DEEP TRANSFER LEARNING FOR COVID-19 DIAGNOSIS USING MEDICAL IMAGING

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Abstract: This study has been undertaken to determine a viable way to detect and diagnose COVID-19 by using deep transfer learning methods. Medical image analysis is one of the most important fields of study, offering diagnosis and decision-making tools for a variety of diseases, such as the Middle East respiratory syndrome (MERS) or COVID-19. X-ray and CT scan images are employed for image analysis to detect a disease in early stage and diagnose a person by preventing an outbreak. This study ensures an uncertainty transfer learning approach to extract more informative and discriminative features. The transfer learning algorithm is fine-tuned by a novel adaptive mechanism which automatically determines how many and which layers of a CNN to fine-tune for a given set of images.

***Keywords* - Machine learning techniques, convolutional neural networks (CNNs) and deep learning models, COVID-19.**

I. INTRODUCTION

The new virus called COVID-19 was identified in Wuhan, China, in December 2019 [1]. It belongs to the Corona family of viruses, but it is more deadly and dangerous than the rest of the coronaviruses [2]. Due to the restricted testing resources available, several countries are only willing to apply the COVID-19 test to a small number of people. Despite considerable efforts to find a viable way to diagnose COVID-19, a major obstacle remains the medical services available in many countries. There is also an urgent need to identify a quick and convenient process for effectively detecting and diagnosing COVID-19. As the number of patients infected by this disease increases every day, it turns out to be extremely hard for radiologists to finish the diagnostic process in the constrained accessible time [3]. Recently, many efforts and more attention are paid to imaging modalities. Therefore, interpretation of these images requires expertise and necessitates several algorithms to enhance, accelerate and make an accurate diagnosis [4].

Most of the studies show encouraging outcomes for CNN models trained on a small set of images. Deep neural networks frequently include hundreds of thousands of trainable parameters, and fine-tuning them necessitates vast volumes of data. Furthermore, the small sample size raises questions about epistemic certainty. It is unclear how these models can be trusted for a new instance, given that they were developed with a very small number of training examples. None of these models can express a lack of confidence in new cases. Motivated by these shortcomings, this research proposes Deep transfer learning methods for reliable detection of COVID-19 cases from X-ray and CT images.

Training multilayer CNNs requires a massive amount of data and compute resources. The availability of thousands of images with proper labels is difficult to develop reliable CNNs for the detection of COVID-19 using computer vision techniques. This is achieved by applying transfer learning on CNN. Transfer learning supports the transfer of knowledge from pretrained models which avoid the massive requirement of data and computer resources.

II. OBJECTIVE

In reliable detection of COVID-19 cases from X-ray and CT images uses four pretrained CNN models (VGG16, DenseNet121, InceptinResNetV2, and ResNet50) to hierarchically extract informative and discriminative features from X-ray and CT images.

III. RELATED WORKS

Randhawa et al. [5] proposed supervised machine learning techniques with digital signal processing (MLDSP) for COVID-19 detection using intrinsic genomic signatures for rapid classification of novel pathogens.

Mohammed et al. [6] present a comprehensive investigation of different machine learning for automated identification of COVID-19 from Chest X-ray Images (CXR) using ANN, SM, RBF, k-NN, and DT and different architectures of convolutional deep learning models.

Li et al. [7] developed a fully automatic framework to detect COVID-19 from chest CT using a deep learning model (COVNet). The dataset was collected from 6 hospitals to detect COVID-19 accurately and differentiate it from pneumonia and other lung diseases.

Rajpurkar et al. [8] proposed a novel deep learning algorithm that can detect pneumonia from chest X-rays at a level exceeding practicing radiologists. The CheXNet is a 121 CNN that has been trained using 112 120 frontal-view chest X-ray images individually labeled

Al-Waisy et al. [9] proposed a hybrid deep learning framework for identifying COVID-19 in CXR images (COVID-CheXNet). The learning features obtained from two different pre-trained deep learning models are fused and used to classify and discriminate between the healthy and COVID-19 infected people. They improved their work based on CXR images for Pneumonia COVID-19 detection using a hybrid multimodal deep learning system (COVID-DeepNet).Apostolopoulos.

Bessiana [10] applied the transfer learning concept and used five pretrained CNNs for extracting features and processing them using feedforward neural networks. Obtained results indicate that the VGG19 and the MobileNet 1409 outperform others in terms of classification accuracy. Also, it is observed that the MobileNet outperforms VGG19 in terms of specificity. ResNet50, InceptionV3. Inception- ResNetV2 networks are used in [11] for automatic detection of COVID-19 using X-rays. Performance results suggest that the ResNet50 pretrained model achieves the highest accuracy of 98% among considered CNNs.

Wang et al. [12] proposed a clinical diagnosis of the pathogenic test by extracting covid -19s specific graphical features using Artificial Intelligence's deep learning. The modified Inception transfer learning model was proposed as deep learning. The gray level and gray variance based features only used in this work.

Xu et al. [13] proposed an automated screening model based on deep learning techniques to discriminate CT cases that were infected by COVID-19 or influenza-A viral pneumonia from those cases for patients who had healthy lungs. The model with location-attention mechanism could more accurately classify COVID-19.However better exclusive models should be designed for more effective training.

Song, et al. [14] developed an automated deep learning diagnosis system to help clinicians detect and recognize the patients who are infected by COVID-19. The collected dataset included 88, 86 and 100 CT scans of COVID-19, healthy and bacterial pneumonia cases, respectively. A Details Relation Extraction neural network (DRE-Net) was designed to extract the top-K details in the CT images and obtain the image-level predictions. Finally, the image-level predictions were aggregated to achieve patient-level diagnoses.

IV. Methodology

The proposed study ensures the use of information content of X-rays and CT images to identify the presence of COVID-19. Mainly five pretrained networks on the ImageNet dataset that is VGG16, ResNet50, DenseNet121, and InceptionResNetV2 are imported and adapted for the process of COVID-19 detection. All these networks have achieved state-of-the-art performance for correctly classifying images of the ImageNet data set. Training of these networks is computationally very demanding as they have many layers and millions of trainable parameters. The main hypothesis in the proposed framework is that there are fundamental similarities between image detection/recognition tasks and the binary classification problem of COVID-19 using images. Accordingly, learnings from the former one can be safely ported to the latter one to shorten the training process. While all five pretrained networks have been developed using nonmedical images, it is reasonable to assume that their transformation of X-ray and CT image pixels could make the classification task easier.

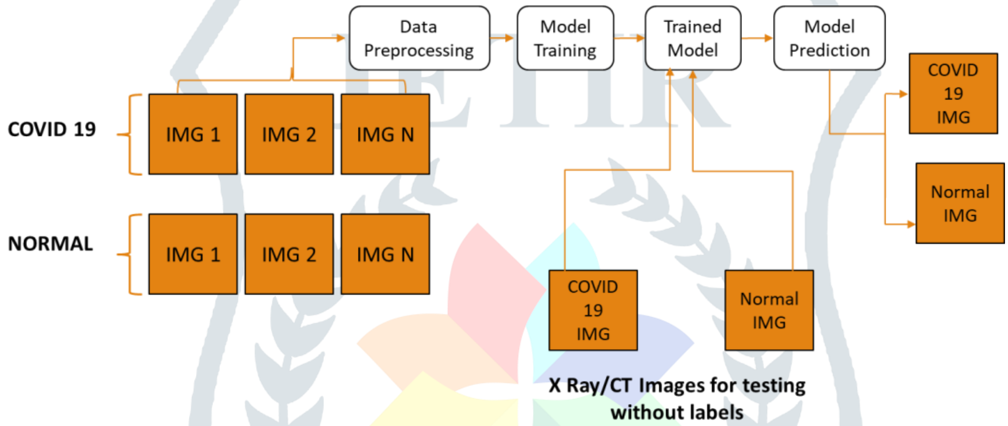


Fig.1: Process Flow of Data Model

3.1 CNN and SVM

The convolutional layers of these five pretrained models are fed by X-ray and CT images for hierarchical feature extractions. The front end of the pretrained networks is then replaced by different machine learning classifiers to separate Covid and non-Covid cases. It is important to mention that we drop the pooling operation in the last convolutional layer of these pretrained networks. This is to avoid losing informative features before passing them to the classification models.

1) VGG16: This model is similar to AlexNet and consists of 13 convolution, nonlinear rectification, pooling, and three fully connected layers [15]. The filter size of the convolutional network is 3 × 3 and the pooling size is 2 × 2. Due to its simple architecture, the VGG network performs better than AlexNet.

2) ResNet50: Residual convolutional network (ResNet) is one of the most popular deep structures, which is used for classification problems (winner of ImageNet competition in 2015). Residual blocks enable the network to provide a direct path to its early layers. This helps the gradient flow easily in the backpropagation algorithm.

3) DenseNet121: DenseNet won the ImageNet competition in 2017. Traditional deep networks have only one connection between layers. However, in DenseNet, all layers receive all feature maps from previous layers as input [17]. This helps the network to decrease the number of parameters and also relieve the gradient vanishing.

4) InceptionResNetV2: Szegedy et al. [16] presented a novel structure that helps to go deeper through convolution networks. Deep networks are prone to overfitting. They solve this solution using inception blocks. Furthermore, they use residual blocks and create InceptionResNetV2, which uses the combination of residual and inception blocks wisely.

SVM: It is a practical solution for classification problems, especially in high dimensions. SVM uses line or hyperplane for dividing the data into appropriate classes. It tries to find a hyperplane with the largest distance to the nearest data for each class (margin). The lower generalization error will be achieved when the margin becomes large [17].

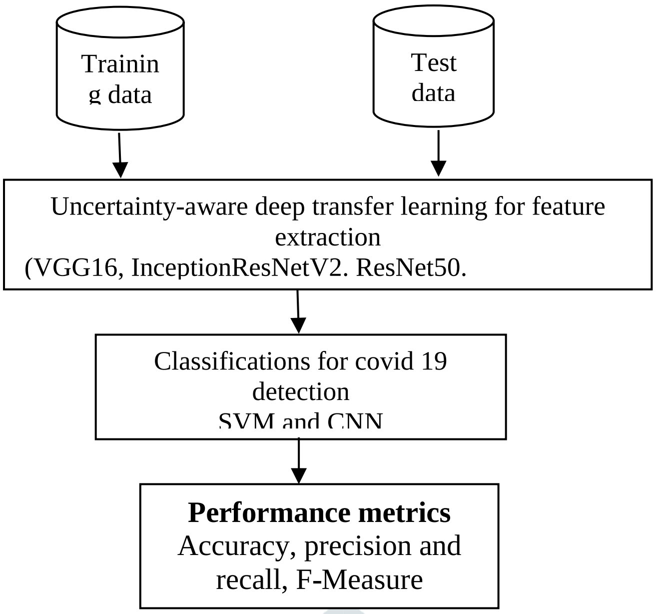


Fig.2: Methodology of Data Model

3.2 Uncertainty Measure

Uncertainty classification which estimates the noise inherent in the process of generating the data that is X-ray and CT images. In this study epistemic uncertainty is focused, which captures the model that lacks knowledge about the data. Then, an ensemble of neural network models trained using different deep features to generate predictive uncertainty estimates. The quantified epistemic uncertainties provide informative hints about where and how much one can trust the model predictions. The ensemble epistemic uncertainty is computed as the entropy of the mean predictive distribution (taking averaging of all predicted distributions).

$$\hat{p}(y|x) = \frac{1}{N}\sum_{i=1}^{N} p_{\theta_i}(y|x)$$

3.3 Dataset

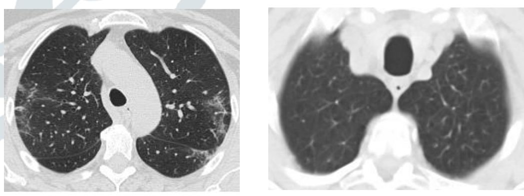
In this study two different datasets are employed such as 1) X-ray images 2) CT Scan images. This image data is the main source of information to detect and diagnose COVID-19 by clinicians. CNN method is used to extract features that are processed by machine learning classification techniques.

1)X-ray images: There are 25 images of COVID-19 are taken initially and another 75 non-Covid cases of chest X-ray images are included. It is essential to consider that these non-Covid cases may have other unhealthy conditions, such as bacterial or viral infections, chronic obstructive pulmonary disease, and even a combination of two or more. Therefore, through this resultant can't declare these cases have lower respiratory syndrome issues and conclude that they are COVID19 case [18].

2) CT Scan Dataset: There are 300 COVID 19 images taken and 300 non COVID19 images are used and then compared with X-ray image results to use for medical diagnosis.

(a) **(b)**

Fig.3: A sample Chest X-ray images of a) COVID 19 b) Normal



(a) **(b)**

Fig.4: A sample CT Scan images of a) COVID 19 b) Normal

V. RESULTS AND CONCLUSION

The proposed study is to investigate appropriate deep learning techniques for COVID-19 diagnosis by using medical images. The main objective of the study is to discover methods to access large volume and high quality medical images to develop deep neural networks. By leveraging transfer learning mechanisms such as pretrained models of CNN like VGG16, ResNet50, DenseNet121, and InceptionResNetV2 are used to extract informative and discriminative features from chest X-ray and CT images. Initially, multiple classification techniques are processed to extract accurate features and then CNN concept is applied to filter the image with certain set of parameters. Acquired results ensure that SVM and multilayer CNN outperforms other methods in terms of medical images. In which it is observed that X-ray images come with better prediction results compared with CT Scan images.

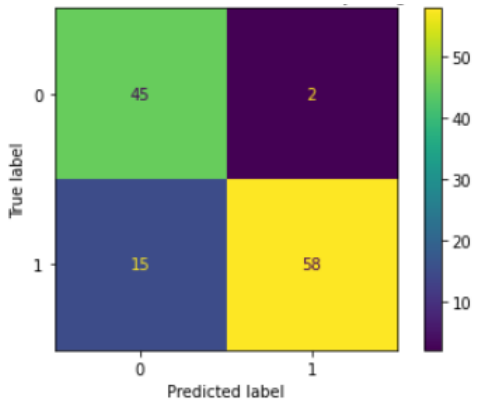


Fig.6: Confusion Matrix CNN+SVM:– X-ray Image

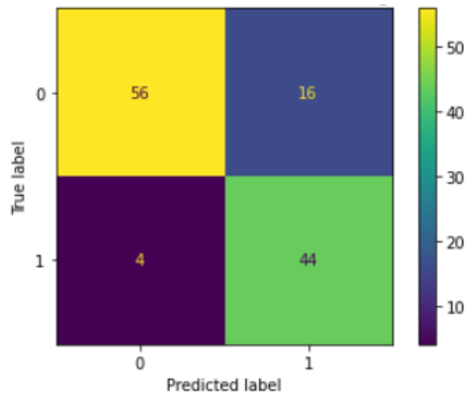


Fig.7: Confusion Matrix CNN+SVM: – CT Scan Image

- Confusion Matrix results are obtained by applying test data and predicted data result using following formula, *confusion_matrix(y_test_ct,pred2).ravel()*
- Accuracy are measured by summing true positive and true negative and that is divided by all true positive, true negative, false positive and false negative as *(tp+tn)/(tp+tn+fp+fn)*
- Precision is calculated by a true positive divided by the sum of true positive and false positive. *tp/(tp+fp)*
- Recall is obtained by calculating true positive by sum of true positive and false negative. *tp/(tp+fn)*
- F-Measure is obtained by applying the result of precision and recall into the formula. *(2*pre1*re1)/(pre1+re1)*

Table 1: Performance Analysis for X-ray and CT images

Performance Metrics	X-ray	CT Scan
Accuracy	85.8	83.3
Precision	95.7	77.8
Recall	75.0	93.3
F-Measure	84.1	84.8

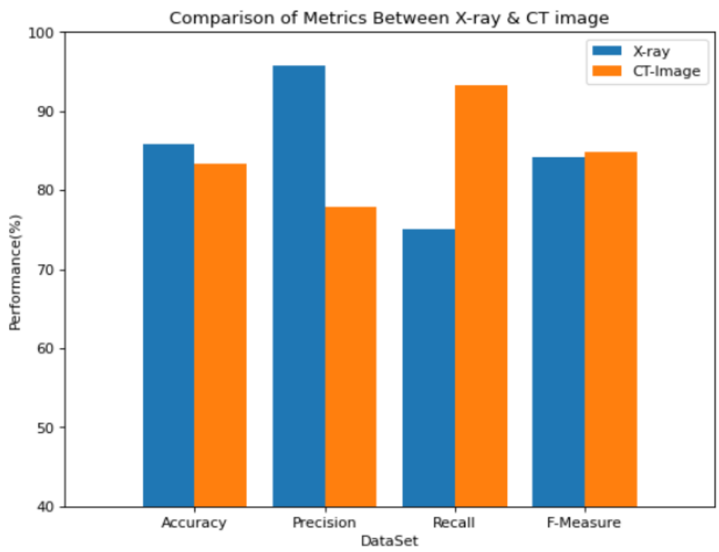


Fig.8: Comparison of Metrics Between X-ray & CT Scan Image

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