Kaggle Project

Chest X-ray images of Pneumonia

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Summary

Introduction

I) Defining the project
1) Datasets
2) Pre-processing

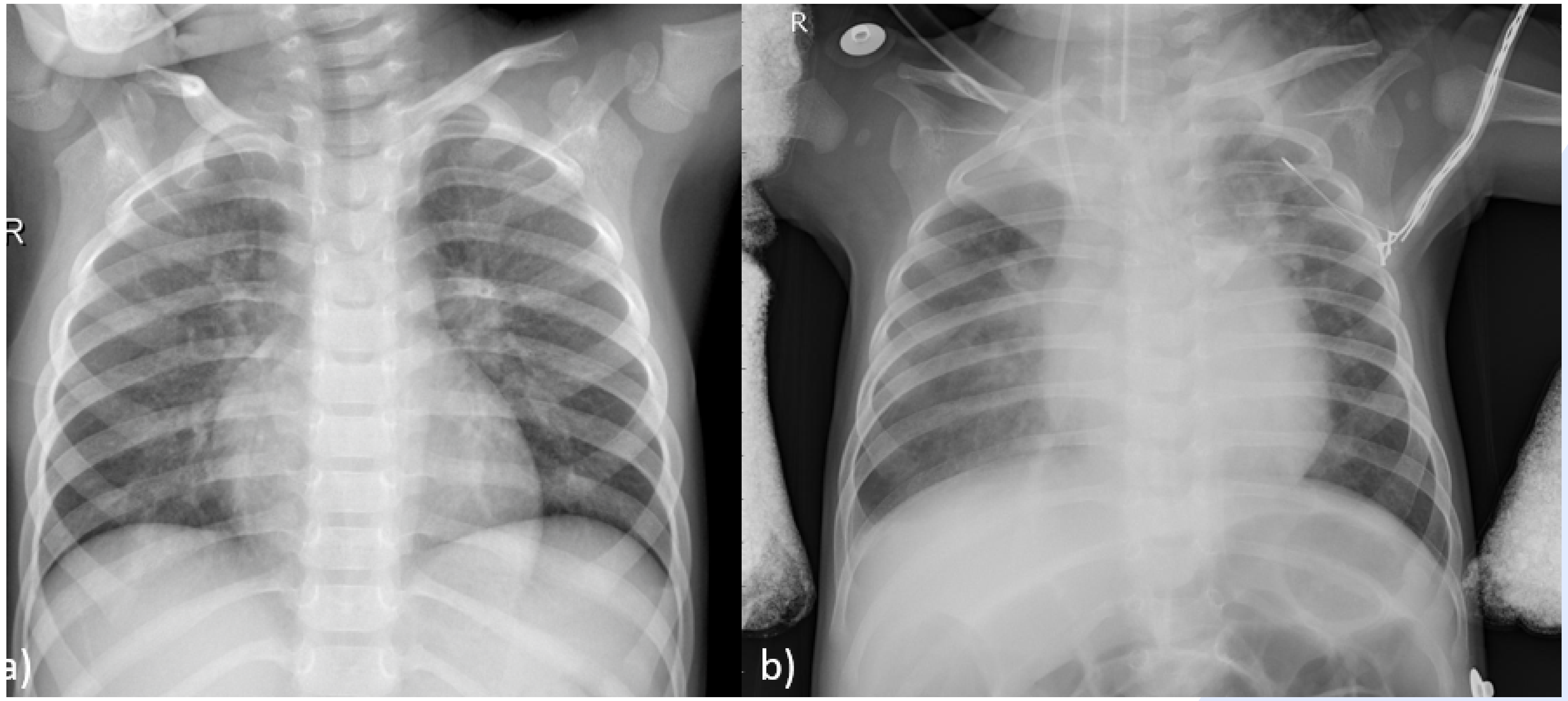
II) Neural networks
1) Convolutional Neural Network
2) Residual Network

III) Results
1) CNN
2) ResNet

IV) Conclusion/Future perspectives

Introduction

- Pneumonia :
  - Inflammatory disease affecting lung
  - By viruses or bacteria
- X-ray Imaging
  - Standard imaging for detection



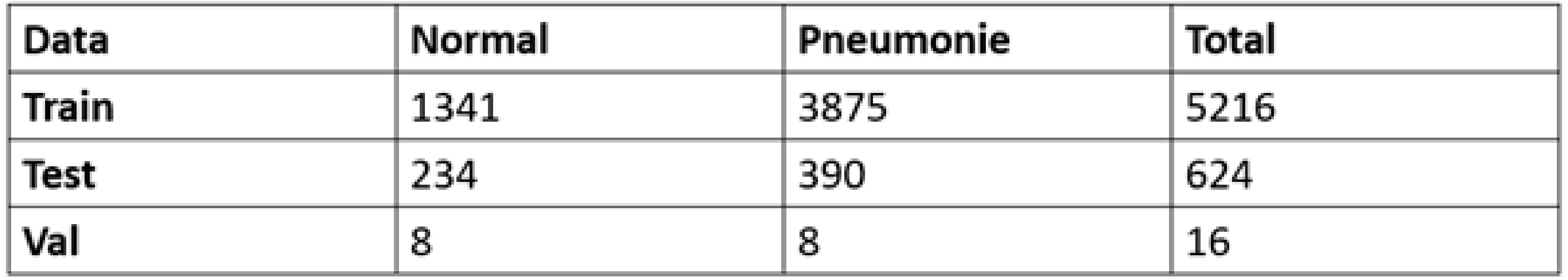
Example from dataset
a) Normal lung, b) Pneumonia lung

AI-assisted detection of pneumonia

I) Defining the project

Dataset

- 5 863 radiographs
    - 3 datasets
    - 2 classes
    - Different shapes
        - (1017, 1268)
        - (1322, 1742)
        - (920, 1306)
        - (1167, 1644)
        - (2534, 2890)



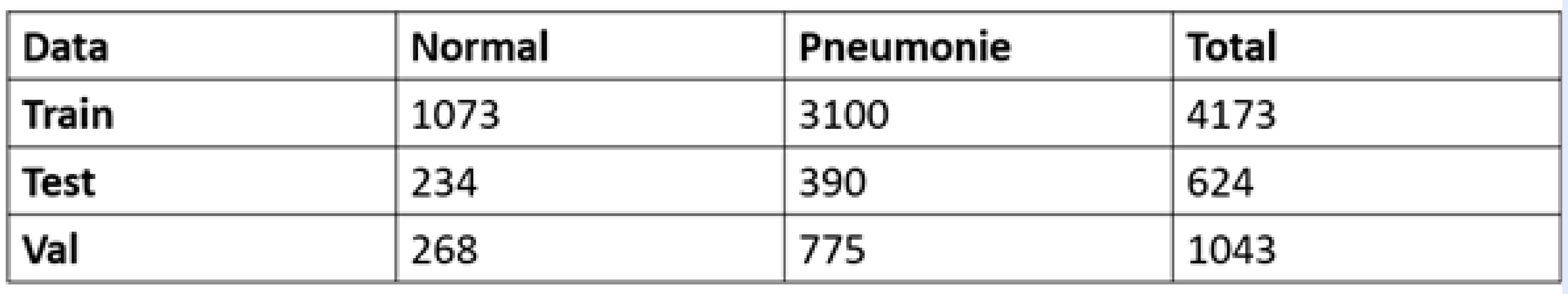
Data	Normal	Pneumonie	Total
Train	1341	3875	5216
Test	234	390	624
Val	8	8	16

Presentation of original dataset

Pre-processing

- Data Modification
  - Rescale shape to (64, 64)
  - Split data to create a bigger validation dataset
  - DataGenerator to increase data variability

- Sample weighting



Data	Normal	Pneumonie	Total
Train	1073	3100	4173
Test	234	390	624
Val	268	775	1043

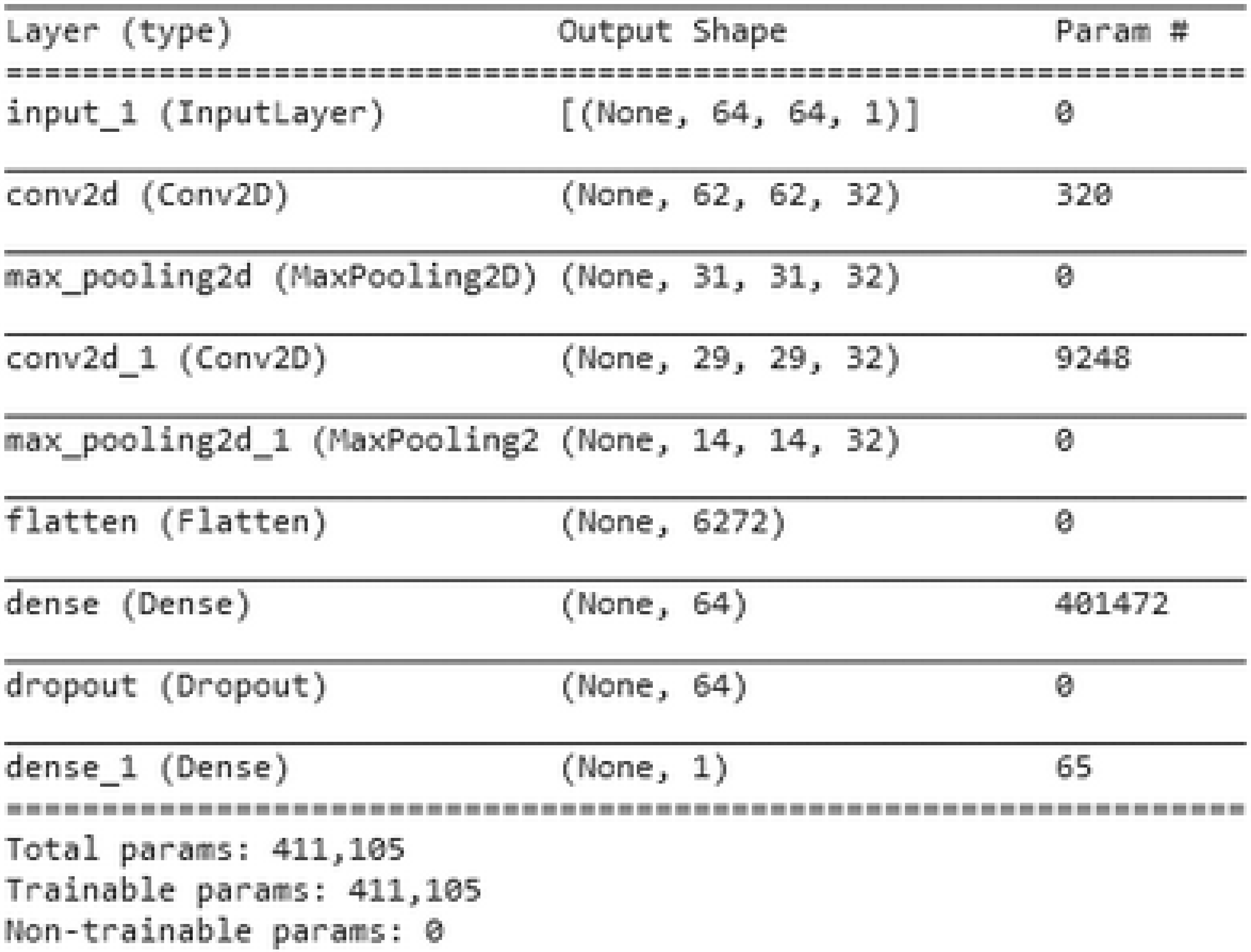
Presentation of adjusted dataset

II) Neural Network

1) Networks description

CNN

- 2 convolution layers
- 411 105 parameters
- (64,64,1) input images
- ReLu function
- Binary classification
- MaxPooling2D -> maximum value of the feature map

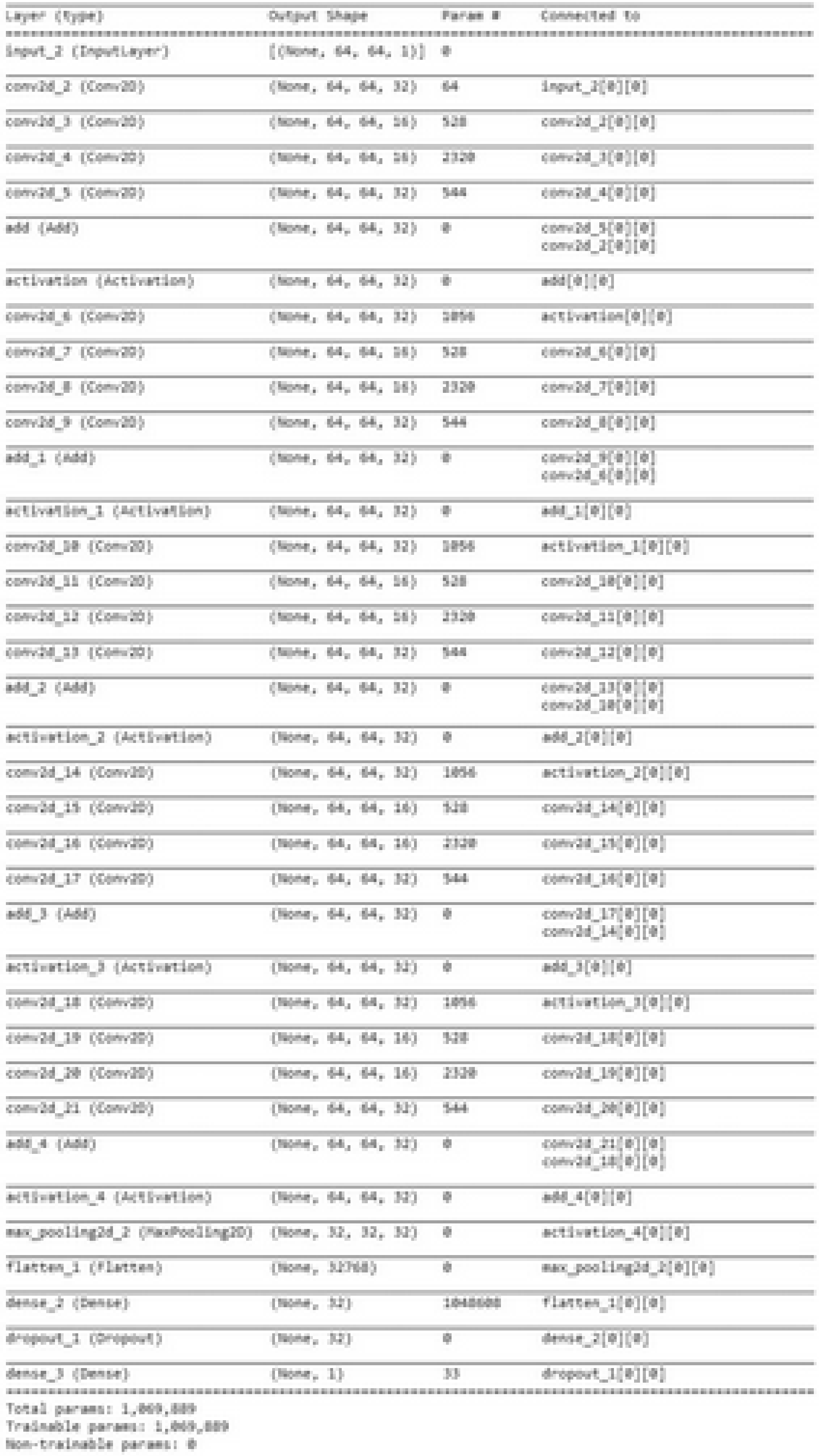


```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 64, 64, 1)]       0
_________________________________________________________________
conv2d (Conv2D)              (None, 62, 62, 32)        320
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 31, 31, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 29, 29, 32)        9248
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
flatten (Flatten)            (None, 6272)              0
_________________________________________________________________
dense (Dense)                (None, 64)                401472
_________________________________________________________________
dropout (Dropout)            (None, 64)                0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 65
=================================================================
Total params: 411,105
Trainable params: 411,105
Non-trainable params: 0
```

1) Networks description

ResNet

- 5 modules with 3 convolution
- 1 069 886 parameters
- (64,64,1) input images
- ReLu function
- Binary classification
- MaxPooling2D -> maximum value of the feature map



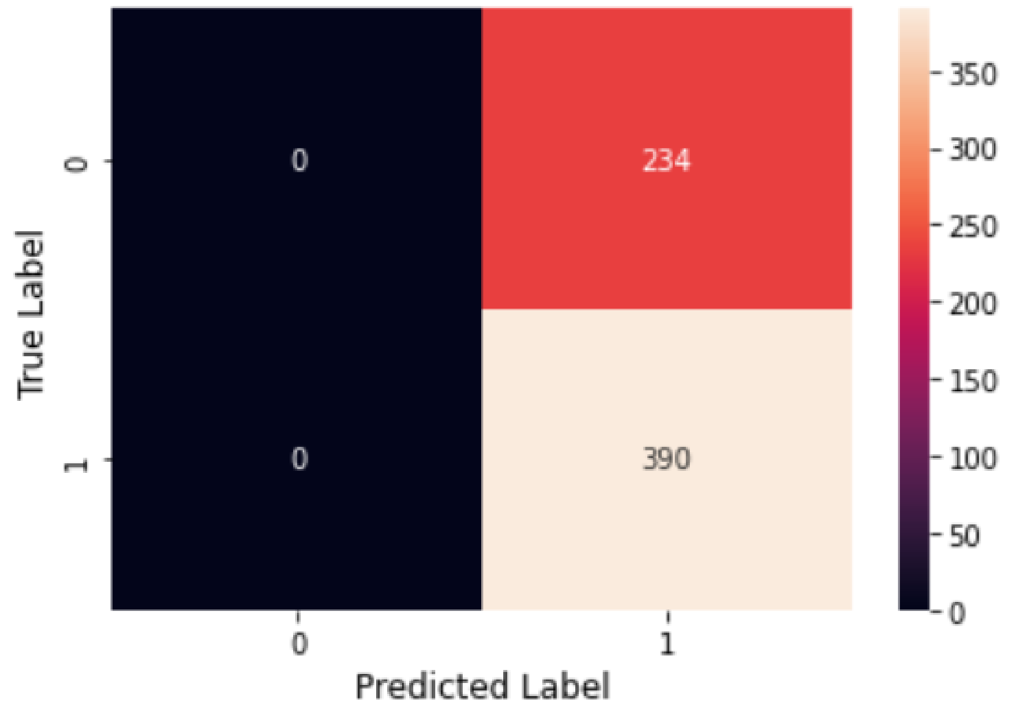
```
______________________________________________________________________________________________
Layer (type)                    Output Shape          Param #     Connected to
==============================================================================================
input_2 (InputLayer)            [(None, 64, 64, 1)]   0
______________________________________________________________________________________________
conv2d_2 (Conv2D)               (None, 64, 64, 32)    64          input_2[0][0]
______________________________________________________________________________________________
conv2d_3 (Conv2D)               (None, 64, 64, 16)    528         conv2d_2[0][0]
______________________________________________________________________________________________
conv2d_4 (Conv2D)               (None, 64, 64, 16)    2320        conv2d_3[0][0]
______________________________________________________________________________________________
conv2d_5 (Conv2D)               (None, 64, 64, 32)    544         conv2d_4[0][0]
______________________________________________________________________________________________
add (Add)                       (None, 64, 64, 32)    0           conv2d_5[0][0]
                                                                  conv2d_2[0][0]
______________________________________________________________________________________________
activation (Activation)         (None, 64, 64, 32)    0           add[0][0]
______________________________________________________________________________________________
conv2d_6 (Conv2D)               (None, 64, 64, 32)    1056        activation[0][0]
______________________________________________________________________________________________
conv2d_7 (Conv2D)               (None, 64, 64, 16)    528         conv2d_6[0][0]
______________________________________________________________________________________________
conv2d_8 (Conv2D)               (None, 64, 64, 16)    2320        conv2d_7[0][0]
______________________________________________________________________________________________
conv2d_9 (Conv2D)               (None, 64, 64, 32)    544         conv2d_8[0][0]
______________________________________________________________________________________________
add_1 (Add)                     (None, 64, 64, 32)    0           conv2d_9[0][0]
                                                                  conv2d_6[0][0]
______________________________________________________________________________________________
activation_1 (Activation)       (None, 64, 64, 32)    0           add_1[0][0]
______________________________________________________________________________________________
conv2d_10 (Conv2D)              (None, 64, 64, 32)    1056        activation_1[0][0]
______________________________________________________________________________________________
conv2d_11 (Conv2D)              (None, 64, 64, 16)    528         conv2d_10[0][0]
______________________________________________________________________________________________
conv2d_12 (Conv2D)              (None, 64, 64, 16)    2320        conv2d_11[0][0]
______________________________________________________________________________________________
conv2d_13 (Conv2D)              (None, 64, 64, 32)    544         conv2d_12[0][0]
______________________________________________________________________________________________
add_2 (Add)                     (None, 64, 64, 32)    0           conv2d_13[0][0]
                                                                  conv2d_10[0][0]
______________________________________________________________________________________________
activation_2 (Activation)       (None, 64, 64, 32)    0           add_2[0][0]
______________________________________________________________________________________________
conv2d_14 (Conv2D)              (None, 64, 64, 32)    1056        activation_2[0][0]
______________________________________________________________________________________________
conv2d_15 (Conv2D)              (None, 64, 64, 16)    528         conv2d_14[0][0]
______________________________________________________________________________________________
conv2d_16 (Conv2D)              (None, 64, 64, 16)    2320        conv2d_15[0][0]
______________________________________________________________________________________________
conv2d_17 (Conv2D)              (None, 64, 64, 32)    544         conv2d_16[0][0]
______________________________________________________________________________________________
add_3 (Add)                     (None, 64, 64, 32)    0           conv2d_17[0][0]
                                                                  conv2d_14[0][0]
______________________________________________________________________________________________
activation_3 (Activation)       (None, 64, 64, 32)    0           add_3[0][0]
______________________________________________________________________________________________
conv2d_18 (Conv2D)              (None, 64, 64, 32)    1056        activation_3[0][0]
______________________________________________________________________________________________
conv2d_19 (Conv2D)              (None, 64, 64, 16)    528         conv2d_18[0][0]
______________________________________________________________________________________________
conv2d_20 (Conv2D)              (None, 64, 64, 16)    2320        conv2d_19[0][0]
______________________________________________________________________________________________
conv2d_21 (Conv2D)              (None, 64, 64, 32)    544         conv2d_20[0][0]
______________________________________________________________________________________________
add_4 (Add)                     (None, 64, 64, 32)    0           conv2d_21[0][0]
                                                                  conv2d_18[0][0]
______________________________________________________________________________________________
activation_4 (Activation)       (None, 64, 64, 32)    0           add_4[0][0]
______________________________________________________________________________________________
max_pooling2d_2 (MaxPooling2D)  (None, 32, 32, 32)    0           activation_4[0][0]
______________________________________________________________________________________________
flatten_1 (Flatten)             (None, 32768)         0           max_pooling2d_2[0][0]
______________________________________________________________________________________________
dense_2 (Dense)                 (None, 32)            1048608     flatten_1[0][0]
______________________________________________________________________________________________
dropout_1 (Dropout)             (None, 32)            0           dense_2[0][0]
______________________________________________________________________________________________
dense_3 (Dense)                 (None, 1)             33          dropout_1[0][0]
==============================================================================================
Total params: 1,069,889
Trainable params: 1,069,889
Non-trainable params: 0
```

1) Parameters

- Rectified Linear Unit (ReLu) function
  - Simple, fast, better performance
  - Rectify vanishing gradient

- Output function : Sigmoid activation
  - Binary classification
  - Fixed value range : 0 and 1

- MaxPooling2D
  - Decrease parameters
  - Better spatial recognition

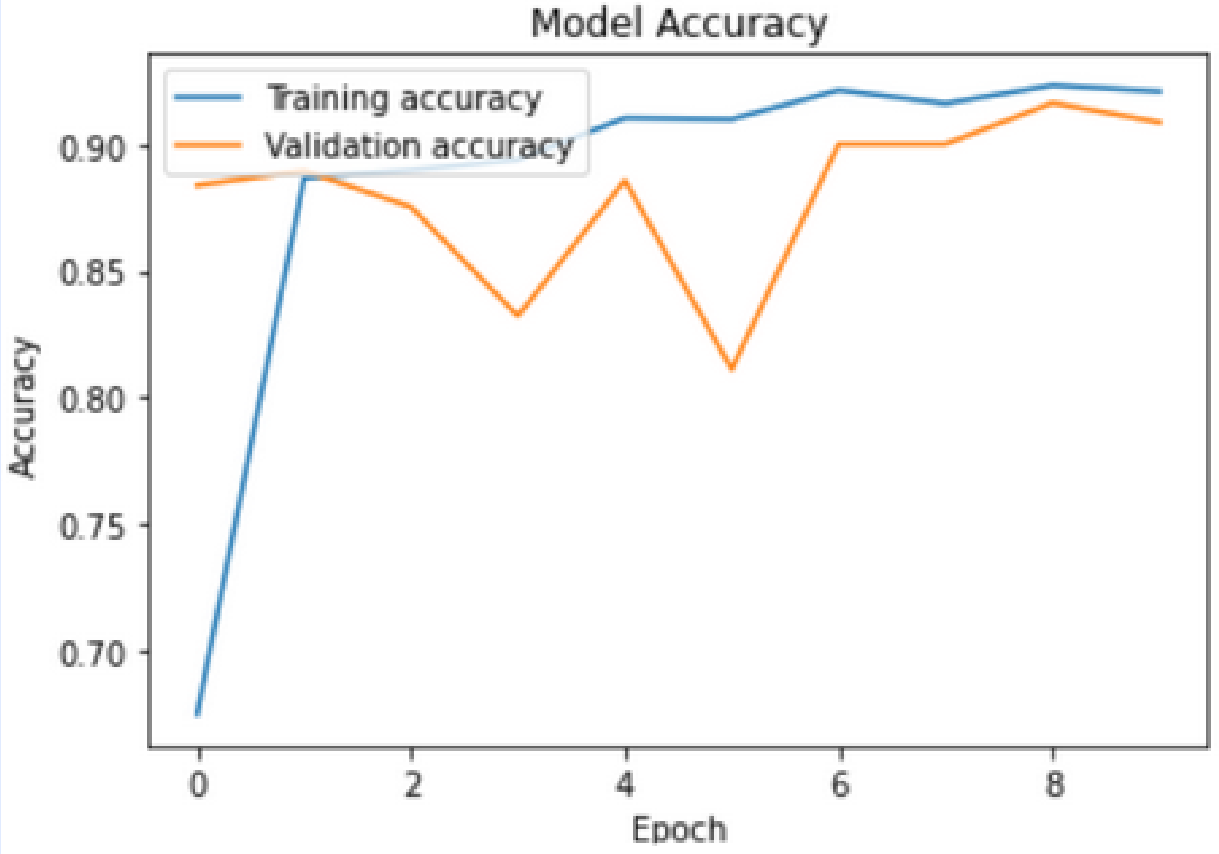


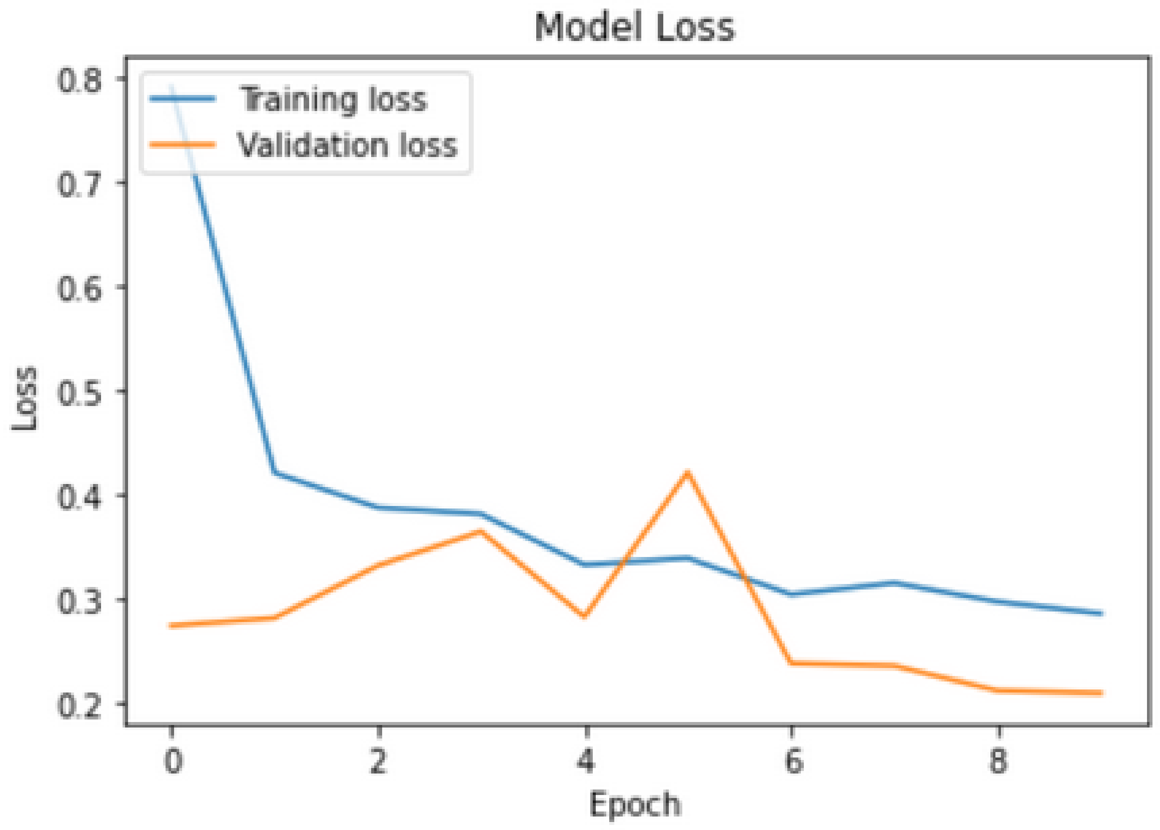
Heatmap of CNN with Softmax output function

III) Results

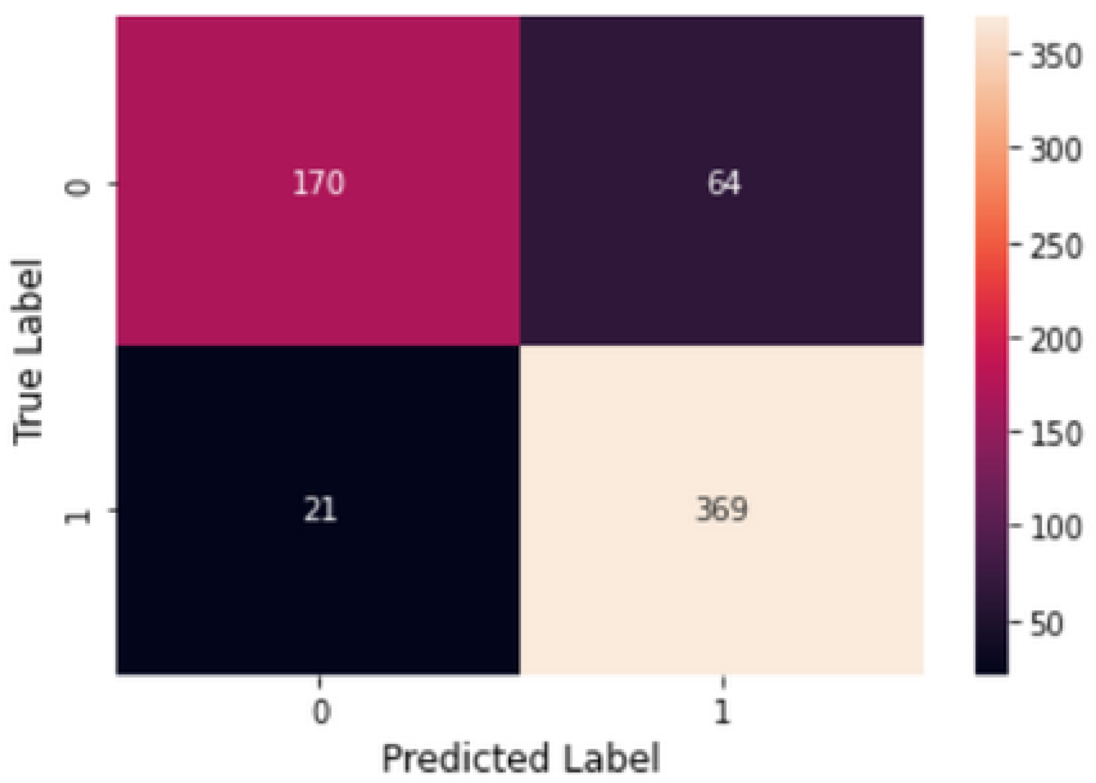
CNN

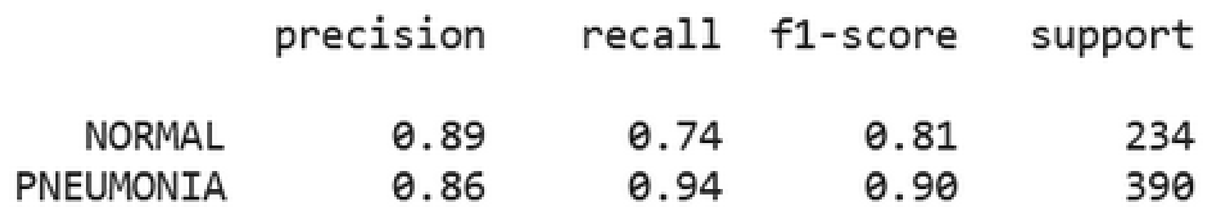
- Increased accuracy and decreased loss over epochs
- No intersecting of curves
- Fluctuation for validation set -> overfitting and/or insufficient data set
- Accuracy = 0,87
- Loss = 0,37





CNN



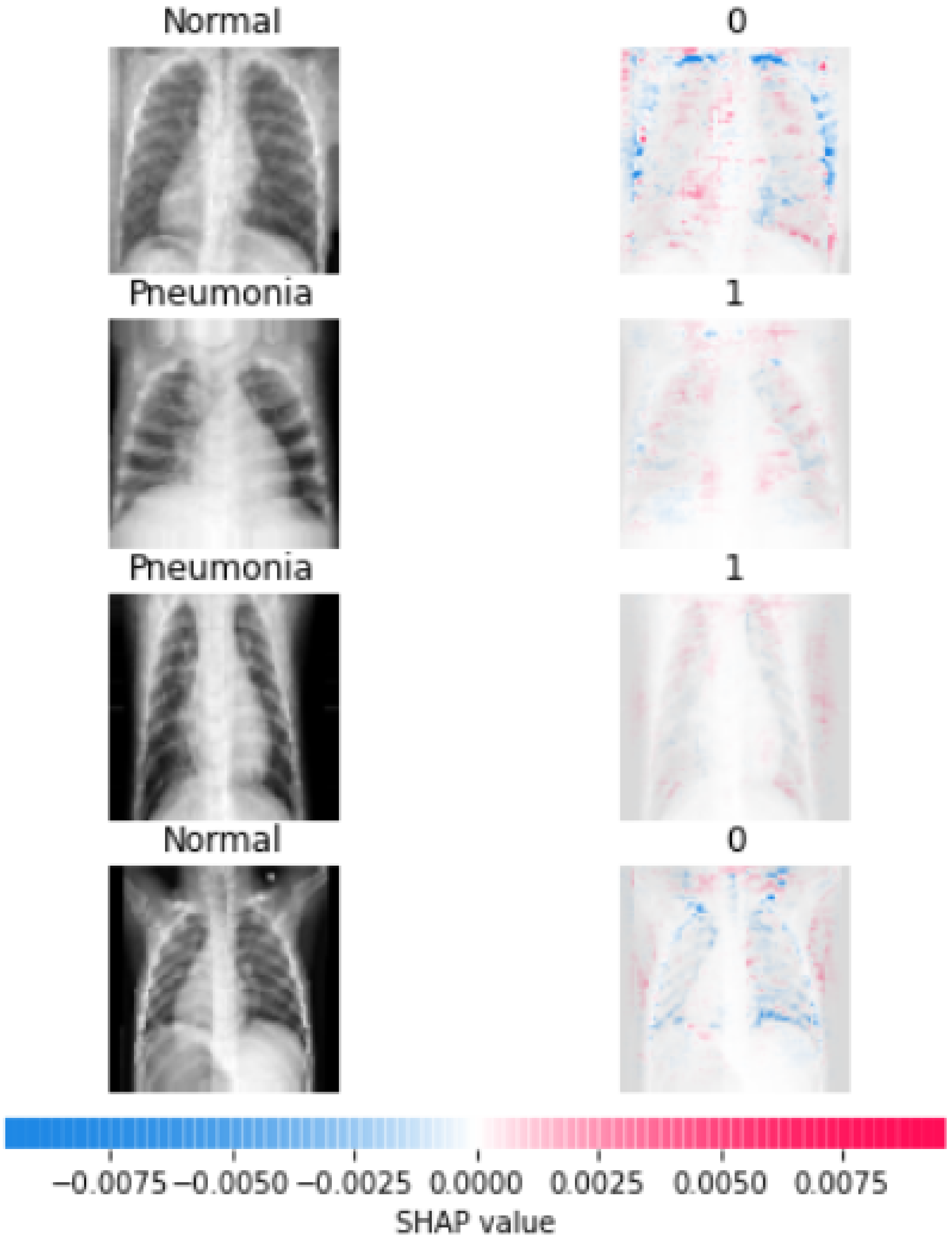


```
              precision    recall  f1-score   support

      NORMAL       0.89      0.74      0.81       234
   PNEUMONIA       0.86      0.94      0.90       390
```

- More false positives than false negative
- Satisfying F1 score -> Ours CNN is well suited

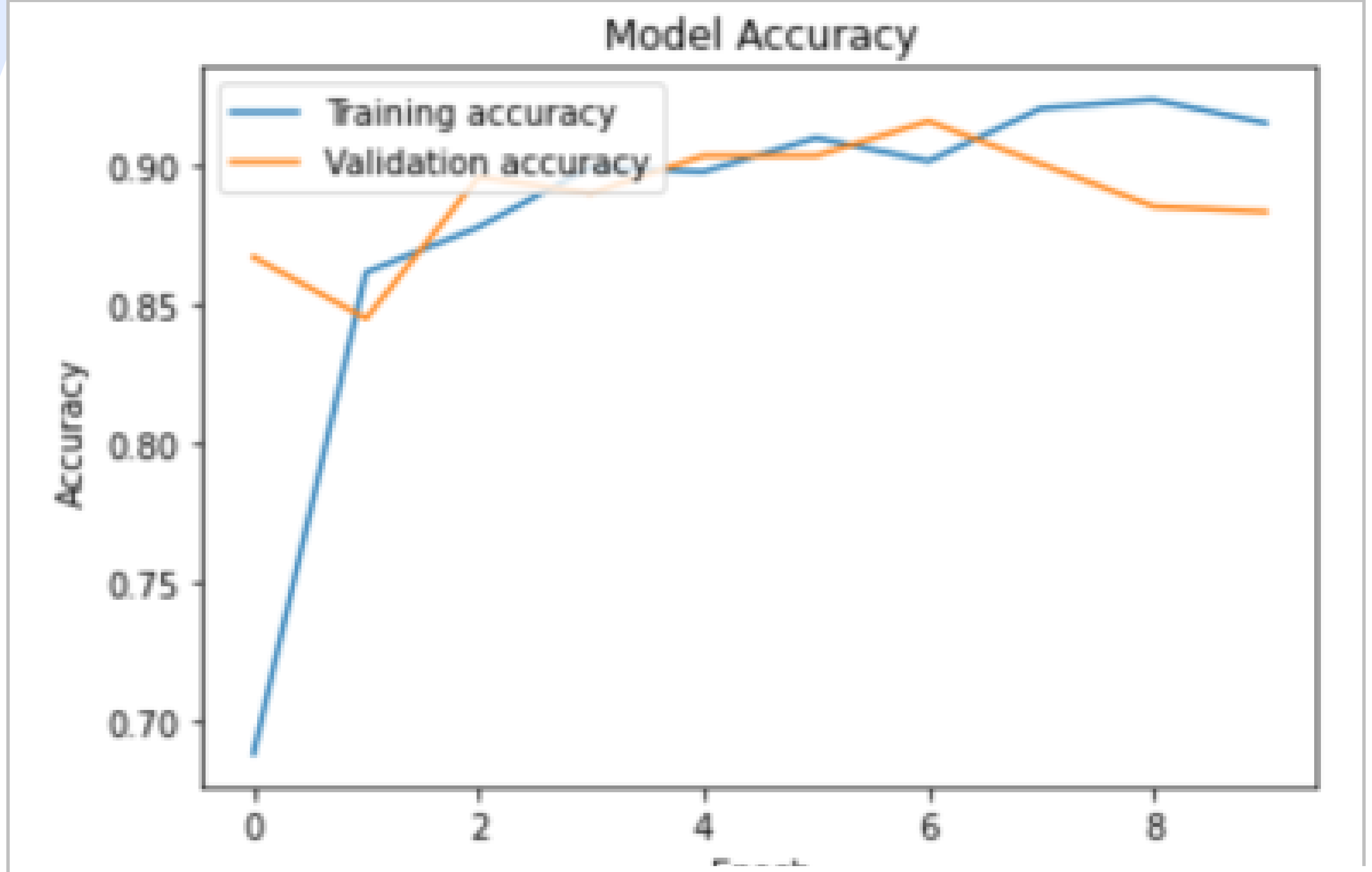
CNN

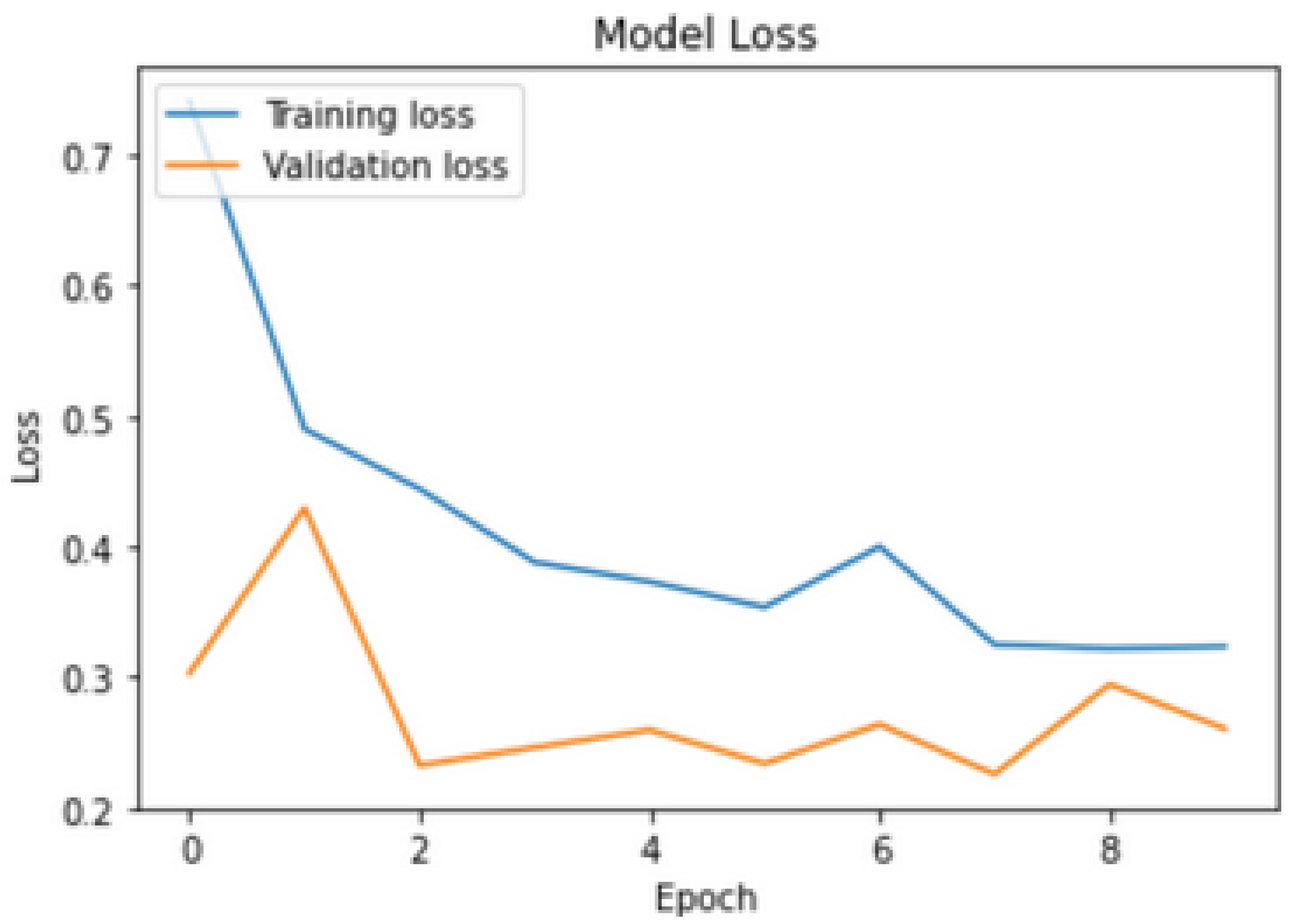
- In some cases areas around the rib cage were taken into account -> Artifact of patient arm position
- Area of the lungs were used in most cases



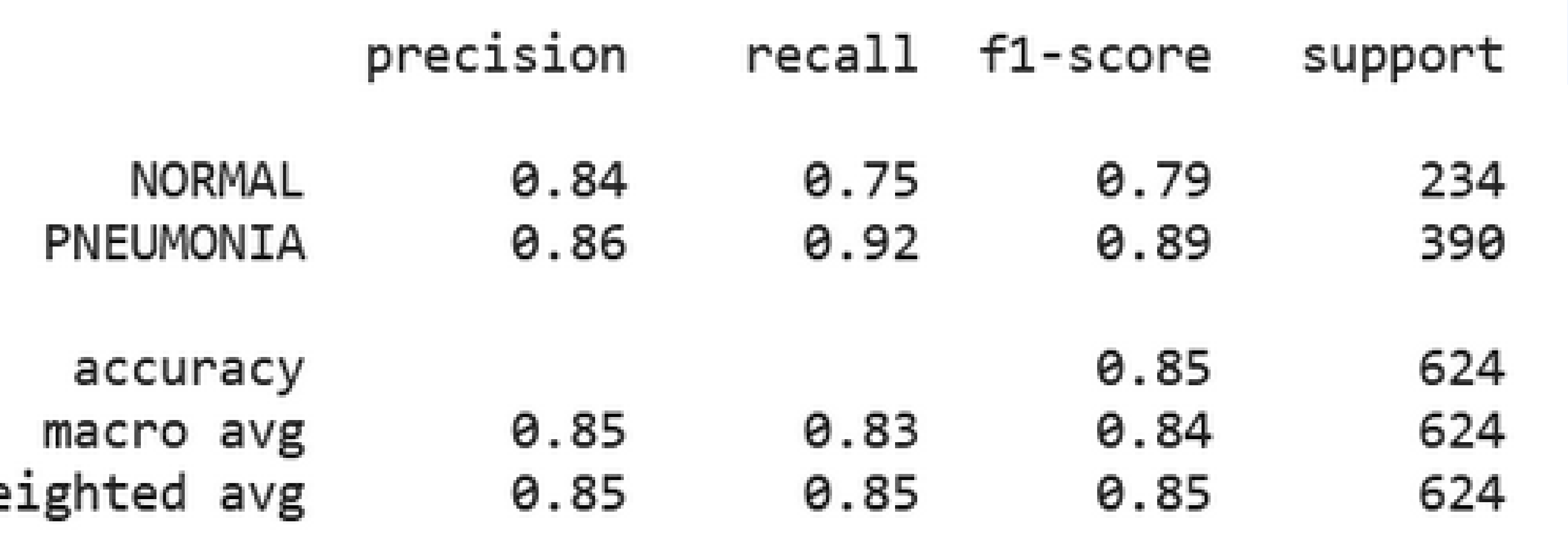
2) ResNet

- 10 epochs
- Batch size of 128
- Accuracy: 0.84
- Loss : 0.40



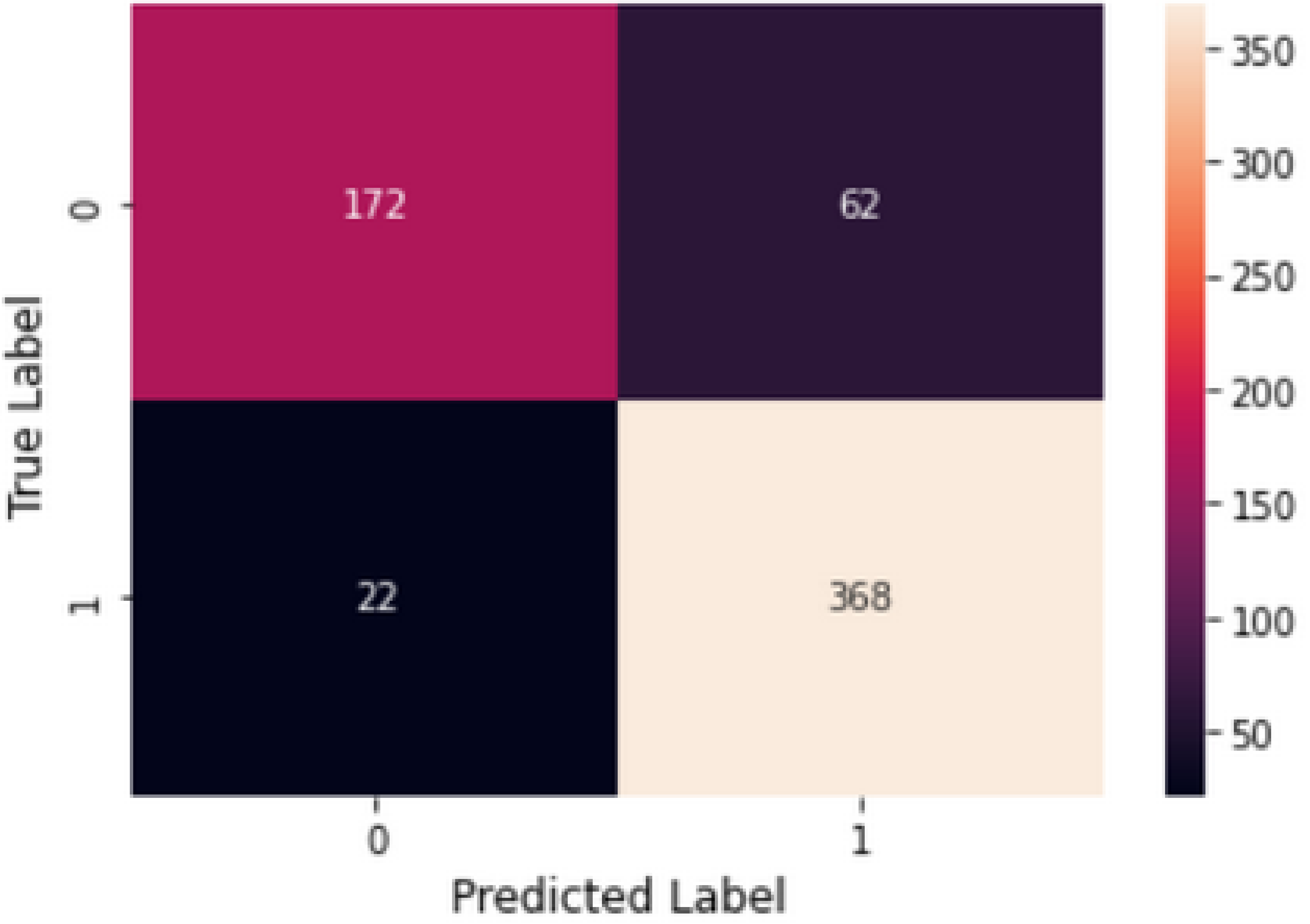


Heatmap of prediction results



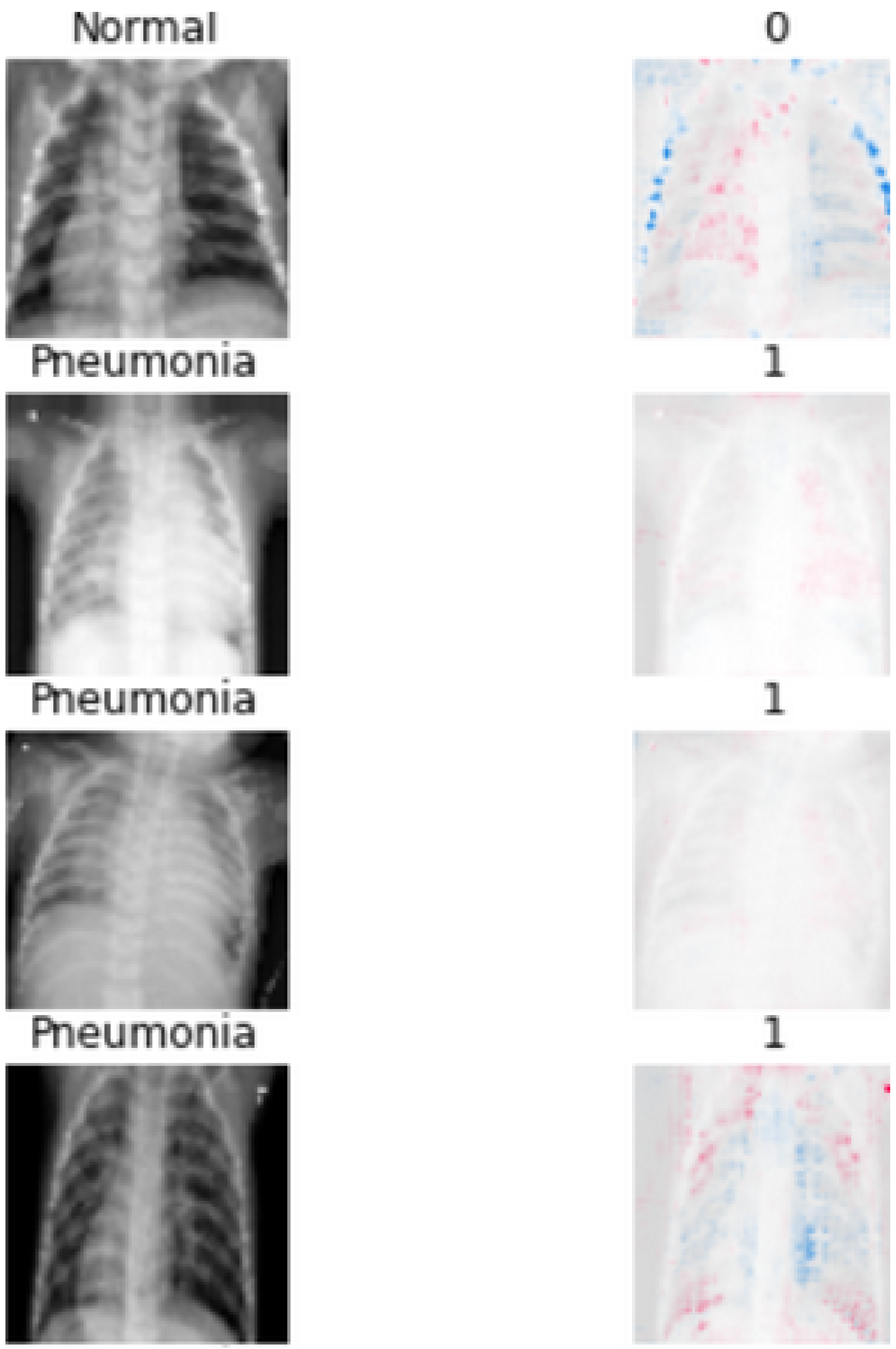
```
              precision    recall  f1-score   support

      NORMAL       0.84      0.75      0.79       234
   PNEUMONIA       0.86      0.92      0.89       390

    accuracy                           0.85       624
   macro avg       0.85      0.83      0.84       624
eighted avg       0.85      0.85      0.85       624
```

- Precision : 0.86
- Recall : 0.94
- F1 score well suited
- ROC AUC : 0.93



SHAP figure

- Areas of interest within the lungs
- Shape of the rib cage less important



Conclusion

- Success in creating two working networks
- ResNet less efficient than CNN

PERSPECTIVE

- Limit artifact by randomly occluding areas of the image (Data Generator)
- K-fold cross validation to limit overfitting
- EfficientNet V1 (more efficient than ResNet)
- Type of pneumonia : bacterial or viral
- Set weight for favorise one class
- Transfer learning for other lung diseases

THANKS FOR YOUR ATTENTION