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Creating virtual doctors by deploying the deep learning model for identifying pneumonia disease using chest-Xray

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***Abstract*---**Pneumonia is a lung infection that is caused due to viruses, bacteria, and fungus. Pneumonia is a type of disease that can be cured if it was founded in its early stages. The website designed using this research acts as a virtual doctor and identifies the presence of pneumonia. This is done with the help of the Deep Learning (DL) method named the Convolutional Neural Network (CNN). A dataset consisting of both normal and pneumonia affected images is collected and it is used to train, test, and validate the DL model. The images are the X-ray images of the chest of the human being. Along with the model, a website is designed using HTML. This website provides the result of whether the image uploaded is pneumonia-affected or not

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using the DL model. The model is then trained again and again to achieve higher accuracy. The model is then integrated with the website and it acts as a virtual doctor. This website can reduce the risk of pneumonia to reach a critical stage.

Keywords---pneumonia, web development, virtual doctor, neural network, image processing, CNN.

Introduction

Pneumonia is an infection that directly affects the lungs of the patient. Various triggers can cause pneumonia. It includes a bacteria named Streptococcus pneumonia and a virus named respiratory syncytial virus or the influenza virus. It is a mild to serious infection that is life-threatening at times. Yet, the patient affected by pneumonia suffers from severe cough, stabbing pain in the chest, fever, etc. which can tire the patient to the maximum extent. About 30000 people died in India due to pneumonia and flu induced by another similar virus to the ones that cause pneumonia. Rural areas and semi-urban areas of India are prone to such diseases as the people are unaware of the symptoms [1]. Mostly, the usage of chest X-rays is used to detect the presence of pneumonia. But the identification takes a lot of time and human power to make sure the accuracy of prediction is high [2]. Due to the pandemic situation caused by the COVID- 19 virus, the patients tend to suffer both physically and mentally. This is due to the symptoms of Covid being similar to that of pneumonia [3]. The time delay may worsen the situation of the patients at some stage. The research aims the development of a DL model which can verify the image of an X-ray and predict the results within seconds [4]. The DL model is first trained and tested for maximum accuracy. Once the maximum accuracy is reached, the model is integrated with the website that was designed using a hypertext markup language. The prediction of the DL model is then displayed on the website when the user uploads the X-ray image of the chest. There are two possible outputs.

Literature Survey

According to Pagliano P et al. Viral pneumonia is an underappreciated disease that has a significant impact on the elderly and immunocompromised. In adults, rhinovirus is the most prevalent cause of viral pneumonia. The influenza virus is commonly diagnosed, and some cases have been documented among individuals who have been infected with the influenza A (H1N1) virus. Nonproductive cough, dyspnea, fever, and severe chest discomfort are some of the major symptoms of pneumonia caused by viruses, but severe instances can quickly develop respiratory failure. The efficacy of currently available drugs is limited. They also claimed that the present pandemic is making people aware of other lung infections like pneumonia. It also draws attention to hitherto unstudied treatments. Because of the scarcity and ineffectiveness of antivirals active against the etiologic agents of viral pneumonia, researchers are repositioning medications now used for other viral etiologies, as they have done for other diseases. The efficacy of practically all antiviral medicines studied so far has been demonstrated to be ineffective [5]. Abdullahi Umar Ibrahim et al implemented the technology of

CNN in the detection of pneumonia. Their research shows how to utilize a Deep Neural Network (DNN) based on the TL technique or the AlexNet model to detect three types of pneumonia using a DNN based on the TL approach. Two binary classes and a multiclass model were used to train the models (three and four classes). Three types of pneumonia including the coronaviruses are all identified in two binary categories, along with healthy CXR pictures. They concluded that hybrid models performed better than single models. The model's performance can also be improved by combining the support vector machine model with the CNN [6].

Researchers from Tianjin University of China including Yixin Dong et al introduced an idea to use the optimized building to prevent the causes that trigger the symptoms of pneumonia. They use CFD and the Wells-Riley model to compute the infection rate distribution in space. Finally, create an optimization model employing building opening design parameters and infection rate data to investigate the relationship between geometric factors and variation in infection rates. Building opening design factors in transition spaces have a considerable impact on interior infection rates, even though the wind speed at the building openings remains constant. Optimizing a building's doors and windows have been shown to dramatically limit the spread of disease. In the area with the highest reduction, the infection rate has dropped by 18% [7]. Covid-19 itself is a severe disease that can kill the lives of many people. In certain cases, the coronavirus of the patient can cause pneumonia and vice versa. Katarzyna Guziejko et al wrote a case study explaining the severity of this combination. COVID-19 has been linked to an increase in the incidence of neurological symptoms and consequences. However, neurological signs in severely sick COVID-19 patients are frequently misdiagnosed amid life-threatening respiratory failure. The death rate can significantly increase when the pneumonia is combined with the Covid-19 virus [8]. Klein et al. concluded that while bacterial co-infection should be considered in the differential diagnosis of all influenza patients admitted to the hospital, not all patients are co-infected. The most often co-infecting organisms were Staphylococcus aureus and Streptococcus pneumonia. Bacterial co-infection has been related to more severe symptoms and an increased risk of death [9].

Materials and Methods

Various components, such as a DL model and a website, are used to diagnose pneumonia. Figure 1 depicts the whole operation of the model and website.

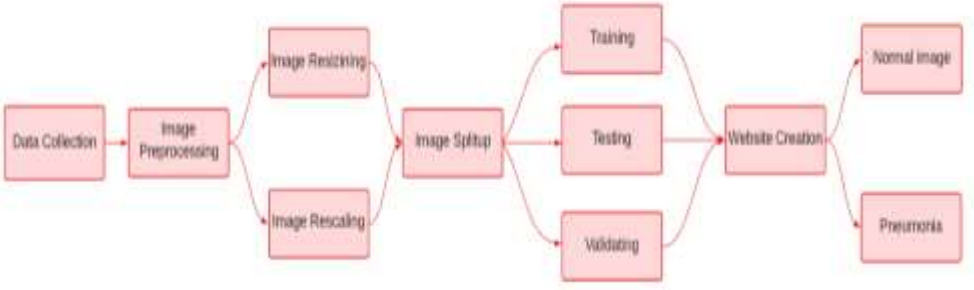

Fig. 1. Workflow of pneumonia detection

As shown in figure 1, the images of chest X-rays are collected from Kaggle. The images are then preprocessed using two preprocessing techniques named image resizing and image rescaling. The processed images are then split into three parts for training, testing, and validating the model. Once the validation provides maximum accuracy and minimum loss value, the DL model is then deployed into the website which was created using the hypertext markup language. The DL model is designed in such a way that it can predict the presence of pneumonia in the image that the user uploads to the website. The website is then used to display the output along with the suggestion to the user just like a real doctor. The further procedure is clearly explained below.

Data Acquisition and Preprocessing

The dataset consisting of 3000 images of chest X-rays is collected from the Kaggle database. The dataset contains both normal images and pneumonia-affected images in an equal ratio. Table 1 depicts the look of the normal image and pneumonia-affected image.

Table I. Chest condition based on x-ray

Chest Xray Image	Chest Health Condition
	The normal lung of the human being
	Pneumonia affected lung

The images collected are then preprocessed to make sure that the dimensions of all the images are the same. The preprocessing techniques include image resizing and image rescaling.

Image resizing

The act of adjusting the dimensions of all the images in a dataset so that they are all the same size is known as image resizing. When scaling an image, the total number of pixels can be raised or lowered. Picture resizing ensures that image quality is kept when an image is zoomed or expanded. The collected images are resized in the 128:128 dimension to provide uniformity among the images.

Image Rescaling

The technique of resizing a digital image is known as image scaling. When you scale a picture down, it gets smaller, and when you scale it up, it gets bigger. Although both raster and vector drawings may be resized, the effects are not the same. Because scaling the image does not affect its quality, it can give superior results. Another key advantage of image scaling is the ability to remove undesired image portions. The images are rescaled from 0 to 1. These images then jumbled and randomly split into three parts. The first part contains 2400 images and is used to train the DL model. The second part contains 300 images and this part is used to validate the model. The third part also contains 300 images and it is used to test the DL model which will be constructed using the CNN algorithm.

DL Model

A DL model is a computer-generated classification system for images, texts, and even noises. A variety of DL algorithms can be used to generate this DL model. CNN, radial basis function networks, recurrent neural networks, transfer learning, and other algorithms are among the algorithms. The model which was constructed using the DL algorithm in this study was created using CNN. This is because the CNN algorithm outperforms several other DL algorithms in terms of accuracy.

CNN, for instance, is a DL system that can take a photograph, assign meaning to various objects or elements in the image, and then differentiate amongst them. In contrast to previous DL-based classification techniques, the CNN methodology does not require extensive preprocessing. Comparable to the connective theory of neurons in the human brain, the Visual Cortex is organized similarly to the CNN algorithm [10]. By classifying images in several convolutional layers using CNN, the number of DL models required to complete a job can be decreased. Using the CNN method, a photograph's high-level features, such as edges, can be retrieved. The CNN model for the pneumonia detection technique was created in the order listed below.

The CNN method can also classify images in multiple convolution operation, lowering the number of DL models needed to complete a single task. The CNN is one of the best methods for extracting high-level characteristics from an image, such as edges [11]. The following figure 2 is the sequence in which the CNN model was built for the glaucoma detection procedure.

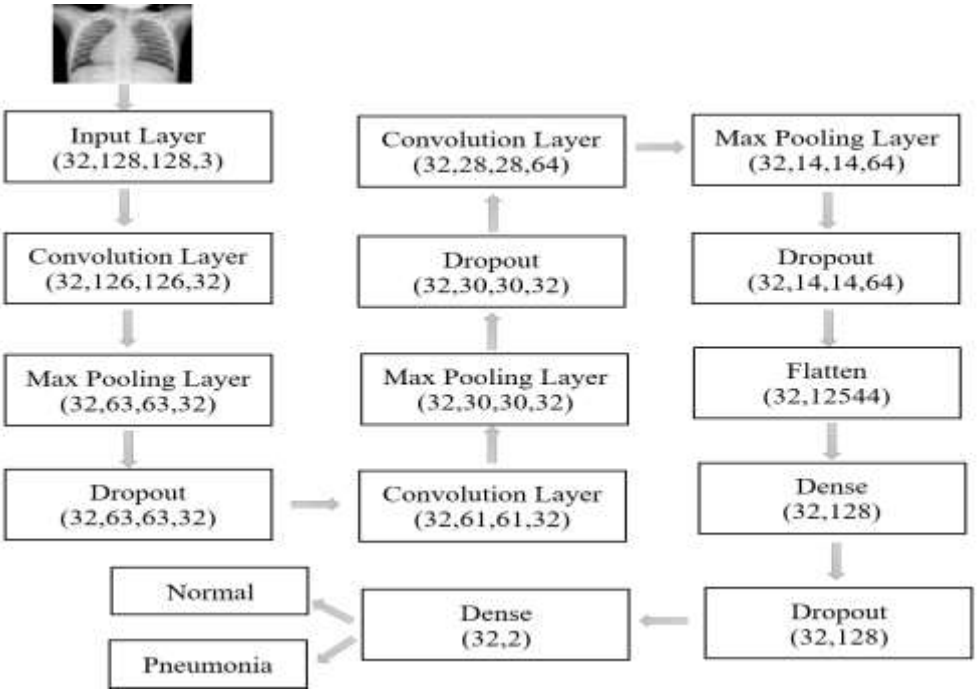

Fig. 2. CNN for Pneumonia Detection

The DL model of the CNN algorithm is constructed in such a way that it contains 14 layers. It includes the input, convolutional, max-pooling, dropout, flatten, and dense. The X-ray image of the human chest is first sent to the input which is the first layer of the DL model. After that, the image is passed to the convolutional, and the convolutional output is sent to the max-pooling. The output of the max-pooling is then sent to the dropout. The process of the last three layers is then repeated three times. The last output is then sent to the flatten and the dense layer. The dense layer's output is then sent to the dropout layer again. The final layer, dense gets in input from the output of the two final layers classifies the image into two types – normal and pneumonia. The images obtained go through the same procedure again and again so that the accuracy of the DL model increases.

Web Development

The most crucial aspect of this pneumonia detection is the web page. The user may upload an image to this website, and it utilizes DL architecture to detect the presence of melanoma and offer the findings to the user [12]. This webpage was created using the hypertext markup language. The website is also powered using the DL model which is constructed using the CNN algorithm. The criteria for adding a picture to the website are described in a header and accompanying text [13]. The user can also look about and choose the right image. When there isn't an image to upload, the website looks like figure 3.

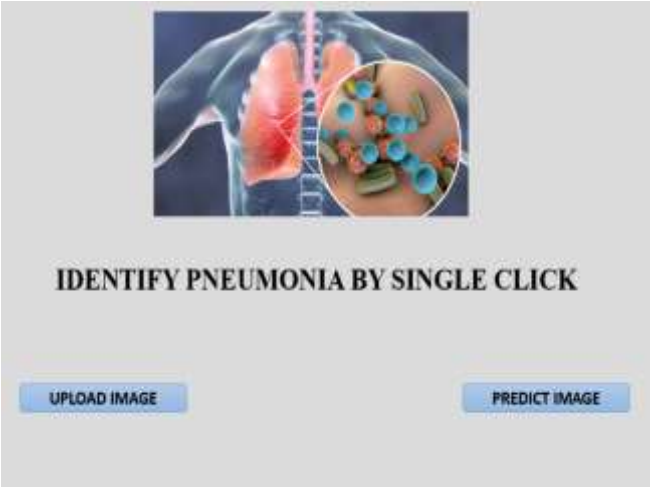

Fig. 3. Home page of the website for pneumonia detection

The webpage allows the user to upload the X-ray image of the chest using the "UPLOAD IMAGE" button. Once the image is uploaded, the user has to click the "PREDICT IMAGE" button.

Result And Discussion

A DL model was created using the CNN approach. Once the model is constructed, it is trained, validated, and tested. The test results are then analyzed using a variety of performance metrics. The test results are then analyzed using a variety of performance metrics. Among the performance, measurements are the models' true positive (TP), true negative (TN), false positive (FP), and false negative (FN).

Table II. Performance of CNN at each epoch

Epoch	Time in sec	TA	VA	TL	VL
0	81	0.5656	0.7357	0.7562	0.6698
1	70	0.7696	0.8785	0.4997	0.4171
2	71	0.8645	0.9167	0.3346	0.3581
3	7	0.8855	0.8715	0.2836	0.3484
4	67	0.8829	0.9375	0.2834	0.2124
5	69	0.8888	0.9375	0.2707	0.2379
6	68	0.9135	0.9132	0.2296	0.2394
7	75	0.9143	0.9306	0.2296	0.2209
8	78	0.9172	0.9618	0.2181	0.1495
9	75	0.9168	0.9306	0.2084	0.1617

A confusion matrix is also produced based on the above-mentioned performance indicators. The accuracy and loss value of the algorithm must be evaluated at this step. When pneumonia is present in an image and the model properly detects it, the result is TP. When the model properly identifies non-pneumonia in an image, the outcome is TN. When pneumonia is present in an image but the model fails to detect it, the result is shown as FN. If pneumonia is not present in an image and

the algorithm incorrectly identifies it, the outcome is given as FP. Using the provided performance criteria, the accuracy and loss value of both approaches are determined. The training and validation accuracy (TA/VA), training and validation loss (TL/VL), and the time taken to display the output play a crucial role in the efficiency of the website. The values collected for the above-mentioned parameters for every epoch are tabulated below.

From table 2, it can be inferred that the accuracy of the model increases with an increase in every epoch in both testing and validation. The accuracy reaches its maximum of 0.96 at the eighth epoch of validation. The loss works inversely proportional to the accuracy. When the epochs go on, the loss value starts to diminish. The accuracy reaches its minimum of 0.14 at the eighth epoch of validation. The values can be best understood when they're described pictorially. Thus, the accuracy of the CNN algorithm during training and validation is illustrated in figure 4 in the form of a graph.

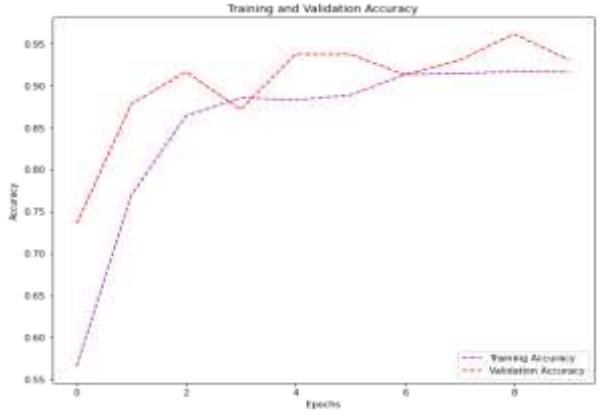

Fig. 4. TA and VA of the CNN model

The loss of the model during training and validation is represented in the form of a graph in figure 5.

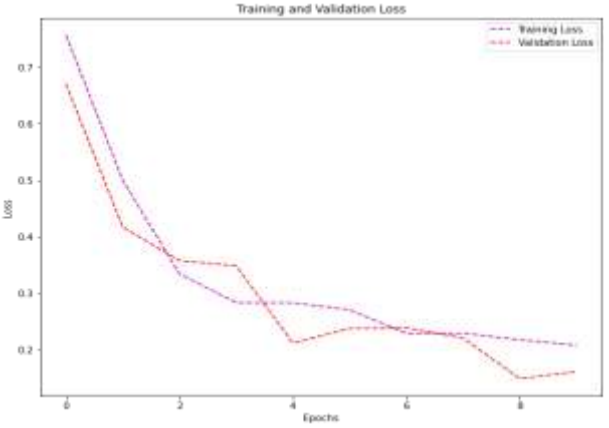

Fig. 5. TL and VL of the CNN model

At some point, the accuracy of the DL model reaches its maximum and the loss value reaches its minimum value. When it reaches the optimum values, the model is then deployed to the website. The optimum values of accuracy and loss when it was deployed into the website are shown in table 3 and it also visualized in figure 6.

Table III. CNN performance of test data

Data	Accuracy	Loss
Test	93.44	3.15%

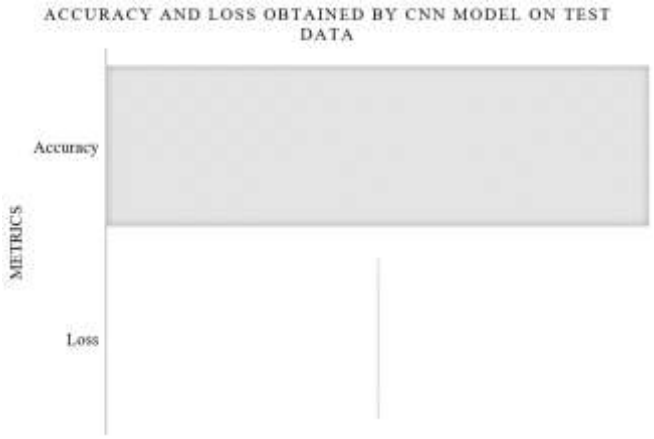

Fig. 6. CNN model output on test data

The website will look like figure 7 when the X-ray image of pneumonia affected lung is uploaded by the user.

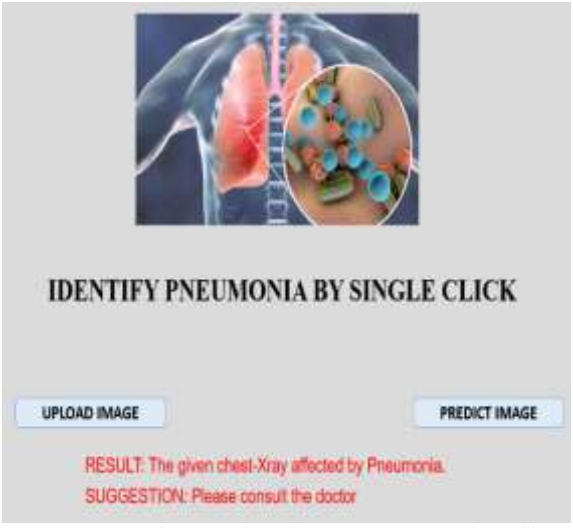

Fig. 7. Website response after uploading pneumonia affected chest X-ray

When pneumonia is detected, the website displays the result as “The given chest-Xray is affected by pneumonia”. It also suggests with the text “Please consult the doctor” to make the user understand the situation just like a real doctor does which is why the website can be termed as a virtual doctor.

Conclusion

A total of 3000 images were gathered from the Kaggle database. After that, the images are divided into three sections train, test, and validate. A DL model was created using the CNN approach. The model is then trained until the maximum and lowest accuracy values are achieved. The training and validation values of the models are tallied and examined. Finally, the model can achieve a higher accuracy of 93.44% while maintaining a very low loss value of 3.15%. Because the accuracy percentage of the developed DL model is so good, it might be a beneficial first-level test in the process of pneumonia prediction, together with the severity level. Thus, this model can act as a virtual doctor at times when the patient is unable to consult a doctor in person due to undesirable circumstances.

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