# Detecting Pneumonia in Chest X-Rays

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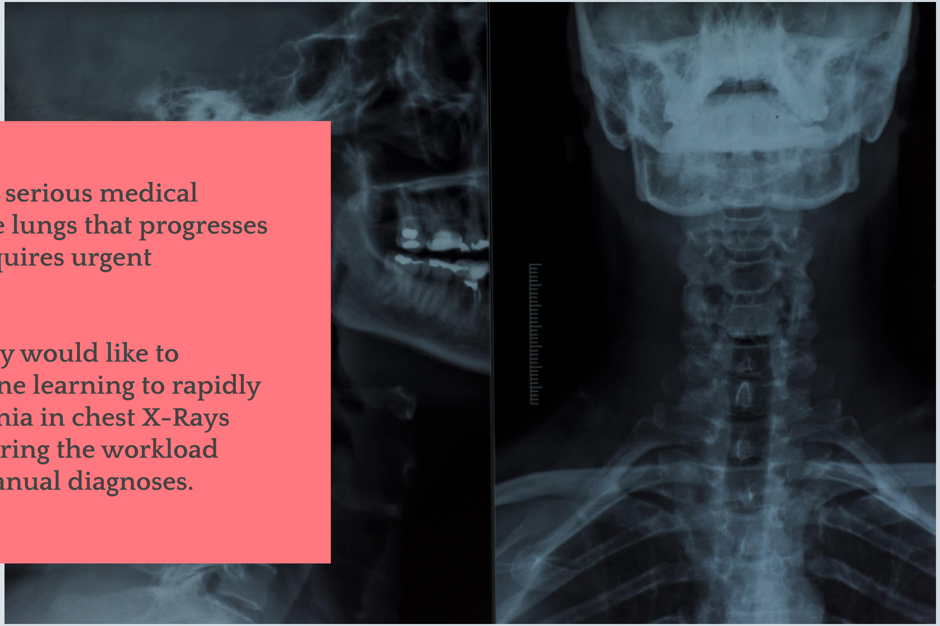
Flatiron School

# INTRODUCTION



Pneumonia is a serious medical condition of the lungs that progresses quickly and requires urgent treatment.[1]

ACME Radiology would like to leverage machine learning to rapidly detect Pneumonia in chest X-Rays while also lowering the workload required for manual diagnoses.



1. https://frontlineer.com/when-to-go-to-urgent-care-for-pneumonia/

# BUSINESS PROBLEMS

1. Save time for ACME Radiology department from having to manually evaluate chest x-rays for Pneumonia
2. Develop machine learning model that achieves at least 90% F1 score
3. Identify model limitations before implementing into the field

# SUCCESS METRICS

## F1 SCORE

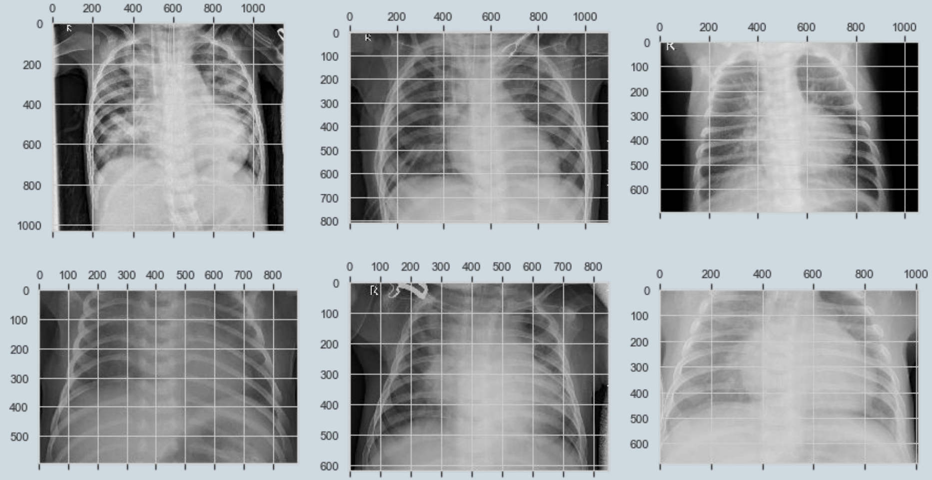
Balance between precision (no false positives) and recall (tolerating some false positives)

## Recall

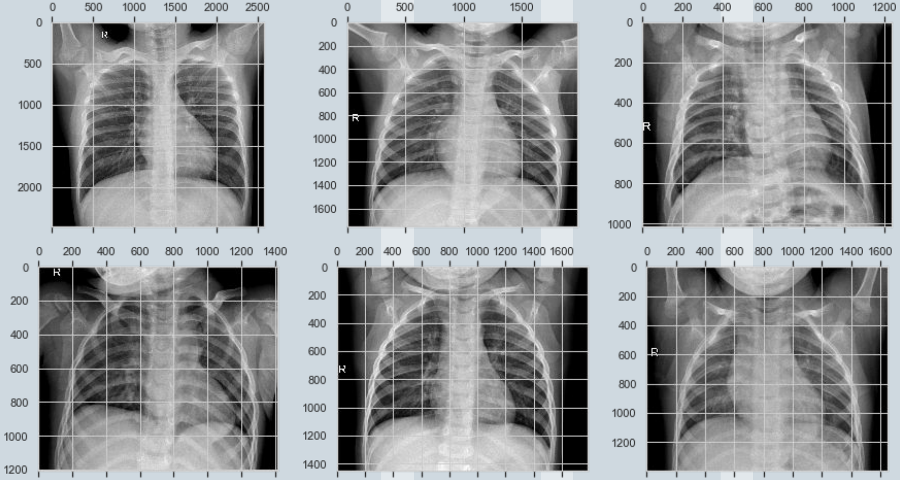
While F1 is the primary metric, we can use Recall as a tiebreaker

# DATA & METHODS

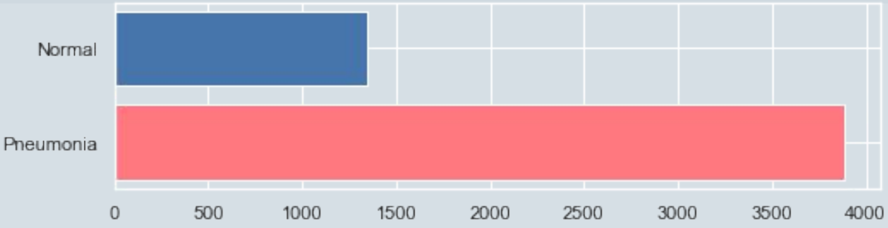
Chest X-Rays with Pneumonia



Chest X-Rays without Pneumonia



# of Training Images by Class



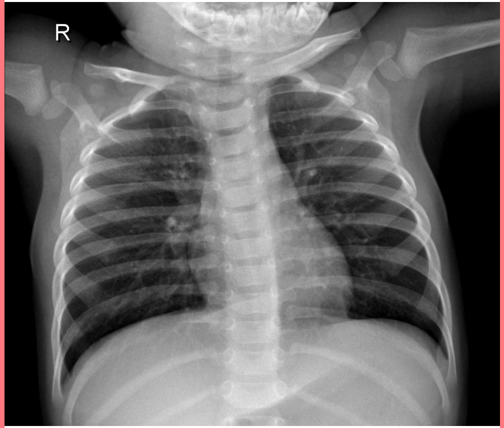

**5,232**

CHEST X-RAYS

From Kermany et al. (Mendeley)

# WHAT IS THE NEURAL NETWORK LOOKING FOR?

## NO PNEUMONIA




## PNEUMONIA DETECTED

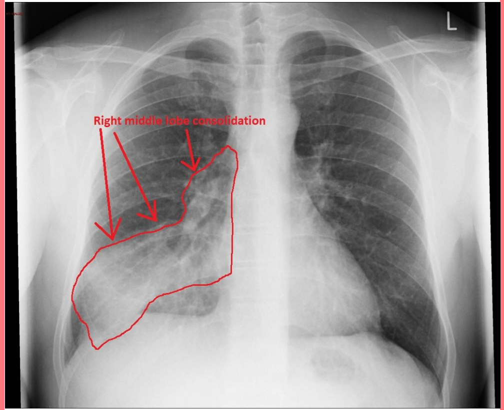


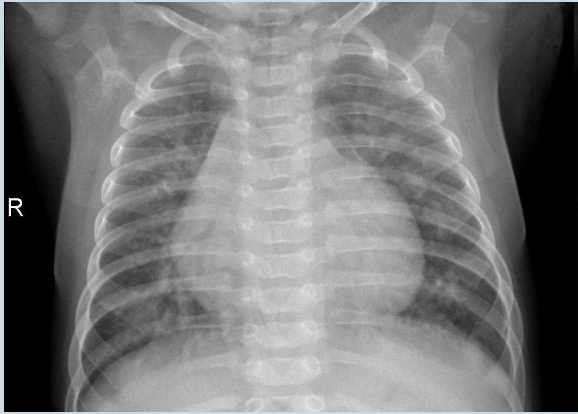

Image Source: https://www.wikidoc.org/index.php/Pneumonia_chest_x_ray

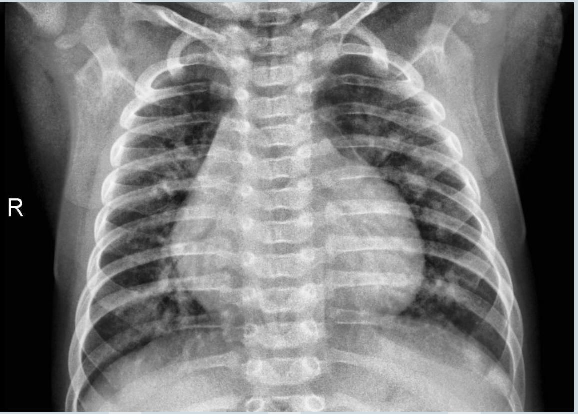
ORIGINAL IMAGE

AFTER HISTOGRAM EQUALIZATION

## Histogram Equalization

Research shows this technique **improved model performance** for pneumonia detection and our best performing model incorporated transformed images




## MODEL ITERATIONS

# VALIDATION DATA SCORES

| | Accuracy | Precision | Recall | F1 |
|---|---|---|---|---|
| **Baseline** | 0.97 | 0.94 | 0.96 | 0.95 |
| **‘Complex’ Dense Model** | 0.97 | 0.96 | 0.95 | 0.95 |
| **‘Simple’ CNN** | 0.97 | 0.97 | 0.92 | 0.94 |
| **CNN on High-Contrast X-Rays** | 0.97 | 0.99 | 0.87 | 0.93 |
| **VGG-19** | 0.98 | 0.99 | 0.99 | 0.99 |
| **ResNet-50** | 0.97 | 0.99 | 0.97 | 0.98 |

## DATA METHODS

VGG-19 NEURAL NETWORK

MODEL STRUCTURE

- 1 Input Layer (224 x 224 x 3)
- 5 MaxPooling2D Layers
- 16 Conv2D Layers

20,024,384 Non-Trainable Parameters

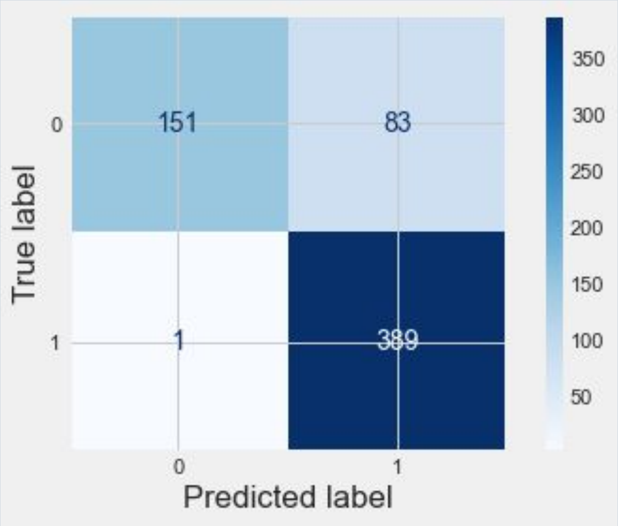
↓

- 1 MaxPooling2D Layer
- 1 Flatten, 1 Dropout Layer
- 1 Output Layer

50, 178 Trainable Parameters

# FINAL MODEL EVALUATION

## VGG-19 NEURAL NETWORK




- Accuracy: 0.87
- Precision: 0.82
- Recall: 0.99
- F1 score: 0.90

# RECOMMENDATIONS


Take
high-contrast
X-Ray

# RECOMMENDATIONS

1

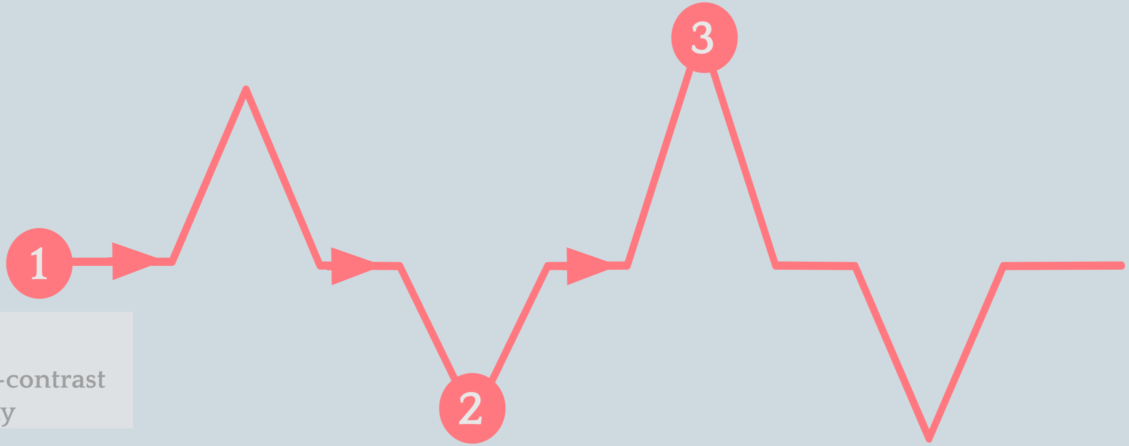
Take
high-contrast
X-Ray

2

Feed image into
database for
processing

# RECOMMENDATIONS

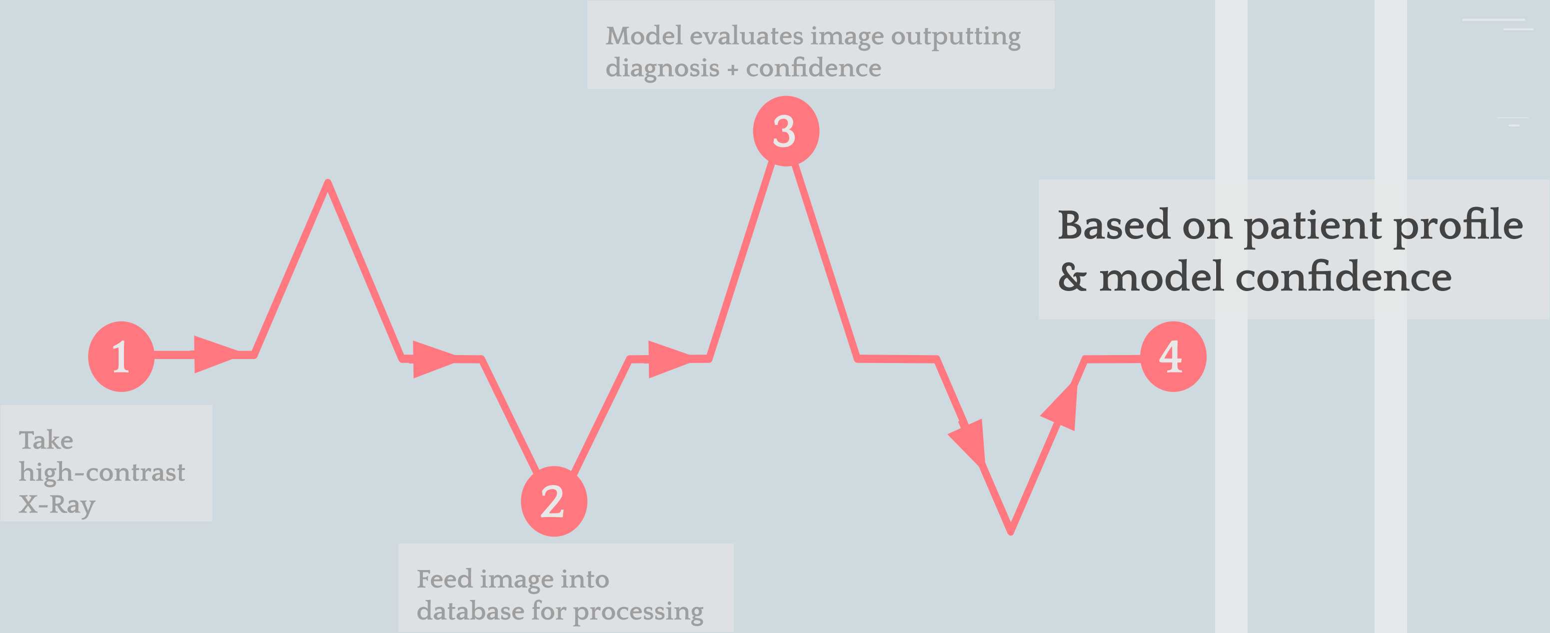
Model evaluates image outputting diagnosis + confidence



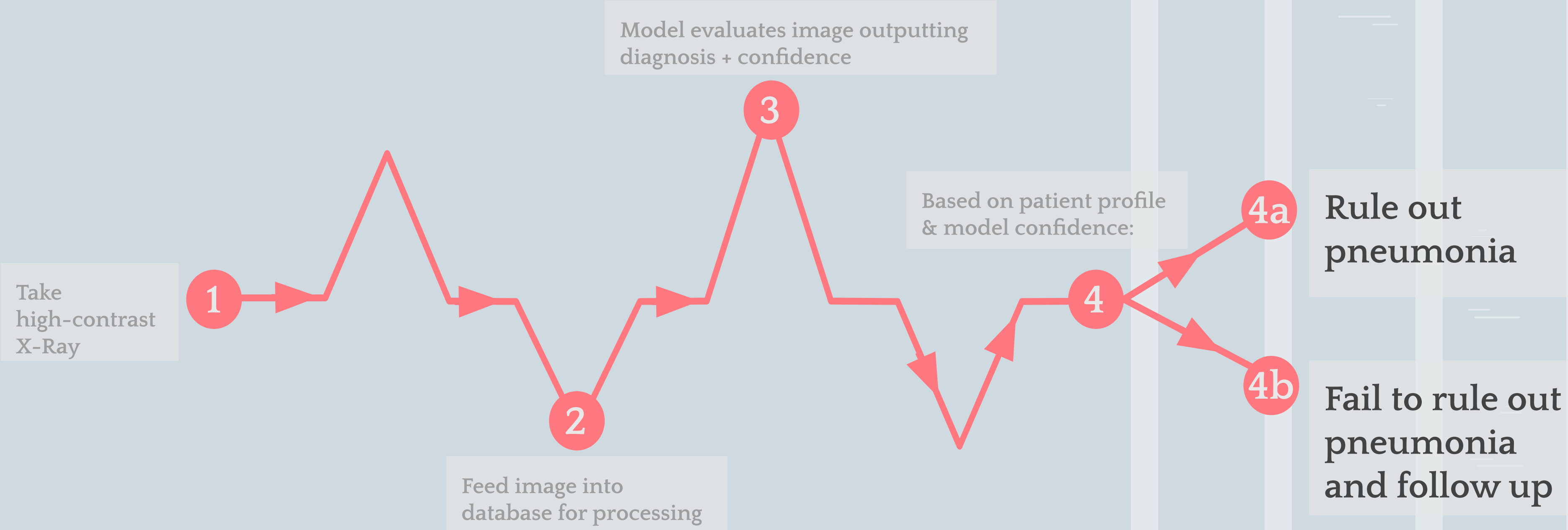

Take high-contrast X-Ray

Feed image into database for processing

# RECOMMENDATIONS



# RECOMMENDATIONS



# MODEL LIMITATIONS

**Limited healthy samples** in training set

**Confidence threshold** is currently arbitrarily set at 50%

**Potential for misdiagnosis** when diseases present symptoms similar to Pneumonia

# CONCLUSIONS & NEXT STEPS

- **Productionize and deploy** model into ACME workflow
    - **Develop web interface** for medical staff
- **Collect more healthy samples** to train model
- **Educate staff** on how to interpret model results
- Future work should **explore transfer learning with other promising models**, including MobileNet and DenseNet-201

# THANK YOU

Does anyone have any questions?

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# APPENDIX

# TRANSFER LEARNING

*"Transfer learning is a machine learning method where a **model developed for a task is reused as the starting point for a model on a second task**." – Jason Brownlee, Machine Learning Mastery*

- *Naronglerdrit P, Mporas I, Sheikh-Akbari A. COVID-19 detection from chest X-rays using transfer learning with deep convolutional neural networks – Epub (2021)*
- *Chakraborty S, Paul S, Hasan KMA. A transfer learning-based approach with deep CNN for COVID-19- and pneumonia-affected chest X-ray image classification. – PubMed (2022)*
- *B. Pardamean, T.W. Cenggoro, R. Rahutomo, A. Budiarto, E.K. Karuppiah. Transfer Learning from Chest X-Ray Pre-trained Convolutional Neural Network for Learning Mammogram Data – Procedia Comput. Sci., 135 (2018)*

# FULL MODEL STRUCTURE

VGG-19 NEURAL NETWORK

MODEL STRUCTURE

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 224, 224, 3)]     0

block1_conv1 (Conv2D)        (None, 224, 224, 64)      1792

block1_conv2 (Conv2D)        (None, 224, 224, 64)      36928

block1_pool (MaxPooling2D)   (None, 112, 112, 64)      0

block2_conv1 (Conv2D)        (None, 112, 112, 128)     73856

block2_conv2 (Conv2D)        (None, 112, 112, 128)     147584

block2_pool (MaxPooling2D)   (None, 56, 56, 128)       0

block3_conv1 (Conv2D)        (None, 56, 56, 256)       295168

block3_conv2 (Conv2D)        (None, 56, 56, 256)       590080

block3_conv3 (Conv2D)        (None, 56, 56, 256)       590080

block3_conv4 (Conv2D)        (None, 56, 56, 256)       590080

block3_pool (MaxPooling2D)   (None, 28, 28, 256)       0

block4_conv1 (Conv2D)        (None, 28, 28, 512)       1180160

block4_conv2 (Conv2D)        (None, 28, 28, 512)       2359808

block4_conv3 (Conv2D)        (None, 28, 28, 512)       2359808

block4_conv4 (Conv2D)        (None, 28, 28, 512)       2359808

block4_pool (MaxPooling2D)   (None, 14, 14, 512)       0

block5_conv1 (Conv2D)        (None, 14, 14, 512)       2359808

block5_conv2 (Conv2D)        (None, 14, 14, 512)       2359808

block5_conv3 (Conv2D)        (None, 14, 14, 512)       2359808

block5_conv4 (Conv2D)        (None, 14, 14, 512)       2359808

block5_pool (MaxPooling2D)   (None, 7, 7, 512)         0

flatten (Flatten)            (None, 25088)             0

dropout (Dropout)            (None, 25088)             0

dense_13 (Dense)             (None, 2)                 50178

=================================================================
Total params: 20,074,562
Trainable params: 50,178
Non-trainable params: 20,024,384
_________________________________________________________________
```

These layers are pre-trained on over **1 MILLION** images

We transfer the model's learnings from those million images to our image classification problem

We then add additional output layers to train model on our X-Ray Images