided is a great option for the purposes of broad classification. Because of this, the problem of overfitting has very little of an impact on the model that has been proposed. The findings of the study show that this framework performs better than other deep learning models that are in competition. The new method offers significant gains in precision, accuracy, measure, sensitivity, and specificity in contrast to the prior methods.

TABLE I. PERFORMANCE ANALYSIS OF PERFORMANCE EVALUATION FOR COVID-19 DIAGNOSTIC USING PROPOSED CNN METHOD.

Model	Accuracy	Sensitivity	Specificity	F-score
Proposed Model - CNN	99.4	97.2	98.7	98.8

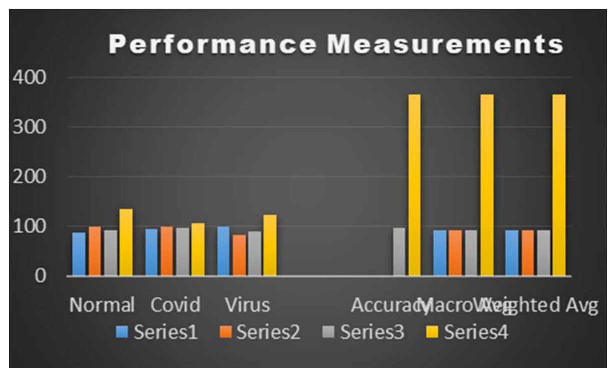

Figure 12. Comparative analysis of performance evaluation for COVID-19 diagnostic identification using proposed AI-Deep learning model.

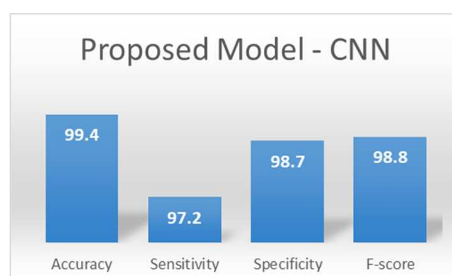

Figure 13. Comparative analysis of performance evaluation for COVID-19 diagnostic identification using proposed AI-Deep learning model.

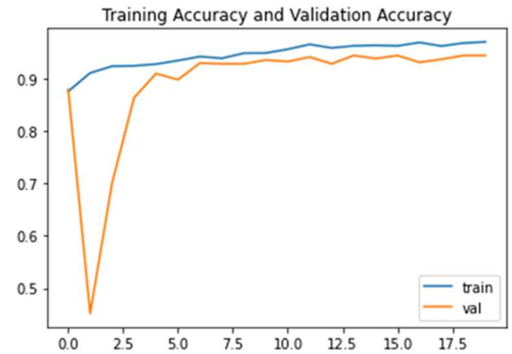

Figure 13. Training Accuracy.

This section discusses the performance evaluation of implementation of proposed work and the corresponding parameters are being checked.

V. CONCLUSION

Researchers demonstrated that AI may be able to assist in the accurate diagnosis of COVID-19 using Chest X-ray images by using CNN platform that is accessible for commercial purchase. We have focused our attention on this technology's ability to solve developing health issues such as COVID-19, despite the fact that there is a vast array of uses for it in the field of radiology. The findings can be utilized in a variety of contexts, including illness monitoring, early identification, patient selection, and risk stratification. In light of the findings, a CNN algorithm was proposed and the results are validated of about 99.4%. In future to assist the battle against organizations such as COVID-19 our findings provide a look into the potential applications of AI in the medical field ensemble deep learning, an Internet of Things (IoT)-based automated coronavirus detection system will be built.

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