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Pneumonia Detection using Transfer Learning

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Abstract : Pneumonia is a common respiratory disease that affects millions of people worldwide, with serious consequences for vulnerable populations such as children under 5 years of age, elderly adults, and those with weakened immune systems. Early detection is crucial for effective treatment and improved patient outcomes. However, diagnosing pneumonia can be challenging for radiologists due to the similarity of its symptoms with those of other diseases. To address this issue, recent studies have shown the potential of deep learning approaches in achieving higher prediction accuracy than traditional radiological methods. In this context, we propose a systematic model for pneumonia detection and classification based on deep transfer learning. Our model is trained on digital chest X-ray images and aims to accurately detect pneumonic lungs while further classifying the type of pneumonia (viral or bacterial). The proposed model has significant potential in improving the accuracy and efficiency of pneumonia diagnosis, benefiting medical professionals and patients alike. By detecting pneumonia at an early stage, we can reduce the severity of the disease and prevent complications, ultimately saving lives.

IndexTerms - pneumonia, bacterial ,viral, transfer learning, ResNet50V2, DenseNet201, VGG 16, MobileNetV2

Introduction

Pneumonia is a lung infection that causes inflammation of the air sacs in one or both lungs. When the air sacs fill with fluid or pus, it can cause cough with phlegm or pus, fever, chills, and difficult in breathing (purulent material). Pneumonia can be caused by bacteria, viruses, or fungi. In simple terms, it's a microbe-caused infection in the lungs that causes water to enter the lungs and makes breathing difficult[1]. The goal of pneumonia treatment is to eliminate the illness while also preventing consequences. People with community-acquired pneumonia can usually be treated with medicines at home. Although most symptoms fade after a few days or weeks, fatigue might last for a month or longer.Treatment options are determined by the type and severity of your pneumonia, as well as your age and overall health. Chest X-rays are the most common and cheapest way to detect pneumonia . Likewise, there is a shortage of radiologist experts, especially in low-resource countries and in rural regions, causing long waits for diagnoses, which increases the death rate. Because of the nature of chest X-ray images, pneumonia diagnosis by X-ray images are often unclear and can be confused with other diseases that have similar features, such as opacity, cavity, and pleural effusions. Thus, chest X-rays cannot be as easily used for detecting diseases. However, even for a trained radiologist, it is a challenging task to examine chest X-rays. There is a need to improve diagnosis accuracy. The motivation behind this work is to have a deep learning model to aid in the interpretation task that could overcome the intrinsic limitations of human perception and bias, and reduce errors, It can also be used to assist novice radiologists in remote areas that lack expert radiologists to make the right decision. Depending on factors like the type of germ causing the infection, age of the person and overall health condition, the signs and symptoms of pneumonia vary from mild to severe.The symptoms of pneumonia are often similar to those of flu or a cold. The symptoms may include chest pain,cough, fever, nausea,sweating, vomiting, loss of appetite, shaking chills, diarrhea, dizziness, shortness of breath, dizziness. The signs of infection may not be shown in newborns and infants but they can show some symptoms like having a fever, cough or difficulty in breathing. Many germs can cause pneumonia. Pneumonia can be categorized based on the bacteria that causes it and where the infection has occurred. Those are Community-acquired pneumonia, Hospital-acquired pneumonia, Healthcare-acquired pneumonia, Aspiration pneumonia. Anyone at any age can be affected with pneumonia but the two age groups who are at high risk are children who are 2 years old or younger than that and people who are of age 65 or older than that.

I. Materials and methods

The dataset contains 5863 X-ray pictures that are divided into two categories. They are Pneumonia and Normal, as well as three subfolders within each category: a training set, a test set, and a validation setas shown in Fig Chest X-ray images from Guangzhou Women and Children's Medical Centre, Guangzhou, were chosen from retrospective cohorts of pediatric patients aged one to five years. All chest X-ray imaging was done as part of the patient's regular medical treatment.All chest radiographs were originally examined for quality control, with any scans that were low quality or unreadable being removed. The images were then graded by two experts before being approved for use in training the AI system. In order to account for any grading errors, the evaluation set was also checked by a third expert. Example images of each case are shown in Fig. 1.

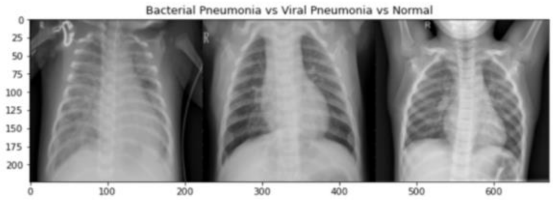

Figure 1. Train images a) bacterial pneumonia b) viral pneumonia c) healthy person

As previously stated, each section of raw, intact data, namely train, validation, and test, was initially classified as normal or with pneumonia. The neural network that was used was tasked with classifying test data into three categories, so images of various pneumonia types had to be divided into two new groups representing bacterial and viral pneumonia, respectively as shown in Fig. 2. Because the original pre-made validation dataset was relatively small (only 16 files) and did not contain any viral pneumonia examples, a few files from the test directory were randomly selected, resulting in a larger and more reliable validation set containing 30 images of each case - 75 images in total, which is sufficient for proper validation during training, The size of the validation dataset should be correlated with the size of the training dataset, as well as the number of hyperparameters to train. Table 1 contains detailed information about the dataset with the described adjustment.

TABLE. 1. DATASET DISTRIBUTION

Dataset	**Healthy**	**Bacterial**	**Viral**
Train	1341	2054	1345
Test	217	225	123
Validation	25	25	25

After extracting the data, Exploratory Data Analysis was done, which showed that this is an unbalanced dataset, weighted to the chest X-rays with bacterial pneumonia. Considering bacterial pneumonia is more severe than viral pneumonia. Model will learn about the specifics of bacterial pneumonia the most.

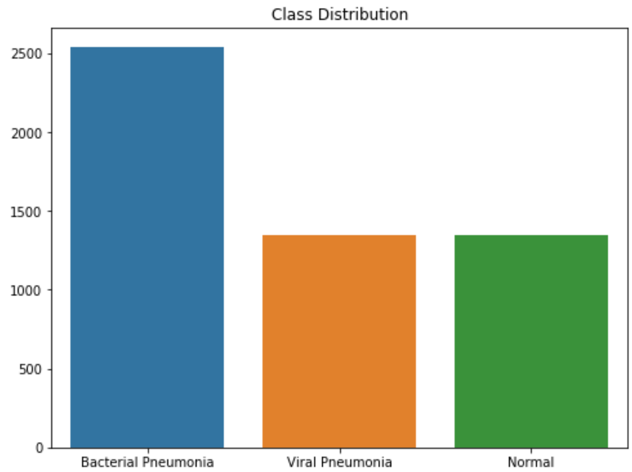

Figure 2. Plotting the bar graph between the three different classes

It seems like image size is not uniform across the dataset and also too large to train a neural network in terms of time complexity. Fig. 3 shows the image size distribution of train dataset

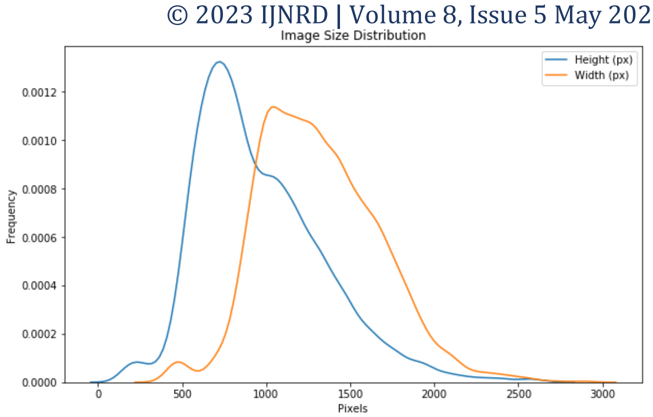

Figure 3.Image size distribution

Most images were at least 224 × 224 pixels and contained RGB color channels. Images that were smaller than 224 x 224 pixels or in greyscale should be removed from analysis. This was done after getting poor results with preprocessed images to smaller size and grayscale mode even though it gave faster results.Pneumonia positive images seem to be more faint as the borders between organs are less sharp because of the soft tissue (water) in the lungs, Black-air, Dark Grey-Fat, Light Grey-Soft tissue, Off white-Bone, Bright white-Metal.

When it is manually checked the images,it was found that there are a lot of variations for such a small dataset.The height/width ratio ,zooming range ,angle of body etc features differ among different X ray images. Even the physical dimensions are vastly different.A generator class was used to modify images within the train data with optimal rotation_range, shear_range,zoom_range, horizontal flip to get additional observations to train the model with.

II. RESULT AND DISCUSSION

Four transfer learning models were used to create and implement by adding new layers to each of the four models. The accuracies were compared for all the four models and got highest and better accuracy for the DenseNet201 modified model which is 91.8%. The second model which has given the better accuracy is the ResNet50V2 modified model but comparatively less than the DenseNet201 modified model which is 87.5%. For the VGG 16 modified model, the accuracy obtained is 86.8%.For MobileNetV2 modified model, the accuracy obtained is 66.6%.

TABLE. 2. MODEL ACCURACY

Models	Accuracy
DenseNet 201	91.8%
ResNet50V2	87.5%
VGG 16	86.8%
MobileNetV2	66.6%

III. CONCLUSION

Pneumonia is an infection which leads to inflammation in the air sacs of the lungs, which are called alveoli. The alveoli will be filled with fluid or pus, making it difficult to breathe, both viral and bacterial pneumonia are contagious, which means they can spread from person to person through inhalation of airborne droplets from a sneeze or cough. A person can also get these types of pneumonia by coming into contact with surfaces or objects that are contaminated with pneumonia-causing bacteria or viruses.
There is a need for early identification and classification of pneumonia as late detection can also lead to a lung abscess, where part of the lung tissue dies.

This study presents a deep-CNN-based transfer learning approach for the automatic detection of pneumonia and its classes. Four different popular CNN-based deep learning algorithms were trained and tested for classifying normal and pneumonia patients using chest x-ray images. It was observed that DenseNet201(91.8%) outperforms the other three different deep CNN networks.

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