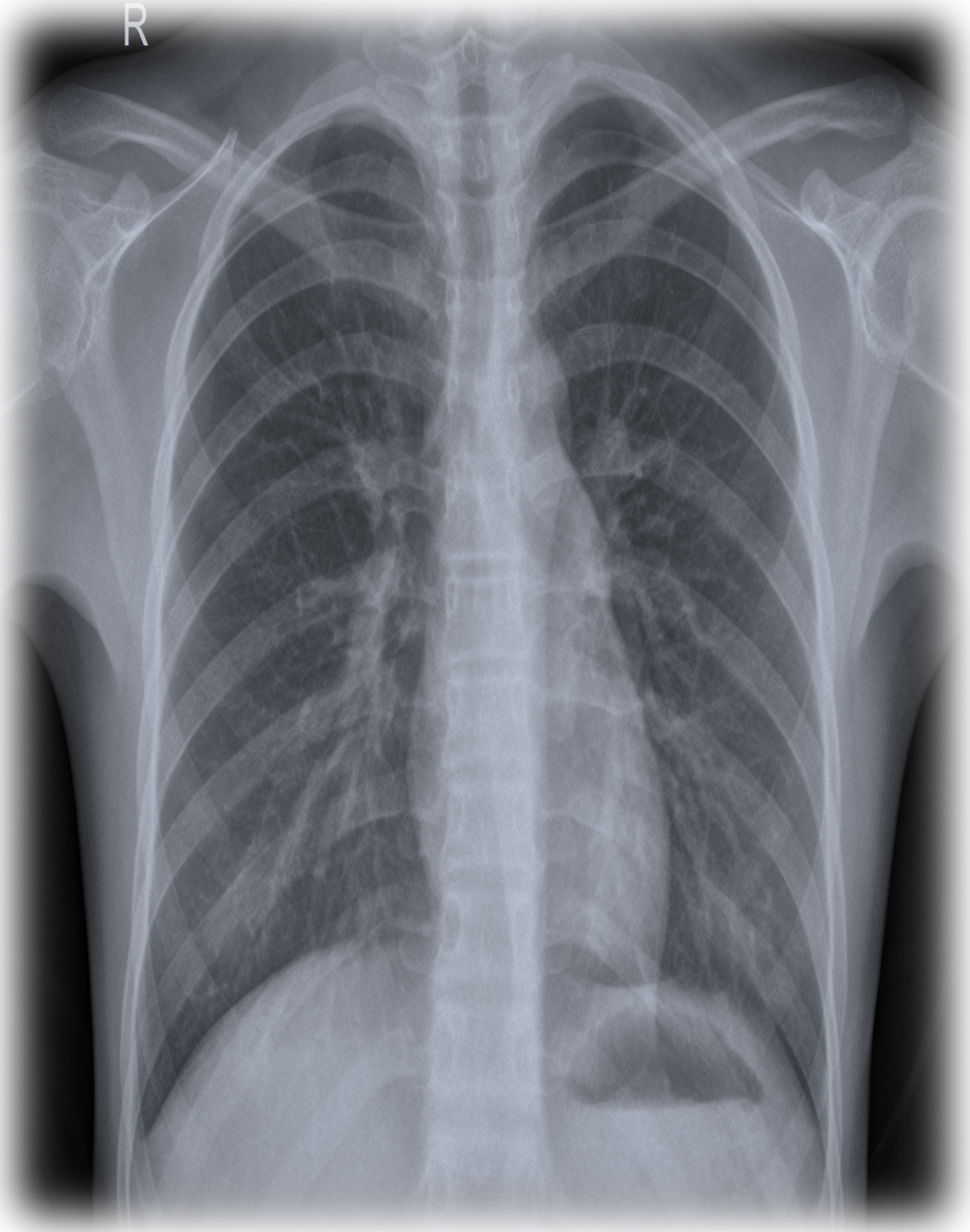
X-ray Image Classification for Pneumonia

Convolutional Neural Network



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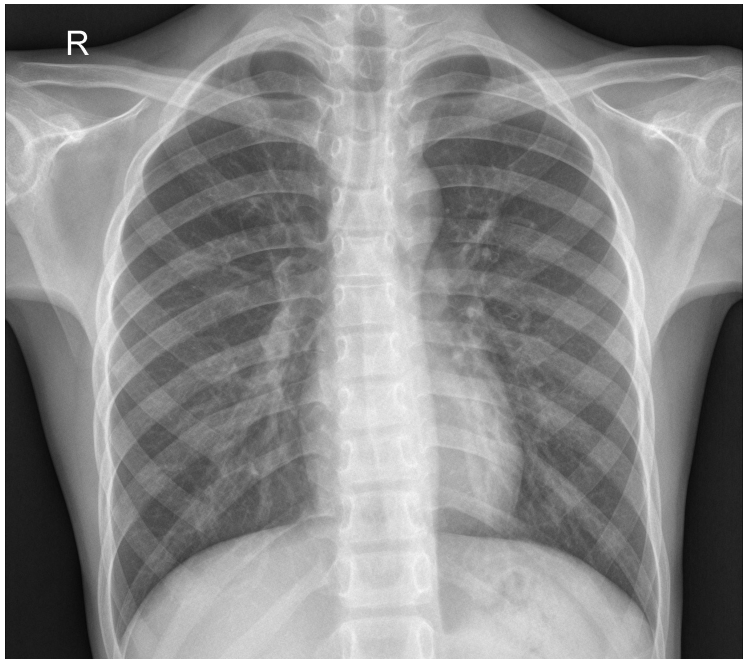
A chest X-ray is used to help the doctors in finding the cause of symptoms such as cough, shortness of breath, or chest pain.

Density by color:

- **Black: air**
- **Dark grey: fat**
- **Light grey: soft tissue**
- **Off white: bone**
- **Bright white: metal**



Detect signs of:

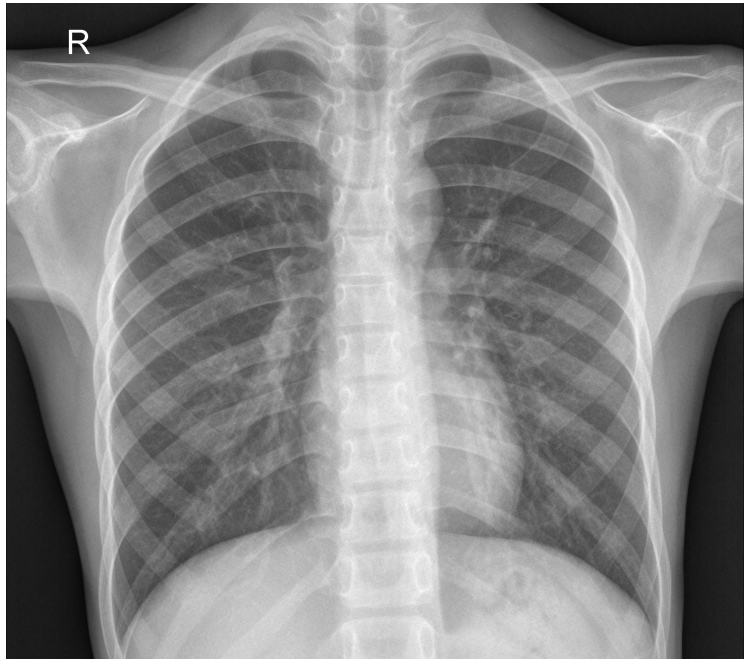
- **Pneumonia**
- **Asthma**
- **Collapsed lung**
- **Heart problems**
- **Broken ribs**

X-ray shows the difference in density for objects next to each other.

Source: https://www.mayoclinic.org/diseases-conditions/pneumonia/symptoms-causes/syc-20354204

Pneumonia is an infection that inflames the air sacs in one or both lungs.

Normal



Signs for pneumonia:

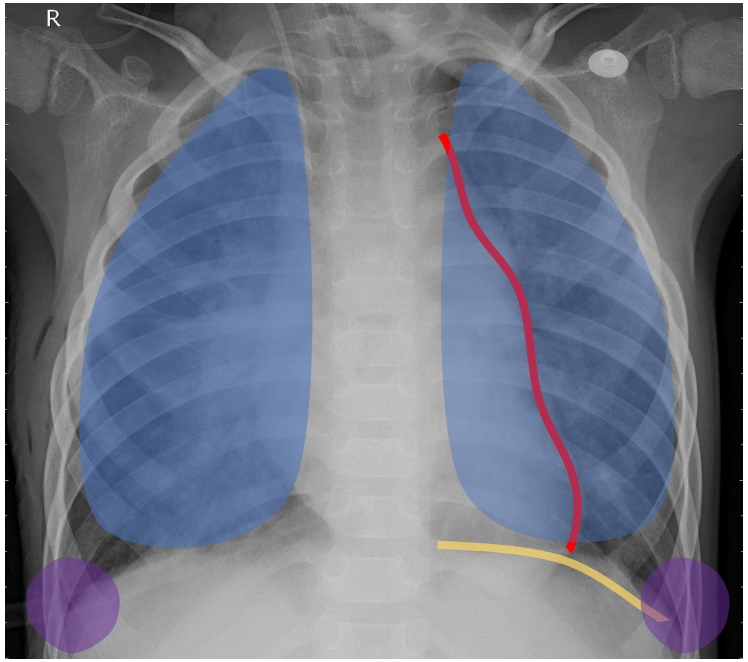
↑ shadows

↑ heart border

↑ hemidiaphragm

↓ costophrenic angles

Pneumonia



Pneumonia turns an air dense lung into a water dense lung.

Source: https://www.mayoclinic.org/diseases-conditions/pneumonia/symptoms-causes/syc-20354204

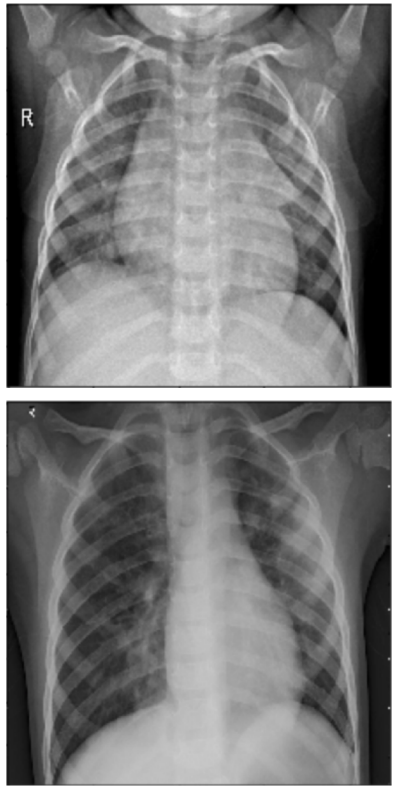
Can machine learning, especially neural networks assist doctors in making better diagnosis for pneumonia?

Pneumonia
or
Not?

Data Source: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

To identify pneumonia cases using transfer learning with convolutional neural network.

Input



Convolutional Neural Network

Transfer Learning (VGG16)

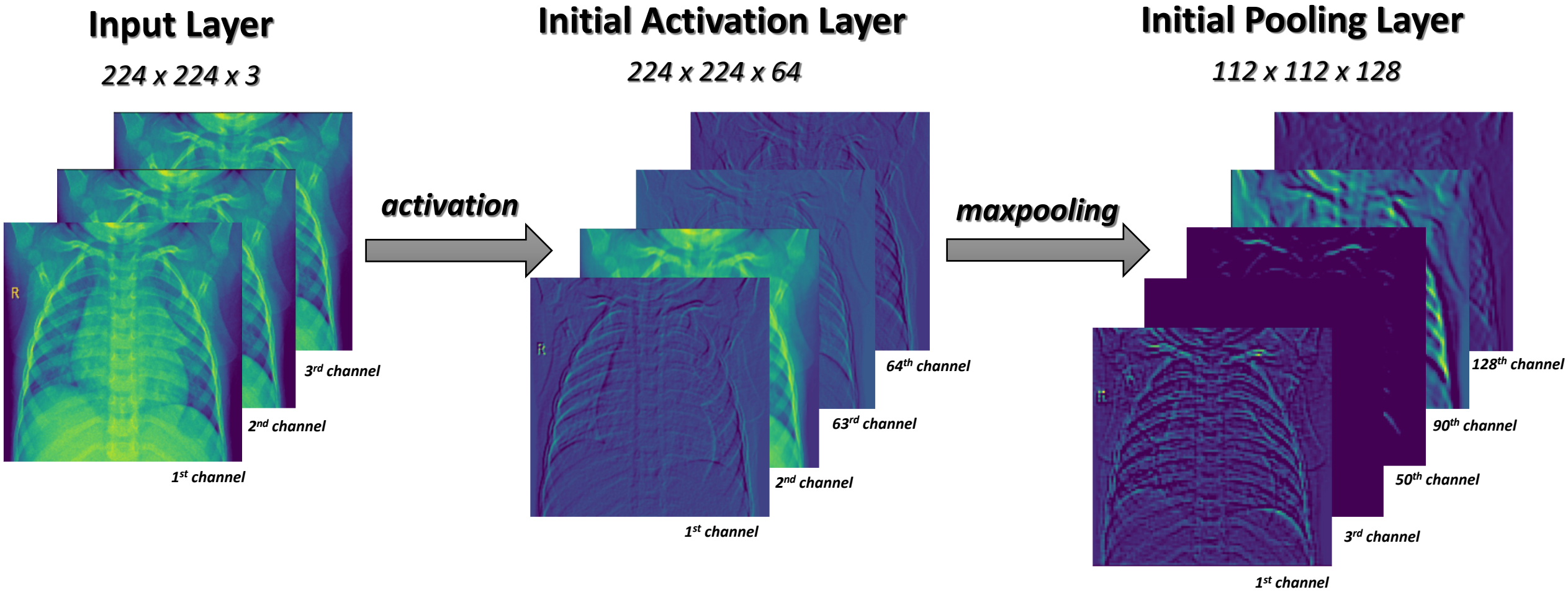
Output

Pneumonia or Not?

VGG16 is a pre-trained convolutional neural network.

Data Source: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

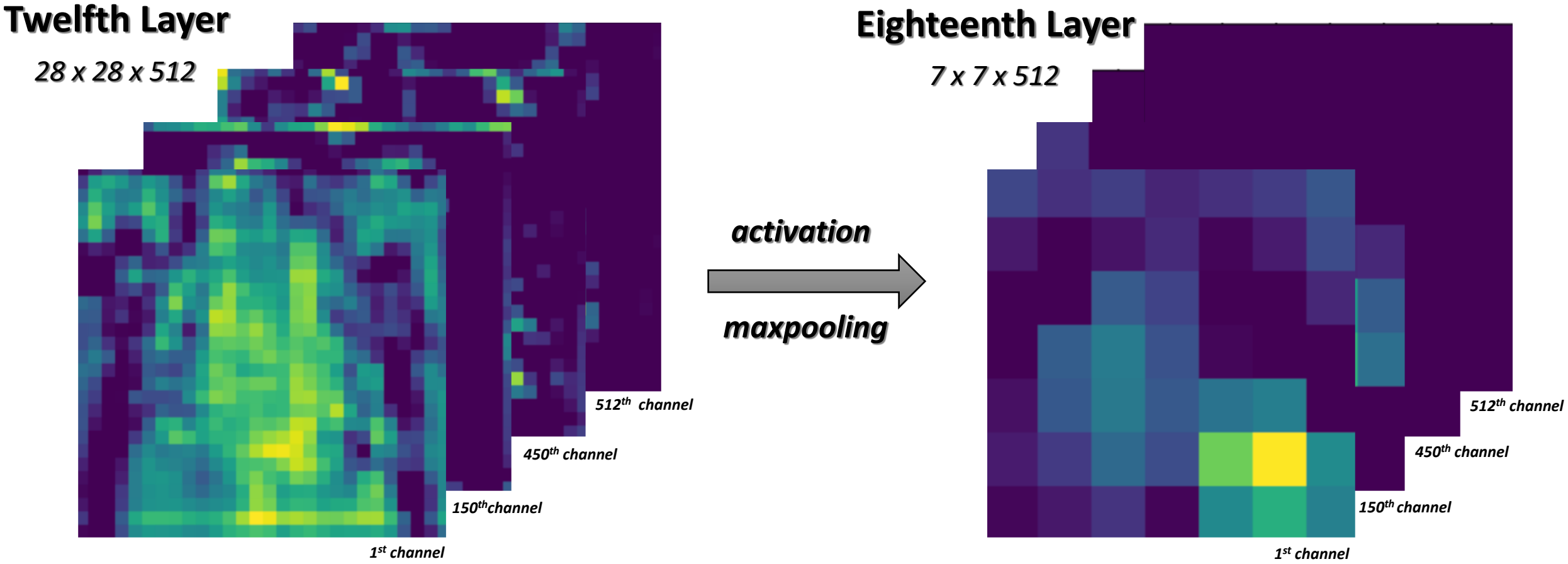
In the first few layers, almost all of the information present in the initial image is retained.



VGG16 has 12 activation layers, 5 maxpooling layers, and 4 fully connected layers.

Source: https://github.com/gabrielpierobon/cnnshapes/blob/master/README.md

As it goes deeper in layers, image carries increasingly less information about the visual contents, but more information related to the class of the image.



Source: https://github.com/gabrielpierobon/cnnshapes/blob/master/README.md

88% of total pneumonia cases were correctly classified by the transfer learning model.

Input

Convolutional Neural Network

Transfer Learning (VGG16)

Output

Normal

Pneumonia

VGG16 correctly predicted normal and pneumonia cases in this example.

Data Source: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

Pneumonia Prediction

local

Future studies can focus on:

- Bacterial pneumonia vs. viral pneumonia
- Community-acquired pneumonia vs. healthcare-associated pneumonia
- Young pneumonia patients vs. senior pneumonia patients
- Pneumonia vs. other chest diseases

More information about the data

Thank you!

Supplement:

- VGG16 model architecture
- ROC-AUC curve
- Model accuracy and loss
- Evaluation matrix
- Cost matrix and cost function

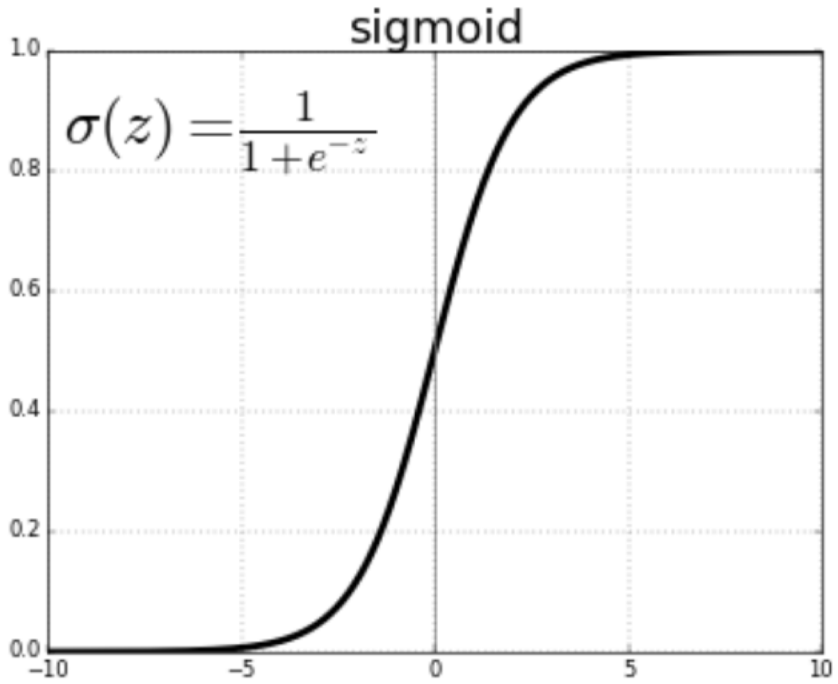
Sample Distribution:

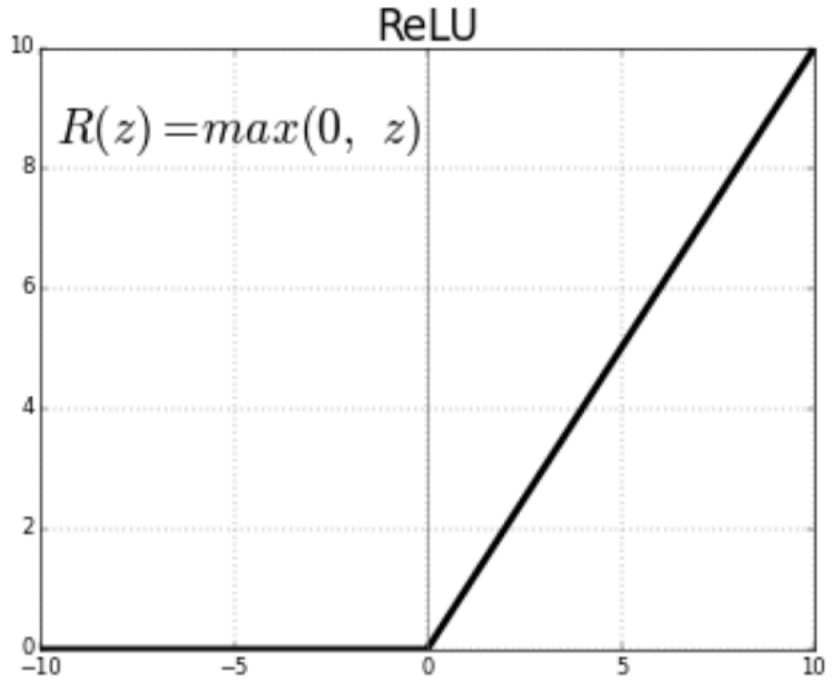
- Total: 5,856 cases
  - Normal: 1,583 cases; Pneumonia: 3,543 cases
- Train: 3,747 cases
  - Normal: 995 cases; Pneumonia: 2,752 cases
- Test: 1,172 cases
  - Normal: 327 cases; Pneumonia: 845 cases
- Validation: 937 cases
  - Normal: 261 cases; Pneumonia: 676 cases

VGG16 is a pre-trained convolutional neural network, it has 12 activation layers, 5 maxpooling layers, and 4 fully connected layers.

Layer		Feature Map	Size	Kernel Size	Stride	Activation
Input	Image	1	224 x 224 x 3	-	-	-
1	2 X Convolution	64	224 x 224 x 64	3x3	1	relu
	Max Pooling	64	112 x 112 x 64	3x3	2	relu
3	2 X Convolution	128	112 x 112 x 128	3x3	1	relu
	Max Pooling	128	56 x 56 x 128	3x3	2	relu
5	2 X Convolution	256	56 x 56 x 256	3x3	1	relu
	Max Pooling	256	28 x 28 x 256	3x3	2	relu
7	3 X Convolution	512	28 x 28 x 512	3x3	1	relu
	Max Pooling	512	14 x 14 x 512	3x3	2	relu
10	3 X Convolution	512	14 x 14 x 512	3x3	1	relu
	Max Pooling	512	7 x 7 x 512	3x3	2	relu
13	FC	-	25088	-	-	relu
14	FC	-	4096	-	-	relu
15	FC	-	4096	-	-	relu
Output	FC	-	1000	-	-	Softmax

Sigmoid/softmax and ReLu (Rectified Linear Unit)



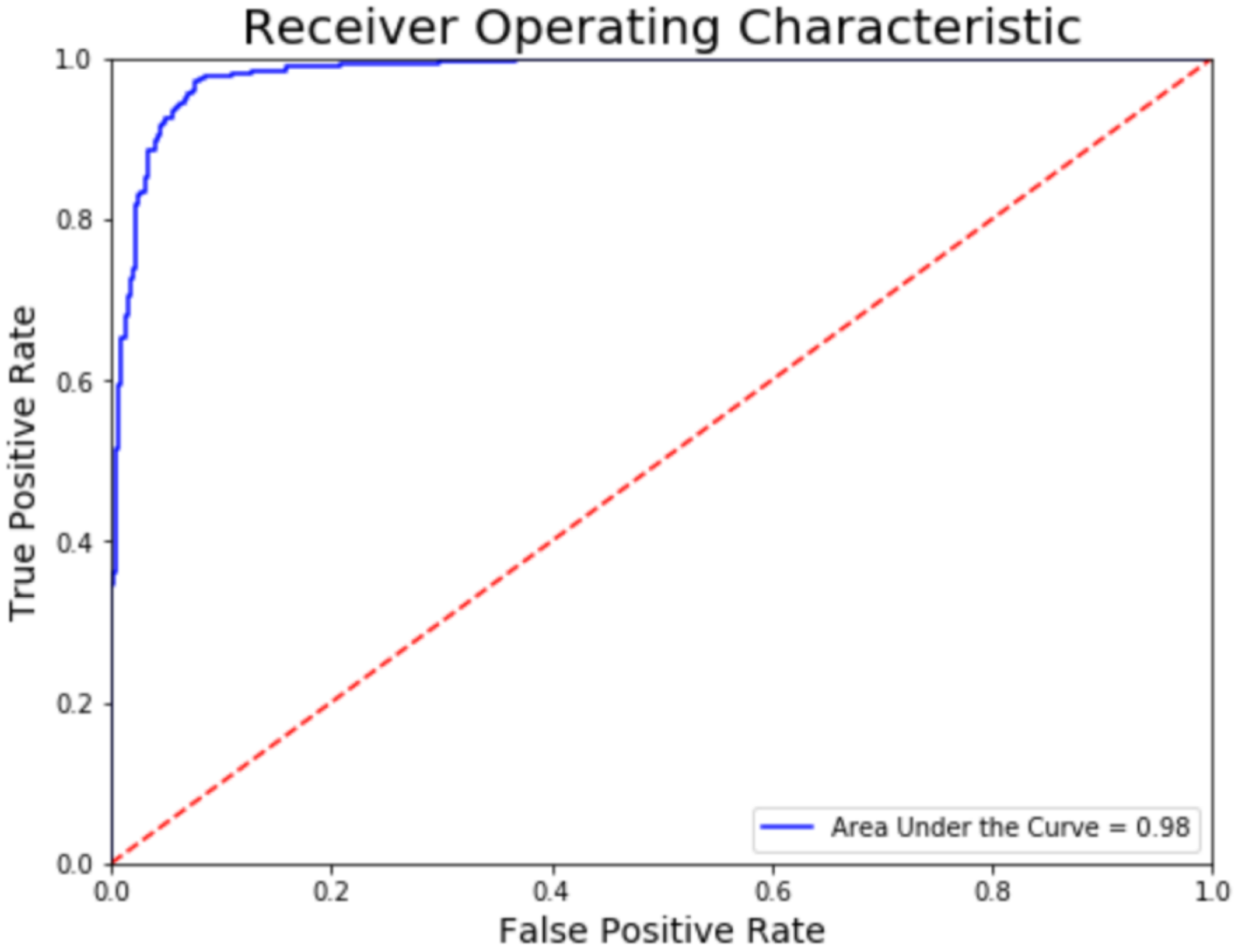


Sigmoid is especially used for models where we have to predict the probability as an output

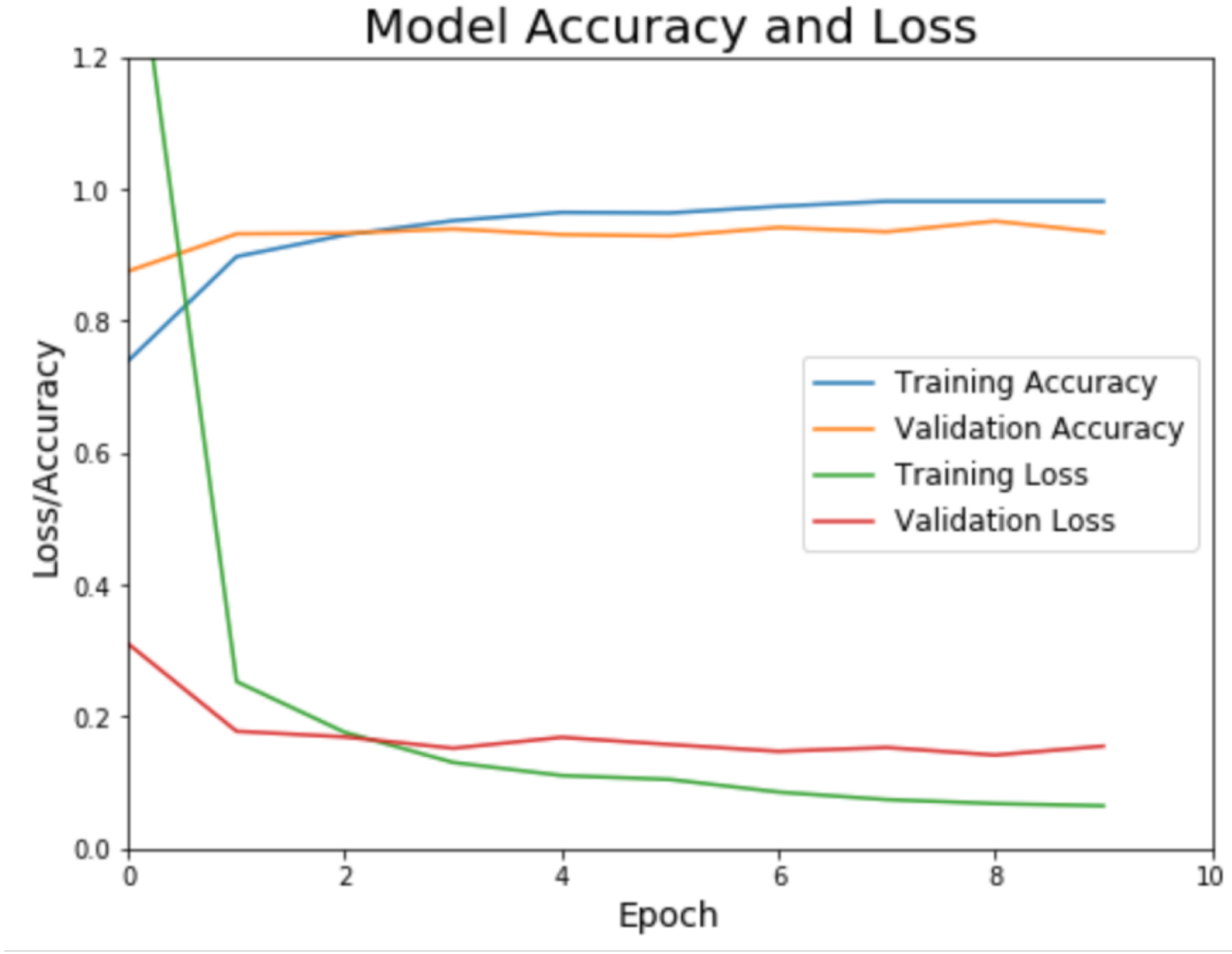
Any negative input given to the ReLu activation function turns the value into zero.

Data Source: https://towardsdatascience.com/activation-functions-neural-networks-1cbd9f8d91d6

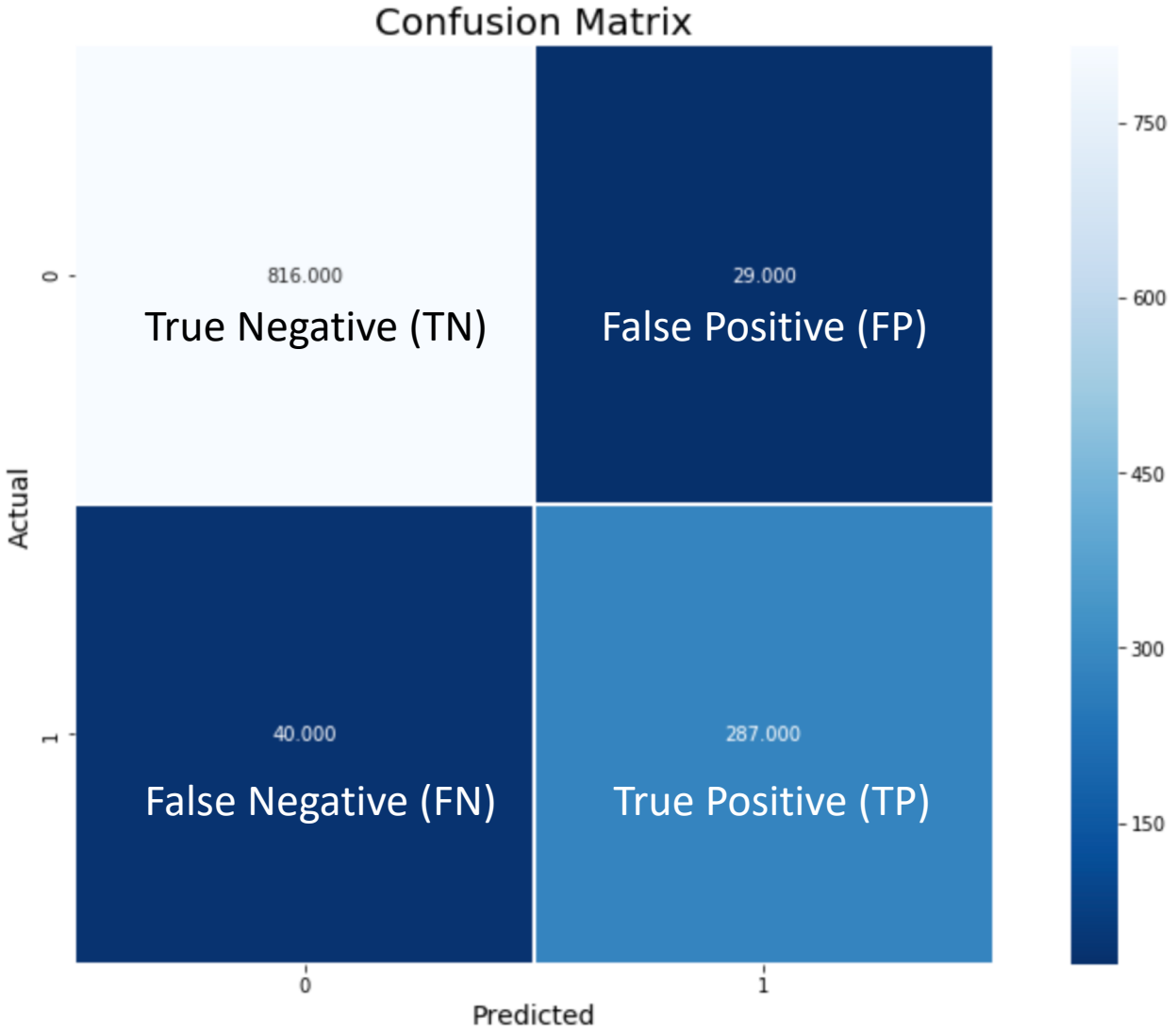
Higher the AUC, better the model is at predicting 0s and 1s.



Transfer learning model achieved 95% accuracy and 88% recall rate.



Evaluation Matrix.



Recall:

$$\frac{TP}{TP + FN} = \frac{287}{287 + 40} = 0.88$$

Precision:

$$\frac{TP}{TP + FP} = \frac{287}{287 + 29} = 0.91$$

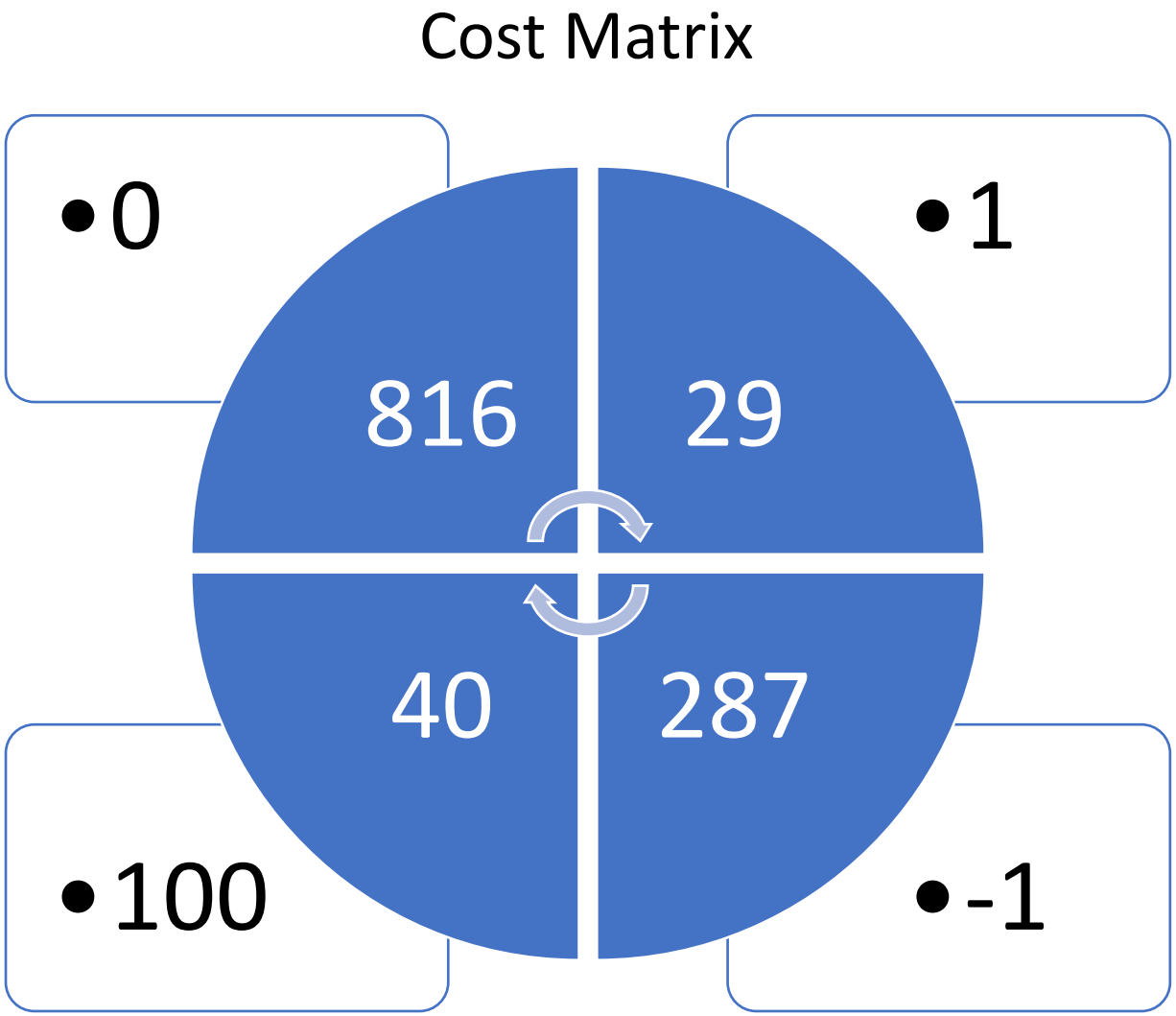
Accuracy:

$$\frac{TP + TN}{TN + FP + FN + TP} = 0.95$$

F-1 score:

$$2 \times \frac{Precision \times Recall}{Precision + Recall} = 0.89$$

Cost matrix and cost function.



Cost function:

816 x 0 + 29 x 1 + 40 x 100 – 287 x 1 = 3,742