

Class Challenge: Image Classification of COVID-19 X-rays

Task 2 [Total points: 30]

In [1]:

```
import tensorflow as tf
device_name = tf.test.gpu_device_name()
if device_name != '/device:GPU:0':
    raise SystemError('GPU device not found')
print('Found GPU at: {}'.format(device_name))
```

Found GPU at: /device:GPU:0

In [2]:

```
from google.colab import drive
drive.mount('/content/drive')
```

Mounted at /content/drive

Setup

- This assignment involves the following packages: 'matplotlib', 'numpy', and 'sklearn'.
- If you are using conda, use the following commands to install the above packages:

```
conda install matplotlib
conda install numpy
conda install -c anaconda scikit-learn
```

- If you are using pip, use the following commands to install the above packages:

```
pip install matplotlib
pip install numpy
pip install sklearn
```

Data

Please download the data using the following link: [COVID-19 \(https://drive.google.com/file/d/1Y88tgqpQ1Pjko_7rntcPowOJs_QNOrJ-/view\)](https://drive.google.com/file/d/1Y88tgqpQ1Pjko_7rntcPowOJs_QNOrJ-/view).

- After downloading 'Covid_Data_GradientCrescent.zip', unzip the file and you should see the following data structure:

```
|--all
|-----train
|-----test
|--two
|-----train
|-----test
```

- Put the 'all' folder, the 'two' folder and this python notebook in the **same directory** so that the following code can correctly locate the data.

[20 points] Multi-class Classification

In [55]:

```
import os
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from keras.applications.mobilenet import MobileNet
from keras.applications.vgg16 import VGG16
from keras import models
from keras import layers
from keras import optimizers
from keras.layers import BatchNormalization, GlobalAveragePooling2D
from keras.layers.core import Flatten, Dense
import keras.backend as K
from sklearn.manifold import TSNE
os.environ['OMP_NUM_THREADS'] = '1'
os.environ['CUDA_VISIBLE_DEVICES'] = '-1'
tf.__version__
```

Out[55]:

'2.8.0'

Load Image Data

In [56]:

```
DATA_LIST = os.listdir('/content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/all/train')
DATASET_PATH = '/content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/all/train'
TEST_DIR = '/content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/all/test'
IMAGE_SIZE = (224, 224)
NUM_CLASSES = len(DATA_LIST)
BATCH_SIZE = 10 # try reducing batch size or freeze more layers if your GPU runs out of memory
NUM_EPOCHS = 100
LEARNING_RATE = 0.0001 # start off with high rate first 0.001 and experiment with reducing it gradually
```

Generate Training and Validation Batches

In [57]:

```
train_datagen = ImageDataGenerator(rescale=1./255,rotation_range=50,featurewise_center = True,
                                   featurewise_std_normalization = True,width_shift_range=0.2,
                                   height_shift_range=0.2,shear_range=0.25,zoom_range=0.1,
                                   zca_whitening = True,channel_shift_range = 20,
                                   horizontal_flip = True,vertical_flip = True,validation_split = 0.2,fill_mode='constant')

train_batches = train_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE_SIZE,
                                                  shuffle=True,batch_size=BATCH_SIZE,
                                                  subset = "training",seed=42,
                                                  class_mode="categorical")

valid_batches = train_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE_SIZE,
                                                  shuffle=True,batch_size=BATCH_SIZE,
                                                  subset = "validation",
                                                  seed=42,class_mode="categorical")
```

```
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_generator.py:342: UserWarning: This ImageDataGenerator specifies `zca_whitening` which overrides setting of `featurewise_std_normalization`.
  warnings.warn('This ImageDataGenerator specifies '
```

```
Found 216 images belonging to 4 classes.
```

```
Found 54 images belonging to 4 classes.
```

[10 points] Build Model

Hint: Starting from a pre-trained model typically helps performance on a new task, e.g. starting with weights obtained by training on ImageNet.

In [58]:

```
#VGG16
VGG16 = VGG16(weights='imagenet',
               include_top=False,
               input_shape=(224, 224, 3))
VGG16.trainable = False
vgg16 = models.Sequential(name='VGG16')
vgg16.add(VGG16)

vgg16.add(layers.Flatten())
vgg16.add(layers.Dense(256, name='feature_dense', activation='relu'))
vgg16.add(layers.Dense(4, activation='softmax'))
vgg16.summary()

vgg16.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.0005), loss='categorical_crossentropy', metrics=["acc"])
```

Model: "VGG16"

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_12 (Flatten)	(None, 25088)	0
feature_dense (Dense)	(None, 256)	6422784
dense_11 (Dense)	(None, 4)	1028
Total params: 21,138,500		
Trainable params: 6,423,812		
Non-trainable params: 14,714,688		

In [48]:

```
# MobileNet

mobile = MobileNet(include_top=False, weights='imagenet', input_shape=(224, 224, 3))

mobilenet = models.Sequential(name='MobileNet')
mobilenet.add(mobile)
mobilenet.add(GlobalAveragePooling2D())
mobilenet.add(layers.Flatten())
mobilenet.add(layers.Dense(512, activation='relu'))
mobilenet.add(layers.Dense(256, name='feature_dense'))

mobilenet.add(layers.Dense(4, activation='softmax'))

mobilenet.summary()
mobilenet.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.0001), loss='categorical_crossentropy', metrics=["acc"])
```

Model: "MobileNet"

Layer (type)	Output Shape	Param #
=====		
mobilenet_1.00_224 (Functional)	(None, 7, 7, 1024)	3228864
global_average_pooling2d_5 (GlobalAveragePooling2D)	(None, 1024)	0
flatten_11 (Flatten)	(None, 1024)	0
dense_9 (Dense)	(None, 512)	524800
feature_dense (Dense)	(None, 256)	131328
dense_10 (Dense)	(None, 4)	1028
=====		
Total params: 3,886,020		
Trainable params: 3,864,132		
Non-trainable params: 21,888		
=====		

[5 points] Train Model

In [59]:

```
#FIT MODEL
print(len(train_batches))
print(len(valid_batches))

STEP_SIZE_TRAIN=train_batches.n//train_batches.batch_size
STEP_SIZE_VALID=valid_batches.n//valid_batches.batch_size
```

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6

In [60]:

```
#VGG16
vgg16_model = vgg16.fit(train_batches,
                        steps_per_epoch=STEP_SIZE_TRAIN,
                        epochs = 100,
                        validation_data=valid_batches,
                        validation_steps=STEP_SIZE_VALID
                        )

# shuffle=True
# raise NotImplementedError("Use the model.fit function to train your network")
```

```
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/ima  
ge_data_generator.py:720: UserWarning: This ImageDataGenerator speci  
fies `featurewise_center`, but it hasn't been fit on any training da  
ta. Fit it first by calling `.fit(numpy_data)`.
```

```
warnings.warn('This ImageDataGenerator specifies '  
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/ima  
ge_data_generator.py:739: UserWarning: This ImageDataGenerator speci  
fies `zca_whitening`, but it hasn't been fit on any training data. F  
it it first by calling `.fit(numpy_data)`.
```

```
warnings.warn('This ImageDataGenerator specifies '
```

```
Epoch 1/100
21/21 [=====] - 9s 411ms/step - loss: 2.159
4 - acc: 0.3301 - val_loss: 1.2102 - val_acc: 0.4800
Epoch 2/100
21/21 [=====] - 8s 390ms/step - loss: 1.213
7 - acc: 0.4757 - val_loss: 0.9627 - val_acc: 0.6400
Epoch 3/100
21/21 [=====] - 8s 384ms/step - loss: 1.088
2 - acc: 0.4951 - val_loss: 0.8244 - val_acc: 0.7200
Epoch 4/100
21/21 [=====] - 8s 390ms/step - loss: 1.027
6 - acc: 0.5728 - val_loss: 0.9864 - val_acc: 0.5200
Epoch 5/100
21/21 [=====] - 8s 389ms/step - loss: 0.988
2 - acc: 0.6165 - val_loss: 0.8828 - val_acc: 0.6600
Epoch 6/100
21/21 [=====] - 8s 387ms/step - loss: 1.075
4 - acc: 0.5680 - val_loss: 0.9325 - val_acc: 0.5200
Epoch 7/100
21/21 [=====] - 8s 390ms/step - loss: 0.905
3 - acc: 0.5680 - val_loss: 0.8394 - val_acc: 0.5800
Epoch 8/100
21/21 [=====] - 8s 377ms/step - loss: 0.867
2 - acc: 0.6311 - val_loss: 0.8822 - val_acc: 0.6200
Epoch 9/100
21/21 [=====] - 8s 395ms/step - loss: 0.901
2 - acc: 0.6505 - val_loss: 0.7763 - val_acc: 0.6200
Epoch 10/100
21/21 [=====] - 8s 387ms/step - loss: 0.871
1 - acc: 0.6505 - val_loss: 0.7291 - val_acc: 0.6200
Epoch 11/100
21/21 [=====] - 8s 380ms/step - loss: 0.826
1 - acc: 0.6650 - val_loss: 0.8383 - val_acc: 0.6200
Epoch 12/100
21/21 [=====] - 8s 381ms/step - loss: 0.782
2 - acc: 0.6942 - val_loss: 0.9880 - val_acc: 0.5600
Epoch 13/100
21/21 [=====] - 8s 395ms/step - loss: 0.795
9 - acc: 0.6505 - val_loss: 0.7630 - val_acc: 0.6400
Epoch 14/100
21/21 [=====] - 8s 388ms/step - loss: 0.795
7 - acc: 0.6602 - val_loss: 0.6895 - val_acc: 0.6600
Epoch 15/100
21/21 [=====] - 8s 393ms/step - loss: 0.677
6 - acc: 0.7039 - val_loss: 0.6999 - val_acc: 0.7200
Epoch 16/100
21/21 [=====] - 8s 391ms/step - loss: 0.752
8 - acc: 0.7039 - val_loss: 0.7791 - val_acc: 0.6400
Epoch 17/100
21/21 [=====] - 8s 394ms/step - loss: 0.744
9 - acc: 0.6553 - val_loss: 0.7346 - val_acc: 0.7000
Epoch 18/100
21/21 [=====] - 8s 387ms/step - loss: 0.744
4 - acc: 0.6699 - val_loss: 0.9277 - val_acc: 0.5200
Epoch 19/100
21/21 [=====] - 8s 385ms/step - loss: 0.781
7 - acc: 0.7087 - val_loss: 0.7715 - val_acc: 0.7000
Epoch 20/100
21/21 [=====] - 8s 391ms/step - loss: 0.679
5 - acc: 0.7087 - val_loss: 0.9009 - val_acc: 0.6200
Epoch 21/100
```



```
21/21 [=====] - 8s 387ms/step - loss: 0.796
5 - acc: 0.6602 - val_loss: 0.7138 - val_acc: 0.6600
Epoch 22/100
21/21 [=====] - 8s 389ms/step - loss: 0.714
3 - acc: 0.7233 - val_loss: 0.8226 - val_acc: 0.5800
Epoch 23/100
21/21 [=====] - 8s 384ms/step - loss: 0.694
2 - acc: 0.6942 - val_loss: 0.8100 - val_acc: 0.6400
Epoch 24/100
21/21 [=====] - 8s 391ms/step - loss: 0.708
8 - acc: 0.7184 - val_loss: 0.7186 - val_acc: 0.6400
Epoch 25/100
21/21 [=====] - 8s 387ms/step - loss: 0.629
4 - acc: 0.7184 - val_loss: 0.7841 - val_acc: 0.6800
Epoch 26/100
21/21 [=====] - 8s 394ms/step - loss: 0.693
6 - acc: 0.6845 - val_loss: 0.7016 - val_acc: 0.7200
Epoch 27/100
21/21 [=====] - 8s 400ms/step - loss: 0.669
6 - acc: 0.6942 - val_loss: 0.6036 - val_acc: 0.7200
Epoch 28/100
21/21 [=====] - 8s 393ms/step - loss: 0.673
2 - acc: 0.7427 - val_loss: 0.7567 - val_acc: 0.6000
Epoch 29/100
21/21 [=====] - 8s 388ms/step - loss: 0.626
0 - acc: 0.7670 - val_loss: 0.7274 - val_acc: 0.6600
Epoch 30/100
21/21 [=====] - 8s 392ms/step - loss: 0.705
4 - acc: 0.6893 - val_loss: 0.9401 - val_acc: 0.5600
Epoch 31/100
21/21 [=====] - 8s 383ms/step - loss: 0.732
4 - acc: 0.6845 - val_loss: 0.5446 - val_acc: 0.7000
Epoch 32/100
21/21 [=====] - 8s 390ms/step - loss: 0.592
9 - acc: 0.7427 - val_loss: 0.7379 - val_acc: 0.6800
Epoch 33/100
21/21 [=====] - 8s 392ms/step - loss: 0.635
0 - acc: 0.7524 - val_loss: 0.9842 - val_acc: 0.5200
Epoch 34/100
21/21 [=====] - 8s 388ms/step - loss: 0.582
8 - acc: 0.7476 - val_loss: 0.6998 - val_acc: 0.6600
Epoch 35/100
21/21 [=====] - 8s 396ms/step - loss: 0.583
0 - acc: 0.7670 - val_loss: 0.8025 - val_acc: 0.6400
Epoch 36/100
21/21 [=====] - 8s 392ms/step - loss: 0.714
9 - acc: 0.7190 - val_loss: 0.8865 - val_acc: 0.6600
Epoch 37/100
21/21 [=====] - 8s 390ms/step - loss: 0.650
2 - acc: 0.6796 - val_loss: 0.7115 - val_acc: 0.6600
Epoch 38/100
21/21 [=====] - 8s 395ms/step - loss: 0.631
3 - acc: 0.7184 - val_loss: 0.9736 - val_acc: 0.6400
Epoch 39/100
21/21 [=====] - 8s 389ms/step - loss: 0.583
3 - acc: 0.7476 - val_loss: 0.7085 - val_acc: 0.6600
Epoch 40/100
21/21 [=====] - 8s 393ms/step - loss: 0.626
0 - acc: 0.7379 - val_loss: 0.7374 - val_acc: 0.7000
Epoch 41/100
21/21 [=====] - 9s 444ms/step - loss: 0.552
```

```
5 - acc: 0.7718 - val_loss: 0.7911 - val_acc: 0.6400
Epoch 42/100
21/21 [=====] - 8s 385ms/step - loss: 0.660
2 - acc: 0.7233 - val_loss: 0.6949 - val_acc: 0.7000
Epoch 43/100
21/21 [=====] - 8s 390ms/step - loss: 0.695
8 - acc: 0.7184 - val_loss: 0.6801 - val_acc: 0.6400
Epoch 44/100
21/21 [=====] - 8s 392ms/step - loss: 0.593
7 - acc: 0.7330 - val_loss: 0.5773 - val_acc: 0.6800
Epoch 45/100
21/21 [=====] - 8s 391ms/step - loss: 0.587
9 - acc: 0.7864 - val_loss: 0.9509 - val_acc: 0.5400
Epoch 46/100
21/21 [=====] - 8s 392ms/step - loss: 0.591
0 - acc: 0.7330 - val_loss: 0.9701 - val_acc: 0.5600
Epoch 47/100
21/21 [=====] - 8s 383ms/step - loss: 0.587
6 - acc: 0.7476 - val_loss: 0.6868 - val_acc: 0.7400
Epoch 48/100
21/21 [=====] - 8s 397ms/step - loss: 0.626
0 - acc: 0.7379 - val_loss: 0.8409 - val_acc: 0.6000
Epoch 49/100
21/21 [=====] - 8s 392ms/step - loss: 0.599
6 - acc: 0.7233 - val_loss: 0.8180 - val_acc: 0.6400
Epoch 50/100
21/21 [=====] - 8s 395ms/step - loss: 0.596
4 - acc: 0.7524 - val_loss: 0.7686 - val_acc: 0.6400
Epoch 51/100
21/21 [=====] - 8s 399ms/step - loss: 0.584
3 - acc: 0.7767 - val_loss: 0.7334 - val_acc: 0.7000
Epoch 52/100
21/21 [=====] - 8s 388ms/step - loss: 0.602
4 - acc: 0.7524 - val_loss: 0.6984 - val_acc: 0.7200
Epoch 53/100
21/21 [=====] - 8s 388ms/step - loss: 0.554
6 - acc: 0.7718 - val_loss: 0.6975 - val_acc: 0.7400
Epoch 54/100
21/21 [=====] - 8s 391ms/step - loss: 0.532
2 - acc: 0.7718 - val_loss: 0.7302 - val_acc: 0.7000
Epoch 55/100
21/21 [=====] - 8s 388ms/step - loss: 0.508
7 - acc: 0.8107 - val_loss: 0.6479 - val_acc: 0.6800
Epoch 56/100
21/21 [=====] - 8s 392ms/step - loss: 0.553
0 - acc: 0.7718 - val_loss: 0.6737 - val_acc: 0.6200
Epoch 57/100
21/21 [=====] - 8s 390ms/step - loss: 0.565
3 - acc: 0.7670 - val_loss: 0.7575 - val_acc: 0.6200
Epoch 58/100
21/21 [=====] - 8s 386ms/step - loss: 0.581
9 - acc: 0.7670 - val_loss: 0.6804 - val_acc: 0.7200
Epoch 59/100
21/21 [=====] - 8s 388ms/step - loss: 0.551
5 - acc: 0.7379 - val_loss: 0.7621 - val_acc: 0.7000
Epoch 60/100
21/21 [=====] - 8s 384ms/step - loss: 0.558
7 - acc: 0.7718 - val_loss: 0.7091 - val_acc: 0.6000
Epoch 61/100
21/21 [=====] - 8s 393ms/step - loss: 0.627
4 - acc: 0.7282 - val_loss: 0.7467 - val_acc: 0.6800
```

```
Epoch 62/100
21/21 [=====] - 8s 391ms/step - loss: 0.517
3 - acc: 0.7767 - val_loss: 0.5992 - val_acc: 0.6800
Epoch 63/100
21/21 [=====] - 8s 396ms/step - loss: 0.560
4 - acc: 0.7767 - val_loss: 0.6629 - val_acc: 0.6600
Epoch 64/100
21/21 [=====] - 8s 389ms/step - loss: 0.501
4 - acc: 0.7913 - val_loss: 0.7208 - val_acc: 0.6600
Epoch 65/100
21/21 [=====] - 8s 396ms/step - loss: 0.528
3 - acc: 0.7476 - val_loss: 0.7954 - val_acc: 0.6800
Epoch 66/100
21/21 [=====] - 8s 393ms/step - loss: 0.508
9 - acc: 0.8048 - val_loss: 0.7439 - val_acc: 0.7200
Epoch 67/100
21/21 [=====] - 8s 393ms/step - loss: 0.647
7 - acc: 0.7282 - val_loss: 0.7253 - val_acc: 0.6400
Epoch 68/100
21/21 [=====] - 8s 393ms/step - loss: 0.548
4 - acc: 0.7573 - val_loss: 0.8718 - val_acc: 0.4800
Epoch 69/100
21/21 [=====] - 8s 390ms/step - loss: 0.541
9 - acc: 0.7670 - val_loss: 0.8435 - val_acc: 0.5400
Epoch 70/100
21/21 [=====] - 8s 394ms/step - loss: 0.471
4 - acc: 0.8252 - val_loss: 0.6871 - val_acc: 0.6600
Epoch 71/100
21/21 [=====] - 8s 388ms/step - loss: 0.603
9 - acc: 0.7476 - val_loss: 0.5000 - val_acc: 0.7400
Epoch 72/100
21/21 [=====] - 8s 395ms/step - loss: 0.587
4 - acc: 0.7767 - val_loss: 0.6767 - val_acc: 0.7000
Epoch 73/100
21/21 [=====] - 8s 389ms/step - loss: 0.614
5 - acc: 0.7330 - val_loss: 0.9293 - val_acc: 0.5400
Epoch 74/100
21/21 [=====] - 8s 386ms/step - loss: 0.537
9 - acc: 0.7427 - val_loss: 0.6488 - val_acc: 0.7000
Epoch 75/100
21/21 [=====] - 8s 393ms/step - loss: 0.551
2 - acc: 0.7961 - val_loss: 0.8361 - val_acc: 0.6600
Epoch 76/100
21/21 [=====] - 8s 395ms/step - loss: 0.533
6 - acc: 0.7816 - val_loss: 0.5689 - val_acc: 0.6800
Epoch 77/100
21/21 [=====] - 8s 394ms/step - loss: 0.446
5 - acc: 0.8252 - val_loss: 0.5762 - val_acc: 0.7200
Epoch 78/100
21/21 [=====] - 8s 382ms/step - loss: 0.546
5 - acc: 0.7718 - val_loss: 0.6611 - val_acc: 0.6600
Epoch 79/100
21/21 [=====] - 8s 385ms/step - loss: 0.523
9 - acc: 0.7524 - val_loss: 0.6583 - val_acc: 0.7200
Epoch 80/100
21/21 [=====] - 8s 391ms/step - loss: 0.588
6 - acc: 0.7379 - val_loss: 0.8412 - val_acc: 0.6600
Epoch 81/100
21/21 [=====] - 8s 390ms/step - loss: 0.475
0 - acc: 0.8155 - val_loss: 0.8145 - val_acc: 0.6600
Epoch 82/100
```

```
21/21 [=====] - 8s 386ms/step - loss: 0.474
5 - acc: 0.7961 - val_loss: 0.6249 - val_acc: 0.6600
Epoch 83/100
21/21 [=====] - 8s 395ms/step - loss: 0.463
7 - acc: 0.8010 - val_loss: 0.8369 - val_acc: 0.6400
Epoch 84/100
21/21 [=====] - 8s 385ms/step - loss: 0.520
1 - acc: 0.7718 - val_loss: 0.6279 - val_acc: 0.6400
Epoch 85/100
21/21 [=====] - 8s 392ms/step - loss: 0.473
9 - acc: 0.7952 - val_loss: 0.7062 - val_acc: 0.6000
Epoch 86/100
21/21 [=====] - 8s 393ms/step - loss: 0.502
7 - acc: 0.7816 - val_loss: 1.0830 - val_acc: 0.5400
Epoch 87/100
21/21 [=====] - 8s 394ms/step - loss: 0.545
1 - acc: 0.7379 - val_loss: 0.9031 - val_acc: 0.6200
Epoch 88/100
21/21 [=====] - 8s 386ms/step - loss: 0.450
9 - acc: 0.7864 - val_loss: 0.5349 - val_acc: 0.7000
Epoch 89/100
21/21 [=====] - 8s 392ms/step - loss: 0.574
5 - acc: 0.7857 - val_loss: 0.5987 - val_acc: 0.6800
Epoch 90/100
21/21 [=====] - 8s 395ms/step - loss: 0.599
6 - acc: 0.7621 - val_loss: 0.6162 - val_acc: 0.6800
Epoch 91/100
21/21 [=====] - 8s 388ms/step - loss: 0.511
8 - acc: 0.7524 - val_loss: 0.6943 - val_acc: 0.6800
Epoch 92/100
21/21 [=====] - 8s 376ms/step - loss: 0.577
9 - acc: 0.7282 - val_loss: 0.7491 - val_acc: 0.6600
Epoch 93/100
21/21 [=====] - 8s 381ms/step - loss: 0.478
2 - acc: 0.7816 - val_loss: 0.6965 - val_acc: 0.6800
Epoch 94/100
21/21 [=====] - 8s 387ms/step - loss: 0.484
8 - acc: 0.8107 - val_loss: 0.6054 - val_acc: 0.6800
Epoch 95/100
21/21 [=====] - 8s 389ms/step - loss: 0.572
7 - acc: 0.7476 - val_loss: 1.0214 - val_acc: 0.6000
Epoch 96/100
21/21 [=====] - 9s 421ms/step - loss: 0.574
6 - acc: 0.7670 - val_loss: 0.6953 - val_acc: 0.6600
Epoch 97/100
21/21 [=====] - 8s 383ms/step - loss: 0.462
0 - acc: 0.8398 - val_loss: 0.5763 - val_acc: 0.7000
Epoch 98/100
21/21 [=====] - 8s 395ms/step - loss: 0.475
7 - acc: 0.8010 - val_loss: 0.6667 - val_acc: 0.7000
Epoch 99/100
21/21 [=====] - 8s 400ms/step - loss: 0.508
5 - acc: 0.8010 - val_loss: 0.6881 - val_acc: 0.6600
Epoch 100/100
21/21 [=====] - 8s 398ms/step - loss: 0.481
7 - acc: 0.7864 - val_loss: 0.5624 - val_acc: 0.7200
```

In [26]:

```
#MobileNet
mobilenet_model=mobilenet.fit(train_batches,
                               steps_per_epoch=STEP_SIZE_TRAIN,
                               epochs = 100,
                               validation_data=valid_batches,
                               validation_steps=STEP_SIZE_VALID,
                               shuffle=True)
```

```
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_generator.py:720: UserWarning: This ImageDataGenerator specifies `featurewise_center`, but it hasn't been fit on any training data. Fit it first by calling `.fit(numpy_data)`.
```

```
warnings.warn('This ImageDataGenerator specifies '  
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_generator.py:739: UserWarning: This ImageDataGenerator specifies `zca_whitening`, but it hasn't been fit on any training data. Fit it first by calling `.fit(numpy_data)`.
```

```
warnings.warn('This ImageDataGenerator specifies '
```

```
Epoch 1/100
21/21 [=====] - 13s 451ms/step - loss: 1.21
23 - acc: 0.4417 - val_loss: 2.4747 - val_acc: 0.2600
Epoch 2/100
21/21 [=====] - 8s 401ms/step - loss: 0.705
6 - acc: 0.7136 - val_loss: 2.9546 - val_acc: 0.2000
Epoch 3/100
21/21 [=====] - 9s 402ms/step - loss: 0.615
9 - acc: 0.7282 - val_loss: 2.9787 - val_acc: 0.3000
Epoch 4/100
21/21 [=====] - 9s 405ms/step - loss: 0.561
6 - acc: 0.7913 - val_loss: 3.0249 - val_acc: 0.2400
Epoch 5/100
21/21 [=====] - 8s 403ms/step - loss: 0.549
6 - acc: 0.7767 - val_loss: 2.3122 - val_acc: 0.3000
Epoch 6/100
21/21 [=====] - 8s 401ms/step - loss: 0.531
3 - acc: 0.7621 - val_loss: 2.3439 - val_acc: 0.3000
Epoch 7/100
21/21 [=====] - 8s 399ms/step - loss: 0.442
2 - acc: 0.8204 - val_loss: 1.6809 - val_acc: 0.4200
Epoch 8/100
21/21 [=====] - 8s 399ms/step - loss: 0.494
4 - acc: 0.7816 - val_loss: 2.5028 - val_acc: 0.3600
Epoch 9/100
21/21 [=====] - 8s 402ms/step - loss: 0.438
0 - acc: 0.8350 - val_loss: 1.7472 - val_acc: 0.3600
Epoch 10/100
21/21 [=====] - 10s 460ms/step - loss: 0.37
02 - acc: 0.8738 - val_loss: 2.2474 - val_acc: 0.4200
Epoch 11/100
21/21 [=====] - 8s 406ms/step - loss: 0.392
1 - acc: 0.8495 - val_loss: 2.3004 - val_acc: 0.3600
Epoch 12/100
21/21 [=====] - 8s 399ms/step - loss: 0.415
6 - acc: 0.8204 - val_loss: 1.5798 - val_acc: 0.4400
Epoch 13/100
21/21 [=====] - 8s 394ms/step - loss: 0.374
7 - acc: 0.8495 - val_loss: 1.2463 - val_acc: 0.5200
Epoch 14/100
21/21 [=====] - 8s 405ms/step - loss: 0.385
4 - acc: 0.8398 - val_loss: 1.6831 - val_acc: 0.4400
Epoch 15/100
21/21 [=====] - 8s 400ms/step - loss: 0.454
0 - acc: 0.8252 - val_loss: 2.2206 - val_acc: 0.3200
Epoch 16/100
21/21 [=====] - 8s 401ms/step - loss: 0.294
2 - acc: 0.8786 - val_loss: 2.0693 - val_acc: 0.3600
Epoch 17/100
21/21 [=====] - 8s 407ms/step - loss: 0.406
0 - acc: 0.8301 - val_loss: 1.6325 - val_acc: 0.4400
Epoch 18/100
21/21 [=====] - 8s 404ms/step - loss: 0.306
2 - acc: 0.8592 - val_loss: 1.5158 - val_acc: 0.4200
Epoch 19/100
21/21 [=====] - 8s 399ms/step - loss: 0.285
2 - acc: 0.8738 - val_loss: 0.8467 - val_acc: 0.5600
Epoch 20/100
21/21 [=====] - 8s 396ms/step - loss: 0.284
9 - acc: 0.8689 - val_loss: 1.1628 - val_acc: 0.5600
Epoch 21/100
```

```
21/21 [=====] - 8s 394ms/step - loss: 0.235
8 - acc: 0.9078 - val_loss: 1.6709 - val_acc: 0.4200
Epoch 22/100
21/21 [=====] - 8s 403ms/step - loss: 0.259
1 - acc: 0.9029 - val_loss: 1.6148 - val_acc: 0.5000
Epoch 23/100
21/21 [=====] - 8s 402ms/step - loss: 0.273
4 - acc: 0.9029 - val_loss: 1.2389 - val_acc: 0.6000
Epoch 24/100
21/21 [=====] - 8s 395ms/step - loss: 0.327
6 - acc: 0.8738 - val_loss: 0.9777 - val_acc: 0.6200
Epoch 25/100
21/21 [=====] - 8s 395ms/step - loss: 0.251
2 - acc: 0.9126 - val_loss: 0.9395 - val_acc: 0.6600
Epoch 26/100
21/21 [=====] - 8s 404ms/step - loss: 0.266
3 - acc: 0.8883 - val_loss: 0.6061 - val_acc: 0.7200
Epoch 27/100
21/21 [=====] - 8s 404ms/step - loss: 0.248
6 - acc: 0.8932 - val_loss: 0.6149 - val_acc: 0.7800
Epoch 28/100
21/21 [=====] - 8s 403ms/step - loss: 0.164
2 - acc: 0.9320 - val_loss: 0.4695 - val_acc: 0.7800
Epoch 29/100
21/21 [=====] - 8s 403ms/step - loss: 0.164
0 - acc: 0.9466 - val_loss: 0.5033 - val_acc: 0.8200
Epoch 30/100
21/21 [=====] - 8s 395ms/step - loss: 0.254
6 - acc: 0.9126 - val_loss: 0.7416 - val_acc: 0.6600
Epoch 31/100
21/21 [=====] - 8s 391ms/step - loss: 0.302
0 - acc: 0.8592 - val_loss: 0.5365 - val_acc: 0.7600
Epoch 32/100
21/21 [=====] - 8s 397ms/step - loss: 0.169
2 - acc: 0.9078 - val_loss: 0.9456 - val_acc: 0.6800
Epoch 33/100
21/21 [=====] - 8s 402ms/step - loss: 0.175
5 - acc: 0.9369 - val_loss: 0.7911 - val_acc: 0.7200
Epoch 34/100
21/21 [=====] - 8s 391ms/step - loss: 0.080
5 - acc: 0.9854 - val_loss: 0.5854 - val_acc: 0.7800
Epoch 35/100
21/21 [=====] - 8s 397ms/step - loss: 0.154
5 - acc: 0.9417 - val_loss: 1.0097 - val_acc: 0.7800
Epoch 36/100
21/21 [=====] - 9s 413ms/step - loss: 0.202
1 - acc: 0.9143 - val_loss: 0.8347 - val_acc: 0.7800
Epoch 37/100
21/21 [=====] - 8s 398ms/step - loss: 0.170
7 - acc: 0.9272 - val_loss: 0.8581 - val_acc: 0.6600
Epoch 38/100
21/21 [=====] - 8s 398ms/step - loss: 0.156
2 - acc: 0.9320 - val_loss: 0.5998 - val_acc: 0.8000
Epoch 39/100
21/21 [=====] - 8s 408ms/step - loss: 0.234
0 - acc: 0.9320 - val_loss: 0.7261 - val_acc: 0.7200
Epoch 40/100
21/21 [=====] - 8s 399ms/step - loss: 0.127
1 - acc: 0.9417 - val_loss: 0.6601 - val_acc: 0.7600
Epoch 41/100
21/21 [=====] - 8s 404ms/step - loss: 0.111
```



```
3 - acc: 0.9714 - val_loss: 0.4811 - val_acc: 0.8000
Epoch 42/100
21/21 [=====] - 8s 397ms/step - loss: 0.068
2 - acc: 0.9757 - val_loss: 0.7911 - val_acc: 0.7400
Epoch 43/100
21/21 [=====] - 8s 398ms/step - loss: 0.089
3 - acc: 0.9709 - val_loss: 0.6227 - val_acc: 0.8000
Epoch 44/100
21/21 [=====] - 8s 393ms/step - loss: 0.109
1 - acc: 0.9476 - val_loss: 1.1026 - val_acc: 0.7200
Epoch 45/100
21/21 [=====] - 8s 400ms/step - loss: 0.182
2 - acc: 0.9320 - val_loss: 1.0055 - val_acc: 0.6600
Epoch 46/100
21/21 [=====] - 8s 396ms/step - loss: 0.166
6 - acc: 0.9320 - val_loss: 0.7135 - val_acc: 0.8000
Epoch 47/100
21/21 [=====] - 8s 394ms/step - loss: 0.219
7 - acc: 0.9272 - val_loss: 0.7175 - val_acc: 0.7800
Epoch 48/100
21/21 [=====] - 8s 401ms/step - loss: 0.118
9 - acc: 0.9563 - val_loss: 0.6342 - val_acc: 0.8000
Epoch 49/100
21/21 [=====] - 8s 405ms/step - loss: 0.112
6 - acc: 0.9612 - val_loss: 0.7755 - val_acc: 0.7800
Epoch 50/100
21/21 [=====] - 8s 408ms/step - loss: 0.166
5 - acc: 0.9272 - val_loss: 0.6273 - val_acc: 0.7800
Epoch 51/100
21/21 [=====] - 8s 404ms/step - loss: 0.228
7 - acc: 0.9095 - val_loss: 0.4424 - val_acc: 0.8400
Epoch 52/100
21/21 [=====] - 8s 398ms/step - loss: 0.162
6 - acc: 0.9320 - val_loss: 0.8378 - val_acc: 0.7400
Epoch 53/100
21/21 [=====] - 8s 391ms/step - loss: 0.101
7 - acc: 0.9660 - val_loss: 0.7555 - val_acc: 0.8000
Epoch 54/100
21/21 [=====] - 8s 405ms/step - loss: 0.125
2 - acc: 0.9515 - val_loss: 1.1830 - val_acc: 0.7000
Epoch 55/100
21/21 [=====] - 8s 406ms/step - loss: 0.159
5 - acc: 0.9429 - val_loss: 0.8862 - val_acc: 0.7600
Epoch 56/100
21/21 [=====] - 8s 403ms/step - loss: 0.128
2 - acc: 0.9417 - val_loss: 1.0566 - val_acc: 0.7800
Epoch 57/100
21/21 [=====] - 8s 398ms/step - loss: 0.165
3 - acc: 0.9466 - val_loss: 0.8299 - val_acc: 0.6600
Epoch 58/100
21/21 [=====] - 8s 397ms/step - loss: 0.186
3 - acc: 0.9320 - val_loss: 1.2668 - val_acc: 0.6000
Epoch 59/100
21/21 [=====] - 8s 400ms/step - loss: 0.162
1 - acc: 0.9417 - val_loss: 0.6520 - val_acc: 0.7000
Epoch 60/100
21/21 [=====] - 8s 405ms/step - loss: 0.109
9 - acc: 0.9515 - val_loss: 0.5125 - val_acc: 0.8200
Epoch 61/100
21/21 [=====] - 8s 399ms/step - loss: 0.152
0 - acc: 0.9466 - val_loss: 0.6334 - val_acc: 0.7200
```

```
Epoch 62/100
21/21 [=====] - 8s 401ms/step - loss: 0.129
3 - acc: 0.9524 - val_loss: 1.3792 - val_acc: 0.6400
Epoch 63/100
21/21 [=====] - 8s 403ms/step - loss: 0.168
9 - acc: 0.9369 - val_loss: 1.0849 - val_acc: 0.7400
Epoch 64/100
21/21 [=====] - 8s 401ms/step - loss: 0.122
9 - acc: 0.9466 - val_loss: 1.2191 - val_acc: 0.7000
Epoch 65/100
21/21 [=====] - 8s 400ms/step - loss: 0.111
1 - acc: 0.9563 - val_loss: 0.6663 - val_acc: 0.7400
Epoch 66/100
21/21 [=====] - 8s 402ms/step - loss: 0.098
3 - acc: 0.9709 - val_loss: 0.8634 - val_acc: 0.8200
Epoch 67/100
21/21 [=====] - 8s 400ms/step - loss: 0.121
4 - acc: 0.9417 - val_loss: 0.5059 - val_acc: 0.8400
Epoch 68/100
21/21 [=====] - 8s 400ms/step - loss: 0.059
2 - acc: 0.9806 - val_loss: 0.6825 - val_acc: 0.7200
Epoch 69/100
21/21 [=====] - 8s 402ms/step - loss: 0.056
0 - acc: 0.9709 - val_loss: 0.5376 - val_acc: 0.8000
Epoch 70/100
21/21 [=====] - 8s 402ms/step - loss: 0.064
3 - acc: 0.9806 - val_loss: 0.7946 - val_acc: 0.7200
Epoch 71/100
21/21 [=====] - 8s 402ms/step - loss: 0.091
2 - acc: 0.9757 - val_loss: 0.6210 - val_acc: 0.8200
Epoch 72/100
21/21 [=====] - 8s 399ms/step - loss: 0.142
9 - acc: 0.9320 - val_loss: 0.9032 - val_acc: 0.7200
Epoch 73/100
21/21 [=====] - 8s 408ms/step - loss: 0.080
2 - acc: 0.9709 - val_loss: 0.9703 - val_acc: 0.7800
Epoch 74/100
21/21 [=====] - 8s 398ms/step - loss: 0.087
8 - acc: 0.9660 - val_loss: 0.7244 - val_acc: 0.7800
Epoch 75/100
21/21 [=====] - 8s 401ms/step - loss: 0.091
2 - acc: 0.9709 - val_loss: 0.9685 - val_acc: 0.7600
Epoch 76/100
21/21 [=====] - 8s 400ms/step - loss: 0.142
5 - acc: 0.9515 - val_loss: 0.7558 - val_acc: 0.7600
Epoch 77/100
21/21 [=====] - 8s 404ms/step - loss: 0.099
8 - acc: 0.9660 - val_loss: 1.2212 - val_acc: 0.7400
Epoch 78/100
21/21 [=====] - 8s 408ms/step - loss: 0.149
1 - acc: 0.9466 - val_loss: 1.1664 - val_acc: 0.7400
Epoch 79/100
21/21 [=====] - 8s 404ms/step - loss: 0.114
2 - acc: 0.9563 - val_loss: 1.1171 - val_acc: 0.7000
Epoch 80/100
21/21 [=====] - 8s 405ms/step - loss: 0.097
1 - acc: 0.9563 - val_loss: 0.8948 - val_acc: 0.7200
Epoch 81/100
21/21 [=====] - 8s 404ms/step - loss: 0.083
7 - acc: 0.9757 - val_loss: 1.1408 - val_acc: 0.7200
Epoch 82/100
```

```
21/21 [=====] - 8s 402ms/step - loss: 0.079
1 - acc: 0.9762 - val_loss: 0.9764 - val_acc: 0.7400
Epoch 83/100
21/21 [=====] - 8s 406ms/step - loss: 0.074
6 - acc: 0.9709 - val_loss: 0.7694 - val_acc: 0.8000
Epoch 84/100
21/21 [=====] - 8s 399ms/step - loss: 0.085
2 - acc: 0.9757 - val_loss: 0.7009 - val_acc: 0.8000
Epoch 85/100
21/21 [=====] - 8s 392ms/step - loss: 0.040
8 - acc: 0.9903 - val_loss: 0.6142 - val_acc: 0.8600
Epoch 86/100
21/21 [=====] - 8s 401ms/step - loss: 0.079
4 - acc: 0.9709 - val_loss: 0.8260 - val_acc: 0.7600
Epoch 87/100
21/21 [=====] - 8s 399ms/step - loss: 0.123
5 - acc: 0.9612 - val_loss: 1.4495 - val_acc: 0.6800
Epoch 88/100
21/21 [=====] - 8s 401ms/step - loss: 0.150
0 - acc: 0.9515 - val_loss: 0.9965 - val_acc: 0.7400
Epoch 89/100
21/21 [=====] - 8s 398ms/step - loss: 0.164
4 - acc: 0.9612 - val_loss: 1.1376 - val_acc: 0.7400
Epoch 90/100
21/21 [=====] - 8s 392ms/step - loss: 0.088
5 - acc: 0.9660 - val_loss: 0.9903 - val_acc: 0.7200
Epoch 91/100
21/21 [=====] - 8s 398ms/step - loss: 0.071
4 - acc: 0.9806 - val_loss: 0.8294 - val_acc: 0.7600
Epoch 92/100
21/21 [=====] - 8s 401ms/step - loss: 0.105
1 - acc: 0.9563 - val_loss: 0.8390 - val_acc: 0.8000
Epoch 93/100
21/21 [=====] - 8s 402ms/step - loss: 0.075
9 - acc: 0.9806 - val_loss: 0.7582 - val_acc: 0.8000
Epoch 94/100
21/21 [=====] - 8s 406ms/step - loss: 0.070
6 - acc: 0.9806 - val_loss: 0.9262 - val_acc: 0.8400
Epoch 95/100
21/21 [=====] - 8s 394ms/step - loss: 0.025
6 - acc: 0.9951 - val_loss: 1.3100 - val_acc: 0.8000
Epoch 96/100
21/21 [=====] - 8s 387ms/step - loss: 0.063
0 - acc: 0.9806 - val_loss: 0.7656 - val_acc: 0.8400
Epoch 97/100
21/21 [=====] - 8s 403ms/step - loss: 0.032
5 - acc: 0.9854 - val_loss: 0.5082 - val_acc: 0.8200
Epoch 98/100
21/21 [=====] - 8s 399ms/step - loss: 0.054
4 - acc: 0.9854 - val_loss: 0.5319 - val_acc: 0.8400
Epoch 99/100
21/21 [=====] - 8s 406ms/step - loss: 0.053
4 - acc: 0.9757 - val_loss: 0.8367 - val_acc: 0.7800
Epoch 100/100
21/21 [=====] - 8s 399ms/step - loss: 0.137
7 - acc: 0.9466 - val_loss: 1.0237 - val_acc: 0.7800
```

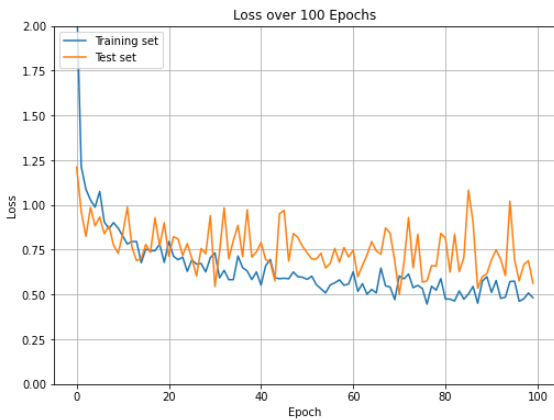
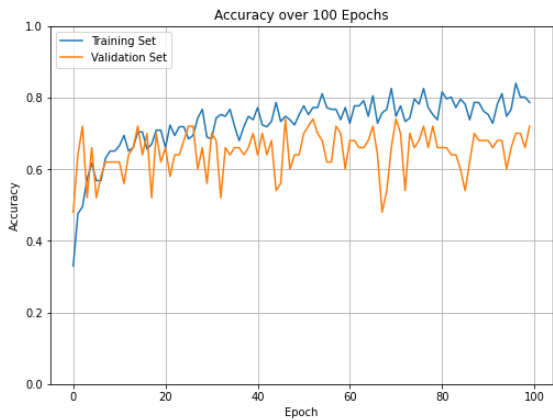
[5 points] Plot Accuracy and Loss During Training

In [61]:

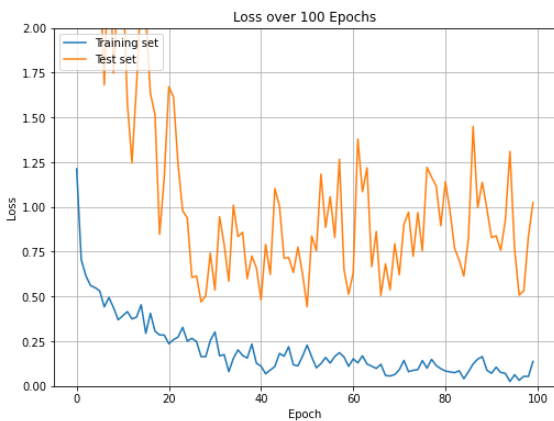
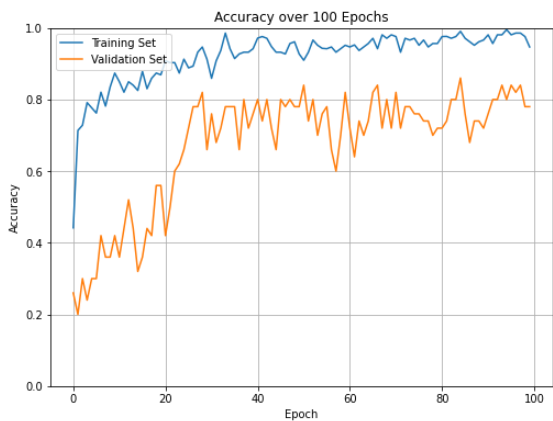
```
import matplotlib.pyplot as plt
%matplotlib inline

# #Accuracy
# plt.subplot(1,2,1)
def plot_acc_loss(result):
    plt.figure(figsize=(18,6))
    plt.subplot(1,2,1)
    plt.plot(result.history["acc"])
    plt.plot(result.history["val_acc"])
    plt.title("Accuracy over 100 Epochs")
    plt.ylim((0, 1))
    plt.xlabel("Epoch")
    plt.ylabel("Accuracy")
    plt.legend(["Training Set", "Validation Set"], loc="upper left")
    plt.grid(True)
    # Loss
    plt.subplot(1,2,2)
    plt.ylim((0,2))
    plt.plot(result.history["loss"])
    plt.plot(result.history["val_loss"])
    plt.title("Loss over 100 Epochs")
    plt.xlabel("Epoch")
    plt.ylabel("Loss")
    plt.legend(["Training set", "Test set"], loc="upper left")
    plt.grid(True)
    plt.show()
print("VGG16")
plot_acc_loss(vgg16_model)
print("MobileNet")
plot_acc_loss(mobilenet_model)
```

VGG16



MobileNet



Testing Model

In [51]:

```
test_datagen = ImageDataGenerator(rescale=1. / 255)

eval_generator = test_datagen.flow_from_directory(TEST_DIR,target_size=IMAGE_SIZE,
                                                  batch_size=1,shuffle=True,seed
=42,class_mode="categorical")
eval_generator.reset()
print(len(eval_generator))
def Test(model):
    x = model.evaluate_generator(eval_generator,steps = np.ceil(len(eval_generator)
    ),
                                use_multiprocessing = False,verbose = 1,workers=1)

    return x
```

Found 36 images belonging to 4 classes.

36

In [62]:

```
print('vgg16')
print('Test loss:' , Test(vgg16)[0])
print('Test accuracy:',Test(vgg16)[1])
```

vgg16

5/36 [==>.....] - ETA: 0s - loss: 1.9903 - acc: 0.2000

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:9: User Warning: `Model.evaluate_generator` is deprecated and will be removed in a future version. Please use `Model.evaluate`, which supports generators.

```
if __name__ == '__main__':
```

36/36 [=====] - 1s 25ms/step - loss: 0.7133
- acc: 0.7500

Test loss: 0.7132667899131775

36/36 [=====] - 1s 24ms/step - loss: 0.7133
- acc: 0.7500

Test accuracy: 0.75

In [28]:

```
print('mobilenet')
print('Test loss:', Test(mobilenet)[0])
print('Test accuracy:', Test(mobilenet)[1])
```

mobilenet

4/36 [==>.....] - ETA: 0s - loss: 0.7772 - acc: 0.7500

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:9: User Warning: `Model.evaluate_generator` is deprecated and will be removed in a future version. Please use `Model.evaluate`, which supports generators.

```
if __name__ == '__main__':
```

36/36 [=====] - 1s 27ms/step - loss: 1.2211 - acc: 0.8333

Test loss: 1.2210861444473267

36/36 [=====] - 1s 26ms/step - loss: 1.2211 - acc: 0.8333

Test accuracy: 0.8333333134651184

[10 points] TSNE Plot

t-Distributed Stochastic Neighbor Embedding (t-SNE) is a widely used technique for dimensionality reduction that is particularly well suited for the visualization of high-dimensional datasets. After training is complete, extract features from a specific deep layer of your choice, use t-SNE to reduce the dimensionality of your extracted features to 2 dimensions and plot the resulting 2D features.

In [66]:

```

intermediate_layer_model = models.Model(inputs=vgg16.input,
                                         outputs=vgg16.get_layer('feature_dense')
                                         .output)

tsne_eval_generator = test_datagen.flow_from_directory(DATASET_PATH,target_size=
IMAGE_SIZE,
                                                         batch_size=1,shuffle=False,see
d=42,class_mode="categorical")
tsne_eval_generator.reset()
labels = tsne_eval_generator.classes

X = TSNE().fit_transform(intermediate_layer_model.predict_generator(tsne_eval_ge
nerator, verbose=1))

classes = ["COVID-19", "Normal", "pneumonia_bac", "pneumonia_vir"]
plt.figure(figsize=(18,6))
plt.subplot(1,2,1)
plt.title('VGG16')
for i in range(4):
    cluster = X[np.where(labels == i)]
    plt.scatter(cluster[:, 0], cluster[:, 1], label = classes[i])
plt.legend()

intermediate_layer_model = models.Model(inputs=mobilenet.input,
                                         outputs=mobilenet.get_layer('feature_den
se').output)

tsne_eval_generator = test_datagen.flow_from_directory(DATASET_PATH,target_size=
IMAGE_SIZE,
                                                         batch_size=1,shuffle=False,see
d=42,class_mode="categorical")

labels = tsne_eval_generator.classes

X = TSNE().fit_transform(intermediate_layer_model. predict_generator(tsne_eval_g
enerator, verbose=1))

classes = ["COVID-19", "Normal", "pneumonia_bac", "pneumonia_vir"]
plt.subplot(1,2,2)
plt.title('MobileNet')
for i in range(4):
    cluster = X[np.where(labels == i)]
    plt.scatter(cluster[:, 0], cluster[:, 1], label = classes[i])
plt.legend()
plt.show()

```


Found 270 images belonging to 4 classes.

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:9: User
Warning: `Model.predict_generator` is deprecated and will be removed
in a future version. Please use `Model.predict`, which supports gene
rators.
```

```
if __name__ == '__main__':
```

270/270 [=====] - 7s 23ms/step

```
/usr/local/lib/python3.7/dist-packages/sklearn/manifold/_t_sne.py:78
3: FutureWarning: The default initialization in TSNE will change fro
m 'random' to 'pca' in 1.2.
```

```
FutureWarning,
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/manifold/_t_sne.py:79
3: FutureWarning: The default learning rate in TSNE will change from
200.0 to 'auto' in 1.2.
```

```
FutureWarning,
```

Found 270 images belonging to 4 classes.

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:28: Use
rWarning: `Model.predict_generator` is deprecated and will be remove
d in a future version. Please use `Model.predict`, which supports ge
nerators.
```

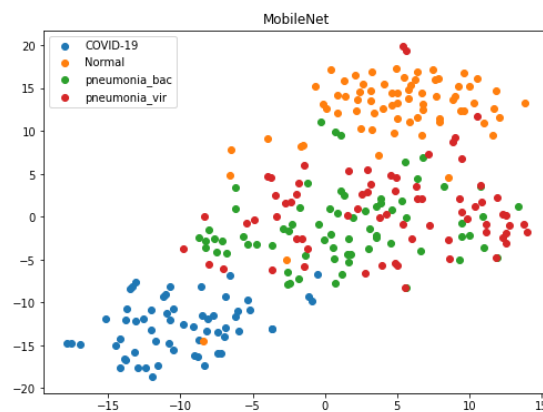
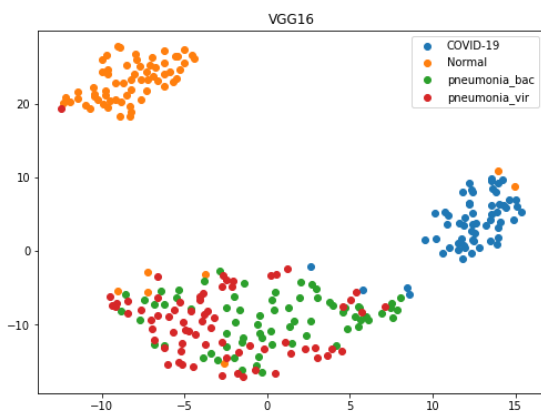
270/270 [=====] - 7s 24ms/step

```
/usr/local/lib/python3.7/dist-packages/sklearn/manifold/_t_sne.py:78
3: FutureWarning: The default initialization in TSNE will change fro
m 'random' to 'pca' in 1.2.
```

```
FutureWarning,
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/manifold/_t_sne.py:79
3: FutureWarning: The default learning rate in TSNE will change from
200.0 to 'auto' in 1.2.
```

```
FutureWarning,
```



In [69]:

```
!jupyter nbconvert --to html '/content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/task2_code.ipynb'
```

```
[NbConvertApp] Converting notebook /content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/task2_code.ipynb to html
```

```
[NbConvertApp] Writing 620994 bytes to /content/drive/MyDrive/CS 542 Machine Learning/Challenge/Covid_Data_GradientCrescent/task2_code.html
```