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COVID DETECTION USING MEDICAL IMAGES

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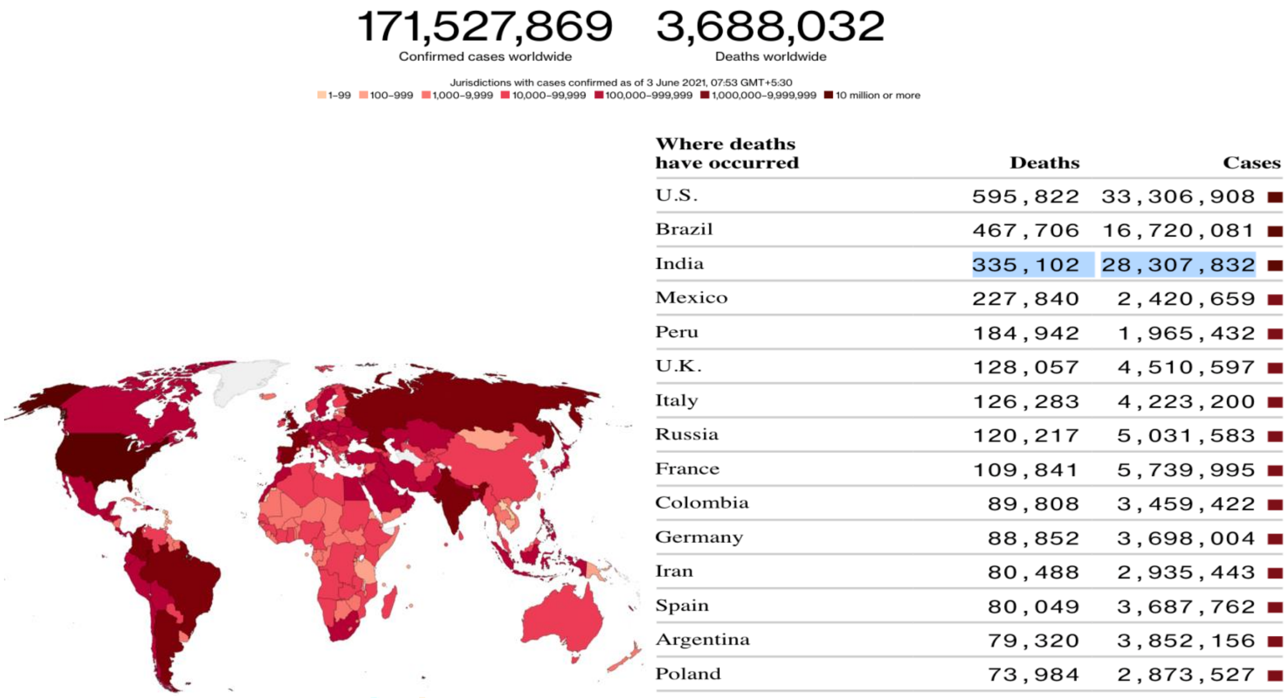
Abstract: Innovation progressions have a fast and colossal impact on each field of life, be it clinical field or different other various fields. Man-made reasoning has portrayed the promising outcomes in medical services through its dynamic by examining the information. Coronavirus has influenced very in excess of 100 nations during a question of no time. Individuals from everywhere the world are exceptionally helpless against its approaching results in the coming future. It is basic to foster a control framework that will recognize the Covid. One of the answers for control the momentum ruin can be the finding of infection with the assistance of different AI instruments. A clinical examination of COVID-19 infected people revealed that these individuals are significantly harmed by lung illness as a result of engaging with this virus. Chest x-ray (radiography) and chest CT are more powerful imaging techniques for identifying lurch-related problems. In any case, an impressive chest x-beam might be a cheaper interaction when contrasted with chest CT. Profound learning is viewed as perhaps the best method of AI, which gives different helpful investigation to contemplate a tremendous measure of chest x-beam pictures that can basically affect screening of Covid-19. In this work, we have taken the perspective on chest x-beam and CT checks for Coronavirus influenced patients just as sound patients and prepared our model to have the option to deliver results for the location of the infection.

Index Terms - Deep Learning, Convolutional Neural Network, ResNet, Inception V3. Machine Learning

I. Introduction

The COVID-19 or 2019 novel coronavirus, takes its name as “CO” stands for corona, “VI” stands for virus and “D” for disease. It has spread like a bat out of hell among people living in a variety of other nations around the globe. The initial samples were discovered during the 2019-2020 pandemic, and official confirmation by WHO on 31stDecember 2019 for the specimen of pneumonia by unknown cause, which likely to spread at the end of December 2019 in Wuhan, the capital of the Chinese province of Hubei. On 30th January 2020, WHO Director-General- Dr Tedros AdhanomGhebreyesus, at the timeannounced thevirus outbreak a public health emergency of international concern (PHEIC), which is WHO's highest level of alarm. The casualties were none but found 98 cases among 18 countries outside China.Just a monthlater there were right around 11 thousand COVID-19 confirmed cases within China only where the world count is in lower 200s, while a year later on June3, 2021, there were almost 171 Million COVID-19 confirmed cases[1]with 3.6 Million death worldwide andfatality rate as high as 7.2% (Onder et al., 2020) [3]This virus affect lungs because it attack host cells via the receptor for the angiotensinconverting enzyme 2(ACE2), which is most rich on the surface of type 2 alveolar cells of lungs. This ultimately shows symptoms such as cough, shortness of breath and fever. The spread can happen through droplets, airborne transmission upon sneezing and surface transformation via touch to nose, eyes or mouth. It can live on surfaces for 2 to 3 days.[4] This is enough proof to understand how deadly this virus is and how crucial it is to come up with any means possible to stop the spread. Governments around the world have imposed laws for the use of face masks to avoid the airborne transmission and applied the social distancing strategy for minimising person to person transfer of the virus. [5]And lastly the touch based transmission is controlled by the use of hand sanitizer and other medical PPE kits.



Where deaths have occurred	Deaths	Cases
U.S.	595,822	33,306,908
Brazil	467,706	16,720,081
India	335,102	28,307,832
Mexico	227,840	2,420,659
Peru	184,942	1,965,432
U.K.	128,057	4,510,597
Italy	126,283	4,223,200
Russia	120,217	5,031,583
France	109,841	5,739,995
Colombia	89,808	3,459,422
Germany	88,852	3,698,004
Iran	80,488	2,935,443
Spain	80,049	3,687,762
Argentina	79,320	3,852,156
Poland	73,984	2,873,527

Fig 1. Represents the statistics of the virus [9]

The Corona virus Disease 2019 (COVID-19) pandemic continues to have a severe impact on the global population's health and well-being. Because of the rapid spread and rising number of corona virus disease (COVID-19) and severe acute respiratory syndrome corona virus 2 (SARS-COV-2) cases, rapid and accurate detection of virus and/or disease is becoming increasingly important in order to control the sources of infection and assist patients in preventing the illness from spreading. The ensuing writing affirms that viable screening of contaminated patients is a basic advance in the battle against COVID-19, with one of the key screening approaches utilizing radiology assessments utilizing chest imaging methods. Was likewise recognized in primer work that patient present irregularities in chest pictures that are normal for each one of those tainted with COVID-19. Persuaded by this and roused by the exploration local area's open-source tries, we give a profound convolutional neural organization configuration streamlined for the analysis of COVID-19 cases from chest X-beams[6] in this audit. The expectation is to speed up the improvement of exceptionally exact yet useful profound learning answers for identifying COVID-19 cases and speed up treatment of these who need it the first.

2. Literature Review :

In the study of Rodrigues et al.[7], CT scan and X-ray images of lungs were examined. Due to the scarcity of RT-PCR testing kits and also due to the rising false negative results of the kit, the techniques of detecting COVID-19 using alternate methods is gaining attention. One such method is detection using medical images and appropriate machine learning techniques. Another Study by Nair et al. [8] where the CT image diagnosis for COVID-19 in UK was done and patients were invited for a Question-Answer session.However, evaluating many medical images in epidemic situations will undoubtedly be a time-consuming and error-prone process. For the detection, henceforth AI based methods of machine learning and deep learning can be put to use.

According to Hani et al. [9], CT imaging has been point to a critical additionto the diagnosis of COVID-19. The main features of CT in this study of Zhu et al[10] are air bronchogram sign,ground-glass opacities (GGOs), consolidation, crazy-paving pattern, pleural thickening, lymphadenopathy, and pleural effusion, respectively.

Another aspect of the Chest medical imaging research and study is related to Chest X-Ray images. These CXR images will be a major breakthrough in fighting against COVID-19 as the study Jacobi of et al.[11] the investigation is made possible due to its availability in most clinical centres and the abundance of normal chest X-Ray dataset. CXR is believed to be better cause of its relative lesser radiation, especially for young children, as in the study of Wang et al.[12] the diagnostic pillars of CT images have not been solidified.

Challenges such as unavailability of PCR testing kits and high false-negative rate[13]which has been pointed out many times in the medical field, the medical imaging have received a lot more attention in early detection of COVID-19.Because lab tests are often negative despite the person being infected with the virus, and asymptomatic infections can easily spread the infection, a more cautious approach to diagnosing the virus is required. As a result, in cases where the above tests are unavailable, medical imaging can be used to diagnose the disease and prevent the virus from spreading through more asymptomatic individuals.

To develop automated diagnosis methods, distinguishing features must first be extracted from the image.The characteristics must first be extracted from the image to create automatic methods of diagnosis. Handcrafted feature extraction methods or deep learning approaches can be used in the feature extraction process.[14] Based on the extracted features, machine learning approaches can then be used for medical image classification, medical image segmentation, disease severity assessment, and other possible tasks.

Deep learning algorithms can be used for medical visual classification, medical imaging segmentation, illness severity assessment, and other possible activities based on extracted features. For image analysis Convolution Neural Network(CNNs)[15] have been widely used and this study cites several approaches used in COVID-19 detection from CT or CXR images. CNN consists of three layer namely convolution layer ,pooling layer and fully-connected layers. The unavailability of big dataset is still a challenge as its not long since the COVID-19 outbreak. Therefore data augmentation techniques are being used[16].Narin et al.[17] did the transfer learning on three deep CNNs including InceptionV3, ResNet50 and InceptionResNetV2.

A combined total of 100 Chest X-Ray images were fed to the models, comprising of 50 images of patients infected with COVID-19 and 50 normal chest X-ray images. The study revealed that a comparative study can yield a accuracy of 98%.Most of the approaches uses transfer learning concept along with Data augmentation to tackle low dataset size. These studies and finding have produced outstanding results with the pre-existing pneumonia dataset and this same method can be applied to learn and detect the presence of Corona Virus from the radiographic Chest image.[18][19].

2.1 Existing System:

2.1.1.PCR Testing:

PCR testing is used to screen for the presence of viral RNA in the body, which can be detected before antibodies are formed or signs of disease appear. This means that tests can tell if someone has the virus very early in their life. Diseases. Reverse transcriptase or DNA polymerase is added to the nasopharyngeal sample in the laboratory during PCR testing. These chemicals work by replicating whatever viral RNA may be present. This is to ensure that enough copies of the RNA are made.

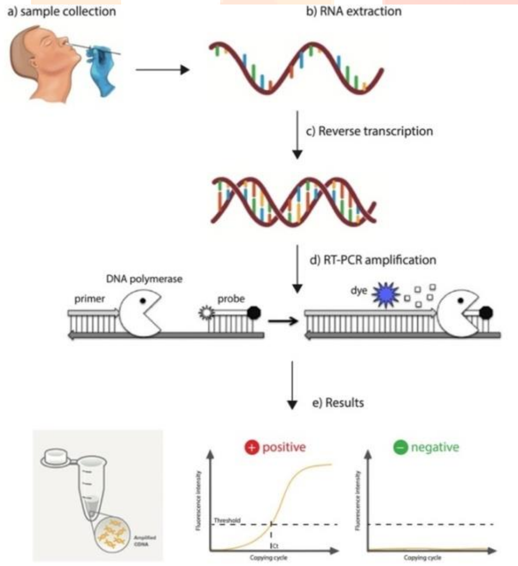


Fig 2. PCR testing process

Public health experts can acquire a better picture of the virus’s distribution by using PCR assays to screen broad areas of nasopharyngeal swab samples in a community. PCR, on the other hand, has significant drawbacks. Because these Covid-19 tests must be sent to a lab for analysis, patients may have to wait days for results. With various PCR tests, false negatives can occur up to 30% of the time, making them more effective at confirming the existence of disease than for continuing. They can also provide false positive results because they are so sensitive that they can report a positive result while a dead and dormant virus is still in the human bodyrestored.

2.1.2 LFT-Testing

The parallel stream test can identify Covid-19 on the spot. LFTs and PCR tests are both antigen tests intended to distinguish dynamic Covid. 19 contamination instead of antibodies to the infection. Utilizing Covid-19, an example of nasopharyngeal liquid is set on a little permeable cushion and got along the cushion through a fine way to a band covered with antibodies bound to SARS-Cov-2 proteins. In the event that these proteins are available, a shaded line will have appeared upon on test, showing a disease.

The biggest advantage of LFTs over PCR is that they don't require confirmation and can give you results in 15-30 minutes. What they gain in speed, however, they lose in accuracy. LFTs properly identified 58 percent of individuals infected among people who had no symptoms. Experts have questioned the utility of Covid-19 tests in this case, despite the fact that the use of LFTs for asymptomatic mass screening has been recommended in nations such as the UK.

2.1.3 Antibody Testing

Antibody (or serological) tests can't analyse a functioning disease, yet they can help advise if an individual is invulnerable to Covid-19. Neutralizer testing mentions to us what extent of the populace has been tainted. It will not reveal to you who has been tainted, as antibodies are created following possibly 14 days, after which the infection ought to have been cleared from the framework. In any case, it discloses to you who has been contaminated and who will be resistant to the infection

Blood samples are commonly utilized for antibody testing, unlike the PCR technique, which normally uses swabs to detect Covid-19. Despite the fact that there will be a modest amount of Covid-19 in the blood compared to the respiratory tract, there will be a large and measurable number of antibodies in the blood after infection. Antibody tests are used to assess immune responses in people who have been immunized against Covid-19. Researchers do not know how long the immunity generated by the vaccine will last or if a booster is needed. Although there is some evidence that variations in Covid-19 make some vaccines less effective, they still appear to provide adequate protection in most severe cases. As death cases have been rising it becomes important to consider every method in the arsenal.

3. Proposed Model:

The project aims to help speed up Covid-19 testing with the use of deep learning performed on the x-rays of suspected patients. We compare the different models available and modify them to meet our virus testing needs. The project specifically focused on CNN, InceptionV3 and ResNET and compared the two models based on their accuracy and ability to detect viruses. Here we use the ability of the neural network to act like the human brain and so with each class different image details, also known as medical image processing.

The three main methods for effectively employing CNNs for medical visual categorization include training CNNs from scratch, leveraging pre-trained CNN features off the shelf, and improving unsupervised learning.

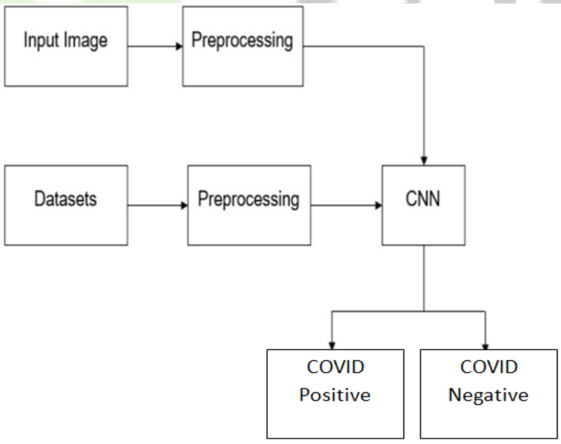


Fig 3.Flow diagram Proposed System

Although the field between two sets of medical image data can alsobe transferred, transfer learning or fine-tuning of pre-trained (supervised) CNN models from natural image datasets to medical imaging problems is an effective way for doing so. Training a deep complex neural network (CNN) from start is tough since it need a large amount of labelled training data and a lot of experience to ensure good, well-matched convergence. We can fine-tune the pre-trained CNN to accomplish this better.

3.1 Dataset Selection:

Imaging databases and registries are essential for diagnosis in radiology, as well as for the development of artificial intelligence tools for machine-based diagnosis. The search strategy for publicly available COVID-19 chest X-ray datasets consisted of two complementary approaches: a direct search for datasets using a dataset search engine, known compilation websites as well as direct extraction of data sources from reviews, and an indirect search for papers that describe prediction models for COVID-19.The dataset for this project comes from two sources:

1. Chest X-ray images (1000 images) from kagglepaultimothymooneychest-Xray-pneumonia and covid-chest Xray-dataset.[20][21]

2. Computed tomography images (750 images) from UCSD-AI4H/ COVID-CT/ tree/master/ Data-split.[22]

Data preprocessing is performed in order to remove undesirable noise and transformed according to the normalization base choosen, aggregation etc. The data reduction is done to reduce data without compromising the information of the original data via dimension reduction and data compression.To gain a better accuracy from the models the dataset is made via mixing positive and negative image dataset from different resources. Since the Present Dataset is not large enough the split_data=0.8 is used in order to make the dataset divide into two parts80% of the images were used for training themodels and the remaining 20% for testing the accuracy of the models.

3.2 Building Models

To train the models on the selected dataset, firstly three custom layers are added to the pre-trained models. The sample code for adding custom layers to the ResNet50 model, is provided below. The remainder of the models' code remains the same. Simply replace ResNet50 with the name of the preferred model in the first line.

```
res = ResNet50(weights="imagenet", include_top=False,
input_tensor=Input(shape=(224, 224, 3)))
outputs = res.output
outputs = Flatten(name="flatten")(outputs)
outputs = Dropout(0.5)(outputs)
outputs = Dense(2, activation="softmax")(outputs)
model = Model(inputs=res.input, outputs=outputs)
for layer in res.layers:
  layer.trainable = False
model.compile(loss='categorical_crossentropy', optimizer='adam',
metrics=['accuracy'])
```

The images in the dataset were of different sizes. Thus, we needed to resize them to a fixed size before they can be fed to the deep learning models for training. We resized the images to a size of 224 x 224 px which is considered to be the ideal size for the ResNet50 model. Therefore, we added the input tensor of shape (224, 224 , 3) to the pretrained ResNet50 model, 3 being the number of channels. Similar, process was carried out for all the other trained models.[23]

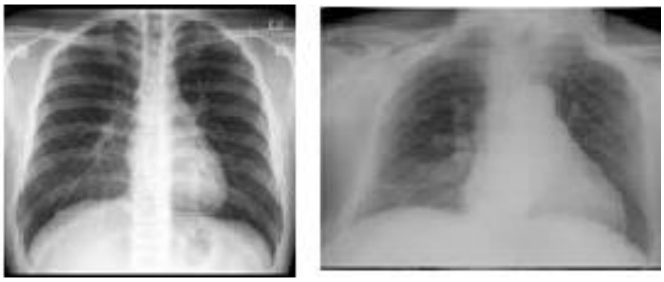
3.3 Training Models

We first defined an Image Data Generator to train the models at modified versions of the images, such as at different angles, flips, rotations or shift. The code snippet for the same is shown below:

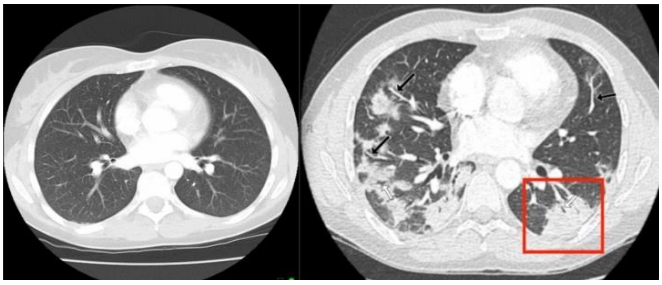
```
train_aug = ImageDataGenerator(rotation_range=20,
width_shift_range=0.2, height_shift_range=0.2, horizontal_flip=True)
```

3.4 Feature Extraction:

In multiple studies, COVID (corona virus) has reported various chest imaging findings[22]. Combining the existing data, we found the characteristic patterns and distributions of chest imaging manifestations: ground glass opacity (GGO) (88.0%), next, bilateral involvement (87.5%), undeniable peripheral distribution (76.0%), and multiple lobe (more than one lung lobe) Involved (78.8%). Isolated GGO or the combination of GGO and consolidation opacity are some of the most common findings in chest imagination. Other chest imaging findings include thickening of the interlobular septum, bronchiectasis, thickening of the pleura, and subpleural involvement. The incidence varies from research to research. Pleural effusion, pericardial effusion, lymphadenopathy, cavitation, chest imaging signs and pneumothorax are rare or occasional.



1a. Normal lung X-ray image *1b. Covid Positive X Ray Image*



1.c Normal CT Scan Image *1.d* Covid Positive *CT Scan Image*

Fig 4. Covid vs Non-Covid

4. MODEL ARCHITECTURE:

4.1 Convolutional Neural Network:

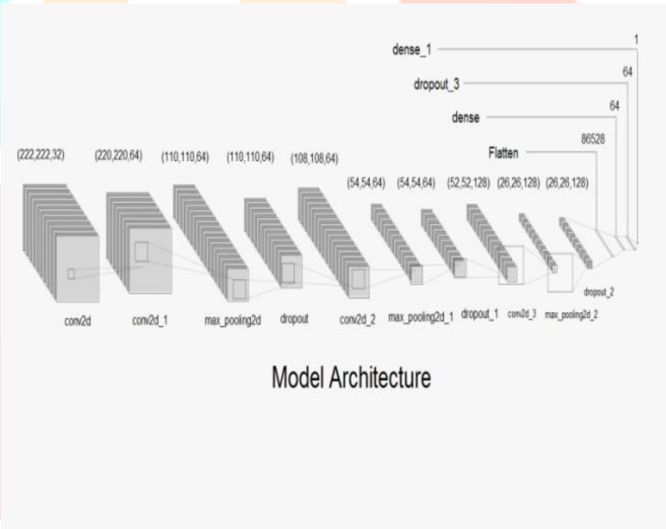


Fig 5. Model Architecture

The CNN structure in neural networks is specifically designed to process two-dimensional image tasks, while it can also be used to process one- and three-dimensional data. CNN is a type of DNN, inspired by the visual system of the human brain, and is most commonly used in the analysis of visual imagery. The dataset for training the CNN model was taken from GitHub. To overcome the difficulty of having a very-limited-sized X-ray image dataset, it has been greatly extended utilizing data augmentation techniques to enhance its size and also to make the model training feature rich.

```
model.summary()

Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 222, 222, 32)      896
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 220, 220, 64)      18496
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 110, 110, 64)      0
_________________________________________________________________
dropout (Dropout)            (None, 110, 110, 64)      0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 108, 108, 64)      36928
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 54, 54, 64)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 54, 54, 64)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 52, 52, 128)       73856
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 26, 26, 128)       0
_________________________________________________________________
dropout_2 (Dropout)          (None, 26, 26, 128)       0
_________________________________________________________________
flatten (Flatten)            (None, 86528)             0
_________________________________________________________________
dense (Dense)                (None, 64)                5537856
_________________________________________________________________
dropout_3 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 65
=================================================================
Total params: 5,668,097
Trainable params: 5,668,097
Non-trainable params: 0
_________________________________________________________________
```

Fig 6. Model Summary

To generate extra data, image flipping and rotation at various angles were used. The dataset has been further enlarged with some more image instances of the minority class for dataset balancing in terms of proportion of photos with distinct class labels. After data augmentation and dataset balancing, the CNN model has been trained and then the model has been tested by using a test set. The CNN model's performance was then assessed using various performance indicators. The process of chest X-Ray image based COVID-19 from disease classification also involves repeated classification calculations and computations.

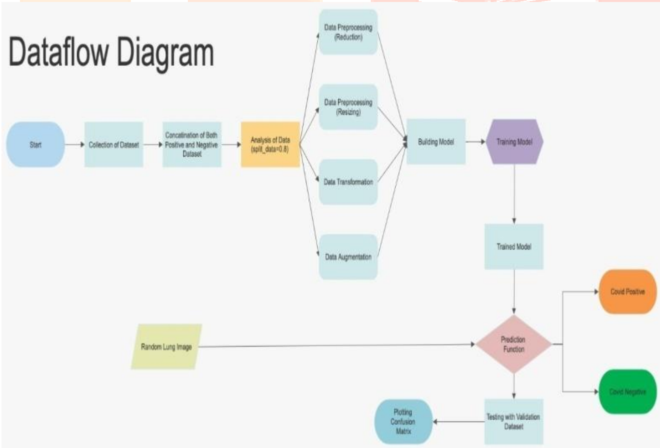


Fig 7. Dataflow for CNN

4.2 Inception V3:

Inceptionv3 improves upon the previous inception architectures by being more computationally inexpensive. Inception modules are the fundamental components of an inception model. An Inception Module allows for efficient computation and deeper networks through a dimensionality reduction with stacked 1×1 convolution. The modules were designed to address a variety of difficulties, including computational cost and overfitting. The inception module's core principle is to run many filters of varied sizes in parallel rather than in series. The Inception modules' networks feature an extra 1x1 convolution layer before the 3x3 and 5x5 convolution layers, making the method computationally cheap and reliable.

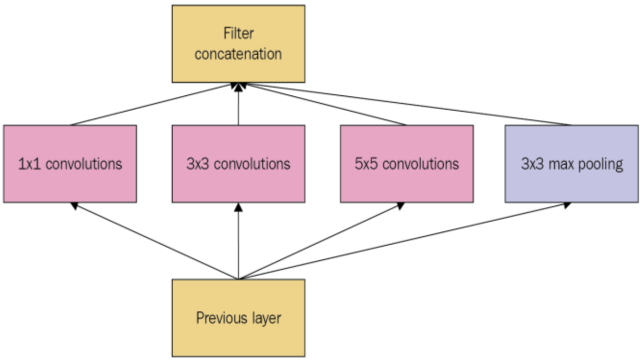


Fig 8. InceptionV3 architecture

A pre-trained inceptionv3 model (trained on the Imagenet dataset) is used in our research. The classification part of the model, i.e., the head of the model, is then replaced with dense layers of 128 x 1 for binary classification and 128 x, 12 x 1 for ternary classification, respectively. The model is then fine-tuned for enhanced feature extraction using COVID X-ray images. Inception v3 is given a 224 × 224 x 3 input image for training. The input is then passed through multiple inception modules, which help minimize overfitting while lowering computing costs.

4.3 ResNet:

We exploit the strength of transfer learning using ResNet-50 for training the network on a set of pre-processed X-RAY/CT-Scan images. With more layers, the network learns more features and generalizes better. ResNet does this by creating a "identity shortcut link" that bypasses one or more intermediate levels. In other words, an early layer's output gets passed on to a deeper layer. It was trained on the ImageNet dataset, which has 11 million images and 11,000 categories, which is massive in comparison to the dataset we have here.

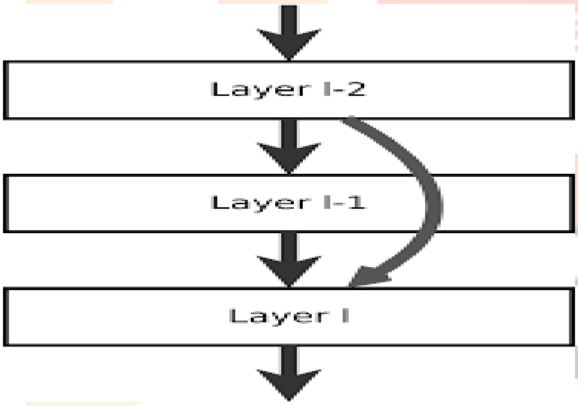


Fig 9. ResNet Layer Skipping

5 Experimental Results

After training the different models for the detection of COVID-19 using chest X-ray and CT scan, we have been able to attain the results as shown in the following table. The different models perform differently on a given image input based on their trained architecture and weights. However, in all models the detection of a normal i.e. non-covid chest X-ray or CT scan, the results gave discrepancies mainly.

We even tested the model with COVID positive half lung images and got correct results implying that the models are able to perform adequately well. The accuracy can be calculated for all the models using the table and the formula given below:

Accuracy = (TP+TN)/(TP+TN+FP+FN).

Where,

TP = True Positive, FP= False Positive

TN = True Negative FN=False Negative

Model	Covid detection Accuracy	Covid Detection Failure	Non-Covid Detection Accuracy	Non-Covid Detection Failure
CNN for X-ray	86%	14%	66%	34%
ResNet for X-ray	94%	6%	71%	29%
ResNet for CT-scan	96%	4%	81%	19%
InceptionV3 for X-ray	95%	5%	92%	8%
InceptionV3 for CT-scan	67%	33%	81%	19%

Table : Comparing Accuracies among different approaches and Radiographic Images

6 CONCLUSIONS

The rapid spread of COVID-19 across the world and the increasing number of deaths require urgent actions from all sectors. Future prediction of potential infections will enable authorities to tackle the consequences effectively.

In this paper, deep learning techniques were proposed for the detection of COVID-19. Detection models such as the Inception v3, ResNet and CNN algorithms were used to detect the COVID-19 confirmations.

7 References

[1]Organization, W.H. WHO Coronavirus Disease (COVID-19) Dashboard. Available from: https://covid19.who.int

[2]"COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)". ArcGIS. Johns Hopkins University. Retrieved 3 June 2021.

[3]Y. LeCun, Y. Bengio, G. Hinton, Deep learning Nature, 521 (2015), pp. 436-444, 10.1038/nature14539

[4]Muhammad AdnanShereen, SulimanKhana, AbeerKazmi, NadiaBashir, RabeeaSiddiqueCOVID-19 infection: Emergence, transmission, and characteristics of human coronaviruses. In Journal of Advanced Research Volume 24, July 2020, Pages 91-98

[5]Organization, W.H.Coronavirus disease (COVID-19) advice for the public. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

[6]SudhenB.Desai, AnujPareekMatthew P.LungrenDeep learning and its role in COVID-19 medical imaging. In Intelligence-Baswd Medicine Volume 3-4, December 2020,100013

[7]Rodrigues, J., et al., An update on COVID-19 for the radiologist-A British society of Thoracic Imaging statement. Clinical radiology, 2020. 75(5): p. 323-325

[8]Nair, A., et al., A British Society of Thoracic Imaging statement: considerations in designing local imaging diagnostic algorithms for the COVID-19 pandemic. Clinical Radiology, 2020. 75(5): p. 329-334.

[9]Hani, C., et al., COVID-19 pneumonia: A review of typical CT findings and differential diagnosis. Diagnostic and interventional imaging, 2020.

[10]Zhu, J., et al., CT imaging features of 4,121 patients with COVID-19: a meta-analysis. Journal of Medical Virology, 2020.

[11]Jacobi, A., et al., Portable chest X-ray in coronavirus disease-19 (COVID-19): A pictorial review. Clinical Imaging, 2020.

[12]Wang, Y.X.J., et al., The role of CT for Covid-19 patient's management remains poorly defined. Annals of Translational Medicine, 2020. 8(4).

[13]Li, D., et al., False-negative results of real-time reverse-transcriptase polymerase chain reaction for severe acute respiratory syndrome coronavirus 2: role of deep-learning-based CT diagnosis and insights from two cases. Korean journal of radiology, 2020. 21(4): p. 505-508.

[14]Nanni, L., S. Ghidoni, and S. Brahnam, Handcrafted vs. non-handcrafted features for computer vision classification. Pattern Recognition, 2017. 71: p. 158-172.

[15]LeCun, Y.and Y.Bengio, Convolutional networks for images, speech, and time series. The handbook of brain theory and neural networks, 1995. 3361(10): p. 1995.

[16]Shorten, C. and T.M. Khoshgoftaar, A survey on image data augmentation for deep learning. Journal of Big Data, 2019. 6(1): p. 60.

[17]Narin, A., C. Kaya, and Z. Pamuk, Automatic detection of coronavirus disease (covid-19) using x-ray images and deep convolutional neural networks. arXiv preprint arXiv:2003.10849, 2020.

[18]Covid-19 Detection Android app based on chest X-Rays CT scans. NitinBasantwani , Ashish Kumar , SumitGangwar , AshishOlkha , PrincePrijwal Gauri Mathur

[19]Medical Imaging and Computational Image Analysis in COVID-19 Diagnosis: A Review.ShahabedinNabavi, Azar Ejmalian, Mohsen Ebrahimi Moghaddam, Ahmad Ali Abin, Alejandro F. Frangi, Mohammad Mohammadi, HamidrezaSaligheh Rad COVID-19 research Community, ResearchGate

[20] Chest X-Ray Images(Pneumonia) Available from: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

[21] Covid-chestxray-dataset. Available from: https://github.com/ieee8023/covid-chestxray-dataset

[22] CT Diagnosis of COVID, Available from:https://covid-ct.grand-challenge.org/CT-diagnosis-of-COVID-19/

[23]LucaBrunese, FrancescoMercaldoa, AlfonsoReginelli, AntonellaSantone,Explainable Deep Learning for Pulmonary Disease and Coronavirus COVID-19 Detection from X-rays.Computer Methods and Programs in Biomedicine Volume 196, November 2020, 105608