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Detection of Pneumonia Using Deep Transfer Learning

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***Abstract*: Pneumonia is one of the most not unusual infections in the world these days typically due to microorganisms, fungi or viruses. Pneumonia is swelling of the tissue in one or each lung. It's typically because of a bacterial infection. A few of the maximum common signs of pneumonia consist of cough, hard breathing, speedy heartbeat, high temperature, sweating and shivering, lack of urge for food, chest ache and many others. It is accountable for greater than one million hospitalizations and fifty thousand deaths in the United States o. Most are not unusual practices to pick out the symptoms of pneumonia by using chest X - rays. Two of the most commonplace types of pneumonia determined in human lungs are viral and bacterial. Doctors can distinguish between viral and bacterial pneumonia with the aid of examining the chest X-ray.**

***Keywords*: Pneumonia, Chest x-ray.**

1. Objective

In this challenge, we're going to visualize and expand a Convolution Neural Network (CNN) to hit upon pneumonia signs in the affected person and further differentiate between bacterial pneumonia and viral pneumonia and we are also going to preprocess the photo dataset the use of various the photo-processing algorithms.

A. Dataset Used

https://kaggle.Com/paultimothymooney/chest-xray-pneumonia

Digital Image Processing method processing virtual photos by way of a virtual laptop. It includes the use of pc algorithms, so one can get enhanced photographs to extract some beneficial statistics. Image processing consists of the various steps along with uploading the photo referred to as Image Acquisition. After that, analysing and manipulating the picture involves the usage of numerous algorithms after which acquiring the output which may be the altered picture or a report that is based totally on the evaluation of the input picture.

We already accrued the photo dataset in the first evaluation, now we're going to carry out manipulation of images the use of under referred to strategies.

B. Literature Review

JC Souza et al. [1] proposed that one of the most used imaging techniques for detection of pneumonia is Chest X-ray (CXR). Researchers are exploring the application of various image processing and machine learning algorithms to develop computer aided detection (CAD) systems which provide support in the challenging task. This paper proposed a fully automatic method using a CNN model for lung field segmentation in CXR.

HJ Zar et al. [2] proposed that one of the most important causes of morbidity in youngsters has become pneumonia. A study finished by means of Darkenstein Child Health shows pneumonia is spreading enormously despite awesome immunization coverage. According to the examination, new interventions are required for preventing formative years LRTI to ensure long term health.

JD Dear [3] proposed that puppies are broadly speaking diagnosed with bacterial pneumonia while in the case of cat inflammatory bronchial sickness is more frequent than bacterial pneumonia. A study tells that during younger dogs, viral infection is accompanied by a bacterial attack. Hence, the basic motive of pneumonia needs to be diagnosed for the treatment observed with the aid of antibiotic remedy and prevention from air secretions.

D. Wilmes et al. [4] proposed that people who present process immunosuppressive therapy after kidney transplant are extra at risk of bacterial pneumonia. The creator has defined the most common pneumonia-causing pathogen after kidney transplant, their scientific presentation, radiological capabilities and treatments. This article shows that spotting the worried pathogen is most essential to initiate any antibiotic therapy and to calculate the duration of remedy.

O. Henig et al. [5] proposed that older adults are more at risk of pneumonia due to resistant organisms which include Gram-negative bacilli. Various related symptoms include confusion, scientific deterioration, new onset of recurrent fall and many others. The creator suggests the remedy of pneumonia be based on chance elements and multidrug-resistant organisms not unusual in older adults.

JL Wong et al. [6] proposed that patients with cancer have disproportionate morbidity and mortality. Cancer-related dysfunctions of the lungs, mucositis all lead to bacterial pneumonia risks. Patients suspected of bacterial pneumonia are suggested to take early antibiotic therapy to cover pathogens encountered in the health care setting.

D. Das et al. [7] proposed that chest X-ray manifestations of

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pneumonia are important as they guide the patients to undergo appropriate therapy and anticipate complications. CXR patterns can help the readers to find out different causes. Frequent CXRs should be taken during the treatment as the persistence or progression of the initial CXR can indicate the progress or failure of treatment.

AR Falsey et al. [8] proposed that most frequent victims of viral pneumonia are extreme age groups i.e., children and elders. In most of the cases the initial attack by the respiratory virus results in pneumonia in children who don't have immunity

S.No.	Author	Technique	Data Set	Metrics
1	JC Souza JOB Diniz JL Ferreira GLF da Silva AC Silva AC de Paiva	• AlexNet based CNN • ResNet-18-based CNN • Chest X-ray • Image segmentation • Image Reconstruction • Keras Algorithm • Tensorflow	The Montgomery county dataset is used which is a public chest x-ray dataset from the Department of health and human services of Montgomery County, Maryland. 138 CXRs out of which 80 are normal and 58 affected.	• Segmentation • Sensitivity • Specificity • Accuracy • Dice • Jaccard
2	HJ Zar	• Lung Ultrasound • Chest X-ray • PCR Analysis	The dataset consists of 1140 mother-child pairs with completion of all 1 year follow-up visits and high cohort retention.	• Environmental factors • Infectious factors • Nutritional factors • Genetic factors • Psychological factors • Maternal factors • Immunological factors
3	JD Dear	• Thoracic Radiography • CT Scan • Hematology • Genetic factors	The research was conducted on an 8-year-old female spayed Chihuahua mix a presented for wet cough and a 5-year-old male catered domestic medium hair cat presented for evaluation of acute respiratory distress.	• Temperature • Pulse • Respiratory rate • White blood cell count • Cellularity
4	D Wilmes E Coche H Rodriguez Villalobos N Kanaan	• Chest X-ray • Lung CT-scan • Spectrometry	Chest X-ray of a 75-year-old man admitted for 17 years after kidney transplantation and a 54-year-old man transplanted with a kidney one year ago presented with cough, fatigue and anorexia.	• Morbidity • Mortality • Bacterial behavior
5	O Henig KS Kaye	• Management of Community acquired Pneumonia • Outcomes of Pneumonia Among Residents of Long-term Care Facilities	Epidemiology of bacterial pathogens causing CAP among elderly patients and residents of LTCF, and risk factors for each organism.	• Range of Prevalence
6	JL Wong SE Evans	• Radiographic images • Computed tomography • Microbiologic • techniques • Molecular Diagnostics • Antibiotic Therapy • Nonbronchoscopic Diagnostics	Radiographic presentations of bacterial pneumonia in patients with cancer. Computed tomography images of patients with cancer with documented bacterial pneumonias	• Presence of • Gram-positive bacteria • Gram-negative bacteria • Atypical Bacteria
7	D Das DC Howlett	• Chest X-ray	Chest X-ray patterns, including lobar pneumonia, bronchopneumonia, nodular consolidation, interstitial consolidation, atypical pneumonia, and lung abscesses.	• Lung abscess • Nodular consolidation • Nodular opacification
8	AR Falsey	• Chest Radiography • Reverse transcription polymerase chain reaction (RT PCR)	• Chest radiograph of a 63-year-old woman who had mitral stenosis • Chest radiograph of a 75-year-old with fever, cough, and dyspnea • Chest radiograph of a 68-year-old man with history of emphysema.	• Opacity in chest radiography images • White blood cell count
9	S Nayak D Pradhan H Singh MS Reddy	• Computational screening of potential drug targets • Comparative mining of putative drug targets • Chokepoint enzyme • PPI network analysis and Identification of hub genes	Representation of steps involved in comparative target identification of 13 bacterial pathogens. Identified targets of Streptococcus pneumoniae TIGR4 were used to develop drugs or vaccines.	• Drug Targets • Metabolic pathways • Protein-Protein Interaction • Chokepoint enzymes
10	SB Erdem D Can S Girit F Catal V Sen S Pekcan R Ersu	• Virus detection and identification • Skin Prick test • Statistical Analysis • Ethical Approval	A total of 280 patients from nine centers were included in the study. of these patients, 163 (58.2%) were male. RSV (29.7%), Influenza (20.5%), and many more were isolated from respiratory samples.	• Atopy • Age • Body mass index • Hospitalization Period • Fever • SaO_2

and the airways are not developed. Influenza virus is found to be the main cause of morbidity in older adults. Respiratory viruses show different clinical syndromes within themselves and other bacterial pathogens.

S. Nayak et al. [9] proposed that broad spectrum antibiotics are used to treat pneumonia because it is difficult to diagnose the pneumonia causing organism. The solution is to target the drug to a protein that is common to bacteria species. It can be used before identification of pneumonia causing organisms as soon as symptoms are identified. The author discussed computational subtractive genomics approach which facilitates identification of putative drug targets.

SB Erdem et al. [10] proposed that atopy presence has an effect on young children within age 1 to 6 years suffering from viral pneumonia. Atopy is referred to as positive skin prick tests to one or more allergens. The results of this study revealed that moderate pneumonia patients were compared with severe pneumonia patients, the frequency of atopy was not different. Hence, there was no effect of atopy on severity of pneumonia on children.

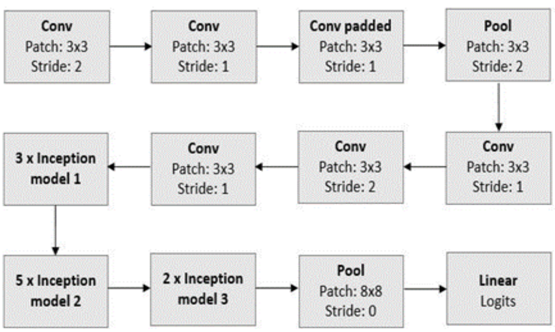


Fig. 1. Basic architecture of inception -V3

2. Image Enhancement in the Frequency Domain

A. Fourier Transform

It converts the entered photograph from spatial area to frequency area. It plots the picture as a hard and fast of excessive and low frequencies with low frequencies located toward the centre while high frequencies are scattered around.

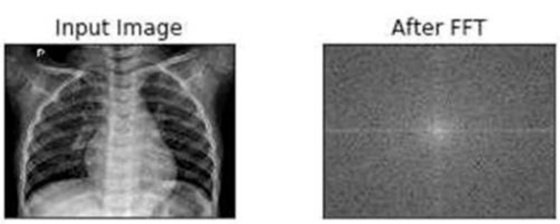


Fig. 2. Input image and after FFT

The Fourier rework of the image can be further processed for software like aspect detection, the use of excessive bypass or band pass filter out, noise reduction and blurring the use of a low bypass filter.

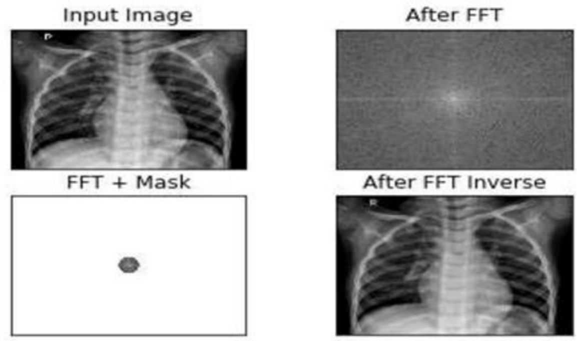


Fig. 3. Applying high pass filter

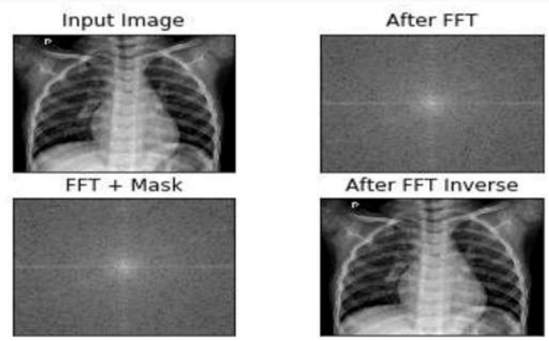


Fig. 4. Applying low pass filter

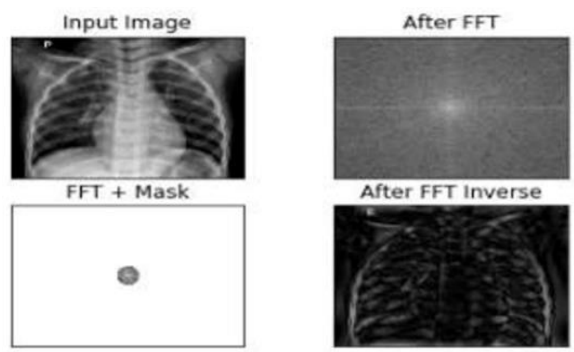


Fig. 5. Applying band pass filter

3. Image Restoration Using Morphological Process

Introducing noise to image:

Here we are adding Gaussian noise to the input image.

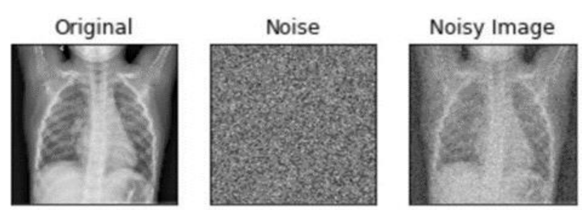


Fig. 6. Introducing noise to image

To reduce the noise introduced in the image various filters are tried.

2D Convolution:

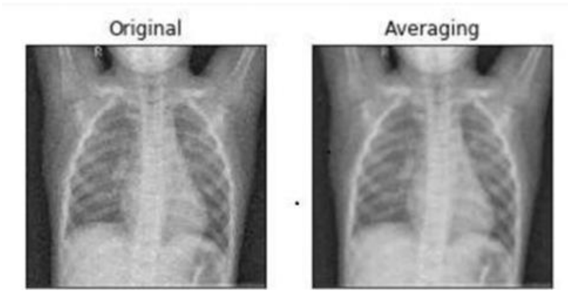


Fig. 7. Averaging filter

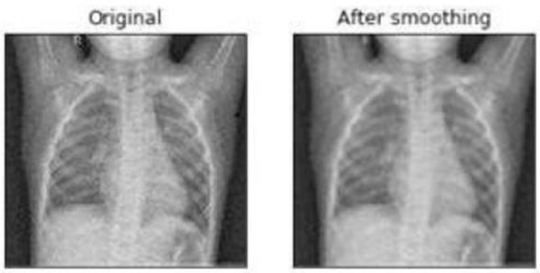


Fig. 8. Median filter

Fig. 9.

4. Image Segmentation

A. *Image Thresholding*

Fig. 10.

B. *Morphological Process (for noisy and original)*

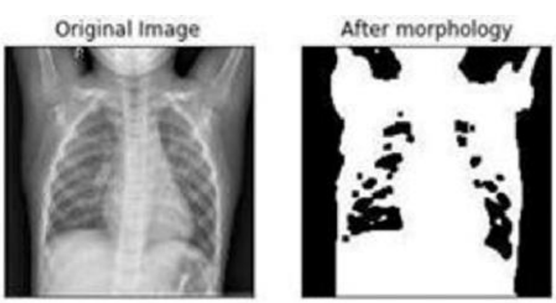


Fig. 11.

Canny algorithm:

Here we have used the canny algorithm of the OpenCV library in python for the detection of edges.

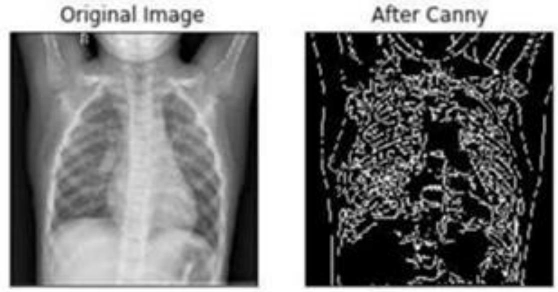


Fig. 12.

Contours:

The next block of code is written to draw the image contours using draw contours function of the OpenCV.

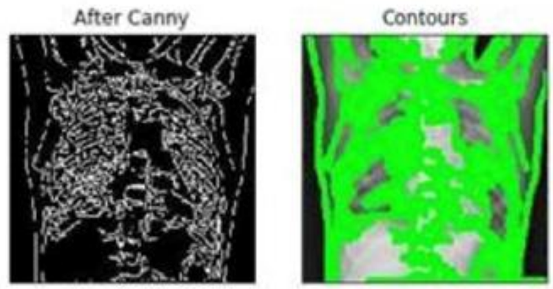


Fig. 13.

5. Methodology

In this section, we're going to visualize and expand a Convolution Neural Network (CNN) to hit upon pneumonia symptoms in the patient and further differentiate between bacterial pneumonia and viral pneumonia.

Recently, CNN-inspired deep learning algorithms have come to be the same old choice for clinical picture classifications even though the modern-day CNN-based totally classification techniques pose similar fixated network architectures of the trial-and-error system that have been their designing principle.

Here is a demonstration of the way a health practitioner classifies a chest x-ray of an ordinary affected person with that of the affected person diagnosed with pneumonia. The left photograph depicts ordinary lungs with no regions of opacification within the photo. The centre photo depicts bacterial pneumonia displaying a focallobar consolidation in the proper higher lobe (proven by way of the arrows). The proper photo depicts viral pneumonia with an extra diffuse sample in each lung.

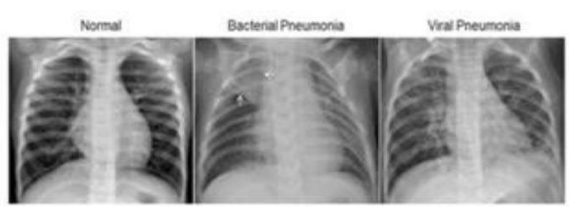


Fig. 14.

How is pneumonia recognized and evaluated?

Your primary doctor will begin by asking you approximately your clinical records and signs. You may also undergo a bodily exam, in order that your health practitioner can concentrate on your lungs. In checking for pneumonia, your physician will listen for abnormal feelings like crackling, rumbling or wheezing. If your physician thinks you may have pneumonia, an imaging takes a look at may be performed to affirm the diagnosis.

One or more of the subsequent tests can be ordered to evaluate for pneumonia:

Chest x-ray: An x-ray exam will permit your health practitioner to see your lungs, heart and blood vessels to help determine if you have pneumonia. When interpreting the x-ray, the radiologist will search for white spots inside the lungs (known as infiltrates) that become aware of contamination. This exam will also assist decide if you have any complications associated with pneumonia along with abscesses or pleural effusions (fluid surrounding the lungs).

Dataset used:

https://kaggle.Com/paultimothymooney/chest-xray-pneumonia

This dataset consists of 5,863 jpeg photographs of chest X-rays divided into two categories – Pneumonia and normal. These photographs have been selected from retrospective cohorts of pediatric patients of age one to 5 years from Guangzhou Women and Children's Medical Center, Guangzhou. All chest x-rays were imaged as a part of recurring fitness care.

For the evaluation of chest x-ray pix, all chest radiographs were first of all screened for great management with the aid of getting rid of all low first-rate or unreadable scans. The diagnoses for the pics had been then graded through two expert physicians before being cleared for schooling the AI gadget. In order to account for any grading mistakes, the assessment set is also checked by a 3rd expert.

Chest X-Ray Dataset:

Table 2
Number of images under test and train files

Type	**Test**	**Train**
Normal	234	1341
Pneumonia	390	3875

Expected Result:

To find out how accurately the applied algorithm can distinguish between patients diagnosed with pneumonia or not on the basis of the chest x rays.

6. Algorithm Used

Transfer Learning:

Transfer learning is a machine learning method where a version advanced for a project is reused as the starting point for a version on a second task. It is a famous approach in deep mastering wherein pre-skilled models are used because the starting point on laptop imaginative and prescient and herbal language processing duties given the sizeable compute and time assets required to broaden neural network fashions on those issues and from the massive jumps in ability that they provide on related problems.

Goals:

1. To classify images without making any custom version however instead the usage of keras built in fashions.
2. To get excessive accuracy for classifying almost any photo.

Advantages of Transfer Learning:

1. Super easy to include.
2. Achieve equal or maybe better (depending on the dataset) version overall performance speed.
3. There's not as many classified statistics required.
4. Versatile makes use of instances from transfer studying, prediction, and feature extraction.

Implementation:

Importing libraries

```
In [4]: import pandas as pd
        import cv2
        import numpy as np
        import os
        from random import shuffle
        from tqdm import tqdm
        import scipy
        import skimage
        from skimage.transform import resize
```

A function to label the images in the dataset based upon whether the person is normal or diagnosed with pneumonia Normal patient has been labeled 0.

A characteristic that takes the dataset directory as an argument written to carry out preprocessing at the photograph dataset which incorporates

- Image grey-scaling
- Image resizing
- Storing the grayscale values and labels in x and y variables

Combining the above two features to write the characteristic get data with directory as an argument returning the x and y variables containing arrays of image greyscales and labels respectively.

```
In [10]:
def get_data(Dir):
    X = []
    y = []
    for nextDir in os.listdir(Dir):
        if not nextDir.startswith('.'):
            if nextDir in ['NORMAL']:
                label = 0
            elif nextDir in ['PNEUMONIA']:
                label = 1
            else:
                label = 2

            temp = Dir + nextDir

            for file in tqdm(os.listdir(temp)):
                img = cv2.imread(temp + '/' + file)
                if img is not None:
                    img = skimage.transform.resize(img, (150, 150, 3))
                    #img_file = scipy.misc.imresize(arr=img_file, size=(299, 299, 3))
                    img = np.asarray(img)
                    X.append(img)
                    y.append(label)

    X = np.asarray(X)
    y = np.asarray(y)
    return X,y
```

Applying the get_data function to train and test directories to get (X_train, y_train) and (X_test, y_test) pairs respectively.

```
In [11]: X_train, y_train = get_data(TRAIN_DIR)

100%|██████████| 3876/3876 [07:54<00:00,  8.18it/s]
100%|██████████| 1342/1342 [09:48<00:00,  2.85it/s]
```

```
In [12]: X_test , y_test = get_data(TEST_DIR)

100%|██████████| 390/390 [00:36<00:00, 12.23it/s]
100%|██████████| 234/234 [01:41<00:00,  2.08it/s]
```

```
In [37]: print(X_train.shape,'\n',X_test.shape)

(5216, 3, 150, 150)
 (624, 3, 150, 150)
```

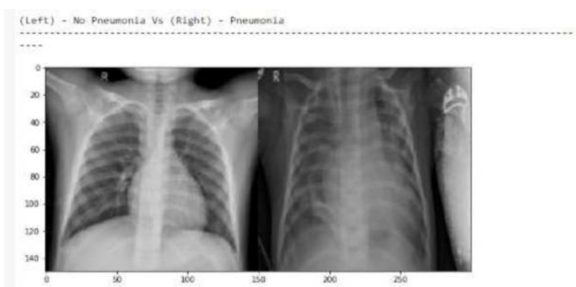
```
In [57]: print(y_train.shape,'\n',y_test.shape)

(5216, 2, 2)
 (624, 2, 2)
```

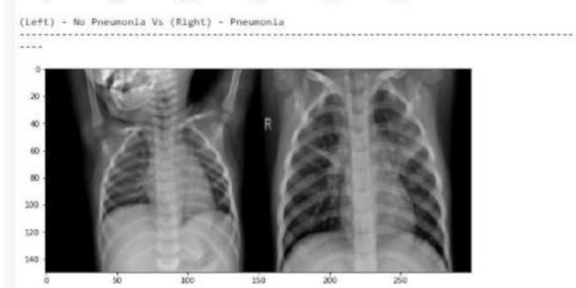
Using matplotlib to demonstrate pneumonia and no pneumonia images side by side.

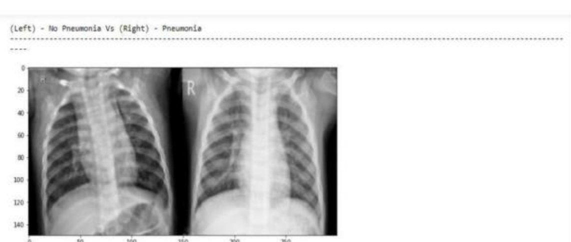
```
In [17]: Pimages = os.listdir(TRAIN_DIR + "PNEUMONIA")
         Nimages = os.listdir(TRAIN_DIR + "NORMAL")
```

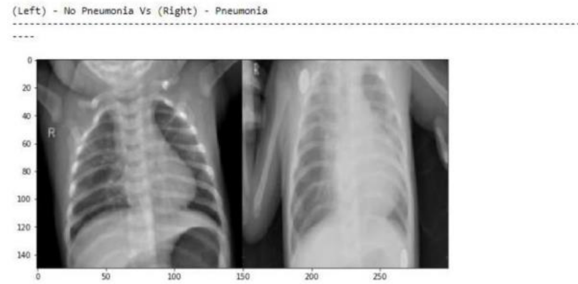
```
In [20]: import matplotlib.pyplot as plt
         def plotter(i):
             imagep1 = cv2.imread(TRAIN_DIR+"PNEUMONIA/"+Pimages[i])
             imagep1 = skimage.transform.resize(imagep1, (150, 150, 3) , mode = 'reflect')
             imagen1 = cv2.imread(TRAIN_DIR+"NORMAL/"+Nimages[i])
             imagen1 = skimage.transform.resize(imagen1, (150, 150, 3))
             pair = np.concatenate((imagen1, imagep1), axis=1)
             print("(Left) - No Pneumonia Vs (Right) - Pneumonia")
             print("-----------------------------------------------------------------
             plt.figure(figsize=(10,5))
             plt.imshow(pair)
             plt.show()
         for i in range(5,10):
             plotter(i)
```

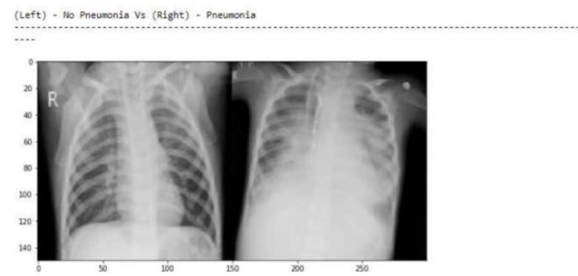
In the below images, it can be seen that the right-side images are chest x-rays of the person diagnosed with pneumonia. It is differentiated by observing the increased amount of cloudiness in the lungs.











Models often benefit from reducing the learning rate once learning stagnates. For this, we used ReduceLROnPlateau which monitors accuracy by setting the factor by which to reduce the learning rate as 0.1. Verbose is 1: update messages.

Patience: number of epochs that produced the monitored quantity with no improvement after which training will be stopped.

```
In [21]: from keras.callbacks import ReduceLROnPlateau , ModelCheckpoint , LearningRateScheduler
         lr_reduce = ReduceLROnPlateau(monitor='val_acc', factor=0.1, epsilon=0.0001, patience=1, verbose=1)

/anaconda3/lib/python3.7/site-packages/keras/callbacks.py:1335: UserWarning: `epsilon` argument is deprecated and will be remov
ed, use `min_delta` instead.
  warnings.warn('`epsilon` argument is deprecated and '
```

Transfer learning is a machine learning method where a model developed for a task is reused as the starting point for a model on a second task.

It is a popular approach in deep learning where pre-trained models are used as the starting point on computer vision and natural language processing tasks given the vast compute and time resources required to develop neural network models on these problems and from the huge jumps in skill that they provide on related problems.

We specified the transfer learning weights filepath and called it Model CheckPoint to save the model to the given file path after every epoch.

```
In [22]: filepath="transferlearning_weights.hdf5"
         checkpoint = ModelCheckpoint(filepath, monitor='val_acc', verbose=1, save_best_only=True, mode='max')
```

Inception v3 is a widely-used image recognition model that has been shown to attain greater than 78.1% accuracy on the ImageNet dataset. The model is the culmination of many ideas developed by multiple researchers over the years.

Importing and preparing the base InceptionV3 model

```
In [39]: from keras.applications.inception_v3 import InceptionV3
         # create the base pre-trained model
         base_model = InceptionV3(weights=None, include_top=False , input_shape=(150, 150,3))
```

```
In [40]: x = base_model.output
         x = Dropout(0.5)(x)
         x = GlobalAveragePooling2D()(x)
         x = Dense(128, activation='relu')(x)
         x = BatchNormalization()(x)
         predictions = Dense(2, activation='sigmoid')(x)
```

Model summary:

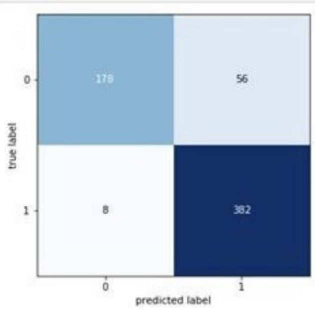
```
In [45]: print(model.summary())

Model: "model_1"
```

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 150, 150, 3)	0	
conv2d_1 (Conv2D)	(None, 74, 74, 32)	864	input_1[0][0]
batch_normalization_1 (BatchNor	(None, 74, 74, 32)	96	conv2d_1[0][0]
activation_1 (Activation)	(None, 74, 74, 32)	0	batch_normalization_1[0][0]
conv2d_2 (Conv2D)	(None, 72, 72, 32)	9216	activation_1[0][0]
batch_normalization_2 (BatchNor	(None, 72, 72, 32)	96	conv2d_2[0][0]
activation_2 (Activation)	(None, 72, 72, 32)	0	batch_normalization_2[0][0]
conv2d_3 (Conv2D)	(None, 72, 72, 64)	18432	activation_2[0][0]
batch_normalization_3 (BatchNor	(None, 72, 72, 64)	192	conv2d_3[0][0]
activation_3 (Activation)	(None, 72, 72, 64)	0	batch_normalization_3[0][0]
max_pooling2d_1 (MaxPooling2D)	(None, 35, 35, 64)	0	activation_3[0][0]

7. Results

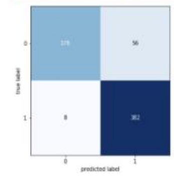
Hence, we achieve 97% accuracy of actually being diagnosed with Pneumonia after applying Convolution Neural network to the given dataset and 76% accuracy of not being diagnosed with Pneumonia.

```
In [50]: from sklearn.metrics import confusion_matrix
         pred = model.predict(X_test)
         pred = np.argmax(pred,axis = 1)
         y_true = np.argmax(y_test,axis = 1)

In [52]: CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()
```

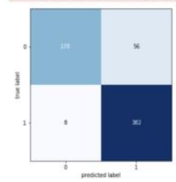



```
In [1]: 178/(178+56)
Out[1]: 0.7606837606837606

In [54]: 382/(382+8)
Out[54]: 0.9794871794871794
```

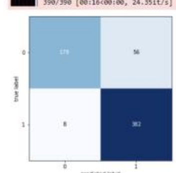
```
In [47]: fx_test , fy_test = get_data("Median/")
         fy_test = to_categorical(fy_test, 2)
         fx_test=fx_test.reshape(624,150,150,3)

         fpred = model.predict(fx_test)
         fpred = np.argmax(fpred,axis = 1)
         fy_true = np.argmax(fy_test,axis = 1)
         CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()

100%| 234/234 [00:10<00:00, 21.91it/s]
100%| 390/390 [00:16<00:00, 23.22it/s]
```



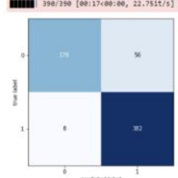

```
In [49]: fx_test , fy_test = get_data("Blurring/")
         fy_test = to_categorical(fy_test, 2)
         fx_test=fx_test.reshape(624,150,150,3)

         fpred = model.predict(fx_test)
         fpred = np.argmax(fpred,axis = 1)
         fy_true = np.argmax(fy_test,axis = 1)
         CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()

100%| 234/234 [00:09<00:00, 24.07it/s]
100%| 390/390 [00:16<00:00, 23.76it/s]
```



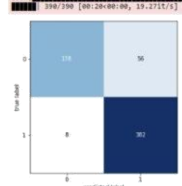

```
In [48]: fx_test , fy_test = get_data("Bilateral/")
         fy_test = to_categorical(fy_test, 2)
         fx_test=fx_test.reshape(624,150,150,3)

         fpred = model.predict(fx_test)
         fpred = np.argmax(fpred,axis = 1)
         fy_true = np.argmax(fy_test,axis = 1)
         CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()

100%| 234/234 [00:11<00:00, 20.74it/s]
100%| 390/390 [00:16<00:00, 24.35it/s]
```




```
In [46]: fx_test , fy_test = get_data("Affine/")
         fy_test = to_categorical(fy_test, 2)
         fx_test=fx_test.reshape(624,150,150,3)

         fpred = model.predict(fx_test)
         fpred = np.argmax(fpred,axis = 1)
         fy_true = np.argmax(fy_test,axis = 1)
         CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()

100%| 234/234 [00:10<00:00, 21.34it/s]
100%| 390/390 [00:17<00:00, 22.75it/s]
```




```
In [46]: fx_test , fy_test = get_data("2DConv/")
         fy_test = to_categorical(fy_test, 2)
         fx_test=fx_test.reshape(624,150,150,3)

         fpred = model.predict(fx_test)
         fpred = np.argmax(fpred,axis = 1)
         fy_true = np.argmax(fy_test,axis = 1)
         CM = confusion_matrix(y_true, pred)
         from mlxtend.plotting import plot_confusion_matrix
         fig, ax = plot_confusion_matrix(conf_mat=CM ,  figsize=(5, 5))
         plt.show()

100%| 234/234 [00:10<00:00, 23.28it/s]
100%| 390/390 [00:20<00:00, 19.27it/s]
```



8. Conclusion

This project is a small step toward the huge contribution of image processing and deep learning towards the medical field with a lot more to come in the future. The model we prepared was successful with 98% approximately when the patient was diagnosed with pneumonia. Transfer Learning along with image processing algorithms are the main driving force behind this project. Transfer learning is going to be one of the key drivers for machine learning and deep learning success in mainstream adoption in the industry.

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