ISTANBUL TECHNICAL UNIVERSITY

Siamese Networks in Corona Disease Diagnosis from X-Ray Chest Images

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1 Introduction

The new type of coronavirus disease (COVID-19) is a highly infectious disease which is discovered in China in 2019. The disease is well-known with devastating effects on the human respiratory system and shown deathly results especially on elderly people and people with permanent diseases. Scientists around the world has been trying to solve the challenge of diagnosing coronavirus from chest x-ray images since only limited amount of COVID-19 tests can be supplied. In this project, it is focused to solve the diagnosis problem with "Siamese deep convolutional neural networks" which is successful at classification with few samples.

2 Dataset Overview

In this project Praveen's "CoronaHack - Chest X-Ray-Dataset" [1] dataset is used. In the dataset we have 2 basic classes "Normal" and "Pneumonia". The samples with pneumonia have two labels "Label-1" and "Label-2". I prefer to choose "Label-1" category since "Label-2" has same diseases with under different labels like "Streptococcus" and empty labeled samples are both belong to "bacteria" label under "Label-1". So merging them under the "Label-1" category is the first preprocess of the dataset. It is also important to mention that under the label-1 category only 3 of classes,COVID, unknown and bacteria, are used to classify COVID-19 cases. Final preprocessing step is generating more images since there is only 58 number of COVID-19 X-ray images in the dataset, synthetic data is augmented with random cropping. All images are also normalized before fed into the neural network. Whole dataset overview can be seen under the fig 1.

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

Figure 1: COVID-19 Dataset Overview

There is one thing to mention that, not all images have good quality in the dataset which causes extra challenges for neural network to identify COVID and bacteria cases like Fig 2.

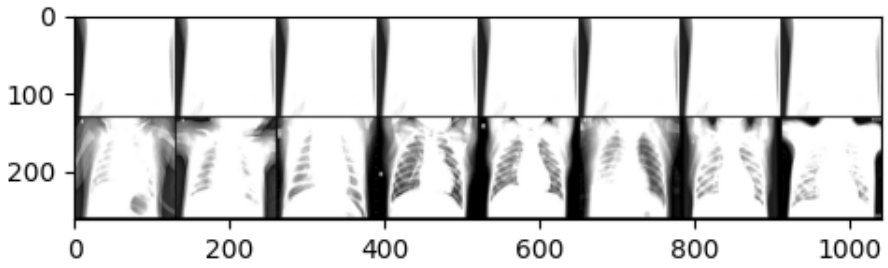


Figure 2: Images above are claimed to be COVID-19 cases

3 Baseline Methodology

3.1 Resnet-9 Based Classification Approach

In most of classification projects neural network architectures like resnet, alexnet, vgg, squeezenet, densenet, inception are used widely. In the notebook of the baseline method proposed by 'tim-stefaniak'[2] 'RESNET-9" architecture is used without transfer learning. The model is trained with the ADAM optimizer which is reset after some number of epochs, and this led to achieving better performance with less steps. Also gradients are saturated.

3.2 Resnet-9 Results

Resnet-9 baseline methodology is worked great with only 50 number of epoch it achieved **%83** accuracy and **0.01** training loss. The results are shown below in Fig 3

Figure 3: Resnet-9 Results

4 Proposed Approach

4.1 Model

In my proposed model architecture, the "Siamese Network" is used to teach neural network identify the difference between each classes. As Koch [3] and others shown in the paper "Siamese Neural Networks for One-shot Image Recognition" siamese networks are good at ranking similarity between samples. This method is also my baseline method with few differences. In my method instead of ranking similarity, the network rank differences between images and use 'triplet loss' instead of binary cross entropy loss.

The triplet loss have 3 data points : anchor, positive and negative. Anchor point is any arbitrary data point, positive point is the point with the anchor's class and negative point which has the difference class with the anchor point. Thus minimizing the difference between positive difference and negative difference leads to more effective learning. The triplet loss is show in Fig 4.

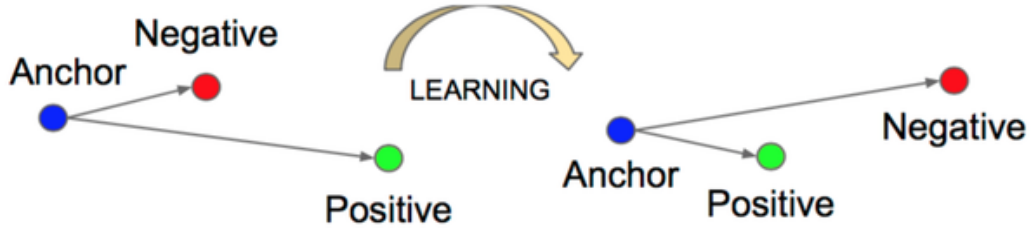


Figure 4: Triplet Loss

4.2 Network Architecture

The proposed method has the same neural network architecture with Resnet-9. But in my model, modified Resnet-9 model has by half parameters for each layer to finish the training in reasonable amount of time. The gradient clipping method is also used like the baseline method, and ADAM optimizer as learning rate scheduler.

4.3 Training/Testing Pipeline

When the model is training,in each time two samples are randomly draw from the dataset. One is a positive sample (in this case a COVID X-ray image) and other is the negative sample (bacteria or unknown). Each images are passed and embedded by the neural network. Then embedded samples are passed to the triplet loss function and loss backpropagated to update the neural network weights. For the test part, since there is no class information on the neural network output layer, it is necessary to draw random samples for a couple of times to calculate mean distances for each class. In this way, class with minimum distance value means the image is belong to that class.

4.4 Results

The overall architecture could successfully learn to rank differences between each class. The results can be seen below in Fig 5. (The blue line and red line are belong to the same training with different time, so color differences do not matter)

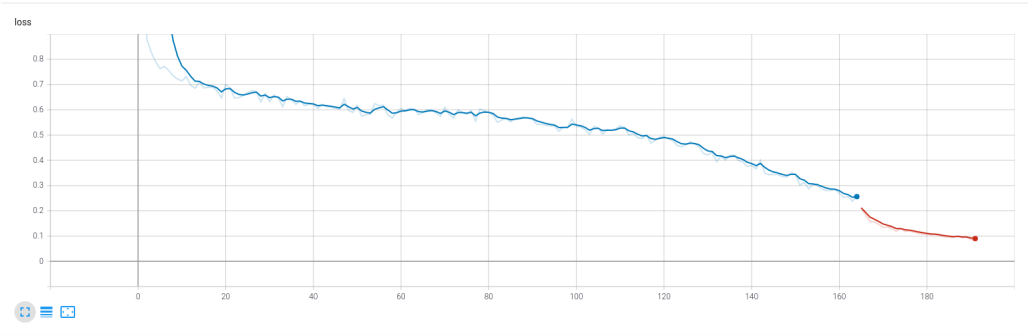
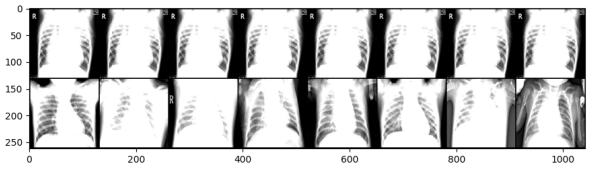


Figure 5: Siamese Network Loss Curve

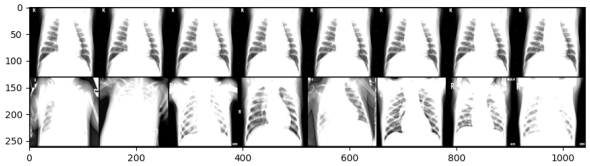
More results from testing are below. "MeanDist" stands for mean distances for each class. Furthermore, while the images above are same with each other and belong to COVID class, images below drawn randomly from different classes to see success of the ranking.



	unknown	bacteria	Virus	Virus	Virus	unknown	Virus	bacteria
OriginalClass	Virus	Virus	Virus	Virus	Virus	Virus	Virus	Virus
EuclideanDistances	2.748211	0.973583	0.897354	0.097271	0.430918	2.486997	0.517825	0.445929

	covid	unknown	bacteria
MeanDist	0.4858420416712761	2.6176036596298218	0.7097561061382294

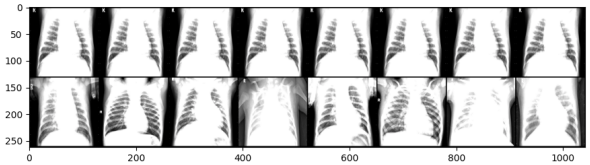
Figure 6: Siamese Network Test - 1



	Virus	Virus	Virus	Virus	bacteria	unknown	bacteria	Virus
OriginalClass	Virus	Virus	Virus	Virus	Virus	Virus	Virus	Virus
EuclideanDistances	1.941609	0.953934	1.376979	0.319095	1.723118	0.869112	0.613055	0.389943

	covid	unknown	bacteria
MeanDist	0.996312016248703	0.8691115975379944	1.168086588382721

Figure 7: Siamese Network Test - 2



	Virus	unknown	Virus	Virus	Virus	bacteria	bacteria	Virus
OriginalClass	Virus	Virus	Virus	Virus	Virus	Virus	Virus	Virus
EuclideanDistances	0.891703	1.708812	1.483523	1.257595	0.794936	1.029587	2.286584	0.982806

	covid	unknown	bacteria
MeanDist	1.0821125388145447	1.7088118715915802	1.658085286617279

Figure 8: Siamese Network Test - 3

5 References

[1] https://www.kaggle.com/praveengovi/coronahack-chest-xraydataset

[2] https://www.kaggle.com/timstefaniak/multi-classification-of-x-ray-imagesSetting-up-Neural-Network

[3] Siamese Neural Networks for One-shot Image Recognition, Koch et.al