# Detección De Neumonía Utilizando Redes Convolucionales Y Transfer Learning

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In [1]:

```
import pandas as pd
import numpy as np
import tensorflow as tf
import seaborn as sns
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.optimizers import RMSprop, Adam
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
import tensorflow.keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, MaxPool2D, Flatten, Dropout, BatchNorma
from sklearn.metrics import classification_report, confusion_matrix
from tensorflow.keras.callbacks import ReduceLROnPlateau
import cv2
import os
from tensorflow.keras import layers, optimizers
```

In [2]:

```
batch_size = 128
epochs = 35
image_size = (300,300)
test_size = 0.2
```

## Load Data And Division Of Data

In [3]:

```
training_images = tf.io.gfile.glob('C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Pr
validation_images = tf.io.gfile.glob('C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/

print(f'Before division of 80:20')
print(f'Total number of training images = {len(training_images)}')
print(f'Total number of validation images = {len(validation_images)}\n')


total_files = training_images
total_files.extend(validation_images)
print(f'Total number of images : training_images + validation_images = {len(total_files)}\

train_images, val_images = train_test_split(total_files, test_size = test_size)
print(f'After division of 80:20')
print(f'Total number of training images = {len(train_images)}')
print(f'Total number of validation images = {len(val_images)}')
```

```
Before division of 80:20
Total number of training images = 5216
Total number of validation images = 16

Total number of images : training_images + validation_images = 5232
```

```
After division of 80:20
Total number of training images = 4185
Total number of validation images = 1047
```

In [4]:

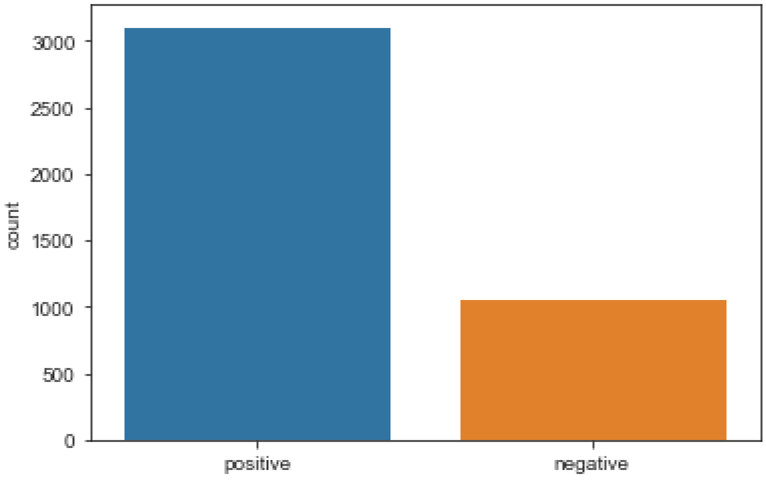
```
count_normal = len([x for x in train_images if "NORMAL" in x])
print(f'Normal images count in training set: {count_normal}')

count_pneumonia = len([x for x in train_images if "PNEUMONIA" in x])
print(f'Pneumonia images count in training set: {count_pneumonia}')

count_array = []
count_array += ['positive']*count_pneumonia
count_array += ['negative']*count_normal

sns.set_style('ticks')
sns.countplot(count_array)
```

```
Normal images count in training set: 1070
Pneumonia images count in training set: 3115
```

```
C:\Users\ameri\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass
the following variable as a keyword arg: x. From version 0.12, the only valid positional a
rgument will be `data`, and passing other arguments without an explicit keyword will resul
t in an error or misinterpretation.
  warnings.warn(
```

Out[4]:

```
<AxesSubplot:ylabel='count'>
```



In [5]:

```
train_datagen = ImageDataGenerator(rescale = 1/255,
                                 rotation_range = 30,
                                 zoom_range = 0.2,
                                 width_shift_range = 0.1,
                                 height_shift_range = 0.1)
val_datagen = ImageDataGenerator(rescale = 1/255)


train_generator = train_datagen.flow_from_directory(
    'C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Preprocesamiento de datos/Proyect
    target_size = image_size,
    batch_size = batch_size ,
    class_mode = 'binary'
)

validation_generator = val_datagen.flow_from_directory(
    'C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Preprocesamiento de datos/Proyect
    target_size = image_size,
    batch_size = batch_size ,
    class_mode = 'binary'
)
```

```
Found 4185 images belonging to 2 classes.
Found 1047 images belonging to 2 classes.
```

In [6]:

```
eval_datagen = ImageDataGenerator(rescale = 1/255)

test_generator = eval_datagen.flow_from_directory(
    'C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Preprocesamiento de datos/Proyect
    target_size = image_size,
    batch_size = batch_size ,
    class_mode = 'binary'
)
```

```
Found 624 images belonging to 2 classes.
```

# Correction For Data Imbalance

In [7]:

```
initial_bias = np.log([count_pneumonia/count_normal])
initial_bias
```

Out[7]:

```
array([1.0685705])
```

In [8]:

```
weight_for_0 = (1 / count_normal)*(len(train_images))/2.0
weight_for_1 = (1 / count_pneumonia)*(len(train_images))/2.0

class_weight = {0: weight_for_0, 1: weight_for_1}

print('Weight for class 0: {:.2f}'.format(weight_for_0))
print('Weight for class 1: {:.2f}'.format(weight_for_1))
```

```
Weight for class 0: 1.96
Weight for class 1: 0.67
```

# CNN Model

In [9]:

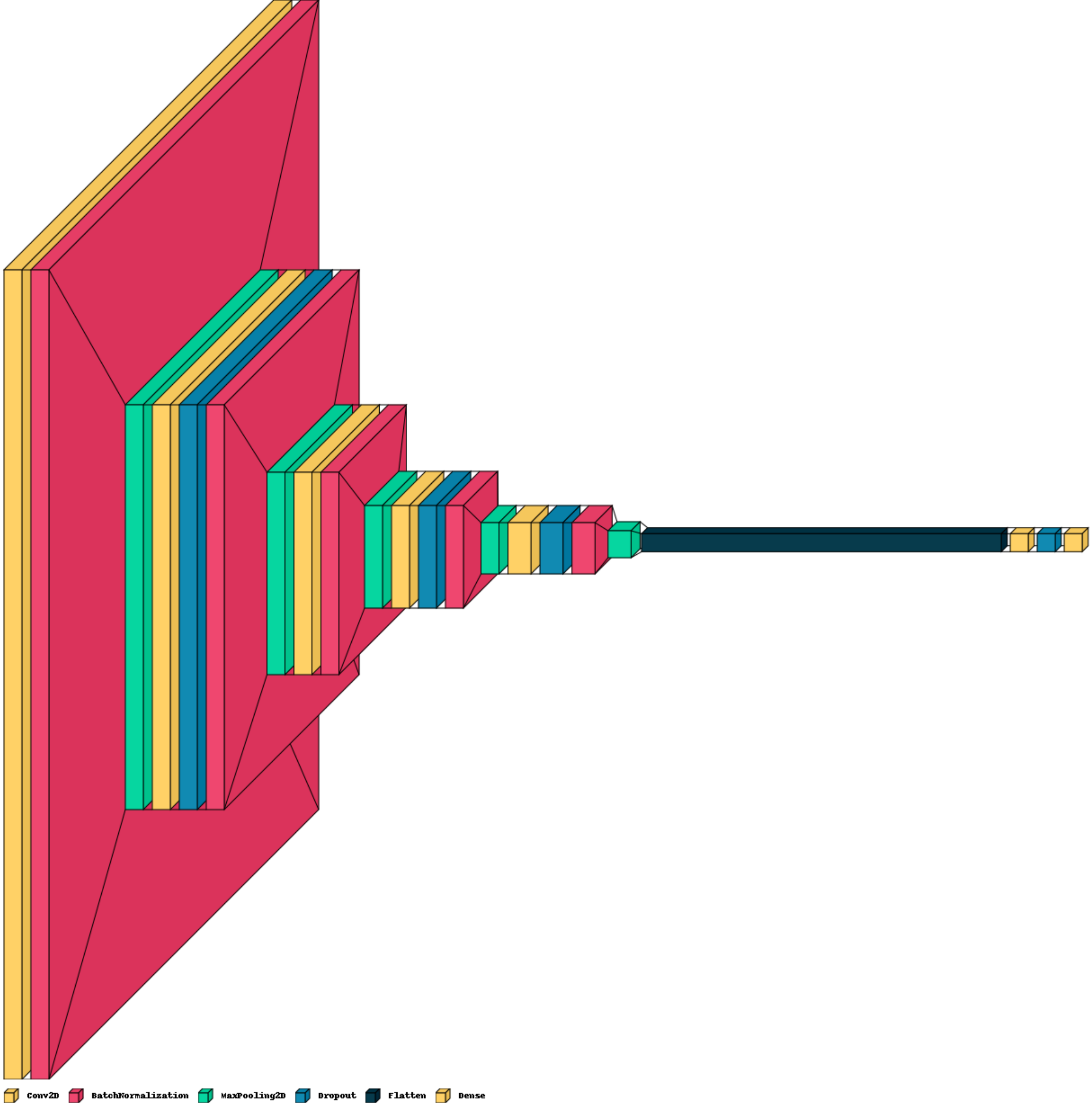
```
model = Sequential()
model.add(Conv2D(32, (3,3), strides = 1, padding = 'same', activation = 'relu', input_shap
model.add(BatchNormalization())
model.add(MaxPool2D((2,2), strides = 2, padding = 'same'))
model.add(Conv2D(64, (3,3), strides = 1, padding = 'same', activation = 'relu'))
model.add(Dropout(0.1))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2), strides = 2, padding = 'same'))
model.add(Conv2D(64, (3,3), strides = 1, padding = 'same', activation = 'relu'))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2), strides = 2, padding = 'same'))
model.add(Conv2D(128, (3,3), strides = 1, padding = 'same', activation = 'relu'))
model.add(Dropout(0.2))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2), strides = 2, padding = 'same'))
model.add(Conv2D(256, (3,3), strides = 1, padding = 'same', activation = 'relu'))
model.add(Dropout(0.2))
model.add(BatchNormalization())
model.add(MaxPool2D((2,2), strides = 2, padding = 'same'))
model.add(Flatten())
model.add(Dense(units = 128, activation = 'relu'))
model.add(Dropout(0.2))
model.add(Dense(units = 1, activation = 'sigmoid'))
model.compile(optimizer = "rmsprop", loss = 'binary_crossentropy', metrics = ['accuracy'])
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 300, 300, 32)      896
_________________________________________________________________
batch_normalization (BatchNo (None, 300, 300, 32)      128
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 150, 150, 32)      0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 150, 150, 64)      18496
_________________________________________________________________
dropout (Dropout)            (None, 150, 150, 64)      0
_________________________________________________________________
batch_normalization_1 (Batch (None, 150, 150, 64)      256
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 75, 75, 64)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 75, 75, 64)        36928
_________________________________________________________________
batch_normalization_2 (Batch (None, 75, 75, 64)        256
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 38, 38, 64)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 38, 38, 128)       73856
_________________________________________________________________
dropout_1 (Dropout)          (None, 38, 38, 128)       0
_________________________________________________________________
batch_normalization_3 (Batch (None, 38, 38, 128)       512
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 19, 19, 128)       0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 19, 19, 256)       295168
_________________________________________________________________
dropout_2 (Dropout)          (None, 19, 19, 256)       0
_________________________________________________________________
batch_normalization_4 (Batch (None, 19, 19, 256)       1024
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 10, 10, 256)       0
_________________________________________________________________
flatten (Flatten)            (None, 25600)             0
_________________________________________________________________
dense (Dense)                (None, 128)               3276928
_________________________________________________________________
dropout_3 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 129
=================================================================
Total params: 3,704,577
Trainable params: 3,703,489
Non-trainable params: 1,088
_________________________________________________________________
```

In [10]:

```
import visualkeras
visualkeras.layered_view(model, scale_xy = 3, legend = True,)
```

Out[10]:



In [11]:

```
learning_rate_reduction = ReduceLROnPlateau(monitor = 'val_loss', patience = 2, verbose =
```

## Train The Model

In [12]:

```
history = model.fit(train_generator, epochs = 12, validation_data = validation_generator,
```

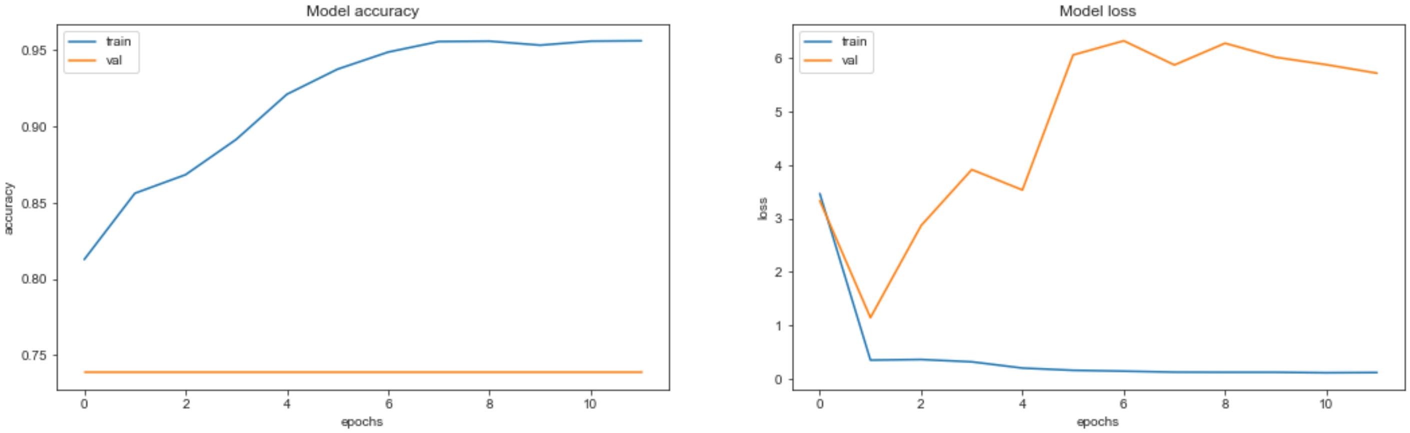
```
Epoch 1/12
33/33 [==============================] - 1972s 60s/step - loss: 3.4664 - accuracy: 0.8127
- val_loss: 3.3336 - val_accuracy: 0.7383
Epoch 2/12
33/33 [==============================] - 1339s 41s/step - loss: 0.3506 - accuracy: 0.8562
- val_loss: 1.1450 - val_accuracy: 0.7383
Epoch 3/12
33/33 [==============================] - 1419s 43s/step - loss: 0.3619 - accuracy: 0.8683
- val_loss: 2.8666 - val_accuracy: 0.7383
Epoch 4/12
33/33 [==============================] - ETA: 0s - loss: 0.3184 - accuracy: 0.8915
```

```
Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0003000000142492354.
33/33 [==============================] - 1317s 40s/step - loss: 0.3184 - accuracy: 0.8915
- val_loss: 3.9144 - val_accuracy: 0.7383
Epoch 5/12
33/33 [==============================] - 1360s 41s/step - loss: 0.2016 - accuracy: 0.9211
- val_loss: 3.5334 - val_accuracy: 0.7383
Epoch 6/12
33/33 [==============================] - ETA: 0s - loss: 0.1598 - accuracy: 0.9376
Epoch 00006: ReduceLROnPlateau reducing learning rate to 9.000000427477062e-05.
33/33 [==============================] - 1410s 43s/step - loss: 0.1598 - accuracy: 0.9376
- val_loss: 6.0589 - val_accuracy: 0.7383
Epoch 7/12
33/33 [==============================] - 1406s 43s/step - loss: 0.1439 - accuracy: 0.9489
- val_loss: 6.3239 - val_accuracy: 0.7383
Epoch 8/12
33/33 [==============================] - ETA: 0s - loss: 0.1257 - accuracy: 0.9558
Epoch 00008: ReduceLROnPlateau reducing learning rate to 2.700000040931627e-05.
33/33 [==============================] - 1400s 42s/step - loss: 0.1257 - accuracy: 0.9558
- val_loss: 5.8719 - val_accuracy: 0.7383
Epoch 9/12
33/33 [==============================] - 1407s 43s/step - loss: 0.1234 - accuracy: 0.9560
- val_loss: 6.2781 - val_accuracy: 0.7383
Epoch 10/12
33/33 [==============================] - ETA: 0s - loss: 0.1231 - accuracy: 0.9534
Epoch 00010: ReduceLROnPlateau reducing learning rate to 8.100000013655517e-06.
33/33 [==============================] - 1436s 44s/step - loss: 0.1231 - accuracy: 0.9534
- val_loss: 6.0159 - val_accuracy: 0.7383
Epoch 11/12
33/33 [==============================] - 1456s 44s/step - loss: 0.1138 - accuracy: 0.9560
- val_loss: 5.8771 - val_accuracy: 0.7383
Epoch 12/12
33/33 [==============================] - ETA: 0s - loss: 0.1183 - accuracy: 0.9563
Epoch 00012: ReduceLROnPlateau reducing learning rate to 2.429999949526973e-06.
33/33 [==============================] - 1461s 44s/step - loss: 0.1183 - accuracy: 0.9563
- val_loss: 5.7177 - val_accuracy: 0.7383
```

## Visualise The Model Performance

In [13]:

```
figure, axis = plt.subplots(1, 2, figsize=(18,5))
axis = axis.ravel()

for i,element in enumerate(['accuracy', 'loss']):
    axis[i].plot(history.history[element])
    axis[i].plot(history.history['val_' + element])
    axis[i].set_title('Model {}'.format(element))
    axis[i].set_xlabel('epochs')
    axis[i].set_ylabel(element)
    axis[i].legend(['train', 'val'])
```



## Predict And Evaluate On Test Dataset

In [14]:

```
eval_result1 = model.evaluate_generator(test_generator, 624)
print('loss rate at evaluation data :', eval_result1[0])
print('accuracy rate at evaluation data :', eval_result1[1])
```

```
WARNING:tensorflow:From C:\Users\ameri\AppData\Local\Temp/ipykernel_9048/1655442623.py:1:
Model.evaluate_generator (from tensorflow.python.keras.engine.training) is deprecated and
will be removed in a future version.
Instructions for updating:
Please use Model.evaluate, which supports generators.
WARNING:tensorflow:Your input ran out of data; interrupting training. Make sure that your
dataset or generator can generate at least `steps_per_epoch * epochs` batches (in this cas
e, 624 batches). You may need to use the repeat() function when building your dataset.
loss rate at evaluation data : 9.311220169067383
accuracy rate at evaluation data : 0.625
```

In [15]:

```
predictions = model.predict_classes(test_generator)
predictions = predictions.reshape(1,-1)[0]
predictions[:15]
```

```
WARNING:tensorflow:From C:\Users\ameri\AppData\Local\Temp/ipykernel_9048/2744101793.py:1:
Sequential.predict_classes (from tensorflow.python.keras.engine.sequential) is deprecated
and will be removed after 2021-01-01.
Instructions for updating:
Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if your model does multi-cl
ass classification   (e.g. if it uses a `softmax` last-layer activation).* `(model.predict
(x) > 0.5).astype("int32")`,   if your model does binary classification   (e.g. if it uses
a `sigmoid` last-layer activation).
```

Out[15]:

```
array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
```

In [16]:

```
print(classification_report(test_generator.classes, predictions, target_names = ['Pneumoni
```

```
                    precision    recall  f1-score   support

Pneumonia (Class 1)       0.00      0.00      0.00       234
   Normal (Class 0)       0.62      1.00      0.77       390

           accuracy                           0.62       624
          macro avg       0.31      0.50      0.38       624
       weighted avg       0.39      0.62      0.48       624

C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [17]:

```
cm = confusion_matrix(test_generator.classes, predictions)
cm
```

Out[17]:

```
array([[  0, 234],
       [  0, 390]], dtype=int64)
```

In [18]:

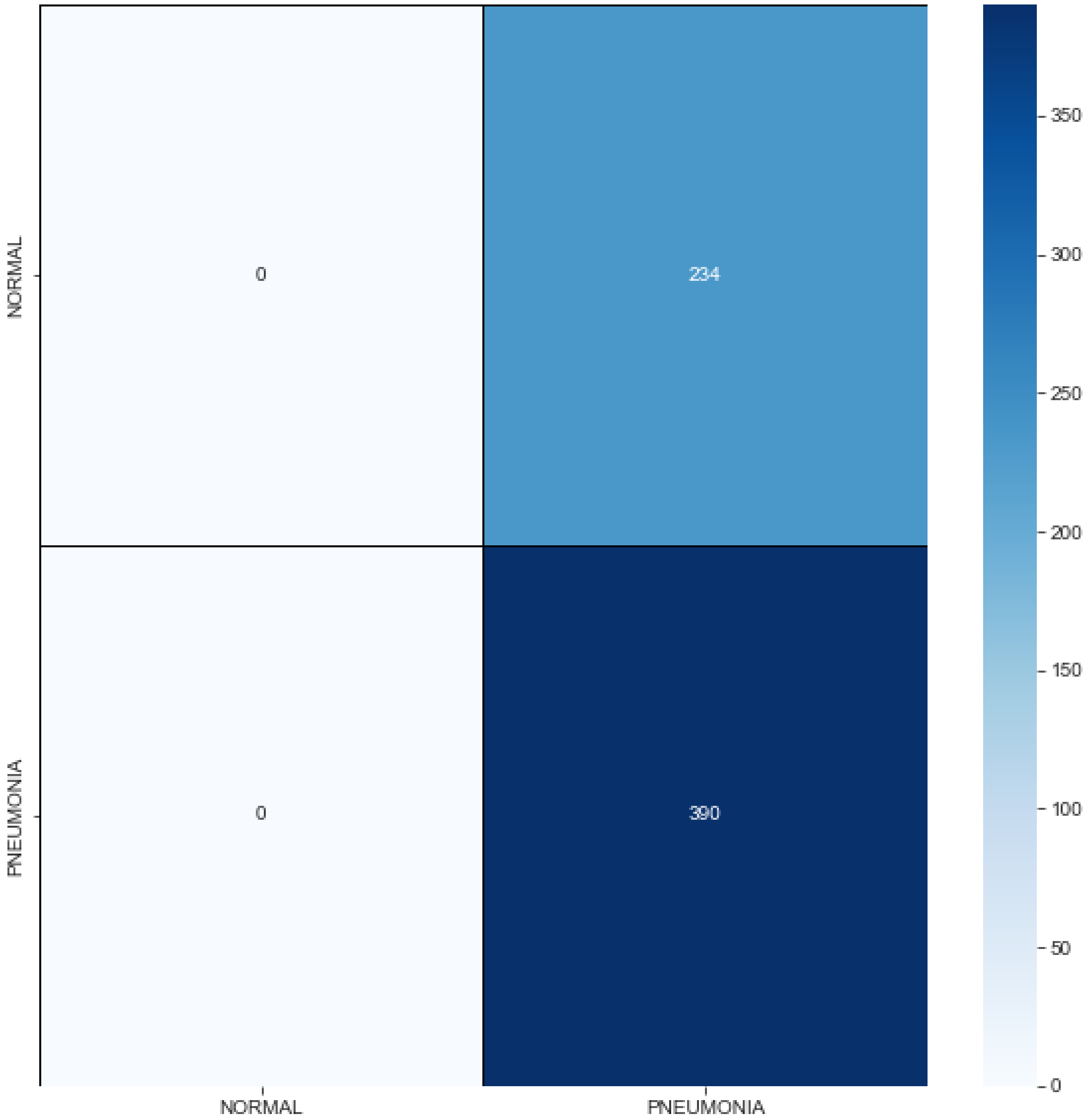
```
cm = pd.DataFrame(cm, index = ['0','1'], columns = ['0','1'])
```

In [19]:

```
labels = ['NORMAL', 'PNEUMONIA']
plt.figure(figsize = (10,10))
sns.heatmap(cm, cmap = "Blues", linecolor = 'black', linewidth = 1, annot = True, fmt = ''
```

Out[19]:

```
<AxesSubplot:>
```



In [20]:

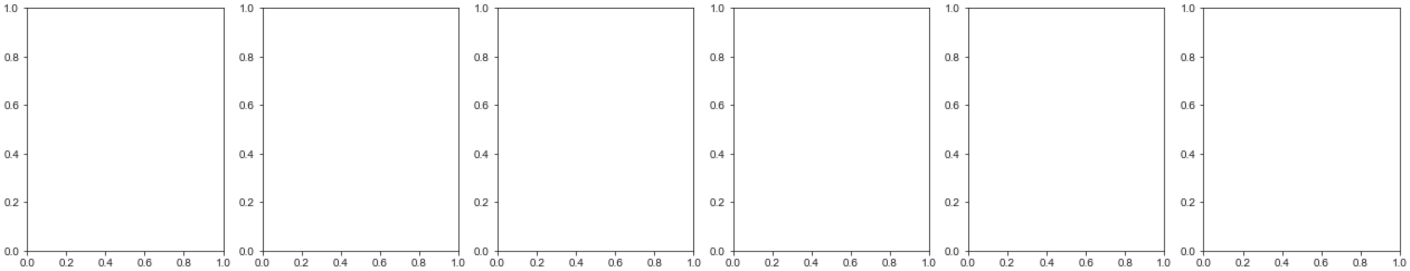
```
correct = np.nonzero(predictions == test_generator.classes)[0]
incorrect = np.nonzero(predictions != test_generator.classes)[0]
```

## Images On Which Output Predicted Incorrectly By Model

In [21]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in incorrect[:0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'wrong_prediction_by_model --- {incorrect[1]}')
```

```
wrong_prediction_by_model --- 1
```

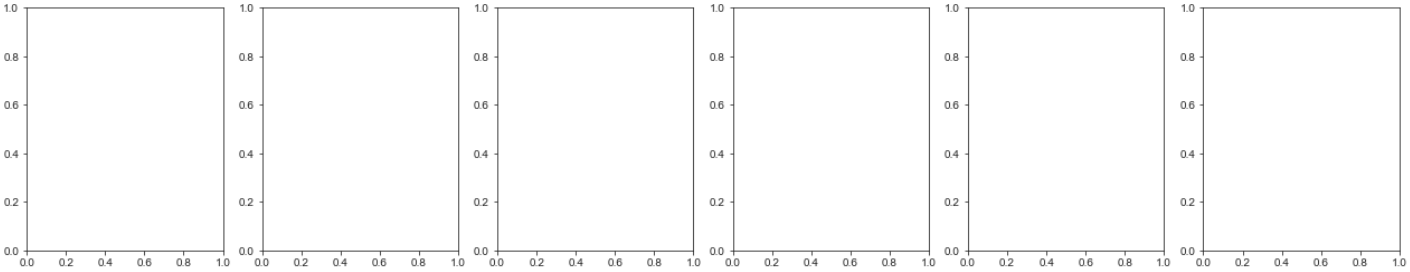


## Images On Which Output Predicted Correctly By Model

In [22]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in correct[:0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'correct_prediction_by_model --- {correct[1]}')
```

```
correct_prediction_by_model --- 235
```



# Inception Net Model

In [23]:

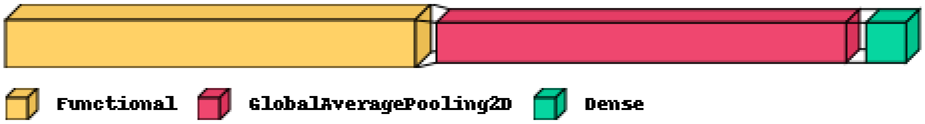
```
base_model2 = tf.keras.applications.InceptionV3(input_shape = (300, 300, 3), include_top =

for layers in base_model2.layers[:200]:
    layers.trainable = False

model2 = tf.keras.Sequential([
        base_model2,
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(1, activation = tf.nn.sigmoid)
        ])

model2.compile(loss = 'binary_crossentropy', optimizer = RMSprop(lr = 0.001), metrics = ['

model2.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
inception_v3 (Functional)    (None, 8, 8, 2048)        21802784  
_________________________________________________________________
global_average_pooling2d (Gl (None, 2048)              0         
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 2049
=================================================================
Total params: 21,804,833
Trainable params: 14,806,337
Non-trainable params: 6,998,496

_________________________________________________________________
```

In [24]:

```python
import visualkeras
visualkeras.layered_view(model2, scale_xy = 3, legend = True,)
```

Out[24]:



In [25]:

```python
checkpoint_cb2 = tf.keras.callbacks.ModelCheckpoint("model1_inceptionNet.h5",
                                                    save_best_only = True)

early_stopping_cb2 = tf.keras.callbacks.EarlyStopping(monitor = 'val_loss', patience = 20,
```

## Train The Model

In [26]:

```python
history2 = model2.fit(
    train_generator,
    steps_per_epoch = 10,
    epochs = epochs,
    validation_data = validation_generator,
    class_weight = class_weight,
    callbacks = [checkpoint_cb2, early_stopping_cb2]
)
```

```
Epoch 1/35
10/10 [==============================] - 227s 23s/step - loss: 0.6204 - accuracy: 0.8047 -
val_loss: 2.0066 - val_accuracy: 0.8701
Epoch 2/35
10/10 [==============================] - 226s 23s/step - loss: 0.1127 - accuracy: 0.9563 -
val_loss: 2.8255 - val_accuracy: 0.8223
Epoch 3/35
10/10 [==============================] - 225s 22s/step - loss: 0.0946 - accuracy: 0.9678 -
val_loss: 5.8045 - val_accuracy: 0.4651
Epoch 4/35
10/10 [==============================] - 228s 23s/step - loss: 0.0885 - accuracy: 0.9742 -
val_loss: 0.2725 - val_accuracy: 0.9427
Epoch 5/35
10/10 [==============================] - 217s 22s/step - loss: 0.0613 - accuracy: 0.9766 -
val_loss: 1.2956 - val_accuracy: 0.8453
Epoch 6/35
10/10 [==============================] - 220s 22s/step - loss: 0.0763 - accuracy: 0.9734 -
val_loss: 0.6245 - val_accuracy: 0.9284
Epoch 7/35
10/10 [==============================] - 223s 22s/step - loss: 0.0704 - accuracy: 0.9750 -
val_loss: 2.5115 - val_accuracy: 0.7937
Epoch 8/35
10/10 [==============================] - 223s 22s/step - loss: 0.0666 - accuracy: 0.9734 -
val_loss: 0.3556 - val_accuracy: 0.9580
Epoch 9/35
10/10 [==============================] - 226s 23s/step - loss: 0.0370 - accuracy: 0.9867 -
val_loss: 0.2812 - val_accuracy: 0.9542
Epoch 10/35
10/10 [==============================] - 226s 23s/step - loss: 0.0615 - accuracy: 0.9773 -
```

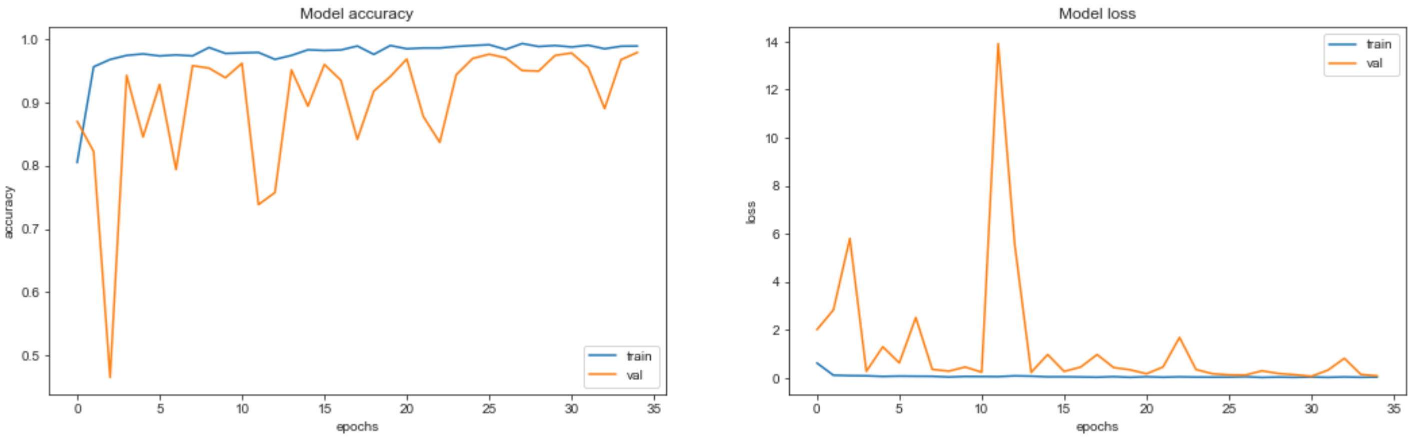
```
val_loss: 0.4534 - val_accuracy: 0.9389
Epoch 11/35
10/10 [==============================] - 218s 22s/step - loss: 0.0581 - accuracy: 0.9782 -
val_loss: 0.2362 - val_accuracy: 0.9618
Epoch 12/35
10/10 [==============================] - 224s 22s/step - loss: 0.0532 - accuracy: 0.9789 -
val_loss: 13.9139 - val_accuracy: 0.7383
Epoch 13/35
10/10 [==============================] - 235s 24s/step - loss: 0.0863 - accuracy: 0.9680 -
val_loss: 5.5599 - val_accuracy: 0.7574
Epoch 14/35
10/10 [==============================] - 220s 22s/step - loss: 0.0733 - accuracy: 0.9742 -
val_loss: 0.2291 - val_accuracy: 0.9513
Epoch 15/35
10/10 [==============================] - 223s 22s/step - loss: 0.0442 - accuracy: 0.9831 -
val_loss: 0.9727 - val_accuracy: 0.8940
Epoch 16/35
10/10 [==============================] - 222s 22s/step - loss: 0.0466 - accuracy: 0.9820 -
val_loss: 0.2700 - val_accuracy: 0.9599
Epoch 17/35
10/10 [==============================] - 225s 23s/step - loss: 0.0391 - accuracy: 0.9828 -
val_loss: 0.4504 - val_accuracy: 0.9351
Epoch 18/35
10/10 [==============================] - 225s 22s/step - loss: 0.0286 - accuracy: 0.9891 -
val_loss: 0.9721 - val_accuracy: 0.8415
Epoch 19/35
10/10 [==============================] - 220s 22s/step - loss: 0.0519 - accuracy: 0.9758 -
val_loss: 0.4316 - val_accuracy: 0.9179
Epoch 20/35
10/10 [==============================] - 224s 22s/step - loss: 0.0246 - accuracy: 0.9898 -
val_loss: 0.3379 - val_accuracy: 0.9408
Epoch 21/35
10/10 [==============================] - 218s 22s/step - loss: 0.0480 - accuracy: 0.9847 -
val_loss: 0.1708 - val_accuracy: 0.9685
Epoch 22/35
10/10 [==============================] - 228s 23s/step - loss: 0.0284 - accuracy: 0.9859 -
val_loss: 0.4556 - val_accuracy: 0.8777
Epoch 23/35
10/10 [==============================] - 231s 23s/step - loss: 0.0445 - accuracy: 0.9859 -
val_loss: 1.6853 - val_accuracy: 0.8367
Epoch 24/35
10/10 [==============================] - 226s 23s/step - loss: 0.0342 - accuracy: 0.9883 -
val_loss: 0.3487 - val_accuracy: 0.9436
Epoch 25/35
10/10 [==============================] - 220s 22s/step - loss: 0.0315 - accuracy: 0.9898 -
val_loss: 0.1732 - val_accuracy: 0.9694
Epoch 26/35
10/10 [==============================] - 218s 22s/step - loss: 0.0339 - accuracy: 0.9911 -
val_loss: 0.1270 - val_accuracy: 0.9761
Epoch 27/35
10/10 [==============================] - 224s 22s/step - loss: 0.0477 - accuracy: 0.9836 -
val_loss: 0.1195 - val_accuracy: 0.9704
Epoch 28/35
10/10 [==============================] - 224s 22s/step - loss: 0.0215 - accuracy: 0.9930 -
val_loss: 0.2945 - val_accuracy: 0.9503
Epoch 29/35
10/10 [==============================] - 222s 22s/step - loss: 0.0350 - accuracy: 0.9883 -
val_loss: 0.1835 - val_accuracy: 0.9494
Epoch 30/35
10/10 [==============================] - 225s 22s/step - loss: 0.0249 - accuracy: 0.9898 -
val_loss: 0.1324 - val_accuracy: 0.9742
Epoch 31/35
10/10 [==============================] - 224s 22s/step - loss: 0.0388 - accuracy: 0.9875 -
val_loss: 0.0674 - val_accuracy: 0.9780
Epoch 32/35
10/10 [==============================] - 216s 22s/step - loss: 0.0242 - accuracy: 0.9903 -
```

```
val_loss: 0.3226 - val_accuracy: 0.9551
Epoch 33/35
10/10 [==============================] - 216s 22s/step - loss: 0.0403 - accuracy: 0.9847 -
val_loss: 0.8153 - val_accuracy: 0.8902
Epoch 34/35
10/10 [==============================] - 225s 22s/step - loss: 0.0266 - accuracy: 0.9887 -
val_loss: 0.1452 - val_accuracy: 0.9675
Epoch 35/35
10/10 [==============================] - 227s 23s/step - loss: 0.0365 - accuracy: 0.9891 -
val_loss: 0.0859 - val_accuracy: 0.9790
```

## Visualise The Model Performance

In [27]:

```
figure, axis = plt.subplots(1, 2, figsize = (18,5))
axis = axis.ravel()

for i,element in enumerate(['accuracy', 'loss']):
    axis[i].plot(history2.history[element])
    axis[i].plot(history2.history['val_' + element])
    axis[i].set_title('Model {}'.format(element))
    axis[i].set_xlabel('epochs')
    axis[i].set_ylabel(element)
    axis[i].legend(['train', 'val'])
```



## Predict And Evaluate On Test Dataset

In [28]:

```
eval_result2 = model2.evaluate_generator(test_generator, 624)
print('loss rate at evaluation data :', eval_result2[0])
print('accuracy rate at evaluation data :', eval_result2[1])
```

```
WARNING:tensorflow:Your input ran out of data; interrupting training. Make sure that your
dataset or generator can generate at least `steps_per_epoch * epochs` batches (in this cas
e, 624 batches). You may need to use the repeat() function when building your dataset.
loss rate at evaluation data : 0.9154806137084961
accuracy rate at evaluation data : 0.8685897588729858
```

In [29]:

```
predictions = model2.predict_classes(test_generator)
predictions = predictions.reshape(1,-1)[0]
predictions[:15]
```

Out[29]:

```
array([1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1])
```

In [30]:

```
print(classification_report(test_generator.classes, predictions, target_names = ['Pneumoni
```

```
                precision    recall  f1-score   support
```

```
Pneumonia (Class 1)       0.34      0.22      0.27       234
   Normal (Class 0)       0.61      0.74      0.67       390

           accuracy                           0.55       624
          macro avg       0.48      0.48      0.47       624
       weighted avg       0.51      0.55      0.52       624
```

In [31]:

```
cm = confusion_matrix(test_generator.classes, predictions)
cm
```

Out[31]:

```
array([[ 52, 182],
       [100, 290]], dtype=int64)
```

In [32]:

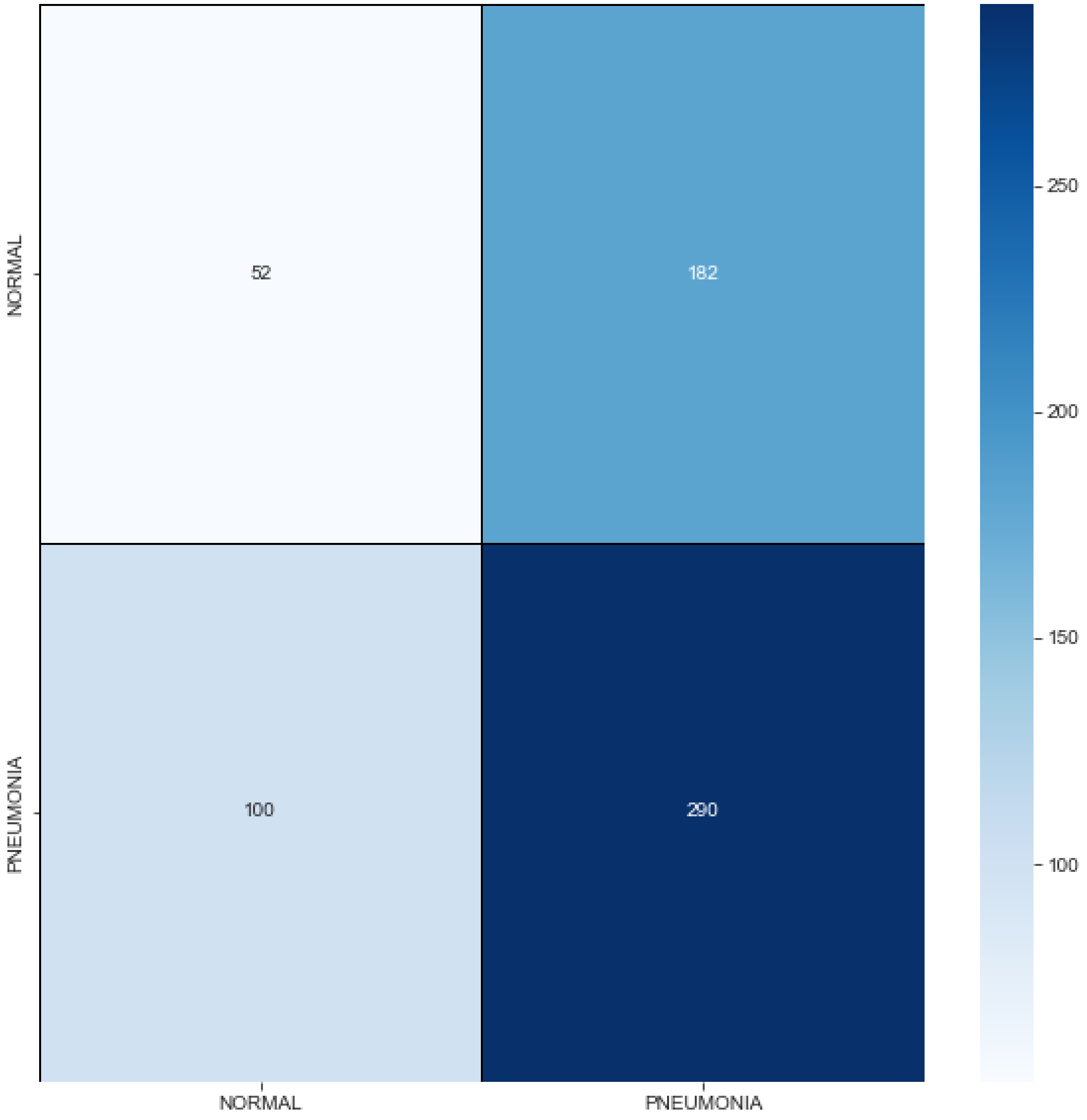
```
cm = pd.DataFrame(cm , index = ['0','1'], columns = ['0','1'])
```

In [33]:

```
labels = ['NORMAL', 'PNEUMONIA']
plt.figure(figsize = (10,10))
sns.heatmap(cm, cmap = "Blues", linecolor = 'black', linewidth = 1, annot = True, fmt = ''
```

Out[33]:

```
<AxesSubplot:>
```



In [34]:

```
model2.save('C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Preprocesamiento de datos
Inception_model = tf.keras.models.load_model('C:/Users/ameri/OneDrive/Documents/MCD/Tetram
wrong_predicted_image = [[],[]]
correct_predicted_image = [[],[]]
i = 0
while i< 5 and len(wrong_predicted_image[0]) < 6:
    j = 0
    while j < 128 and len(wrong_predicted_image[0]) < 6:

        image_array = (test_generator[i][0][j]).reshape(1,300,300,3)

        prediction = Inception_model.predict(image_array)

        if int(round(prediction[0][0])) != test_generator[i][1][j]:
            wrong_predicted_image[0].append(image_array)
            wrong_predicted_image[1].append(int(round(prediction[0][0])))

        elif len(correct_predicted_image[0]) < 6:
            correct_predicted_image[0].append(image_array)
            correct_predicted_image[1].append(int(round(prediction[0][0])))
        j += 1

    i += 1
```

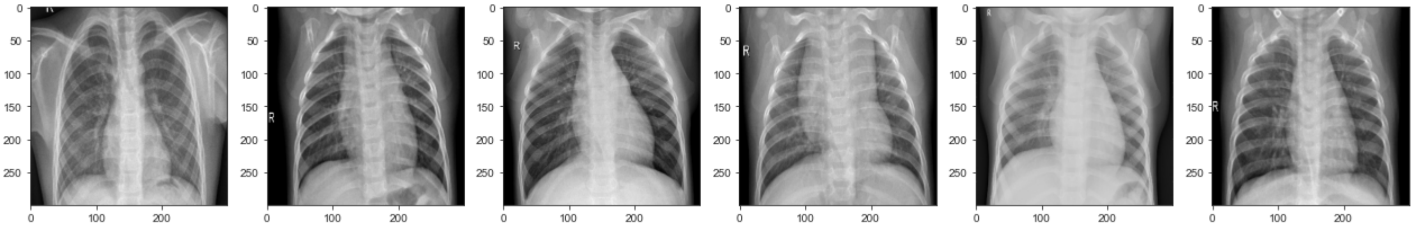
```
WARNING:tensorflow:From C:\Users\ameri\anaconda3\lib\site-packages\tensorflow\python\train
ing\tracking\tracking.py:111: Model.state_updates (from tensorflow.python.keras.engine.tra
ining) is deprecated and will be removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied automatically.
WARNING:tensorflow:From C:\Users\ameri\anaconda3\lib\site-packages\tensorflow\python\train
ing\tracking\tracking.py:111: Layer.updates (from tensorflow.python.keras.engine.base_laye
r) is deprecated and will be removed in a future version.
Instructions for updating:
This property should not be used in TensorFlow 2.0, as updates are applied automatically.
INFO:tensorflow:Assets written to: C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Pre
procesamiento de datos/Proyecto Final/assets
```

## Images On Which Output Predicted Incorrectly By Model

In [35]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in wrong_predicted_image[0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'wrong_prediction_by_model --- {wrong_predicted_image[1]}')
```

```
wrong_prediction_by_model --- [1, 1, 1, 1, 1, 1]
```



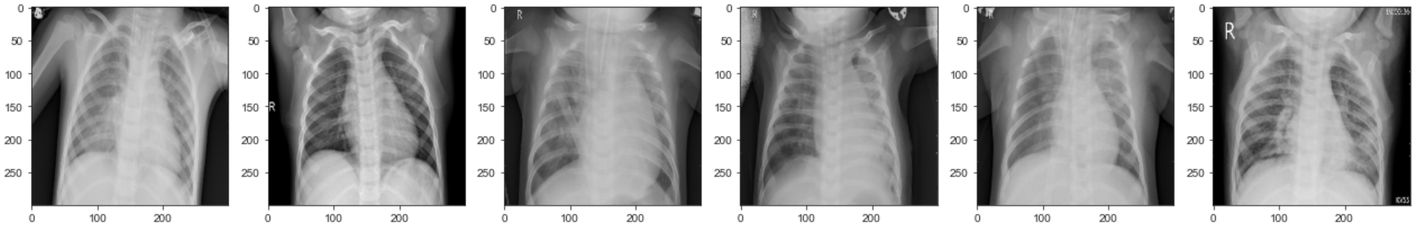
## Images On Which Output Predicted Correctly By Model

In [36]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
```

```
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in correct_predicted_image[0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'correct_prediction_by_model --- {correct_predicted_image[1]}')
```

```
correct_prediction_by_model --- [1, 0, 1, 1, 1, 1]
```



# Residual Net Model

In [37]:

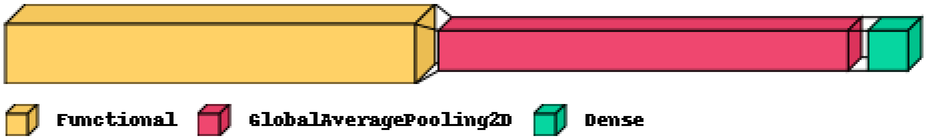
```
base_model3 = tf.keras.applications.ResNet50(input_shape = (300, 300, 3), include_top = Fa
for layers in base_model3.layers[:100]:
    layers.trainable = False

model3 = tf.keras.Sequential([
        base_model3,
        tf.keras.layers.GlobalAveragePooling2D(),
        tf.keras.layers.Dense(1,activation = tf.nn.sigmoid),
        ])

model3.compile(loss = 'binary_crossentropy', optimizer = RMSprop(lr = 0.001), metrics = ['
model3.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
resnet50 (Functional)        (None, 10, 10, 2048)      23587712  
_________________________________________________________________
global_average_pooling2d_1 ( (None, 2048)              0         
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 2049      
=================================================================
Total params: 23,589,761
Trainable params: 19,454,977
Non-trainable params: 4,134,784
_________________________________________________________________
```

In [38]:

```
import visualkeras
visualkeras.layered_view(model3, scale_xy = 3, legend = True,)
```

Out[38]:



In [39]:

```
checkpoint_cb3 = tf.keras.callbacks.ModelCheckpoint("model3_resnet.h5",
                                                    save_best_only = True)
```

```
early_stopping_cb3 = tf.keras.callbacks.EarlyStopping(monitor = 'val_loss', patience = 20,
```

## Train The Model

In [40]:

```
history3 = model3.fit(
    train_generator,
    steps_per_epoch = 10,
    epochs = epochs,
    validation_data = validation_generator,
    class_weight = class_weight,
    callbacks = [checkpoint_cb3, early_stopping_cb3]
)
```

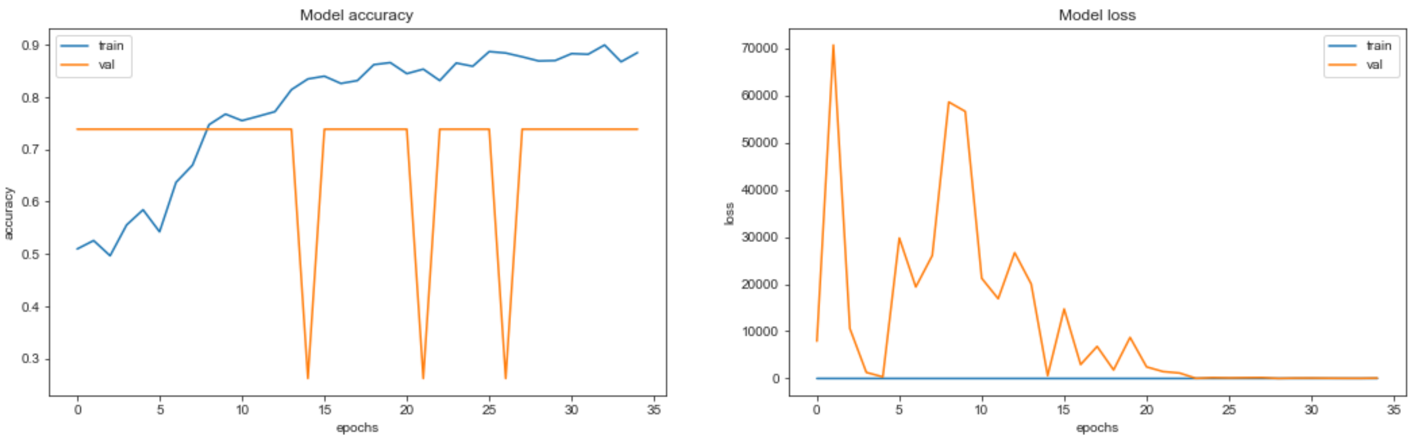
```
Epoch 1/35
10/10 [==============================] - 447s 45s/step - loss: 2.1717 - accuracy: 0.5093 -
val_loss: 7905.6841 - val_accuracy: 0.7383
Epoch 2/35
10/10 [==============================] - 443s 44s/step - loss: 0.8234 - accuracy: 0.5254 -
val_loss: 70697.2422 - val_accuracy: 0.7383
Epoch 3/35
10/10 [==============================] - 442s 44s/step - loss: 0.7078 - accuracy: 0.4964 -
val_loss: 10586.3291 - val_accuracy: 0.7383
Epoch 4/35
10/10 [==============================] - 443s 44s/step - loss: 0.6628 - accuracy: 0.5552 -
val_loss: 1285.2543 - val_accuracy: 0.7383
Epoch 5/35
10/10 [==============================] - 438s 44s/step - loss: 0.7132 - accuracy: 0.5842 -
val_loss: 337.0464 - val_accuracy: 0.7383
Epoch 6/35
10/10 [==============================] - 450s 45s/step - loss: 0.8692 - accuracy: 0.5422 -
val_loss: 29779.3555 - val_accuracy: 0.7383
Epoch 7/35
10/10 [==============================] - 448s 45s/step - loss: 0.6355 - accuracy: 0.6367 -
val_loss: 19402.6152 - val_accuracy: 0.7383
Epoch 8/35
10/10 [==============================] - 438s 44s/step - loss: 0.5610 - accuracy: 0.6696 -
val_loss: 26071.0801 - val_accuracy: 0.7383
Epoch 9/35
10/10 [==============================] - 449s 45s/step - loss: 0.5068 - accuracy: 0.7469 -
val_loss: 58610.2461 - val_accuracy: 0.7383
Epoch 10/35
10/10 [==============================] - 440s 44s/step - loss: 0.4658 - accuracy: 0.7672 -
val_loss: 56616.7734 - val_accuracy: 0.7383
Epoch 11/35
10/10 [==============================] - 450s 45s/step - loss: 0.5116 - accuracy: 0.7547 -
val_loss: 21237.8906 - val_accuracy: 0.7383
Epoch 12/35
10/10 [==============================] - 437s 44s/step - loss: 0.4823 - accuracy: 0.7631 -
val_loss: 16904.0918 - val_accuracy: 0.7383
Epoch 13/35
10/10 [==============================] - 447s 45s/step - loss: 0.4414 - accuracy: 0.7719 -
val_loss: 26667.9863 - val_accuracy: 0.7383
Epoch 14/35
10/10 [==============================] - 435s 43s/step - loss: 0.4291 - accuracy: 0.8139 -
val_loss: 20037.3965 - val_accuracy: 0.7383
Epoch 15/35
10/10 [==============================] - 451s 45s/step - loss: 0.3770 - accuracy: 0.8344 -
val_loss: 588.8405 - val_accuracy: 0.2617
Epoch 16/35
10/10 [==============================] - 434s 43s/step - loss: 0.3327 - accuracy: 0.8396 -
val_loss: 14730.9990 - val_accuracy: 0.7383
Epoch 17/35
```

```
10/10 [==============================] - 448s 45s/step - loss: 0.3920 - accuracy: 0.8258 -
val_loss: 2946.8240 - val_accuracy: 0.7383
Epoch 18/35
10/10 [==============================] - 453s 45s/step - loss: 0.3463 - accuracy: 0.8313 -
val_loss: 6793.0552 - val_accuracy: 0.7383
Epoch 19/35
10/10 [==============================] - 448s 45s/step - loss: 0.3332 - accuracy: 0.8617 -
val_loss: 1804.1760 - val_accuracy: 0.7383
Epoch 20/35
10/10 [==============================] - 446s 45s/step - loss: 0.3112 - accuracy: 0.8656 -
val_loss: 8708.8398 - val_accuracy: 0.7383
Epoch 21/35
10/10 [==============================] - 445s 44s/step - loss: 0.3204 - accuracy: 0.8445 -
val_loss: 2455.2632 - val_accuracy: 0.7383
Epoch 22/35
10/10 [==============================] - 445s 44s/step - loss: 0.3470 - accuracy: 0.8531 -
val_loss: 1460.0182 - val_accuracy: 0.2617
Epoch 23/35
10/10 [==============================] - 451s 45s/step - loss: 0.3384 - accuracy: 0.8313 -
val_loss: 1154.5377 - val_accuracy: 0.7383
Epoch 24/35
10/10 [==============================] - 443s 44s/step - loss: 0.3363 - accuracy: 0.8648 -
val_loss: 30.6373 - val_accuracy: 0.7383
Epoch 25/35
10/10 [==============================] - 440s 44s/step - loss: 0.3085 - accuracy: 0.8586 -
val_loss: 175.5571 - val_accuracy: 0.7383
Epoch 26/35
10/10 [==============================] - 441s 44s/step - loss: 0.2478 - accuracy: 0.8867 -
val_loss: 119.3478 - val_accuracy: 0.7383
Epoch 27/35
10/10 [==============================] - 435s 43s/step - loss: 0.3056 - accuracy: 0.8840 -
val_loss: 159.5069 - val_accuracy: 0.2617
Epoch 28/35
10/10 [==============================] - 432s 43s/step - loss: 0.2760 - accuracy: 0.8767 -
val_loss: 191.5379 - val_accuracy: 0.7383
Epoch 29/35
10/10 [==============================] - 446s 45s/step - loss: 0.3094 - accuracy: 0.8687 -
val_loss: 12.5595 - val_accuracy: 0.7383
Epoch 30/35
10/10 [==============================] - 448s 45s/step - loss: 0.2849 - accuracy: 0.8695 -
val_loss: 80.0333 - val_accuracy: 0.7383
Epoch 31/35
10/10 [==============================] - 443s 44s/step - loss: 0.2521 - accuracy: 0.8828 -
val_loss: 93.7007 - val_accuracy: 0.7383
Epoch 32/35
10/10 [==============================] - 434s 43s/step - loss: 0.2831 - accuracy: 0.8815 -
val_loss: 58.2127 - val_accuracy: 0.7383
Epoch 33/35
10/10 [==============================] - 747s 75s/step - loss: 0.2493 - accuracy: 0.8993 -
val_loss: 39.5574 - val_accuracy: 0.7383
Epoch 34/35
10/10 [==============================] - 993s 99s/step - loss: 0.3071 - accuracy: 0.8672 -
val_loss: 33.3505 - val_accuracy: 0.7383
Epoch 35/35
10/10 [==============================] - 879s 88s/step - loss: 0.2924 - accuracy: 0.8848 -
val_loss: 88.6057 - val_accuracy: 0.7383
```

## Visualise The Model Performance

In [41]:

```python
figure, axis = plt.subplots(1, 2, figsize = (18,5))
axis = axis.ravel()

for i,element in enumerate(['accuracy', 'loss']):
    axis[i].plot(history3.history[element])
    axis[i].plot(history3.history['val_' + element])
    axis[i].set_title('Model {}'.format(element))
    axis[i].set_xlabel('epochs')
    axis[i].set_ylabel(element)
    axis[i].legend(['train', 'val'])
```



## Predict And Evaluate On Test Dataset

In [42]:

```
eval_result3 = model3.evaluate_generator(test_generator, 624)
print('loss rate at evaluation data :', eval_result3[0])
print('accuracy rate at evaluation data :', eval_result3[1])
```

```
WARNING:tensorflow:Your input ran out of data; interrupting training. Make sure that your
dataset or generator can generate at least `steps_per_epoch * epochs` batches (in this cas
e, 624 batches). You may need to use the repeat() function when building your dataset.
loss rate at evaluation data : 131.0426788330078
accuracy rate at evaluation data : 0.625
```

In [43]:

```
predictions = model3.predict_classes(test_generator)
predictions = predictions.reshape(1,-1)[0]
predictions[:15]
```

Out[43]:

```
array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1])
```

In [44]:

```
print(classification_report(test_generator.classes, predictions, target_names = ['Pneumoni
```

```
                    precision    recall  f1-score   support

Pneumonia (Class 1)       0.00      0.00      0.00       234
   Normal (Class 0)       0.62      1.00      0.77       390

           accuracy                           0.62       624
          macro avg       0.31      0.50      0.38       624
       weighted avg       0.39      0.62      0.48       624

C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\ameri\anaconda3\lib\site-packages\sklearn\metrics\_classification.py:1248: Undefi
nedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels wit
```

```
h no predicted samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [45]:

```
cm = confusion_matrix(test_generator.classes, predictions)
cm
```

Out[45]:

```
array([[  0, 234],
       [  0, 390]], dtype=int64)
```

In [46]:

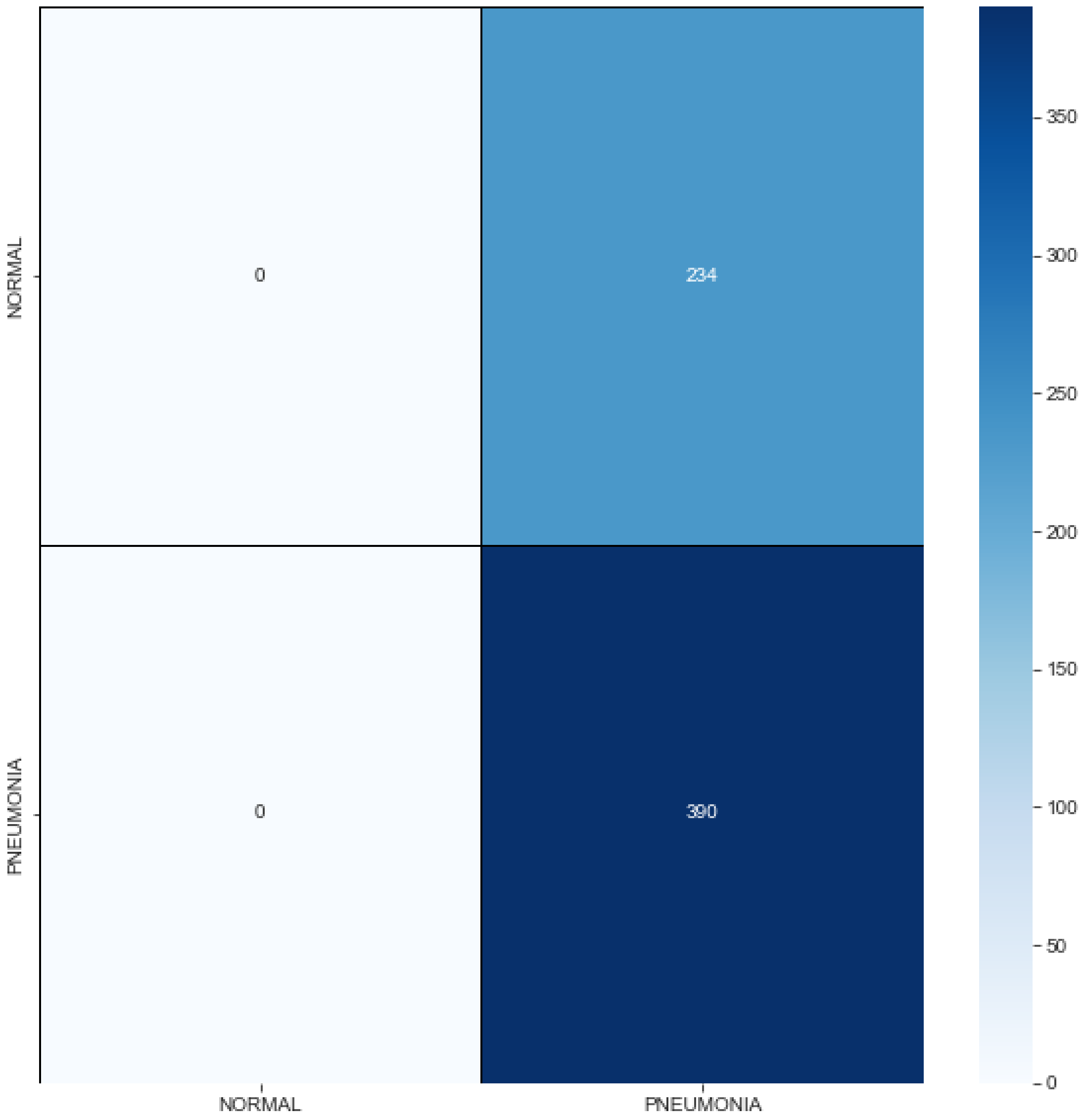
```
cm = pd.DataFrame(cm, index = ['0','1'], columns = ['0','1'])
```

In [47]:

```
labels = ['NORMAL', 'PNEUMONIA']
plt.figure(figsize = (10,10))
sns.heatmap(cm, cmap = "Blues", linecolor = 'black', linewidth = 1, annot = True, fmt = ''
```

Out[47]:

```
<AxesSubplot:>
```



In [48]:

```
model3.save('C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Preprocesamiento de datos
Residual_model = tf.keras.models.load_model('C:/Users/ameri/OneDrive/Documents/MCD/Tetrame

wrong_predicted_image = [[],[]]
correct_predicted_image = [[],[]]
i = 0
while i< 5 and len(wrong_predicted_image[0]) < 6:
    j = 0
    while j < 128 and len(wrong_predicted_image[0]) < 6:

        image_array = (test_generator[i][0][j]).reshape(1,300,300,3)

        prediction = Residual_model.predict(image_array)

        if int(round(prediction[0][0])) != test_generator[i][1][j]:
            wrong_predicted_image[0].append(image_array)
            wrong_predicted_image[1].append(int(round(prediction[0][0])))

        elif len(correct_predicted_image[0]) < 6:
            correct_predicted_image[0].append(image_array)
            correct_predicted_image[1].append(int(round(prediction[0][0])))
        j += 1

    i += 1
```

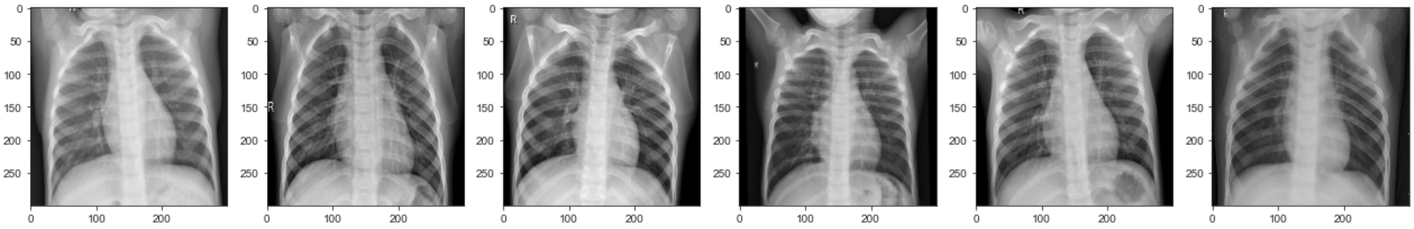
```
INFO:tensorflow:Assets written to: C:/Users/ameri/OneDrive/Documents/MCD/Tetramestre 4/Pre
procesamiento de datos/Proyecto Final/assets
```

## Images On Which Output Predicted Incorrectly By Model

In [49]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in wrong_predicted_image[0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'wrong_prediction_by_model --- {wrong_predicted_image[1]}')
```

```
wrong_prediction_by_model --- [1, 1, 1, 1, 1, 1]
```

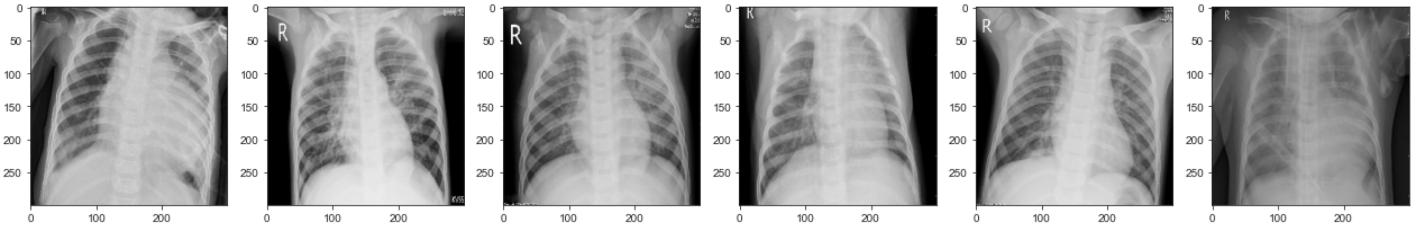


## Images On Which Output Predicted Correctly By Model

In [50]:

```
import matplotlib.pyplot as plt
from matplotlib import rcParams
rcParams['figure.figsize'] = 22,4
fig, ax = plt.subplots(1,6)

i = 0
for ele in correct_predicted_image[0]:
    image = tf.keras.preprocessing.image.array_to_img(ele.reshape(300,300,3))
    ax[i].imshow(image)
    i += 1

print(f'correct_prediction_by_model --- {correct_predicted_image[1]}')
```

```
correct_prediction_by_model --- [1, 1, 1, 1, 1, 1]
```



# The End