CS440 Class Challenge

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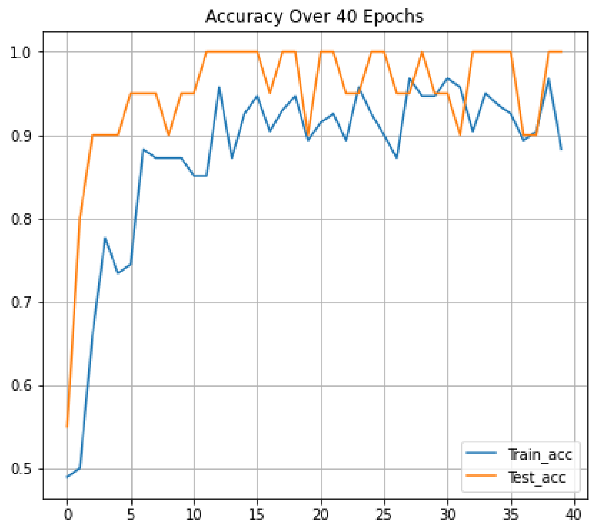
Task 1:

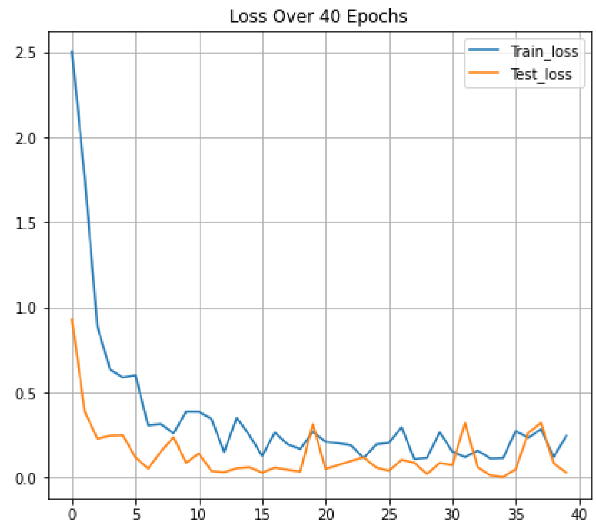
Architecture Used:

For this task, we are using a model with the following layers: VGG16 layer with input shape 224 by 224 by 3, flatten layer, dense layers with 1000, 500, and 125 neurons each, a dropout layer with 0.2 dropout rate after each of these dense layers, and finally, an output layer with sigmoid activation. We initialized the model parameters with ImageNet weights. For the loss function, we are using binary cross entropy with the Adam optimizer and a learning rate of 0.0005.

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_5 (Flatten)	(None, 25088)	0
dense_8 (Dense)	(None, 1000)	25089000
dropout_6 (Dropout)	(None, 1000)	0
dense_9 (Dense)	(None, 500)	500500
dropout_7 (Dropout)	(None, 500)	0
dense_10 (Dense)	(None, 125)	62625
dropout_8 (Dropout)	(None, 125)	0
dense_11 (Dense)	(None, 1)	126

Architecture Performance:

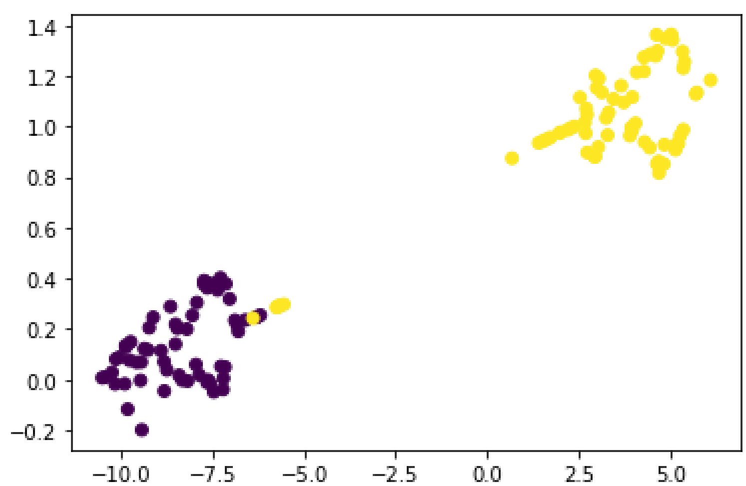




Test loss: 0.03205887973308563
Test accuracy: 1.0

The accuracy and loss of our model was very good! In the first few epochs, it quickly jumps from 0.6 up to 0.9, and then effectively stays there, many times getting every single test case correct in the training set. The loss similarly has a sharp decline, and then stays very close to 0 for many epochs. We were very happy with the performance of our model, especially given that the model doesn't have a ton of data to train on.

t-SNE Visualization:



Our t-SNE visualization was slightly different than the example provided, but showed just as good, distinct clustering even when reduced to just two features instead of the whole set. To perform the t-SNE visualization, we used the penultimate layer of our model, with 125 features in the dense layer. From there, we used sklearn to generate the t-SNE visualization with these parameters: `n_components=2, perplexity=48, learning_rate='auto', init='pca', square_distances=True`. We know how many components there should be so that was simple, but finding the right perplexity was a little more tricky. The output graph is very very sensitive to this parameter, which from what we could tell, helped define how tightly our data is clustered, with values too low not being clustered enough, and values too high attempted to be clustered too much, resulting in dispersed ring or donut shapes. After trial and error, it seems that 48 was a great pick. While the shape isn't triangular like the sample, and there are a few outliers in the bottom left cluster, we are quite happy with how clean and distinct the clusters it has found are in just two dimensions.

Task 2:

Architecture Used:

We started with a pre-trained VGG system, and just added one layer to flatten it, taking it from a 3 dimensional tensor of shape 7x7x512, to just a single dimensional layer of size 25088. Then, we applied a fully-connected layer, reducing the shape to 128, and finally an output fully connected layer, giving us our 4 categories. For the loss, we used a categorical cross entropy with the Adam optimizer and a learning rate of 0.0005, similar to task 1 but with a different cross entropy function to suit categorical classification instead of binary classification.

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_1 (Flatten)	(None, 25088)	0
dense_2 (Dense)	(None, 128)	3211392
dense_3 (Dense)	(None, 4)	516

Architecture Investigation and Comparison:

VGG16 Improvement with more layers and dropout:

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_25 (Flatten)	(None, 25088)	0
dense_76 (Dense)	(None, 500)	12544500
dropout_49 (Dropout)	(None, 500)	0
dense_77 (Dense)	(None, 125)	62625
dropout_50 (Dropout)	(None, 125)	0
dense_78 (Dense)	(None, 4)	504

To improve our accuracy from our simple model, we decided to try out a more complicated model that adds in additional dropout layers, which should reduce overfitting and give us higher accuracy. To be more clear, we added a fully connected layer before our first fully-connected layer of size 500, with a dropout layer of the same size after it. Then, we also added a dropout layer after our initial fully connected layer. However, in our testing, the accuracy actually decreased by 0.05%, so we looked elsewhere for improvements.

Extra data augmentation:

Layer (type)	Output Shape	Param #
vgg16 (Functional)	(None, 7, 7, 512)	14714688
flatten_34 (Flatten)	(None, 25088)	0
dense_98 (Dense)	(None, 128)	3211392
dense_99 (Dense)	(None, 4)	516

Next we tried to use extra data augmentation. From what we could tell, this meant that we had to increase how many epochs we ran it with, as each one perturbed our input images slightly and gave the rest a larger dataset to work with. Besides that, it has the same parameters as our initial model. The accuracy still leveled out at the same spot, although with so many more epochs, it was much more gradual getting there.

AlexNet:

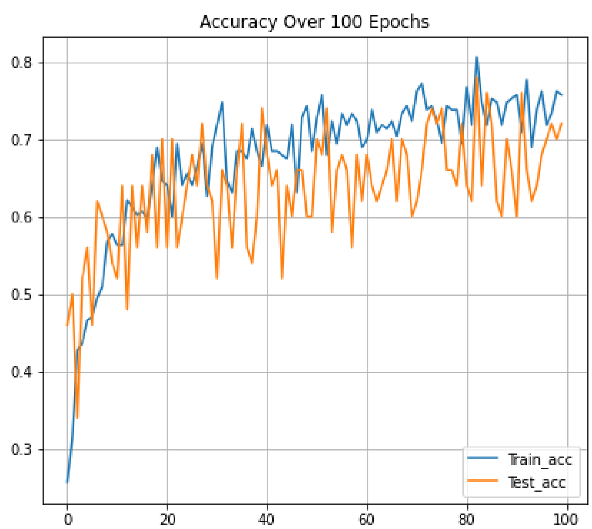
Layer (type)	Output Shape	Param #
conv2d_60 (Conv2D)	(None, 54, 54, 96)	34944
batch_normalization_60 (Batc	(None, 54, 54, 96)	384
max_pooling2d_36 (MaxPooling	(None, 26, 26, 96)	0
conv2d_61 (Conv2D)	(None, 26, 26, 256)	614656
batch_normalization_61 (Batc	(None, 26, 26, 256)	1024
max_pooling2d_37 (MaxPooling	(None, 12, 12, 256)	0
conv2d_62 (Conv2D)	(None, 12, 12, 384)	885120
batch_normalization_62 (Batc	(None, 12, 12, 384)	1536
conv2d_63 (Conv2D)	(None, 12, 12, 384)	1327488

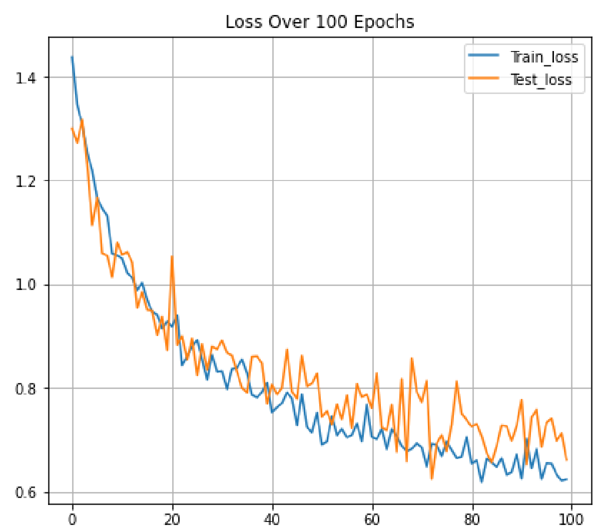
batch_normalization_63 (Batc	(None, 12, 12, 384)	1536
conv2d_64 (Conv2D)	(None, 12, 12, 256)	884992
batch_normalization_64 (Batc	(None, 12, 12, 256)	1024
max_pooling2d_38 (MaxPooling	(None, 5, 5, 256)	0
flatten_32 (Flatten)	(None, 6400)	0
dense_93 (Dense)	(None, 4096)	26218496
dropout_55 (Dropout)	(None, 4096)	0
dense_94 (Dense)	(None, 4096)	16781312
dropout_56 (Dropout)	(None, 4096)	0
dense_95 (Dense)	(None, 4)	16388

We then tried a very different approach, using the AlexNet image classifier, which was almost completely different from our model. We thought that by using more Conv2D layers for the image, our performance would improve, but this accuracy was much lower than our first. However, it does give us a good idea of how some standard models perform on this dataset!

Architecture Performance:

Best model:

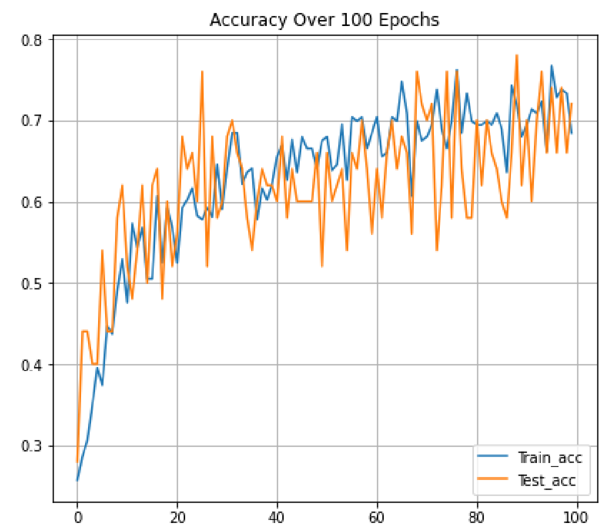


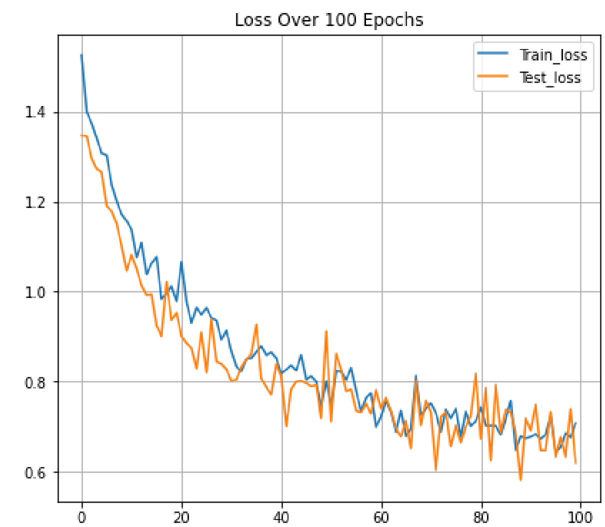


Test loss: 0.7604448795318604
Test accuracy: 0.6944444179534912

Our simplest model turned out to have the highest accuracy we could achieve, around 0.69. It has a steady even rise until capping out at that level. The loss also steadily decreases, but never drops below 0.6. We think that the small size of the input dataset may have been the reason behind the much smaller accuracy, as with categorical classification, especially with similar classes, it is harder to tell apart the distinct differences for all the classes.

VGC16 More layers and dropout:

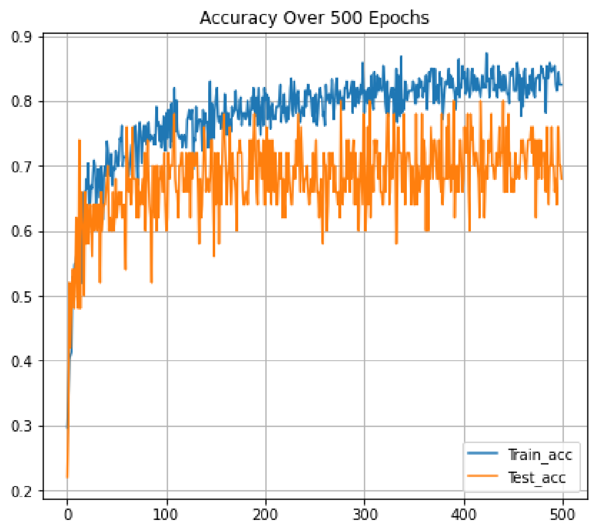


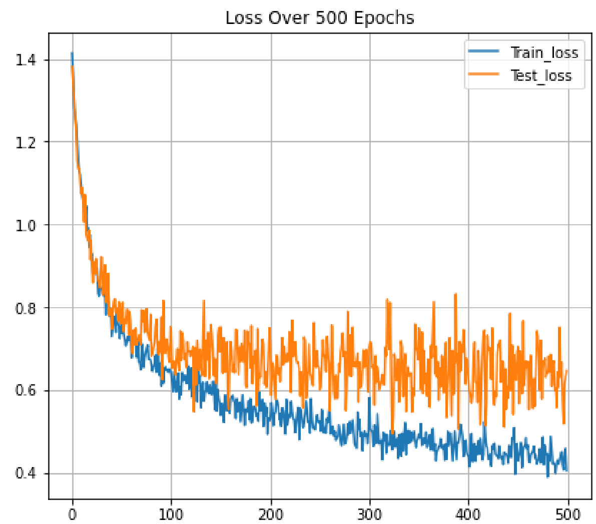


Test loss: 0.8460082411766052
Test accuracy: 0.6388888955116272

Adding more layers did very little to change the accuracy of the model at all, but managed to have slightly lower accuracy than our simpler first model! We were disappointed but given our first model can find more complicated weights and is already building off of the VGG16 model, it is not entirely surprising in retrospect either.

Extra data augmentation:

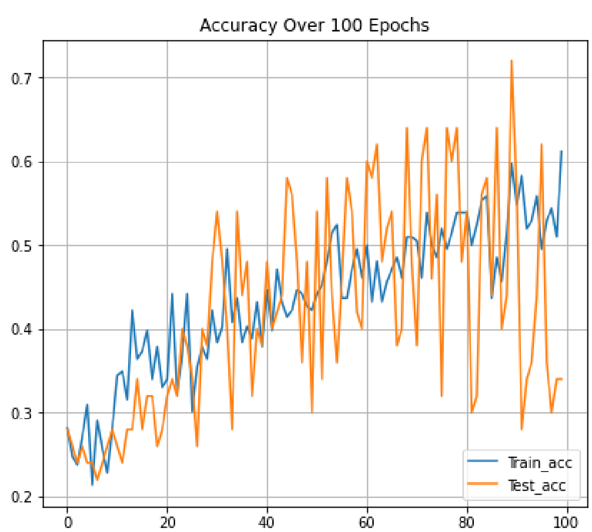


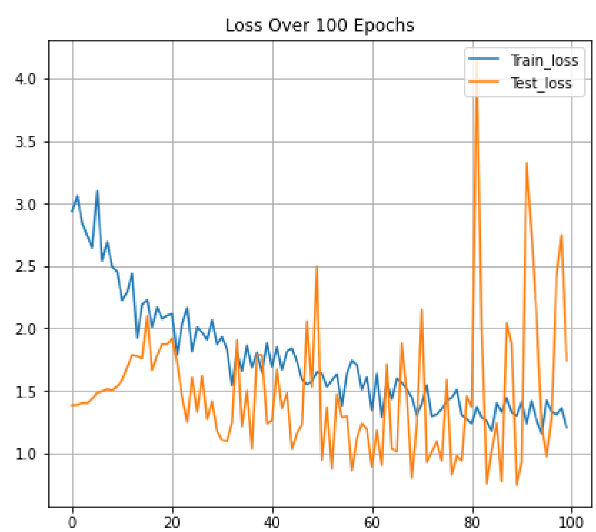


Test loss: 0.7342052459716797
Test accuracy: 0.6944444179534912

Adding many more epochs and augmenting the data did not seem to help much. After a certain point, much like our first one, it leveled out around the same spot. This was also slightly disappointing, since we had figured that more data would be the limiting factor that could make our model improve, but with the extra data augmentation, while our training set could improve, our testing set still didn’t. Perhaps we needed truly novel new data to help perform better, instead of label preserving transformations which can only do so much.

AlexNet:





Test loss: 1.9850109815597534

Test accuracy: 0.5277777910232544

Alexnet's performance left a lot to be desired. It bounced all over the place, was very inconsistent, and the most complicated of our models, so it seemed clear to us not to spend too much time pursuing this route. Although it does

Our best attempt turned out to be with our first and most simple model. While we are somewhat happy with the accuracy, and feel good having thoroughly exhausted other options, it does feel a bit strange having these additional tools not work very well on this particular task!

t-SNE Visualization:

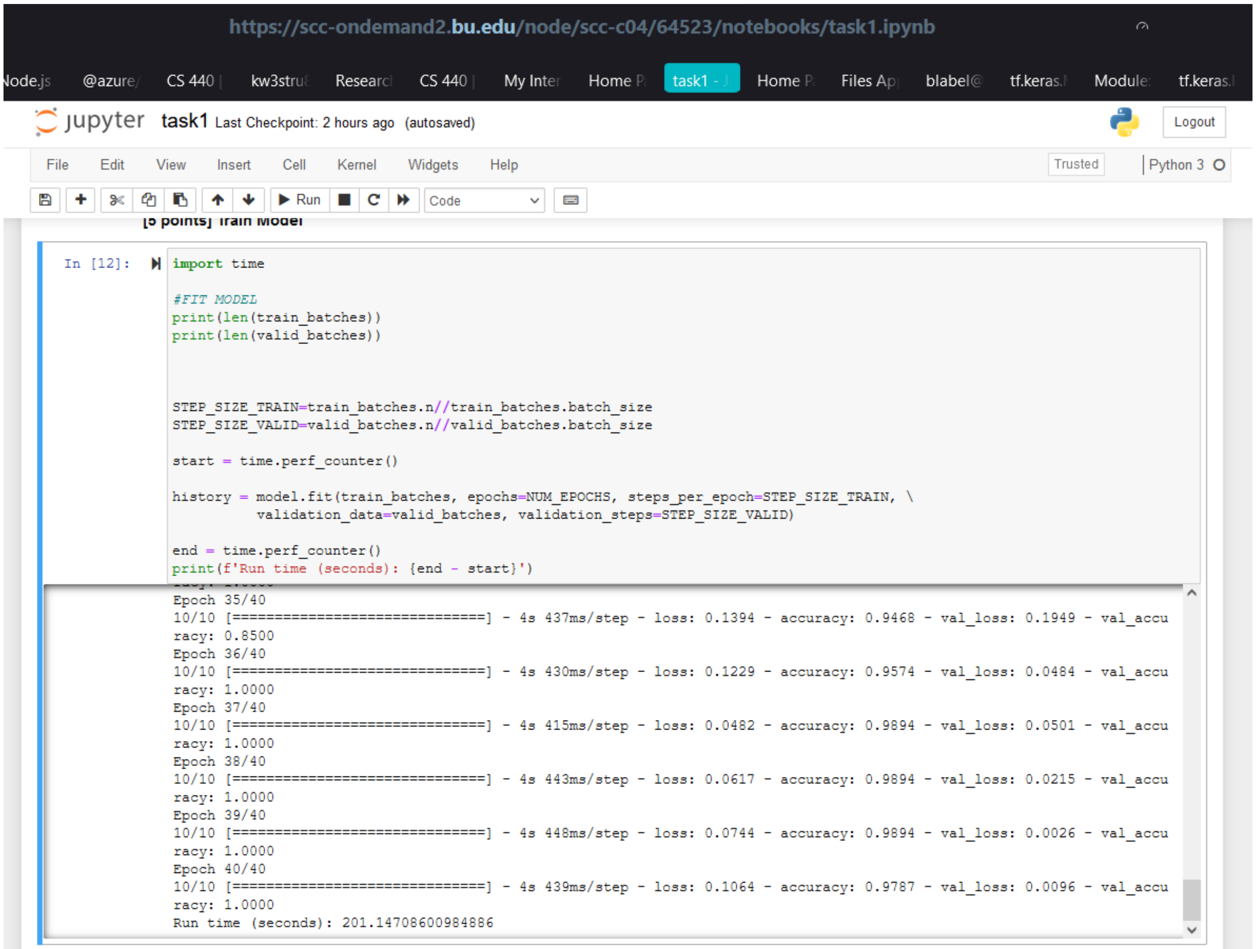
We could not successfully use t-SNE to visualize our categorical data, but we will leave the code for that section and our changes to it here.

```
from sklearn.manifold import TSNE

intermediate_layer_model = tf.keras.models.Model(inputs=model.input,

outputs=model.get_layer('dense_2').output)
tsne_data_generator =
test_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE_SIZE,

batch_size=1,shuffle=False,seed=42,class_mode="binary")

intermediate_layer_model.compile(optimizer='adam',
                loss='categorical_crossentropy',
                metrics=['accuracy'])

predictions = intermediate_layer_model.predict(tsne_data_generator)

tsne_model = TSNE(n_components=4, perplexity=48, learning_rate='auto',
init='pca', square_distances=True).fit_transform(predictions)

tsne_data_generator.reset

print(tsne_model.shape)

plt.scatter(tsne_model[:, 0], tsne_model[:, 1],
c=tsne_data_generator.labels)
```

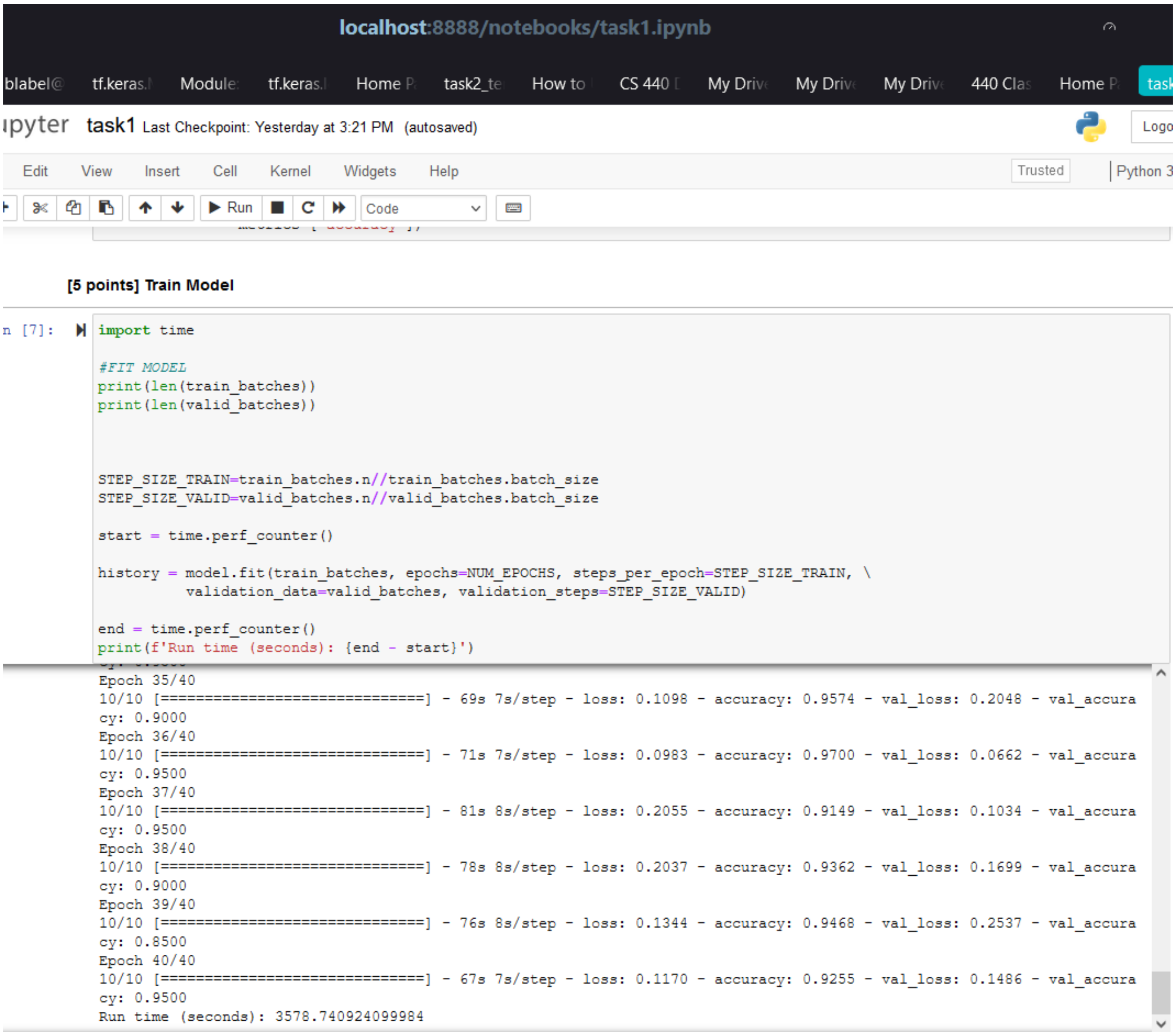
```
plt.show()
```

Bonus:

We set up our notebook to run using the GPUs in the SCC cluster. Doing so led to a massive boost in performance! We asked for 2 hours with 4 CPU cores, and 4 GPU cores (using the 3.5 setting so that any available GPU cards would be considered. Here is the time it took to train the first model in the SCC cluster:



201.147 seconds! Now, for running it locally on my laptop without a GPU:



3578 seconds! More than 10x slower! It is clear that having a GPU that can do these calculations using hardware suited for the job is a great enabler for deep learning tasks.

[30 points] Report

- [5 points] Describe the architectures used in detail: layers, layer dimensions, dropout layers, etc. for both tasks. List the optimizer, loss function, parameters, and any regularization used in both tasks
- [10 points] Comparison of the performance of different architectures for the second task and relating this to the architecture and parameter settings used

- [10 points] Plot and comment on the accuracy and the loss for both tasks
- [5 points] Plot and comment on the t-SNE visualizations
- [Bonus: 5 points] Run the training on a GPU on the SCC cluster and include a CPU vs. GPU training time comparison by taking snapshots from your terminal

Task 1 Code

Jupyter Notebook printout, ran in Google Colab

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

Task 1 [Total points: 30]

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 use the following commands to install the above packages:

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

Google Colab moment

```
!git clone https://github.com/RichardChen123/CS440-Class-Challenge.git
```

```
Cloning into 'CS440-Class-Challenge'...
remote: Enumerating objects: 336, done.
remote: Counting objects: 100% (336/336), done.
remote: Compressing objects: 100% (331/331), done.
remote: Total 336 (delta 3), reused 333 (delta 3), pack-reused 0
Receiving objects: 100% (336/336), 83.51 MiB | 30.81 MiB/s, done.
Resolving deltas: 100% (3/3), done.
Checking out files: 100% (465/465), done.
```

Data

Please download the data using the following link: COVID-19.

- After downloading 'Covid_Data_GradientCrescent.zip', unzip the file and you should see the

|--------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] Binary Classification: COVID-19 vs. Normal

```
import os

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.image import ImageDataGenerator

os.environ['OMP_NUM_THREADS'] = '1'
os.environ['CUDA_VISIBLE_DEVICES'] = '-1'
tf.__version__
```

```
'2.7.0'
```

Load Image Data

```
DATA_LIST = os.listdir('/content/CS440-Class-Challenge/two/train')
DATASET_PATH  = '/content/CS440-Class-Challenge/two/train'
TEST_DIR =  '/content/CS440-Class-Challenge/two/test'
IMAGE_SIZE    = (224, 224)
NUM_CLASSES   = len(DATA_LIST)
BATCH_SIZE    = 10  # try reducing batch size or freeze more layers if your GPU ru
NUM_EPOCHS    = 40
LEARNING_RATE = 0.0005 # start off with high rate first 0.001 and experiment with 
```

Generate Training and Validation Batches

```
train_datagen = ImageDataGenerator(rescale=1./255,rotation_range=50,featurewise_ce
                                   featurewise_std_normalization = True,width_shif
```

```
                                             subset = "validation",seed=42,
                                             class_mode="binary")
```

```
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_g
  warnings.warn('This ImageDataGenerator specifies '
Found 104 images belonging to 2 classes.
Found 26 images belonging to 2 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.

```
vgg16 = tf.keras.applications.VGG16(weights='imagenet', include_top=False, input_sh
vgg16.trainable = False
model = tf.keras.models.Sequential([
    vgg16,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(1000, activation='relu'),
    tf.keras.layers.Dropout(rate=0.2),
    tf.keras.layers.Dense(500, activation='relu'),
    tf.keras.layers.Dropout(rate=0.2),
    tf.keras.layers.Dense(125, activation='relu'),
    tf.keras.layers.Dropout(rate=0.2),
    tf.keras.layers.Dense(1, activation='sigmoid')
])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applica
58892288/58889256 [==============================] - 0s 0us/step
58900480/58889256 [==============================] - 0s 0us/step
```

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
```

```
Trainable params: 25,652,251
Non-trainable params: 14,714,688
_________________________________________________________________
```

```
model.compile(optimizer='adam',
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

[5 points] Train Model

```
#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
```

```
history = model.fit(train_batches, epochs=NUM_EPOCHS, steps_per_epoch=STEP_SIZE_TRA
          validation_data=valid_batches, validation_steps=STEP_SIZE_VALID)
```

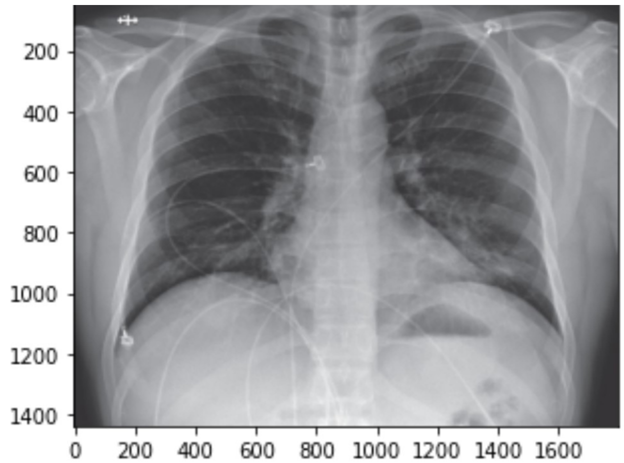
```
11
3
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_g
  warnings.warn('This ImageDataGenerator specifies '
/usr/local/lib/python3.7/dist-packages/keras_preprocessing/image/image_data_g
  warnings.warn('This ImageDataGenerator specifies '
Epoch 1/40
10/10 [==============================] - 64s 7s/step - loss: 2.5016 - accurac
```

```
10/10 [==============================] - 63s 6s/step - loss: 0.2475 - accurac
Epoch 16/40
10/10 [==============================] - 64s 6s/step - loss: 0.1270 - accurac
Epoch 17/40
10/10 [==============================] - 63s 6s/step - loss: 0.2646 - accurac
Epoch 18/40
10/10 [==============================] - 66s 7s/step - loss: 0.1953 - accurac
Epoch 19/40
10/10 [==============================] - 63s 6s/step - loss: 0.1671 - accurac
Epoch 20/40
10/10 [==============================] - 63s 6s/step - loss: 0.2690 - accurac
Epoch 21/40
10/10 [==============================] - 63s 7s/step - loss: 0.2099 - accurac
Epoch 22/40
10/10 [==============================] - 63s 6s/step - loss: 0.2016 - accurac
Epoch 23/40
10/10 [==============================] - 64s 6s/step - loss: 0.1894 - accurac
Epoch 24/40
10/10 [==============================] - 63s 7s/step - loss: 0.1147 - accurac
Epoch 25/40
10/10 [==============================] - 63s 6s/step - loss: 0.1945 - accurac
Epoch 26/40
10/10 [==============================] - 68s 7s/step - loss: 0.2045 - accurac
```

[5 points] Plot Accuracy and Loss During Training

Plot Test Results

```
import matplotlib.image as mpimg

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=4
eval_generator.reset()
pred = model.predict_generator(eval_generator,18,verbose=1)
for index, probability in enumerate(pred):
    image_path = TEST_DIR + "/" +eval_generator.filenames[index]
```



covid/nejmoa2001191_f5-PA.jpeg

```
#           validation_data=valid_batches, validation_steps=STEP_SIZE_VALID)

tsne_model = TSNE(n_components=2, perplexity=48, learning_rate='auto', init='pca',

tsne_data_generator.reset
```

```
Found 130 images belonging to 2 classes.
```

Task 2 Code

Jupyter Notebook printout, ran in Google Colab

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

Task 2 [Total points: 30]

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 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.

- 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 [2]:

```
import os

import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

```
os.environ['OMP_NUM_THREADS'] = '1'
os.environ['CUDA_VISIBLE_DEVICES'] = '-1'
tf.__version__
```

Out[2]:
```
'2.6.0'
```

Load Image Data

In [20]:
```
DATA_LIST = os.listdir('all/train')
DATASET_PATH  = 'all/train'
TEST_DIR =  '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 ou
NUM_EPOCHS    = 100
LEARNING_RATE = 0.0005 # start off with high rate first 0.001 and experiment with reduc
```

Generate Training and Validation Batches

In [4]:
```
train_datagen = ImageDataGenerator(rescale=1./255,rotation_range=50,featurewise_center
                                   featurewise_std_normalization = True,width_shift_ran
                                   height_shift_range=0.2,shear_range=0.25,zoom_range=0
                                   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.
C:\ProgramData\Anaconda3\lib\site-packages\keras_preprocessing\image\image_data_generato
r.py:342: UserWarning: This ImageDataGenerator specifies `zca_whitening` which overrides
setting of`featurewise_std_normalization`.
  warnings.warn('This ImageDataGenerator specifies '
```

Model 1: VGG16

[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 [5]:
```
vgg16 = tf.keras.applications.VGG16(weights='imagenet', include_top=False, input_shape=
vgg16.trainable = False
```

```
model = tf.keras.Sequential([
    vgg16,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(4, activation='softmax')
])
model.compile(optimizer = 'adam', loss = 'categorical_crossentropy', metrics = ['catego
```

In [6]:

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
vgg16 (Functional)           (None, 7, 7, 512)         14714688  
_________________________________________________________________
flatten (Flatten)            (None, 25088)             0         
_________________________________________________________________
dense (Dense)                (None, 128)               3211392   
_________________________________________________________________
dense_1 (Dense)              (None, 4)                 516       
=================================================================
Total params: 17,926,596
Trainable params: 3,211,908
Non-trainable params: 14,714,688
_________________________________________________________________
```

[5 points] Train Model

In [8]:

```
#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



res = model.fit(train_batches, epochs=NUM_EPOCHS, steps_per_epoch=STEP_SIZE_TRAIN, \
          validation_data=valid_batches, validation_steps=STEP_SIZE_VALID)
```

```
22
6
C:\ProgramData\Anaconda3\lib\site-packages\keras_preprocessing\image\image_data_generato
r.py:720: UserWarning: This ImageDataGenerator specifies `featurewise_center`, but it ha
sn't been fit on any training data. Fit it first by calling `.fit(numpy_data)`.
  warnings.warn('This ImageDataGenerator specifies '
C:\ProgramData\Anaconda3\lib\site-packages\keras_preprocessing\image\image_data_generato
r.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 [==============================] - 15s 679ms/step - loss: 2.2291 - categorical_acc
uracy: 0.3641 - val_loss: 1.0474 - val_categorical_accuracy: 0.5200
Epoch 2/100
21/21 [==============================] - 13s 627ms/step - loss: 1.2767 - categorical_acc
```

```
uracy: 0.5049 - val_loss: 0.9806 - val_categorical_accuracy: 0.6400
Epoch 3/100
21/21 [==============================] - 13s 630ms/step - loss: 1.2193 - categorical_acc
uracy: 0.5388 - val_loss: 1.4163 - val_categorical_accuracy: 0.5600
Epoch 4/100
21/21 [==============================] - 13s 627ms/step - loss: 1.2170 - categorical_acc
uracy: 0.5485 - val_loss: 1.2122 - val_categorical_accuracy: 0.5800
Epoch 5/100
21/21 [==============================] - 13s 633ms/step - loss: 1.0722 - categorical_acc
uracy: 0.5922 - val_loss: 1.0407 - val_categorical_accuracy: 0.4800
Epoch 6/100
21/21 [==============================] - 13s 630ms/step - loss: 1.0387 - categorical_acc
uracy: 0.5922 - val_loss: 0.9112 - val_categorical_accuracy: 0.6400
Epoch 7/100
21/21 [==============================] - 13s 630ms/step - loss: 0.8511 - categorical_acc
uracy: 0.6796 - val_loss: 0.8962 - val_categorical_accuracy: 0.7200
Epoch 8/100
21/21 [==============================] - 13s 627ms/step - loss: 0.9210 - categorical_acc
uracy: 0.6019 - val_loss: 0.7324 - val_categorical_accuracy: 0.6600
Epoch 9/100
21/21 [==============================] - 13s 625ms/step - loss: 0.8463 - categorical_acc
uracy: 0.6359 - val_loss: 0.8045 - val_categorical_accuracy: 0.6200
Epoch 10/100
21/21 [==============================] - 13s 625ms/step - loss: 0.8257 - categorical_acc
uracy: 0.6748 - val_loss: 0.8133 - val_categorical_accuracy: 0.7000
Epoch 11/100
21/21 [==============================] - 14s 651ms/step - loss: 0.7880 - categorical_acc
uracy: 0.6602 - val_loss: 0.8591 - val_categorical_accuracy: 0.6000
Epoch 12/100
21/21 [==============================] - 13s 633ms/step - loss: 0.7562 - categorical_acc
uracy: 0.6796 - val_loss: 0.8321 - val_categorical_accuracy: 0.6400
Epoch 13/100
21/21 [==============================] - 13s 630ms/step - loss: 0.7302 - categorical_acc
uracy: 0.7039 - val_loss: 0.8407 - val_categorical_accuracy: 0.6600
Epoch 14/100
21/21 [==============================] - 13s 629ms/step - loss: 0.7030 - categorical_acc
uracy: 0.7233 - val_loss: 1.0960 - val_categorical_accuracy: 0.5200
Epoch 15/100
21/21 [==============================] - 13s 631ms/step - loss: 0.7846 - categorical_acc
uracy: 0.6748 - val_loss: 0.6260 - val_categorical_accuracy: 0.7000
Epoch 16/100
21/21 [==============================] - 13s 639ms/step - loss: 0.9256 - categorical_acc
uracy: 0.6165 - val_loss: 1.0902 - val_categorical_accuracy: 0.5800
Epoch 17/100
21/21 [==============================] - 13s 630ms/step - loss: 0.8917 - categorical_acc
uracy: 0.6117 - val_loss: 1.3743 - val_categorical_accuracy: 0.4600
Epoch 18/100
21/21 [==============================] - 13s 626ms/step - loss: 0.7073 - categorical_acc
uracy: 0.6748 - val_loss: 0.6242 - val_categorical_accuracy: 0.7200
Epoch 19/100
21/21 [==============================] - 13s 631ms/step - loss: 0.8487 - categorical_acc
uracy: 0.6505 - val_loss: 0.7225 - val_categorical_accuracy: 0.7000
Epoch 20/100
21/21 [==============================] - 14s 655ms/step - loss: 0.7119 - categorical_acc
uracy: 0.6990 - val_loss: 0.8855 - val_categorical_accuracy: 0.5000
Epoch 21/100
21/21 [==============================] - 14s 675ms/step - loss: 0.7167 - categorical_acc
uracy: 0.7087 - val_loss: 0.5505 - val_categorical_accuracy: 0.8000
Epoch 22/100
21/21 [==============================] - 14s 674ms/step - loss: 0.6908 - categorical_acc
```

```
uracy: 0.6796 - val_loss: 0.7556 - val_categorical_accuracy: 0.5600
Epoch 23/100
21/21 [==============================] - 14s 687ms/step - loss: 0.6635 - categorical_acc
uracy: 0.6893 - val_loss: 0.7624 - val_categorical_accuracy: 0.6400
Epoch 24/100
21/21 [==============================] - 15s 712ms/step - loss: 0.6713 - categorical_acc
uracy: 0.6845 - val_loss: 0.5872 - val_categorical_accuracy: 0.8200
Epoch 25/100
21/21 [==============================] - 15s 717ms/step - loss: 0.6898 - categorical_acc
uracy: 0.6990 - val_loss: 0.6140 - val_categorical_accuracy: 0.7200
Epoch 26/100
21/21 [==============================] - 15s 704ms/step - loss: 0.6735 - categorical_acc
uracy: 0.6650 - val_loss: 0.7307 - val_categorical_accuracy: 0.6400
Epoch 27/100
21/21 [==============================] - 14s 657ms/step - loss: 0.7651 - categorical_acc
uracy: 0.6505 - val_loss: 0.6007 - val_categorical_accuracy: 0.6800
Epoch 28/100
21/21 [==============================] - 15s 706ms/step - loss: 0.6848 - categorical_acc
uracy: 0.6650 - val_loss: 0.6771 - val_categorical_accuracy: 0.6600
Epoch 29/100
21/21 [==============================] - 15s 704ms/step - loss: 0.6156 - categorical_acc
uracy: 0.7476 - val_loss: 0.5150 - val_categorical_accuracy: 0.7400
Epoch 30/100
21/21 [==============================] - 15s 708ms/step - loss: 0.6662 - categorical_acc
uracy: 0.7282 - val_loss: 0.8201 - val_categorical_accuracy: 0.7000
Epoch 31/100
21/21 [==============================] - 15s 697ms/step - loss: 0.6923 - categorical_acc
uracy: 0.7427 - val_loss: 0.6378 - val_categorical_accuracy: 0.7200
Epoch 32/100
21/21 [==============================] - 15s 708ms/step - loss: 0.5876 - categorical_acc
uracy: 0.7330 - val_loss: 0.5242 - val_categorical_accuracy: 0.7800
Epoch 33/100
21/21 [==============================] - 15s 717ms/step - loss: 0.6702 - categorical_acc
uracy: 0.7573 - val_loss: 0.5628 - val_categorical_accuracy: 0.7400
Epoch 34/100
21/21 [==============================] - 15s 720ms/step - loss: 0.6760 - categorical_acc
uracy: 0.6796 - val_loss: 0.6085 - val_categorical_accuracy: 0.6400
Epoch 35/100
21/21 [==============================] - 16s 745ms/step - loss: 0.5811 - categorical_acc
uracy: 0.7573 - val_loss: 1.3283 - val_categorical_accuracy: 0.6000
Epoch 36/100
21/21 [==============================] - 14s 667ms/step - loss: 0.7387 - categorical_acc
uracy: 0.6602 - val_loss: 0.7400 - val_categorical_accuracy: 0.6400
Epoch 37/100
21/21 [==============================] - 15s 707ms/step - loss: 0.7457 - categorical_acc
uracy: 0.6408 - val_loss: 0.6764 - val_categorical_accuracy: 0.6600
Epoch 38/100
21/21 [==============================] - 15s 703ms/step - loss: 0.6712 - categorical_acc
uracy: 0.6990 - val_loss: 1.0589 - val_categorical_accuracy: 0.5600
Epoch 39/100
21/21 [==============================] - 15s 710ms/step - loss: 0.6915 - categorical_acc
uracy: 0.7087 - val_loss: 0.6743 - val_categorical_accuracy: 0.6200
Epoch 40/100
21/21 [==============================] - 15s 694ms/step - loss: 0.5852 - categorical_acc
uracy: 0.7621 - val_loss: 0.7640 - val_categorical_accuracy: 0.6400
Epoch 41/100
21/21 [==============================] - 14s 672ms/step - loss: 0.6454 - categorical_acc
uracy: 0.7233 - val_loss: 0.9113 - val_categorical_accuracy: 0.6000
Epoch 42/100
21/21 [==============================] - 14s 674ms/step - loss: 0.6946 - categorical_acc
```

```
uracy: 0.7039 - val_loss: 0.7954 - val_categorical_accuracy: 0.6800
Epoch 43/100
21/21 [==============================] - 14s 672ms/step - loss: 0.6023 - categorical_acc
uracy: 0.7476 - val_loss: 0.5490 - val_categorical_accuracy: 0.6800
Epoch 44/100
21/21 [==============================] - 14s 671ms/step - loss: 0.5570 - categorical_acc
uracy: 0.7621 - val_loss: 0.6132 - val_categorical_accuracy: 0.7200
Epoch 45/100
21/21 [==============================] - 14s 684ms/step - loss: 0.5531 - categorical_acc
uracy: 0.7718 - val_loss: 0.7525 - val_categorical_accuracy: 0.6600
Epoch 46/100
21/21 [==============================] - 14s 663ms/step - loss: 0.6058 - categorical_acc
uracy: 0.7573 - val_loss: 0.5611 - val_categorical_accuracy: 0.7000
Epoch 47/100
21/21 [==============================] - 14s 681ms/step - loss: 0.5574 - categorical_acc
uracy: 0.7524 - val_loss: 0.5471 - val_categorical_accuracy: 0.7800
Epoch 48/100
21/21 [==============================] - 14s 673ms/step - loss: 0.5269 - categorical_acc
uracy: 0.7816 - val_loss: 0.6566 - val_categorical_accuracy: 0.6600
Epoch 49/100
21/21 [==============================] - 14s 679ms/step - loss: 0.5212 - categorical_acc
uracy: 0.7767 - val_loss: 0.5557 - val_categorical_accuracy: 0.7400
Epoch 50/100
21/21 [==============================] - 14s 680ms/step - loss: 0.5532 - categorical_acc
uracy: 0.7913 - val_loss: 0.7965 - val_categorical_accuracy: 0.6400
Epoch 51/100
21/21 [==============================] - 14s 679ms/step - loss: 0.6079 - categorical_acc
uracy: 0.7330 - val_loss: 0.8610 - val_categorical_accuracy: 0.6400
Epoch 52/100
21/21 [==============================] - 14s 673ms/step - loss: 0.5460 - categorical_acc
uracy: 0.7718 - val_loss: 0.9379 - val_categorical_accuracy: 0.6200
Epoch 53/100
21/21 [==============================] - 14s 675ms/step - loss: 0.6140 - categorical_acc
uracy: 0.7476 - val_loss: 0.8440 - val_categorical_accuracy: 0.6000
Epoch 54/100
21/21 [==============================] - 14s 676ms/step - loss: 0.5954 - categorical_acc
uracy: 0.7476 - val_loss: 0.6495 - val_categorical_accuracy: 0.7600
Epoch 55/100
21/21 [==============================] - 14s 674ms/step - loss: 0.5348 - categorical_acc
uracy: 0.7864 - val_loss: 0.6188 - val_categorical_accuracy: 0.7000
Epoch 56/100
21/21 [==============================] - 14s 677ms/step - loss: 0.5560 - categorical_acc
uracy: 0.7427 - val_loss: 0.5679 - val_categorical_accuracy: 0.7400
Epoch 57/100
21/21 [==============================] - 14s 673ms/step - loss: 0.5875 - categorical_acc
uracy: 0.7476 - val_loss: 0.6813 - val_categorical_accuracy: 0.6000
Epoch 58/100
21/21 [==============================] - 14s 682ms/step - loss: 0.5748 - categorical_acc
uracy: 0.7476 - val_loss: 0.5886 - val_categorical_accuracy: 0.7200
Epoch 59/100
21/21 [==============================] - 15s 702ms/step - loss: 0.5368 - categorical_acc
uracy: 0.7524 - val_loss: 0.6768 - val_categorical_accuracy: 0.7200
Epoch 60/100
21/21 [==============================] - 15s 697ms/step - loss: 0.5298 - categorical_acc
uracy: 0.8010 - val_loss: 0.6979 - val_categorical_accuracy: 0.7200
Epoch 61/100
21/21 [==============================] - 15s 726ms/step - loss: 0.5597 - categorical_acc
uracy: 0.7233 - val_loss: 0.6975 - val_categorical_accuracy: 0.6000
Epoch 62/100
21/21 [==============================] - 15s 706ms/step - loss: 0.5936 - categorical_acc
```

```
uracy: 0.7233 - val_loss: 0.7930 - val_categorical_accuracy: 0.6600
Epoch 63/100
21/21 [==============================] - 15s 708ms/step - loss: 0.5644 - categorical_acc
uracy: 0.7767 - val_loss: 0.7554 - val_categorical_accuracy: 0.5800
Epoch 64/100
21/21 [==============================] - 15s 722ms/step - loss: 0.6012 - categorical_acc
uracy: 0.7282 - val_loss: 0.4864 - val_categorical_accuracy: 0.7800
Epoch 65/100
21/21 [==============================] - 15s 692ms/step - loss: 0.6084 - categorical_acc
uracy: 0.7233 - val_loss: 0.7780 - val_categorical_accuracy: 0.6200
Epoch 66/100
21/21 [==============================] - 14s 682ms/step - loss: 0.6100 - categorical_acc
uracy: 0.7621 - val_loss: 0.9396 - val_categorical_accuracy: 0.5600
Epoch 67/100
21/21 [==============================] - 15s 722ms/step - loss: 0.5931 - categorical_acc
uracy: 0.7282 - val_loss: 0.8330 - val_categorical_accuracy: 0.6200
Epoch 68/100
21/21 [==============================] - 14s 679ms/step - loss: 0.5809 - categorical_acc
uracy: 0.7621 - val_loss: 0.7627 - val_categorical_accuracy: 0.6400
Epoch 69/100
21/21 [==============================] - 14s 655ms/step - loss: 0.5396 - categorical_acc
uracy: 0.8058 - val_loss: 0.8683 - val_categorical_accuracy: 0.6000
Epoch 70/100
21/21 [==============================] - 14s 682ms/step - loss: 0.6343 - categorical_acc
uracy: 0.7184 - val_loss: 1.2533 - val_categorical_accuracy: 0.5400
Epoch 71/100
21/21 [==============================] - 14s 679ms/step - loss: 0.6970 - categorical_acc
uracy: 0.6748 - val_loss: 0.7456 - val_categorical_accuracy: 0.6400
Epoch 72/100
21/21 [==============================] - 14s 682ms/step - loss: 0.5303 - categorical_acc
uracy: 0.7816 - val_loss: 0.8743 - val_categorical_accuracy: 0.6600
Epoch 73/100
21/21 [==============================] - 14s 683ms/step - loss: 0.5717 - categorical_acc
uracy: 0.7427 - val_loss: 0.5851 - val_categorical_accuracy: 0.7000
Epoch 74/100
21/21 [==============================] - 14s 687ms/step - loss: 0.5119 - categorical_acc
uracy: 0.7621 - val_loss: 0.5795 - val_categorical_accuracy: 0.7200
Epoch 75/100
21/21 [==============================] - 14s 675ms/step - loss: 0.5298 - categorical_acc
uracy: 0.7961 - val_loss: 0.6762 - val_categorical_accuracy: 0.7000
Epoch 76/100
21/21 [==============================] - 14s 684ms/step - loss: 0.4929 - categorical_acc
uracy: 0.8107 - val_loss: 0.6786 - val_categorical_accuracy: 0.7200
Epoch 77/100
21/21 [==============================] - 14s 675ms/step - loss: 0.5242 - categorical_acc
uracy: 0.7767 - val_loss: 0.8066 - val_categorical_accuracy: 0.6400
Epoch 78/100
21/21 [==============================] - 14s 688ms/step - loss: 0.5971 - categorical_acc
uracy: 0.7864 - val_loss: 1.1145 - val_categorical_accuracy: 0.6200
Epoch 79/100
21/21 [==============================] - 14s 680ms/step - loss: 0.5152 - categorical_acc
uracy: 0.7621 - val_loss: 0.4777 - val_categorical_accuracy: 0.8400
Epoch 80/100
21/21 [==============================] - 14s 658ms/step - loss: 0.5537 - categorical_acc
uracy: 0.7864 - val_loss: 0.5568 - val_categorical_accuracy: 0.7600
Epoch 81/100
21/21 [==============================] - 14s 688ms/step - loss: 0.5500 - categorical_acc
uracy: 0.7816 - val_loss: 0.6957 - val_categorical_accuracy: 0.6600
Epoch 82/100
21/21 [==============================] - 14s 650ms/step - loss: 0.4785 - categorical_acc
```

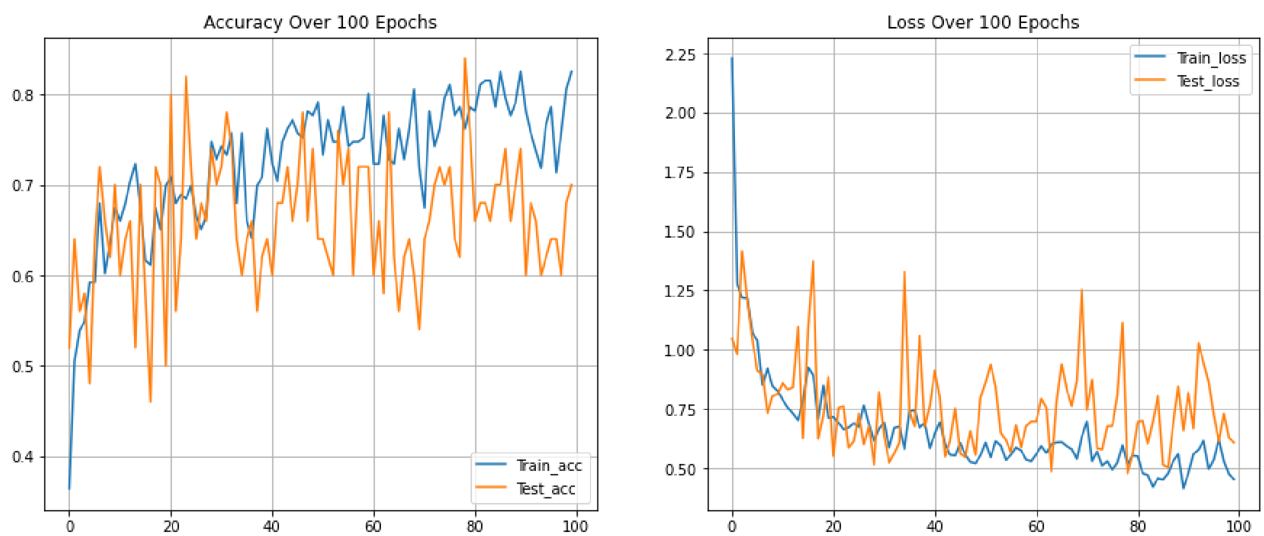
```
uracy: 0.8107 - val_loss: 0.7011 - val_categorical_accuracy: 0.6800
Epoch 83/100
21/21 [==============================] - 14s 670ms/step - loss: 0.4707 - categorical_acc
uracy: 0.8155 - val_loss: 0.6044 - val_categorical_accuracy: 0.6800
Epoch 84/100
21/21 [==============================] - 14s 683ms/step - loss: 0.4212 - categorical_acc
uracy: 0.8155 - val_loss: 0.6969 - val_categorical_accuracy: 0.6600
Epoch 85/100
21/21 [==============================] - 14s 679ms/step - loss: 0.4575 - categorical_acc
uracy: 0.7864 - val_loss: 0.8051 - val_categorical_accuracy: 0.7000
Epoch 86/100
21/21 [==============================] - 14s 679ms/step - loss: 0.4523 - categorical_acc
uracy: 0.8252 - val_loss: 0.5153 - val_categorical_accuracy: 0.7000
Epoch 87/100
21/21 [==============================] - 14s 675ms/step - loss: 0.4786 - categorical_acc
uracy: 0.7961 - val_loss: 0.5039 - val_categorical_accuracy: 0.7400
Epoch 88/100
21/21 [==============================] - 14s 675ms/step - loss: 0.5296 - categorical_acc
uracy: 0.7767 - val_loss: 0.6858 - val_categorical_accuracy: 0.6600
Epoch 89/100
21/21 [==============================] - 15s 687ms/step - loss: 0.5598 - categorical_acc
uracy: 0.7913 - val_loss: 0.8444 - val_categorical_accuracy: 0.7000
Epoch 90/100
21/21 [==============================] - 14s 674ms/step - loss: 0.4149 - categorical_acc
uracy: 0.8252 - val_loss: 0.6589 - val_categorical_accuracy: 0.7400
Epoch 91/100
21/21 [==============================] - 14s 675ms/step - loss: 0.4783 - categorical_acc
uracy: 0.7816 - val_loss: 0.8178 - val_categorical_accuracy: 0.6000
Epoch 92/100
21/21 [==============================] - 14s 680ms/step - loss: 0.5592 - categorical_acc
uracy: 0.7573 - val_loss: 0.6674 - val_categorical_accuracy: 0.6800
Epoch 93/100
21/21 [==============================] - 14s 671ms/step - loss: 0.5789 - categorical_acc
uracy: 0.7379 - val_loss: 1.0272 - val_categorical_accuracy: 0.6600
Epoch 94/100
21/21 [==============================] - 14s 659ms/step - loss: 0.6158 - categorical_acc
uracy: 0.7184 - val_loss: 0.9452 - val_categorical_accuracy: 0.6000
Epoch 95/100
21/21 [==============================] - 14s 679ms/step - loss: 0.4965 - categorical_acc
uracy: 0.7670 - val_loss: 0.8646 - val_categorical_accuracy: 0.6200
Epoch 96/100
21/21 [==============================] - 15s 695ms/step - loss: 0.5369 - categorical_acc
uracy: 0.7864 - val_loss: 0.7234 - val_categorical_accuracy: 0.6400
Epoch 97/100
21/21 [==============================] - 14s 681ms/step - loss: 0.6235 - categorical_acc
uracy: 0.7136 - val_loss: 0.6121 - val_categorical_accuracy: 0.6400
Epoch 98/100
21/21 [==============================] - 14s 686ms/step - loss: 0.5301 - categorical_acc
uracy: 0.7573 - val_loss: 0.7294 - val_categorical_accuracy: 0.6000
Epoch 99/100
21/21 [==============================] - 14s 680ms/step - loss: 0.4741 - categorical_acc
uracy: 0.8058 - val_loss: 0.6275 - val_categorical_accuracy: 0.6800
Epoch 100/100
21/21 [==============================] - 14s 685ms/step - loss: 0.4540 - categorical_acc
uracy: 0.8252 - val_loss: 0.6081 - val_categorical_accuracy: 0.7000
```

[5 points] Plot Accuracy and Loss During Training

In [9]:

```
import matplotlib.pyplot as plt
```

```
fig, (ax1, ax2) = plt.subplots(1, 2)
fig.set_figheight(6)
fig.set_figwidth(15)
ax1.plot(res.history['categorical_accuracy'])
ax1.plot(res.history['val_categorical_accuracy'])
ax1.set_title('Accuracy Over ' + str(NUM_EPOCHS) + ' Epochs')
ax1.legend(['Train_acc', 'Test_acc'], loc='lower right')
ax1.grid(True)
ax2.set_title('Loss Over ' + str(NUM_EPOCHS) + ' Epochs')
ax2.plot(res.history['loss'])
ax2.plot(res.history['val_loss'])
ax2.legend(['Train_loss', 'Test_loss'], loc='upper right')
ax2.grid(True)
plt.show()
```



Testing Model

In [10]:

```
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,cla
eval_generator.reset()
print(len(eval_generator))
x = model.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.
36
 2/36 [>.............................] - ETA: 2s - loss: 3.9921 - categorical_accuracy:
0.5000
C:\ProgramData\Anaconda3\lib\site-packages\keras\engine\training.py:2006: 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 [==============================] - 2s 61ms/step - loss: 0.7604 - categorical_accur
acy: 0.6944
Test loss: 0.7604448795318604
Test accuracy: 0.6944444179534912
```

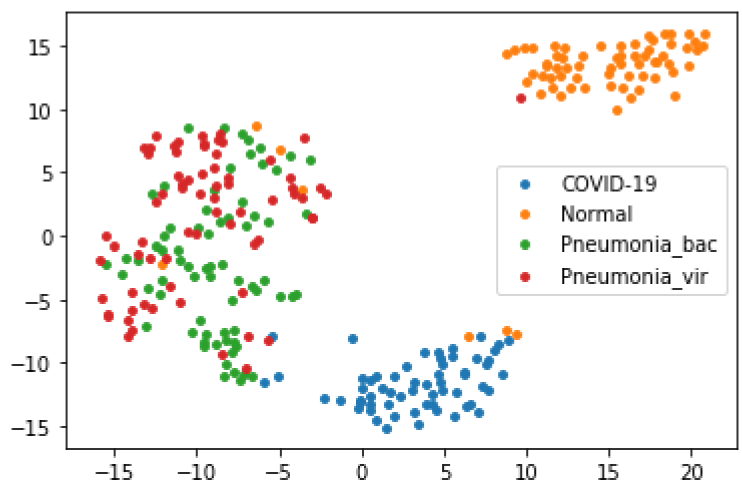
[10 points] TSNE Plot

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 [15]:

```
from sklearn.manifold import TSNE

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

tsne_eval_generator = test_datagen.flow_from_directory(DATASET_PATH,target_size=IMAGE_S
                                                  batch_size=1,shuffle=True,seed=42,cla

raise NotImplementedError("Extract features from the tsne_data_generator and fit a t-SN
                          "and plot the resulting 2D features of the four classes.")
```

```
Found 270 images belonging to 4 classes.
{'covid': 0, 'normal': 1, 'pneumonia_bac': 2, 'pneumonia_vir': 3}
Extracting features for 270 images.
270/270 [==============================] - 71s 265ms/step
Training TSNE model.
```



Attempt 2: Revising the vgg16 model with additional layers

[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 [106…

```
vgg16 = tf.keras.applications.VGG16(weights='imagenet', include_top=False, input_shape=
vgg16.trainable = False
model = tf.keras.Sequential([
    vgg16,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(500, activation='relu'),
```

```
    tf.keras.layers.Dropout(rate=0.2),
    tf.keras.layers.Dense(125, activation='relu'),
    tf.keras.layers.Dropout(rate=0.2),
    tf.keras.layers.Dense(4, activation='softmax')
])
model.compile(optimizer = tf.keras.optimizers.Adam(learning_rate=1e-5), loss = 'categor
              metrics = ['categorical_accuracy'])
```

In [107…

```
model.summary()
```

```
Model: "sequential_25"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
vgg16 (Functional)           (None, 7, 7, 512)         14714688  
_________________________________________________________________
flatten_25 (Flatten)         (None, 25088)             0         
_________________________________________________________________
dense_76 (Dense)             (None, 500)               12544500  
_________________________________________________________________
dropout_49 (Dropout)         (None, 500)               0         
_________________________________________________________________
dense_77 (Dense)             (None, 125)               62625     
_________________________________________________________________
dropout_50 (Dropout)         (None, 125)               0         
_________________________________________________________________
dense_78 (Dense)             (None, 4)                 504       
=================================================================
Total params: 27,322,317
Trainable params: 12,607,629
Non-trainable params: 14,714,688
_________________________________________________________________
```

[5 points] Train Model

In [108…

```
#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



res = model.fit(train_batches, epochs=NUM_EPOCHS, steps_per_epoch=STEP_SIZE_TRAIN, \
          validation_data=valid_batches, validation_steps=STEP_SIZE_VALID)
```

```
22
6
Epoch 1/100
21/21 [==============================] - 16s 730ms/step - loss: 1.5256 - categorical_acc
uracy: 0.2571 - val_loss: 1.3473 - val_categorical_accuracy: 0.2800
Epoch 2/100
21/21 [==============================] - 15s 736ms/step - loss: 1.3996 - categorical_acc
uracy: 0.2864 - val_loss: 1.3457 - val_categorical_accuracy: 0.4400
Epoch 3/100
21/21 [==============================] - 15s 737ms/step - loss: 1.3743 - categorical_acc
```

```
uracy: 0.3058 - val_loss: 1.2964 - val_categorical_accuracy: 0.4400
Epoch 4/100
21/21 [==============================] - 17s 793ms/step - loss: 1.3410 - categorical_acc
uracy: 0.3495 - val_loss: 1.2727 - val_categorical_accuracy: 0.4000
Epoch 5/100
21/21 [==============================] - 17s 788ms/step - loss: 1.3080 - categorical_acc
uracy: 0.3952 - val_loss: 1.2660 - val_categorical_accuracy: 0.4000
Epoch 6/100
21/21 [==============================] - 16s 776ms/step - loss: 1.3034 - categorical_acc
uracy: 0.3738 - val_loss: 1.1904 - val_categorical_accuracy: 0.5400
Epoch 7/100
21/21 [==============================] - 16s 785ms/step - loss: 1.2384 - categorical_acc
uracy: 0.4466 - val_loss: 1.1790 - val_categorical_accuracy: 0.4400
Epoch 8/100
21/21 [==============================] - 16s 772ms/step - loss: 1.2014 - categorical_acc
uracy: 0.4369 - val_loss: 1.1511 - val_categorical_accuracy: 0.4400
Epoch 9/100
21/21 [==============================] - 16s 766ms/step - loss: 1.1721 - categorical_acc
uracy: 0.4903 - val_loss: 1.1022 - val_categorical_accuracy: 0.5800
Epoch 10/100
21/21 [==============================] - 16s 761ms/step - loss: 1.1569 - categorical_acc
uracy: 0.5291 - val_loss: 1.0469 - val_categorical_accuracy: 0.6200
Epoch 11/100
21/21 [==============================] - 16s 775ms/step - loss: 1.1385 - categorical_acc
uracy: 0.4757 - val_loss: 1.0814 - val_categorical_accuracy: 0.5200
Epoch 12/100
21/21 [==============================] - 16s 765ms/step - loss: 1.0762 - categorical_acc
uracy: 0.5728 - val_loss: 1.0509 - val_categorical_accuracy: 0.4800
Epoch 13/100
21/21 [==============================] - 16s 771ms/step - loss: 1.1088 - categorical_acc
uracy: 0.5437 - val_loss: 1.0136 - val_categorical_accuracy: 0.5400
Epoch 14/100
21/21 [==============================] - 17s 783ms/step - loss: 1.0383 - categorical_acc
uracy: 0.5680 - val_loss: 0.9926 - val_categorical_accuracy: 0.6200
Epoch 15/100
21/21 [==============================] - 17s 791ms/step - loss: 1.0628 - categorical_acc
uracy: 0.5049 - val_loss: 0.9945 - val_categorical_accuracy: 0.5000
Epoch 16/100
21/21 [==============================] - 16s 770ms/step - loss: 1.0770 - categorical_acc
uracy: 0.5049 - val_loss: 0.9241 - val_categorical_accuracy: 0.6200
Epoch 17/100
21/21 [==============================] - 16s 772ms/step - loss: 0.9833 - categorical_acc
uracy: 0.6068 - val_loss: 0.9012 - val_categorical_accuracy: 0.6400
Epoch 18/100
21/21 [==============================] - 16s 766ms/step - loss: 0.9968 - categorical_acc
uracy: 0.5243 - val_loss: 1.0218 - val_categorical_accuracy: 0.4800
Epoch 19/100
21/21 [==============================] - 17s 797ms/step - loss: 1.0115 - categorical_acc
uracy: 0.5922 - val_loss: 0.9368 - val_categorical_accuracy: 0.6000
Epoch 20/100
21/21 [==============================] - 17s 783ms/step - loss: 0.9791 - categorical_acc
uracy: 0.5680 - val_loss: 0.9529 - val_categorical_accuracy: 0.5200
Epoch 21/100
21/21 [==============================] - 17s 788ms/step - loss: 1.0664 - categorical_acc
uracy: 0.5243 - val_loss: 0.9011 - val_categorical_accuracy: 0.5600
Epoch 22/100
21/21 [==============================] - 17s 794ms/step - loss: 0.9774 - categorical_acc
uracy: 0.5922 - val_loss: 0.8851 - val_categorical_accuracy: 0.6800
Epoch 23/100
21/21 [==============================] - 17s 798ms/step - loss: 0.9305 - categorical_acc
```

```
uracy: 0.6019 - val_loss: 0.8752 - val_categorical_accuracy: 0.6400
Epoch 24/100
21/21 [==============================] - 16s 793ms/step - loss: 0.9641 - categorical_acc
uracy: 0.6165 - val_loss: 0.8295 - val_categorical_accuracy: 0.6600
Epoch 25/100
21/21 [==============================] - 17s 789ms/step - loss: 0.9490 - categorical_acc
uracy: 0.5825 - val_loss: 0.9095 - val_categorical_accuracy: 0.6000
Epoch 26/100
21/21 [==============================] - 17s 792ms/step - loss: 0.9637 - categorical_acc
uracy: 0.5777 - val_loss: 0.8205 - val_categorical_accuracy: 0.7600
Epoch 27/100
21/21 [==============================] - 17s 790ms/step - loss: 0.9420 - categorical_acc
uracy: 0.5922 - val_loss: 0.9387 - val_categorical_accuracy: 0.5200
Epoch 28/100
21/21 [==============================] - 17s 804ms/step - loss: 0.9356 - categorical_acc
uracy: 0.5810 - val_loss: 0.8439 - val_categorical_accuracy: 0.6800
Epoch 29/100
21/21 [==============================] - 16s 782ms/step - loss: 0.8930 - categorical_acc
uracy: 0.6456 - val_loss: 0.8396 - val_categorical_accuracy: 0.5800
Epoch 30/100
21/21 [==============================] - 17s 813ms/step - loss: 0.9135 - categorical_acc
uracy: 0.5905 - val_loss: 0.8276 - val_categorical_accuracy: 0.6000
Epoch 31/100
21/21 [==============================] - 17s 795ms/step - loss: 0.8680 - categorical_acc
uracy: 0.6408 - val_loss: 0.8018 - val_categorical_accuracy: 0.6800
Epoch 32/100
21/21 [==============================] - 16s 785ms/step - loss: 0.8336 - categorical_acc
uracy: 0.6845 - val_loss: 0.8046 - val_categorical_accuracy: 0.7000
Epoch 33/100
21/21 [==============================] - 15s 725ms/step - loss: 0.8228 - categorical_acc
uracy: 0.6845 - val_loss: 0.8323 - val_categorical_accuracy: 0.6600
Epoch 34/100
21/21 [==============================] - 16s 762ms/step - loss: 0.8506 - categorical_acc
uracy: 0.6214 - val_loss: 0.8489 - val_categorical_accuracy: 0.6400
Epoch 35/100
21/21 [==============================] - 16s 780ms/step - loss: 0.8518 - categorical_acc
uracy: 0.6359 - val_loss: 0.8607 - val_categorical_accuracy: 0.5800
Epoch 36/100
21/21 [==============================] - 16s 747ms/step - loss: 0.8660 - categorical_acc
uracy: 0.6408 - val_loss: 0.9271 - val_categorical_accuracy: 0.5400
Epoch 37/100
21/21 [==============================] - 16s 742ms/step - loss: 0.8793 - categorical_acc
uracy: 0.5777 - val_loss: 0.8072 - val_categorical_accuracy: 0.6000
Epoch 38/100
21/21 [==============================] - 16s 774ms/step - loss: 0.8588 - categorical_acc
uracy: 0.6165 - val_loss: 0.7877 - val_categorical_accuracy: 0.6400
Epoch 39/100
21/21 [==============================] - 16s 772ms/step - loss: 0.8651 - categorical_acc
uracy: 0.6019 - val_loss: 0.7711 - val_categorical_accuracy: 0.6200
Epoch 40/100
21/21 [==============================] - 17s 803ms/step - loss: 0.8522 - categorical_acc
uracy: 0.6214 - val_loss: 0.8392 - val_categorical_accuracy: 0.6200
Epoch 41/100
21/21 [==============================] - 15s 718ms/step - loss: 0.8181 - categorical_acc
uracy: 0.6553 - val_loss: 0.8123 - val_categorical_accuracy: 0.6000
Epoch 42/100
21/21 [==============================] - 17s 795ms/step - loss: 0.8270 - categorical_acc
uracy: 0.6699 - val_loss: 0.7008 - val_categorical_accuracy: 0.6800
Epoch 43/100
21/21 [==============================] - 18s 875ms/step - loss: 0.8361 - categorical_acc
```

```
uracy: 0.6262 - val_loss: 0.7835 - val_categorical_accuracy: 0.5800
Epoch 44/100
21/21 [==============================] - 18s 868ms/step - loss: 0.8245 - categorical_acc
uracy: 0.6762 - val_loss: 0.8003 - val_categorical_accuracy: 0.6400
Epoch 45/100
21/21 [==============================] - 17s 806ms/step - loss: 0.8592 - categorical_acc
uracy: 0.6359 - val_loss: 0.8018 - val_categorical_accuracy: 0.6000
Epoch 46/100
21/21 [==============================] - 16s 762ms/step - loss: 0.8045 - categorical_acc
uracy: 0.6796 - val_loss: 0.7967 - val_categorical_accuracy: 0.6000
Epoch 47/100
21/21 [==============================] - 17s 816ms/step - loss: 0.8124 - categorical_acc
uracy: 0.6650 - val_loss: 0.7897 - val_categorical_accuracy: 0.6000
Epoch 48/100
21/21 [==============================] - 17s 836ms/step - loss: 0.8001 - categorical_acc
uracy: 0.6650 - val_loss: 0.7925 - val_categorical_accuracy: 0.6000
Epoch 49/100
21/21 [==============================] - 18s 865ms/step - loss: 0.7459 - categorical_acc
uracy: 0.6408 - val_loss: 0.7188 - val_categorical_accuracy: 0.6600
Epoch 50/100
21/21 [==============================] - 16s 750ms/step - loss: 0.8010 - categorical_acc
uracy: 0.6748 - val_loss: 0.9118 - val_categorical_accuracy: 0.5200
Epoch 51/100
21/21 [==============================] - 17s 810ms/step - loss: 0.7472 - categorical_acc
uracy: 0.6796 - val_loss: 0.7118 - val_categorical_accuracy: 0.6600
Epoch 52/100
21/21 [==============================] - 18s 832ms/step - loss: 0.8241 - categorical_acc
uracy: 0.6381 - val_loss: 0.8619 - val_categorical_accuracy: 0.6000
Epoch 53/100
21/21 [==============================] - 18s 868ms/step - loss: 0.8229 - categorical_acc
uracy: 0.6456 - val_loss: 0.8276 - val_categorical_accuracy: 0.6200
Epoch 54/100
21/21 [==============================] - 17s 820ms/step - loss: 0.8040 - categorical_acc
uracy: 0.6952 - val_loss: 0.7786 - val_categorical_accuracy: 0.6400
Epoch 55/100
21/21 [==============================] - 17s 827ms/step - loss: 0.8307 - categorical_acc
uracy: 0.6262 - val_loss: 0.7834 - val_categorical_accuracy: 0.5400
Epoch 56/100
21/21 [==============================] - 18s 846ms/step - loss: 0.7791 - categorical_acc
uracy: 0.7039 - val_loss: 0.7350 - val_categorical_accuracy: 0.6600
Epoch 57/100
21/21 [==============================] - 18s 860ms/step - loss: 0.7337 - categorical_acc
uracy: 0.6990 - val_loss: 0.7322 - val_categorical_accuracy: 0.6400
Epoch 58/100
21/21 [==============================] - 18s 856ms/step - loss: 0.7646 - categorical_acc
uracy: 0.7039 - val_loss: 0.7506 - val_categorical_accuracy: 0.7000
Epoch 59/100
21/21 [==============================] - 19s 878ms/step - loss: 0.7742 - categorical_acc
uracy: 0.6650 - val_loss: 0.7285 - val_categorical_accuracy: 0.6400
Epoch 60/100
21/21 [==============================] - 18s 831ms/step - loss: 0.6988 - categorical_acc
uracy: 0.6845 - val_loss: 0.7820 - val_categorical_accuracy: 0.5600
Epoch 61/100
21/21 [==============================] - 18s 863ms/step - loss: 0.7218 - categorical_acc
uracy: 0.7039 - val_loss: 0.7406 - val_categorical_accuracy: 0.6400
Epoch 62/100
21/21 [==============================] - 19s 899ms/step - loss: 0.7581 - categorical_acc
uracy: 0.6553 - val_loss: 0.7649 - val_categorical_accuracy: 0.5800
Epoch 63/100
21/21 [==============================] - 19s 884ms/step - loss: 0.7337 - categorical_acc
```

```
uracy: 0.6602 - val_loss: 0.7345 - val_categorical_accuracy: 0.6600
Epoch 64/100
21/21 [==============================] - 19s 904ms/step - loss: 0.6880 - categorical_acc
uracy: 0.7039 - val_loss: 0.6959 - val_categorical_accuracy: 0.7000
Epoch 65/100
21/21 [==============================] - 18s 872ms/step - loss: 0.7359 - categorical_acc
uracy: 0.6990 - val_loss: 0.6780 - val_categorical_accuracy: 0.6400
Epoch 66/100
21/21 [==============================] - 18s 874ms/step - loss: 0.6784 - categorical_acc
uracy: 0.7476 - val_loss: 0.7135 - val_categorical_accuracy: 0.6800
Epoch 67/100
21/21 [==============================] - 19s 881ms/step - loss: 0.6953 - categorical_acc
uracy: 0.7087 - val_loss: 0.6518 - val_categorical_accuracy: 0.6600
Epoch 68/100
21/21 [==============================] - 20s 936ms/step - loss: 0.8135 - categorical_acc
uracy: 0.6068 - val_loss: 0.8039 - val_categorical_accuracy: 0.5600
Epoch 69/100
21/21 [==============================] - 19s 907ms/step - loss: 0.7258 - categorical_acc
uracy: 0.6990 - val_loss: 0.7028 - val_categorical_accuracy: 0.7600
Epoch 70/100
21/21 [==============================] - 19s 885ms/step - loss: 0.7403 - categorical_acc
uracy: 0.6748 - val_loss: 0.7585 - val_categorical_accuracy: 0.7200
Epoch 71/100
21/21 [==============================] - 19s 906ms/step - loss: 0.7517 - categorical_acc
uracy: 0.6796 - val_loss: 0.7324 - val_categorical_accuracy: 0.7000
Epoch 72/100
21/21 [==============================] - 16s 767ms/step - loss: 0.7306 - categorical_acc
uracy: 0.6942 - val_loss: 0.6031 - val_categorical_accuracy: 0.7200
Epoch 73/100
21/21 [==============================] - 16s 748ms/step - loss: 0.6886 - categorical_acc
uracy: 0.7379 - val_loss: 0.7213 - val_categorical_accuracy: 0.5400
Epoch 74/100
21/21 [==============================] - 16s 746ms/step - loss: 0.7387 - categorical_acc
uracy: 0.6893 - val_loss: 0.7330 - val_categorical_accuracy: 0.6200
Epoch 75/100
21/21 [==============================] - 16s 753ms/step - loss: 0.7185 - categorical_acc
uracy: 0.6650 - val_loss: 0.6559 - val_categorical_accuracy: 0.7600
Epoch 76/100
21/21 [==============================] - 16s 769ms/step - loss: 0.7401 - categorical_acc
uracy: 0.6990 - val_loss: 0.7027 - val_categorical_accuracy: 0.5800
Epoch 77/100
21/21 [==============================] - 16s 758ms/step - loss: 0.6770 - categorical_acc
uracy: 0.7621 - val_loss: 0.6649 - val_categorical_accuracy: 0.7600
Epoch 78/100
21/21 [==============================] - 16s 753ms/step - loss: 0.7340 - categorical_acc
uracy: 0.6845 - val_loss: 0.6997 - val_categorical_accuracy: 0.6400
Epoch 79/100
21/21 [==============================] - 16s 764ms/step - loss: 0.7009 - categorical_acc
uracy: 0.7330 - val_loss: 0.7243 - val_categorical_accuracy: 0.5800
Epoch 80/100
21/21 [==============================] - 16s 783ms/step - loss: 0.7129 - categorical_acc
uracy: 0.6990 - val_loss: 0.8181 - val_categorical_accuracy: 0.5800
Epoch 81/100
21/21 [==============================] - 16s 768ms/step - loss: 0.7428 - categorical_acc
uracy: 0.6942 - val_loss: 0.6730 - val_categorical_accuracy: 0.7000
Epoch 82/100
21/21 [==============================] - 16s 781ms/step - loss: 0.7018 - categorical_acc
uracy: 0.6942 - val_loss: 0.7864 - val_categorical_accuracy: 0.6200
Epoch 83/100
21/21 [==============================] - 17s 790ms/step - loss: 0.7019 - categorical_acc
```

```
uracy: 0.6990 - val_loss: 0.6251 - val_categorical_accuracy: 0.7000
Epoch 84/100
21/21 [==============================] - 17s 792ms/step - loss: 0.7014 - categorical_acc
uracy: 0.6942 - val_loss: 0.7933 - val_categorical_accuracy: 0.6600
Epoch 85/100
21/21 [==============================] - 16s 781ms/step - loss: 0.6824 - categorical_acc
uracy: 0.7087 - val_loss: 0.6870 - val_categorical_accuracy: 0.6400
Epoch 86/100
21/21 [==============================] - 16s 771ms/step - loss: 0.7167 - categorical_acc
uracy: 0.6893 - val_loss: 0.7381 - val_categorical_accuracy: 0.6000
Epoch 87/100
21/21 [==============================] - 16s 752ms/step - loss: 0.7577 - categorical_acc
uracy: 0.6359 - val_loss: 0.7317 - val_categorical_accuracy: 0.5800
Epoch 88/100
21/21 [==============================] - 16s 761ms/step - loss: 0.6477 - categorical_acc
uracy: 0.7427 - val_loss: 0.6850 - val_categorical_accuracy: 0.6600
Epoch 89/100
21/21 [==============================] - 15s 734ms/step - loss: 0.6786 - categorical_acc
uracy: 0.7184 - val_loss: 0.5812 - val_categorical_accuracy: 0.7800
Epoch 90/100
21/21 [==============================] - 15s 728ms/step - loss: 0.6739 - categorical_acc
uracy: 0.6796 - val_loss: 0.7188 - val_categorical_accuracy: 0.6200
Epoch 91/100
21/21 [==============================] - 15s 731ms/step - loss: 0.6774 - categorical_acc
uracy: 0.6942 - val_loss: 0.6916 - val_categorical_accuracy: 0.7000
Epoch 92/100
21/21 [==============================] - 15s 731ms/step - loss: 0.6837 - categorical_acc
uracy: 0.7136 - val_loss: 0.7494 - val_categorical_accuracy: 0.6000
Epoch 93/100
21/21 [==============================] - 16s 748ms/step - loss: 0.6728 - categorical_acc
uracy: 0.7087 - val_loss: 0.6472 - val_categorical_accuracy: 0.7000
Epoch 94/100
21/21 [==============================] - 16s 764ms/step - loss: 0.6821 - categorical_acc
uracy: 0.7233 - val_loss: 0.6472 - val_categorical_accuracy: 0.7600
Epoch 95/100
21/21 [==============================] - 16s 742ms/step - loss: 0.7226 - categorical_acc
uracy: 0.6619 - val_loss: 0.7326 - val_categorical_accuracy: 0.6600
Epoch 96/100
21/21 [==============================] - 17s 780ms/step - loss: 0.6432 - categorical_acc
uracy: 0.7670 - val_loss: 0.6320 - val_categorical_accuracy: 0.7400
Epoch 97/100
21/21 [==============================] - 16s 764ms/step - loss: 0.6542 - categorical_acc
uracy: 0.7282 - val_loss: 0.6764 - val_categorical_accuracy: 0.6600
Epoch 98/100
21/21 [==============================] - 16s 747ms/step - loss: 0.6859 - categorical_acc
uracy: 0.7379 - val_loss: 0.6319 - val_categorical_accuracy: 0.7400
Epoch 99/100
21/21 [==============================] - 16s 748ms/step - loss: 0.6761 - categorical_acc
uracy: 0.7330 - val_loss: 0.7390 - val_categorical_accuracy: 0.6600
Epoch 100/100
21/21 [==============================] - 16s 759ms/step - loss: 0.7077 - categorical_acc
uracy: 0.6845 - val_loss: 0.6197 - val_categorical_accuracy: 0.7200
```

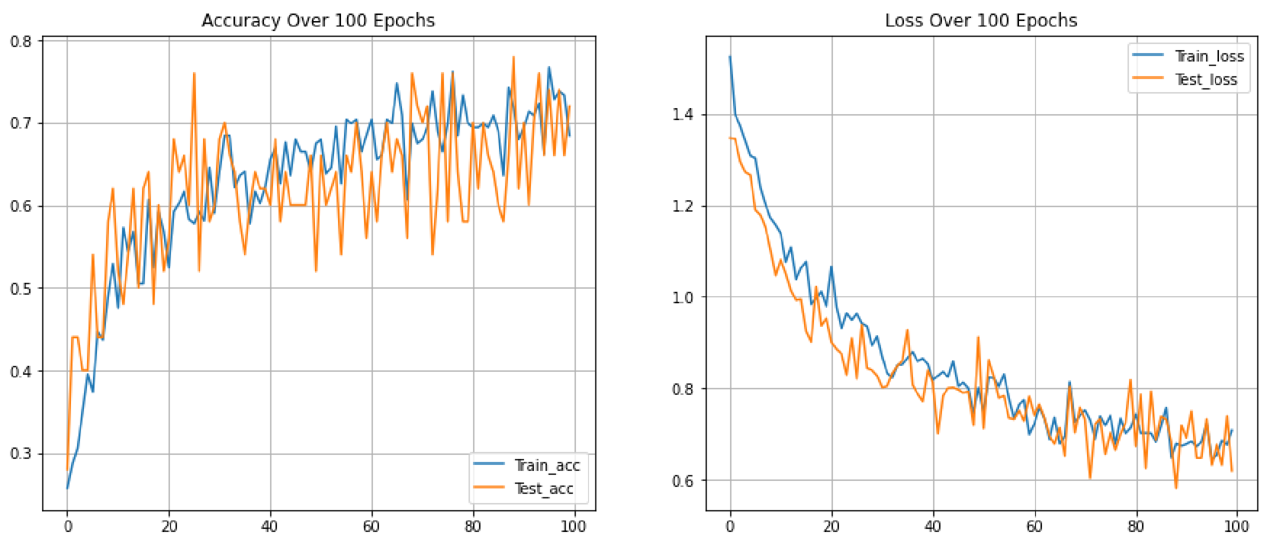
[5 points] Plot Accuracy and Loss During Training

In [111…

```python
import matplotlib.pyplot as plt

fig, (ax1, ax2) = plt.subplots(1, 2)
fig.set_figheight(6)
```

```
fig.set_figwidth(15)
ax1.plot(res.history['categorical_accuracy'])
ax1.plot(res.history['val_categorical_accuracy'])
ax1.set_title('Accuracy Over ' + str(NUM_EPOCHS) + ' Epochs')
ax1.legend(['Train_acc', 'Test_acc'], loc='lower right')
ax1.grid(True)
ax2.set_title('Loss Over ' + str(NUM_EPOCHS) + ' Epochs')
ax2.plot(res.history['loss'])
ax2.plot(res.history['val_loss'])
ax2.legend(['Train_loss', 'Test_loss'], loc='upper right')
ax2.grid(True)
plt.show()
```



Testing Model

In [112…

```
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,cla
eval_generator.reset()
print(len(eval_generator))
x = model.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.
36
36/36 [==============================] - 3s 82ms/step - loss: 0.8460 - categorical_accur
acy: 0.6389
Test loss: 0.8460082411766052
Test accuracy: 0.6388888955116272
```

Attempt 3: Try generating more fake data with data augmentation

Generate Training and Validation Batches

In [115…

```
train_datagen = ImageDataGenerator(rescale=1./255,rotation_range=50,featurewise_center
```

```
                                    featurewise_std_normalization = True,width_shift_ran
                                    height_shift_range=0.2,shear_range=0.25,zoom_range=0
                                    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.
```

[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 [123…

```
vgg16 = tf.keras.applications.VGG16(weights='imagenet', include_top=False, input_shape=
vgg16.trainable = False
model = tf.keras.Sequential([
    vgg16,
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(4, activation='softmax')
])
model.compile(optimizer = tf.keras.optimizers.Adam(learning_rate=1e-5),
              loss = 'categorical_crossentropy', metrics = ['categorical_accuracy'])
```

In [124…

```
model.summary()
```

```
Model: "sequential_29"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
vgg16 (Functional)           (None, 7, 7, 512)         14714688
_________________________________________________________________
flatten_29 (Flatten)         (None, 25088)             0
_________________________________________________________________
dense_85 (Dense)             (None, 128)               3211392
_________________________________________________________________
dense_86 (Dense)             (None, 4)                 516
=================================================================
Total params: 17,926,596
Trainable params: 3,211,908
Non-trainable params: 14,714,688
_________________________________________________________________
```

[5 points] Train Model

In [125…

```
#FIT MODEL


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

NUM_EPOCHS = 500

res = model.fit(train_batches, epochs=NUM_EPOCHS, steps_per_epoch = STEP_SIZE_TRAIN, \
         validation_data=valid_batches, validation_steps= STEP_SIZE_VALID)
```

```
Epoch 1/500
21/21 [==============================] - 15s 694ms/step - loss: 1.4142 - categorical_acc
uracy: 0.2961 - val_loss: 1.3821 - val_categorical_accuracy: 0.2200
Epoch 2/500
21/21 [==============================] - 14s 647ms/step - loss: 1.3580 - categorical_acc
uracy: 0.3398 - val_loss: 1.3469 - val_categorical_accuracy: 0.3000
Epoch 3/500
21/21 [==============================] - 13s 641ms/step - loss: 1.2848 - categorical_acc
uracy: 0.4029 - val_loss: 1.2987 - val_categorical_accuracy: 0.5200
Epoch 4/500
21/21 [==============================] - 14s 643ms/step - loss: 1.2616 - categorical_acc
uracy: 0.4078 - val_loss: 1.2541 - val_categorical_accuracy: 0.4200
Epoch 5/500
21/21 [==============================] - 14s 642ms/step - loss: 1.2389 - categorical_acc
uracy: 0.4126 - val_loss: 1.2271 - val_categorical_accuracy: 0.4800
Epoch 6/500
21/21 [==============================] - 14s 643ms/step - loss: 1.1970 - categorical_acc
uracy: 0.5291 - val_loss: 1.1538 - val_categorical_accuracy: 0.5400
Epoch 7/500
21/21 [==============================] - 14s 643ms/step - loss: 1.1588 - categorical_acc
uracy: 0.5146 - val_loss: 1.1344 - val_categorical_accuracy: 0.5400
Epoch 8/500
21/21 [==============================] - 14s 642ms/step - loss: 1.1269 - categorical_acc
uracy: 0.5485 - val_loss: 1.1357 - val_categorical_accuracy: 0.4800
Epoch 9/500
21/21 [==============================] - 14s 662ms/step - loss: 1.1215 - categorical_acc
uracy: 0.5485 - val_loss: 1.0950 - val_categorical_accuracy: 0.5400
Epoch 10/500
21/21 [==============================] - 14s 651ms/step - loss: 1.0991 - categorical_acc
uracy: 0.5631 - val_loss: 1.0731 - val_categorical_accuracy: 0.6200
Epoch 11/500
21/21 [==============================] - 14s 650ms/step - loss: 1.0718 - categorical_acc
uracy: 0.5194 - val_loss: 1.0887 - val_categorical_accuracy: 0.5000
Epoch 12/500
21/21 [==============================] - 14s 652ms/step - loss: 1.0591 - categorical_acc
uracy: 0.5485 - val_loss: 1.0651 - val_categorical_accuracy: 0.4800
Epoch 13/500
21/21 [==============================] - 14s 654ms/step - loss: 1.0345 - categorical_acc
uracy: 0.6262 - val_loss: 1.0061 - val_categorical_accuracy: 0.7400
Epoch 14/500
21/21 [==============================] - 14s 652ms/step - loss: 1.0067 - categorical_acc
uracy: 0.5825 - val_loss: 1.0708 - val_categorical_accuracy: 0.4800
Epoch 15/500
21/21 [==============================] - 14s 648ms/step - loss: 1.0443 - categorical_acc
uracy: 0.5194 - val_loss: 0.9748 - val_categorical_accuracy: 0.6600
Epoch 16/500
21/21 [==============================] - 14s 657ms/step - loss: 0.9873 - categorical_acc
uracy: 0.6359 - val_loss: 0.9666 - val_categorical_accuracy: 0.6200
Epoch 17/500
```

```
21/21 [==============================] - 14s 651ms/step - loss: 0.9907 - categorical_acc
uracy: 0.6019 - val_loss: 0.9611 - val_categorical_accuracy: 0.6000
Epoch 18/500
21/21 [==============================] - 14s 653ms/step - loss: 0.9447 - categorical_acc
uracy: 0.6602 - val_loss: 0.9859 - val_categorical_accuracy: 0.5000
Epoch 19/500
21/21 [==============================] - 14s 655ms/step - loss: 0.9752 - categorical_acc
uracy: 0.5922 - val_loss: 0.9143 - val_categorical_accuracy: 0.6600
Epoch 20/500
21/21 [==============================] - 14s 659ms/step - loss: 0.9234 - categorical_acc
uracy: 0.6796 - val_loss: 0.9621 - val_categorical_accuracy: 0.5800
Epoch 21/500
21/21 [==============================] - 14s 653ms/step - loss: 0.9292 - categorical_acc
uracy: 0.6650 - val_loss: 0.9041 - val_categorical_accuracy: 0.6400
Epoch 22/500
21/21 [==============================] - 14s 657ms/step - loss: 0.8825 - categorical_acc
uracy: 0.7039 - val_loss: 0.8591 - val_categorical_accuracy: 0.5800
Epoch 23/500
21/21 [==============================] - 14s 655ms/step - loss: 0.9003 - categorical_acc
uracy: 0.6408 - val_loss: 0.9096 - val_categorical_accuracy: 0.6200
Epoch 24/500
21/21 [==============================] - 14s 671ms/step - loss: 0.8947 - categorical_acc
uracy: 0.6429 - val_loss: 0.8812 - val_categorical_accuracy: 0.6400
Epoch 25/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8806 - categorical_acc
uracy: 0.6699 - val_loss: 0.9165 - val_categorical_accuracy: 0.6000
Epoch 26/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8937 - categorical_acc
uracy: 0.6650 - val_loss: 0.8861 - val_categorical_accuracy: 0.5600
Epoch 27/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8334 - categorical_acc
uracy: 0.6942 - val_loss: 0.8626 - val_categorical_accuracy: 0.6400
Epoch 28/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8270 - categorical_acc
uracy: 0.7087 - val_loss: 0.8623 - val_categorical_accuracy: 0.6000
Epoch 29/500
21/21 [==============================] - 14s 662ms/step - loss: 0.8505 - categorical_acc
uracy: 0.6990 - val_loss: 0.8460 - val_categorical_accuracy: 0.6400
Epoch 30/500
21/21 [==============================] - 14s 654ms/step - loss: 0.8454 - categorical_acc
uracy: 0.6408 - val_loss: 0.9214 - val_categorical_accuracy: 0.6400
Epoch 31/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8427 - categorical_acc
uracy: 0.6650 - val_loss: 0.9201 - val_categorical_accuracy: 0.6000
Epoch 32/500
21/21 [==============================] - 14s 663ms/step - loss: 0.8299 - categorical_acc
uracy: 0.6952 - val_loss: 0.8307 - val_categorical_accuracy: 0.6400
Epoch 33/500
21/21 [==============================] - 14s 656ms/step - loss: 0.8275 - categorical_acc
uracy: 0.6796 - val_loss: 0.8540 - val_categorical_accuracy: 0.6400
Epoch 34/500
21/21 [==============================] - 14s 660ms/step - loss: 0.8345 - categorical_acc
uracy: 0.6505 - val_loss: 0.9021 - val_categorical_accuracy: 0.5200
Epoch 35/500
21/21 [==============================] - 14s 652ms/step - loss: 0.7812 - categorical_acc
uracy: 0.6990 - val_loss: 0.8136 - val_categorical_accuracy: 0.6600
Epoch 36/500
21/21 [==============================] - 14s 654ms/step - loss: 0.8276 - categorical_acc
uracy: 0.6748 - val_loss: 0.8104 - val_categorical_accuracy: 0.6000
Epoch 37/500
```

```
21/21 [==============================] - 14s 654ms/step - loss: 0.8460 - categorical_acc
uracy: 0.6165 - val_loss: 0.8809 - val_categorical_accuracy: 0.6200
Epoch 38/500
21/21 [==============================] - 14s 662ms/step - loss: 0.8028 - categorical_acc
uracy: 0.6845 - val_loss: 0.7799 - val_categorical_accuracy: 0.6400
Epoch 39/500
21/21 [==============================] - 14s 653ms/step - loss: 0.7774 - categorical_acc
uracy: 0.6990 - val_loss: 0.7913 - val_categorical_accuracy: 0.6400
Epoch 40/500
21/21 [==============================] - 14s 652ms/step - loss: 0.7964 - categorical_acc
uracy: 0.6845 - val_loss: 0.7951 - val_categorical_accuracy: 0.6600
Epoch 41/500
21/21 [==============================] - 14s 659ms/step - loss: 0.7293 - categorical_acc
uracy: 0.7379 - val_loss: 0.7460 - val_categorical_accuracy: 0.6800
Epoch 42/500
21/21 [==============================] - 14s 662ms/step - loss: 0.7546 - categorical_acc
uracy: 0.7233 - val_loss: 0.7928 - val_categorical_accuracy: 0.7000
Epoch 43/500
21/21 [==============================] - 14s 665ms/step - loss: 0.7776 - categorical_acc
uracy: 0.6893 - val_loss: 0.8132 - val_categorical_accuracy: 0.6000
Epoch 44/500
21/21 [==============================] - 14s 655ms/step - loss: 0.7727 - categorical_acc
uracy: 0.6845 - val_loss: 0.8192 - val_categorical_accuracy: 0.6200
Epoch 45/500
21/21 [==============================] - 14s 652ms/step - loss: 0.7388 - categorical_acc
uracy: 0.7184 - val_loss: 0.7871 - val_categorical_accuracy: 0.6000
Epoch 46/500
21/21 [==============================] - 14s 657ms/step - loss: 0.7962 - categorical_acc
uracy: 0.6699 - val_loss: 0.7937 - val_categorical_accuracy: 0.6000
Epoch 47/500
21/21 [==============================] - 14s 653ms/step - loss: 0.7595 - categorical_acc
uracy: 0.6699 - val_loss: 0.7656 - val_categorical_accuracy: 0.6600
Epoch 48/500
21/21 [==============================] - 14s 654ms/step - loss: 0.7570 - categorical_acc
uracy: 0.6990 - val_loss: 0.8123 - val_categorical_accuracy: 0.6000
Epoch 49/500
21/21 [==============================] - 14s 656ms/step - loss: 0.7235 - categorical_acc
uracy: 0.6942 - val_loss: 0.8031 - val_categorical_accuracy: 0.6200
Epoch 50/500
21/21 [==============================] - 14s 663ms/step - loss: 0.7546 - categorical_acc
uracy: 0.7233 - val_loss: 0.7603 - val_categorical_accuracy: 0.6800
Epoch 51/500
21/21 [==============================] - 14s 663ms/step - loss: 0.7368 - categorical_acc
uracy: 0.7136 - val_loss: 0.7727 - val_categorical_accuracy: 0.6200
Epoch 52/500
21/21 [==============================] - 14s 653ms/step - loss: 0.7649 - categorical_acc
uracy: 0.6990 - val_loss: 0.8109 - val_categorical_accuracy: 0.6400
Epoch 53/500
21/21 [==============================] - 14s 653ms/step - loss: 0.7345 - categorical_acc
uracy: 0.7087 - val_loss: 0.7407 - val_categorical_accuracy: 0.6600
Epoch 54/500
21/21 [==============================] - 14s 657ms/step - loss: 0.7229 - categorical_acc
uracy: 0.7427 - val_loss: 0.7707 - val_categorical_accuracy: 0.6400
Epoch 55/500
21/21 [==============================] - 14s 663ms/step - loss: 0.7067 - categorical_acc
uracy: 0.7379 - val_loss: 0.7603 - val_categorical_accuracy: 0.6600
Epoch 56/500
21/21 [==============================] - 14s 655ms/step - loss: 0.7148 - categorical_acc
uracy: 0.7621 - val_loss: 0.7937 - val_categorical_accuracy: 0.6200
Epoch 57/500
```

```
21/21 [==============================] - 14s 650ms/step - loss: 0.7286 - categorical_acc
uracy: 0.6990 - val_loss: 0.7928 - val_categorical_accuracy: 0.6200
Epoch 58/500
21/21 [==============================] - 14s 655ms/step - loss: 0.7184 - categorical_acc
uracy: 0.7136 - val_loss: 0.7332 - val_categorical_accuracy: 0.6400
Epoch 59/500
21/21 [==============================] - 14s 655ms/step - loss: 0.7291 - categorical_acc
uracy: 0.7136 - val_loss: 0.7883 - val_categorical_accuracy: 0.6200
Epoch 60/500
21/21 [==============================] - 14s 656ms/step - loss: 0.7228 - categorical_acc
uracy: 0.7136 - val_loss: 0.7645 - val_categorical_accuracy: 0.5400
Epoch 61/500
21/21 [==============================] - 14s 659ms/step - loss: 0.6774 - categorical_acc
uracy: 0.7330 - val_loss: 0.6944 - val_categorical_accuracy: 0.7600
Epoch 62/500
21/21 [==============================] - 14s 654ms/step - loss: 0.7264 - categorical_acc
uracy: 0.7039 - val_loss: 0.6878 - val_categorical_accuracy: 0.7000
Epoch 63/500
21/21 [==============================] - 14s 655ms/step - loss: 0.7253 - categorical_acc
uracy: 0.6845 - val_loss: 0.7436 - val_categorical_accuracy: 0.6600
Epoch 64/500
21/21 [==============================] - 14s 656ms/step - loss: 0.7344 - categorical_acc
uracy: 0.6990 - val_loss: 0.7091 - val_categorical_accuracy: 0.6800
Epoch 65/500
21/21 [==============================] - 14s 667ms/step - loss: 0.7315 - categorical_acc
uracy: 0.7190 - val_loss: 0.7491 - val_categorical_accuracy: 0.6400
Epoch 66/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6791 - categorical_acc
uracy: 0.7330 - val_loss: 0.7089 - val_categorical_accuracy: 0.6600
Epoch 67/500
21/21 [==============================] - 14s 656ms/step - loss: 0.7234 - categorical_acc
uracy: 0.6893 - val_loss: 0.7178 - val_categorical_accuracy: 0.7600
Epoch 68/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6670 - categorical_acc
uracy: 0.7330 - val_loss: 0.7202 - val_categorical_accuracy: 0.6800
Epoch 69/500
21/21 [==============================] - 14s 662ms/step - loss: 0.6665 - categorical_acc
uracy: 0.7524 - val_loss: 0.7328 - val_categorical_accuracy: 0.6800
Epoch 70/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6485 - categorical_acc
uracy: 0.7621 - val_loss: 0.7090 - val_categorical_accuracy: 0.6800
Epoch 71/500
21/21 [==============================] - 14s 649ms/step - loss: 0.6895 - categorical_acc
uracy: 0.7039 - val_loss: 0.7922 - val_categorical_accuracy: 0.6200
Epoch 72/500
21/21 [==============================] - 14s 654ms/step - loss: 0.7097 - categorical_acc
uracy: 0.6699 - val_loss: 0.7654 - val_categorical_accuracy: 0.6800
Epoch 73/500
21/21 [==============================] - 14s 670ms/step - loss: 0.6543 - categorical_acc
uracy: 0.7476 - val_loss: 0.7910 - val_categorical_accuracy: 0.6200
Epoch 74/500
21/21 [==============================] - 14s 666ms/step - loss: 0.6765 - categorical_acc
uracy: 0.7670 - val_loss: 0.7384 - val_categorical_accuracy: 0.6600
Epoch 75/500
21/21 [==============================] - 14s 668ms/step - loss: 0.6890 - categorical_acc
uracy: 0.7524 - val_loss: 0.7511 - val_categorical_accuracy: 0.6400
Epoch 76/500
21/21 [==============================] - 14s 652ms/step - loss: 0.7002 - categorical_acc
uracy: 0.7039 - val_loss: 0.7950 - val_categorical_accuracy: 0.6600
Epoch 77/500
```

```
21/21 [==============================] - 14s 659ms/step - loss: 0.7083 - categorical_acc
uracy: 0.7330 - val_loss: 0.7377 - val_categorical_accuracy: 0.6800
Epoch 78/500
21/21 [==============================] - 14s 667ms/step - loss: 0.6738 - categorical_acc
uracy: 0.7621 - val_loss: 0.7289 - val_categorical_accuracy: 0.6400
Epoch 79/500
21/21 [==============================] - 14s 661ms/step - loss: 0.6749 - categorical_acc
uracy: 0.7379 - val_loss: 0.7194 - val_categorical_accuracy: 0.7200
Epoch 80/500
21/21 [==============================] - 14s 670ms/step - loss: 0.6732 - categorical_acc
uracy: 0.7621 - val_loss: 0.7827 - val_categorical_accuracy: 0.6000
Epoch 81/500
21/21 [==============================] - 14s 657ms/step - loss: 0.6605 - categorical_acc
uracy: 0.7330 - val_loss: 0.6818 - val_categorical_accuracy: 0.7000
Epoch 82/500
21/21 [==============================] - 14s 665ms/step - loss: 0.6446 - categorical_acc
uracy: 0.7427 - val_loss: 0.6890 - val_categorical_accuracy: 0.7400
Epoch 83/500
21/21 [==============================] - 14s 656ms/step - loss: 0.6541 - categorical_acc
uracy: 0.7670 - val_loss: 0.7012 - val_categorical_accuracy: 0.6800
Epoch 84/500
21/21 [==============================] - 14s 656ms/step - loss: 0.6619 - categorical_acc
uracy: 0.7379 - val_loss: 0.7140 - val_categorical_accuracy: 0.6400
Epoch 85/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6830 - categorical_acc
uracy: 0.7476 - val_loss: 0.7522 - val_categorical_accuracy: 0.6200
Epoch 86/500
21/21 [==============================] - 14s 660ms/step - loss: 0.6419 - categorical_acc
uracy: 0.7427 - val_loss: 0.7710 - val_categorical_accuracy: 0.5200
Epoch 87/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6996 - categorical_acc
uracy: 0.7427 - val_loss: 0.6979 - val_categorical_accuracy: 0.7000
Epoch 88/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6542 - categorical_acc
uracy: 0.7330 - val_loss: 0.6852 - val_categorical_accuracy: 0.6600
Epoch 89/500
21/21 [==============================] - 14s 653ms/step - loss: 0.6346 - categorical_acc
uracy: 0.7476 - val_loss: 0.7164 - val_categorical_accuracy: 0.6200
Epoch 90/500
21/21 [==============================] - 14s 659ms/step - loss: 0.6649 - categorical_acc
uracy: 0.7330 - val_loss: 0.6902 - val_categorical_accuracy: 0.7000
Epoch 91/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6092 - categorical_acc
uracy: 0.7913 - val_loss: 0.7757 - val_categorical_accuracy: 0.6000
Epoch 92/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6453 - categorical_acc
uracy: 0.7621 - val_loss: 0.6256 - val_categorical_accuracy: 0.7000
Epoch 93/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6158 - categorical_acc
uracy: 0.7670 - val_loss: 0.8152 - val_categorical_accuracy: 0.6200
Epoch 94/500
21/21 [==============================] - 14s 661ms/step - loss: 0.6506 - categorical_acc
uracy: 0.7379 - val_loss: 0.6905 - val_categorical_accuracy: 0.6800
Epoch 95/500
21/21 [==============================] - 14s 663ms/step - loss: 0.6553 - categorical_acc
uracy: 0.7619 - val_loss: 0.6883 - val_categorical_accuracy: 0.6800
Epoch 96/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6471 - categorical_acc
uracy: 0.7282 - val_loss: 0.7228 - val_categorical_accuracy: 0.7000
Epoch 97/500
```

```
21/21 [==============================] - 14s 649ms/step - loss: 0.6481 - categorical_acc
uracy: 0.7476 - val_loss: 0.7072 - val_categorical_accuracy: 0.6600
Epoch 98/500
21/21 [==============================] - 14s 650ms/step - loss: 0.6418 - categorical_acc
uracy: 0.7767 - val_loss: 0.6805 - val_categorical_accuracy: 0.6600
Epoch 99/500
21/21 [==============================] - 14s 663ms/step - loss: 0.6507 - categorical_acc
uracy: 0.7330 - val_loss: 0.6660 - val_categorical_accuracy: 0.7200
Epoch 100/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6485 - categorical_acc
uracy: 0.7233 - val_loss: 0.7528 - val_categorical_accuracy: 0.6400
Epoch 101/500
21/21 [==============================] - 14s 648ms/step - loss: 0.6363 - categorical_acc
uracy: 0.7816 - val_loss: 0.7405 - val_categorical_accuracy: 0.6000
Epoch 102/500
21/21 [==============================] - 14s 656ms/step - loss: 0.6138 - categorical_acc
uracy: 0.7427 - val_loss: 0.6523 - val_categorical_accuracy: 0.6200
Epoch 103/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5949 - categorical_acc
uracy: 0.7864 - val_loss: 0.6699 - val_categorical_accuracy: 0.7200
Epoch 104/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6433 - categorical_acc
uracy: 0.7816 - val_loss: 0.6656 - val_categorical_accuracy: 0.6800
Epoch 105/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6125 - categorical_acc
uracy: 0.7282 - val_loss: 0.6369 - val_categorical_accuracy: 0.7000
Epoch 106/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5947 - categorical_acc
uracy: 0.7961 - val_loss: 0.6747 - val_categorical_accuracy: 0.7000
Epoch 107/500
21/21 [==============================] - 14s 660ms/step - loss: 0.6216 - categorical_acc
uracy: 0.7379 - val_loss: 0.6994 - val_categorical_accuracy: 0.7000
Epoch 108/500
21/21 [==============================] - 14s 656ms/step - loss: 0.6399 - categorical_acc
uracy: 0.7379 - val_loss: 0.6638 - val_categorical_accuracy: 0.7600
Epoch 109/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5779 - categorical_acc
uracy: 0.8204 - val_loss: 0.6461 - val_categorical_accuracy: 0.7800
Epoch 110/500
21/21 [==============================] - 14s 662ms/step - loss: 0.6066 - categorical_acc
uracy: 0.7524 - val_loss: 0.7418 - val_categorical_accuracy: 0.6800
Epoch 111/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5882 - categorical_acc
uracy: 0.8010 - val_loss: 0.6703 - val_categorical_accuracy: 0.6600
Epoch 112/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6411 - categorical_acc
uracy: 0.7573 - val_loss: 0.7378 - val_categorical_accuracy: 0.6600
Epoch 113/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6215 - categorical_acc
uracy: 0.7476 - val_loss: 0.7194 - val_categorical_accuracy: 0.6200
Epoch 114/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6335 - categorical_acc
uracy: 0.7427 - val_loss: 0.6743 - val_categorical_accuracy: 0.7000
Epoch 115/500
21/21 [==============================] - 14s 658ms/step - loss: 0.6350 - categorical_acc
uracy: 0.7427 - val_loss: 0.6859 - val_categorical_accuracy: 0.7000
Epoch 116/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6151 - categorical_acc
uracy: 0.7476 - val_loss: 0.6546 - val_categorical_accuracy: 0.7200
Epoch 117/500
```

```
21/21 [==============================] - 14s 660ms/step - loss: 0.6157 - categorical_acc
uracy: 0.7286 - val_loss: 0.7151 - val_categorical_accuracy: 0.7200
Epoch 118/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6570 - categorical_acc
uracy: 0.7427 - val_loss: 0.6916 - val_categorical_accuracy: 0.6600
Epoch 119/500
21/21 [==============================] - 14s 661ms/step - loss: 0.6019 - categorical_acc
uracy: 0.7476 - val_loss: 0.6935 - val_categorical_accuracy: 0.6800
Epoch 120/500
21/21 [==============================] - 14s 653ms/step - loss: 0.6227 - categorical_acc
uracy: 0.7379 - val_loss: 0.6806 - val_categorical_accuracy: 0.6600
Epoch 121/500
21/21 [==============================] - 14s 656ms/step - loss: 0.6531 - categorical_acc
uracy: 0.7282 - val_loss: 0.6946 - val_categorical_accuracy: 0.7200
Epoch 122/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5831 - categorical_acc
uracy: 0.7718 - val_loss: 0.6838 - val_categorical_accuracy: 0.7000
Epoch 123/500
21/21 [==============================] - 14s 651ms/step - loss: 0.6079 - categorical_acc
uracy: 0.7767 - val_loss: 0.7039 - val_categorical_accuracy: 0.6600
Epoch 124/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5949 - categorical_acc
uracy: 0.7864 - val_loss: 0.5464 - val_categorical_accuracy: 0.7200
Epoch 125/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6076 - categorical_acc
uracy: 0.7718 - val_loss: 0.7020 - val_categorical_accuracy: 0.6200
Epoch 126/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6194 - categorical_acc
uracy: 0.7767 - val_loss: 0.6127 - val_categorical_accuracy: 0.7200
Epoch 127/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5712 - categorical_acc
uracy: 0.7864 - val_loss: 0.7186 - val_categorical_accuracy: 0.6800
Epoch 128/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6624 - categorical_acc
uracy: 0.6942 - val_loss: 0.6821 - val_categorical_accuracy: 0.7200
Epoch 129/500
21/21 [==============================] - 14s 652ms/step - loss: 0.6160 - categorical_acc
uracy: 0.7427 - val_loss: 0.6464 - val_categorical_accuracy: 0.7000
Epoch 130/500
21/21 [==============================] - 14s 648ms/step - loss: 0.6333 - categorical_acc
uracy: 0.7379 - val_loss: 0.6983 - val_categorical_accuracy: 0.7000
Epoch 131/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5566 - categorical_acc
uracy: 0.7913 - val_loss: 0.6611 - val_categorical_accuracy: 0.7200
Epoch 132/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5958 - categorical_acc
uracy: 0.7524 - val_loss: 0.6338 - val_categorical_accuracy: 0.7200
Epoch 133/500
21/21 [==============================] - 14s 654ms/step - loss: 0.6173 - categorical_acc
uracy: 0.7621 - val_loss: 0.7271 - val_categorical_accuracy: 0.6600
Epoch 134/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5729 - categorical_acc
uracy: 0.7718 - val_loss: 0.8153 - val_categorical_accuracy: 0.5800
Epoch 135/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5944 - categorical_acc
uracy: 0.7718 - val_loss: 0.6326 - val_categorical_accuracy: 0.6800
Epoch 136/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5969 - categorical_acc
uracy: 0.7670 - val_loss: 0.7190 - val_categorical_accuracy: 0.6200
Epoch 137/500
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21/21 [==============================] - 14s 655ms/step - loss: 0.6187 - categorical_acc
uracy: 0.7233 - val_loss: 0.6729 - val_categorical_accuracy: 0.6400
Epoch 138/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5940 - categorical_acc
uracy: 0.7864 - val_loss: 0.7383 - val_categorical_accuracy: 0.7000
Epoch 139/500
21/21 [==============================] - 14s 669ms/step - loss: 0.5905 - categorical_acc
uracy: 0.7427 - val_loss: 0.6269 - val_categorical_accuracy: 0.7600
Epoch 140/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6116 - categorical_acc
uracy: 0.7816 - val_loss: 0.6510 - val_categorical_accuracy: 0.7400
Epoch 141/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5905 - categorical_acc
uracy: 0.7670 - val_loss: 0.7577 - val_categorical_accuracy: 0.6600
Epoch 142/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5883 - categorical_acc
uracy: 0.7670 - val_loss: 0.7339 - val_categorical_accuracy: 0.6800
Epoch 143/500
21/21 [==============================] - 14s 658ms/step - loss: 0.6195 - categorical_acc
uracy: 0.7282 - val_loss: 0.6982 - val_categorical_accuracy: 0.6800
Epoch 144/500
21/21 [==============================] - 14s 655ms/step - loss: 0.6043 - categorical_acc
uracy: 0.7718 - val_loss: 0.6339 - val_categorical_accuracy: 0.6600
Epoch 145/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5516 - categorical_acc
uracy: 0.8301 - val_loss: 0.6749 - val_categorical_accuracy: 0.6800
Epoch 146/500
21/21 [==============================] - 14s 673ms/step - loss: 0.6239 - categorical_acc
uracy: 0.7282 - val_loss: 0.6150 - val_categorical_accuracy: 0.7400
Epoch 147/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5487 - categorical_acc
uracy: 0.7961 - val_loss: 0.6319 - val_categorical_accuracy: 0.7400
Epoch 148/500
21/21 [==============================] - 14s 664ms/step - loss: 0.6007 - categorical_acc
uracy: 0.7767 - val_loss: 0.7328 - val_categorical_accuracy: 0.6400
Epoch 149/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5800 - categorical_acc
uracy: 0.7427 - val_loss: 0.7503 - val_categorical_accuracy: 0.5600
Epoch 150/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5695 - categorical_acc
uracy: 0.7864 - val_loss: 0.6920 - val_categorical_accuracy: 0.7200
Epoch 151/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5378 - categorical_acc
uracy: 0.8058 - val_loss: 0.7519 - val_categorical_accuracy: 0.6400
Epoch 152/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5663 - categorical_acc
uracy: 0.8204 - val_loss: 0.7105 - val_categorical_accuracy: 0.6600
Epoch 153/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5582 - categorical_acc
uracy: 0.7767 - val_loss: 0.6403 - val_categorical_accuracy: 0.7200
Epoch 154/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5221 - categorical_acc
uracy: 0.7670 - val_loss: 0.7253 - val_categorical_accuracy: 0.5800
Epoch 155/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5867 - categorical_acc
uracy: 0.7767 - val_loss: 0.6426 - val_categorical_accuracy: 0.7000
Epoch 156/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5850 - categorical_acc
uracy: 0.7573 - val_loss: 0.6474 - val_categorical_accuracy: 0.6400
Epoch 157/500
```

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21/21 [==============================] - 14s 657ms/step - loss: 0.5498 - categorical_acc
uracy: 0.7816 - val_loss: 0.7152 - val_categorical_accuracy: 0.7000
Epoch 158/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5956 - categorical_acc
uracy: 0.7621 - val_loss: 0.5751 - val_categorical_accuracy: 0.7600
Epoch 159/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5548 - categorical_acc
uracy: 0.7621 - val_loss: 0.5522 - val_categorical_accuracy: 0.7800
Epoch 160/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5428 - categorical_acc
uracy: 0.8107 - val_loss: 0.6632 - val_categorical_accuracy: 0.7400
Epoch 161/500
21/21 [==============================] - 14s 662ms/step - loss: 0.5780 - categorical_acc
uracy: 0.7913 - val_loss: 0.7154 - val_categorical_accuracy: 0.7000
Epoch 162/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5811 - categorical_acc
uracy: 0.7476 - val_loss: 0.6978 - val_categorical_accuracy: 0.6400
Epoch 163/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5860 - categorical_acc
uracy: 0.7816 - val_loss: 0.6426 - val_categorical_accuracy: 0.6800
Epoch 164/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5739 - categorical_acc
uracy: 0.7524 - val_loss: 0.6600 - val_categorical_accuracy: 0.7000
Epoch 165/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5696 - categorical_acc
uracy: 0.7718 - val_loss: 0.6410 - val_categorical_accuracy: 0.7600
Epoch 166/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5308 - categorical_acc
uracy: 0.7524 - val_loss: 0.7462 - val_categorical_accuracy: 0.6400
Epoch 167/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5785 - categorical_acc
uracy: 0.7913 - val_loss: 0.7427 - val_categorical_accuracy: 0.6800
Epoch 168/500
21/21 [==============================] - 14s 667ms/step - loss: 0.5467 - categorical_acc
uracy: 0.7767 - val_loss: 0.6857 - val_categorical_accuracy: 0.7200
Epoch 169/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5564 - categorical_acc
uracy: 0.7816 - val_loss: 0.6365 - val_categorical_accuracy: 0.6800
Epoch 170/500
21/21 [==============================] - 14s 666ms/step - loss: 0.5699 - categorical_acc
uracy: 0.7864 - val_loss: 0.7030 - val_categorical_accuracy: 0.6800
Epoch 171/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5234 - categorical_acc
uracy: 0.8155 - val_loss: 0.6679 - val_categorical_accuracy: 0.6600
Epoch 172/500
21/21 [==============================] - 14s 663ms/step - loss: 0.5565 - categorical_acc
uracy: 0.7864 - val_loss: 0.7113 - val_categorical_accuracy: 0.6000
Epoch 173/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5872 - categorical_acc
uracy: 0.7816 - val_loss: 0.6886 - val_categorical_accuracy: 0.7200
Epoch 174/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5515 - categorical_acc
uracy: 0.7718 - val_loss: 0.6664 - val_categorical_accuracy: 0.7200
Epoch 175/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5140 - categorical_acc
uracy: 0.8010 - val_loss: 0.7428 - val_categorical_accuracy: 0.7400
Epoch 176/500
21/21 [==============================] - 14s 668ms/step - loss: 0.5526 - categorical_acc
uracy: 0.8058 - val_loss: 0.6113 - val_categorical_accuracy: 0.7200
Epoch 177/500
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21/21 [==============================] - 14s 657ms/step - loss: 0.5532 - categorical_acc
uracy: 0.7621 - val_loss: 0.6056 - val_categorical_accuracy: 0.7200
Epoch 178/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5453 - categorical_acc
uracy: 0.7816 - val_loss: 0.7411 - val_categorical_accuracy: 0.6600
Epoch 179/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5738 - categorical_acc
uracy: 0.7767 - val_loss: 0.7093 - val_categorical_accuracy: 0.6400
Epoch 180/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5275 - categorical_acc
uracy: 0.7816 - val_loss: 0.7101 - val_categorical_accuracy: 0.6400
Epoch 181/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5784 - categorical_acc
uracy: 0.7718 - val_loss: 0.6531 - val_categorical_accuracy: 0.6600
Epoch 182/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5200 - categorical_acc
uracy: 0.7767 - val_loss: 0.7552 - val_categorical_accuracy: 0.6600
Epoch 183/500
21/21 [==============================] - 14s 667ms/step - loss: 0.5265 - categorical_acc
uracy: 0.8000 - val_loss: 0.6147 - val_categorical_accuracy: 0.6400
Epoch 184/500
21/21 [==============================] - 14s 663ms/step - loss: 0.5592 - categorical_acc
uracy: 0.7816 - val_loss: 0.6806 - val_categorical_accuracy: 0.6800
Epoch 185/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5594 - categorical_acc
uracy: 0.7621 - val_loss: 0.6649 - val_categorical_accuracy: 0.7400
Epoch 186/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5540 - categorical_acc
uracy: 0.7816 - val_loss: 0.6958 - val_categorical_accuracy: 0.6800
Epoch 187/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5354 - categorical_acc
uracy: 0.8058 - val_loss: 0.5609 - val_categorical_accuracy: 0.7400
Epoch 188/500
21/21 [==============================] - 14s 668ms/step - loss: 0.5397 - categorical_acc
uracy: 0.7864 - val_loss: 0.7479 - val_categorical_accuracy: 0.6800
Epoch 189/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5241 - categorical_acc
uracy: 0.8204 - val_loss: 0.5969 - val_categorical_accuracy: 0.7400
Epoch 190/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5944 - categorical_acc
uracy: 0.8010 - val_loss: 0.6383 - val_categorical_accuracy: 0.7800
Epoch 191/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5494 - categorical_acc
uracy: 0.7767 - val_loss: 0.6310 - val_categorical_accuracy: 0.7200
Epoch 192/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5548 - categorical_acc
uracy: 0.8058 - val_loss: 0.6838 - val_categorical_accuracy: 0.6600
Epoch 193/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5761 - categorical_acc
uracy: 0.7621 - val_loss: 0.7220 - val_categorical_accuracy: 0.6400
Epoch 194/500
21/21 [==============================] - 14s 667ms/step - loss: 0.5112 - categorical_acc
uracy: 0.8204 - val_loss: 0.7089 - val_categorical_accuracy: 0.7400
Epoch 195/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5674 - categorical_acc
uracy: 0.7864 - val_loss: 0.6131 - val_categorical_accuracy: 0.7000
Epoch 196/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5370 - categorical_acc
uracy: 0.7476 - val_loss: 0.6436 - val_categorical_accuracy: 0.7200
Epoch 197/500
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21/21 [==============================] - 14s 655ms/step - loss: 0.5572 - categorical_acc
uracy: 0.7913 - val_loss: 0.6058 - val_categorical_accuracy: 0.6800
Epoch 198/500
21/21 [==============================] - 14s 667ms/step - loss: 0.4922 - categorical_acc
uracy: 0.8058 - val_loss: 0.6343 - val_categorical_accuracy: 0.6800
Epoch 199/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5313 - categorical_acc
uracy: 0.7621 - val_loss: 0.6927 - val_categorical_accuracy: 0.7400
Epoch 200/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5254 - categorical_acc
uracy: 0.8204 - val_loss: 0.7500 - val_categorical_accuracy: 0.6400
Epoch 201/500
21/21 [==============================] - 14s 664ms/step - loss: 0.5301 - categorical_acc
uracy: 0.8010 - val_loss: 0.7077 - val_categorical_accuracy: 0.6400
Epoch 202/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5681 - categorical_acc
uracy: 0.8107 - val_loss: 0.5865 - val_categorical_accuracy: 0.7600
Epoch 203/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5531 - categorical_acc
uracy: 0.7718 - val_loss: 0.6647 - val_categorical_accuracy: 0.6800
Epoch 204/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5130 - categorical_acc
uracy: 0.8058 - val_loss: 0.6556 - val_categorical_accuracy: 0.6600
Epoch 205/500
21/21 [==============================] - 14s 666ms/step - loss: 0.5419 - categorical_acc
uracy: 0.7913 - val_loss: 0.6152 - val_categorical_accuracy: 0.7400
Epoch 206/500
21/21 [==============================] - 14s 658ms/step - loss: 0.5452 - categorical_acc
uracy: 0.7573 - val_loss: 0.5776 - val_categorical_accuracy: 0.7000
Epoch 207/500
21/21 [==============================] - 14s 670ms/step - loss: 0.5757 - categorical_acc
uracy: 0.7905 - val_loss: 0.6833 - val_categorical_accuracy: 0.6400
Epoch 208/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5724 - categorical_acc
uracy: 0.7961 - val_loss: 0.6793 - val_categorical_accuracy: 0.7400
Epoch 209/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5603 - categorical_acc
uracy: 0.7718 - val_loss: 0.6374 - val_categorical_accuracy: 0.7200
Epoch 210/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5278 - categorical_acc
uracy: 0.7767 - val_loss: 0.6513 - val_categorical_accuracy: 0.6600
Epoch 211/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5411 - categorical_acc
uracy: 0.7718 - val_loss: 0.6194 - val_categorical_accuracy: 0.7200
Epoch 212/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5117 - categorical_acc
uracy: 0.7913 - val_loss: 0.6653 - val_categorical_accuracy: 0.6400
Epoch 213/500
21/21 [==============================] - 14s 666ms/step - loss: 0.5560 - categorical_acc
uracy: 0.7913 - val_loss: 0.7259 - val_categorical_accuracy: 0.6400
Epoch 214/500
21/21 [==============================] - 14s 663ms/step - loss: 0.5487 - categorical_acc
uracy: 0.7913 - val_loss: 0.6607 - val_categorical_accuracy: 0.6800
Epoch 215/500
21/21 [==============================] - 14s 664ms/step - loss: 0.5251 - categorical_acc
uracy: 0.8058 - val_loss: 0.7039 - val_categorical_accuracy: 0.7200
Epoch 216/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4927 - categorical_acc
uracy: 0.8252 - val_loss: 0.6685 - val_categorical_accuracy: 0.6800
Epoch 217/500
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21/21 [==============================] - 14s 651ms/step - loss: 0.5768 - categorical_acc
uracy: 0.7670 - val_loss: 0.6666 - val_categorical_accuracy: 0.7200
Epoch 218/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5144 - categorical_acc
uracy: 0.7913 - val_loss: 0.6870 - val_categorical_accuracy: 0.6200
Epoch 219/500
21/21 [==============================] - 14s 667ms/step - loss: 0.5283 - categorical_acc
uracy: 0.7816 - val_loss: 0.6686 - val_categorical_accuracy: 0.6800
Epoch 220/500
21/21 [==============================] - 14s 662ms/step - loss: 0.5402 - categorical_acc
uracy: 0.8107 - val_loss: 0.7399 - val_categorical_accuracy: 0.6400
Epoch 221/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5338 - categorical_acc
uracy: 0.7767 - val_loss: 0.6956 - val_categorical_accuracy: 0.6200
Epoch 222/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5723 - categorical_acc
uracy: 0.7670 - val_loss: 0.5932 - val_categorical_accuracy: 0.7200
Epoch 223/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5466 - categorical_acc
uracy: 0.7913 - val_loss: 0.7676 - val_categorical_accuracy: 0.6600
Epoch 224/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5303 - categorical_acc
uracy: 0.7718 - val_loss: 0.6810 - val_categorical_accuracy: 0.7200
Epoch 225/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5273 - categorical_acc
uracy: 0.7864 - val_loss: 0.6906 - val_categorical_accuracy: 0.6800
Epoch 226/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4970 - categorical_acc
uracy: 0.8204 - val_loss: 0.7155 - val_categorical_accuracy: 0.6600
Epoch 227/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5228 - categorical_acc
uracy: 0.8350 - val_loss: 0.6732 - val_categorical_accuracy: 0.6400
Epoch 228/500
21/21 [==============================] - 14s 668ms/step - loss: 0.5421 - categorical_acc
uracy: 0.7864 - val_loss: 0.6643 - val_categorical_accuracy: 0.6400
Epoch 229/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5572 - categorical_acc
uracy: 0.7767 - val_loss: 0.6669 - val_categorical_accuracy: 0.6800
Epoch 230/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4791 - categorical_acc
uracy: 0.8301 - val_loss: 0.6519 - val_categorical_accuracy: 0.7000
Epoch 231/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5553 - categorical_acc
uracy: 0.8058 - val_loss: 0.5853 - val_categorical_accuracy: 0.6800
Epoch 232/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5494 - categorical_acc
uracy: 0.7816 - val_loss: 0.6421 - val_categorical_accuracy: 0.7400
Epoch 233/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5278 - categorical_acc
uracy: 0.8107 - val_loss: 0.6296 - val_categorical_accuracy: 0.7000
Epoch 234/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5084 - categorical_acc
uracy: 0.8155 - val_loss: 0.5566 - val_categorical_accuracy: 0.7800
Epoch 235/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5192 - categorical_acc
uracy: 0.7864 - val_loss: 0.7274 - val_categorical_accuracy: 0.7200
Epoch 236/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5420 - categorical_acc
uracy: 0.7670 - val_loss: 0.7166 - val_categorical_accuracy: 0.6600
Epoch 237/500
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21/21 [==============================] - 14s 656ms/step - loss: 0.5725 - categorical_acc
uracy: 0.7816 - val_loss: 0.5799 - val_categorical_accuracy: 0.7600
Epoch 238/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5465 - categorical_acc
uracy: 0.7913 - val_loss: 0.5992 - val_categorical_accuracy: 0.7200
Epoch 239/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5214 - categorical_acc
uracy: 0.7816 - val_loss: 0.6527 - val_categorical_accuracy: 0.6800
Epoch 240/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5239 - categorical_acc
uracy: 0.7767 - val_loss: 0.7102 - val_categorical_accuracy: 0.6600
Epoch 241/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4954 - categorical_acc
uracy: 0.8155 - val_loss: 0.6402 - val_categorical_accuracy: 0.6800
Epoch 242/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5785 - categorical_acc
uracy: 0.7913 - val_loss: 0.6338 - val_categorical_accuracy: 0.6800
Epoch 243/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5340 - categorical_acc
uracy: 0.8155 - val_loss: 0.6196 - val_categorical_accuracy: 0.7000
Epoch 244/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5076 - categorical_acc
uracy: 0.8252 - val_loss: 0.6101 - val_categorical_accuracy: 0.6600
Epoch 245/500
21/21 [==============================] - 14s 662ms/step - loss: 0.5081 - categorical_acc
uracy: 0.8095 - val_loss: 0.7619 - val_categorical_accuracy: 0.6400
Epoch 246/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5036 - categorical_acc
uracy: 0.8155 - val_loss: 0.6658 - val_categorical_accuracy: 0.6600
Epoch 247/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5228 - categorical_acc
uracy: 0.8010 - val_loss: 0.6548 - val_categorical_accuracy: 0.6800
Epoch 248/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5386 - categorical_acc
uracy: 0.7767 - val_loss: 0.6949 - val_categorical_accuracy: 0.6600
Epoch 249/500
21/21 [==============================] - 14s 665ms/step - loss: 0.5245 - categorical_acc
uracy: 0.8048 - val_loss: 0.6564 - val_categorical_accuracy: 0.7200
Epoch 250/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5205 - categorical_acc
uracy: 0.7670 - val_loss: 0.6543 - val_categorical_accuracy: 0.6600
Epoch 251/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5247 - categorical_acc
uracy: 0.8058 - val_loss: 0.6005 - val_categorical_accuracy: 0.7000
Epoch 252/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5002 - categorical_acc
uracy: 0.8107 - val_loss: 0.6071 - val_categorical_accuracy: 0.7400
Epoch 253/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5517 - categorical_acc
uracy: 0.7621 - val_loss: 0.6627 - val_categorical_accuracy: 0.6600
Epoch 254/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5266 - categorical_acc
uracy: 0.7816 - val_loss: 0.7201 - val_categorical_accuracy: 0.6600
Epoch 255/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4958 - categorical_acc
uracy: 0.8107 - val_loss: 0.6810 - val_categorical_accuracy: 0.6200
Epoch 256/500
21/21 [==============================] - 14s 649ms/step - loss: 0.5081 - categorical_acc
uracy: 0.8204 - val_loss: 0.6815 - val_categorical_accuracy: 0.6600
Epoch 257/500
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21/21 [==============================] - 14s 654ms/step - loss: 0.4953 - categorical_acc
uracy: 0.8058 - val_loss: 0.6437 - val_categorical_accuracy: 0.6800
Epoch 258/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5309 - categorical_acc
uracy: 0.8058 - val_loss: 0.7287 - val_categorical_accuracy: 0.6000
Epoch 259/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5213 - categorical_acc
uracy: 0.7767 - val_loss: 0.6999 - val_categorical_accuracy: 0.5800
Epoch 260/500
21/21 [==============================] - 14s 662ms/step - loss: 0.5509 - categorical_acc
uracy: 0.7816 - val_loss: 0.6622 - val_categorical_accuracy: 0.7200
Epoch 261/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5616 - categorical_acc
uracy: 0.7621 - val_loss: 0.5491 - val_categorical_accuracy: 0.7000
Epoch 262/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4927 - categorical_acc
uracy: 0.8252 - val_loss: 0.6330 - val_categorical_accuracy: 0.7000
Epoch 263/500
21/21 [==============================] - 14s 664ms/step - loss: 0.5030 - categorical_acc
uracy: 0.8010 - val_loss: 0.7563 - val_categorical_accuracy: 0.6000
Epoch 264/500
21/21 [==============================] - 14s 650ms/step - loss: 0.5108 - categorical_acc
uracy: 0.8058 - val_loss: 0.6686 - val_categorical_accuracy: 0.6400
Epoch 265/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4884 - categorical_acc
uracy: 0.8107 - val_loss: 0.5992 - val_categorical_accuracy: 0.7200
Epoch 266/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4998 - categorical_acc
uracy: 0.7961 - val_loss: 0.5786 - val_categorical_accuracy: 0.6800
Epoch 267/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4785 - categorical_acc
uracy: 0.8058 - val_loss: 0.6344 - val_categorical_accuracy: 0.7200
Epoch 268/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4841 - categorical_acc
uracy: 0.8333 - val_loss: 0.5789 - val_categorical_accuracy: 0.7000
Epoch 269/500
21/21 [==============================] - 14s 650ms/step - loss: 0.4862 - categorical_acc
uracy: 0.8058 - val_loss: 0.5819 - val_categorical_accuracy: 0.7200
Epoch 270/500
21/21 [==============================] - 14s 666ms/step - loss: 0.5145 - categorical_acc
uracy: 0.7718 - val_loss: 0.6629 - val_categorical_accuracy: 0.6600
Epoch 271/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5039 - categorical_acc
uracy: 0.7961 - val_loss: 0.6421 - val_categorical_accuracy: 0.7000
Epoch 272/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4749 - categorical_acc
uracy: 0.8252 - val_loss: 0.6905 - val_categorical_accuracy: 0.6600
Epoch 273/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4646 - categorical_acc
uracy: 0.8350 - val_loss: 0.7072 - val_categorical_accuracy: 0.6600
Epoch 274/500
21/21 [==============================] - 14s 663ms/step - loss: 0.4916 - categorical_acc
uracy: 0.7961 - val_loss: 0.7368 - val_categorical_accuracy: 0.6400
Epoch 275/500
21/21 [==============================] - 14s 663ms/step - loss: 0.5163 - categorical_acc
uracy: 0.7961 - val_loss: 0.6804 - val_categorical_accuracy: 0.6600
Epoch 276/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4685 - categorical_acc
uracy: 0.8155 - val_loss: 0.6917 - val_categorical_accuracy: 0.6200
Epoch 277/500
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21/21 [==============================] - 14s 650ms/step - loss: 0.4731 - categorical_acc
uracy: 0.8010 - val_loss: 0.5501 - val_categorical_accuracy: 0.8000
Epoch 278/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4866 - categorical_acc
uracy: 0.7864 - val_loss: 0.6174 - val_categorical_accuracy: 0.7200
Epoch 279/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5174 - categorical_acc
uracy: 0.8058 - val_loss: 0.7890 - val_categorical_accuracy: 0.6400
Epoch 280/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4919 - categorical_acc
uracy: 0.7864 - val_loss: 0.7243 - val_categorical_accuracy: 0.6800
Epoch 281/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5235 - categorical_acc
uracy: 0.8204 - val_loss: 0.6337 - val_categorical_accuracy: 0.6800
Epoch 282/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4945 - categorical_acc
uracy: 0.8204 - val_loss: 0.7319 - val_categorical_accuracy: 0.6600
Epoch 283/500
21/21 [==============================] - 14s 660ms/step - loss: 0.5108 - categorical_acc
uracy: 0.8301 - val_loss: 0.6333 - val_categorical_accuracy: 0.7400
Epoch 284/500
21/21 [==============================] - 14s 661ms/step - loss: 0.5266 - categorical_acc
uracy: 0.8048 - val_loss: 0.7514 - val_categorical_accuracy: 0.6800
Epoch 285/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4986 - categorical_acc
uracy: 0.8107 - val_loss: 0.6579 - val_categorical_accuracy: 0.7400
Epoch 286/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4676 - categorical_acc
uracy: 0.8107 - val_loss: 0.6662 - val_categorical_accuracy: 0.6600
Epoch 287/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4632 - categorical_acc
uracy: 0.8204 - val_loss: 0.6551 - val_categorical_accuracy: 0.7200
Epoch 288/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4586 - categorical_acc
uracy: 0.8301 - val_loss: 0.6703 - val_categorical_accuracy: 0.6800
Epoch 289/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5461 - categorical_acc
uracy: 0.7816 - val_loss: 0.6878 - val_categorical_accuracy: 0.7200
Epoch 290/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5039 - categorical_acc
uracy: 0.8301 - val_loss: 0.5696 - val_categorical_accuracy: 0.7400
Epoch 291/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5283 - categorical_acc
uracy: 0.8155 - val_loss: 0.6663 - val_categorical_accuracy: 0.6400
Epoch 292/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4875 - categorical_acc
uracy: 0.7913 - val_loss: 0.6057 - val_categorical_accuracy: 0.7200
Epoch 293/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4966 - categorical_acc
uracy: 0.8204 - val_loss: 0.6093 - val_categorical_accuracy: 0.6400
Epoch 294/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4530 - categorical_acc
uracy: 0.8204 - val_loss: 0.6500 - val_categorical_accuracy: 0.6800
Epoch 295/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4901 - categorical_acc
uracy: 0.7961 - val_loss: 0.6964 - val_categorical_accuracy: 0.6000
Epoch 296/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5000 - categorical_acc
uracy: 0.8058 - val_loss: 0.6547 - val_categorical_accuracy: 0.6800
Epoch 297/500
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21/21 [==============================] - 14s 652ms/step - loss: 0.4872 - categorical_acc
uracy: 0.8252 - val_loss: 0.6655 - val_categorical_accuracy: 0.7200
Epoch 298/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4935 - categorical_acc
uracy: 0.8107 - val_loss: 0.6973 - val_categorical_accuracy: 0.6800
Epoch 299/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4693 - categorical_acc
uracy: 0.8592 - val_loss: 0.6049 - val_categorical_accuracy: 0.6400
Epoch 300/500
21/21 [==============================] - 14s 665ms/step - loss: 0.4897 - categorical_acc
uracy: 0.8238 - val_loss: 0.5941 - val_categorical_accuracy: 0.7800
Epoch 301/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5807 - categorical_acc
uracy: 0.7816 - val_loss: 0.7048 - val_categorical_accuracy: 0.7000
Epoch 302/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5039 - categorical_acc
uracy: 0.8155 - val_loss: 0.7153 - val_categorical_accuracy: 0.6000
Epoch 303/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5020 - categorical_acc
uracy: 0.8058 - val_loss: 0.7078 - val_categorical_accuracy: 0.6400
Epoch 304/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4975 - categorical_acc
uracy: 0.7961 - val_loss: 0.6536 - val_categorical_accuracy: 0.7600
Epoch 305/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4632 - categorical_acc
uracy: 0.8204 - val_loss: 0.6584 - val_categorical_accuracy: 0.6400
Epoch 306/500
21/21 [==============================] - 14s 657ms/step - loss: 0.5138 - categorical_acc
uracy: 0.8058 - val_loss: 0.5631 - val_categorical_accuracy: 0.8000
Epoch 307/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4963 - categorical_acc
uracy: 0.7961 - val_loss: 0.6824 - val_categorical_accuracy: 0.6200
Epoch 308/500
21/21 [==============================] - 14s 650ms/step - loss: 0.4706 - categorical_acc
uracy: 0.8398 - val_loss: 0.6174 - val_categorical_accuracy: 0.7000
Epoch 309/500
21/21 [==============================] - 14s 655ms/step - loss: 0.5411 - categorical_acc
uracy: 0.7961 - val_loss: 0.6556 - val_categorical_accuracy: 0.7000
Epoch 310/500
21/21 [==============================] - 14s 653ms/step - loss: 0.5030 - categorical_acc
uracy: 0.7864 - val_loss: 0.6409 - val_categorical_accuracy: 0.6600
Epoch 311/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4690 - categorical_acc
uracy: 0.8447 - val_loss: 0.5998 - val_categorical_accuracy: 0.7400
Epoch 312/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4722 - categorical_acc
uracy: 0.8058 - val_loss: 0.6100 - val_categorical_accuracy: 0.7200
Epoch 313/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4777 - categorical_acc
uracy: 0.8107 - val_loss: 0.6194 - val_categorical_accuracy: 0.7400
Epoch 314/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4308 - categorical_acc
uracy: 0.8398 - val_loss: 0.6364 - val_categorical_accuracy: 0.7000
Epoch 315/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4970 - categorical_acc
uracy: 0.8155 - val_loss: 0.6138 - val_categorical_accuracy: 0.6800
Epoch 316/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4771 - categorical_acc
uracy: 0.8350 - val_loss: 0.6121 - val_categorical_accuracy: 0.7200
Epoch 317/500
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21/21 [==============================] - 14s 654ms/step - loss: 0.4924 - categorical_acc
uracy: 0.8204 - val_loss: 0.7032 - val_categorical_accuracy: 0.6600
Epoch 318/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4472 - categorical_acc
uracy: 0.8155 - val_loss: 0.6822 - val_categorical_accuracy: 0.6600
Epoch 319/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4910 - categorical_acc
uracy: 0.8155 - val_loss: 0.8182 - val_categorical_accuracy: 0.6400
Epoch 320/500
21/21 [==============================] - 14s 667ms/step - loss: 0.4671 - categorical_acc
uracy: 0.8544 - val_loss: 0.7251 - val_categorical_accuracy: 0.6400
Epoch 321/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4648 - categorical_acc
uracy: 0.8350 - val_loss: 0.6988 - val_categorical_accuracy: 0.7000
Epoch 322/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4677 - categorical_acc
uracy: 0.7961 - val_loss: 0.8105 - val_categorical_accuracy: 0.6600
Epoch 323/500
21/21 [==============================] - 14s 651ms/step - loss: 0.5024 - categorical_acc
uracy: 0.7816 - val_loss: 0.6308 - val_categorical_accuracy: 0.7200
Epoch 324/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4552 - categorical_acc
uracy: 0.8301 - val_loss: 0.4931 - val_categorical_accuracy: 0.7800
Epoch 325/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4965 - categorical_acc
uracy: 0.7767 - val_loss: 0.5362 - val_categorical_accuracy: 0.7800
Epoch 326/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4996 - categorical_acc
uracy: 0.8010 - val_loss: 0.6861 - val_categorical_accuracy: 0.6400
Epoch 327/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4611 - categorical_acc
uracy: 0.8107 - val_loss: 0.6720 - val_categorical_accuracy: 0.6600
Epoch 328/500
21/21 [==============================] - 14s 670ms/step - loss: 0.4734 - categorical_acc
uracy: 0.8204 - val_loss: 0.6219 - val_categorical_accuracy: 0.7200
Epoch 329/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4822 - categorical_acc
uracy: 0.8058 - val_loss: 0.6314 - val_categorical_accuracy: 0.6800
Epoch 330/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4336 - categorical_acc
uracy: 0.8204 - val_loss: 0.6737 - val_categorical_accuracy: 0.7200
Epoch 331/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4897 - categorical_acc
uracy: 0.7670 - val_loss: 0.5700 - val_categorical_accuracy: 0.7800
Epoch 332/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4917 - categorical_acc
uracy: 0.7961 - val_loss: 0.6157 - val_categorical_accuracy: 0.7200
Epoch 333/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4393 - categorical_acc
uracy: 0.8495 - val_loss: 0.7174 - val_categorical_accuracy: 0.5800
Epoch 334/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4949 - categorical_acc
uracy: 0.7670 - val_loss: 0.7013 - val_categorical_accuracy: 0.6600
Epoch 335/500
21/21 [==============================] - 14s 669ms/step - loss: 0.4521 - categorical_acc
uracy: 0.8398 - val_loss: 0.5837 - val_categorical_accuracy: 0.7600
Epoch 336/500
21/21 [==============================] - 14s 671ms/step - loss: 0.4929 - categorical_acc
uracy: 0.8010 - val_loss: 0.6561 - val_categorical_accuracy: 0.7200
Epoch 337/500
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21/21 [==============================] - 14s 666ms/step - loss: 0.5206 - categorical_acc
uracy: 0.7762 - val_loss: 0.6865 - val_categorical_accuracy: 0.7200
Epoch 338/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4429 - categorical_acc
uracy: 0.8689 - val_loss: 0.5472 - val_categorical_accuracy: 0.7200
Epoch 339/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5013 - categorical_acc
uracy: 0.7816 - val_loss: 0.6250 - val_categorical_accuracy: 0.6600
Epoch 340/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4698 - categorical_acc
uracy: 0.8010 - val_loss: 0.6550 - val_categorical_accuracy: 0.6600
Epoch 341/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5016 - categorical_acc
uracy: 0.7864 - val_loss: 0.6339 - val_categorical_accuracy: 0.7800
Epoch 342/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4721 - categorical_acc
uracy: 0.8301 - val_loss: 0.6384 - val_categorical_accuracy: 0.6400
Epoch 343/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4977 - categorical_acc
uracy: 0.8252 - val_loss: 0.6400 - val_categorical_accuracy: 0.7000
Epoch 344/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4762 - categorical_acc
uracy: 0.8010 - val_loss: 0.5456 - val_categorical_accuracy: 0.7200
Epoch 345/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4886 - categorical_acc
uracy: 0.8107 - val_loss: 0.6040 - val_categorical_accuracy: 0.7200
Epoch 346/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5000 - categorical_acc
uracy: 0.8155 - val_loss: 0.5854 - val_categorical_accuracy: 0.7200
Epoch 347/500
21/21 [==============================] - 14s 667ms/step - loss: 0.4769 - categorical_acc
uracy: 0.8155 - val_loss: 0.7586 - val_categorical_accuracy: 0.7000
Epoch 348/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4605 - categorical_acc
uracy: 0.8155 - val_loss: 0.6990 - val_categorical_accuracy: 0.6400
Epoch 349/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4770 - categorical_acc
uracy: 0.8155 - val_loss: 0.6990 - val_categorical_accuracy: 0.7000
Epoch 350/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4821 - categorical_acc
uracy: 0.8301 - val_loss: 0.6735 - val_categorical_accuracy: 0.6800
Epoch 351/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4918 - categorical_acc
uracy: 0.8252 - val_loss: 0.7496 - val_categorical_accuracy: 0.6400
Epoch 352/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4834 - categorical_acc
uracy: 0.7961 - val_loss: 0.7007 - val_categorical_accuracy: 0.6400
Epoch 353/500
21/21 [==============================] - 14s 652ms/step - loss: 0.5183 - categorical_acc
uracy: 0.7961 - val_loss: 0.6018 - val_categorical_accuracy: 0.7800
Epoch 354/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4653 - categorical_acc
uracy: 0.8252 - val_loss: 0.7391 - val_categorical_accuracy: 0.6400
Epoch 355/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4796 - categorical_acc
uracy: 0.8058 - val_loss: 0.5911 - val_categorical_accuracy: 0.7000
Epoch 356/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4827 - categorical_acc
uracy: 0.8350 - val_loss: 0.6952 - val_categorical_accuracy: 0.6800
Epoch 357/500
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21/21 [==============================] - 14s 653ms/step - loss: 0.4693 - categorical_acc
uracy: 0.8204 - val_loss: 0.6151 - val_categorical_accuracy: 0.6600
Epoch 358/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4976 - categorical_acc
uracy: 0.8301 - val_loss: 0.6386 - val_categorical_accuracy: 0.6800
Epoch 359/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4604 - categorical_acc
uracy: 0.8301 - val_loss: 0.5848 - val_categorical_accuracy: 0.7800
Epoch 360/500
21/21 [==============================] - 14s 650ms/step - loss: 0.4633 - categorical_acc
uracy: 0.8058 - val_loss: 0.6743 - val_categorical_accuracy: 0.6800
Epoch 361/500
21/21 [==============================] - 14s 668ms/step - loss: 0.4828 - categorical_acc
uracy: 0.8204 - val_loss: 0.6475 - val_categorical_accuracy: 0.7400
Epoch 362/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4905 - categorical_acc
uracy: 0.8155 - val_loss: 0.5579 - val_categorical_accuracy: 0.7200
Epoch 363/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4545 - categorical_acc
uracy: 0.8398 - val_loss: 0.7069 - val_categorical_accuracy: 0.6000
Epoch 364/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4973 - categorical_acc
uracy: 0.7864 - val_loss: 0.6783 - val_categorical_accuracy: 0.7000
Epoch 365/500
21/21 [==============================] - 14s 654ms/step - loss: 0.5059 - categorical_acc
uracy: 0.8252 - val_loss: 0.7408 - val_categorical_accuracy: 0.6000
Epoch 366/500
21/21 [==============================] - 14s 653ms/step - loss: 0.4532 - categorical_acc
uracy: 0.8447 - val_loss: 0.8126 - val_categorical_accuracy: 0.7000
Epoch 367/500
21/21 [==============================] - 14s 665ms/step - loss: 0.4693 - categorical_acc
uracy: 0.8301 - val_loss: 0.6383 - val_categorical_accuracy: 0.6800
Epoch 368/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4285 - categorical_acc
uracy: 0.8495 - val_loss: 0.7046 - val_categorical_accuracy: 0.7600
Epoch 369/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4494 - categorical_acc
uracy: 0.8495 - val_loss: 0.6310 - val_categorical_accuracy: 0.7200
Epoch 370/500
21/21 [==============================] - 14s 668ms/step - loss: 0.4537 - categorical_acc
uracy: 0.8495 - val_loss: 0.6672 - val_categorical_accuracy: 0.6800
Epoch 371/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4613 - categorical_acc
uracy: 0.7961 - val_loss: 0.5753 - val_categorical_accuracy: 0.7400
Epoch 372/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4612 - categorical_acc
uracy: 0.8495 - val_loss: 0.6524 - val_categorical_accuracy: 0.7400
Epoch 373/500
21/21 [==============================] - 14s 667ms/step - loss: 0.4814 - categorical_acc
uracy: 0.8010 - val_loss: 0.6069 - val_categorical_accuracy: 0.7200
Epoch 374/500
21/21 [==============================] - 14s 651ms/step - loss: 0.4652 - categorical_acc
uracy: 0.8155 - val_loss: 0.6828 - val_categorical_accuracy: 0.6800
Epoch 375/500
21/21 [==============================] - 14s 669ms/step - loss: 0.4574 - categorical_acc
uracy: 0.8252 - val_loss: 0.6710 - val_categorical_accuracy: 0.6800
Epoch 376/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4647 - categorical_acc
uracy: 0.7961 - val_loss: 0.5922 - val_categorical_accuracy: 0.7400
Epoch 377/500
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21/21 [==============================] - 14s 665ms/step - loss: 0.4300 - categorical_acc
uracy: 0.8447 - val_loss: 0.6358 - val_categorical_accuracy: 0.6800
Epoch 378/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4695 - categorical_acc
uracy: 0.8252 - val_loss: 0.7140 - val_categorical_accuracy: 0.6600
Epoch 379/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4322 - categorical_acc
uracy: 0.8350 - val_loss: 0.5330 - val_categorical_accuracy: 0.7800
Epoch 380/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4997 - categorical_acc
uracy: 0.7718 - val_loss: 0.6027 - val_categorical_accuracy: 0.6400
Epoch 381/500
21/21 [==============================] - 14s 651ms/step - loss: 0.4645 - categorical_acc
uracy: 0.7961 - val_loss: 0.6476 - val_categorical_accuracy: 0.6800
Epoch 382/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4932 - categorical_acc
uracy: 0.8190 - val_loss: 0.7255 - val_categorical_accuracy: 0.6800
Epoch 383/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4953 - categorical_acc
uracy: 0.8301 - val_loss: 0.6368 - val_categorical_accuracy: 0.6800
Epoch 384/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4593 - categorical_acc
uracy: 0.8252 - val_loss: 0.5372 - val_categorical_accuracy: 0.7600
Epoch 385/500
21/21 [==============================] - 14s 665ms/step - loss: 0.4283 - categorical_acc
uracy: 0.8333 - val_loss: 0.6953 - val_categorical_accuracy: 0.6800
Epoch 386/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4661 - categorical_acc
uracy: 0.8495 - val_loss: 0.5890 - val_categorical_accuracy: 0.7800
Epoch 387/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4999 - categorical_acc
uracy: 0.8204 - val_loss: 0.6029 - val_categorical_accuracy: 0.7000
Epoch 388/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4637 - categorical_acc
uracy: 0.8398 - val_loss: 0.8315 - val_categorical_accuracy: 0.6600
Epoch 389/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4311 - categorical_acc
uracy: 0.8204 - val_loss: 0.6658 - val_categorical_accuracy: 0.7000
Epoch 390/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4736 - categorical_acc
uracy: 0.8350 - val_loss: 0.6861 - val_categorical_accuracy: 0.6800
Epoch 391/500
21/21 [==============================] - 14s 651ms/step - loss: 0.4722 - categorical_acc
uracy: 0.8204 - val_loss: 0.5046 - val_categorical_accuracy: 0.8000
Epoch 392/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4859 - categorical_acc
uracy: 0.8107 - val_loss: 0.7161 - val_categorical_accuracy: 0.6200
Epoch 393/500
21/21 [==============================] - 14s 656ms/step - loss: 0.5159 - categorical_acc
uracy: 0.7864 - val_loss: 0.6450 - val_categorical_accuracy: 0.7000
Epoch 394/500
21/21 [==============================] - 14s 671ms/step - loss: 0.5028 - categorical_acc
uracy: 0.8204 - val_loss: 0.7090 - val_categorical_accuracy: 0.6600
Epoch 395/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4858 - categorical_acc
uracy: 0.8107 - val_loss: 0.6905 - val_categorical_accuracy: 0.7000
Epoch 396/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4387 - categorical_acc
uracy: 0.8641 - val_loss: 0.7451 - val_categorical_accuracy: 0.6600
Epoch 397/500
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21/21 [==============================] - 14s 656ms/step - loss: 0.4701 - categorical_acc
uracy: 0.8058 - val_loss: 0.6899 - val_categorical_accuracy: 0.7400
Epoch 398/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4779 - categorical_acc
uracy: 0.8252 - val_loss: 0.6134 - val_categorical_accuracy: 0.7400
Epoch 399/500
21/21 [==============================] - 14s 665ms/step - loss: 0.4495 - categorical_acc
uracy: 0.8204 - val_loss: 0.6759 - val_categorical_accuracy: 0.7000
Epoch 400/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4414 - categorical_acc
uracy: 0.8544 - val_loss: 0.6700 - val_categorical_accuracy: 0.6600
Epoch 401/500
21/21 [==============================] - 14s 680ms/step - loss: 0.4402 - categorical_acc
uracy: 0.8350 - val_loss: 0.6249 - val_categorical_accuracy: 0.6800
Epoch 402/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4132 - categorical_acc
uracy: 0.8447 - val_loss: 0.5967 - val_categorical_accuracy: 0.7600
Epoch 403/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4713 - categorical_acc
uracy: 0.8107 - val_loss: 0.5873 - val_categorical_accuracy: 0.7200
Epoch 404/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4942 - categorical_acc
uracy: 0.8155 - val_loss: 0.5678 - val_categorical_accuracy: 0.7200
Epoch 405/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4262 - categorical_acc
uracy: 0.8495 - val_loss: 0.5853 - val_categorical_accuracy: 0.7800
Epoch 406/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4439 - categorical_acc
uracy: 0.8204 - val_loss: 0.6781 - val_categorical_accuracy: 0.6600
Epoch 407/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4699 - categorical_acc
uracy: 0.8058 - val_loss: 0.7146 - val_categorical_accuracy: 0.6000
Epoch 408/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4274 - categorical_acc
uracy: 0.8107 - val_loss: 0.6188 - val_categorical_accuracy: 0.7800
Epoch 409/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4622 - categorical_acc
uracy: 0.8447 - val_loss: 0.6158 - val_categorical_accuracy: 0.7400
Epoch 410/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4437 - categorical_acc
uracy: 0.8495 - val_loss: 0.5688 - val_categorical_accuracy: 0.7600
Epoch 411/500
21/21 [==============================] - 14s 652ms/step - loss: 0.4767 - categorical_acc
uracy: 0.8155 - val_loss: 0.6952 - val_categorical_accuracy: 0.7200
Epoch 412/500
21/21 [==============================] - 14s 651ms/step - loss: 0.4441 - categorical_acc
uracy: 0.8398 - val_loss: 0.6529 - val_categorical_accuracy: 0.7000
Epoch 413/500
21/21 [==============================] - 14s 677ms/step - loss: 0.4820 - categorical_acc
uracy: 0.8333 - val_loss: 0.5158 - val_categorical_accuracy: 0.7200
Epoch 414/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4570 - categorical_acc
uracy: 0.8155 - val_loss: 0.6059 - val_categorical_accuracy: 0.7200
Epoch 415/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4303 - categorical_acc
uracy: 0.8350 - val_loss: 0.6844 - val_categorical_accuracy: 0.7000
Epoch 416/500
21/21 [==============================] - 14s 665ms/step - loss: 0.4421 - categorical_acc
uracy: 0.8252 - val_loss: 0.7333 - val_categorical_accuracy: 0.6800
Epoch 417/500
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21/21 [==============================] - 14s 654ms/step - loss: 0.5232 - categorical_acc
uracy: 0.8155 - val_loss: 0.7434 - val_categorical_accuracy: 0.6200
Epoch 418/500
21/21 [==============================] - 14s 670ms/step - loss: 0.4855 - categorical_acc
uracy: 0.8058 - val_loss: 0.5129 - val_categorical_accuracy: 0.8000
Epoch 419/500
21/21 [==============================] - 14s 669ms/step - loss: 0.4640 - categorical_acc
uracy: 0.8238 - val_loss: 0.5660 - val_categorical_accuracy: 0.7400
Epoch 420/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4587 - categorical_acc
uracy: 0.8398 - val_loss: 0.7318 - val_categorical_accuracy: 0.6600
Epoch 421/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4315 - categorical_acc
uracy: 0.8204 - val_loss: 0.6954 - val_categorical_accuracy: 0.7400
Epoch 422/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4376 - categorical_acc
uracy: 0.8252 - val_loss: 0.7025 - val_categorical_accuracy: 0.6200
Epoch 423/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4441 - categorical_acc
uracy: 0.8204 - val_loss: 0.6817 - val_categorical_accuracy: 0.6800
Epoch 424/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4151 - categorical_acc
uracy: 0.8738 - val_loss: 0.6261 - val_categorical_accuracy: 0.7000
Epoch 425/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4641 - categorical_acc
uracy: 0.8301 - val_loss: 0.7493 - val_categorical_accuracy: 0.6800
Epoch 426/500
21/21 [==============================] - 14s 675ms/step - loss: 0.4575 - categorical_acc
uracy: 0.8350 - val_loss: 0.5859 - val_categorical_accuracy: 0.7400
Epoch 427/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4708 - categorical_acc
uracy: 0.8058 - val_loss: 0.5629 - val_categorical_accuracy: 0.7200
Epoch 428/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4457 - categorical_acc
uracy: 0.8155 - val_loss: 0.5969 - val_categorical_accuracy: 0.7400
Epoch 429/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4406 - categorical_acc
uracy: 0.8495 - val_loss: 0.5839 - val_categorical_accuracy: 0.7800
Epoch 430/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4419 - categorical_acc
uracy: 0.8350 - val_loss: 0.6880 - val_categorical_accuracy: 0.7000
Epoch 431/500
21/21 [==============================] - 14s 668ms/step - loss: 0.4332 - categorical_acc
uracy: 0.8544 - val_loss: 0.7100 - val_categorical_accuracy: 0.7000
Epoch 432/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4635 - categorical_acc
uracy: 0.8155 - val_loss: 0.7050 - val_categorical_accuracy: 0.6800
Epoch 433/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4459 - categorical_acc
uracy: 0.8252 - val_loss: 0.7191 - val_categorical_accuracy: 0.6800
Epoch 434/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4337 - categorical_acc
uracy: 0.8204 - val_loss: 0.6177 - val_categorical_accuracy: 0.7200
Epoch 435/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4366 - categorical_acc
uracy: 0.8058 - val_loss: 0.6694 - val_categorical_accuracy: 0.7000
Epoch 436/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4196 - categorical_acc
uracy: 0.8544 - val_loss: 0.6664 - val_categorical_accuracy: 0.7200
Epoch 437/500
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21/21 [==============================] - 14s 660ms/step - loss: 0.4490 - categorical_acc
uracy: 0.8204 - val_loss: 0.5099 - val_categorical_accuracy: 0.7600
Epoch 438/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4459 - categorical_acc
uracy: 0.8447 - val_loss: 0.6506 - val_categorical_accuracy: 0.7000
Epoch 439/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4440 - categorical_acc
uracy: 0.8155 - val_loss: 0.5537 - val_categorical_accuracy: 0.7200
Epoch 440/500
21/21 [==============================] - 14s 675ms/step - loss: 0.4372 - categorical_acc
uracy: 0.8155 - val_loss: 0.6082 - val_categorical_accuracy: 0.7200
Epoch 441/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4228 - categorical_acc
uracy: 0.8398 - val_loss: 0.5801 - val_categorical_accuracy: 0.8000
Epoch 442/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4646 - categorical_acc
uracy: 0.8155 - val_loss: 0.6662 - val_categorical_accuracy: 0.6600
Epoch 443/500
21/21 [==============================] - 14s 654ms/step - loss: 0.4387 - categorical_acc
uracy: 0.8398 - val_loss: 0.7844 - val_categorical_accuracy: 0.6600
Epoch 444/500
21/21 [==============================] - 14s 663ms/step - loss: 0.4362 - categorical_acc
uracy: 0.8252 - val_loss: 0.5982 - val_categorical_accuracy: 0.7600
Epoch 445/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4829 - categorical_acc
uracy: 0.8107 - val_loss: 0.7075 - val_categorical_accuracy: 0.6600
Epoch 446/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4807 - categorical_acc
uracy: 0.8107 - val_loss: 0.5402 - val_categorical_accuracy: 0.7800
Epoch 447/500
21/21 [==============================] - 14s 659ms/step - loss: 0.5079 - categorical_acc
uracy: 0.7961 - val_loss: 0.6846 - val_categorical_accuracy: 0.7000
Epoch 448/500
21/21 [==============================] - 14s 657ms/step - loss: 0.3957 - categorical_acc
uracy: 0.8447 - val_loss: 0.6282 - val_categorical_accuracy: 0.7200
Epoch 449/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4628 - categorical_acc
uracy: 0.8398 - val_loss: 0.6233 - val_categorical_accuracy: 0.6600
Epoch 450/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4702 - categorical_acc
uracy: 0.8398 - val_loss: 0.6921 - val_categorical_accuracy: 0.6800
Epoch 451/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4282 - categorical_acc
uracy: 0.8495 - val_loss: 0.7043 - val_categorical_accuracy: 0.6600
Epoch 452/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4404 - categorical_acc
uracy: 0.8155 - val_loss: 0.5662 - val_categorical_accuracy: 0.6600
Epoch 453/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4494 - categorical_acc
uracy: 0.8155 - val_loss: 0.6938 - val_categorical_accuracy: 0.7200
Epoch 454/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4721 - categorical_acc
uracy: 0.8155 - val_loss: 0.6686 - val_categorical_accuracy: 0.6800
Epoch 455/500
21/21 [==============================] - 14s 674ms/step - loss: 0.4118 - categorical_acc
uracy: 0.8592 - val_loss: 0.5904 - val_categorical_accuracy: 0.7000
Epoch 456/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4532 - categorical_acc
uracy: 0.8447 - val_loss: 0.7660 - val_categorical_accuracy: 0.7000
Epoch 457/500
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21/21 [==============================] - 14s 657ms/step - loss: 0.4634 - categorical_acc
uracy: 0.8010 - val_loss: 0.6104 - val_categorical_accuracy: 0.6800
Epoch 458/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4642 - categorical_acc
uracy: 0.8398 - val_loss: 0.6432 - val_categorical_accuracy: 0.7000
Epoch 459/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4838 - categorical_acc
uracy: 0.7767 - val_loss: 0.6700 - val_categorical_accuracy: 0.7400
Epoch 460/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4575 - categorical_acc
uracy: 0.8350 - val_loss: 0.6537 - val_categorical_accuracy: 0.7200
Epoch 461/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4658 - categorical_acc
uracy: 0.7913 - val_loss: 0.6684 - val_categorical_accuracy: 0.7400
Epoch 462/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4274 - categorical_acc
uracy: 0.8447 - val_loss: 0.5526 - val_categorical_accuracy: 0.7200
Epoch 463/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4246 - categorical_acc
uracy: 0.8495 - val_loss: 0.6498 - val_categorical_accuracy: 0.7000
Epoch 464/500
21/21 [==============================] - 14s 663ms/step - loss: 0.4450 - categorical_acc
uracy: 0.8107 - val_loss: 0.6831 - val_categorical_accuracy: 0.6800
Epoch 465/500
21/21 [==============================] - 14s 669ms/step - loss: 0.4476 - categorical_acc
uracy: 0.8048 - val_loss: 0.5975 - val_categorical_accuracy: 0.7200
Epoch 466/500
21/21 [==============================] - 14s 663ms/step - loss: 0.4524 - categorical_acc
uracy: 0.8252 - val_loss: 0.5550 - val_categorical_accuracy: 0.7400
Epoch 467/500
21/21 [==============================] - 14s 663ms/step - loss: 0.4627 - categorical_acc
uracy: 0.8107 - val_loss: 0.6268 - val_categorical_accuracy: 0.7400
Epoch 468/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4336 - categorical_acc
uracy: 0.8398 - val_loss: 0.5602 - val_categorical_accuracy: 0.7400
Epoch 469/500
21/21 [==============================] - 14s 674ms/step - loss: 0.4433 - categorical_acc
uracy: 0.8252 - val_loss: 0.6359 - val_categorical_accuracy: 0.7600
Epoch 470/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4208 - categorical_acc
uracy: 0.8155 - val_loss: 0.7417 - val_categorical_accuracy: 0.7200
Epoch 471/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4271 - categorical_acc
uracy: 0.8495 - val_loss: 0.7297 - val_categorical_accuracy: 0.7600
Epoch 472/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4317 - categorical_acc
uracy: 0.8107 - val_loss: 0.6838 - val_categorical_accuracy: 0.7000
Epoch 473/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4570 - categorical_acc
uracy: 0.8058 - val_loss: 0.5992 - val_categorical_accuracy: 0.7400
Epoch 474/500
21/21 [==============================] - 14s 667ms/step - loss: 0.4235 - categorical_acc
uracy: 0.8350 - val_loss: 0.7189 - val_categorical_accuracy: 0.6200
Epoch 475/500
21/21 [==============================] - 14s 668ms/step - loss: 0.4441 - categorical_acc
uracy: 0.8350 - val_loss: 0.5782 - val_categorical_accuracy: 0.7400
Epoch 476/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4853 - categorical_acc
uracy: 0.8398 - val_loss: 0.6689 - val_categorical_accuracy: 0.6800
Epoch 477/500
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21/21 [==============================] - 14s 688ms/step - loss: 0.4188 - categorical_acc
uracy: 0.8398 - val_loss: 0.6603 - val_categorical_accuracy: 0.7400
Epoch 478/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4654 - categorical_acc
uracy: 0.8155 - val_loss: 0.6763 - val_categorical_accuracy: 0.7000
Epoch 479/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4432 - categorical_acc
uracy: 0.8544 - val_loss: 0.6302 - val_categorical_accuracy: 0.7400
Epoch 480/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4469 - categorical_acc
uracy: 0.8447 - val_loss: 0.6427 - val_categorical_accuracy: 0.6800
Epoch 481/500
21/21 [==============================] - 14s 661ms/step - loss: 0.3886 - categorical_acc
uracy: 0.8495 - val_loss: 0.6396 - val_categorical_accuracy: 0.7200
Epoch 482/500
21/21 [==============================] - 14s 659ms/step - loss: 0.4430 - categorical_acc
uracy: 0.8350 - val_loss: 0.6812 - val_categorical_accuracy: 0.7200
Epoch 483/500
21/21 [==============================] - 14s 657ms/step - loss: 0.4275 - categorical_acc
uracy: 0.8350 - val_loss: 0.6431 - val_categorical_accuracy: 0.7200
Epoch 484/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4867 - categorical_acc
uracy: 0.7816 - val_loss: 0.6852 - val_categorical_accuracy: 0.6600
Epoch 485/500
21/21 [==============================] - 14s 675ms/step - loss: 0.4550 - categorical_acc
uracy: 0.8544 - val_loss: 0.6087 - val_categorical_accuracy: 0.7600
Epoch 486/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4209 - categorical_acc
uracy: 0.8350 - val_loss: 0.6606 - val_categorical_accuracy: 0.6800
Epoch 487/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4238 - categorical_acc
uracy: 0.8350 - val_loss: 0.6702 - val_categorical_accuracy: 0.6400
Epoch 488/500
21/21 [==============================] - 14s 664ms/step - loss: 0.4179 - categorical_acc
uracy: 0.8592 - val_loss: 0.5993 - val_categorical_accuracy: 0.7000
Epoch 489/500
21/21 [==============================] - 14s 659ms/step - loss: 0.3983 - categorical_acc
uracy: 0.8544 - val_loss: 0.6044 - val_categorical_accuracy: 0.7000
Epoch 490/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4180 - categorical_acc
uracy: 0.8447 - val_loss: 0.5570 - val_categorical_accuracy: 0.7600
Epoch 491/500
21/21 [==============================] - 14s 670ms/step - loss: 0.4295 - categorical_acc
uracy: 0.8476 - val_loss: 0.6415 - val_categorical_accuracy: 0.7000
Epoch 492/500
21/21 [==============================] - 14s 679ms/step - loss: 0.4208 - categorical_acc
uracy: 0.8495 - val_loss: 0.6066 - val_categorical_accuracy: 0.7000
Epoch 493/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4297 - categorical_acc
uracy: 0.8544 - val_loss: 0.7514 - val_categorical_accuracy: 0.6600
Epoch 494/500
21/21 [==============================] - 14s 656ms/step - loss: 0.4387 - categorical_acc
uracy: 0.8252 - val_loss: 0.6310 - val_categorical_accuracy: 0.6800
Epoch 495/500
21/21 [==============================] - 14s 662ms/step - loss: 0.4497 - categorical_acc
uracy: 0.8155 - val_loss: 0.6661 - val_categorical_accuracy: 0.6400
Epoch 496/500
21/21 [==============================] - 14s 655ms/step - loss: 0.4174 - categorical_acc
uracy: 0.8252 - val_loss: 0.5709 - val_categorical_accuracy: 0.7600
Epoch 497/500
```

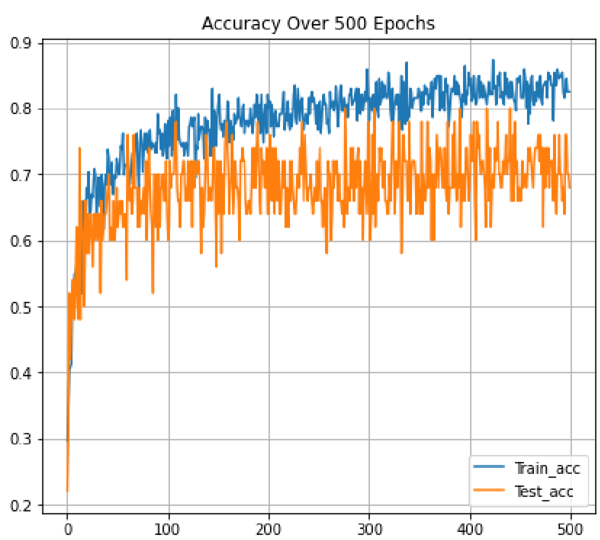
```
21/21 [==============================] - 14s 656ms/step - loss: 0.4063 - categorical_acc
uracy: 0.8447 - val_loss: 0.5175 - val_categorical_accuracy: 0.7600
Epoch 498/500
21/21 [==============================] - 14s 658ms/step - loss: 0.4515 - categorical_acc
uracy: 0.8252 - val_loss: 0.6129 - val_categorical_accuracy: 0.7000
Epoch 499/500
21/21 [==============================] - 14s 661ms/step - loss: 0.4582 - categorical_acc
uracy: 0.8252 - val_loss: 0.6290 - val_categorical_accuracy: 0.7000
Epoch 500/500
21/21 [==============================] - 14s 660ms/step - loss: 0.4044 - categorical_acc
uracy: 0.8252 - val_loss: 0.6464 - val_categorical_accuracy: 0.6800
```

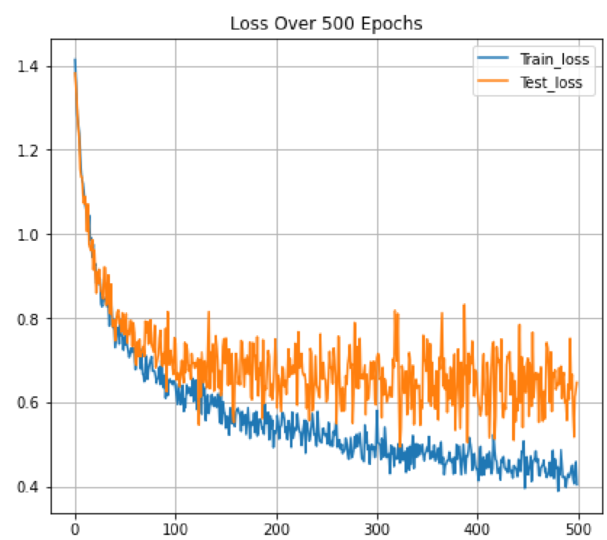
[5 points] Plot Accuracy and Loss During Training

In [126…

```python
import matplotlib.pyplot as plt

fig, (ax1, ax2) = plt.subplots(1, 2)
fig.set_figheight(6)
fig.set_figwidth(15)
ax1.plot(res.history['categorical_accuracy'])
ax1.plot(res.history['val_categorical_accuracy'])
ax1.set_title('Accuracy Over ' + str(NUM_EPOCHS) + ' Epochs')
ax1.legend(['Train_acc', 'Test_acc'], loc='lower right')
ax1.grid(True)
ax2.set_title('Loss Over ' + str(NUM_EPOCHS) + ' Epochs')
ax2.plot(res.history['loss'])
ax2.plot(res.history['val_loss'])
ax2.legend(['Train_loss', 'Test_loss'], loc='upper right')
ax2.grid(True)
plt.show()
```





Testing Model

In [127…

```python
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,cla
eval_generator.reset()
print(len(eval_generator))
x = model.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.
36
36/36 [==============================] - 3s 69ms/step - loss: 0.7342 - categorical_accur
acy: 0.6944
Test loss: 0.7342052459716797
Test accuracy: 0.6944444179534912
```

Model 2: AlexNet

[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 [128…

```
# from https://towardsdatascience.com/implementing-alexnet-cnn-architecture-using-tenso
model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(filters=96, kernel_size=(11,11), strides=(4,4), activation='
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPool2D(pool_size=(3,3), strides=(2,2)),
    tf.keras.layers.Conv2D(filters=256, kernel_size=(5,5), strides=(1,1), activation='r
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPool2D(pool_size=(3,3), strides=(2,2)),
    tf.keras.layers.Conv2D(filters=384, kernel_size=(3,3), strides=(1,1), activation='r
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.Conv2D(filters=384, kernel_size=(3,3), strides=(1,1), activation='r
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.Conv2D(filters=256, kernel_size=(3,3), strides=(1,1), activation='r
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.MaxPool2D(pool_size=(3,3), strides=(2,2)),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(4096, activation='relu'),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(4096, activation='relu'),
    tf.keras.layers.Dropout(0.5),
    tf.keras.layers.Dense(4, activation='softmax')
])
model.compile(loss='categorical_crossentropy', optimizer=tf.optimizers.SGD(lr=1e-7), me
```

In [129…

```
model.summary()
```

```
Model: "sequential_30"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_50 (Conv2D)           (None, 54, 54, 96)        34944
_________________________________________________________________
batch_normalization_50 (Batc (None, 54, 54, 96)        384
_________________________________________________________________
max_pooling2d_30 (MaxPooling (None, 26, 26, 96)        0
_________________________________________________________________
conv2d_51 (Conv2D)           (None, 26, 26, 256)       614656
_________________________________________________________________
```

```
batch_normalization_51 (Batc (None, 26, 26, 256)        1024
_________________________________________________________________
max_pooling2d_31 (MaxPooling (None, 12, 12, 256)        0
_________________________________________________________________
conv2d_52 (Conv2D)           (None, 12, 12, 384)        885120
_________________________________________________________________
batch_normalization_52 (Batc (None, 12, 12, 384)        1536
_________________________________________________________________
conv2d_53 (Conv2D)           (None, 12, 12, 384)        1327488
_________________________________________________________________
batch_normalization_53 (Batc (None, 12, 12, 384)        1536
_________________________________________________________________
conv2d_54 (Conv2D)           (None, 12, 12, 256)        884992
_________________________________________________________________
batch_normalization_54 (Batc (None, 12, 12, 256)        1024
_________________________________________________________________
max_pooling2d_32 (MaxPooling (None, 5, 5, 256)          0
_________________________________________________________________
flatten_30 (Flatten)         (None, 6400)               0
_________________________________________________________________
dense_87 (Dense)             (None, 4096)               26218496
_________________________________________________________________
dropout_51 (Dropout)         (None, 4096)               0
_________________________________________________________________
dense_88 (Dense)             (None, 4096)               16781312
_________________________________________________________________
dropout_52 (Dropout)         (None, 4096)               0
_________________________________________________________________
dense_89 (Dense)             (None, 4)                  16388
=================================================================
Total params: 46,768,900
Trainable params: 46,766,148
Non-trainable params: 2,752
_________________________________________________________________
```

[5 points] Train Model

In [ ]:

```
#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

NUM_EPOCHS = 100


res = model.fit(train_batches, epochs=NUM_EPOCHS, steps_per_epoch=STEP_SIZE_TRAIN, \
          validation_data=valid_batches, validation_steps=STEP_SIZE_VALID)
```

```
22
6
Epoch 1/100
21/21 [==============================] - 8s 374ms/step - loss: 3.2500 - categorical_accu
racy: 0.2476 - val_loss: 1.4232 - val_categorical_accuracy: 0.2600
Epoch 2/100
21/21 [==============================] - 8s 371ms/step - loss: 3.0390 - categorical_accu
racy: 0.2718 - val_loss: 1.4285 - val_categorical_accuracy: 0.2600
```

```
Epoch 3/100
21/21 [==============================] - 8s 370ms/step - loss: 3.2938 - categorical_accu
racy: 0.2476 - val_loss: 1.4257 - val_categorical_accuracy: 0.2600
Epoch 4/100
21/21 [==============================] - 8s 375ms/step - loss: 3.0958 - categorical_accu
racy: 0.2718 - val_loss: 1.4125 - val_categorical_accuracy: 0.2800
Epoch 5/100
21/21 [==============================] - 8s 374ms/step - loss: 3.0334 - categorical_accu
racy: 0.2573 - val_loss: 1.4218 - val_categorical_accuracy: 0.2800
Epoch 6/100
21/21 [==============================] - 8s 376ms/step - loss: 3.2283 - categorical_accu
racy: 0.2087 - val_loss: 1.4867 - val_categorical_accuracy: 0.2600
Epoch 7/100
21/21 [==============================] - 8s 375ms/step - loss: 2.9507 - categorical_accu
racy: 0.2282 - val_loss: 1.4934 - val_categorical_accuracy: 0.2600
Epoch 8/100
21/21 [==============================] - 8s 373ms/step - loss: 2.9717 - categorical_accu
racy: 0.2816 - val_loss: 1.5868 - val_categorical_accuracy: 0.2400
Epoch 9/100
21/21 [==============================] - 8s 376ms/step - loss: 3.0975 - categorical_accu
racy: 0.1942 - val_loss: 1.5387 - val_categorical_accuracy: 0.2800
Epoch 10/100
21/21 [==============================] - 8s 376ms/step - loss: 2.7252 - categorical_accu
racy: 0.3010 - val_loss: 1.5172 - val_categorical_accuracy: 0.3600
Epoch 11/100
21/21 [==============================] - 8s 378ms/step - loss: 2.8656 - categorical_accu
racy: 0.2571 - val_loss: 1.5545 - val_categorical_accuracy: 0.3400
Epoch 12/100
21/21 [==============================] - 8s 376ms/step - loss: 3.1151 - categorical_accu
racy: 0.1942 - val_loss: 1.5722 - val_categorical_accuracy: 0.3000
Epoch 13/100
21/21 [==============================] - 8s 382ms/step - loss: 3.1457 - categorical_accu
racy: 0.2952 - val_loss: 1.7581 - val_categorical_accuracy: 0.2600
Epoch 14/100
21/21 [==============================] - 8s 372ms/step - loss: 3.0388 - categorical_accu
racy: 0.2524 - val_loss: 1.7039 - val_categorical_accuracy: 0.3000
Epoch 15/100
21/21 [==============================] - 8s 368ms/step - loss: 2.9528 - categorical_accu
racy: 0.2621 - val_loss: 1.7320 - val_categorical_accuracy: 0.3200
Epoch 16/100
21/21 [==============================] - 8s 374ms/step - loss: 2.9095 - categorical_accu
racy: 0.2718 - val_loss: 1.6356 - val_categorical_accuracy: 0.3000
Epoch 17/100
21/21 [==============================] - 8s 376ms/step - loss: 2.9198 - categorical_accu
racy: 0.3107 - val_loss: 1.6825 - val_categorical_accuracy: 0.3000
Epoch 18/100
21/21 [==============================] - 8s 376ms/step - loss: 2.8891 - categorical_accu
racy: 0.3010 - val_loss: 1.6258 - val_categorical_accuracy: 0.3400
Epoch 19/100
21/21 [==============================] - 8s 387ms/step - loss: 2.6624 - categorical_accu
racy: 0.3143 - val_loss: 1.7134 - val_categorical_accuracy: 0.2400
Epoch 20/100
21/21 [==============================] - 8s 378ms/step - loss: 3.4338 - categorical_accu
racy: 0.2087 - val_loss: 1.6353 - val_categorical_accuracy: 0.2800
Epoch 21/100
21/21 [==============================] - 8s 375ms/step - loss: 3.0901 - categorical_accu
racy: 0.2427 - val_loss: 1.6709 - val_categorical_accuracy: 0.2800
Epoch 22/100
21/21 [==============================] - 8s 376ms/step - loss: 2.7610 - categorical_accu
racy: 0.3010 - val_loss: 1.6204 - val_categorical_accuracy: 0.3200
```

```
Epoch 23/100
21/21 [==============================] - 8s 368ms/step - loss: 2.9169 - categorical_accu
racy: 0.2670 - val_loss: 1.5241 - val_categorical_accuracy: 0.3000
Epoch 24/100
21/21 [==============================] - 8s 376ms/step - loss: 2.8818 - categorical_accu
racy: 0.2864 - val_loss: 1.6931 - val_categorical_accuracy: 0.2400
Epoch 25/100
21/21 [==============================] - 8s 383ms/step - loss: 3.1545 - categorical_accu
racy: 0.2427 - val_loss: 1.4648 - val_categorical_accuracy: 0.4000
Epoch 26/100
21/21 [==============================] - 8s 375ms/step - loss: 3.0472 - categorical_accu
racy: 0.2184 - val_loss: 1.4986 - val_categorical_accuracy: 0.3400
Epoch 27/100
21/21 [==============================] - 8s 378ms/step - loss: 3.0456 - categorical_accu
racy: 0.2864 - val_loss: 1.6133 - val_categorical_accuracy: 0.2800
Epoch 28/100
21/21 [==============================] - 8s 378ms/step - loss: 2.8187 - categorical_accu
racy: 0.2573 - val_loss: 1.5099 - val_categorical_accuracy: 0.3200
Epoch 29/100
21/21 [==============================] - 8s 371ms/step - loss: 3.0556 - categorical_accu
racy: 0.2427 - val_loss: 1.5298 - val_categorical_accuracy: 0.3400
Epoch 30/100
21/21 [==============================] - 8s 382ms/step - loss: 3.3274 - categorical_accu
racy: 0.1748 - val_loss: 1.5871 - val_categorical_accuracy: 0.3000
Epoch 31/100
21/21 [==============================] - 8s 382ms/step - loss: 2.9146 - categorical_accu
racy: 0.2136 - val_loss: 1.6541 - val_categorical_accuracy: 0.2600
Epoch 32/100
21/21 [==============================] - 8s 377ms/step - loss: 2.6200 - categorical_accu
racy: 0.3252 - val_loss: 1.7945 - val_categorical_accuracy: 0.1600
Epoch 33/100
21/21 [==============================] - 8s 372ms/step - loss: 2.8069 - categorical_accu
racy: 0.2913 - val_loss: 1.6282 - val_categorical_accuracy: 0.2400
Epoch 34/100
21/21 [==============================] - 8s 375ms/step - loss: 2.6941 - categorical_accu
racy: 0.2816 - val_loss: 1.4641 - val_categorical_accuracy: 0.3600
Epoch 35/100
21/21 [==============================] - 8s 367ms/step - loss: 2.9790 - categorical_accu
racy: 0.2379 - val_loss: 1.5833 - val_categorical_accuracy: 0.2800
Epoch 36/100
21/21 [==============================] - 8s 380ms/step - loss: 2.9263 - categorical_accu
racy: 0.2864 - val_loss: 1.6305 - val_categorical_accuracy: 0.3400
Epoch 37/100
21/21 [==============================] - 8s 368ms/step - loss: 2.8294 - categorical_accu
racy: 0.2767 - val_loss: 1.7364 - val_categorical_accuracy: 0.2400
Epoch 38/100
21/21 [==============================] - 8s 374ms/step - loss: 2.9047 - categorical_accu
racy: 0.2864 - val_loss: 1.4907 - val_categorical_accuracy: 0.3000
Epoch 39/100
21/21 [==============================] - 8s 370ms/step - loss: 2.7538 - categorical_accu
racy: 0.2864 - val_loss: 1.5621 - val_categorical_accuracy: 0.2400
Epoch 40/100
21/21 [==============================] - 8s 374ms/step - loss: 2.9262 - categorical_accu
racy: 0.2718 - val_loss: 1.4995 - val_categorical_accuracy: 0.2400
Epoch 41/100
21/21 [==============================] - 8s 372ms/step - loss: 2.7213 - categorical_accu
racy: 0.3010 - val_loss: 1.7151 - val_categorical_accuracy: 0.2600
Epoch 42/100
21/21 [==============================] - 8s 373ms/step - loss: 2.5731 - categorical_accu
racy: 0.2961 - val_loss: 1.4888 - val_categorical_accuracy: 0.3200
```

```
Epoch 43/100
21/21 [==============================] - 8s 373ms/step - loss: 2.9637 - categorical_accu
racy: 0.2621 - val_loss: 1.6893 - val_categorical_accuracy: 0.2600
Epoch 44/100
21/21 [==============================] - 8s 369ms/step - loss: 3.3102 - categorical_accu
racy: 0.2282 - val_loss: 1.5662 - val_categorical_accuracy: 0.3000
Epoch 45/100
21/21 [==============================] - 8s 367ms/step - loss: 2.9954 - categorical_accu
racy: 0.2767 - val_loss: 1.5912 - val_categorical_accuracy: 0.3000
Epoch 46/100
21/21 [==============================] - 8s 373ms/step - loss: 2.9564 - categorical_accu
racy: 0.2718 - val_loss: 1.6003 - val_categorical_accuracy: 0.3000
Epoch 47/100
21/21 [==============================] - 8s 373ms/step - loss: 2.7251 - categorical_accu
racy: 0.2670 - val_loss: 1.7495 - val_categorical_accuracy: 0.2800
Epoch 48/100
21/21 [==============================] - 8s 378ms/step - loss: 3.0171 - categorical_accu
racy: 0.2476 - val_loss: 1.5963 - val_categorical_accuracy: 0.3200
Epoch 49/100
21/21 [==============================] - 8s 367ms/step - loss: 2.8032 - categorical_accu
racy: 0.2767 - val_loss: 1.5506 - val_categorical_accuracy: 0.2400
Epoch 50/100
21/21 [==============================] - 8s 374ms/step - loss: 2.8737 - categorical_accu
racy: 0.2427 - val_loss: 1.5835 - val_categorical_accuracy: 0.2800
Epoch 51/100
21/21 [==============================] - 8s 373ms/step - loss: 2.8583 - categorical_accu
racy: 0.2427 - val_loss: 1.4519 - val_categorical_accuracy: 0.3400
Epoch 52/100
21/21 [==============================] - 8s 373ms/step - loss: 3.1376 - categorical_accu
racy: 0.2379 - val_loss: 1.6366 - val_categorical_accuracy: 0.2800
Epoch 53/100
21/21 [==============================] - 8s 373ms/step - loss: 2.9074 - categorical_accu
racy: 0.2330 - val_loss: 1.5327 - val_categorical_accuracy: 0.3000
Epoch 54/100
21/21 [==============================] - 8s 369ms/step - loss: 2.7461 - categorical_accu
racy: 0.2718 - val_loss: 1.6341 - val_categorical_accuracy: 0.3000
Epoch 55/100
21/21 [==============================] - 8s 371ms/step - loss: 2.8589 - categorical_accu
racy: 0.1990 - val_loss: 1.3422 - val_categorical_accuracy: 0.4400
Epoch 56/100
21/21 [==============================] - 8s 383ms/step - loss: 2.4142 - categorical_accu
racy: 0.3447 - val_loss: 1.6218 - val_categorical_accuracy: 0.2800
Epoch 57/100
21/21 [==============================] - 8s 370ms/step - loss: 2.9390 - categorical_accu
racy: 0.2136 - val_loss: 1.5937 - val_categorical_accuracy: 0.3800
Epoch 58/100
21/21 [==============================] - 8s 374ms/step - loss: 2.5998 - categorical_accu
racy: 0.2476 - val_loss: 1.5012 - val_categorical_accuracy: 0.2800
Epoch 59/100
21/21 [==============================] - 8s 374ms/step - loss: 2.7625 - categorical_accu
racy: 0.2767 - val_loss: 1.5073 - val_categorical_accuracy: 0.2800
Epoch 60/100
21/21 [==============================] - 8s 367ms/step - loss: 3.0342 - categorical_accu
racy: 0.2330 - val_loss: 1.4351 - val_categorical_accuracy: 0.3800
Epoch 61/100
21/21 [==============================] - 8s 367ms/step - loss: 2.8924 - categorical_accu
racy: 0.2621 - val_loss: 1.3189 - val_categorical_accuracy: 0.4400
Epoch 62/100
21/21 [==============================] - 8s 372ms/step - loss: 2.8798 - categorical_accu
racy: 0.2670 - val_loss: 1.3600 - val_categorical_accuracy: 0.3400
```

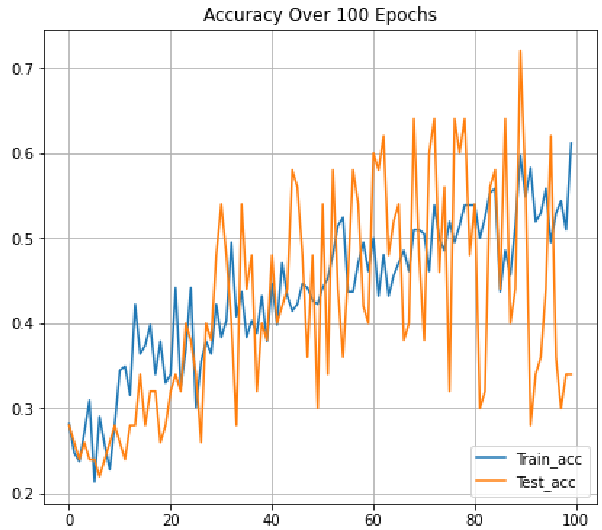
```
Epoch 63/100
21/21 [==============================] - 8s 380ms/step - loss: 3.0546 - categorical_accu
racy: 0.2476 - val_loss: 1.4634 - val_categorical_accuracy: 0.2800
Epoch 64/100
21/21 [==============================] - 8s 376ms/step - loss: 2.9795 - categorical_accu
racy: 0.2330 - val_loss: 1.3874 - val_categorical_accuracy: 0.3800
Epoch 65/100
21/21 [==============================] - 8s 377ms/step - loss: 2.6955 - categorical_accu
racy: 0.2379 - val_loss: 1.5295 - val_categorical_accuracy: 0.2600
Epoch 66/100
21/21 [==============================] - 8s 368ms/step - loss: 2.6305 - categorical_accu
racy: 0.2961 - val_loss: 1.5572 - val_categorical_accuracy: 0.3000
Epoch 67/100
21/21 [==============================] - 9s 430ms/step - loss: 2.9958 - categorical_accu
racy: 0.2670 - val_loss: 1.3838 - val_categorical_accuracy: 0.4000
Epoch 68/100
21/21 [==============================] - 8s 389ms/step - loss: 2.5636 - categorical_accu
racy: 0.3544 - val_loss: 1.5708 - val_categorical_accuracy: 0.3000
Epoch 69/100
21/21 [==============================] - 8s 374ms/step - loss: 2.7185 - categorical_accu
racy: 0.3350 - val_loss: 1.4388 - val_categorical_accuracy: 0.3200
Epoch 70/100
21/21 [==============================] - 8s 370ms/step - loss: 2.6305 - categorical_accu
racy: 0.2816 - val_loss: 1.4986 - val_categorical_accuracy: 0.2600
Epoch 71/100
21/21 [==============================] - 8s 392ms/step - loss: 2.8454 - categorical_accu
racy: 0.3010 - val_loss: 1.6267 - val_categorical_accuracy: 0.3200
Epoch 72/100
21/21 [==============================] - ETA: 0s - loss: 2.9368 - categorical_accuracy:
0.2573
```

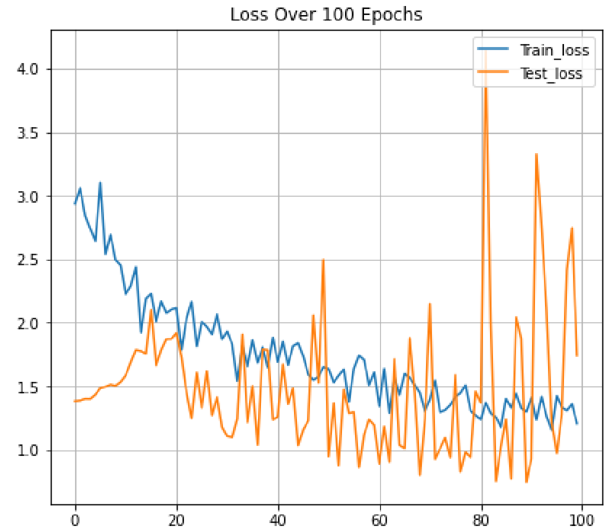
[5 points] Plot Accuracy and Loss During Training

In [70]:

```python
import matplotlib.pyplot as plt

fig, (ax1, ax2) = plt.subplots(1, 2)
fig.set_figheight(6)
fig.set_figwidth(15)
ax1.plot(res.history['categorical_accuracy'])
ax1.plot(res.history['val_categorical_accuracy'])
ax1.set_title('Accuracy Over ' + str(NUM_EPOCHS) + ' Epochs')
ax1.legend(['Train_acc', 'Test_acc'], loc='lower right')
ax1.grid(True)
ax2.set_title('Loss Over ' + str(NUM_EPOCHS) + ' Epochs')
ax2.plot(res.history['loss'])
ax2.plot(res.history['val_loss'])
ax2.legend(['Train_loss', 'Test_loss'], loc='upper right')
ax2.grid(True)
plt.show()
```





Testing Model

In [66]:

```
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,cla
eval_generator.reset()
print(len(eval_generator))
x = model.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.
36
36/36 [==============================] - 1s 23ms/step - loss: 1.9850 - categorical_accur
acy: 0.5278
Test loss: 1.9850109815597534
Test accuracy: 0.5277777910232544
```