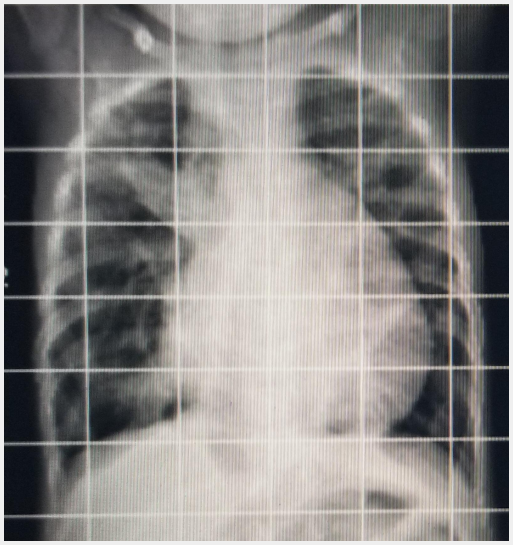
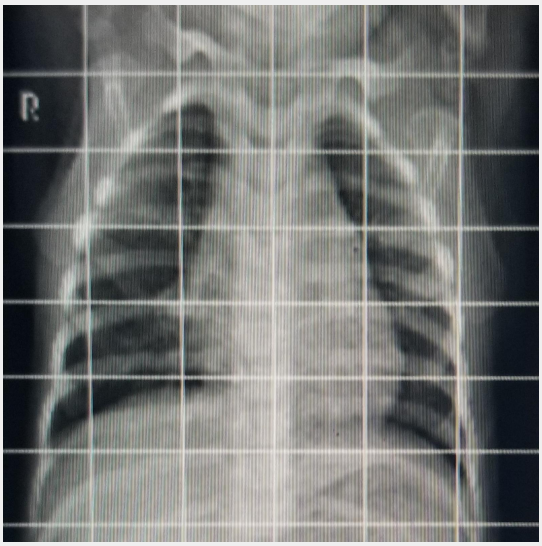
Pneumonia detection convolutional neural network (CNN)

Which image of lungs has pneumonia in it?

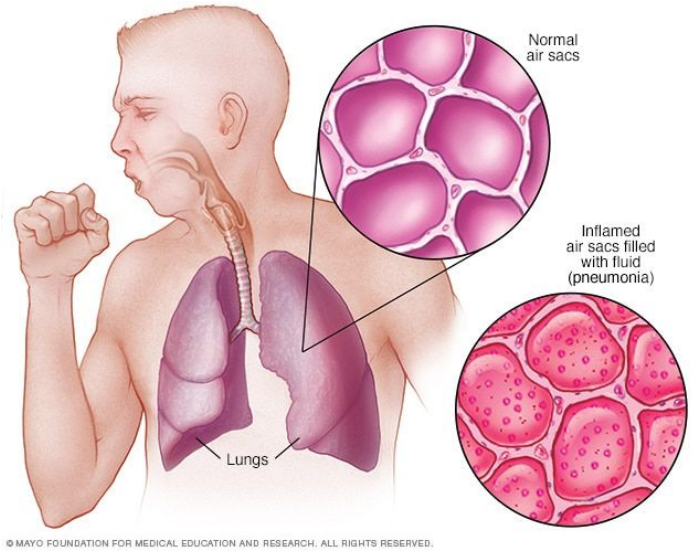




Only an MD or an algorithm can tell. The image of lungs to the left has pneumonia in it. Dense structures block radiation and appear as white while structures that are less dense appear black.

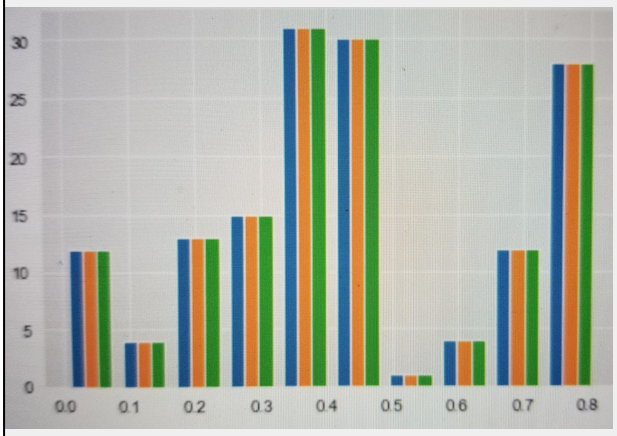
MD Pneumonia Detection Success Rate

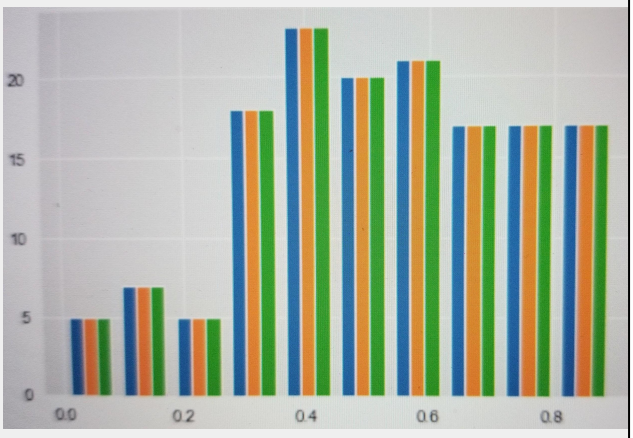
- Muscle Aches
- Dry Cough
- Abdominal Pain
- Cold In The Head Or Throat
- Fever With Shivering
- Chest Pain
- Nausea And Vomiting



When the air sacs in lungs are filled with fluid the sacs are denser, and therefore, cloud the lungs in an x-ray. MDs will diagnose patient with pneumonia, even if a chest x-ray appears negative, if the patient has symptoms of pneumonia.

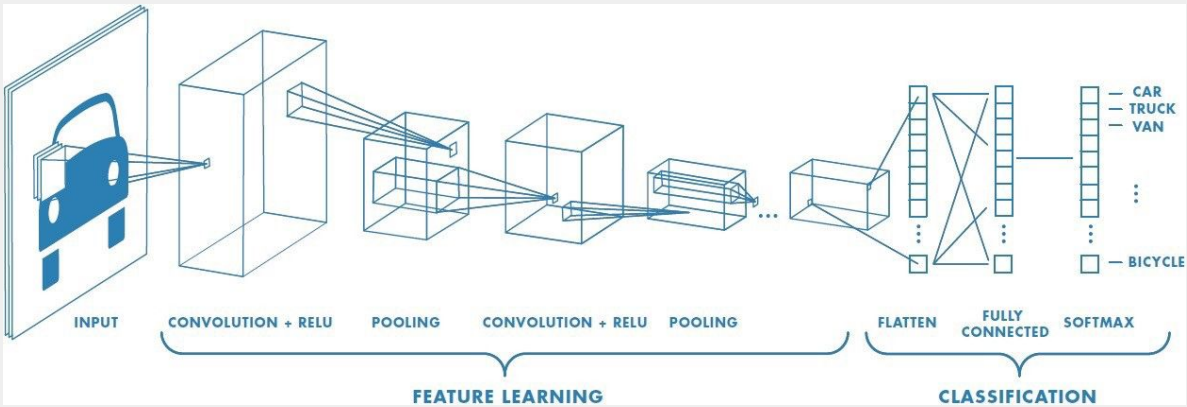
How A Computer Sees Images





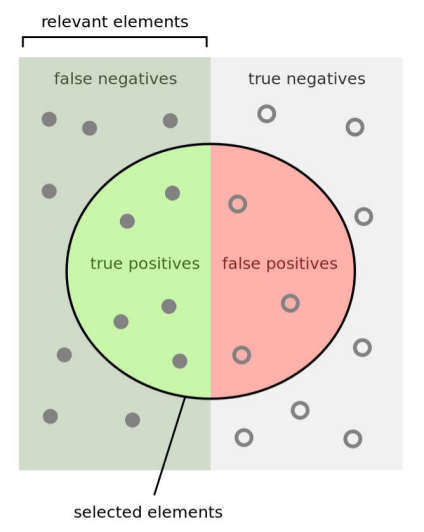
These are distributions of the matrices of the previous x-ray images.

Convolutional Neural Network



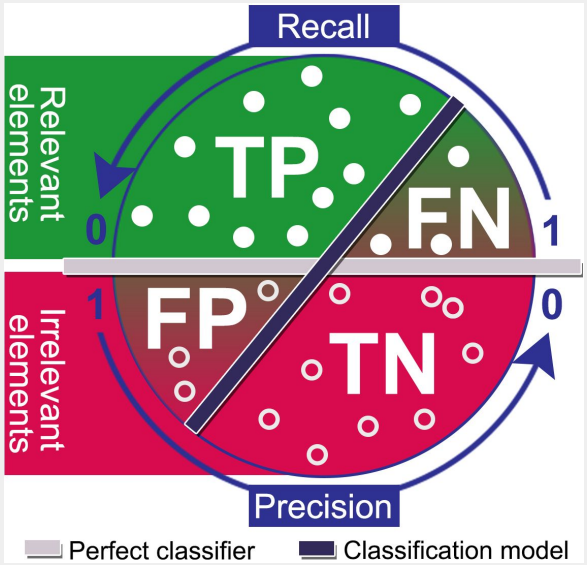
A convolutional neural network (CNN) has an input, output, and multiple hidden layers. The hidden layers have a series of convolutional layers that produce the dot product of filter weights and pixel matrices. A filter is used to dimentionally reduce an image to find high frequency parts of the image. An activation function determines neuron weight from one layer to the next. The convolutional layer is followed by a pooling layer, which uses a filter to reduce the dimensions of the convoluted result into fewer parameters. After the convolutional and pooling layers the the resulting pixel weight matrix is classified.

Four Types Of Classifications



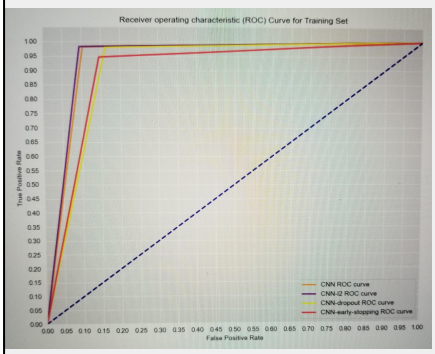
True positive results are correctly classified as pneumonia, true negative results are correctly classified as healthy, false positive results are are misclassified as pneumonia, and false negative results are misclassified as healthy.

Precision Recall Tradeoff



There is a tradeoff between precision and recall. If the model is set for precision, then the model will attempt to correctly classify more false positives as true negatives at the expense of potentially classifying more true positives as false negatives. If the model is set for recall, then the model will attempt to correctly classify more false negatives as true positives at the expense of potentially classifying more true negatives as false positives . We prefer a model with higher recall because we want the model to correctly classify as many true positives, cases of pneumonia, as possible and not miss a case of pneumonia, false positive. However, we want to be mindful of precision because we do not want to misclassify as pneumonia, false positive, and give a patient antibiotic who does not require the medicine.

CNN Results



Model On Training Data	**Loss**	**Accuracy**	**Precision**	**Recall**	**F1**	**ROC**
CNN	0.0678	0.9511	0.9640	0.9712	0.9665	0.9380
CNN-L2	0.0691	0.9549	0.9678	0.9705	0.9683	0.9425
CNN-Dropout	0.1115	0.9099	0.9322	0.9475	0.9383	0.9076
CNN-Early-Stopping	0.1490	0.8762	0.9064	0.9368	0.9146	0.8991
Model on Validation Data						
CNN	0.4735	0.7500	0.6667	1.0000	0.8000	
CNN-L2	0.4101	0.8125	0.7273	1.0000	0.8421	
CNN-Dropout	0.6932	0.7500	0.6667	1.0000	0.8000	
CNN-Early-Stopping	0.5595	0.7500	0.7000	0.8750	0.7778	

CNN is a base convolutional neural network model. CNN-L2 and CNN-Dropout are a regularized versions that purposely do not fit the data as well so as to generalize better to other cases. CNN-Early-Stopping ends training once the validation accuracy begins to decrease. The validation data is used to determine which model generalizes the best and should be used for testing the model. ROC is the rate of true positives to false positives. The model with the best metrics is the CNN-L2 model.

Testing the model

LOSS	ACCURACY	PRECISION	RECALL	F1	ROC
0.2316	0.7997	0.8366	0.8712	0.8356	0.6132

The model classified 53 true negatives, 390 true positives, 181 false positives, and 0 false negatives. If a doctor read the x-ray as negative but the patient had pneumonia symptoms, the doctor would treat the patient for pneumonia. The model does not classify any patients who have pneumonia as healthy, but it does classify healthy patients as having pneumonia, similar to a doctor.

Future Work

Building models that test better by solving for better hyperparameters from high dimensional parameter space.

Thank you

Appendix

- https://acphospitalist.org/archives/2014/03/pneumonia.html
- https://www.mayoclinic.org/tests-procedures/chest-x-rays/about/pac-20393494
- https://en.wikipedia.org/wiki/Sensitivity_and_specificity
- https://commons.wikimedia.org/wiki/File:Precision-Recall_tradeoff.png
- https://www.mayoclinic.org/diseases-conditions/pneumonia/symptoms-causes/syc-20354204
- https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53