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Pneumonia Detection Using Convolution Neural Network

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***Abstract*— Pneumonia is recognized as a highly infectious disease, which spreads rapidly among infants. According to UNICEF, 16% of all infant fatalities under the age of 5 were attributed to pneumonia in 2016. Due to less number and availability of doctors in India makes it a more vulnerable disease. The ultimate motive of this research paper is to utilize a Chest X-ray image to assess whether that individual has symptoms of pneumonia or normal. The reason why Convolution Neural Network (CNN) is utilized in this project is because of its robust processing abilities that make it well-suited for both image classification and image processing job. Several researchers in this wide domain use CNN, which is a quick and well-liked image processing and classification technology. This model will help in analyzing whether the person has pneumonia or not. In this model, we must provide the X-Ray images and it will predict whether he/she is normal or has pneumonia. It will reduce the dependency on the medical staff and results will be produced quickly. Furthermore, it can generate more accurate outcomes than the human eye, which may miss small details in an X-ray. The Chest X-Rays Images have been taken from Kaggle because it has a large dataset and is being divided into two types i.e., Pneumonia and Normal. The dataset comprises over 17,000 Chest X-rays depicting both healthy and pneumonia-infected lungs. The overall accuracy of this model is 88.62%**

Keywords—Pneumonia Detection, CNN, deep learning, lung disease, X-Ray Image.

I. INTRODUCTION

The air sacs which are present in our lungs get infected, it leads to pneumonia, a respiratory illness caused by environmental viruses that can make breathing difficult [1,2]. Pneumonia is majorly detected by analysing Chest X-Ray images due to its less cost. Detection of Pneumonia is difficult to find due to its similarity with other lung infections [3]. Figure 1 shows the lungs with Pneumonia. The obtained images were mostly analysed by radiologists, which is both laboursome and time taking [4]. Creating software that exclusively gathers Chest X-Rays images and detects whether an individual has pneumonia is an important topic of study in this area, owing to this concern [5]. This can be easily used by any person regardless of the fact whether he/she is a doctor or radiologist [6].

The primary aim of this project is to use chest X-ray images to determine if a patient is suffering from pneumonia [8]. Convolution Neural Networks will be used to develop the model because of its excellent accuracy and efficiency compared to SVM image categorization [9]. Chest X-Rays are commonly used to detect or find pneumonia in many countries due to their affordability and accessibility in comparison to other detection methods [10,11]. The machine learning model could be easily used in finding the infection in the lungs and will also reduce dependency on the medical staff [12]. This software will give more accurate results as compared to results that are analyzed by the naked human eye. Figure 2 shows how Pneumonia infects the lungs. Computer Aided solutions have been created for the detection and categorization of pneumonia [13,14]..

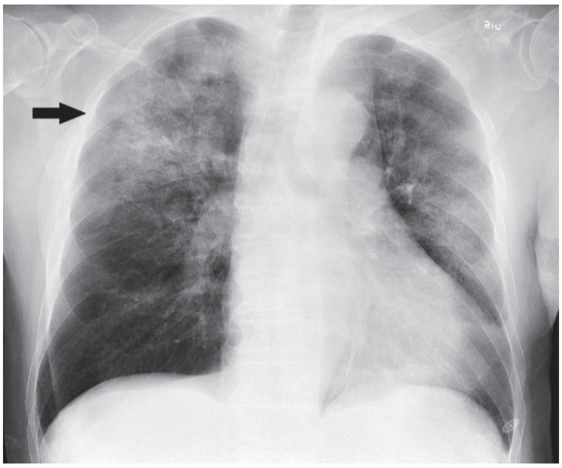

Fig. 1. Pneumonia in Lungs (Source: Browsed on Web Page [7])

Recent progress in machine learning has made image classification a challenging area of research, where images are pre-processed, models are trained using image information, and the most accurate results are generated [15,16]. Image classification has been utilized in the detection of various diseases which are difficult to study through the human eye [17]. This field of Artificial Intelligence is growing day by day because of its highly accurate and effective results which make early detection of disease possible and medications could be provided on time [18,19,20]. Machine learning, which is a subfield of AI (Artificial Intelligence), has accomplished significant success in constructing models for the classification of medical images [21,22,23].

As per healthcare professionals, Pneumonia is a communicable respiratory disease that damages the alveoli in the lungs, making it challenging for the organ to operate properly [25,26]. Most common symptoms which are declared by medical experts include chest pain, fever, cough which is mostly dry, feeling difficulty in breathing [27,28]. The symptoms of this infection will depend from person to person [29]. Major risk factors which are included with pneumonia are asthma, heart attack, poor functioning of the body, etc [30,31,32]. This infection is usually identified using Chest X-Ray images and can also find out using blood test samples [33,34].

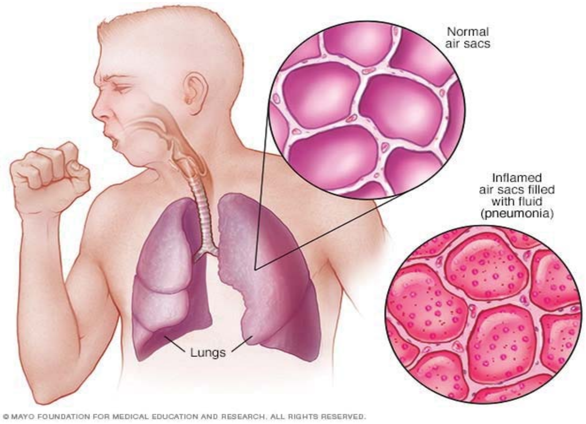

Fig. 2. Person with Pneumonia (Source: Browsed on Web Page [24])

II. Literature Survey

The following researches have been studied for further proceeding in the below proposed methodology:

Convolution neural networks were suggested by Szepesi et al [35] as a Deep Learning model since they are frequently utilised for accuracy and extremely effective results. With training, CNN can quickly identify features in images and is used to detect pneumonia in Chest X-Rays images. The main motive of this research study is the addition of a dropout layer with the different layers of the model which are taken with multiple values. After the creation of the desired model, the effective accuracy of this model is around 97% and it produces the prediction results in 122 ms.

A Machine Learning (ML) Algorithm based on the domain of deep learning image classification was proposed by Kundu et al [36] and is being developed for the diagnosis of pneumonia by taking Chest X-Rays as input and producing outputs of normal or pneumonia. The research which has been carried out was based on three CNN models namely Google Net, Res Net-18, and Dense Net-121. The major metrics which are concluded in this paper are as follows:

1. Accuracy: 98.81%
2. Sensitivity Rate: 98.8%
3. F1 Score: 98.79%
4. Precision Rate: 98.82%

According to Kaushik et al [37] suggested machine a learning model based on CNN image classification. In this paper, authors have created two models, one with 3 Convolution layers and another one with 4 Convolution layers. The overall feature of both models has been discussed below

1. The model with 3 Convolution Layers
   a. Accuracy: 92.3%
   b. F1 Score: 94%
   c. Recall: 98%
2. The model with 4 Convolution Layers
   a. Accuracy: 91.6%
   b. F1 Score: 94%
   c. Recall: 98%

In order to diagnosis of pneumonia using Chest X-Rays, Yu et al [38] proposed a deep learning based machine learning algorithm. They have included the graph implementation for more feature reconstruction-based image datasets. They have created a GNet model which is further converted into a neural network, which is used for pre-processing the images. A large publicly available dataset has been taken for the training of the model. Upon successful training of the model, the overall accuracy came up to 99%.

Rajasen bagam et. al [39], suggested a machine learning-based model which works on Deep Convolution Neural Network. Have created a TensorFlow Model with around 7000 training images of Chest X-Ray. In addition to this, have used a 200-image dataset for testing the created model. The overall accuracy came up to 99.53% upon the training of the model. This accuracy is greater than Res Net and Inception Net Models

III. Proposed Methodology

The following points shows the proposed methodology:

Dataset: The Kaggle platform was utilized to obtain the images for this study, owing for its extensive of Chest X-Rays images into two categories: normal and pneumonia. This data set consists of three subfolders containing images for training, testing, and validation, which are used to construct the model. The training data set includes approximately 5,863 Chest X-Rays images, consisting of both normal and pneumonic cases.

Image Pre-Processing: Then, we have pre-processed the X-rays dataset to make it according to our training model. Image Pre-processing will include Label encoding, data augmentation and resize.

Creating Model: After pre-processing the chest x-rays images dataset, will apply Convolution Neural Network (CNN) machine learning model to train our model.

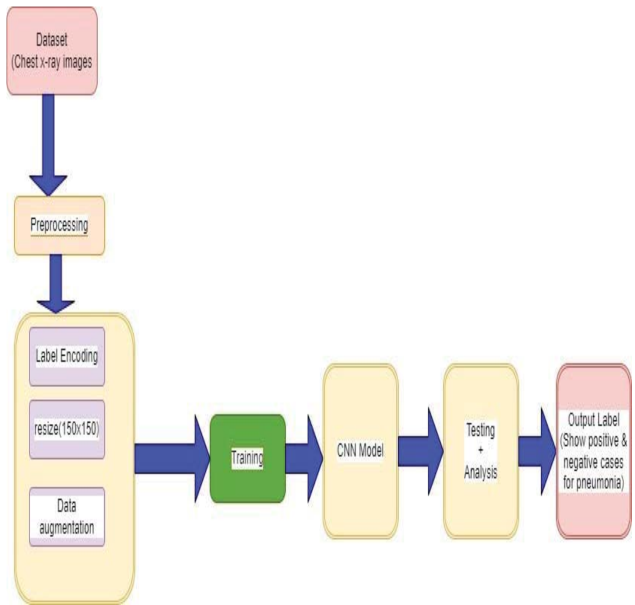

Fig. 3. Proposed Methodology

Testing: The testing Chest X-Ray images, located in the designated test data set folder, will be utilized to determine whether or not an individual has pneumonia.

Result: The output label will indicate "Pneumonia" or "Normal" which will be determined based on the Chest X-Rays. This suggested methodology is depicted in Figure 3.

Following points shows the detailed proposed methodology:

A. *Importing the Libraries*

In order to construct and implement the machine learning model, it is essential to import the necessary libraries. These important libraries are employed in convolution network modelling. The model's design integrates several libraries, such as Panda, Seaborn, Keras, Matplotlib, OpenCV, NumPy, and open dataset to enhance accuracy, performance, and employ effective algorithms with the help of data structures. Keras is an API that is used to represent fast experimentation with the neural network.

B. *Loading, Training, Validating & Testing Data*

The dataset available on Kaggle is segregated into three directories, namely Val (validation dataset), Test (testing dataset), and Train (training dataset). Images of greyscale chest X-rays may be found in these subfolders. There are two categories of images pneumonia or normal. These datasets have been taken from the Kaggle to train the model. After analysing the chest x-ray images, it removes all low-quality images. The diagnosed images are used for training the artificial intelligence system. If any error occurs in the system, then this could be resolved by the third expert to achieve more accuracy.

C. *Data Augmentation*

To improve accuracy while preventing overfitting problems, additional datasets should be incorporated into the existing data. The inclusion of more datasets enhances accuracy, boosts performance, and revitalizes diversity. These modified procedures, which alters arrays portrayal while maintaining the same label, are referred to as data augmentation strategies. The application of various techniques such as horizontal and vertical flips, colour-based grayscale, rotations random colour, colour jitters, and translations can enhance these methods. By incorporating these augmentations, the CNN model can improve the quality of training on the basis of provided data sets, ultimately resulting in the development of a highly resilient model.

Required considerations for data augmentation:

1. The rotation of some training images is around 30 degrees randomly.
2. The increment(zoom) of some images by 20% randomly.
3. The horizontal scaling of photographs by 10% of their width.
4. The 10% vertical scaling down of photos from their height.
5. The horizontal flipping of images. Work on the training dataset after the model is finished or ready.

IV. IMPLEMENTATION

This model utilizes the CNN method, particularly appropriate for image classification and processing, in training the machine learning algorithm. Following points shows the detailed implementation of the CNN model:

A. *Train Model Based on Neural Network*

During the deployment phase, the neural network, is trained for finding pneumonia effectively and accurately from Chest X-Rays images. The optimal weights used during the model training are utilized for further processing across various levels. Subsequently, the activation function is applied to further modify the weights to yield the most appropriate results for the model. Then, will calculate Loss, which is used to identify how well the model is working based on a certain task that is given.

The main aim of this training is to minimize this loss function for more accurate and effective results. For providing the images dataset to the images, there are two types of techniques namely, batch and epochs. The model is trained using epochs, wherein instead of feeding batches of photos for training, the entire image folder is provided during each epoch. This model is configured with 10 epochs, meaning that the complete image dataset is fed to the model ten times to enhance accuracy in the results. The model was developed in 10 epochs and took around an hour to finish with 17457 chest X-ray pictures in the data set, an accuracy near about 88.62%, and the value of loss function equals to 0.29. The summary of this model includes all the necessary details about the model like different types of layers, shape of output layers, parameters that are being taken, and weights which are assigned in the model.

```python
model = Sequential()
model.add(Conv2D(32,(3,3),strides=1,padding='same',activation='relu',input_shape=(150,150,1)))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2),strides=2,padding='same'))

model.add(Conv2D(64,(3,3),strides=1,padding='same',activation='relu'))
model.add(Dropout(0.1))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2),strides=2,padding='same'))

model.add(Conv2D(64,(3,3),strides=1,padding='same',activation='relu'))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2),strides=2,padding='same'))

model.add(Conv2D(128,(3,3),strides=1,padding='same',activation='relu'))
model.add(Dropout(0.2))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2),strides=2,padding='same'))

model.add(Conv2D(256,(3,3),strides=1,padding='same',activation='relu'))
model.add(Dropout(0.2))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2),strides=2,padding='same'))

model.add(Flatten())
model.add(Dense(units=128,activation='relu'))
model.add(Dropout(0.2))
model.add(Dense(units=1,activation='sigmoid'))
model.compile(optimizer="rmsprop",loss='binary_crossentropy',metrics=['accuracy'])
model.summary()
```

Fig. 4. CNN Model Created

This summary () function returns a string about the created model which can further be printed in required form Figure 5 Represents model summary.

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 150, 150, 32)      320

 batch_normalization (BatchN  (None, 150, 150, 32)     128
 ormalization)

 max_pooling2d (MaxPooling2D  (None, 75, 75, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 75, 75, 64)        18496

 dropout (Dropout)           (None, 75, 75, 64)        0

 batch_normalization_1 (Batc  (None, 75, 75, 64)       256
 hNormalization)

 max_pooling2d_1 (MaxPooling  (None, 38, 38, 64)       0
 2D)

 conv2d_2 (Conv2D)           (None, 38, 38, 64)        36928

 batch_normalization_2 (Batc  (None, 38, 38, 64)       256
 hNormalization)

 max_pooling2d_2 (MaxPooling  (None, 19, 19, 64)       0
 2D)

 conv2d_3 (Conv2D)           (None, 19, 19, 128)       73856

 dropout_1 (Dropout)         (None, 19, 19, 128)       0

 batch_normalization_3 (Batc  (None, 19, 19, 128)      512
 hNormalization)

 max_pooling2d_3 (MaxPooling  (None, 10, 10, 128)      0
 2D)

 conv2d_4 (Conv2D)           (None, 10, 10, 256)       295168

 dropout_2 (Dropout)         (None, 10, 10, 256)       0

 batch_normalization_4 (Batc  (None, 10, 10, 256)      1024
 hNormalization)

 max_pooling2d_4 (MaxPooling  (None, 5, 5, 256)        0
 2D)

 flatten (Flatten)           (None, 6400)              0

 dense (Dense)               (None, 128)               819328

 dropout_3 (Dropout)         (None, 128)               0

 dense_1 (Dense)             (None, 1)                 129

=================================================================
Total params: 1,246,401
Trainable params: 1,245,313
Non-trainable params: 1,088
```

Fig. 5. Model Summary (Sequential Model)

B. Model Evaluation on Testing Dataset

A variety of metrics are included in the classification measure employed in it, including Precision, Recall, F1 Scores, which are used to quickly help the CNN model for detecting pneumonia and to identify the various parameters of a model on this collection of data set. When the accuracy signal for categorization is failing to produce the anticipated accurate results, the model uses the accuracy for categorization to foretell model performance and success if the given data is inconsistent. The sample components that the model in the provided dataset properly predicted are identified using the Recall parameter. The F1 score is obtained by combining the two metrics recall and precision, as illustrated in Figure 6.

	precision	recall	f1-score	support
Pneumonia (Class 0)	0.94	0.87	0.91	390
Normal (Class 1)	0.81	0.91	0.86	234
accuracy			0.89	624
macro avg	0.88	0.89	0.88	624
weighted avg	0.89	0.89	0.89	624

Fig. 6. Table for Precision, Recall, f1-Score

C. Generating Confusion Matrix

Accuracy is not the only factor that impacts the model's ability to predict the outcome. Another useful matrix that will be utilized by the model is the Confusion Matrix, which is depicted in Figure 7. The matrix is a tabular representation that helps visualize the model and its outputs. It simplifies the understanding of the model's overall conclusion even for someone unfamiliar with it. The Confusion matrix allows for locating the incidence of a class within each individual column, while each row of the confusion matrix gives the starting of a finished class.

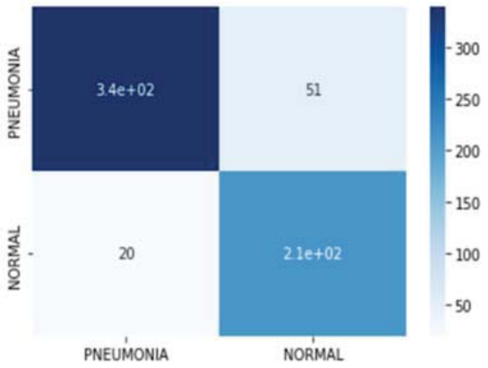

Fig. 7. Confusion Matrix

D. Testing Images on Model

Once the model has completed its training, the final step is to evaluate its ability to accurately predict the X-Ray images in a sample dataset. Figures 10 and 11 demonstrate that the model accurately predicted the outcomes when given input in the form of photographs. Figure 8 shows a Chest X-Ray image of healthy person without any indication of pneumonia, while Figure 9 displays an Chest X-Ray image of pneumonia lungs.

1) Result 1

```
In [60]:
a='C:/Users/bhavye/Downloads/chest-xray-pneumonia/chest_xray/val/NORMAL/NORMAL2-IM-1442-0001.jpeg'
predict = pneumoniaPrediction([prepare(a)])
print(predict,"\n")
IPython.display.Image(filename=a,width=250,height=250)

1/1 [==============================] - 0s 37ms/step
Normal

Out[60]:
```

Fig. 8. Normal Class

2) Result 2

```
In [55]:
a='C:/Users/bhavye/Downloads/chest-xray-pneumonia/chest_xray/val/PNEUMONIA/person1950_bacteria_4881.jpeg'
predict = pneumoniaPrediction([prepare(a)])
print(predict,"\n")
IPython.display.Image(filename=a,width=250,height=350)

1/1 [==============================] - 0s 36ms/step
Pneumonia

Out[55]:
```

Fig. 9. Pneumonia Class

V. Results And Analysis

The following points indicate the results and analysis of the CNN model presented above:

A. *Performance Evaluation*

The CNN Model has an accuracy of 88.62% based on F1 score and recall parameters for classification, indicating its ability to make accurate predictions. The F1 score calculated for the model is approx. 89%. The peak recall value indicates that the CNN model's likelihood of producing false-negative results is minimal, which is crucial in predicting patient's Chest X-Ray outcomes and giving timely treatment.

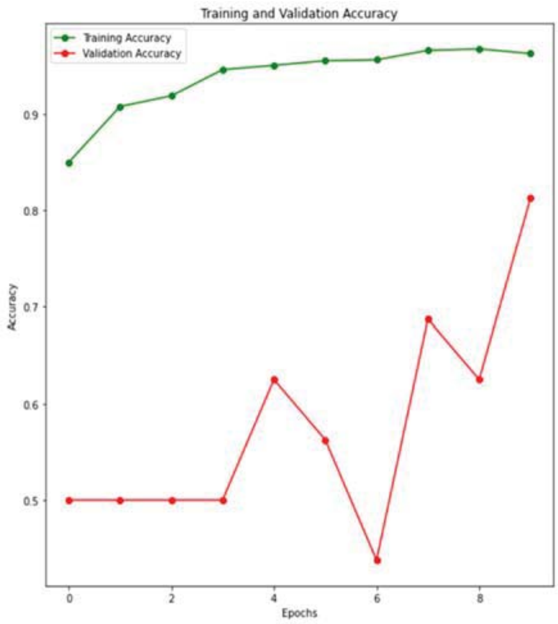

Fig. 10. Accuracy Graph for Training and Validation

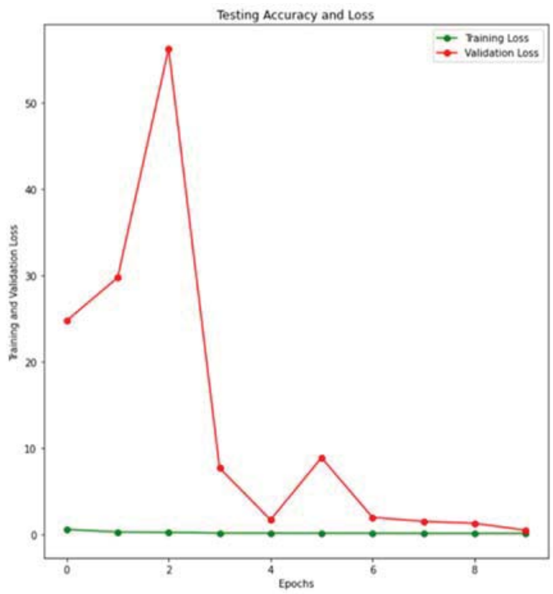

Fig. 11. Losses from Training and Validation

B. *Graphing the Model*

This phase includes plotting the results of the trained model to show its training and validation accuracy and plotted loss during training of our model shown in Figure 10. Through this, Loss Function is calculated upon training on epochs. Then, plotted the curve for each of the iteration in the dataset shown in Figure 11.

C. *Comparison with Related Work*

The research work that has been accomplished by Chakraborty et al [40] has produced an overall accuracy of 95.6%. Also, the Recall is being calculated and produced a value as 95%. This model has been trained upon same dataset which is being available on Kaggle.

The research work that has been accomplished by Liang et al [41] has scored the overall recall value of 96.7% on the dataset available on Kaggle.

VI. Conclusion And Future Work

The similar nature of various lung infections makes it difficult to identify these infections through the naked eye. Also, it is a laboursome and time taking process that is performed by radiologists and medical staff to identify Pneumonia. The ultimate motive of this research study is to predict pneumonia using Chest X-Rays dataset better accurately and effectively. This model has been built using Convolution Neural Network, as CNN is best suited for image classification because of its neural network structure. This model has been trained very well on a large dataset and is very well equipped to predict results based on dataset images. As per the results and observations, it is also showing very good results. So, by using this CNN Model healthcare professionals predict whether a person of any age group has pneumonia or not in very less time and provide treatment timely to save a patient's life. The large number of Chest X-Rays images have been taken as a dataset helps in predicting the result rapidly, which reduce the death rate due to pneumonia in any country and helps in the contribution of social cause by saving the precious life of any person.

It is expected that through the utilization of machine learning techniques and neural networks, the model will be capable of producing accurate results for multiple datasets within a specified timeframe. The plan is to further train this model on extensive datasets comprising hundreds of thousands of Chest X-ray images in the future. Additionally, it is envisaged that this three-layer CNN approach would eventually use a Generative Neural Network, which depends on unsupervised learning, to effectively forecast outcomes.

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