The X-Ray Image Classification with Deep Learning Methods

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***Abstract*— In this study, a dataset that covers X-ray chest images from patients is used to classify chest images as Normal, Pnemonia and Covid-19. By the aim of classification, two approaches are used as ResNet18 and a CNN (Convolutional Neural Network) model which is created by us for this project. The results show that both of these approaches succeed in classifying Covid-19 images. The test accuracy result of the ResNet model is superior to Custom CNN with a percent 2.5. Both of these models can be utilized to diagnose Covid-19.**

***Keywords* — Deep Learning, Image Classification, ResNet18, CNN, Covid-19, Xray Images.**

I. Introduction

Coronavirus is a global disease that started in 2019 in Wuhan, China and affects the whole world. The disease can initially progress without symptoms and a person can infect many people. The virus may result in death with 2% probability. It may be possible to infect less people and prevent massive alveolar damage and progressive respiratory failure with early diagnosis [9].

Publicly available X-rays from healthy cases and patients suffering from Covid-19 enables us to study medical images and identify possible patterns that may lead to the automatic diagnosis of the disease. Deep learning applications can help to classify X-ray images which have Covid-19. The convolutional neural networks (CNNs) can be utilized to detect disease from X-ray images. CNN can be determined as a regularized version of multilayer perceptrons which usually means fully connected neural networks. Each neuron in a layer is linked to all neurons in the upcoming layer. Convolutional networks were obtained by the inspiration of biological processes. In a CNN, there are an input layer, multiple hidden layers, and an output layer. A series of convolutional layers are included in the hidden layers of the CNN. The convolutional layers can be explained as convolving with a multiplication or other dot product. The advantage of CNN is the ability of learning key characteristics on its own, and decreasing the need for hyperparameters [7]. There are many activation functions used in CNN architectures. The widely used ReLU activation function is utilized in the architecture which is created for this project.

The rest of the paper is organized as follows. The utilized methods in the algorithm and approaches in the project are presented in Section 2, while experimental results and datasets information are provided Section 3. Finally the conclusion is drawn in Section 4.

II. Approaches

A. Procedure

1. Data Examination

The first step of the process is examining the dataset and preparing the data for classification. General data distribution is analyzed and visualized. As a result of the visualization, it is determined that there is no Covid-19 image in the test data. In order to measure the classification success of chest images with Covid-19, some training images were moved under the test.

2. Data Preprocessing

As mentioned in the previous part, some of the Covid-19 images are moved into test data from training data. The ratio is determined as 25%.

The resulting classification labels are determined as Normal, Pnemonia and Covid-19. The bar plots of train and test data are obtained as seen in fig. 2.1 and 2.2 respectively.

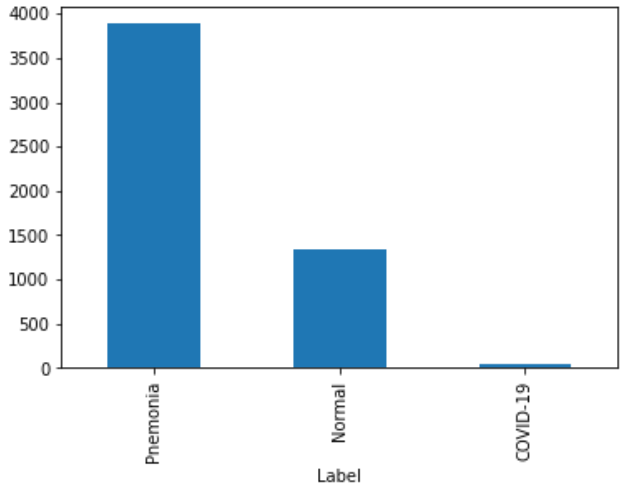

Figure 2.1- Train Data Label Distribution

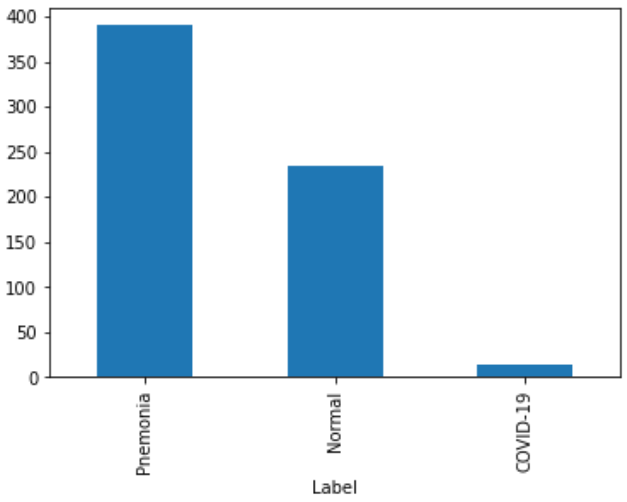

Figure 2.2- Test Data Label Distribution

The image information in the dataset is taken from the csv files. As a result of the examinations made on the dataset, it was found that some image names in the dataset are not in the csv file. Since there is no metadata information for the images, it was decided to remove these images. The following fig. 2.3 covers some examples from the dataset.

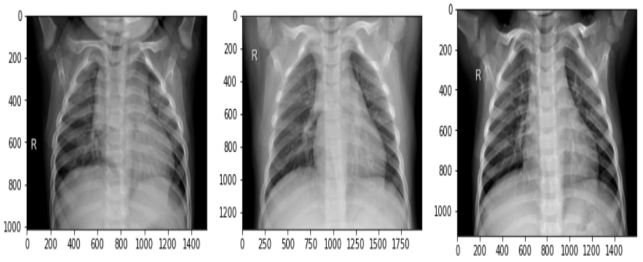

Figure 2.3- The Example Images from the Dataset

The unbalanced dataset affects the classification success. In order to increase the success of the classification and to make the dataset balanced, the upsample process was performed. With the upsample operation, classes with fewer images are equalized to the number of classes with more images. The images obtained as a result of real and upsample saved considering the input size expected by the CNN architecture to be used.

After the preprocessing steps, the train set is divided into 2 as train and validation. The division ratio was determined as 0.15. The validation set was used to observe the training progress.

3. Classification

After the necessary arrangements were made on the dataset, the classification stage was started. The classification was made using 2 different CNN models. While one of these models is ResNet, which is widely used in classification problems, the other is created by us.

ResNet18

The ResNet18 is a pre-trained model on ImageNet which is usually used to prevent the vanishing gradient problem and decrease the amount of time for training a model. The main idea in ResNet is providing identity shortcut connection [5]. By using transfer learning, the weights of ResNet18 are utilized in order to reduce training time and increase accuracy results. Because the output layer of the network gives 1000 labels, it is modified to obtain a necessary number of classes.

After that, the optimizer is determined as Adam, and the learning rate and weight decay are decided as 0.0001 and 0.001 respectively. The cross entropy loss is utilized and the number of epochs is settled as 8. Then, the images are resized as 224×224, horizontally flipped randomly and normalized. The classes are determined as Normal, Pnemonia, and Covid-19. The loss and accuracy curves for both train and validation are plotted and results are given in the section 3.

Custom CNN

Instead of ResNet18, the Custom CNN uses the architecture which is created by us. For this architecture, batch normalization and ReLU activation function is utilized and Xavier normalization which gives the network a chance to initialize with better weight conditions is used for initialization. In this step max pooling is also preferred to reduce dimensionality [6]. In the architecture of the Custom CNN, 5 layers are chosen. After the layers work well, dropout is applied with 0.25. The dropout prevents being prone to overfit. However, it decreases the training accuracy. Model generalization is improved by using Dropout. Although the training accuracy is decreased, the overall accuracy is affected well and it provides a lower generalization error. Also, the optimizer is chosen as Adam where learning rate equals to 0.0001 and weight decay is 0.0001. The cross entropy loss is utilized for loss criteria and number of epochs is determined as 8. The results are given and discussed in section 3.

III. Experiments and Results

A. Dataset

In this study, CoronaHack-Chest X-Ray-Dataset [1][3] is used for classifying the X-ray chest images as Normal, Pnemonia and Covid-19. There are two csv files and a folder with images in the downloaded dataset. Image name and labels are in csv files. Figure 3.2 shows the contents of the csv file.

Label	Label_1_Virus_category	Label_2_Virus_category	Image_Count
Normal	NaN	NaN	1576
Pnemonia	Stress-Smoking	ARDS	2
Pnemonia	Virus	NaN	1493
Pnemonia	Virus	COVID-19	58
Pnemonia	Virus	SARS	4
Pnemonia	bacteria	NaN	2772
Pnemonia	bacteria	Streptococcus	5

Figure 3.1- Csv file content

There are 2 files named train and test under the folder containing the images. The provided dataset distribution is as follows,

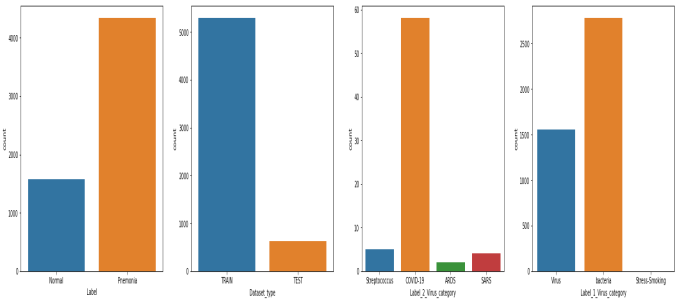

Figure 3.2- The Dataset Distribution

There are 580 images in the test folder and 5309 in the train folder.

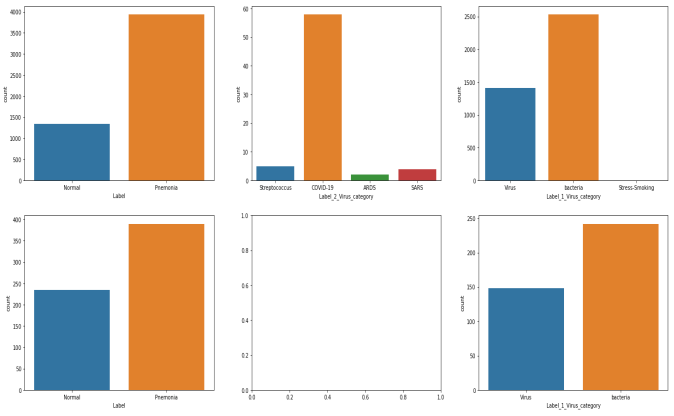

Figure 3.3- The Train and Test Data Distribution

As a result of this visualization, it is observed that X-ray images having Covid-19 are not covered in the test data. In order to correct this situation, it is decided to move some Covid-19 images in the training set as mentioned in section 2.1 and 2.2. The

overall train data and test data labels distributions are shown in fig 2.1 and 2.2 respectively.

B. Evaluation Method

In this study, classification accuracy is used as an evaluation metric. It can be simply defined as the ratio of number of correct predictions to total number of predictions.

$$Accuracy = \frac{number\ of\ correct\ predictions}{total\ number\ of\ predictions} \quad (2)$$

Accuracy metric works well if a balanced dataset that has an equal number of samples for each class is provided [8].

C. Results

When the test accuracy results for two classification methods are examined, classification with ResNet18 is superior with a small difference which is 2.5% nearly. The classification results for both ResNet and Custom CNN models are shown in Table 1. Plots and confusion matrices are provided in the following, separately.

Results/Model	**ResNet18**	**Custom CNN**
Test Accuracy (%)	79.623	77.115

Table 1 - Classification Results

ResNet18

In the model ResNet18, the train accuracy and loss results are observed as 99.979% and 0.0004 for the dataset. The validation accuracy is 99.885% where validation loss equals to 0.0021 for the dataset. The train and validation loss curves are shown in fig. 3.4.

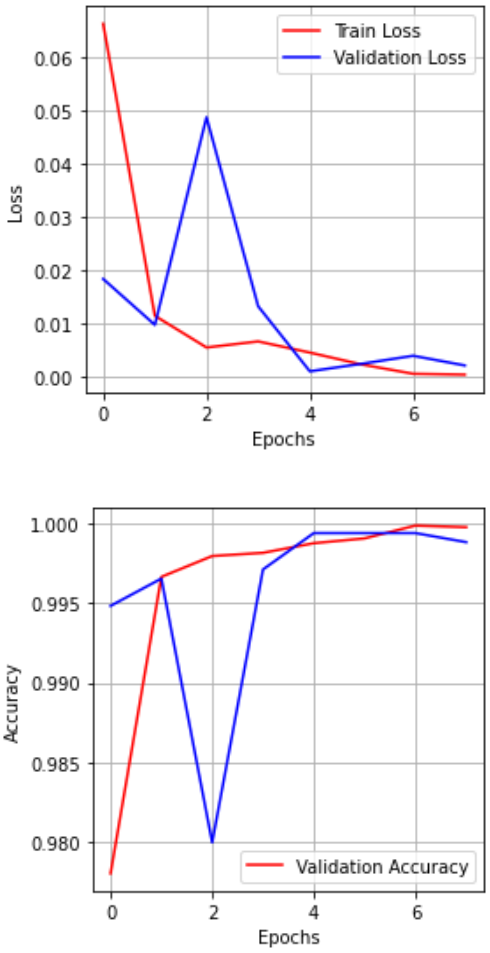

Figure 3.4- The ResNet18 Train-Validation Curves

The confusion matrix given in fig. 3.5 shows the strengths and weaknesses of the model.

When both confusion matrices are examined, it is seen that Covid-19 images are successfully classified. It is also seen that the Pnemonia class is confused with Covid-19 in both models. In the case before the dataset was processed, Covid-19 images were under the Pnemonia class. It is considered natural to experience this confusion.

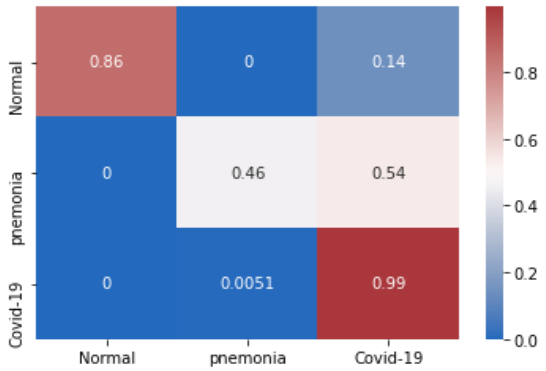

Figure 3.5- The ResNet18 Confusion Matrix

The test accuracy result is obtained as 79.623% for ResNet18.

Custom CNN

In the model Custom CNN, the train accuracy and loss results are nearly equal to 99.808% and 0.0073 for the dataset, respectively. The validation accuracy is 99.713% where validation loss equals to 0.0100 for the dataset. The train and validation loss plots are given in fig. 3.6.

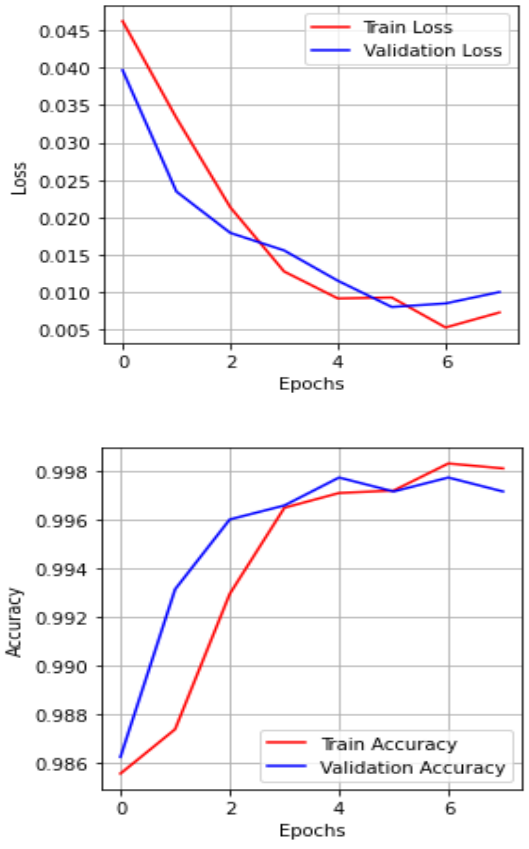

Figure 3.6- The Custom CNN Train-Validation Curves

As similar as the ResNet18, the confusion matrix of Custom CNN is also provided in the fig. 3.7.

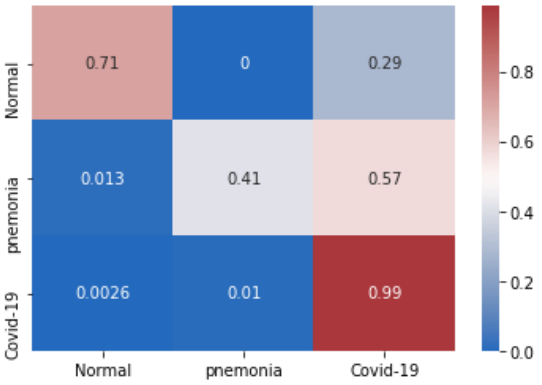

Figure 3.7- The Custom CNN Confusion Matrix

The test accuracy is obtained as 77.115 percent.

IV. Conclusion

In this study, image classification methods that are ResNet and Custom CNN are realized to classify X-ray chest images in the dataset. The results show that both of the models successfully classify X-ray chest images as Normal, Pnemonia, and Covid-19. The test accuracy result of the ResNet model is better than Custom CNN with a percent 2.5. Both of these models can be used to diagnose Covid-19.

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