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Early Detection of Covid-19 in Chest X-ray Images using Deep Learning

[1*]Mahaveer Jain, [2]Sandeep Mathariya, [3]Anil Patidar, [4]Sujin S. Pillai, [5]Ronit Verma, [6]Gourav Mujmer

[1,2,3,4,5,6]Department of Computer Science and Engineering, Medi-Caps University, Indore MP, India.

[1]profmahavir@gmail.com, [2]*mathariya@gmail.com*,[3]*anilpatidar07@gmail.com*, [4]*mujmergourav@gmail.com*, [5]*sujinspillai1@gmail.com*,[6]*ronitv472@gmail.com*

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***Abstract*—**The global COVID-19 pandemic has created a global health crisis, and accurate and effective diagnosis of the disease is crucial to control its spread. In-depth studies have shown good results in detecting COVID-19 using X-ray images. In this study, we introduce the detection of COVID-19 using a deep learning algorithm applied to X-ray images. The proposed model uses neural networks (CNN) to achieve classification of X-ray images as COVID19, non-COVID, or normal. CNN was used to diagnose Covid-19. The data used for the study included x-ray images of Covid-19 patients, as well as x-ray images of patients with other respiratory diseases and healthy people. The findings reveal the potential of deep learning CNN algorithms to detect COVID-19 using X-ray images, helping to quickly diagnose and treat patients with COVID19. The proposed model is available for user as a simple web application that was developed using the Django framework and demonstrates the use of chest x-ray to diagnose COVID-19.

Keywords*— *COVID-19, Chest X-ray, Convolutional Neural Network (CNN)

I. INTRODUCTION

Given the limited availability of adequate equipment in hospitals, it is crucial to have a quick and efficient diagnosis method to prevent the spread of COVID-19, improve medical therapy effectiveness, and enhance chances of survival without intensive care. Currently, the primary screening tool for COVID-19 is the polymerase chain reaction and reverse transcriptase (RT-PCR) method, which detects the presence of SARS CoV-2 ribonucleic acid (RNA) in respiratory tract samples [1]. However, many countries face challenges in providing sufficient testing capacity, leading to delays in obtaining accurate results, with testing primarily reserved for individuals with obvious symptoms. To address these limitations, there is a need for faster and more reliable screening methods, such as imaging-based approaches, that can complement or replace PCR testing. These screening techniques can be used alongside PCR testing to enhance diagnostic certainty or serve as an alternative in areas where PCR testing is not easily accessible. In response to the outbreak, researchers have expedited the development of COVID-19 detection models utilizing artificial intelligence to assist clinicians [2]. These models aim to accurately detect COVID-19 in patients and deliver test results in the shortest possible time. Deep learning workflows have significantly advanced in recent years, starting with the introduction of the AlexNet convolutional neural network in 2012[3]. Convolutional neural networks (CNNs) offer distinct advantages in image processing as they can extract features independently, eliminating the need for feature descriptors or specific extraction methods. Unlike traditional machine learning techniques, CNNs require minimal image pre-processing and can automatically learn optimal data representations directly from raw images. This characteristic makes CNNs a more unbiased and objective approach. CNNs have demonstrated remarkable performance across various domains, including medical analysis using images from MRI, microscopy, CT scans, ultrasound, X-rays, and mammography [4-10]. CNNs have been effectively applied to solve segmentation and classification problems, as well as image synthesis tasks [11-14]. Notably, significant progress has been made in lung analysis using deep learning architectures in studies [15-16]. These studies share similarities with COVID-19 research, as both involve extracting crucial information from lung images, with a specific interest in detecting trace ground glass opacity indicative of COVID-19[17]. However, classifying CT lung imaging between COVID-19 and non-COVID-19 patients can pose substantial challenges, particularly when pneumonia-related lung damage from various causes coexists. The challenges brought about by COVID-19, as mentioned earlier, and the urgent need for fast and accurate testing methods have sparked increased research on deep learning. The success of deep learning in various fields, as demonstrated by previous studies [18-19], has motivated us to delve deep into deep learning and seek a solution that can aid clinicians in the battle against COVID-19. Specifically, we propose a comprehensive investigation into the classification of COVID-19 from chest CT images, which fall into three classes: COVID-19-infected patients, pneumonia-acquired patients, and normal patients without any lung disease. The goal of this study is to develop a precise classification model that can detect COVID-19 from CT images, a widely explored medical imaging technique that allows for non-invasive visualization of the object's interior [20].

II. LITERATURE REVIEW

COVID-19 detection using CNN has been a topic of research in several papers. Various models and techniques have been proposed to improve the accuracy and efficiency of COVID-19 detection. One paper proposed two framework models for COVID-19 detection using CNN [21]. Another paper used CNN on X-ray scans for image processing and pattern detection to detect COVID-19 X-rays with an accuracy of 96% [22]. A different paper introduced a deep CNN model with ResNet50 configuration for detecting COVID-19 from chest radiography scans, achieving approximately 97% accuracy [23]. Ensemble models consisting of multiple CNN architectures have also been evaluated for COVID-19 detection, showing improved accuracy compared to individual models [24]. Additionally, a study used InceptionV3 and U-Net deep learning models to classify chest X-ray images as COVID-19 positive or negative, achieving a detection accuracy of around 99% [25].

III. MATERIAL AND METHODOLOGY

The detection of COVID-19 using deep learning has emerged as a promising approach to assist in the rapid and accurate diagnosis of the disease. Leveraging large datasets of medical images, such as chest X-rays and computed tomography (CT) scans, deep learning models, particularly Convolutional Neural Networks (CNNs), can automatically extract relevant features and identify patterns indicative of COVID-19 infection. These models are trained on annotated datasets, learning to differentiate between COVID-19 and other types of pneumonia or normal lung conditions with high accuracy. The application of deep learning in COVID-19 detection offers several advantages, including scalability, speed, and the potential to reduce the burden on healthcare systems by providing reliable diagnostic support, especially in regions with limited access to expert radiologists. Additionally, deep learning models can be integrated into telemedicine platforms, facilitating remote diagnosis and monitoring. Despite these advancements, challenges such as the need for large, diverse datasets, model interpretability, and ensuring generalizability across different populations and imaging devices remain areas of active research. Nevertheless, the integration of deep learning into COVID-19 detection workflows represents a significant step towards enhancing diagnostic capabilities and improving patient outcomes during the pandemic.

A. Dataset

The chest x-ray image dataset contains 21,719 X-ray images divided into 17,376 images (80%) for training and 4,343 images (20%) for testing. Images are categorized as Covid, non-Covid and normal images. The sample images are shown in figure 1.

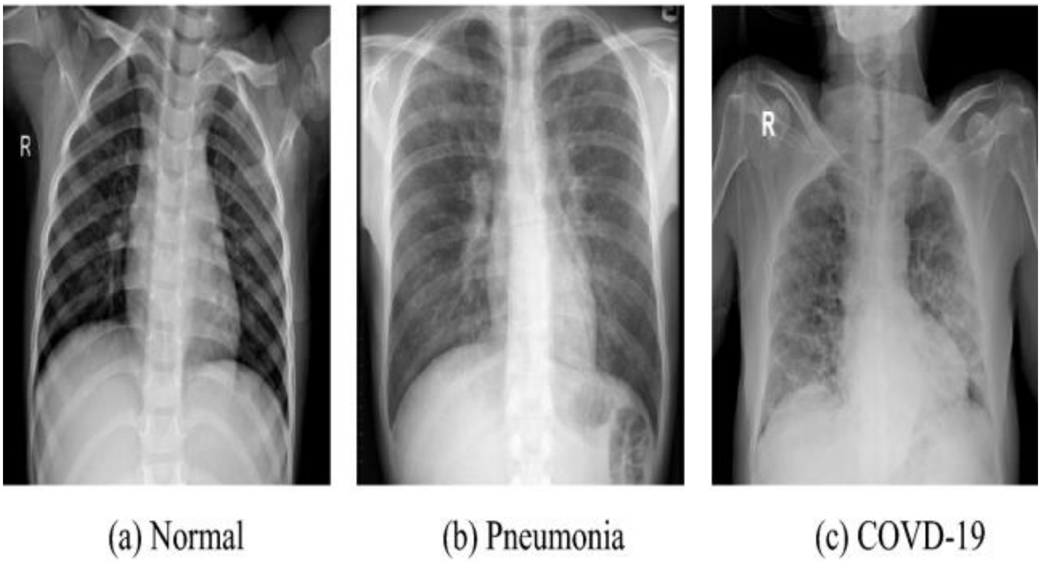

Fig. 1. Sample images of dataset

Table I shows the split of total image into three different categories named Normal, Covid19 and Pneumonia images.

Table I.STATISTICS OF DATASET

#	Normal Images	Pneumonia	Covid-19	Total Data set
1	7,260	6,849	7,662	21,719

B. Proposed Work

The goal of convolutional neural network research is to use convolutional neural networks to achieve good results. The aim of this study is to select a CNN-based deep learning model suitable for examining COVID-19 visual images. In deep learning, convolutional neural network (CNN) is the most used type of neural network in visual image analysis. CNNs use a mathematical algorithm called convolution to transform matrix equations in at least one layer. It is mainly used to process pixel data for image recognition and processing purposes. This applies to many things like image and video recognition, image classification, image segmentation, image editing, natural language processing, brain, computer interfaces, and financial time series. 13 CNN is a modern version of multilayer perceptron. All multilayer sensors are generally integrated systems. This means that every neuron in one layer is connected to every neuron in the next layer. The full connectivity of these networks makes it easier to fit information. Ways to control or prevent damage include negative punishments (like lifting heavy) or joint contractions (joint, recovery, etc.) during training.

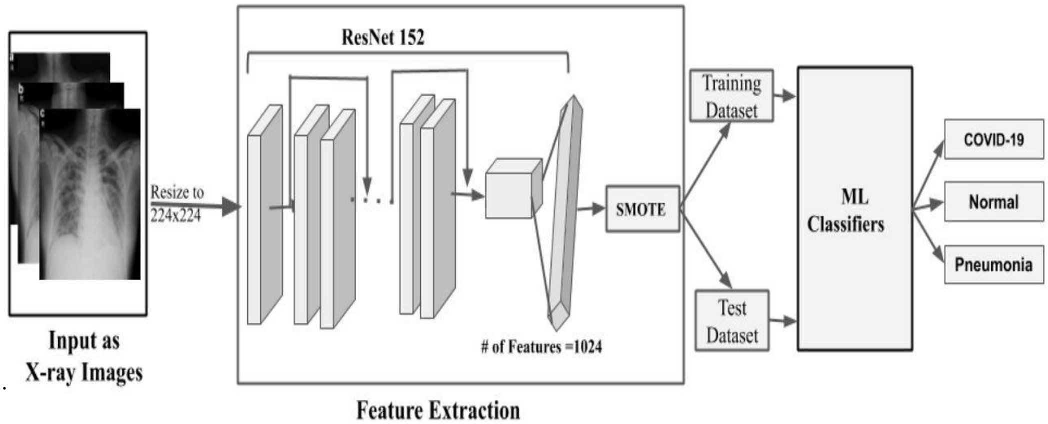

Fig. 2. The block diagram of the proposed model for an early diagnosis of COVID-19

Producing useful information also increases the likelihood that CNN will learn the general principles that inform the information provided, rather than learning the biases of information available to large numbers of people. CNNs, as usual, use different methods: They use hierarchical models in the input, they use small, simpler models placed in the filter to aggregate complexity models. CNNs use a hierarchical structure on the data they process. Instead of trying to complete all the images or ideas at once, CNN breaks them down into smaller, simpler features represented by filters. These filters are used to extract relevant information in many areas of the program. As the network progresses layer by layer, these features are combined and aggregated into more models, allowing the network to learn how to represent ideas. This layering technique allows CNNs to learn patterns in the material while minimizing the risk of overfitting. Therefore, CNNs are at the lowest level in terms of connectivity and complexity. To apply transformation learning to chest x-ray classification, we use the TensorFlow library to load the normal model, train it on the chest x-ray dataset, and classify it into three groups. normal, non-Covid-19 and Covid-19. The deep learning framework developed by Google can control all neurons (nodes) in the system and has a library of functions necessary for image processing. You can change the weights of the neural network to improve its performance. Convolutional neural network is an advanced technique that eliminates most of the inputs. Each factor is responsible for output production. Low-level shapes such as edges, lines, and corners are determined by lower-level operations, while high-level features are extracted from higher-level operations. Using pooling causes the features obtained from the connection to be noisy. There are generally two types of pooling layers: average pooling and max pooling. This is a size reduction or subtraction step. In this study, we use CNN mode to classify COVID-19 chest X-ray into normal, non-COVID and COVID-19 group. In addition, we use adaptive learning using image data to overcome data scarcity and learning time. An example of a traditional CNN model to predict COVID-19 patients, non-COVID-19 patients, and normal patients. Using the chest x-ray as the entry point, the model is used to make SoftMaxjoint by joint, and the whole process is tied together. After completing these tasks, different courses will be determined, and finally General courses will be divided into two: non-COVID-19 and COVID-19. The popular Adam algorithm is used in deep learning because it gives fast results. This is an optimization method that adjusts weights in a linear fashion based on data, rather than classical stochastic gradient descent. The optimizer called Adam is a variant of gradient descent that generally does not need to adjust the learning rate. During the training process, the optimizer uses gradient loss to try to reduce ("optimize") the error in the output model by correcting the error.

IV. RESULT AND DISCUSSION

The experiment used data of 21,719 chest X-ray images for training and testing; of these, 17,376 images were used for training (80%) and 4,343 images were used for testing (20%). To improve the learning process, all data must pass through the same neural network many times. CNN is then used 30 times to update the weight model. The results showed 83% accuracy and 42% loss. Experience shows that some models can accurately identify the presence of COVID-19 in human samples and can complete patient identification as the training model increases. We developed a web application using the Django framework and checked whether X-ray images were infected, virus-free, or normal.

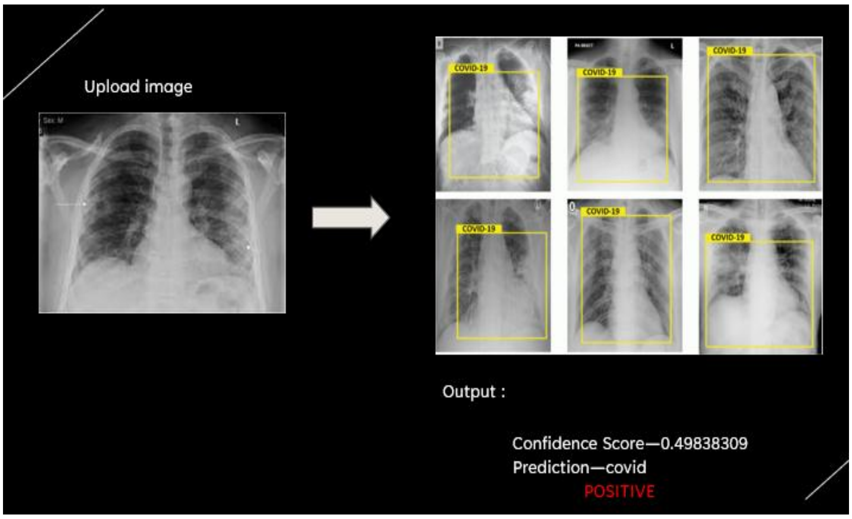

Image 1. Classification of image into levels

Table II.EVALUATION OF PROPOSED MODEL WITH EXISTING MODELS

#	Methodology	Accuracy%
1	**The proposed Model**	**98.55%**
2	Sahinbas and Catak[26]	80%
3	Qi et al.[27]	95%
4	Das et al. [28]	97%
5	Moura et al. [29]	97%

V. CONCLUSION

The results of this study validate the potential role of Deep learning algorithms in quickly identifying patients and helping prevent the Covid-19 outbreak. It can be useful and practical. The proposed CNN model achieved the highest accuracy score among radiologists and represents an effective diagnostic tool for rapid diagnosis of various infectious diseases such as the COVID-19 pandemic. Radiologist referral does not require a separate physical examination. We recommend that future studies address other issues such as disease spread, explore different neural communication pathways such as deep learning models, and improve the interpretation of CNN models.

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