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A Comprehensive Approach to COVID-19 Detection and Management Using Deep Learning--Review

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ABSTRACT:

COVID-19 is a critical global health emergency that has affected millions of people worldwide. Early detection of the virus is essential to prevent its spread and death. The predominant clinical approach for detecting the presence of the covid-19 is through reverse transcription polymerase chain reaction (RT-PCR). Still, it has disadvantages, such as a high cost and a long turnaround time. In this study, different models are tested. These examples were circumstantial. CNN is a great choice for image discovery and consumption projects. Impressive results were obtained, especially in applications dealing with image data. This report focuses on enhancing the capability of Convolutional Neural Networks (CNNs) to identify COVID-19 in chest X-ray images.

Keywords: Convolutional Neural Networks (CNN), Transfer Learning, Deep Learning, Chest X-ray Images, Medical Diagnostics, Image Classification, Vision Transformer, Pneumonia, Biomedical Imaging.

Introduction:

COVID-19, commonly referred to as coronavirus, is an infectious disease that primarily impacts the human respiratory system. "Covid 19" is the abbreviation for "Novel coronavirus disease Coronavirus has affected our daily lives, killed millions or made millions sick. Fever, chills, cough, bone pain, and respiratory issues are the symptoms of this virus, which is common. In addition, patients with heart failure may experience fatigue, sore throats, muscle spasms, loss of taste or smell, and withdrawal Consequently, hygiene size, washing frequently with soap or detergent, avoiding face-to-face contact, wearing masks, and other preventive measures are advised. The virus was first discovered in December 2019 in Wuhan, China. In March 2020, the World Health Organization officially classified the COVID-19 outbreak as an epidemic. In response, the Indian government, led by Prime Minister Narendra Modi, declared a 21-day nationwide curfew on March 23, 2020. This curfew was implemented to limit the movement of India's 1.3 billion citizens in an effort to curb the spread of the coronavirus. [2].

The most popular technique for detecting COVID-19 is RT-PCR, but it is highly costly and takes a long time to produce results. Instead, we employed a well-known technique for all of us: convolutional neural networks, or CNNs, a subset of machine learning.CNN is a deep learning framework, as shown in Figure 1, for tasks such as image recognition and pixel data processing. Its three layers are usually variable, convergent, and fully fused (FC) and are organized like the neurons in the brain. Convolutional layer: The heart of a CNN, after this layer, can be a second convolutional layer.

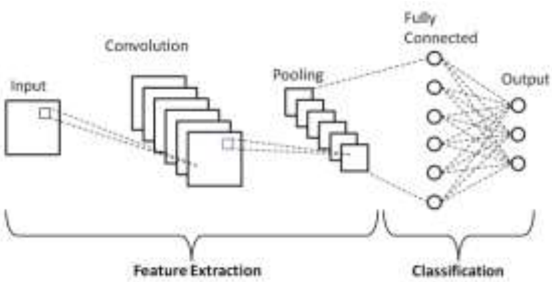

Fig1: A Typical CNN Architecture

The convolution process applies a filter through the receiving regions of the image, searching for features. The filter or kernel deletes the entire image in several iterations, calculating the dot product between the input pixels and the filter after each iteration. The result of a series of points is called a feature map or feature rotation, look at the process. The image runs through some math, which lets CNN read the picture and find any useful stuff. Then comes the pooling layer. It uses a tool - you could call it a filter - to go over the image. This cuts down on details but also keeps what's important. Even with fewer details, this layer actually makes the CNN better! Then, there's a "Fully Connected" layer. It's the one that decides what's in the image, using the details picked up earlier. "Fully connected" means each part of an earlier layer is linked to each part of the next. Now, this isn't like a fully linked-up CNN - they're not all mixed up like in a Fully connected network because that would be too much and less effective.. [3].

LITERATURE SURVEY:

Coronavirus, also known as COVID-19, is an infectious disease that affects people's respiratory system and causes breathing difficulties. It spread and spread like wildfire around the world. The virus was initially identified in Wuhan, China, in 2019, and its classification as an epidemic by the World Health Organization occurred in March. Individuals who are infected are typically isolated from their families and loved ones as a preventive measure [4]. A chest X-ray is a routine diagnostic procedure, especially if there are suspicions of heart or lung diseases. In such cases, a chest X-ray is often among the initial diagnostic tests, and it may also be utilized to monitor the response to treatment. A chest X-ray can reveal conditions in your body, such as cancer, infection, or gas in the space around your lungs that could cause them to collapse. Due to chronic diseases such as cystic fibrosis or emphysema and complications of these diseases [5]. To further prove that the proposed model works better than other models, we conducted a comparative study with various learning machines. While the proposed model is modelled in general and specific terms, model testing is carried out by independent tests. The CNN model was tested in two cases: in the first case, using multiple X-ray images from the initial processed data, and in the second case, it was tested using COVID-19 X-ray images and data [6]. Deep learning is making rapid progress in healthcare, especially in diagnostics. Deep learning models have improved the performance of medical image analysis and computer vision problems. Artificial neural networks outperform image analysis and other methods [7] [8]. Due to its excellent results, CNN is considered the de facto standard for medical image analysis and classification [9] [10]. CNNs have been used in many diagnostic tasks, such as lung diseases [10], identification of malaria in blood samples [11], and classification of diseases using chest X-ray images [14]. Modern CNN architecture was used in this study to determine the patient's COVID-19. The feasibility and adaptability of deconvoluted, transposed, and deep CNNs for COVID-19 detection using chest X-ray image distribution is the subject of another recent investigation [15]. This article describes the use of artificial intelligence, specifically CNN, to identify COVID-19 from X-ray images. Examples include ResNet, DenseNet, InceptionV3, and pre-trained architectures. Applying CNN to big data and small-scale COVID-19 data yields great results. Validation analysis and comparison with conventional methods (RT-PCR) are shown. Overall, CNN demonstrated high performance, flexibility, and competitive performance in diagnosing COVID-19. CT scans require more time and money to produce images than X-ray images; therefore, our findings suggest that X-ray image datasets are more widely used. Chest X-ray has been the standard procedure for diagnosing COVID-19 in studies

COMPARATIVE ANALYSIS:

Interspecies detection using transferable learning is based on the CNN model and dataset options. The researchers examined the pre-trained architecture by classification task on the COVID dataset, using steps such as feature extraction, classification, image preprocessing and segmentation The study confirmed that CNN is a key learning technique for efficient datasets, preprocessing techniques, and ex-model strategies trained and tested.

A: DATASETS:

The study used Cohen [19] and Kaggle [20] chest X-ray data sets, which consisted of 305 COVID-19 images and 234 images from healthy individuals, divided into training, test and validation groups. In another study, data from 682 MRI images. In addition, they used chest X-ray datasets collected in October 2021, which included 3616 COVID-19, 10,192 normal, 6012 lung opacities, and 1345 viral pneumonia images [21] [22]. It enabled the development and analysis of deep learning algorithms using transformers, including detection, diagnosis and segmentation functions.

B: IMAGE PREPROCESSING TECHNIQUES:

All images in the dataset are standardised to a size of 240 x 240 pixels. The preprocessing steps include the removal of noise such as blur and high contrast through operations such as grayscale transformation, image segmentation, morphology operations, etc. [13].

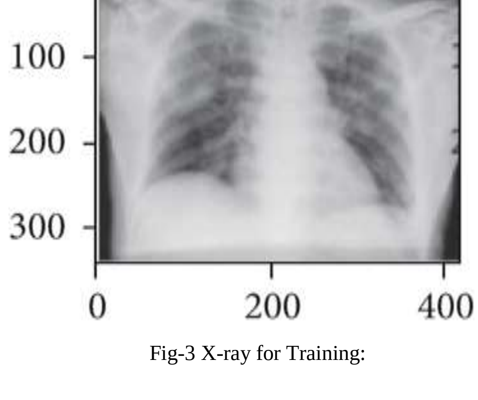

Fig-3 X-ray for Training:

The information presented in Figure 3 indicates we have to take the small parts of the image, also called patches, and separate the images dimensionally with perfect measurement. These techniques are designed to remove unnecessary features from an X-ray image. Once images are collected, several preprocessing techniques, including image stacking and resizing, are used to generate standardized images Initially, the size and shape of the images vary, requiring uniformity for integration in deep learning models. Resizing ensures that all images share the same resolution, facilitating seamless interaction the Mode between images throughout the analysis [18].

C: DATA SEGMENTATION:

Data segmentation is important when using Convolutional Neural Networks (CNNs) for COVID detection. This method segments medical images, such as CT scans or chest X-rays, into discrete areas to identify and extract related structures First, the images are pre-processed by methods such as resizing, normalization, and histogram equalization to improve quality and reduce noise. Images are then recorded to identify areas of interest, such as lung areas or possible COPD lesions. To facilitate CNN's training of COVID-19 models, the data set is then partitioned into training and validation sets. Using selective or individual CNN algorithms, the model derives features from segmented sources, identifying unique patterns of COVID-19-related anomalous features. The classification mask produced by the trained CNNs reveals the regions of interest in the original images. Metrics such as sensitivity and specificity are used to evaluate the performance of the model, and post-processing techniques can be used to improve these results After successfully validating the unobserved data, the model can be tested and finally used to achieve an accurate and reliable COVID-19 diagnosis system.

D: Performance Metrics:

Several metrics, like accuracy, confusion matrix, precision and recall, F1-score, specificity, receiver characteristic curve (ROC), and area under the curve (AOC)

1) ACCURACY

A simple metric for model evaluation is accuracy. It is the ratio of the number of correct predictions to the total number of predictions made for the data set.

Accuracy= (Number of correct predictions/Number of total predictions)

2) CONFUSION MATRIX:

The confusion matrix, which is in Figure 4, is a performance measure for machine learning classification problems whose results can consist of two or more classes [23].

True Positive (TP): Your prediction was positive, and it's correct.

True Negative (TN): Your prediction was negative, and it's correct.

False Positive (FP) - Type 1 Error: You predicted positive, but it's false.

False Negative (FN) - Type 2 Error: You predicted negative, but it's false.

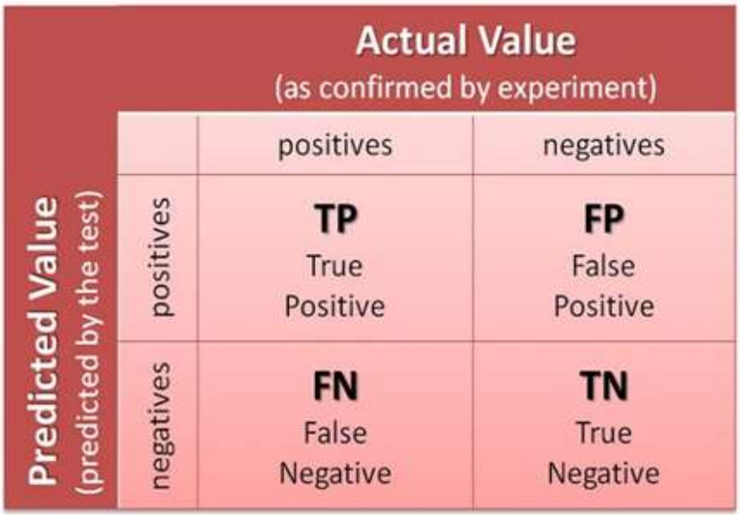

Fig4: Confusion matrix

3) PRECISION:

The number of true positives divided by the number of predicted positives is the definition of precision for a label [23].

Precision = (True positive/ (true positive + False Positive))

4) RECALL (Sensitivity):

The number of true positives divided by the total number of actual positives is the definition of recall for a label [23].

Recall = (True Positive/ (True Positive +False Negative))

5)F1 SCORE:

It is defined as the harmonic mean of precision and recall [23].

F1 Score = 2((Precision*Recall)/ (Precision +Recall))

6) ROC CURVE: Receiver Operating Characteristic Curve:

It gives a visual representation of the trade-off between a false positive rate (FPR) and a true positive rate (TPR)[23].

TPR = (True Positive/False Negative +True Positive)

FPR = (False Positive/True Negative +False Positive)

7) LOG LOSS (LOGISTIC LOSS):

One of the key metrics used to evaluate a classification problem's performance is log loss.[23]

The log loss for a single sample with a true label of y = {0,1} and a probability estimate of p = Pr(y = 1) is:

LOG LOSS(N=1) =y log(p) + (1-y) log (1-p)

For balanced datasets, metrics like accuracy, precision, and recall are useful for assessing classification models; however, in cases where the data is unbalanced, alternative techniques such as ROC/AUC yield better evaluations of the model's performance [23]

RESULTS AND DISCUSSIONS:

TABLE -1 (SUMMARY OF COMPARATIVE ANALYSIS OF SOME RELATED RESEARCH WORK

Papers	Models	Methods/ Key Findings	Performance Metrics	Accuracy	Other Metrics
Paper-5 [13]	CNN	Correct diagnosis of COVID-19 from X-ray images requires less training time than transfer learning models	Accuracy	Comparable to transfer learning models	
Paper-3 [17]	CNN (Segmentation)	For COVID-19 diagnosis, CNN performs better in terms of accuracy and sensitivity than DNN, achieving 93.2% accuracy and 96.1% sensitivity.	Accuracy, Sensitivity	CNN: 93.2%, DNN: 83.4%	Sensitivity: 96.1%
Paper-4 [1]	Vision Transformer (VIT)	VIT beats CNNs like ResNet50 and achieves 99.3% accuracy for COVID-19 detection. Excellent memory, accuracy and F1 points	Accuracy, Precision, Recall, and F1-score	99.3%	Precision, F1-score
Paper-7 [18]	VGG16, VGG19	Estimates of CNN model for real-time detection of COVID-19 and pneumonia: 83.2% accuracy for VGG16+LR and 85.3% accuracy for VGG19+LR	AUC, Accuracy, Precision, Recall, and F1-score	VGG16+LR: 83.2%, VGG19+LR: 85.3%	AUC: 87.05%

The table summarises key findings from four separate papers, each of which explores the use of machine-learning models to detect COVID-19 from medical image data.

The first paper introduces the CNN model for COVID-19 detection from X-ray images and highlights its efficiency and competitive accuracy compared to transfer learning models. Despite the short description, the study praises the ability of the CNN model to detect COVID-19 early.

The second paper focuses on three in-depth methods for classifying lung images of patients with COVID-19, where CNN architecture outperforms DNN in terms of accuracy and sensitivity Approach classification using CNN accurately reflects the detection of infected regions in chest images. This study highlights the promise of artificial intelligence, especially deep learning, for disease detection.

In the third paper, the Vision Transformer (VIT) system demonstrates exceptional performance, with an impressive 99.3% accuracy for the automatic diagnosis of COPD from chest X-ray images. The VIT model outperforms traditional CNNs such as ResNet50 and demonstrates the ability to accurately classify features across multiple classes. Transfer learning and the use of previously trained communication skills contribute to the success of this diagnostic tool.

The fourth paper investigates the performance of the VGG16 and VGG19 models in combination with classifiers for the real-time detection of COVID-19 and pneumonia from chest radiographs. When specific accuracy values are reported for each model and classification combination, the average AUC values reflect the overall efficiency of the model. VGG16 and VGG19 show promising performance, especially when combined with logistic regression, highlighting their utility in medical image analysis. Overall, this article highlights important strategies developed by machine learning models, ranging from traditional CNNs to newer architectures such as Vision Transformers, to highlight state-of-the-art medical image analysis for COVID-19 detection. It also provides additional research and development opportunities to improve diagnostic capabilities and address global health challenges.

CONCLUSION:

In summary, research on COVID-19 detection using neural networks (CNN) offers a promising way to apply artificial intelligence to healthcare. Deep learning has the ability to diagnose COPD from chest scans and x-rays, as shown by the discovery of the best CNN algorithms and new technologies such as Vision Transformer (VIT). It may be beneficial by providing an efficient and effective method of early diagnosis. Transfer learning seems to be a useful strategy to achieve better results, especially when using already trained CNN models. When combined with machine learning classifiers such as the CNN model and logistic regression, the identification accuracy is further improved. In addition to improving medical imaging, these advances have important implications for ongoing efforts to prevent the spread of COVID-19. When the results are promising, more valid research using big data is needed. More research is needed to identify CNN patterns in different imaging modalities such as ultrasound and CT scans. Many studies have demonstrated the importance of transparency in the decision-making process of deep learning, which is also an important driver for large-scale clinical applications. All evidence indicates that CNN's ability to update COVID-19 diagnoses is accurate and valid, providing critical tools for healthcare personnel to combat transmission.

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