Diagnosing Pediatric Pneumonia from Chest X-rays Using Convolutional Neural Networks

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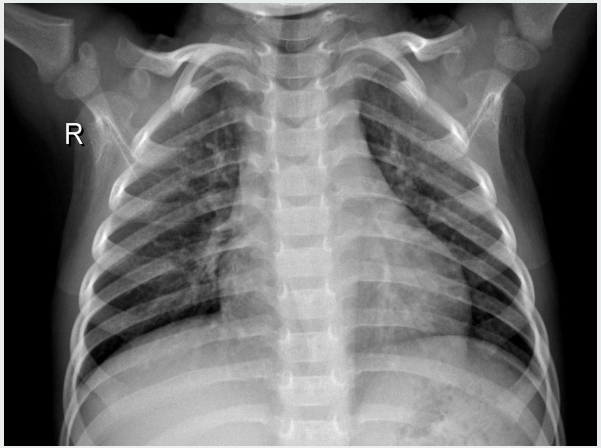
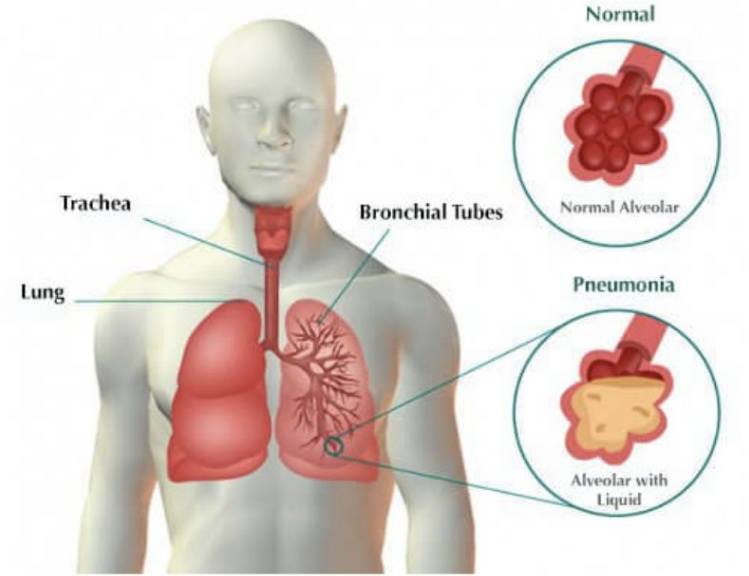


Introduction

Pneumonia is responsible for 16% of child deaths under 5 years old

Disease Profile

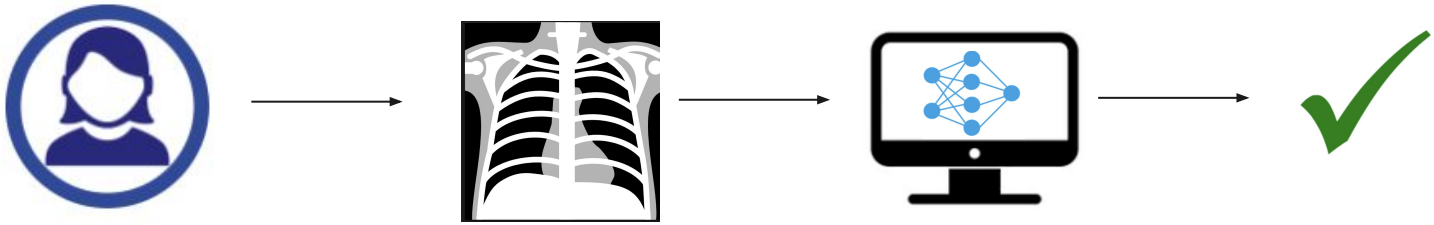
- Acute respiratory infection impacting the lungs
- Caused by infectious agents such as bacteria, viruses, and fungi
- Lung inflammation limits oxygen intake and if left untreated can be deadly
- Different causes require different treatments



Early detection and treatment is critical to reducing pneumonia fatalities in children

Machine learning models can help expedite the disease screening process and serve as a 2nd opinion

Clinical Decision Support System



Physician examines patient with outward symptoms

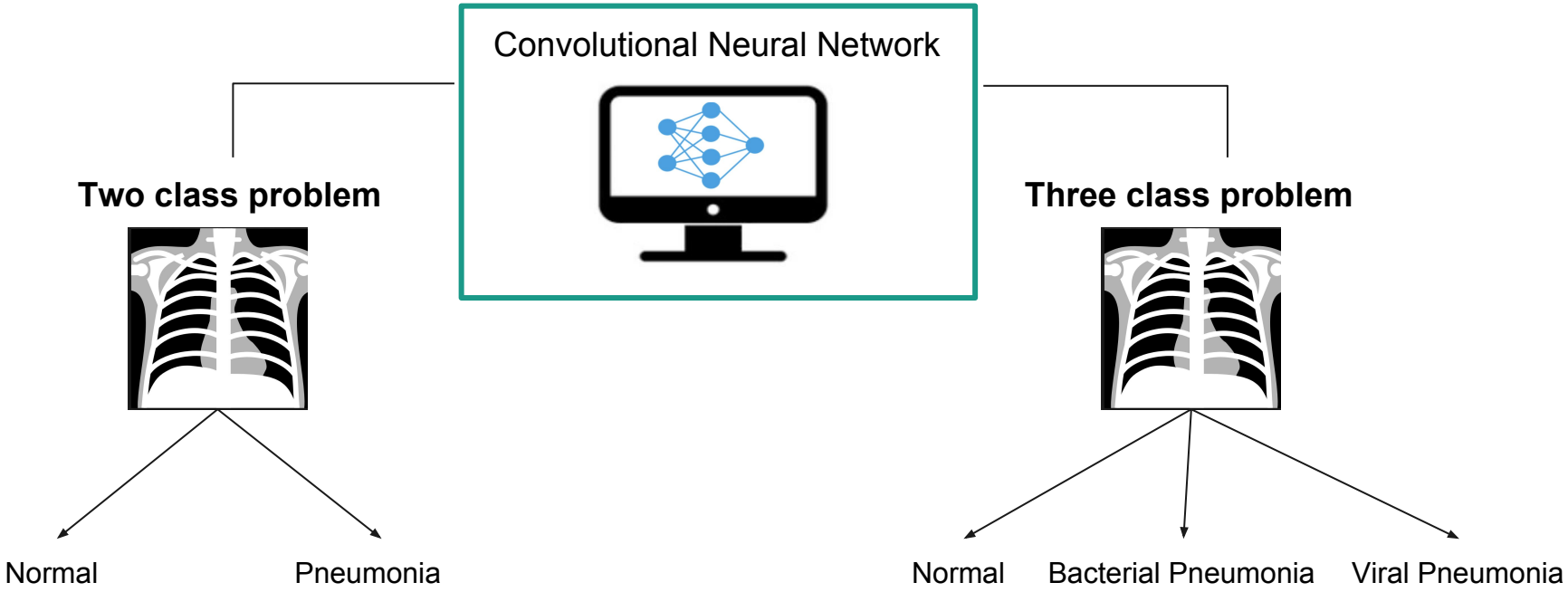
Physician orders X-ray

Machine learning model classifies X-ray

Physician confirms diagnosis

Armed with AI systems, physicians make more accurate diagnoses

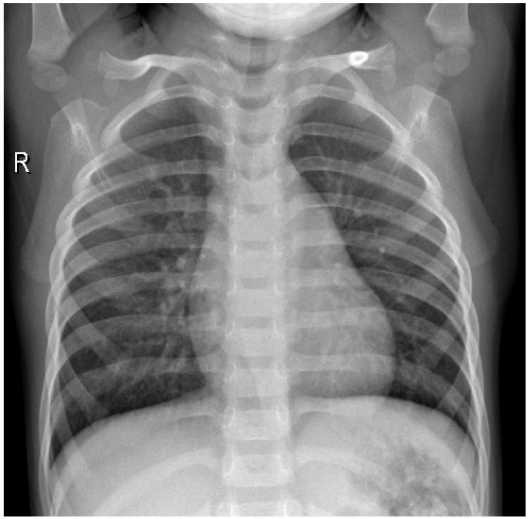
Goal to build a machine learning model to classify pediatric pneumonia from chest X-rays



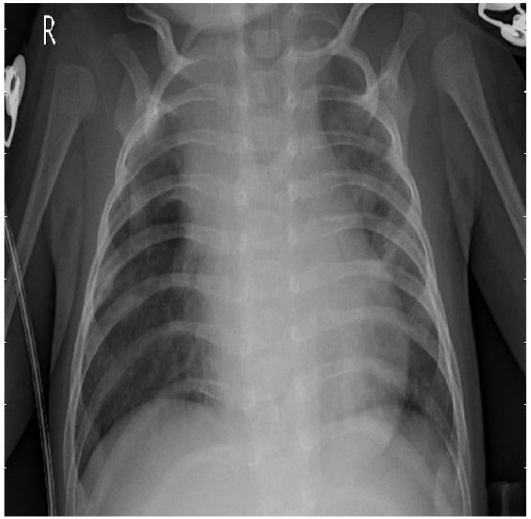
Data Gathering & Analysis

Obtained 5,000+ physician labeled pediatric chest X-rays from a 2018 study by Kermany et al.

Normal



Bacterial Pneumonia



Viral Pneumonia

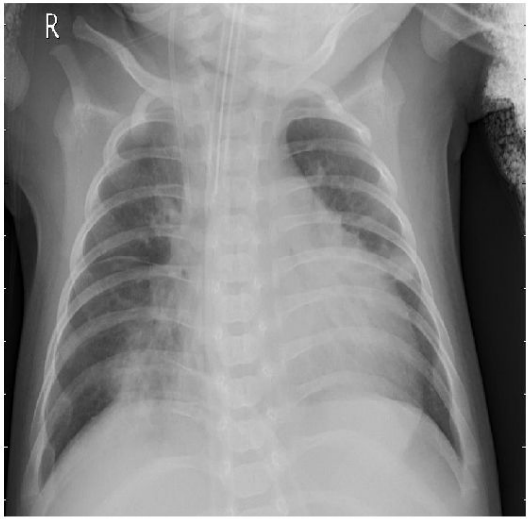
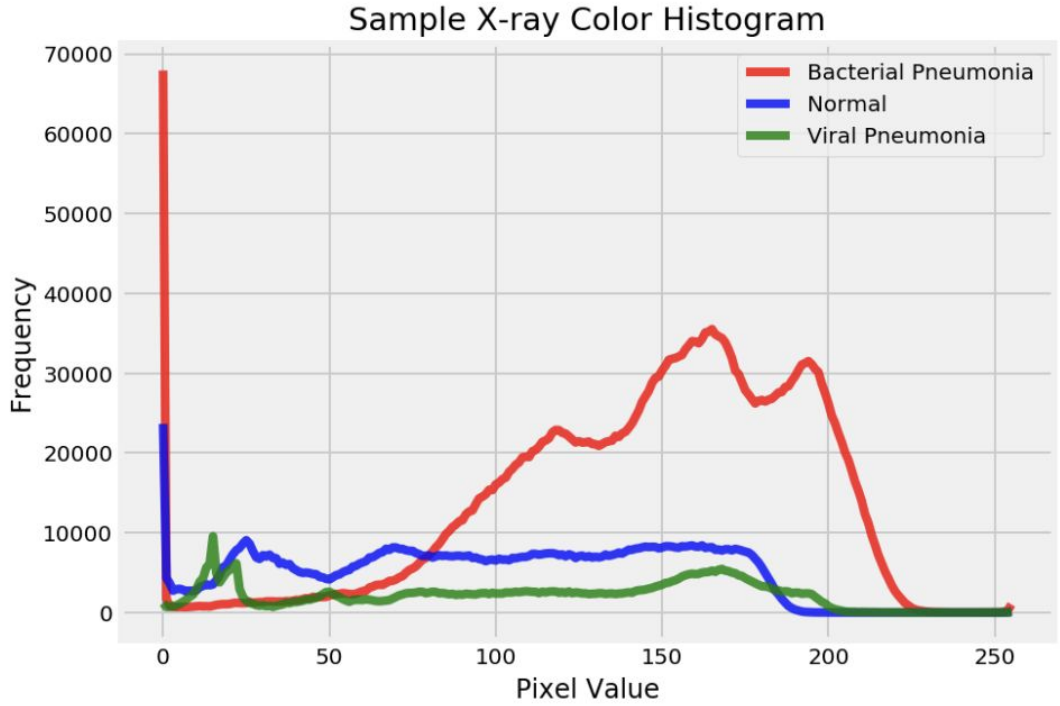
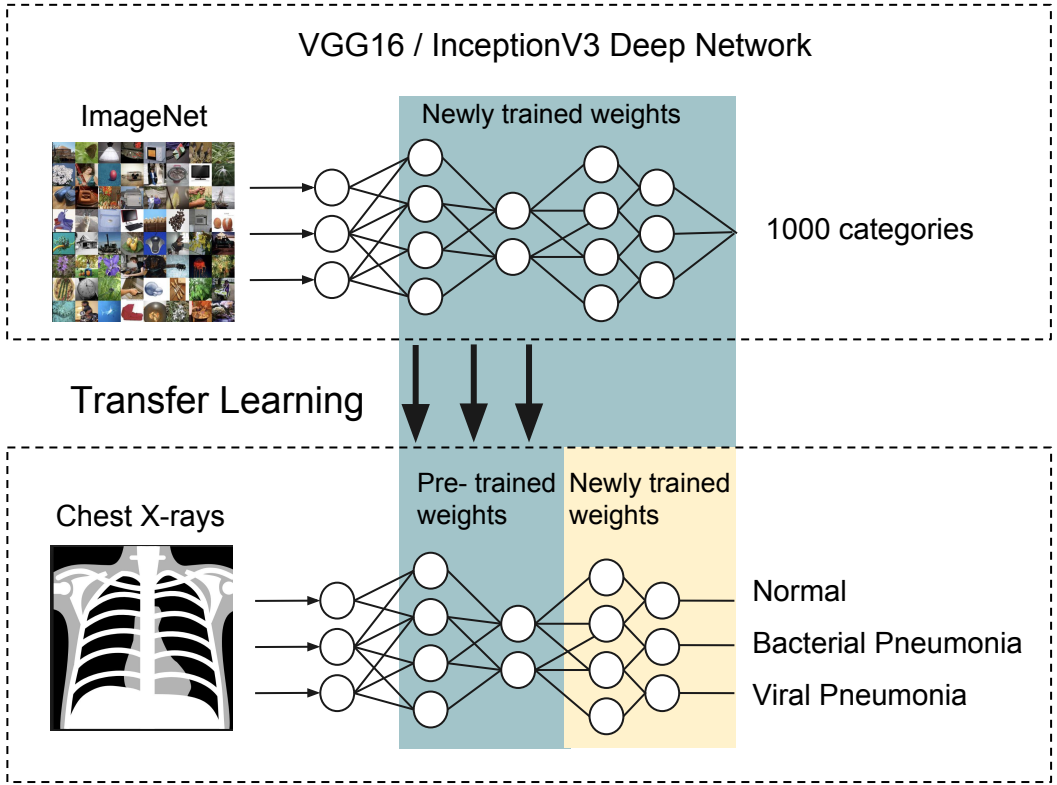


Image analysis revealed varying color distributions and inconsistent sizing in the X-rays



Modeling

Compared performance of newly initialized neural networks to transfer learning approach



Optimized for sensitivity to reduce number of false negatives and ensure delivery of needed treatment

False negatives

- Patient diagnosed as healthy who has pneumonia
- Disease is not treated, which can result in death
- Patient can infect others

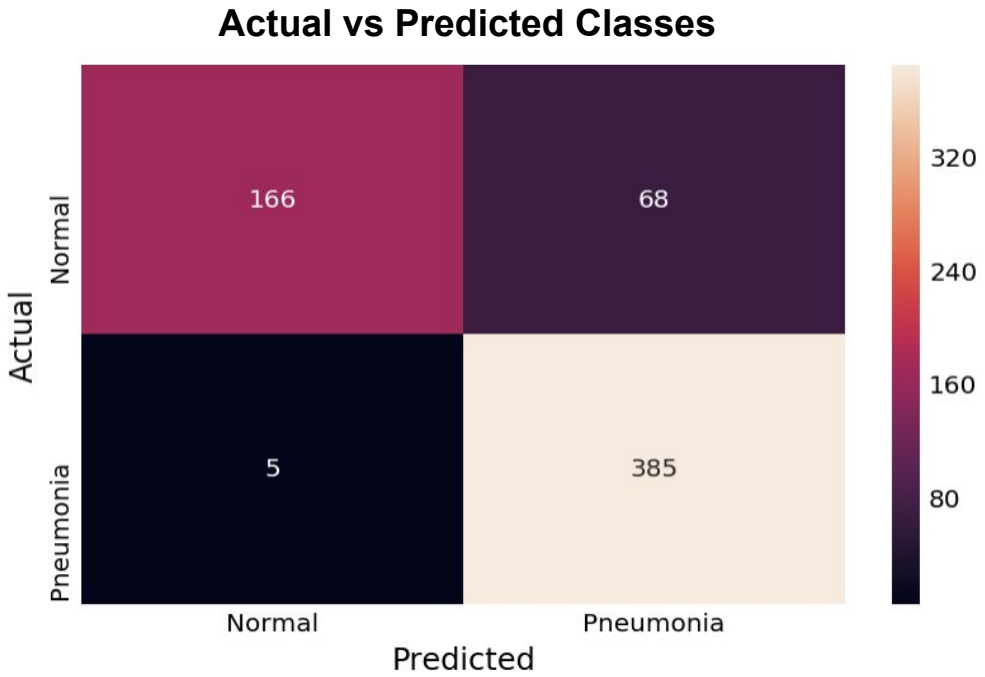
Sensitivity

False positives

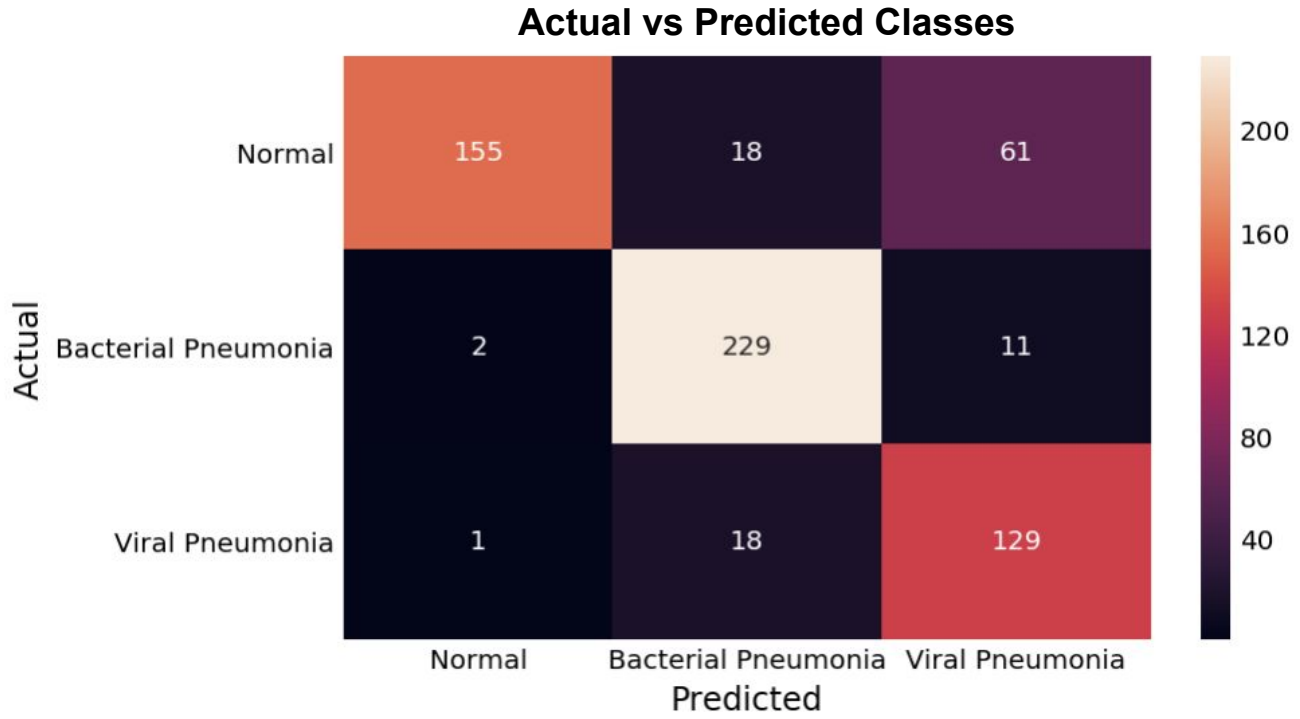
- Patient diagnosed with pneumonia who is healthy
- Treatment administered, which may have adverse health effects
- Over-prescription of antibiotics leads to rise of antibiotic resistant bacteria

Specificity

Binary classification CNN model performed best with 88% accuracy, 99% sensitivity, and 71% specificity



Multi-Class VGG16 model performed best with 82% accuracy, 99% sensitivity, and 66% specificity



Conclusions

Results demonstrate feasibility of using CNNs and transfer learning to diagnose pneumonia from X-rays

Key takeaways

- Models suffered from overfitting
- Binary classification CNN performance comparable to human experts
- Simple network architecture yielded better results for binary classification given small dataset
- Viral pneumonia classification was less accurate compared to bacterial, most likely due to the smaller sample size
- Recommend VGG16 over InceptionV3 for transfer learning applications with X-rays

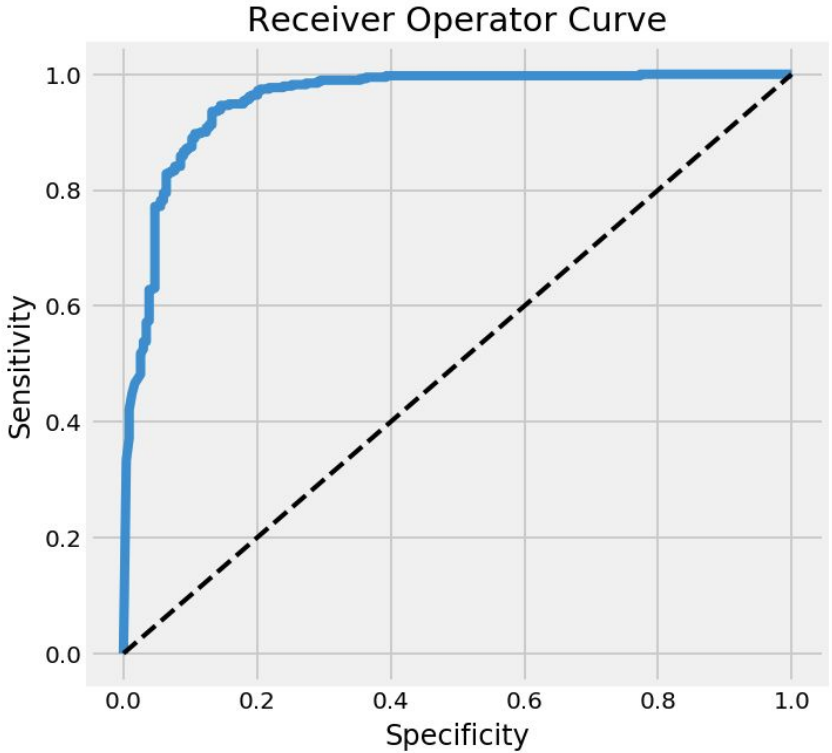
Models can be further improved to increase accuracy and specificity

Next steps

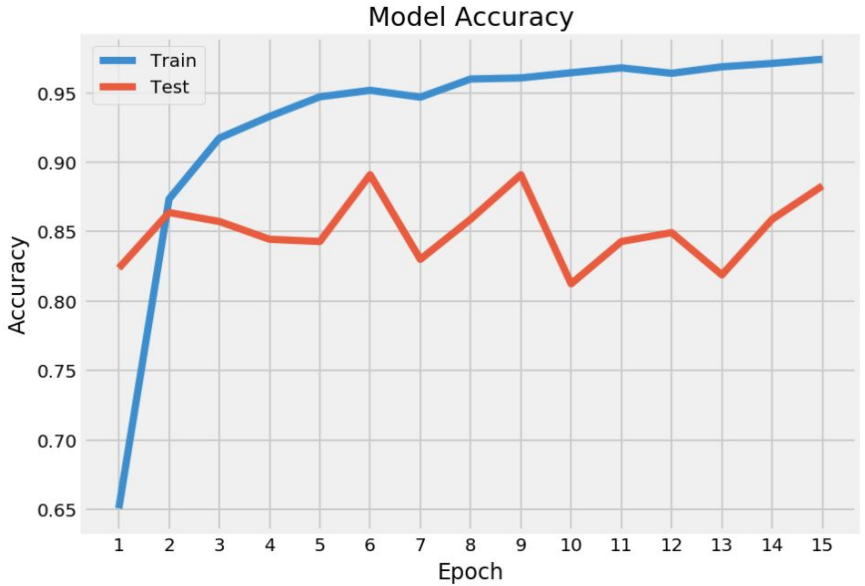
- Explore other transfer learning models (VGG19 and Xception)
- Replicate Kermany et al. study more closely with InceptionV3
- Binary classification between bacterial and viral pneumonia with a larger dataset

Appendix

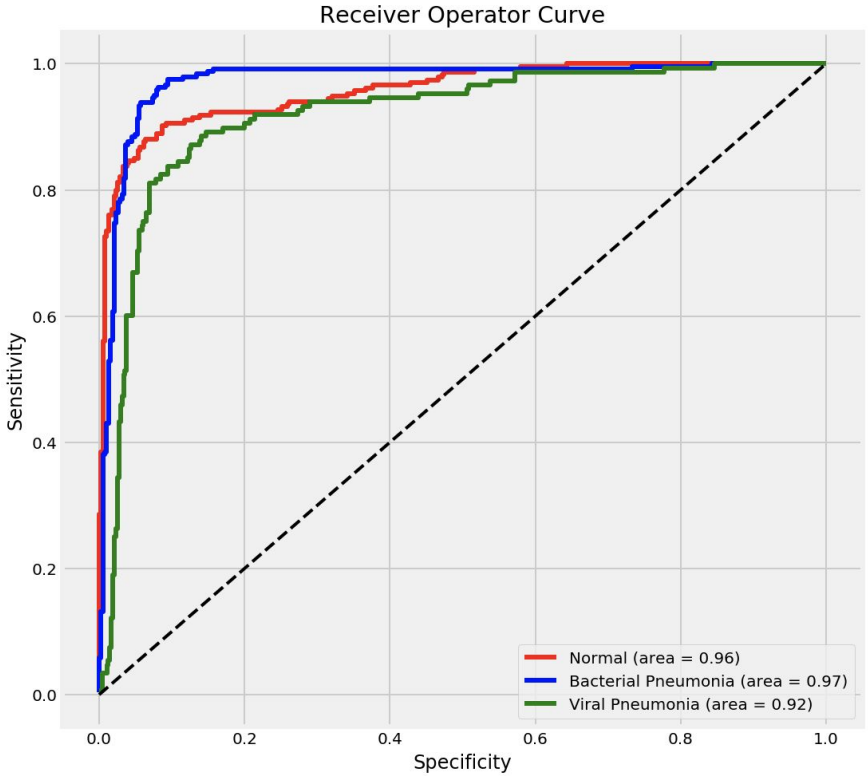
Binary classification CNN model had a 0.96 AUC-ROC score



Binary classification CNN model is overfit due to divergence of test and train loss and accuracy scores



VGG16 multi-class classification model had an average 0.95 AUC-ROC score



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