

Second Model

In [4]:

```
DATA_LIST = os.listdir('/content/drive/MyDrive/all/train')
DATASET_PATH = '/content/drive/MyDrive/all/train'
TEST_DIR = '/content/drive/MyDrive/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
```

In [5]:

```
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")
```

Found 216 images belonging to 4 classes.

Found 54 images belonging to 4 classes.

```
/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 '
```

In [6]:

```
#vgg16 = tf.keras.applications.VGG16(weights='imagenet', include_top=False, input_shape = (224,224,3))
#vgg19 = tf.keras.applications.VGG19(weights='imagenet', include_top=False, input_shape = (224,224,3))
mobile = tf.keras.applications.MobileNet(weights='imagenet', include_top=False, input_shape = (224,224,3))
model2 = tf.keras.models.Sequential([
    mobile,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(256,activation='relu',name='feature_dense'),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(256,activation='relu'),
    tf.keras.layers.Dropout(0.25),
    tf.keras.layers.Dense(4,activation='softmax')
])
model2.summary()
```

Model: "sequential"

| Layer (type) | Output Shape | Param # |
|-------------------------------|--------------------|----------|
| ===== | | |
| mobilenet_1.00_224 (Function) | (None, 7, 7, 1024) | 3228864 |
| flatten (Flatten) | (None, 50176) | 0 |
| feature_dense (Dense) | (None, 256) | 12845312 |
| dropout (Dropout) | (None, 256) | 0 |
| dense (Dense) | (None, 256) | 65792 |
| dropout_1 (Dropout) | (None, 256) | 0 |
| dense_1 (Dense) | (None, 4) | 1028 |
| ===== | | |
| Total params: 16,140,996 | | |
| Trainable params: 16,119,108 | | |
| Non-trainable params: 21,888 | | |

In [7]:

```
#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

opt = tf.keras.optimizers.Adam(learning_rate=0.0001)
model2.compile(optimizer=opt,
                loss=tf.keras.losses.CategoricalCrossentropy(from_logits=False),
                metrics=['accuracy'])
history = model2.fit(train_batches, epochs=100, validation_data=valid_batches,batch_size=BATCH_SIZE,
                    steps_per_epoch=STEP_SIZE_TRAIN, validation_steps = STEP_SIZE_VALID)
```

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```
/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 [=====] - 12s 404ms/step - loss: 3.2244 - accuracy:
0.3205 - val_loss: 2.5598 - val_accuracy: 0.3200

Epoch 2/100
21/21 [=====] - 8s 364ms/step - loss: 2.9088 - accuracy:
0.3606 - val_loss: 1.4326 - val_accuracy: 0.4000

Epoch 3/100
21/21 [=====] - 8s 371ms/step - loss: 1.7023 - accuracy:
0.4242 - val_loss: 1.4225 - val_accuracy: 0.4000

Epoch 4/100
21/21 [=====] - 8s 369ms/step - loss: 1.1997 - accuracy:
0.5547 - val_loss: 1.2527 - val_accuracy: 0.4200

Epoch 5/100
21/21 [=====] - 8s 361ms/step - loss: 1.3344 - accuracy:
0.4898 - val_loss: 1.0782 - val_accuracy: 0.5200

Epoch 6/100
21/21 [=====] - 8s 365ms/step - loss: 1.1895 - accuracy:
0.5071 - val_loss: 1.2429 - val_accuracy: 0.4200

Epoch 7/100
21/21 [=====] - 8s 365ms/step - loss: 0.9994 - accuracy:
0.5529 - val_loss: 1.0805 - val_accuracy: 0.5400

Epoch 8/100
21/21 [=====] - 8s 365ms/step - loss: 0.8427 - accuracy:
0.6494 - val_loss: 1.6659 - val_accuracy: 0.3400

Epoch 9/100
21/21 [=====] - 8s 364ms/step - loss: 0.9321 - accuracy:
0.6116 - val_loss: 1.3326 - val_accuracy: 0.4000

Epoch 10/100
21/21 [=====] - 8s 366ms/step - loss: 0.9085 - accuracy:
0.6522 - val_loss: 1.1486 - val_accuracy: 0.4800

Epoch 11/100
21/21 [=====] - 8s 365ms/step - loss: 0.9437 - accuracy:
0.6254 - val_loss: 0.8821 - val_accuracy: 0.5800

Epoch 12/100
21/21 [=====] - 8s 370ms/step - loss: 0.8434 - accuracy:
0.6670 - val_loss: 0.8297 - val_accuracy: 0.6600

Epoch 13/100
21/21 [=====] - 8s 364ms/step - loss: 0.8021 - accuracy:
0.6658 - val_loss: 0.7789 - val_accuracy: 0.5800

Epoch 14/100
21/21 [=====] - 8s 362ms/step - loss: 0.8520 - accuracy:
0.6747 - val_loss: 0.6146 - val_accuracy: 0.7600

Epoch 15/100
21/21 [=====] - 8s 362ms/step - loss: 0.9015 - accuracy:
0.6313 - val_loss: 0.8360 - val_accuracy: 0.6000

Epoch 16/100
21/21 [=====] - 8s 365ms/step - loss: 0.9276 - accuracy:
0.6149 - val_loss: 0.7827 - val_accuracy: 0.6800

Epoch 17/100
21/21 [=====] - 8s 369ms/step - loss: 0.7192 - accuracy:
0.6905 - val_loss: 0.6249 - val_accuracy: 0.7600

Epoch 18/100
21/21 [=====] - 8s 365ms/step - loss: 0.7790 - accuracy:
0.6527 - val_loss: 0.7691 - val_accuracy: 0.6200

Epoch 19/100
21/21 [=====] - 8s 363ms/step - loss: 0.7325 - accuracy:
0.7097 - val_loss: 0.7682 - val_accuracy: 0.6400

Epoch 20/100
21/21 [=====] - 8s 373ms/step - loss: 0.8104 - accuracy:
0.6734 - val_loss: 0.5327 - val_accuracy: 0.8000

Epoch 21/100

```
21/21 [=====] - 8s 363ms/step - loss: 0.6244 - accuracy:
0.7469 - val_loss: 0.7782 - val_accuracy: 0.7000
Epoch 22/100
21/21 [=====] - 8s 363ms/step - loss: 0.8258 - accuracy:
0.6479 - val_loss: 0.5247 - val_accuracy: 0.7800
Epoch 23/100
21/21 [=====] - 8s 357ms/step - loss: 0.7036 - accuracy:
0.7176 - val_loss: 0.5946 - val_accuracy: 0.7400
Epoch 24/100
21/21 [=====] - 8s 362ms/step - loss: 0.6994 - accuracy:
0.7465 - val_loss: 0.6380 - val_accuracy: 0.7400
Epoch 25/100
21/21 [=====] - 8s 367ms/step - loss: 0.7183 - accuracy:
0.7287 - val_loss: 0.6008 - val_accuracy: 0.6800
Epoch 26/100
21/21 [=====] - 8s 368ms/step - loss: 0.7516 - accuracy:
0.7175 - val_loss: 0.6204 - val_accuracy: 0.7200
Epoch 27/100
21/21 [=====] - 8s 378ms/step - loss: 0.6890 - accuracy:
0.7213 - val_loss: 0.4548 - val_accuracy: 0.8400
Epoch 28/100
21/21 [=====] - 8s 370ms/step - loss: 0.8652 - accuracy:
0.6215 - val_loss: 0.6988 - val_accuracy: 0.7200
Epoch 29/100
21/21 [=====] - 8s 365ms/step - loss: 0.5894 - accuracy:
0.7438 - val_loss: 0.6140 - val_accuracy: 0.7200
Epoch 30/100
21/21 [=====] - 8s 368ms/step - loss: 0.6824 - accuracy:
0.6625 - val_loss: 0.5389 - val_accuracy: 0.7400
Epoch 31/100
21/21 [=====] - 8s 368ms/step - loss: 0.6994 - accuracy:
0.7413 - val_loss: 0.5905 - val_accuracy: 0.7400
Epoch 32/100
21/21 [=====] - 8s 353ms/step - loss: 0.8200 - accuracy:
0.6477 - val_loss: 0.5988 - val_accuracy: 0.6400
Epoch 33/100
21/21 [=====] - 8s 377ms/step - loss: 0.6259 - accuracy:
0.7291 - val_loss: 0.7619 - val_accuracy: 0.7000
Epoch 34/100
21/21 [=====] - 8s 360ms/step - loss: 0.8644 - accuracy:
0.6569 - val_loss: 0.7008 - val_accuracy: 0.6600
Epoch 35/100
21/21 [=====] - 8s 365ms/step - loss: 0.7415 - accuracy:
0.6716 - val_loss: 0.5813 - val_accuracy: 0.7200
Epoch 36/100
21/21 [=====] - 8s 364ms/step - loss: 1.1339 - accuracy:
0.6174 - val_loss: 0.5255 - val_accuracy: 0.7400
Epoch 37/100
21/21 [=====] - 8s 362ms/step - loss: 0.6167 - accuracy:
0.7333 - val_loss: 0.4947 - val_accuracy: 0.7200
Epoch 38/100
21/21 [=====] - 8s 365ms/step - loss: 0.6832 - accuracy:
0.6770 - val_loss: 0.5229 - val_accuracy: 0.6600
Epoch 39/100
21/21 [=====] - 8s 369ms/step - loss: 0.6100 - accuracy:
0.7013 - val_loss: 0.5163 - val_accuracy: 0.8000
Epoch 40/100
21/21 [=====] - 8s 369ms/step - loss: 0.5358 - accuracy:
0.7760 - val_loss: 0.5050 - val_accuracy: 0.7600
Epoch 41/100
21/21 [=====] - 8s 369ms/step - loss: 0.5651 - accuracy:
```

```
0.7727 - val_loss: 0.6356 - val_accuracy: 0.7000
Epoch 42/100
21/21 [=====] - 8s 366ms/step - loss: 0.6338 - accuracy:
0.7918 - val_loss: 0.4848 - val_accuracy: 0.7400
Epoch 43/100
21/21 [=====] - 8s 368ms/step - loss: 0.5551 - accuracy:
0.7471 - val_loss: 0.4330 - val_accuracy: 0.8400
Epoch 44/100
21/21 [=====] - 8s 370ms/step - loss: 0.5675 - accuracy:
0.7496 - val_loss: 0.4400 - val_accuracy: 0.8200
Epoch 45/100
21/21 [=====] - 8s 377ms/step - loss: 0.4654 - accuracy:
0.7921 - val_loss: 0.4322 - val_accuracy: 0.8000
Epoch 46/100
21/21 [=====] - 8s 375ms/step - loss: 0.8685 - accuracy:
0.6608 - val_loss: 0.6167 - val_accuracy: 0.7200
Epoch 47/100
21/21 [=====] - 8s 372ms/step - loss: 0.4975 - accuracy:
0.7884 - val_loss: 0.5123 - val_accuracy: 0.7000
Epoch 48/100
21/21 [=====] - 8s 372ms/step - loss: 0.6498 - accuracy:
0.7086 - val_loss: 0.5768 - val_accuracy: 0.6600
Epoch 49/100
21/21 [=====] - 8s 364ms/step - loss: 0.7019 - accuracy:
0.7424 - val_loss: 0.4271 - val_accuracy: 0.7800
Epoch 50/100
21/21 [=====] - 8s 364ms/step - loss: 0.5929 - accuracy:
0.7144 - val_loss: 0.6279 - val_accuracy: 0.7000
Epoch 51/100
21/21 [=====] - 8s 367ms/step - loss: 0.6992 - accuracy:
0.7458 - val_loss: 0.6215 - val_accuracy: 0.7000
Epoch 52/100
21/21 [=====] - 8s 355ms/step - loss: 0.5107 - accuracy:
0.8249 - val_loss: 0.5284 - val_accuracy: 0.7800
Epoch 53/100
21/21 [=====] - 8s 356ms/step - loss: 0.6303 - accuracy:
0.7146 - val_loss: 0.6107 - val_accuracy: 0.7400
Epoch 54/100
21/21 [=====] - 8s 370ms/step - loss: 0.6789 - accuracy:
0.7985 - val_loss: 0.5035 - val_accuracy: 0.7600
Epoch 55/100
21/21 [=====] - 8s 373ms/step - loss: 0.7141 - accuracy:
0.7071 - val_loss: 0.4851 - val_accuracy: 0.8200
Epoch 56/100
21/21 [=====] - 8s 371ms/step - loss: 0.8564 - accuracy:
0.6786 - val_loss: 0.8247 - val_accuracy: 0.6400
Epoch 57/100
21/21 [=====] - 8s 371ms/step - loss: 0.5634 - accuracy:
0.7799 - val_loss: 0.5165 - val_accuracy: 0.7400
Epoch 58/100
21/21 [=====] - 8s 367ms/step - loss: 0.5802 - accuracy:
0.7048 - val_loss: 0.6019 - val_accuracy: 0.7400
Epoch 59/100
21/21 [=====] - 8s 369ms/step - loss: 0.5893 - accuracy:
0.7463 - val_loss: 0.6412 - val_accuracy: 0.7400
Epoch 60/100
21/21 [=====] - 8s 366ms/step - loss: 0.5813 - accuracy:
0.7722 - val_loss: 0.6006 - val_accuracy: 0.7200
Epoch 61/100
21/21 [=====] - 8s 364ms/step - loss: 0.5003 - accuracy:
0.8267 - val_loss: 0.7409 - val_accuracy: 0.7200
```

Epoch 62/100
21/21 [=====] - 8s 369ms/step - loss: 0.7338 - accuracy:
0.7787 - val_loss: 0.7563 - val_accuracy: 0.7000
Epoch 63/100
21/21 [=====] - 8s 372ms/step - loss: 0.4863 - accuracy:
0.8253 - val_loss: 0.5368 - val_accuracy: 0.7200
Epoch 64/100
21/21 [=====] - 8s 373ms/step - loss: 0.5864 - accuracy:
0.7425 - val_loss: 0.6300 - val_accuracy: 0.7200
Epoch 65/100
21/21 [=====] - 8s 358ms/step - loss: 0.5788 - accuracy:
0.8123 - val_loss: 0.5478 - val_accuracy: 0.8200
Epoch 66/100
21/21 [=====] - 8s 358ms/step - loss: 0.5410 - accuracy:
0.7609 - val_loss: 0.4652 - val_accuracy: 0.7800
Epoch 67/100
21/21 [=====] - 8s 371ms/step - loss: 0.4872 - accuracy:
0.8097 - val_loss: 0.4963 - val_accuracy: 0.7800
Epoch 68/100
21/21 [=====] - 8s 371ms/step - loss: 0.5813 - accuracy:
0.7566 - val_loss: 0.5202 - val_accuracy: 0.7600
Epoch 69/100
21/21 [=====] - 8s 367ms/step - loss: 0.6097 - accuracy:
0.7762 - val_loss: 0.5099 - val_accuracy: 0.8400
Epoch 70/100
21/21 [=====] - 8s 369ms/step - loss: 0.3779 - accuracy:
0.7986 - val_loss: 0.5539 - val_accuracy: 0.7200
Epoch 71/100
21/21 [=====] - 8s 371ms/step - loss: 0.6773 - accuracy:
0.7969 - val_loss: 0.3729 - val_accuracy: 0.8200
Epoch 72/100
21/21 [=====] - 8s 375ms/step - loss: 0.6713 - accuracy:
0.7779 - val_loss: 0.4348 - val_accuracy: 0.8200
Epoch 73/100
21/21 [=====] - 8s 364ms/step - loss: 0.4980 - accuracy:
0.8106 - val_loss: 0.7603 - val_accuracy: 0.7400
Epoch 74/100
21/21 [=====] - 8s 364ms/step - loss: 0.4124 - accuracy:
0.8163 - val_loss: 0.5270 - val_accuracy: 0.7600
Epoch 75/100
21/21 [=====] - 8s 366ms/step - loss: 0.5850 - accuracy:
0.8335 - val_loss: 0.5917 - val_accuracy: 0.7200
Epoch 76/100
21/21 [=====] - 8s 367ms/step - loss: 0.5532 - accuracy:
0.8075 - val_loss: 0.5501 - val_accuracy: 0.7400
Epoch 77/100
21/21 [=====] - 8s 366ms/step - loss: 0.5593 - accuracy:
0.7930 - val_loss: 0.4748 - val_accuracy: 0.8200
Epoch 78/100
21/21 [=====] - 8s 368ms/step - loss: 0.4069 - accuracy:
0.8755 - val_loss: 0.7429 - val_accuracy: 0.7400
Epoch 79/100
21/21 [=====] - 8s 365ms/step - loss: 0.4330 - accuracy:
0.8630 - val_loss: 0.5791 - val_accuracy: 0.7800
Epoch 80/100
21/21 [=====] - 8s 376ms/step - loss: 0.6839 - accuracy:
0.7290 - val_loss: 0.7366 - val_accuracy: 0.6800
Epoch 81/100
21/21 [=====] - 8s 364ms/step - loss: 0.5313 - accuracy:
0.8015 - val_loss: 1.1439 - val_accuracy: 0.6400
Epoch 82/100

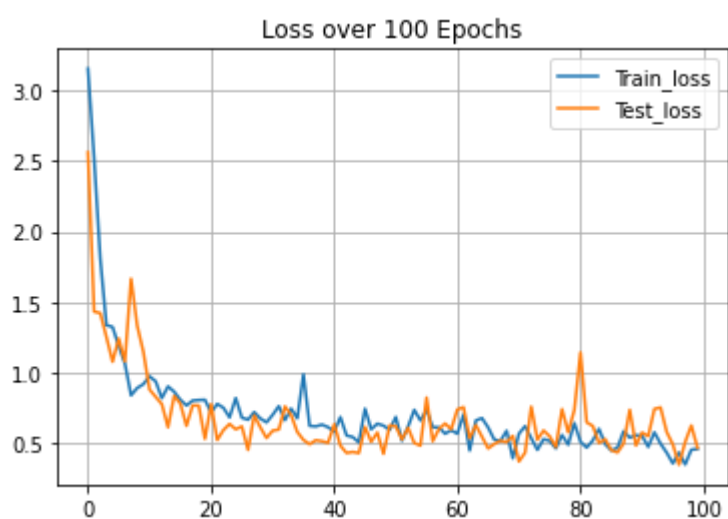
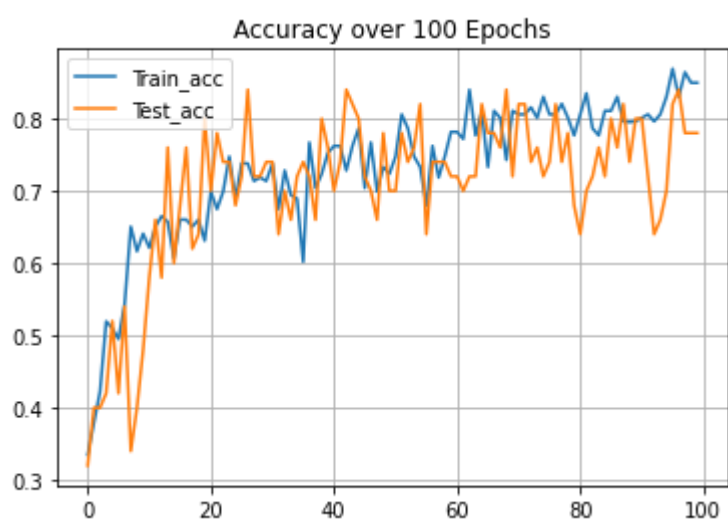

```
21/21 [=====] - 8s 375ms/step - loss: 0.4493 - accuracy:
0.8320 - val_loss: 0.6495 - val_accuracy: 0.7000
Epoch 83/100
21/21 [=====] - 8s 371ms/step - loss: 0.4285 - accuracy:
0.8154 - val_loss: 0.6237 - val_accuracy: 0.7200
Epoch 84/100
21/21 [=====] - 8s 371ms/step - loss: 0.5868 - accuracy:
0.7503 - val_loss: 0.5038 - val_accuracy: 0.7600
Epoch 85/100
21/21 [=====] - 8s 374ms/step - loss: 0.5533 - accuracy:
0.7789 - val_loss: 0.5311 - val_accuracy: 0.7200
Epoch 86/100
21/21 [=====] - 8s 371ms/step - loss: 0.4339 - accuracy:
0.8237 - val_loss: 0.4527 - val_accuracy: 0.8000
Epoch 87/100
21/21 [=====] - 8s 371ms/step - loss: 0.5416 - accuracy:
0.8107 - val_loss: 0.4367 - val_accuracy: 0.7600
Epoch 88/100
21/21 [=====] - 8s 363ms/step - loss: 0.5318 - accuracy:
0.7922 - val_loss: 0.4995 - val_accuracy: 0.8200
Epoch 89/100
21/21 [=====] - 8s 366ms/step - loss: 0.4866 - accuracy:
0.8205 - val_loss: 0.7385 - val_accuracy: 0.7400
Epoch 90/100
21/21 [=====] - 8s 372ms/step - loss: 0.5624 - accuracy:
0.7957 - val_loss: 0.4854 - val_accuracy: 0.8000
Epoch 91/100
21/21 [=====] - 8s 368ms/step - loss: 0.6044 - accuracy:
0.8027 - val_loss: 0.5773 - val_accuracy: 0.8000
Epoch 92/100
21/21 [=====] - 8s 371ms/step - loss: 0.4385 - accuracy:
0.8108 - val_loss: 0.5513 - val_accuracy: 0.7200
Epoch 93/100
21/21 [=====] - 8s 374ms/step - loss: 0.5455 - accuracy:
0.7950 - val_loss: 0.7440 - val_accuracy: 0.6400
Epoch 94/100
21/21 [=====] - 8s 375ms/step - loss: 0.4805 - accuracy:
0.8232 - val_loss: 0.7548 - val_accuracy: 0.6600
Epoch 95/100
21/21 [=====] - 8s 374ms/step - loss: 0.4596 - accuracy:
0.7977 - val_loss: 0.5816 - val_accuracy: 0.7000
Epoch 96/100
21/21 [=====] - 8s 374ms/step - loss: 0.3870 - accuracy:
0.8656 - val_loss: 0.4930 - val_accuracy: 0.8200
Epoch 97/100
21/21 [=====] - 8s 366ms/step - loss: 0.3790 - accuracy:
0.8556 - val_loss: 0.3500 - val_accuracy: 0.8400
Epoch 98/100
21/21 [=====] - 8s 362ms/step - loss: 0.3510 - accuracy:
0.8834 - val_loss: 0.5107 - val_accuracy: 0.7800
Epoch 99/100
21/21 [=====] - 8s 372ms/step - loss: 0.5342 - accuracy:
0.8612 - val_loss: 0.6272 - val_accuracy: 0.7800
Epoch 100/100
21/21 [=====] - 8s 368ms/step - loss: 0.4112 - accuracy:
0.8412 - val_loss: 0.4696 - val_accuracy: 0.7800
```

In [8]:

```
import matplotlib.pyplot as plt

plt.title('Accuracy over 100 Epochs')
plt.plot(history.history['accuracy'], label='Train_acc')
plt.plot(history.history['val_accuracy'], label='Test_acc')
plt.legend(loc='upper left')
plt.grid(True)
plt.show()

plt.title('Loss over 100 Epochs')
plt.plot(history.history['loss'], label='Train_loss')
plt.plot(history.history['val_loss'], label='Test_loss')
plt.legend(loc='upper right')
plt.grid(True)
plt.show()
```



In [9]:

```
#vgg16.trainable = True
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))
x = model2.evaluate_generator(eval_generator,steps = np.ceil(len(eval_generator)),
                             use_multiprocessing = False,verbose = 1,workers=1)

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

Found 36 images belonging to 4 classes.

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1/36 [.....] - ETA: 5s - loss: 0.7011 - accuracy: 1.0000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/keras/engine/training.py:

1877: UserWarning: `Model.evaluate_generator` is deprecated and will be removed in a future version. Please use `Model.evaluate`, which supports generators.

warnings.warn("`Model.evaluate_generator` is deprecated and ")

36/36 [=====] - 1s 22ms/step - loss:0.6889 - accuracy: 0.7500

Test loss: 0.6888864636421204

Test accuracy: 0.75

In [13]:

```

from sklearn.manifold import TSNE

intermediate_layer_model = tf.keras.models.Model(inputs=model2.input,
                                                    outputs=model2.get_layer('feature_dense').output)

tsne_eval_generator = test_datagen.flow_from_directory(DATASET_PATH, target_size=IMAGE_SIZE,
                                                        batch_size=1, shuffle=True, seed=42, class_mode=
"categorical")

#get labels from data generator
labels_array = []
num_labels=[]
a = tsne_eval_generator.class_indices.keys()
for i in range( tsne_eval_generator.__len__() ):
    labels_array.extend(tsne_eval_generator.__getitem__( i )[1] )    #obtain the arrays of index
    to array
    for j in range(len(labels_array[i])):        #obtain the index of item that is equal to 1, a
nd append to the list
        if labels_array[i][j] == 1.0:
            num_labels.append(j)

#feature extraction
tsne_eval_generator.reset()
features = intermediate_layer_model.predict(tsne_eval_generator)

#compress the dimensionality
tsne = TSNE(n_components=2)
tsne_result = tsne.fit_transform(features)
x=[i[0] for i in tsne_result]
y=[i[1] for i in tsne_result]

#plotting values
zero_x=[]
one_x=[]
two_x=[]
three_x=[]

zero_y=[]
one_y=[]
two_y=[]
three_y=[]

for i in range(len(labels_array)):
    if num_labels[i] == 0:
        zero_x.append(x[i])
        zero_y.append(y[i])
    elif num_labels[i] == 1:
        one_x.append(x[i])
        one_y.append(y[i])
    elif num_labels[i] == 2:
        two_x.append(x[i])
        two_y.append(y[i])
    elif num_labels[i] == 3:
        three_x.append(x[i])
        three_y.append(y[i])

#plotting

```

```
plt.scatter(zero_x,zero_y, label='COVID-19', s=15)
plt.scatter(one_x,one_y, label='Normal', s=15)
plt.scatter(two_x,two_y, label='Pneumonia_bac', s=15)
plt.scatter(three_x,three_y, label='Pneumonia_vir', s=15)
plt.legend(loc='lower left')
plt.show()
```

Found 270 images belonging to 4 classes.

