Exploring the Efficacy of Using a Neural Network Trained on Non-Tuberculosis Chest X-Rays for Detecting Tuberculosis

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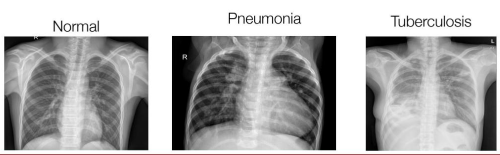
Motivation

- The use of CNNs in healthcare is rapidly rising as machine learning is becoming increasingly better for sorting and classifying healthcare data, reducing costs, and reliably increasing efficiency.
- To explore the limitations of CNNs, we hope to test how a neural network trained to detect pneumonia performs on a different disease that it was not trained on, such tuberculosis.
- We also hope to investigate how well CNNs learn and detect abnormalities when a neural network is trained on a larger dataset of a variety of diseases not including tuberculosis and is tested on the presence of tuberculosis.

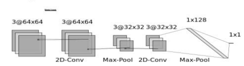
Problem Definition

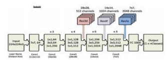
- Firstly, we train a convolutional neural network to detect the presence of pneumonia in X-ray images of lungs. Secondly, we use the CNN trained to detect the presence of pneumonia to detect the presence of tuberculosis.
- Next, we train a CNN on a larger dataset with a variety of diseases to detect if lungs are abnormal or not. Finally, we use this CNN trained on the larger dataset with various diseases to detect the presence of tuberculosis and compare the two CNN performances on tuberculosis detection.
- The data set for pneumonia consisted of 5856 images of lung X-rays: 4273 (73%) images with pneumonia, and 1583 normal lung images (27%). These were divided into 3456 images for training (60%), 1155 images for validation (20%), and 1155 images for testing (20%).
- The larger dataset contained 40,000 images of lung X-rays, 18447 (46%) images were abnormal and 21553 (54%) images were normal. These were randomly divided into 36,000 images for training (90%), 2000 images for validation (5%) and 2000 images for testing (5%).
- The data set for tuberculosis consisted of 138 images of lung X-rays: 58 images with tuberculosis (43%), and 80 normal lung images (57%).



Approaches

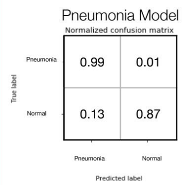
Most of the effort for this project was spent on developing the model to detect tuberculosis from chest x-ray images. In both of our models we fine-tuned a pre-trained ResNet50 model by freezing all but the last four layers, and adding our own dense layers. Our first approach was to train the model on the small pneumonia data set. The second approach involved training on a much larger data set of abnormal and normal lungs.



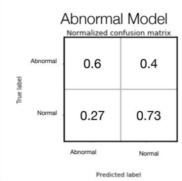


In addition to using these different CNN architectures, we attempted to optimize detection accuracy by altering the ratio of images in our test/validation/training datasets. Furthermore we tried to, among other things, alter the amount of data and number of epochs to train on. We saved these trained models, then used them to detect tuberculosis.

Results

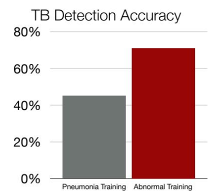


- The model trained on pneumonia achieved 96% accuracy classifying pneumonia.
- However, the model did not perform very well with 45% accuracy when classifying tuberculosis.



- On the other hand, the model trained on abnormal vs. normal images only achieved 67% accuracy during testing.
- However, this model outperformed the pneumonia model achieving about 71% accuracy when classifying tuberculosis.

Analysis



Neither of the networks which we trained on pneumonia/normal images did as well detecting tuberculosis as we would have liked. Some insights we made from our data include:

- The dataset for pneumonia had 2x more pneumonia lung images than normal images, causing high accuracy of detecting pneumonia for lungs with pneumonia, but not as well for normal lungs.
- The more we trained the model on images of normal vs. abnormal images, after a certain point accuracy got no better.
- Despite, having a lower testing accuracy than the pneumonia model, abnormal model far outperformed when testing for TB

Challenges and Future Work

- One significant challenge we faced was understanding how different hyper-parameters and activation functions affected the overall accuracy and why some work better than others.
- Despite tuning several hyper-parameters, we still encountered issues with improving our testing accuracy for the CNN trained on the larger dataset of various diseases
- Utilizing the GCloud platform for the first time was perhaps our biggest challenge, as we lacked experience and there was a significant learning curve to understand how to use the environment.
- In the future, we hope to improve our model with further training and hyper parameter tuning to explore accuracies for both testing and tuberculosis detection

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