final-pneumonia

March 7, 2024

IMPORTING REQUIRED LIBRARIES

[3]:
```
import pandas as pd
import numpy as np
import os
import cv2
import matplotlib.pyplot as plt
import keras
import seaborn as sns
import pathlib
from pathlib import Path
import glob
import tensorflow as tf
from sklearn.model_selection import train_test_split
from tensorflow.keras.utils  import to_categorical
from keras.preprocessing.image import ImageDataGenerator
```

[4]:
```
data_dir='/kaggle/input/pneumonia-xray-img-dataset/pneumonia xray'
root_dir='/kaggle/working/'
```

[42]:
```
def countfiles(root_dir):
    for path in pathlib.Path(root_dir).iterdir():
        if path.is_dir():
             print( str(len([name for name in os.listdir(path) \
            if os.path.isfile(os.path.join(path, name))])) + " files inside the␣
 ↪" + \
            str(path.name),'class')
countfiles(data_dir)
```

```
4273 files inside the PNEUMONIA class
1583 files inside the NORMAL class
```

DATASET PREPARATION

[5]:
```
def data_categories(d_path):
    categories=[]     #listdir-->used to get the list of all files and␣
 ↪directories in the specified directory
    for folder_name in os.listdir(d_path):  #os.path.isdir()--->used to check␣
 ↪whether the specified path is an existing directory or not.
```

```
        if os.path.isdir(os.path.join(d_path,folder_name)):
            no_of_files=len(glob.glob(os.path.join(d_path, folder_name)+"/*.
 ↪jpeg"))
            categories.append(np.array([folder_name,no_of_files]))
    categories.sort(key=lambda a:a[0])
    cat=np.array(categories)
    return list(cat[:, 0]),list(cat[:,1])
categories,no_of_files = data_categories("/kaggle/input/
 ↪pneumonia-xray-img-dataset/pneumonia xray")
print(categories)
```

```
['NORMAL', 'PNEUMONIA']
```

[44]:

```
print("number of categories: ", len(categories))
```

```
number of categories:  2
```

[68]:

```
df = pd.DataFrame({"category": categories, "number of files": no_of_files})
df
```

[68]:

```
    category number of files
0     NORMAL            1583
1  PNEUMONIA            4273
```

[6]:

```
def dataset(data_path, categories, width, height):
    x = []
    y = []
    for category_idx, category in enumerate(categories):
        path = os.path.join(data_path, category)
        count = 0
        for img in os.listdir(path):
            img_array = cv2.imread(os.path.join(path,img))
            img_size = cv2.resize(img_array, (width, height))
            x.append(img_size)
            y.append(category_idx)
            count += 1
        print(f"Number of images in class {category_idx}: {count}")
    y = np.array(y)
    x = np.array(x).reshape(y.shape[0], width, height, 3)
    return x, y

x, y = dataset(data_path=data_dir, categories=['NORMAL', 'PNEUMONIA'],␣
 ↪width=200, height=200)
```

```
Number of images in class 0: 1583
Number of images in class 1: 4273
```

[7]:

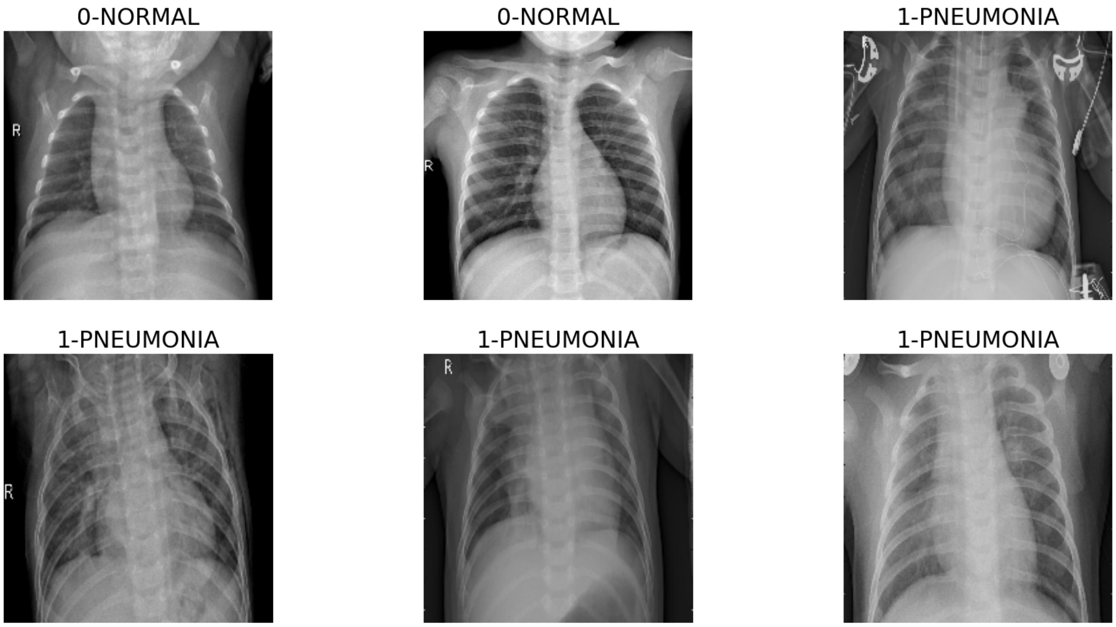
```
print(f'x shape:{x.shape}')
print(f"y shape: {y.shape}")
```

```
x shape:(5856, 200, 200, 3)
y shape: (5856,)
```

IMAGES FROM CLASSES

[129]:

```
plt.figure(figsize=(20, 10))
st, end = 0,1000
for i in range(6):
    plt.subplot(2, 3, i + 1)
    idx = np.random.randint(st, end)
    st = end + 1
    end = (i + 2) * 1000
    plt.rcParams.update({'font.size':18})
    plt.imshow(x[idx][:, :, ::-1])
    plt.title(f"{y[idx]}-{categories[y[idx]]}")
    plt.axis("off")
plt.show()
```



DATASET SPLITTING FOR TRAIN/VAL/TEST SETS

[54]:

```
y=np.reshape(y,(len(y),1))
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.
 ↪1,random_state=42)
print(f"x_train: {x_train.shape}")
print(f"y_train: {y_train.shape}")
print(f"x_test: {x_test.shape}")
print(f"y_test: {y_test.shape}")
```

```
x_train: (5270, 200, 200, 3)
y_train: (5270, 1)
x_test: (586, 200, 200, 3)
y_test: (586, 1)
```

```
[55]: x_train,x_val,y_train,y_val=train_test_split(x_train,y_train,train_size=0.70)
      x_test=x_test

      print(f"x_train:{x_train.shape},y_train:{y_train.shape}")
      print(f"x_val: {x_val.shape},y_val:{y_val.shape}")        #70-20-10
      print(f"x_test:{x_test.shape},y_test:{y_test.shape}")
```

```
x_train:(3688, 200, 200, 3),y_train:(3688, 1)
x_val: (1582, 200, 200, 3),y_val:(1582, 1)
x_test:(586, 200, 200, 3),y_test:(586, 1)
```

```
[56]: y_train = to_categorical(y_train)
      y_val = to_categorical(y_val)
      y_test = to_categorical(y_test)

      print(f"x_train:{x_train.shape},  y_train:{y_train.shape}")
      print(f"x_val:{x_val.shape},  y_val:{y_val.shape}")
      print(f"x_test:{x_test.shape},  y_test:{y_test.shape}")
```

```
x_train:(3688, 200, 200, 3),  y_train:(3688, 2)
x_val:(1582, 200, 200, 3),  y_val:(1582, 2)
x_test:(586, 200, 200, 3),  y_test:(586, 2)
```

DATA PREPROCESSING

```
[57]: train_generator=ImageDataGenerator(rescale=1./255,
                                         rotation_range=2,
                                        horizontal_flip=True,
                                         shear_range=0.5,
                                        zoom_range=0.7)
      val_generator=ImageDataGenerator(rescale=1./255,
                                       rotation_range=2,
                                       horizontal_flip=True,
                                       shear_range=0.5,
                                       zoom_range=0.1)
      test_generator=ImageDataGenerator(rotation_range=2,
                                       horizontal_flip=True,
                                       zoom_range=0.1)

      train_generator.fit(x_train)
```

```
val_generator.fit(x_val)
test_generator.fit(x_test)
```

MODEL BUILDING-CNN

[77]:

```
from keras.models import Sequential, load_model
from keras.layers import Flatten, Dense, Dropout
```

[78]:

```
model = keras.Sequential([
    # Convolutional layers
                   #kernels,  #filters ,  #activation function,          #input
    tf.keras.layers.Conv2D(32, (3,3), activation='relu',␣
 ↪input_shape=(200,200,3)),
    tf.keras.layers.MaxPooling2D((2,2)),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2,2)),
    tf.keras.layers.Conv2D(128, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D((2,2)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(2, activation='sigmoid')

])
```

[79]:

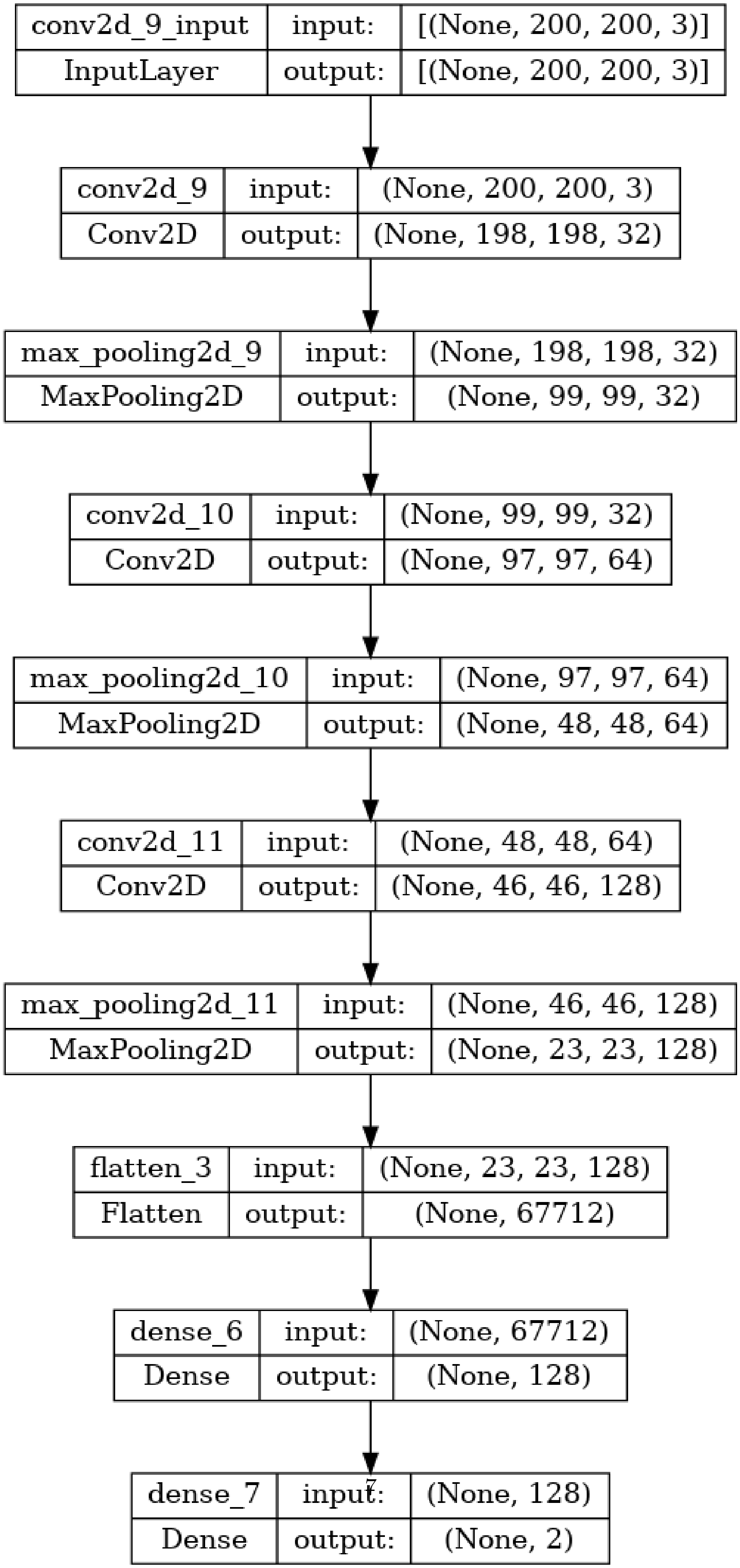
```
model.summary()
```

```
Model: "sequential_3"

_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_9 (Conv2D)           (None, 198, 198, 32)      896

 max_pooling2d_9 (MaxPooling  (None, 99, 99, 32)       0
 2D)

 conv2d_10 (Conv2D)          (None, 97, 97, 64)        18496

 max_pooling2d_10 (MaxPoolin  (None, 48, 48, 64)       0
 g2D)

 conv2d_11 (Conv2D)          (None, 46, 46, 128)       73856

 max_pooling2d_11 (MaxPoolin  (None, 23, 23, 128)      0
 g2D)

 flatten_3 (Flatten)         (None, 67712)             0

 dense_6 (Dense)             (None, 128)               8667264
 dense_7 (Dense)             (None, 2)                 258

=================================================================
Total params: 8,760,770
Trainable params: 8,760,770
Non-trainable params: 0
_________________________________________________________________
```

[80]:

```
from tensorflow.keras.utils import plot_model
plot_model(model,show_shapes=True,to_file='binaryclass model.png')
```

[80]:


conv2d_9_input | input: | [(None, 200, 200, 3)]
InputLayer | output: | [(None, 200, 200, 3)]
conv2d_9 | input: | (None, 200, 200, 3)
Conv2D | output: | (None, 198, 198, 32)
max_pooling2d_9 | input: | (None, 198, 198, 32)
MaxPooling2D | output: | (None, 99, 99, 32)
conv2d_10 | input: | (None, 99, 99, 32)
Conv2D | output: | (None, 97, 97, 64)
max_pooling2d_10 | input: | (None, 97, 97, 64)
MaxPooling2D | output: | (None, 48, 48, 64)
conv2d_11 | input: | (None, 48, 48, 64)
Conv2D | output: | (None, 46, 46, 128)
max_pooling2d_11 | input: | (None, 46, 46, 128)
MaxPooling2D | output: | (None, 23, 23, 128)
flatten_3 | input: | (None, 23, 23, 128)
Flatten | output: | (None, 67712)
dense_6 | input: | (None, 67712)
Dense | output: | (None, 128)
dense_7 | input: | (None, 128)
Dense | output: | (None, 2)

```
[81]: from keras.metrics import Precision,Recall
      import tensorflow_addons as tfa
```

```
[82]: model.compile(optimizer='adam',
                    loss='binary_crossentropy',
                   ␣
        ↪metrics=['accuracy',Precision(name='precision'),Recall(name='Recall'),tfa.
        ↪metrics.F1Score(num_classes=2)])
```

```
[83]: history = model.fit(x_train,y_train, epochs=20,batch_size=100,
                          validation_data = val_generator.
        ↪flow(x_val,y_val,batch_size=100),
                         validation_steps=150,
                         verbose=1)
      history=history.history
      model.save('/kaggle/working/binary_model.h5')
```

```
Epoch 1/20
37/37 [==============================] - 19s 476ms/step - loss: 15.1378 -
accuracy: 0.7535 - precision: 0.7311 - Recall: 0.7747 - f1_score: 0.6930 -
val_loss: 0.6863 - val_accuracy: 0.7459 - val_precision: 0.7471 - val_Recall:
0.7453 - val_f1_score: 0.4320
Epoch 2/20
37/37 [==============================] - 2s 60ms/step - loss: 0.1723 - accuracy:
0.9333 - precision: 0.9350 - Recall: 0.9276 - f1_score: 0.9155
Epoch 3/20
37/37 [==============================] - 2s 60ms/step - loss: 0.1121 - accuracy:
0.9566 - precision: 0.9574 - Recall: 0.9577 - f1_score: 0.9450
Epoch 4/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0935 - accuracy:
0.9672 - precision: 0.9659 - Recall: 0.9666 - f1_score: 0.9585
Epoch 5/20
37/37 [==============================] - 2s 62ms/step - loss: 0.0824 - accuracy:
0.9726 - precision: 0.9715 - Recall: 0.9718 - f1_score: 0.9652
Epoch 6/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0985 - accuracy:
0.9642 - precision: 0.9624 - Recall: 0.9642 - f1_score: 0.9547
Epoch 7/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0726 - accuracy:
0.9742 - precision: 0.9737 - Recall: 0.9729 - f1_score: 0.9674
Epoch 8/20
37/37 [==============================] - 2s 62ms/step - loss: 0.0413 - accuracy:
0.9867 - precision: 0.9848 - Recall: 0.9867 - f1_score: 0.9831
Epoch 9/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0273 - accuracy:
```

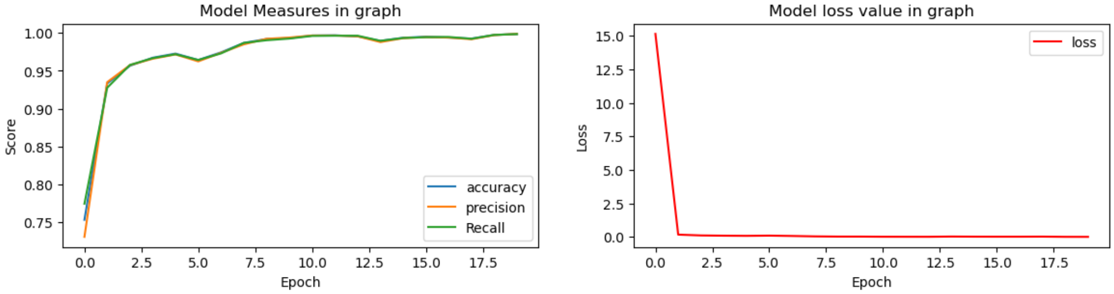
```
0.9919 - precision: 0.9921 - Recall: 0.9902 - f1_score: 0.9897
Epoch 10/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0263 - accuracy:
0.9930 - precision: 0.9938 - Recall: 0.9924 - f1_score: 0.9911
Epoch 11/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0158 - accuracy:
0.9965 - precision: 0.9965 - Recall: 0.9959 - f1_score: 0.9955
Epoch 12/20
37/37 [==============================] - 2s 63ms/step - loss: 0.0135 - accuracy:
0.9967 - precision: 0.9965 - Recall: 0.9962 - f1_score: 0.9959
Epoch 13/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0124 - accuracy:
0.9954 - precision: 0.9954 - Recall: 0.9962 - f1_score: 0.9942
Epoch 14/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0304 - accuracy:
0.9894 - precision: 0.9878 - Recall: 0.9894 - f1_score: 0.9866
Epoch 15/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0217 - accuracy:
0.9935 - precision: 0.9930 - Recall: 0.9932 - f1_score: 0.9918
Epoch 16/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0190 - accuracy:
0.9948 - precision: 0.9943 - Recall: 0.9943 - f1_score: 0.9935
Epoch 17/20
37/37 [==============================] - 2s 59ms/step - loss: 0.0193 - accuracy:
0.9938 - precision: 0.9938 - Recall: 0.9946 - f1_score: 0.9921
Epoch 18/20
37/37 [==============================] - 2s 60ms/step - loss: 0.0245 - accuracy:
0.9924 - precision: 0.9916 - Recall: 0.9921 - f1_score: 0.9904
Epoch 19/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0085 - accuracy:
0.9973 - precision: 0.9970 - Recall: 0.9973 - f1_score: 0.9966
Epoch 20/20
37/37 [==============================] - 2s 61ms/step - loss: 0.0067 - accuracy:
0.9984 - precision: 0.9986 - Recall: 0.9984 - f1_score: 0.9979
```

CNN MODEL EVALUATION

[85]:

```python
fig = plt.figure(figsize=(14, 3))
ax1 = fig.add_subplot(1, 2, 1)
ax1.plot(history['accuracy'])
ax1.plot(history['precision'])
ax1.plot(history["Recall"])
ax1.legend(['accuracy','precision','Recall'])
ax1.set_title('Model Measures in graph')
ax1.set_xlabel('Epoch')
ax1.set_ylabel('Score')

ax2 = fig.add_subplot(1, 2, 2)
```

```
ax2.plot(history['loss'],color='red')
ax2.legend(['loss'])
ax2.set_title('Model loss value in graph')
ax2.set_xlabel('Epoch')
ax2.set_ylabel('Loss')

plt.savefig('graph1.png')
plt.savefig('graph2.png')
plt.show()
```



TEST SET

[109]:

```
testscore=model.evaluate(x_test,y_test)
testscore
```

```
19/19 [==============================] - 0s 9ms/step - loss: 0.3251 - accuracy:
0.9488 - precision: 0.9485 - Recall: 0.9437 - f1_score: 0.9385
```

[109]:

```
[0.3250717222690582,
 0.9488054513931274,
 0.9485419988632202,
 0.9436860084533691,
 array([0.9132948, 0.9636804], dtype=float32)]
```

[93]:

```
print('TEST DATA')
print('')
print(f"Accuracy: {round(testscore[1]*100,2)}%")
print(f"Precision: {round(testscore[2]*100,2)}%")
print(f"Recall: {round(testscore[3]*100,2)}%")
print(f"F1_score: {testscore[4]}")
print(f"Loss: {testscore[0]}")
```

```
TEST DATA

Accuracy: 94.88%
Precision: 94.85%
Recall: 94.37%
```

```
F1_score: [0.9132948 0.9636804]
Loss: 0.3250717222690582
```

[94]:

```
from sklearn.metrics import classification_report,confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay
```

[95]:

```
y_pred=np.argmax(model.predict(x_test),axis=1)
y_true=np.argmax(y_test,axis=1)
```

```
19/19 [==============================] - 0s 6ms/step
```

[96]:

```
c_test=confusion_matrix(y_true,y_pred)
c_test
```

[96]:

```
array([[158,  19],
       [ 11, 398]])
```

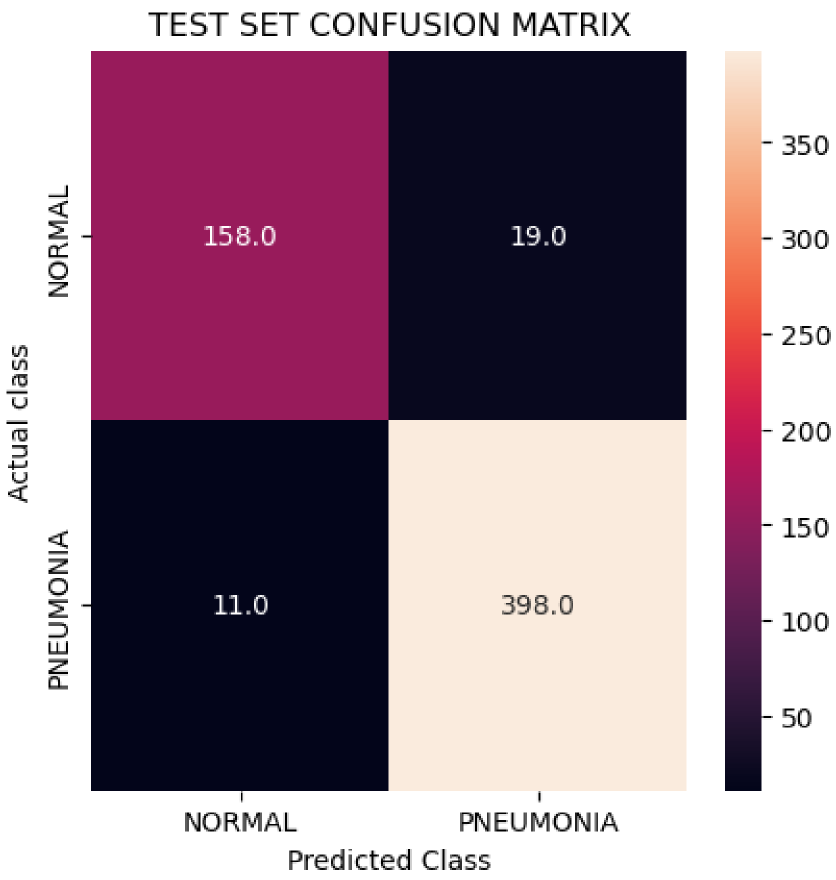
[97]:

```
print(classification_report(y_true,y_pred,target_names=['NORMAL','PNEUMONIA']))
```

```
              precision    recall  f1-score   support

      NORMAL       0.93      0.89      0.91       177
   PNEUMONIA       0.95      0.97      0.96       409

    accuracy                           0.95       586
   macro avg       0.94      0.93      0.94       586
weighted avg       0.95      0.95      0.95       586
```

[98]:

```
class_names=['NORMAL','PNEUMONIA']
plt.figure(figsize=(5,5))
sns.
  ↪heatmap(c_test,annot=True,xticklabels=class_names,yticklabels=class_names,fmt='.
  ↪1f')
plt.title('TEST SET CONFUSION MATRIX')
plt.xlabel("Predicted Class")
plt.ylabel("Actual class")
plt.savefig('cm test.png')
plt.show()
```



[100]:
```
print(f"TEST SET")
print('')
for i in range(2):
    tp = c_test[i, i]
    tn = np.sum(c_test) - np.sum(c_test[i, :]) - np.sum(c_test[:, i]) +␣
 ↪c_test[i, i]
    fp = np.sum(c_test[:, i]) - c_test[i, i]
    fn = np.sum(c_test[i, :]) - c_test[i, i]
    print(f"Class {i}: TP={tp}, TN={tn}, FP={fp}, FN={fn}")
```

```
TEST SET

Class 0: TP=158, TN=398, FP=11, FN=19
Class 1: TP=398, TN=158, FP=19, FN=11
```

VALIDATION SET ANALYSIS

[101]:
```
valscore=model.evaluate(x_val,y_val)
valscore
```

```
50/50 [==============================] - 1s 10ms/step - loss: 0.2868 - accuracy:
0.9431 - precision: 0.9468 - Recall: 0.9343 - f1_score: 0.9243
```

```
[101]: [0.28680965304374695,
        0.9431099891662598,
        0.9468289613723755,
        0.9342604279518127,
        array([0.88664985, 0.9620252 ], dtype=float32)]
```

```
[102]: print('VALIDATION DATA')
       print('')
       print(f"Accuracy: {round(valscore[1]*100,2)}%")
       print(f"Precision: {round(valscore[2]*100,2)}%")
       print(f"Recall: {round(valscore[3]*100,2)}%")
       print(f"F1_score: {valscore[4]}")
       print(f"Loss: {valscore[0]}")
```

```
VALIDATION DATA

Accuracy: 94.31%
Precision: 94.68%
Recall: 93.43%
F1_score: [0.88664985 0.9620252 ]
Loss: 0.28680965304374695
```

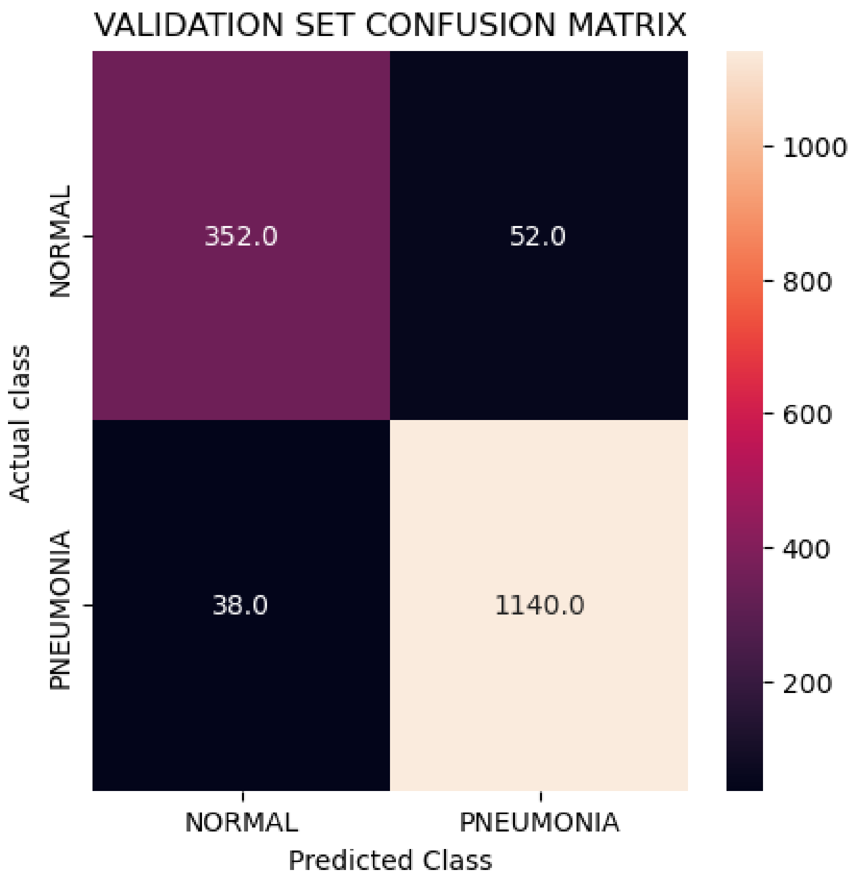
```
[103]: yv_pred=np.argmax(model.predict(x_val),axis=1)
       yv_true=np.argmax(y_val,axis=1)
```

```
50/50 [==============================] - 0s 7ms/step
```

```
[104]: c_val=confusion_matrix(yv_true,yv_pred)
       c_val
```

```
[104]: array([[ 352,   52],
              [  38, 1140]])
```

```
[105]: plt.figure(figsize=(5,5))
       sns.
        ↪heatmap(c_val,annot=True,xticklabels=class_names,yticklabels=class_names,fmt='.
        ↪1f')
       plt.title('VALIDATION SET CONFUSION MATRIX')
       plt.xlabel("Predicted Class")
       plt.ylabel("Actual class")
       plt.savefig('cm VAL.png')
       plt.show()
```



[106]:
```
print(classification_report(yv_true,yv_pred,target_names=['NORMAL','PNEUMONIA']))
```

```
              precision    recall  f1-score   support

      NORMAL       0.90      0.87      0.89       404
   PNEUMONIA       0.96      0.97      0.96      1178

    accuracy                           0.94      1582
   macro avg       0.93      0.92      0.92      1582
weighted avg       0.94      0.94      0.94      1582
```

[107]:
```
print(f"VALIDATION SET")
print('')
for i in range(2):
    tp = c_val[i, i]
    tn = np.sum(c_val) - np.sum(c_val[i, :]) - np.sum(c_val[:, i]) + c_val[i, i]
    fp = np.sum(c_val[:, i]) - c_val[i, i]
    fn = np.sum(c_val[i, :]) - c_val[i, i]
    print(f"Class {i}: TP={tp}, TN={tn}, FP={fp}, FN={fn}")
```

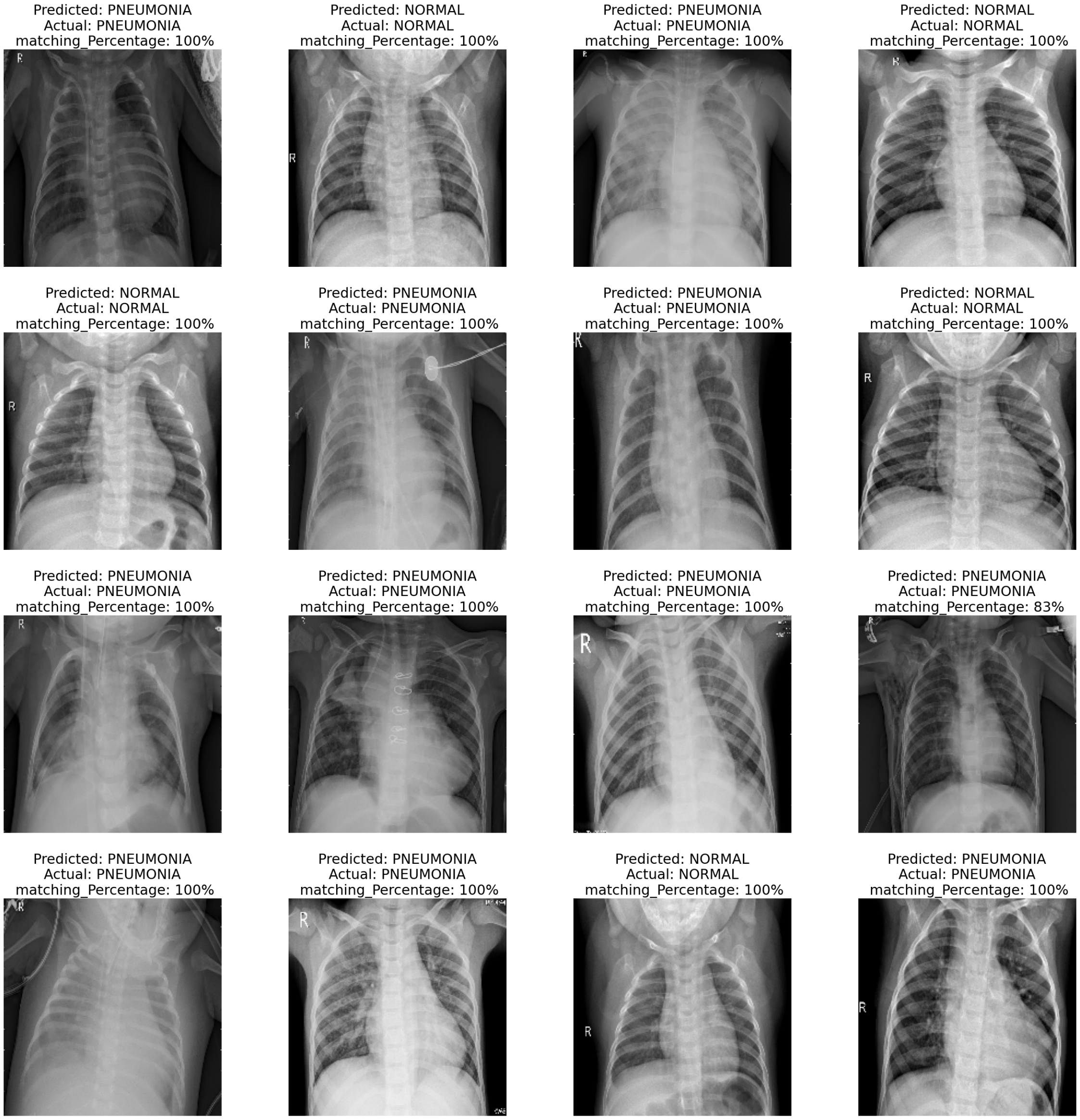
```
VALIDATION SET

Class 0: TP=352, TN=1140, FP=38, FN=52
Class 1: TP=1140, TN=352, FP=52, FN=38
```

IMAGE PREDICTIONS WITH PERCENTAGES

[97]:

```
plt.figure(figsize=(30, 30))
plt.subplots_adjust(wspace=0.3, hspace=0.3)
for i in range(16):
    idx = np.random.randint(len(y))
    img, true_class = x[idx], categories[y[idx].squeeze()]

    # predict class probabilities for the current image
    probs = model.predict(img[None, :, :, :])[0]
    pred_class = categories[np.argmax(probs)]
    max_prob = np.max(probs)*100
    plt.rcParams.update({'font.size':18})
    plt.subplot(4, 4, i + 1)
    plt.imshow(img[:, :, ::-1])
    plt.title(f"Predicted: {pred_class}\nActual: {true_class}\n␣
 ↪matching_Percentage: {round(max_prob)}%")
    plt.axis("off")
plt.show()
```

```
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 15ms/step
```


Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: NORMAL
Actual: NORMAL
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: NORMAL
Actual: NORMAL
matching_Percentage: 100%
Predicted: NORMAL
Actual: NORMAL
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: NORMAL
Actual: NORMAL
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 83%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%
Predicted: NORMAL
Actual: NORMAL
matching_Percentage: 100%
Predicted: PNEUMONIA
Actual: PNEUMONIA
matching_Percentage: 100%