COVID-19 and Viral Pneumonia X-Ray Image Classification Using Deep Learning

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Introduction

My project seeks to gain a deep understanding of Neural Networks by creating various models attempting to classify if a user has a viral disease or is perfectly healthy – all through the users' medical images. There are two datasets that are pulled: the first is a dataset attempting to classify X-ray images as COVID-19, pneumonia, or nothing at all; the second dataset attempts to classify X-ray images as pneumonia or nothing at all.

Approach

The goal of the project is to attempt to tackle one of the major problems of our time, using machine learning to predict whether someone has a viral disease (specifically such as COVID-19 or pneumonia) or has nothing and is completely healthy. The approach taken as as follows:

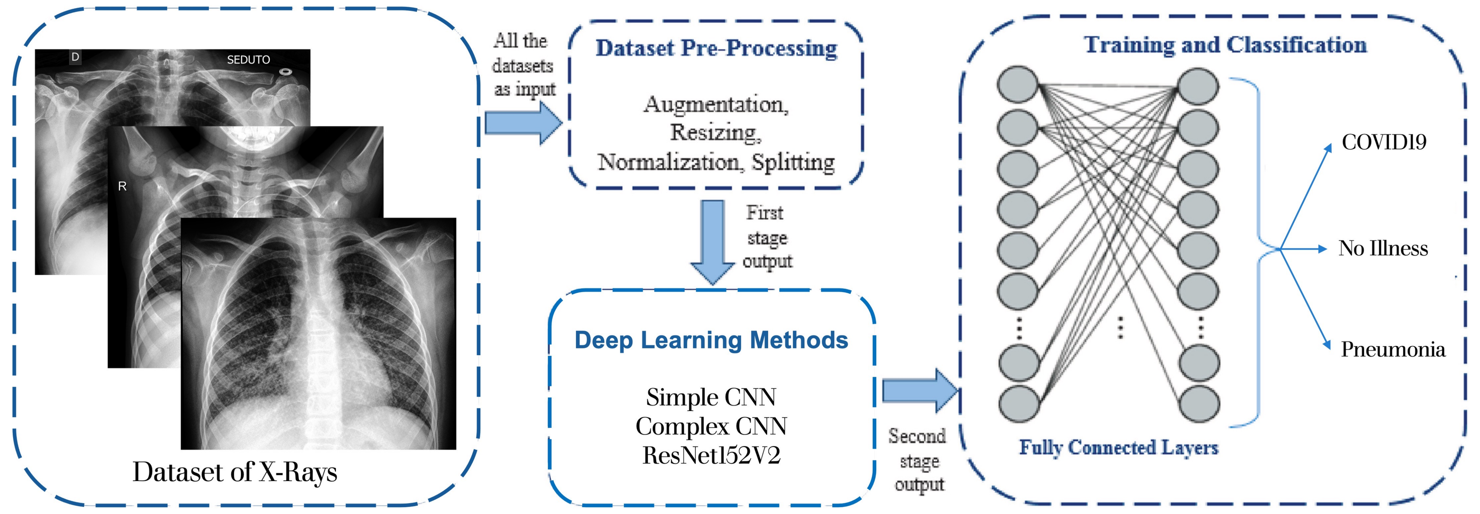
1. Simple Convolutional Neural Network (2 layers)
2. Complex Convolutional Neural Network (4 layers)
3. Pretrained Model – ResNet50 (50+ layers)
4. Data Augmented Tuned Model

Each model was made on 2 different datasets to see how each model would stand up to various datapoints, but the main goal was to replicate as close as possible the incredible results multiple scientific papers achieved in determining COVID-19.

Methodology

The general methodology for each model was as shown below:

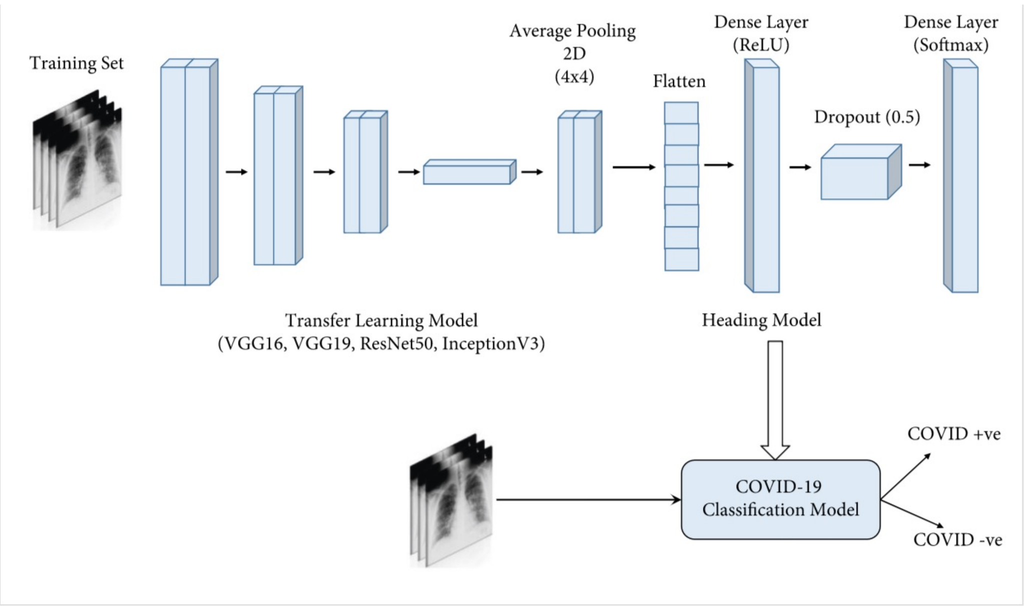
1. Ingest the data
2. Conduct data pre-processing through augmentation, resizing, and normalization
3. Build our CNN models
4. Train and Classify if a person does or does not have a viral disease.



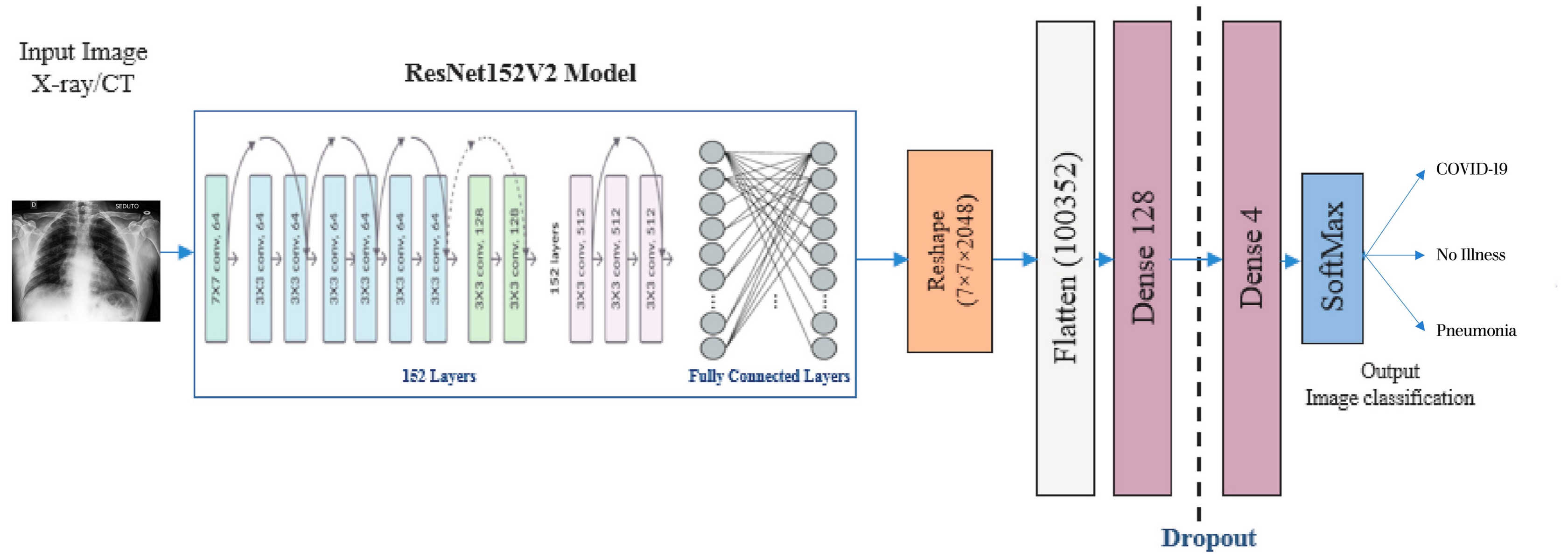
Experiments

For an easily ingestible view of the model, the image below explains how each model was built:

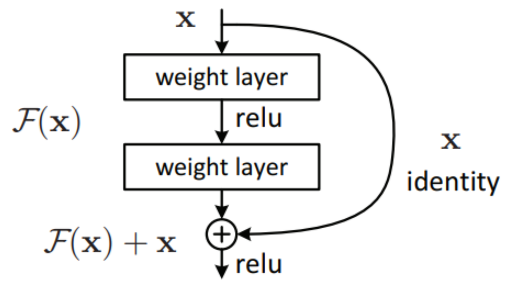
1. The images are stored into the training set
2. The model is built by adding numerous convolutional 2D layers with various steps and strides in each layer. Each of these layers uses a ReLU activation function
3. The convolutional layers are pooled, then flattened
4. A dense layer is started using the ReLU activation function, just like the convolutional layers, and then is wrapped up with a dense layer with the Softmax activation function
5. The model then begins taking test set images and predicting whether the user does or does not have COVID/viral disease



On top of the models above, a ResNet50 pre-trained model was also built, The ResNet50 model is a 50 layer convolutional neural network with multiple dense layers incorporating dropout and batch normalization.



One of the major advantages of the ResNet50 model is that it includes skip connections. This is if any layer hurts the performance of the ResNet architecture, it will be skipped by regularization and will only use the layers that help optimize the loss function. An example of this can be seen below.



Final Summary

While working with each of the datasets, a different model came out on top for highest accuracy. On the first dataset, the ResNet50 model came out on top with 63% accuracy, while on the second dataset the ResNet50 was one of the worst performing ones, and the complex CNN came out the most accurate with 97% accuracy.

Models	Dataset 1 Accuracy	Dataset 2 Accuracy	% diff
Simple CNN	50	74	0.32
Complex CNN	29	96	0.70
Augmented CNN	39	25	-0.56
ResNet50	63	57	-0.11

What's important to note is that while the other models had significant swings in accuracy, the ResNet was the least volatile between datasets and predicting viral diseases. For the time being, the consistency of the ResNet50 may be better than the great volatility of the other models, especially in something like predicting a viral disease, which has severe implications of human life.

Future Work

While these models are certainly not perfect, there is plenty of work ahead to get these models to a stage of productionalization

1. Tweak hyperparameters
   – in building these models, things like learning rate, number of epochs, batch sizes, various filters and strides were not optimized over each dataset. Each of these would need work
1. Get more Data
   – Due to COVID-19 happening so quickly and the lack of historical data on the viral disease, images were pulled from other viral diseases like pneumonia to attempt to get a 'look alike' disease. Going forward, actual imagery of COVID-19 would only make these models better
1. Optimize CNN layers
   – The CNN layers were simply stacked without adding any batch normalization or any dropout. These would all need to be optimized to the images as each model and each layer has its own nuances.

Conclusion

Simply put, with this being an image classification of attempting to predict COVID or not in a person, this project does not successfully publish a model that can do that. The huge variance in accuracy, on top of the low accuracy results (except the complex CNN model for dataset 2), do not lend to an actual productionalized model ready for consumer demand.