Real Estate Image Classification

1. Business Problem

1.1 Description

- **Real Estate Image Classification** is a research paper by Jawadul H. Bappy, Joseph R. Barr, Narayanan Srinivasan, and Amit K. Roy-Chowdhury.
- Selecting a complimentary picture is a necessary part of advertising a home for sale. Typically, agents manually sort through bulk of images for annotating images accompanied by descriptions (bedroom, bathroom, attic, etc.). This is not a problem until the volume of pictures are small, but there is a point this becomes troublesome.
- This research paper tries to help the real estate agents by labeling the images.
- The model in the research takes an image as input and gives label as output. The labels include backyard, bathroom, bedroom, frontyard, kitchen and livingRoom.

1.2 Source Link

Research Paper : https://www.researchgate.net/publication/316494092_Real_Estate_Image_Classification

(OR)
https://ieeexplore.ieee.org/document/6968381

Dataset : https://drive.google.com/drive/folders/0B54qhIps3nofSHVSNVd5Z0k1SzQ

1.3 Real world/Business Objectives and Constraints:

- The goal is to label a real estate image. (labels :backyard, bathroom, bedroom, frontyard, kitchen and livingRoom)
- No Latency constraints. It could finish in few seconds.
- Incorrect label of an image impact customer’s experience.

In [ ]:

```
'''
Problem Statement: Given a real estate image classify it as any one of these, backyard, bathroom, bedroom, fr
'''
```

Out[ ]:

```
'\nProblem Statement: Given a real estate image classify it as any one of these, backyard, bathroom, bedroom,
frontyard, kitchen and livingRoom. \n'
```

success metric : research paper model should out perform existing models.

Importing req libraries:

In [ ]:

```
import seaborn as sns
import numpy as np
import pandas as pd
import os
from matplotlib import pyplot as plt
import cv2
```

Exploratory Data Analysis

In [ ]:

```
!gdown --id 1R5HprLDly8d3cWdDwA7cSKVR7EbvQiiA
```

```
/usr/local/lib/python3.7/dist-packages/gdown/cli.py:131: FutureWarning: Option `--id` was deprecated in versio
n 4.3.1 and will be removed in 5.0. You don't need to pass it anymore to use a file ID.
  category=FutureWarning,
Downloading...
From: https://drive.google.com/uc?id=1R5HprLDly8d3cWdDwA7cSKVR7EbvQiiA
To: /content/REI-Dataset_.zip
100% 302M/302M [00:01<00:00, 220MB/s]
```

In [ ]:

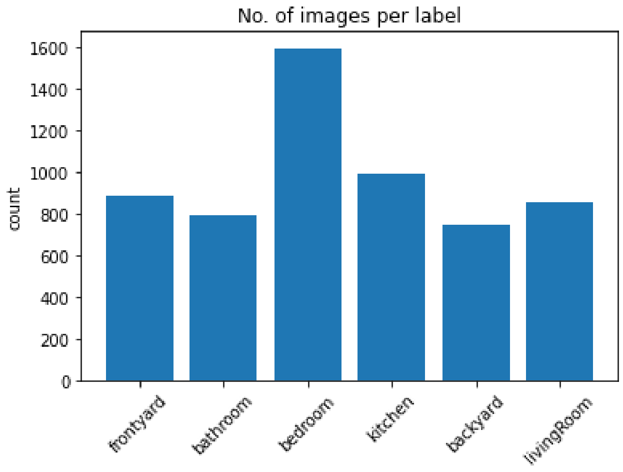
```
!unzip '/content/REI-Dataset_.zip'
```

In [ ]:

```
labels=[]
datapoints_cnt=[]
```

```
for (root,dirs,files) in os.walk('/content/REI-Dataset_', topdown=True):

        if(len(files)>0):
          #print(root[root.rfind('/')+1:])
          labels.append(root[root.rfind('/')+1:])
          datapoints_cnt.append(len(files))

percentages = list(map(lambda x : round(x,2),list((np.array(datapoints_cnt)/sum(datapoints_cnt))*100  )))


from prettytable import PrettyTable

columns = ["Sno.", "label", "count","%age"]

table = PrettyTable()

table.add_column(columns[0], list(range(1,len(labels)+1)))
table.add_column(columns[1], labels)
table.add_column(columns[2], datapoints_cnt)

table.add_column(columns[3],percentages)
print('Number of Data points/images for each label:')
print(table)


# Figure Size
fig = plt.figure(figsize =(6, 4))


plt.bar(labels, datapoints_cnt)
plt.xticks(rotation=45)
plt.ylabel('count')
plt.title('No. of images per label')
plt.show()
```

```
Number of Data points/images for each label:
+------+------------+-------+-------+
| Sno. |   label    | count |  %age |
+------+------------+-------+-------+
|  1   | frontyard  |  884  | 15.09 |
|  2   |  bathroom  |  793  | 13.53 |
|  3   |  bedroom   |  1593 | 27.19 |
|  4   |  kitchen   |  992  | 16.93 |
|  5   |  backyard  |  745  | 12.72 |
|  6   | livingRoom |  852  | 14.54 |
+------+------------+-------+-------+
```



Observation:

- The dataset is slightly imablanced dataset, as number of datapoints(images) of bedroom is more then double the number of backyard datapoints(images).
- Accuracy as the primary performance metric and we will use Precision and Recall as the secondary performance metrics.

In [ ]:

```
# import required module


# get image
```

```
files_path = "/content/REI-Dataset_"

images_df = pd.DataFrame()


image_data=dict()
image_data['height']=[]
image_data['width']=[]
image_data['dimension']=[]
image_data['format']=[]
image_data['file_path']=[]
image_data['label']=[]
for label in labels:
  path =files_path+'/'+label
  file_names = os.listdir(path)
  for file in file_names:
    file_path=path+'/'+file
    image = cv2.imread(file_path,cv2.IMREAD_UNCHANGED)
    #print(image.shape)
    height, width,dimension = image.shape
    image_data['height'].append(height)
    image_data['width'].append(width)
    image_data['dimension'].append(dimension)
    image_data['format'].append(file[file.rfind('.')+1:])
    image_data['label'].append(label)
    image_data['file_path'].append(path+'/'+file)



image_df = pd.DataFrame.from_dict(image_data)
```

In [ ]:

```
image_df.head(2)
```

Out[ ]:

	height	width	dimension	format	file_path	label
0	375	500	3	jpg	/content/REI-Dataset_/bathroom/bathroom (60).jpg	bathroom
1	375	500	3	jpg	/content/REI-Dataset_/bathroom/bathroom (577).jpg	bathroom

In [ ]:

```
def plot_graphs(df,feature):

  sns.set_style("whitegrid")
  sns.FacetGrid(df, hue="label",height=7) \
     .map(sns.scatterplot, "label", feature) \
     .add_legend()
  plt.title("image's "+feature)
  plt.show()
  plt.figure(figsize=(10,7))
  sns.violinplot(x="label", y=feature, data=df)
  plt.show()
```

Height:

In [ ]:

```
image_df['height'].describe()
```

Out[ ]:

```
count    5859.000000
mean      366.814985
std        34.449183
min       179.000000
25%       333.000000
50%       375.000000
75%       375.000000
max       500.000000
Name: height, dtype: float64
```

In [ ]:

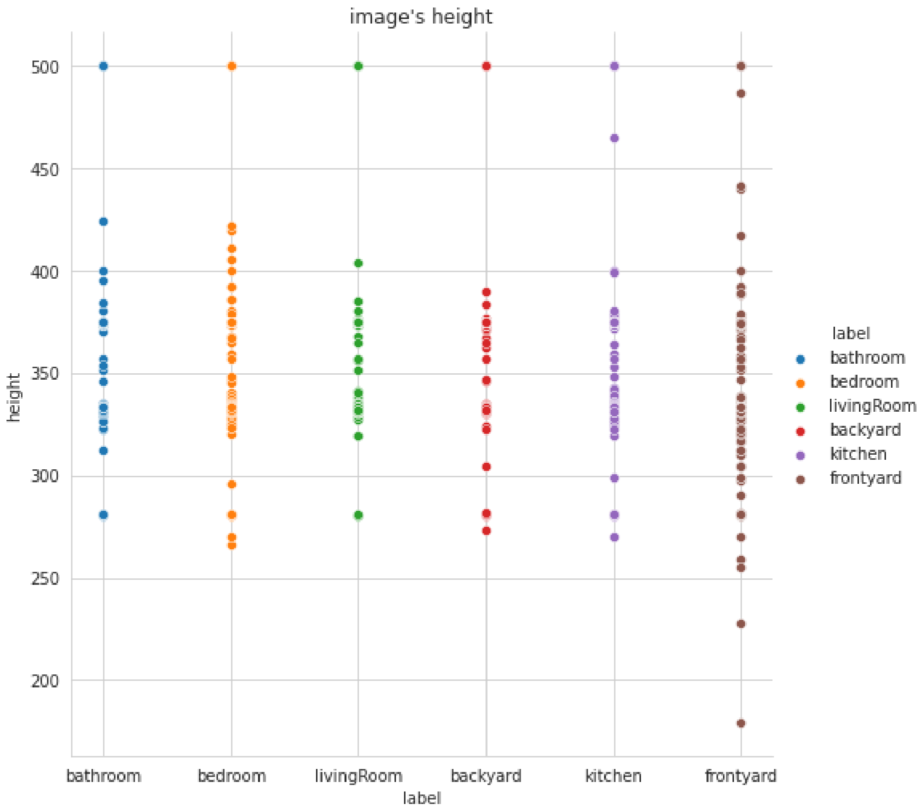
```
sum(image_df['height']==375)/len(image_df['height'])*100
```

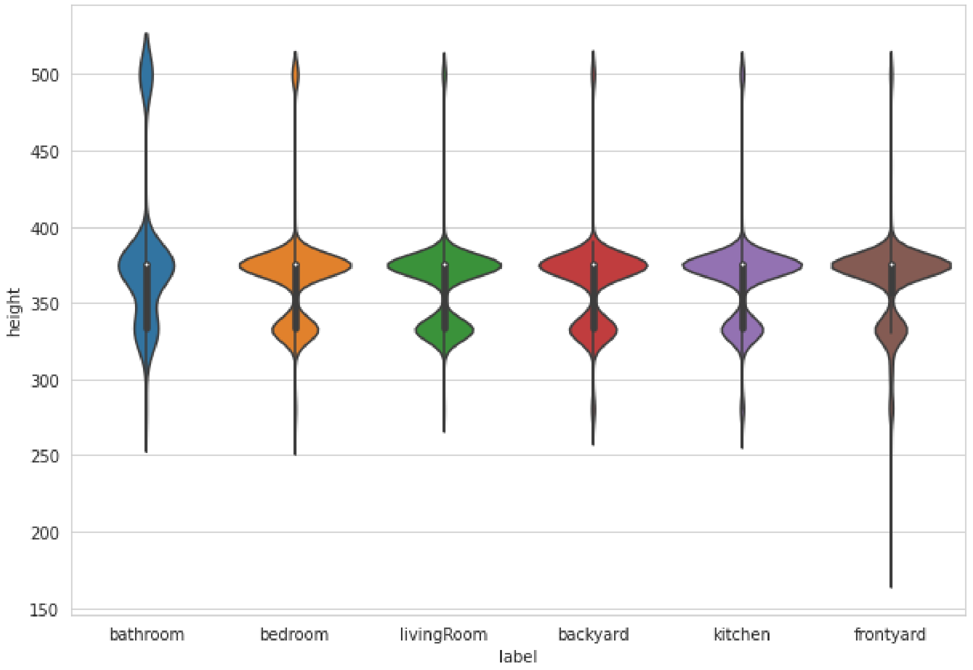
Out[ ]:

```
63.952892985151045
```

In [ ]:

```
plot_graphs(image_df,"height")
```





Observation:

- Images height varies from 179 to 500.
- 63.9% of the images have height of 375.

Width:

In [ ]:

```
image_df['width'].describe()
```

Out[ ]:

```
count    5859.000000
mean      494.717187
std        27.810522
min       280.000000
25%       500.000000
50%       500.000000
75%       500.000000
max       500.000000
Name: width, dtype: float64
```

In [ ]:

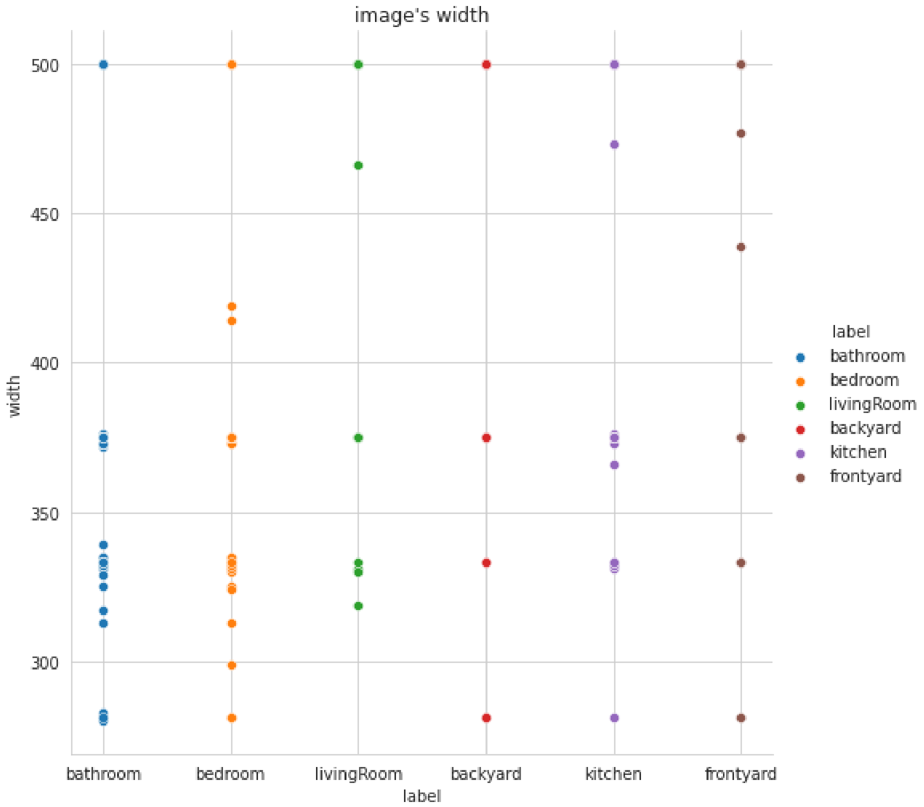
```
sum(image_df['width']==500)/len(image_df['width'])*100
```

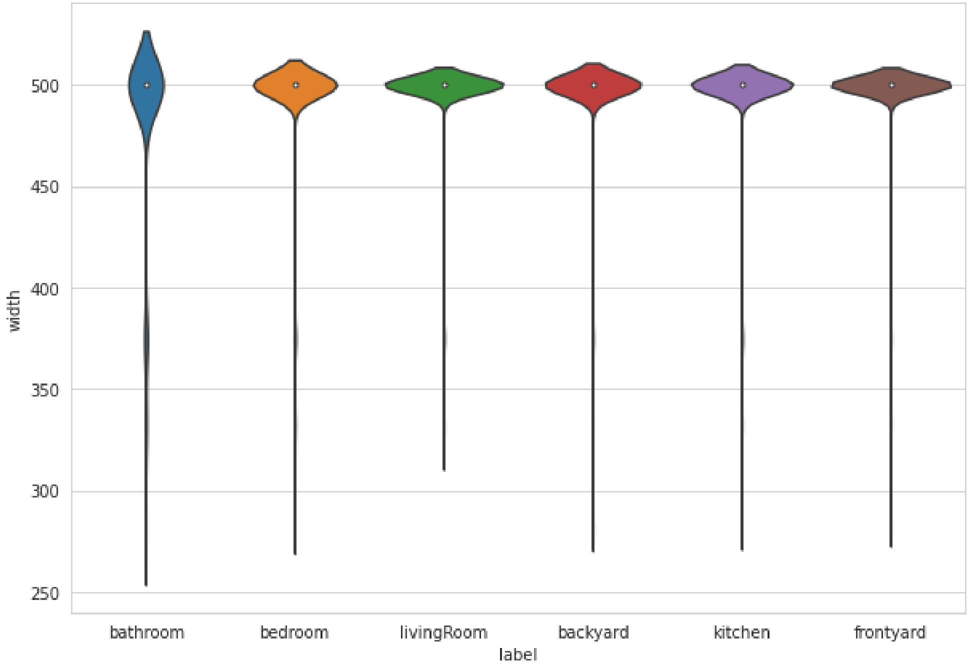
Out[ ]:

```
96.33043181430278
```

In [ ]:

```
plot_graphs(image_df,"width")
```





Observation:

- 96.3% of images have width of 500 (pixels).

Channels:

In [ ]:

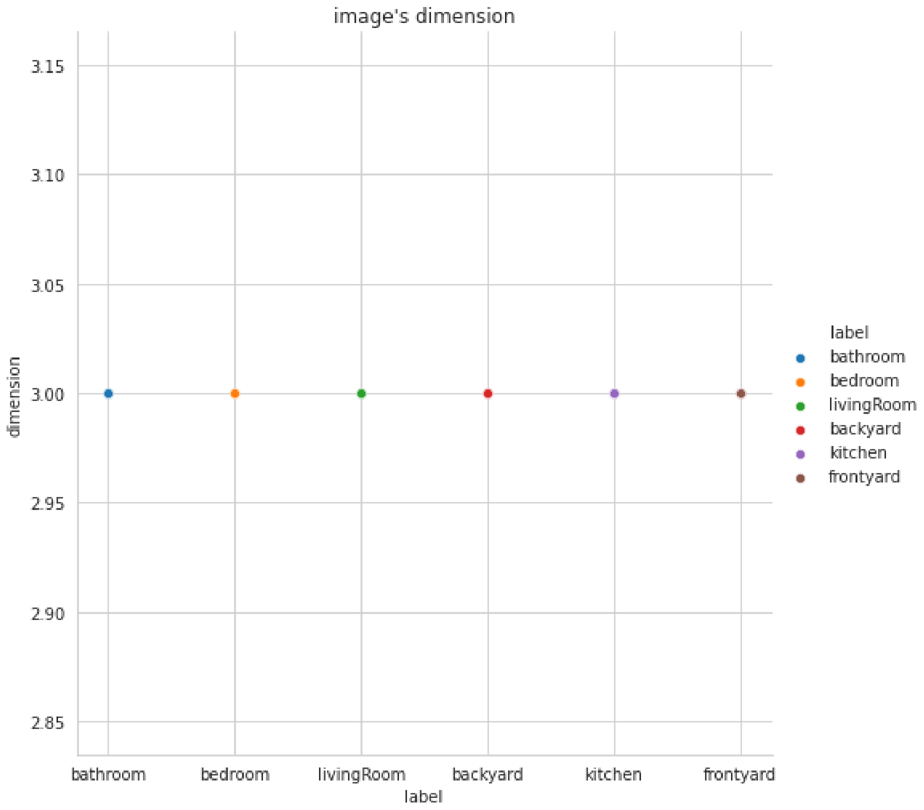
```
image_df['dimension'].describe()
```

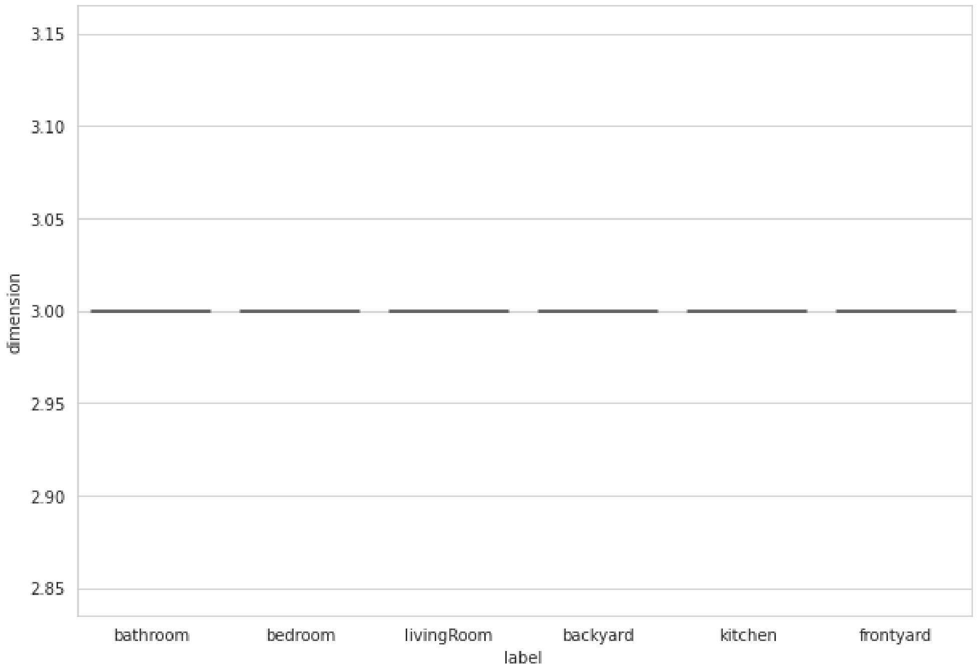
Out[ ]:

```
count    5859.0
mean        3.0
std         0.0
min         3.0
25%         3.0
50%         3.0
75%         3.0
max         3.0
Name: dimension, dtype: float64
```

In [ ]:

```
plot_graphs(image_df,"dimension")
```





Observation:

- All the images are 3 channel images.

Image Format:

In [ ]:

```
image_df['format'].value_counts()
```

Out[ ]:

```
jpg     4246
jpeg    1607
png        5
JPG        1
Name: format, dtype: int64
```

Notes on types of image file formats:

- There are actually no differences between the JPG and JPEG formats.
- JPEG stands for “Joint Photographic Experts Group”.
- PNG is short for "Portable Network Graphic".
- JPEG and PNG both are a type of image format to store images. JPEG uses lossy compression algorithm and image may lost some of its data whereas PNG uses lossless compression algorithm and no image data loss is present in PNG format.

Source:

- https://www.keycdn.com/support/difference-between-jpg-and-jpeg
- https://www.tutorialspoint.com/difference-between-jpeg-and-png#:~:text=JPEG%20and%20PNG%20both%20are,is%20present%20in%20PNG%20format.

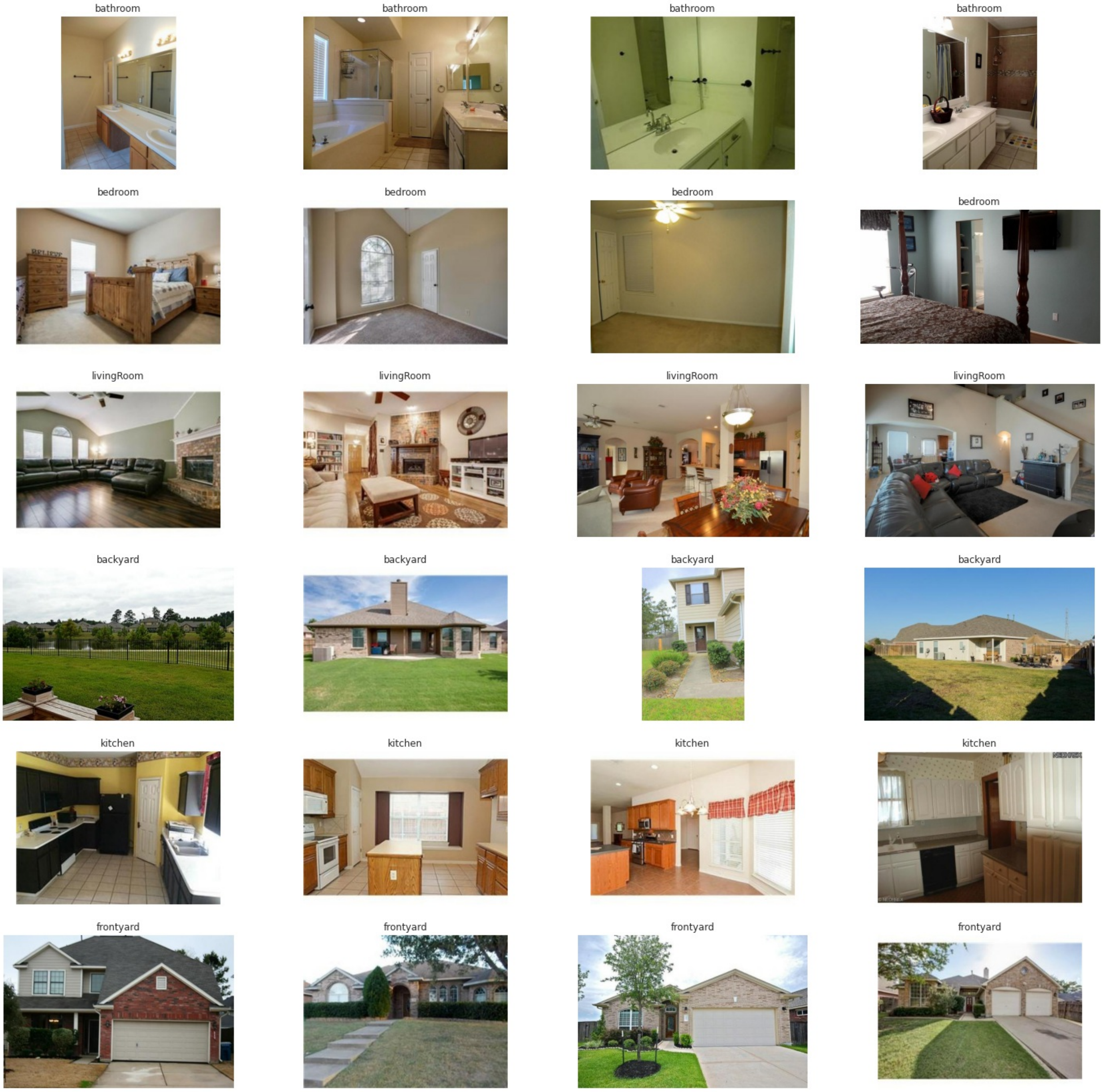
Summary of EDA:

- The dataset we have is imbalance dataset.
- 27.19% of the image are bedroom labeled. (which is more then one-forth of the dataset).
- Since, imbalance dataset we will use precision and recall as primary metric and accuracy as secondary metric.
- The size of the images are not same, need to resize all the image to same size in data preprocessing.
- All the images are 3 channel images.

Some random images of each label:

In [ ]:

```
#image_df
fig = plt.figure(figsize =(25, 25))

import random
cnt=0
for index,label in enumerate(labels):
  #print(index,label)
  paths= image_df[image_df['label']==label]['file_path'].values
  lt = paths[random.sample(range(0, 650), 4)]
  for img_path in lt:

    image = cv2.imread(img_path)
    image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    cnt=cnt+1


    plt.subplot(6, 4, cnt)
    plt.grid(False)
    plt.axis('off')
    plt.title(label)
    plt.imshow(image)
```



In [ ]:

In [ ]:

In [ ]:

In [ ]:

Baseline Model:

In [ ]:

```
from sklearn.preprocessing import LabelEncoder

le_enc = LabelEncoder()

image_df['label_enc'] = le_enc.fit_transform(image_df.label.values)

dict(zip(le_enc.classes_,le_enc.transform(le_enc.classes_)))
```

Out[ ]:

```
{'backyard': 0,
 'bathroom': 1,
 'bedroom': 2,
 'frontyard': 3,
 'kitchen': 4,
 'livingRoom': 5}
```

In [ ]:

```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(image_df, image_df['label_enc'], test_size=0.15, random_st

print(" X_train  shape :", X_train.shape)
print(" X_test shape :", X_test.shape)
print(" y_train shape :", y_train.shape)
print(" y_test  shape :", y_test.shape)
```

```
 X_train  shape : (4980, 7)
 X_test shape : (879, 7)
 y_train shape : (4980,)
 y_test  shape : (879,)
```

In [ ]:

```
#rm -r /content/REI-Dataset_train
```

In [ ]:

```
train_data_images = '/content/REI-Dataset_train'
test_data_images = '/content/REI-Dataset_test'

for dir_name in labels:
    os.makedirs(os.path.join(train_data_images, dir_name))
    os.makedirs(os.path.join(test_data_images, dir_name))
```

In [ ]:

```
import shutil
from tqdm import tqdm
for index in tqdm(X_train['file_path'].index):
  path=X_train["file_path"][index]
  sub_dir=X_train['label'][index]
  shutil.copy(path ,train_data_images+'/'+sub_dir+'/'+ os.path.basename(path))
```

```
100%|██████████| 4980/4980 [00:00<00:00, 5127.65it/s]
```

In [ ]:

```
import shutil
from tqdm import tqdm
for index in tqdm(X_test['file_path'].index):
  path=X_test["file_path"][index]
  sub_dir=X_test['label'][index]
  shutil.copy(path ,test_data_images+'/'+sub_dir+'/'+ os.path.basename(path))
```

```
100%|██████████| 879/879 [00:00<00:00, 5022.15it/s]
```

In [ ]:

```
from keras.layers import Embedding
from keras.layers import Conv1D
from keras.layers.merge import concatenate
from keras.layers import MaxPooling1D
from keras.layers import Flatten
from keras.layers import Dropout
# Shared Feature Extraction Layer
from keras.utils.vis_utils import plot_model
from keras.layers import Dense
import tensorflow as tf
from keras.models import Model
from keras.layers import Input

from keras.layers import Conv2D, MaxPooling2D

from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.callbacks import EarlyStopping
```

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range=15, width_shift_range=0.2,rescale=
                                                            height_shift_range=0.2, horizontal_flip=True)
```

```
ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size=


test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_s
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
```

In [ ]:

```
input_layer = Input(shape=(128,128,3))

conv_layer_1 = Conv2D(512, (2,2), padding='valid', activation = 'relu')(input_layer)

max_pooling_layer_1 = MaxPooling2D( pool_size=(2, 2), strides=None, padding="valid")(conv_layer_1)

conv_layer_2 = Conv2D(256, (2,2), padding='valid', activation = 'relu')(max_pooling_layer_1)

max_pooling_layer_2 = MaxPooling2D( pool_size=(2, 2), strides=None, padding="valid",)(conv_layer_2)

conv_layer_3 = Conv2D(128, (2,2), padding='valid', activation ='relu')(max_pooling_layer_2)

flatten_layer = Flatten()(conv_layer_3)

drop_out_layer = Dropout(0.2)(flatten_layer)

dense_layer_1 = Dense(64, activation='relu')(drop_out_layer)
dense_layer_2 = Dense(48, activation='relu')(dense_layer_1)
dense_layer_3 = Dense(32, activation='relu')(dense_layer_2)
output_layer = Dense(6, activation='softmax')(dense_layer_3)

model = Model(inputs=[input_layer], outputs=[output_layer])
model.summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 input_1 (InputLayer)        [(None, 128, 128, 3)]     0         
                                                                 
 conv2d (Conv2D)             (None, 127, 127, 512)     6656      
                                                                 
 max_pooling2d (MaxPooling2D  (None, 63, 63, 512)      0         
 )                                                               
                                                                 
 conv2d_1 (Conv2D)           (None, 62, 62, 256)       524544    
                                                                 
 max_pooling2d_1 (MaxPooling  (None, 31, 31, 256)      0         
 2D)                                                             
                                                                 
 conv2d_2 (Conv2D)           (None, 30, 30, 128)       131200    
                                                                 
 flatten (Flatten)           (None, 115200)            0         
                                                                 
 dropout (Dropout)           (None, 115200)            0         
                                                                 
 dense (Dense)               (None, 64)                7372864   
                                                                 
 dense_1 (Dense)             (None, 48)                3120      
                                                                 
 dense_2 (Dense)             (None, 32)                1568      
                                                                 
 dense_3 (Dense)             (None, 6)                 198       
                                                                 
=================================================================
Total params: 8,040,150
Trainable params: 8,040,150
Non-trainable params: 0
_________________________________________________________________
```

In [ ]:

```
model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.00001), loss='categorical_crossentropy',\
              metrics=['accuracy'])
```

In [ ]:

```
model.fit(ImageGenerator_train,\
          validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=20)
```

```
Epoch 1/20
128/128 [==============================] - 54s 314ms/step - loss: 1.7435 - accuracy: 0.2551 - val_loss: 1.6794
- val_accuracy: 0.2799
Epoch 2/20
128/128 [==============================] - 41s 319ms/step - loss: 1.6267 - accuracy: 0.3274 - val_loss: 1.5249
- val_accuracy: 0.3982
Epoch 3/20
128/128 [==============================] - 39s 305ms/step - loss: 1.5011 - accuracy: 0.4014 - val_loss: 1.3864
- val_accuracy: 0.4846
Epoch 4/20
128/128 [==============================] - 40s 312ms/step - loss: 1.3756 - accuracy: 0.4540 - val_loss: 1.2675
- val_accuracy: 0.5119
Epoch 5/20
128/128 [==============================] - 39s 304ms/step - loss: 1.2879 - accuracy: 0.4640 - val_loss: 1.2126
- val_accuracy: 0.4881
Epoch 6/20
128/128 [==============================] - 39s 303ms/step - loss: 1.2165 - accuracy: 0.4919 - val_loss: 1.1110
- val_accuracy: 0.5336
Epoch 7/20
128/128 [==============================] - 39s 303ms/step - loss: 1.1641 - accuracy: 0.4946 - val_loss: 1.1613
- val_accuracy: 0.5040
Epoch 8/20
128/128 [==============================] - 39s 306ms/step - loss: 1.1331 - accuracy: 0.5122 - val_loss: 1.0578
- val_accuracy: 0.5540
Epoch 9/20
128/128 [==============================] - 39s 305ms/step - loss: 1.1299 - accuracy: 0.5056 - val_loss: 1.0384
- val_accuracy: 0.5757
Epoch 10/20
128/128 [==============================] - 39s 306ms/step - loss: 1.0928 - accuracy: 0.5274 - val_loss: 0.9847
- val_accuracy: 0.6086
Epoch 11/20
128/128 [==============================] - 39s 306ms/step - loss: 1.0861 - accuracy: 0.5443 - val_loss: 1.0274
- val_accuracy: 0.5870
Epoch 12/20
128/128 [==============================] - 39s 305ms/step - loss: 1.0545 - accuracy: 0.5411 - val_loss: 1.0429
- val_accuracy: 0.5870
Epoch 13/20
128/128 [==============================] - 39s 305ms/step - loss: 1.0603 - accuracy: 0.5448 - val_loss: 1.0309
- val_accuracy: 0.5836
Epoch 14/20
128/128 [==============================] - 39s 304ms/step - loss: 1.0564 - accuracy: 0.5421 - val_loss: 1.1155
- val_accuracy: 0.5836
Epoch 15/20
128/128 [==============================] - 39s 304ms/step - loss: 1.0461 - accuracy: 0.5448 - val_loss: 1.0497
- val_accuracy: 0.6018
Epoch 16/20
128/128 [==============================] - 39s 306ms/step - loss: 1.0320 - accuracy: 0.5547 - val_loss: 1.1163
- val_accuracy: 0.5586
Epoch 17/20
128/128 [==============================] - 39s 306ms/step - loss: 1.0122 - accuracy: 0.5668 - val_loss: 1.0114
- val_accuracy: 0.6143
Epoch 18/20
128/128 [==============================] - 41s 316ms/step - loss: 1.0231 - accuracy: 0.5561 - val_loss: 0.9877
- val_accuracy: 0.6052
Epoch 19/20
128/128 [==============================] - 39s 307ms/step - loss: 1.0147 - accuracy: 0.5612 - val_loss: 1.0357
- val_accuracy: 0.5791
Epoch 20/20
128/128 [==============================] - 39s 307ms/step - loss: 0.9943 - accuracy: 0.5705 - val_loss: 0.9596
- val_accuracy: 0.6303
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d45c7f10>
```

In [ ]:

```
model.fit(ImageGenerator_train,\
          validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=20)
```

```
Epoch 1/20
128/128 [==============================] - 42s 324ms/step - loss: 0.9979 - accuracy: 0.5661 - val_loss: 0.9909
- val_accuracy: 0.6086
Epoch 2/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9807 - accuracy: 0.5835 - val_loss: 0.9499
- val_accuracy: 0.6303
Epoch 3/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9903 - accuracy: 0.5671 - val_loss: 0.9677
- val_accuracy: 0.5995
Epoch 4/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9950 - accuracy: 0.5720 - val_loss: 1.0136
- val_accuracy: 0.5939
Epoch 5/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9688 - accuracy: 0.5884 - val_loss: 0.9640
- val_accuracy: 0.6143
Epoch 6/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9815 - accuracy: 0.5720 - val_loss: 0.9066
- val_accuracy: 0.6325
Epoch 7/20
128/128 [==============================] - 39s 304ms/step - loss: 0.9700 - accuracy: 0.5788 - val_loss: 1.0192
- val_accuracy: 0.6064
Epoch 8/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9722 - accuracy: 0.5803 - val_loss: 0.9978
- val_accuracy: 0.6166
Epoch 9/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9511 - accuracy: 0.5950 - val_loss: 1.0426
- val_accuracy: 0.5927
Epoch 10/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9541 - accuracy: 0.5891 - val_loss: 0.9059
- val_accuracy: 0.6451
Epoch 11/20
128/128 [==============================] - 40s 313ms/step - loss: 0.9525 - accuracy: 0.5891 - val_loss: 0.9287
- val_accuracy: 0.6462
Epoch 12/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9553 - accuracy: 0.5930 - val_loss: 0.9430
- val_accuracy: 0.6064
Epoch 13/20
128/128 [==============================] - 39s 304ms/step - loss: 0.9524 - accuracy: 0.5855 - val_loss: 0.9515
- val_accuracy: 0.6303
Epoch 14/20
128/128 [==============================] - 39s 304ms/step - loss: 0.9516 - accuracy: 0.5930 - val_loss: 1.0124
- val_accuracy: 0.6064
Epoch 15/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9472 - accuracy: 0.5901 - val_loss: 0.9793
- val_accuracy: 0.6303
Epoch 16/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9399 - accuracy: 0.5977 - val_loss: 0.9627
- val_accuracy: 0.6348
Epoch 17/20
128/128 [==============================] - 39s 304ms/step - loss: 0.9293 - accuracy: 0.6014 - val_loss: 0.8951
- val_accuracy: 0.6553
Epoch 18/20
128/128 [==============================] - 39s 303ms/step - loss: 0.9453 - accuracy: 0.6063 - val_loss: 0.8855
- val_accuracy: 0.6496
Epoch 19/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9197 - accuracy: 0.6096 - val_loss: 0.8880
- val_accuracy: 0.6553
Epoch 20/20
128/128 [==============================] - 40s 314ms/step - loss: 0.9265 - accuracy: 0.6082 - val_loss: 0.8459
- val_accuracy: 0.6678
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d3b055d0>
```

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')  # creates a HDF5 file 'my
```

In [ ]:

```
from keras.models import load_model
model = load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')

model.fit(ImageGenerator_train,validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=20)
```

```
Epoch 1/20
128/128 [==============================] - 40s 309ms/step - loss: 0.9181 - accuracy: 0.6082 - val_loss: 0.9479
- val_accuracy: 0.6405
Epoch 2/20
128/128 [==============================] - 39s 303ms/step - loss: 0.9365 - accuracy: 0.5984 - val_loss: 0.9598
- val_accuracy: 0.6234
Epoch 3/20
128/128 [==============================] - 40s 312ms/step - loss: 0.9170 - accuracy: 0.6143 - val_loss: 0.8285
- val_accuracy: 0.6792
Epoch 4/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9213 - accuracy: 0.6058 - val_loss: 0.9770
- val_accuracy: 0.6234
Epoch 5/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9010 - accuracy: 0.6082 - val_loss: 0.9155
- val_accuracy: 0.6496
Epoch 6/20
128/128 [==============================] - 40s 310ms/step - loss: 0.9189 - accuracy: 0.6016 - val_loss: 0.8563
- val_accuracy: 0.6712
Epoch 7/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8983 - accuracy: 0.6207 - val_loss: 0.8583
- val_accuracy: 0.6519
Epoch 8/20
128/128 [==============================] - 40s 315ms/step - loss: 0.8926 - accuracy: 0.6259 - val_loss: 1.0243
- val_accuracy: 0.6189
Epoch 9/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9056 - accuracy: 0.6200 - val_loss: 0.8564
- val_accuracy: 0.6564
Epoch 10/20
128/128 [==============================] - 39s 305ms/step - loss: 0.9091 - accuracy: 0.6151 - val_loss: 0.8555
- val_accuracy: 0.6758
Epoch 11/20
128/128 [==============================] - 39s 307ms/step - loss: 0.8984 - accuracy: 0.6221 - val_loss: 0.9247
- val_accuracy: 0.6291
Epoch 12/20
128/128 [==============================] - 40s 314ms/step - loss: 0.8980 - accuracy: 0.6163 - val_loss: 0.8885
- val_accuracy: 0.6428
Epoch 13/20
128/128 [==============================] - 39s 306ms/step - loss: 0.9001 - accuracy: 0.6170 - val_loss: 0.8347
- val_accuracy: 0.6712
Epoch 14/20
128/128 [==============================] - 39s 305ms/step - loss: 0.8995 - accuracy: 0.6219 - val_loss: 0.8546
- val_accuracy: 0.6701
Epoch 15/20
128/128 [==============================] - 39s 305ms/step - loss: 0.8993 - accuracy: 0.6156 - val_loss: 0.8156
- val_accuracy: 0.6803
Epoch 16/20
128/128 [==============================] - 39s 305ms/step - loss: 0.8855 - accuracy: 0.6354 - val_loss: 0.9326
- val_accuracy: 0.6405
Epoch 17/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8938 - accuracy: 0.6161 - val_loss: 0.8677
- val_accuracy: 0.6712
Epoch 18/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8815 - accuracy: 0.6295 - val_loss: 0.8622
- val_accuracy: 0.6644
Epoch 19/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8942 - accuracy: 0.6153 - val_loss: 0.8287
- val_accuracy: 0.6769
Epoch 20/20
128/128 [==============================] - 39s 308ms/step - loss: 0.8830 - accuracy: 0.6276 - val_loss: 0.8413
- val_accuracy: 0.6712
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d390fd10>
```

In [ ]:

```
model.fit(ImageGenerator_train,validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=20)
```

```
Epoch 1/20
128/128 [==============================] - 42s 329ms/step - loss: 0.8795 - accuracy: 0.6348 - val_loss: 0.7953
- val_accuracy: 0.6894
Epoch 2/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8699 - accuracy: 0.6401 - val_loss: 0.8113
- val_accuracy: 0.6815
Epoch 3/20
128/128 [==============================] - 40s 315ms/step - loss: 0.8755 - accuracy: 0.6374 - val_loss: 0.9149
- val_accuracy: 0.6587
Epoch 4/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8831 - accuracy: 0.6298 - val_loss: 0.8673
- val_accuracy: 0.6769
Epoch 5/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8495 - accuracy: 0.6405 - val_loss: 0.8587
- val_accuracy: 0.6689
Epoch 6/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8696 - accuracy: 0.6339 - val_loss: 0.8120
- val_accuracy: 0.6792
Epoch 7/20
128/128 [==============================] - 39s 307ms/step - loss: 0.8596 - accuracy: 0.6347 - val_loss: 0.8331
- val_accuracy: 0.6860
Epoch 8/20
128/128 [==============================] - 39s 308ms/step - loss: 0.8600 - accuracy: 0.6317 - val_loss: 0.8498
- val_accuracy: 0.6621
Epoch 9/20
128/128 [==============================] - 40s 310ms/step - loss: 0.8446 - accuracy: 0.6379 - val_loss: 0.7852
- val_accuracy: 0.6906
Epoch 10/20
128/128 [==============================] - 40s 309ms/step - loss: 0.8409 - accuracy: 0.6428 - val_loss: 0.8304
- val_accuracy: 0.6758
Epoch 11/20
128/128 [==============================] - 39s 307ms/step - loss: 0.8496 - accuracy: 0.6459 - val_loss: 0.8183
- val_accuracy: 0.6746
Epoch 12/20
128/128 [==============================] - 40s 308ms/step - loss: 0.8610 - accuracy: 0.6367 - val_loss: 0.8557
- val_accuracy: 0.6769
Epoch 13/20
128/128 [==============================] - 39s 306ms/step - loss: 0.8561 - accuracy: 0.6381 - val_loss: 0.8053
- val_accuracy: 0.6724
Epoch 14/20
128/128 [==============================] - 39s 308ms/step - loss: 0.8693 - accuracy: 0.6345 - val_loss: 0.8038
- val_accuracy: 0.6792
Epoch 15/20
128/128 [==============================] - 39s 307ms/step - loss: 0.8530 - accuracy: 0.6501 - val_loss: 0.8367
- val_accuracy: 0.6735
Epoch 16/20
128/128 [==============================] - 40s 308ms/step - loss: 0.8407 - accuracy: 0.6555 - val_loss: 0.7802
- val_accuracy: 0.6871
Epoch 17/20
128/128 [==============================] - 40s 315ms/step - loss: 0.8530 - accuracy: 0.6459 - val_loss: 0.7945
- val_accuracy: 0.6803
Epoch 18/20
128/128 [==============================] - 40s 308ms/step - loss: 0.8273 - accuracy: 0.6530 - val_loss: 0.7787
- val_accuracy: 0.6940
Epoch 19/20
128/128 [==============================] - 47s 364ms/step - loss: 0.8447 - accuracy: 0.6496 - val_loss: 0.7626
- val_accuracy: 0.6974
Epoch 20/20
128/128 [==============================] - 39s 304ms/step - loss: 0.8450 - accuracy: 0.6447 - val_loss: 0.8454
- val_accuracy: 0.6667
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d390fe90>
```

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')  # creates a HDF5 file 'my
```

In [ ]:

```
model.fit(ImageGenerator_train,validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=100)
```

```
Epoch 1/100
128/128 [==============================] - 40s 308ms/step - loss: 0.8467 - accuracy: 0.6440 - val_loss: 0.8614
- val_accuracy: 0.6519
Epoch 2/100
128/128 [==============================] - 39s 304ms/step - loss: 0.8251 - accuracy: 0.6499 - val_loss: 0.8680
- val_accuracy: 0.6724
Epoch 3/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8255 - accuracy: 0.6457 - val_loss: 0.7825
```

```
- val_accuracy: 0.6951
Epoch 4/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8244 - accuracy: 0.6469 - val_loss: 0.8119
- val_accuracy: 0.6894
Epoch 5/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8207 - accuracy: 0.6555 - val_loss: 0.8221
- val_accuracy: 0.6849
Epoch 6/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8277 - accuracy: 0.6570 - val_loss: 0.7687
- val_accuracy: 0.7019
Epoch 7/100
128/128 [==============================] - 39s 307ms/step - loss: 0.8301 - accuracy: 0.6445 - val_loss: 0.8359
- val_accuracy: 0.6735
Epoch 8/100
128/128 [==============================] - 39s 304ms/step - loss: 0.8283 - accuracy: 0.6533 - val_loss: 0.8908
- val_accuracy: 0.6519
Epoch 9/100
128/128 [==============================] - 39s 306ms/step - loss: 0.8273 - accuracy: 0.6492 - val_loss: 0.7764
- val_accuracy: 0.6906
Epoch 10/100
128/128 [==============================] - 40s 312ms/step - loss: 0.8233 - accuracy: 0.6552 - val_loss: 0.7553
- val_accuracy: 0.7031
Epoch 11/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8115 - accuracy: 0.6579 - val_loss: 0.8038
- val_accuracy: 0.6883
Epoch 12/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7989 - accuracy: 0.6719 - val_loss: 0.7116
- val_accuracy: 0.7099
Epoch 13/100
128/128 [==============================] - 40s 308ms/step - loss: 0.8190 - accuracy: 0.6592 - val_loss: 0.7993
- val_accuracy: 0.6860
Epoch 14/100
128/128 [==============================] - 39s 308ms/step - loss: 0.8029 - accuracy: 0.6623 - val_loss: 0.7856
- val_accuracy: 0.6894
Epoch 15/100
128/128 [==============================] - 39s 306ms/step - loss: 0.8239 - accuracy: 0.6577 - val_loss: 0.7834
- val_accuracy: 0.6928
Epoch 16/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7992 - accuracy: 0.6599 - val_loss: 0.7518
- val_accuracy: 0.6997
Epoch 17/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8165 - accuracy: 0.6582 - val_loss: 0.6945
- val_accuracy: 0.7167
Epoch 18/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7913 - accuracy: 0.6763 - val_loss: 0.7360
- val_accuracy: 0.7133
Epoch 19/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7965 - accuracy: 0.6751 - val_loss: 0.8537
- val_accuracy: 0.6655
Epoch 20/100
128/128 [==============================] - 39s 306ms/step - loss: 0.8013 - accuracy: 0.6611 - val_loss: 0.7405
- val_accuracy: 0.7042
Epoch 21/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7947 - accuracy: 0.6697 - val_loss: 0.8469
- val_accuracy: 0.6712
Epoch 22/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7835 - accuracy: 0.6672 - val_loss: 0.8170
- val_accuracy: 0.6746
Epoch 23/100
128/128 [==============================] - 39s 306ms/step - loss: 0.8119 - accuracy: 0.6565 - val_loss: 0.8519
- val_accuracy: 0.6576
Epoch 24/100
128/128 [==============================] - 39s 305ms/step - loss: 0.8032 - accuracy: 0.6504 - val_loss: 0.8205
- val_accuracy: 0.6758
Epoch 25/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7874 - accuracy: 0.6738 - val_loss: 0.7270
- val_accuracy: 0.7099
Epoch 26/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7924 - accuracy: 0.6785 - val_loss: 0.7322
- val_accuracy: 0.7088
Epoch 27/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7773 - accuracy: 0.6756 - val_loss: 0.7179
- val_accuracy: 0.7190
Epoch 28/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7872 - accuracy: 0.6778 - val_loss: 0.7288
- val_accuracy: 0.6940
Epoch 29/100
```

```
128/128 [==============================] - 39s 305ms/step - loss: 0.7920 - accuracy: 0.6746 - val_loss: 0.8087
- val_accuracy: 0.6837
Epoch 30/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7914 - accuracy: 0.6724 - val_loss: 0.8010
- val_accuracy: 0.6883
Epoch 31/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7872 - accuracy: 0.6672 - val_loss: 0.7091
- val_accuracy: 0.7156
Epoch 32/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7772 - accuracy: 0.6731 - val_loss: 0.6981
- val_accuracy: 0.7088
Epoch 33/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7840 - accuracy: 0.6736 - val_loss: 0.7582
- val_accuracy: 0.6974
Epoch 34/100
128/128 [==============================] - 40s 309ms/step - loss: 0.7812 - accuracy: 0.6682 - val_loss: 0.7111
- val_accuracy: 0.7179
Epoch 35/100
128/128 [==============================] - 40s 310ms/step - loss: 0.7911 - accuracy: 0.6680 - val_loss: 0.7009
- val_accuracy: 0.7144
Epoch 36/100
128/128 [==============================] - 40s 311ms/step - loss: 0.7770 - accuracy: 0.6753 - val_loss: 0.7098
- val_accuracy: 0.7144
Epoch 37/100
128/128 [==============================] - 41s 319ms/step - loss: 0.7776 - accuracy: 0.6768 - val_loss: 0.8100
- val_accuracy: 0.6917
Epoch 38/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7761 - accuracy: 0.6768 - val_loss: 0.7839
- val_accuracy: 0.6985
Epoch 39/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7691 - accuracy: 0.6800 - val_loss: 0.7422
- val_accuracy: 0.7088
Epoch 40/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7790 - accuracy: 0.6851 - val_loss: 0.7807
- val_accuracy: 0.6894
Epoch 41/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7470 - accuracy: 0.6917 - val_loss: 0.7593
- val_accuracy: 0.6928
Epoch 42/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7662 - accuracy: 0.6839 - val_loss: 0.6951
- val_accuracy: 0.7076
Epoch 43/100
128/128 [==============================] - 40s 308ms/step - loss: 0.7586 - accuracy: 0.6915 - val_loss: 0.7115
- val_accuracy: 0.7190
Epoch 44/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7580 - accuracy: 0.6858 - val_loss: 0.7701
- val_accuracy: 0.6962
Epoch 45/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7585 - accuracy: 0.6817 - val_loss: 0.7604
- val_accuracy: 0.6951
Epoch 46/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7626 - accuracy: 0.6797 - val_loss: 0.7467
- val_accuracy: 0.7019
Epoch 47/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7566 - accuracy: 0.6882 - val_loss: 0.6982
- val_accuracy: 0.7213
Epoch 48/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7459 - accuracy: 0.6949 - val_loss: 0.7368
- val_accuracy: 0.6917
Epoch 49/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7549 - accuracy: 0.6939 - val_loss: 0.6882
- val_accuracy: 0.7258
Epoch 50/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7586 - accuracy: 0.6854 - val_loss: 0.6887
- val_accuracy: 0.7167
Epoch 51/100
128/128 [==============================] - 41s 315ms/step - loss: 0.7538 - accuracy: 0.6856 - val_loss: 0.7428
- val_accuracy: 0.7065
Epoch 52/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7408 - accuracy: 0.6871 - val_loss: 0.6921
- val_accuracy: 0.7156
Epoch 53/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7553 - accuracy: 0.6827 - val_loss: 0.7309
- val_accuracy: 0.7042
Epoch 54/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7421 - accuracy: 0.6907 - val_loss: 0.7235
- val_accuracy: 0.7099
```

```
Epoch 55/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7543 - accuracy: 0.6856 - val_loss: 0.6796
- val_accuracy: 0.7258
Epoch 56/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7335 - accuracy: 0.6969 - val_loss: 0.7050
- val_accuracy: 0.7270
Epoch 57/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7410 - accuracy: 0.6927 - val_loss: 0.7006
- val_accuracy: 0.7235
Epoch 58/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7504 - accuracy: 0.6893 - val_loss: 0.7526
- val_accuracy: 0.6997
Epoch 59/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7422 - accuracy: 0.6863 - val_loss: 0.7288
- val_accuracy: 0.7088
Epoch 60/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7338 - accuracy: 0.6995 - val_loss: 0.6684
- val_accuracy: 0.7372
Epoch 61/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7330 - accuracy: 0.6900 - val_loss: 0.6729
- val_accuracy: 0.7327
Epoch 62/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7270 - accuracy: 0.7025 - val_loss: 0.6793
- val_accuracy: 0.7281
Epoch 63/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7404 - accuracy: 0.6925 - val_loss: 0.7251
- val_accuracy: 0.7110
Epoch 64/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7433 - accuracy: 0.6934 - val_loss: 0.7009
- val_accuracy: 0.7258
Epoch 65/100
128/128 [==============================] - 41s 315ms/step - loss: 0.7243 - accuracy: 0.7029 - val_loss: 0.6480
- val_accuracy: 0.7406
Epoch 66/100
128/128 [==============================] - 40s 308ms/step - loss: 0.7203 - accuracy: 0.7000 - val_loss: 0.7032
- val_accuracy: 0.7201
Epoch 67/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7338 - accuracy: 0.6996 - val_loss: 0.6475
- val_accuracy: 0.7281
Epoch 68/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7192 - accuracy: 0.7061 - val_loss: 0.7410
- val_accuracy: 0.7042
Epoch 69/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7194 - accuracy: 0.7084 - val_loss: 0.6803
- val_accuracy: 0.7418
Epoch 70/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7173 - accuracy: 0.6959 - val_loss: 0.7019
- val_accuracy: 0.7281
Epoch 71/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7077 - accuracy: 0.7047 - val_loss: 0.6761
- val_accuracy: 0.7201
Epoch 72/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7298 - accuracy: 0.7015 - val_loss: 0.6513
- val_accuracy: 0.7474
Epoch 73/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7209 - accuracy: 0.7040 - val_loss: 0.6766
- val_accuracy: 0.7304
Epoch 74/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7226 - accuracy: 0.7015 - val_loss: 0.6823
- val_accuracy: 0.7213
Epoch 75/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7254 - accuracy: 0.7079 - val_loss: 0.6700
- val_accuracy: 0.7531
Epoch 76/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7206 - accuracy: 0.6992 - val_loss: 0.7025
- val_accuracy: 0.7042
Epoch 77/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7270 - accuracy: 0.7041 - val_loss: 0.7020
- val_accuracy: 0.7190
Epoch 78/100
128/128 [==============================] - 40s 314ms/step - loss: 0.7142 - accuracy: 0.7081 - val_loss: 0.6982
- val_accuracy: 0.7292
Epoch 79/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7220 - accuracy: 0.6992 - val_loss: 0.6761
- val_accuracy: 0.7383
Epoch 80/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7088 - accuracy: 0.7209 - val loss: 0.6682
```

```
- val_accuracy: 0.7361
Epoch 81/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7076 - accuracy: 0.7045 - val_loss: 0.6539
- val_accuracy: 0.7440
Epoch 82/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7022 - accuracy: 0.7152 - val_loss: 0.6547
- val_accuracy: 0.7509
Epoch 83/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7074 - accuracy: 0.7089 - val_loss: 0.7118
- val_accuracy: 0.7156
Epoch 84/100
128/128 [==============================] - 40s 309ms/step - loss: 0.7069 - accuracy: 0.7187 - val_loss: 0.6361
- val_accuracy: 0.7509
Epoch 85/100
128/128 [==============================] - 40s 308ms/step - loss: 0.7020 - accuracy: 0.7081 - val_loss: 0.6431
- val_accuracy: 0.7554
Epoch 86/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7038 - accuracy: 0.7147 - val_loss: 0.6898
- val_accuracy: 0.7361
Epoch 87/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7147 - accuracy: 0.7064 - val_loss: 0.7158
- val_accuracy: 0.7372
Epoch 88/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7066 - accuracy: 0.7069 - val_loss: 0.6274
- val_accuracy: 0.7520
Epoch 89/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6866 - accuracy: 0.7064 - val_loss: 0.6891
- val_accuracy: 0.7383
Epoch 90/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6952 - accuracy: 0.7130 - val_loss: 0.7362
- val_accuracy: 0.7031
Epoch 91/100
128/128 [==============================] - 41s 315ms/step - loss: 0.6905 - accuracy: 0.7133 - val_loss: 0.6709
- val_accuracy: 0.7304
Epoch 92/100
128/128 [==============================] - 39s 305ms/step - loss: 0.7101 - accuracy: 0.7074 - val_loss: 0.6902
- val_accuracy: 0.7327
Epoch 93/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6968 - accuracy: 0.7128 - val_loss: 0.6638
- val_accuracy: 0.7497
Epoch 94/100
128/128 [==============================] - 39s 306ms/step - loss: 0.7117 - accuracy: 0.6988 - val_loss: 0.6761
- val_accuracy: 0.7383
Epoch 95/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6840 - accuracy: 0.7316 - val_loss: 0.7076
- val_accuracy: 0.7224
Epoch 96/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6970 - accuracy: 0.7184 - val_loss: 0.6538
- val_accuracy: 0.7429
Epoch 97/100
128/128 [==============================] - 40s 309ms/step - loss: 0.6779 - accuracy: 0.7322 - val_loss: 0.6884
- val_accuracy: 0.7440
Epoch 98/100
128/128 [==============================] - 39s 307ms/step - loss: 0.7055 - accuracy: 0.7085 - val_loss: 0.7211
- val_accuracy: 0.7042
Epoch 99/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6977 - accuracy: 0.7138 - val_loss: 0.6844
- val_accuracy: 0.7304
Epoch 100/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6786 - accuracy: 0.7282 - val_loss: 0.6335
- val_accuracy: 0.7577
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d37c2910>
```

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')  # creates a HDF5 file 'my
```

In [ ]:

```
model.fit(ImageGenerator_train,validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=100)
```

```
Epoch 1/100
128/128 [==============================] - 44s 340ms/step - loss: 0.6930 - accuracy: 0.7189 - val_loss: 0.6576
- val_accuracy: 0.7349
Epoch 2/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6907 - accuracy: 0.7162 - val_loss: 0.7024
- val_accuracy: 0.7213
Epoch 3/100
```

```
128/128 [==============================] - 39s 305ms/step - loss: 0.6862 - accuracy: 0.7216 - val_loss: 0.6892
- val_accuracy: 0.7383
Epoch 4/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6788 - accuracy: 0.7265 - val_loss: 0.7301
- val_accuracy: 0.7031
Epoch 5/100
128/128 [==============================] - 41s 320ms/step - loss: 0.6876 - accuracy: 0.7189 - val_loss: 0.6321
- val_accuracy: 0.7577
Epoch 6/100
128/128 [==============================] - 39s 303ms/step - loss: 0.6778 - accuracy: 0.7282 - val_loss: 0.6808
- val_accuracy: 0.7383
Epoch 7/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6751 - accuracy: 0.7223 - val_loss: 0.6688
- val_accuracy: 0.7440
Epoch 8/100
128/128 [==============================] - 39s 303ms/step - loss: 0.6609 - accuracy: 0.7309 - val_loss: 0.6523
- val_accuracy: 0.7395
Epoch 9/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6831 - accuracy: 0.7140 - val_loss: 0.6582
- val_accuracy: 0.7497
Epoch 10/100
128/128 [==============================] - 39s 303ms/step - loss: 0.6746 - accuracy: 0.7250 - val_loss: 0.6279
- val_accuracy: 0.7600
Epoch 11/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6615 - accuracy: 0.7297 - val_loss: 0.6315
- val_accuracy: 0.7622
Epoch 12/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6710 - accuracy: 0.7231 - val_loss: 0.6378
- val_accuracy: 0.7531
Epoch 13/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6756 - accuracy: 0.7289 - val_loss: 0.6515
- val_accuracy: 0.7520
Epoch 14/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6748 - accuracy: 0.7304 - val_loss: 0.6862
- val_accuracy: 0.7270
Epoch 15/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6677 - accuracy: 0.7329 - val_loss: 0.6856
- val_accuracy: 0.7270
Epoch 16/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6631 - accuracy: 0.7294 - val_loss: 0.6586
- val_accuracy: 0.7531
Epoch 17/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6721 - accuracy: 0.7236 - val_loss: 0.6585
- val_accuracy: 0.7463
Epoch 18/100
128/128 [==============================] - 40s 313ms/step - loss: 0.6670 - accuracy: 0.7294 - val_loss: 0.7050
- val_accuracy: 0.7247
Epoch 19/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6688 - accuracy: 0.7201 - val_loss: 0.6386
- val_accuracy: 0.7531
Epoch 20/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6790 - accuracy: 0.7253 - val_loss: 0.7124
- val_accuracy: 0.7190
Epoch 21/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6657 - accuracy: 0.7341 - val_loss: 0.7173
- val_accuracy: 0.7258
Epoch 22/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6537 - accuracy: 0.7326 - val_loss: 0.6454
- val_accuracy: 0.7497
Epoch 23/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6561 - accuracy: 0.7239 - val_loss: 0.6463
- val_accuracy: 0.7497
Epoch 24/100
128/128 [==============================] - 39s 303ms/step - loss: 0.6517 - accuracy: 0.7412 - val_loss: 0.6921
- val_accuracy: 0.7327
Epoch 25/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6553 - accuracy: 0.7294 - val_loss: 0.7334
- val_accuracy: 0.7270
Epoch 26/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6670 - accuracy: 0.7297 - val_loss: 0.6393
- val_accuracy: 0.7611
Epoch 27/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6486 - accuracy: 0.7363 - val_loss: 0.6348
- val_accuracy: 0.7588
Epoch 28/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6624 - accuracy: 0.7309 - val_loss: 0.6717
- val_accuracy: 0.7429
```

```
Epoch 29/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6594 - accuracy: 0.7289 - val_loss: 0.6831
- val_accuracy: 0.7349
Epoch 30/100
128/128 [==============================] - 40s 313ms/step - loss: 0.6424 - accuracy: 0.7471 - val_loss: 0.7144
- val_accuracy: 0.7304
Epoch 31/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6606 - accuracy: 0.7338 - val_loss: 0.7262
- val_accuracy: 0.7133
Epoch 32/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6350 - accuracy: 0.7419 - val_loss: 0.6686
- val_accuracy: 0.7474
Epoch 33/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6438 - accuracy: 0.7392 - val_loss: 0.6973
- val_accuracy: 0.7201
Epoch 34/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6639 - accuracy: 0.7302 - val_loss: 0.6309
- val_accuracy: 0.7577
Epoch 35/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6401 - accuracy: 0.7461 - val_loss: 0.6423
- val_accuracy: 0.7611
Epoch 36/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6334 - accuracy: 0.7471 - val_loss: 0.6872
- val_accuracy: 0.7395
Epoch 37/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6363 - accuracy: 0.7338 - val_loss: 0.6859
- val_accuracy: 0.7349
Epoch 38/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6517 - accuracy: 0.7253 - val_loss: 0.6307
- val_accuracy: 0.7509
Epoch 39/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6366 - accuracy: 0.7461 - val_loss: 0.6092
- val_accuracy: 0.7600
Epoch 40/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6403 - accuracy: 0.7431 - val_loss: 0.6514
- val_accuracy: 0.7486
Epoch 41/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6560 - accuracy: 0.7314 - val_loss: 0.6452
- val_accuracy: 0.7486
Epoch 42/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6324 - accuracy: 0.7468 - val_loss: 0.6040
- val_accuracy: 0.7645
Epoch 43/100
128/128 [==============================] - 40s 314ms/step - loss: 0.6451 - accuracy: 0.7351 - val_loss: 0.6485
- val_accuracy: 0.7531
Epoch 44/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6304 - accuracy: 0.7446 - val_loss: 0.6468
- val_accuracy: 0.7543
Epoch 45/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6454 - accuracy: 0.7444 - val_loss: 0.6227
- val_accuracy: 0.7577
Epoch 46/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6397 - accuracy: 0.7419 - val_loss: 0.5910
- val_accuracy: 0.7702
Epoch 47/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6422 - accuracy: 0.7373 - val_loss: 0.6723
- val_accuracy: 0.7418
Epoch 48/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6448 - accuracy: 0.7336 - val_loss: 0.7000
- val_accuracy: 0.7247
Epoch 49/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6436 - accuracy: 0.7439 - val_loss: 0.6409
- val_accuracy: 0.7634
Epoch 50/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6345 - accuracy: 0.7422 - val_loss: 0.6161
- val_accuracy: 0.7452
Epoch 51/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6337 - accuracy: 0.7392 - val_loss: 0.6741
- val_accuracy: 0.7349
Epoch 52/100
128/128 [==============================] - 39s 303ms/step - loss: 0.6506 - accuracy: 0.7419 - val_loss: 0.6360
- val_accuracy: 0.7486
Epoch 53/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6219 - accuracy: 0.7468 - val_loss: 0.6254
- val_accuracy: 0.7509
Epoch 54/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6360 - accuracy: 0.7461 - val_loss: 0.6808
```

```
- val_accuracy: 0.7486
Epoch 55/100
128/128 [==============================] - 40s 314ms/step - loss: 0.6177 - accuracy: 0.7539 - val_loss: 0.6233
- val_accuracy: 0.7611
Epoch 56/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6388 - accuracy: 0.7424 - val_loss: 0.6657
- val_accuracy: 0.7395
Epoch 57/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6382 - accuracy: 0.7397 - val_loss: 0.6322
- val_accuracy: 0.7600
Epoch 58/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6295 - accuracy: 0.7427 - val_loss: 0.6841
- val_accuracy: 0.7509
Epoch 59/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6270 - accuracy: 0.7446 - val_loss: 0.6165
- val_accuracy: 0.7531
Epoch 60/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6324 - accuracy: 0.7427 - val_loss: 0.6202
- val_accuracy: 0.7645
Epoch 61/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6199 - accuracy: 0.7478 - val_loss: 0.5920
- val_accuracy: 0.7770
Epoch 62/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6219 - accuracy: 0.7485 - val_loss: 0.6318
- val_accuracy: 0.7588
Epoch 63/100
128/128 [==============================] - 44s 342ms/step - loss: 0.6237 - accuracy: 0.7495 - val_loss: 0.6763
- val_accuracy: 0.7509
Epoch 64/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6243 - accuracy: 0.7520 - val_loss: 0.6258
- val_accuracy: 0.7577
Epoch 65/100
128/128 [==============================] - 40s 314ms/step - loss: 0.6246 - accuracy: 0.7512 - val_loss: 0.6278
- val_accuracy: 0.7679
Epoch 66/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6240 - accuracy: 0.7517 - val_loss: 0.5994
- val_accuracy: 0.7770
Epoch 67/100
128/128 [==============================] - 40s 312ms/step - loss: 0.6125 - accuracy: 0.7568 - val_loss: 0.6158
- val_accuracy: 0.7622
Epoch 68/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6142 - accuracy: 0.7498 - val_loss: 0.6153
- val_accuracy: 0.7656
Epoch 69/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6120 - accuracy: 0.7483 - val_loss: 0.6978
- val_accuracy: 0.7383
Epoch 70/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6250 - accuracy: 0.7412 - val_loss: 0.6296
- val_accuracy: 0.7736
Epoch 71/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6173 - accuracy: 0.7505 - val_loss: 0.7411
- val_accuracy: 0.7201
Epoch 72/100
128/128 [==============================] - 40s 315ms/step - loss: 0.6122 - accuracy: 0.7559 - val_loss: 0.6917
- val_accuracy: 0.7452
Epoch 73/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6229 - accuracy: 0.7476 - val_loss: 0.6425
- val_accuracy: 0.7554
Epoch 74/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6434 - accuracy: 0.7365 - val_loss: 0.6380
- val_accuracy: 0.7622
Epoch 75/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6198 - accuracy: 0.7485 - val_loss: 0.6123
- val_accuracy: 0.7782
Epoch 76/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6047 - accuracy: 0.7502 - val_loss: 0.6223
- val_accuracy: 0.7645
Epoch 77/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6163 - accuracy: 0.7505 - val_loss: 0.6296
- val_accuracy: 0.7668
Epoch 78/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6101 - accuracy: 0.7578 - val_loss: 0.6548
- val_accuracy: 0.7713
Epoch 79/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6141 - accuracy: 0.7590 - val_loss: 0.5995
- val_accuracy: 0.7782
Epoch 80/100
```

```
128/128 [==============================] - 40s 314ms/step - loss: 0.6183 - accuracy: 0.7478 - val_loss: 0.6039
- val_accuracy: 0.7668
Epoch 81/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6109 - accuracy: 0.7473 - val_loss: 0.6566
- val_accuracy: 0.7622
Epoch 82/100
128/128 [==============================] - 39s 307ms/step - loss: 0.6194 - accuracy: 0.7493 - val_loss: 0.6453
- val_accuracy: 0.7713
Epoch 83/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6085 - accuracy: 0.7527 - val_loss: 0.6295
- val_accuracy: 0.7645
Epoch 84/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6166 - accuracy: 0.7517 - val_loss: 0.6229
- val_accuracy: 0.7679
Epoch 85/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6172 - accuracy: 0.7463 - val_loss: 0.6366
- val_accuracy: 0.7509
Epoch 86/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5965 - accuracy: 0.7551 - val_loss: 0.6441
- val_accuracy: 0.7588
Epoch 87/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6015 - accuracy: 0.7576 - val_loss: 0.6364
- val_accuracy: 0.7611
Epoch 88/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5935 - accuracy: 0.7627 - val_loss: 0.6135
- val_accuracy: 0.7725
Epoch 89/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6064 - accuracy: 0.7568 - val_loss: 0.6544
- val_accuracy: 0.7440
Epoch 90/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6061 - accuracy: 0.7534 - val_loss: 0.6275
- val_accuracy: 0.7713
Epoch 91/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6066 - accuracy: 0.7566 - val_loss: 0.6476
- val_accuracy: 0.7691
Epoch 92/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5976 - accuracy: 0.7586 - val_loss: 0.6589
- val_accuracy: 0.7565
Epoch 93/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5911 - accuracy: 0.7576 - val_loss: 0.6233
- val_accuracy: 0.7702
Epoch 94/100
128/128 [==============================] - 39s 304ms/step - loss: 0.6001 - accuracy: 0.7593 - val_loss: 0.5977
- val_accuracy: 0.7679
Epoch 95/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6095 - accuracy: 0.7490 - val_loss: 0.5834
- val_accuracy: 0.7816
Epoch 96/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6094 - accuracy: 0.7551 - val_loss: 0.6589
- val_accuracy: 0.7520
Epoch 97/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5976 - accuracy: 0.7571 - val_loss: 0.6337
- val_accuracy: 0.7634
Epoch 98/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5951 - accuracy: 0.7630 - val_loss: 0.6014
- val_accuracy: 0.7747
Epoch 99/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5948 - accuracy: 0.7710 - val_loss: 0.7116
- val_accuracy: 0.7418
Epoch 100/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5978 - accuracy: 0.7566 - val_loss: 0.5963
- val_accuracy: 0.7827
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d379ae50>
```

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')  # creates a HDF5 file 'my
```

In [ ]:

```
model.fit(ImageGenerator_train,validation_data=ImageGenerator_test,\
         steps_per_epoch=128, epochs=100)
```

```
Epoch 1/100
128/128 [==============================] - 43s 328ms/step - loss: 0.6022 - accuracy: 0.7539 - val_loss: 0.6660
- val_accuracy: 0.7577
Epoch 2/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5998 - accuracy: 0.7556 - val_loss: 0.6094
- val_accuracy: 0.7679
```

```
Epoch 3/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5867 - accuracy: 0.7652 - val_loss: 0.6943
- val_accuracy: 0.7418
Epoch 4/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5910 - accuracy: 0.7651 - val_loss: 0.6261
- val_accuracy: 0.7668
Epoch 5/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6075 - accuracy: 0.7566 - val_loss: 0.6207
- val_accuracy: 0.7668
Epoch 6/100
128/128 [==============================] - 39s 306ms/step - loss: 0.6121 - accuracy: 0.7507 - val_loss: 0.6334
- val_accuracy: 0.7679
Epoch 7/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5936 - accuracy: 0.7600 - val_loss: 0.6723
- val_accuracy: 0.7622
Epoch 8/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5904 - accuracy: 0.7728 - val_loss: 0.5986
- val_accuracy: 0.7725
Epoch 9/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5880 - accuracy: 0.7679 - val_loss: 0.6448
- val_accuracy: 0.7702
Epoch 10/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5799 - accuracy: 0.7654 - val_loss: 0.6637
- val_accuracy: 0.7543
Epoch 11/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5823 - accuracy: 0.7725 - val_loss: 0.6069
- val_accuracy: 0.7793
Epoch 12/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5782 - accuracy: 0.7762 - val_loss: 0.5885
- val_accuracy: 0.7873
Epoch 13/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5799 - accuracy: 0.7642 - val_loss: 0.6449
- val_accuracy: 0.7679
Epoch 14/100
128/128 [==============================] - 39s 305ms/step - loss: 0.6020 - accuracy: 0.7595 - val_loss: 0.6250
- val_accuracy: 0.7656
Epoch 15/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5717 - accuracy: 0.7769 - val_loss: 0.6578
- val_accuracy: 0.7509
Epoch 16/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5759 - accuracy: 0.7679 - val_loss: 0.6250
- val_accuracy: 0.7702
Epoch 17/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5858 - accuracy: 0.7649 - val_loss: 0.6179
- val_accuracy: 0.7770
Epoch 18/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5621 - accuracy: 0.7752 - val_loss: 0.6317
- val_accuracy: 0.7725
Epoch 19/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5861 - accuracy: 0.7760 - val_loss: 0.6696
- val_accuracy: 0.7520
Epoch 20/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5770 - accuracy: 0.7698 - val_loss: 0.6238
- val_accuracy: 0.7679
Epoch 21/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5903 - accuracy: 0.7610 - val_loss: 0.6210
- val_accuracy: 0.7759
Epoch 22/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5804 - accuracy: 0.7647 - val_loss: 0.6120
- val_accuracy: 0.7770
Epoch 23/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5780 - accuracy: 0.7693 - val_loss: 0.6315
- val_accuracy: 0.7679
Epoch 24/100
128/128 [==============================] - 40s 313ms/step - loss: 0.5859 - accuracy: 0.7627 - val_loss: 0.6208
- val_accuracy: 0.7747
Epoch 25/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5802 - accuracy: 0.7728 - val_loss: 0.5773
- val_accuracy: 0.7782
Epoch 26/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5901 - accuracy: 0.7583 - val_loss: 0.6120
- val_accuracy: 0.7782
Epoch 27/100
128/128 [==============================] - 39s 308ms/step - loss: 0.5701 - accuracy: 0.7728 - val_loss: 0.7114
- val_accuracy: 0.7406
Epoch 28/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5828 - accuracy: 0.7667 - val loss: 0.5591
```

```
- val_accuracy: 0.7873
Epoch 29/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5607 - accuracy: 0.7799 - val_loss: 0.5766
- val_accuracy: 0.7861
Epoch 30/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5689 - accuracy: 0.7730 - val_loss: 0.6437
- val_accuracy: 0.7634
Epoch 31/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5727 - accuracy: 0.7703 - val_loss: 0.6854
- val_accuracy: 0.7440
Epoch 32/100
128/128 [==============================] - 39s 307ms/step - loss: 0.5606 - accuracy: 0.7715 - val_loss: 0.5929
- val_accuracy: 0.7782
Epoch 33/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5740 - accuracy: 0.7701 - val_loss: 0.6131
- val_accuracy: 0.7850
Epoch 34/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5783 - accuracy: 0.7730 - val_loss: 0.5897
- val_accuracy: 0.7793
Epoch 35/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5819 - accuracy: 0.7706 - val_loss: 0.6315
- val_accuracy: 0.7782
Epoch 36/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5785 - accuracy: 0.7725 - val_loss: 0.6523
- val_accuracy: 0.7600
Epoch 37/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5704 - accuracy: 0.7689 - val_loss: 0.6695
- val_accuracy: 0.7611
Epoch 38/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5809 - accuracy: 0.7639 - val_loss: 0.6053
- val_accuracy: 0.7679
Epoch 39/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5706 - accuracy: 0.7711 - val_loss: 0.6090
- val_accuracy: 0.7759
Epoch 40/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5635 - accuracy: 0.7801 - val_loss: 0.5977
- val_accuracy: 0.7827
Epoch 41/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5568 - accuracy: 0.7689 - val_loss: 0.6011
- val_accuracy: 0.7873
Epoch 42/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5482 - accuracy: 0.7789 - val_loss: 0.6470
- val_accuracy: 0.7611
Epoch 43/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5550 - accuracy: 0.7806 - val_loss: 0.5912
- val_accuracy: 0.7941
Epoch 44/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5591 - accuracy: 0.7769 - val_loss: 0.6079
- val_accuracy: 0.7725
Epoch 45/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5580 - accuracy: 0.7811 - val_loss: 0.6011
- val_accuracy: 0.7827
Epoch 46/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5680 - accuracy: 0.7711 - val_loss: 0.6412
- val_accuracy: 0.7668
Epoch 47/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5690 - accuracy: 0.7715 - val_loss: 0.5867
- val_accuracy: 0.7804
Epoch 48/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5626 - accuracy: 0.7782 - val_loss: 0.5830
- val_accuracy: 0.7861
Epoch 49/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5643 - accuracy: 0.7784 - val_loss: 0.5818
- val_accuracy: 0.7918
Epoch 50/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5525 - accuracy: 0.7760 - val_loss: 0.5754
- val_accuracy: 0.7884
Epoch 51/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5605 - accuracy: 0.7715 - val_loss: 0.6177
- val_accuracy: 0.7770
Epoch 52/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5661 - accuracy: 0.7756 - val_loss: 0.6806
- val_accuracy: 0.7463
Epoch 53/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5748 - accuracy: 0.7642 - val_loss: 0.6994
- val_accuracy: 0.7406
Epoch 54/100
```

```
128/128 [==============================] - 39s 305ms/step - loss: 0.5659 - accuracy: 0.7757 - val_loss: 0.6739
- val_accuracy: 0.7474
Epoch 55/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5698 - accuracy: 0.7730 - val_loss: 0.6570
- val_accuracy: 0.7554
Epoch 56/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5571 - accuracy: 0.7791 - val_loss: 0.6650
- val_accuracy: 0.7565
Epoch 57/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5593 - accuracy: 0.7764 - val_loss: 0.6359
- val_accuracy: 0.7634
Epoch 58/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5624 - accuracy: 0.7683 - val_loss: 0.6115
- val_accuracy: 0.7702
Epoch 59/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5485 - accuracy: 0.7845 - val_loss: 0.6748
- val_accuracy: 0.7520
Epoch 60/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5675 - accuracy: 0.7796 - val_loss: 0.5897
- val_accuracy: 0.7884
Epoch 61/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5528 - accuracy: 0.7816 - val_loss: 0.6324
- val_accuracy: 0.7645
Epoch 62/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5533 - accuracy: 0.7782 - val_loss: 0.5868
- val_accuracy: 0.7907
Epoch 63/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5480 - accuracy: 0.7872 - val_loss: 0.5697
- val_accuracy: 0.7986
Epoch 64/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5567 - accuracy: 0.7703 - val_loss: 0.6620
- val_accuracy: 0.7600
Epoch 65/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5482 - accuracy: 0.7839 - val_loss: 0.7090
- val_accuracy: 0.7349
Epoch 66/100
128/128 [==============================] - 40s 311ms/step - loss: 0.5456 - accuracy: 0.7762 - val_loss: 0.6017
- val_accuracy: 0.7793
Epoch 67/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5436 - accuracy: 0.7843 - val_loss: 0.6342
- val_accuracy: 0.7634
Epoch 68/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5641 - accuracy: 0.7698 - val_loss: 0.5864
- val_accuracy: 0.7782
Epoch 69/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5565 - accuracy: 0.7811 - val_loss: 0.6311
- val_accuracy: 0.7804
Epoch 70/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5516 - accuracy: 0.7769 - val_loss: 0.6941
- val_accuracy: 0.7486
Epoch 71/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5513 - accuracy: 0.7826 - val_loss: 0.5700
- val_accuracy: 0.7816
Epoch 72/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5413 - accuracy: 0.7821 - val_loss: 0.6043
- val_accuracy: 0.7702
Epoch 73/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5682 - accuracy: 0.7718 - val_loss: 0.6744
- val_accuracy: 0.7486
Epoch 74/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5401 - accuracy: 0.7784 - val_loss: 0.5992
- val_accuracy: 0.7747
Epoch 75/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5476 - accuracy: 0.7818 - val_loss: 0.5531
- val_accuracy: 0.7964
Epoch 76/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5520 - accuracy: 0.7784 - val_loss: 0.6185
- val_accuracy: 0.7713
Epoch 77/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5407 - accuracy: 0.7848 - val_loss: 0.5650
- val_accuracy: 0.7884
Epoch 78/100
128/128 [==============================] - 39s 304ms/step - loss: 0.5406 - accuracy: 0.7799 - val_loss: 0.6351
- val_accuracy: 0.7725
Epoch 79/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5458 - accuracy: 0.7764 - val_loss: 0.6266
- val_accuracy: 0.7679
```

```
Epoch 80/100
128/128 [==============================] - 41s 318ms/step - loss: 0.5421 - accuracy: 0.7806 - val_loss: 0.6201
- val_accuracy: 0.7736
Epoch 81/100
128/128 [==============================] - 40s 308ms/step - loss: 0.5488 - accuracy: 0.7809 - val_loss: 0.6758
- val_accuracy: 0.7440
Epoch 82/100
128/128 [==============================] - 39s 307ms/step - loss: 0.5446 - accuracy: 0.7823 - val_loss: 0.6415
- val_accuracy: 0.7588
Epoch 83/100
128/128 [==============================] - 39s 307ms/step - loss: 0.5391 - accuracy: 0.7801 - val_loss: 0.6607
- val_accuracy: 0.7577
Epoch 84/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5524 - accuracy: 0.7833 - val_loss: 0.6047
- val_accuracy: 0.7782
Epoch 85/100
128/128 [==============================] - 39s 307ms/step - loss: 0.5421 - accuracy: 0.7835 - val_loss: 0.5917
- val_accuracy: 0.7861
Epoch 86/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5367 - accuracy: 0.7897 - val_loss: 0.6522
- val_accuracy: 0.7611
Epoch 87/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5373 - accuracy: 0.7845 - val_loss: 0.6989
- val_accuracy: 0.7429
Epoch 88/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5432 - accuracy: 0.7821 - val_loss: 0.6735
- val_accuracy: 0.7429
Epoch 89/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5337 - accuracy: 0.8025 - val_loss: 0.6368
- val_accuracy: 0.7747
Epoch 90/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5384 - accuracy: 0.7877 - val_loss: 0.5896
- val_accuracy: 0.7793
Epoch 91/100
128/128 [==============================] - 39s 307ms/step - loss: 0.5264 - accuracy: 0.7882 - val_loss: 0.6450
- val_accuracy: 0.7713
Epoch 92/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5391 - accuracy: 0.7835 - val_loss: 0.6879
- val_accuracy: 0.7361
Epoch 93/100
128/128 [==============================] - 40s 314ms/step - loss: 0.5431 - accuracy: 0.7794 - val_loss: 0.6563
- val_accuracy: 0.7691
Epoch 94/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5262 - accuracy: 0.7946 - val_loss: 0.6905
- val_accuracy: 0.7543
Epoch 95/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5202 - accuracy: 0.7946 - val_loss: 0.5793
- val_accuracy: 0.7850
Epoch 96/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5383 - accuracy: 0.7840 - val_loss: 0.6257
- val_accuracy: 0.7611
Epoch 97/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5151 - accuracy: 0.7965 - val_loss: 0.6414
- val_accuracy: 0.7679
Epoch 98/100
128/128 [==============================] - 39s 305ms/step - loss: 0.5416 - accuracy: 0.7772 - val_loss: 0.6115
- val_accuracy: 0.7668
Epoch 99/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5456 - accuracy: 0.7831 - val_loss: 0.6298
- val_accuracy: 0.7543
Epoch 100/100
128/128 [==============================] - 39s 306ms/step - loss: 0.5405 - accuracy: 0.7883 - val_loss: 0.5725
- val_accuracy: 0.7929
```

Out[ ]:

```
<keras.callbacks.History at 0x7ff2d3644ed0>
```

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/baseline_model.h5')  # creates a HDF5 file 'my
```

In [ ]:

```
y_true=[]
y_pred=[]
cnt=0
for x,y in ImageGenerator_test:
  #print(x.shape)
  #print(y.shape)
  cnt = cnt+1
```

```
    if x.shape[0]==32 and cnt<=1000:
      y_pred.extend(list(np.argmax(model.predict(x),axis=1)))
      y_true.extend(np.argmax(y,axis=1))
    else:
      break
```

In [ ]:

```
len(y_pred)
```

Out[ ]:

```
864
```

In [ ]:

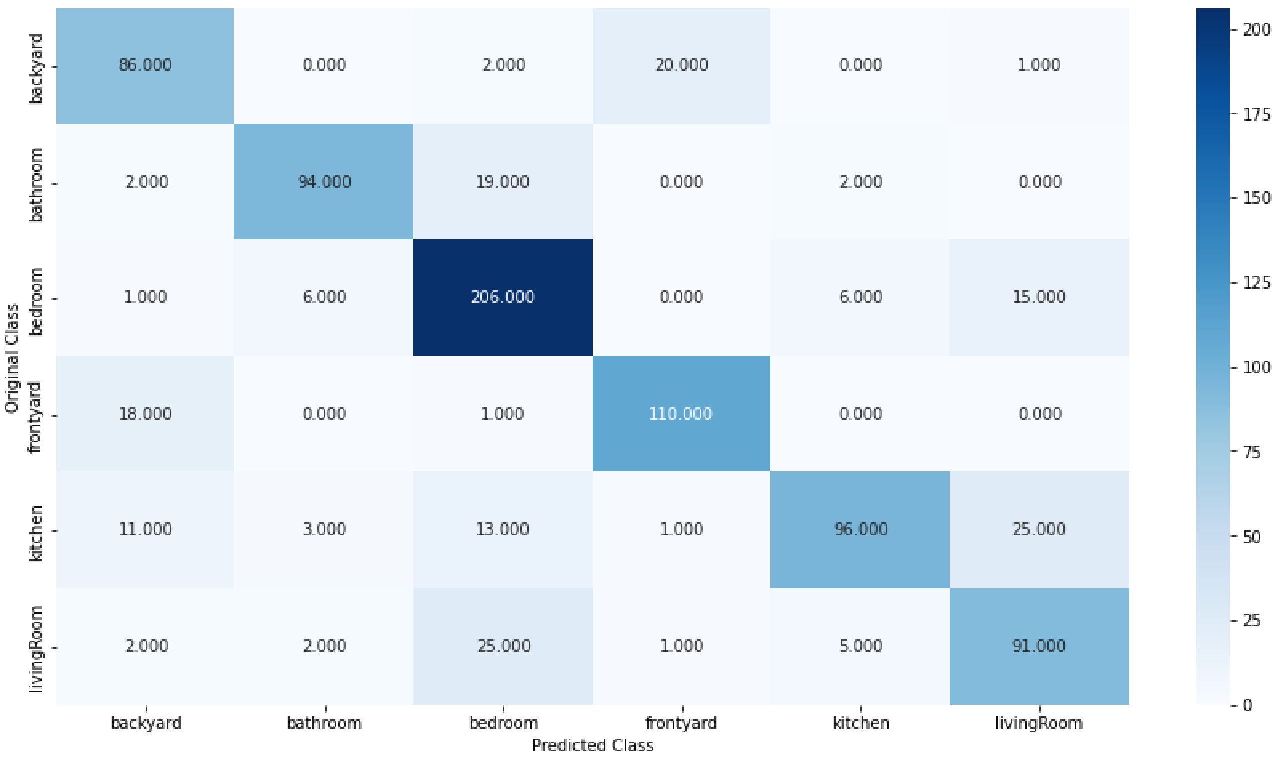
```
list(ImageGenerator_test.class_indices.keys())
```

Out[ ]:

```
['backyard', 'bathroom', 'bedroom', 'frontyard', 'kitchen', 'livingRoom']
```

In [ ]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.ConfusionMatrixDisplay.html
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

labels = list(ImageGenerator_test.class_indices.keys())

cm = confusion_matrix(y_true, y_pred, labels=list(ImageGenerator_test.class_indices.values()))

plt.figure(figsize=(15,8))



sns.heatmap(cm, annot=True, cmap='Blues', fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```



In [ ]:

```
precision = true_pos = np.diag(cm) /np.sum(cm,axis=0)
recall = true_pos = np.diag(cm) /np.sum(cm,axis=1)
```

In [ ]:

```
from prettytable import PrettyTable

columns = ["label", "Precision", "Recall"]

table = PrettyTable()

# Add Columns
table.add_column(columns[0], labels)
table.add_column(columns[1],list(map(lambda x : round(x,4),precision)))
table.add_column(columns[2], list(map(lambda x : round(x,4),recall)))
```

```
print(table)
```

```
+------------+-----------+--------+
|   label    | Precision | Recall |
+------------+-----------+--------+
|  backyard  |   0.7167  | 0.789  |
|  bathroom  |   0.8952  | 0.8034 |
|  bedroom   |   0.7744  | 0.8803 |
| frontyard  |   0.8333  | 0.8527 |
|  kitchen   |   0.8807  | 0.6443 |
| livingRoom |   0.6894  | 0.7222 |
+------------+-----------+--------+
```

Observation:

- Epoch: 340
- Train Accuracy: 78.83%
- Test Accuracy: 79.29%

In [ ]:

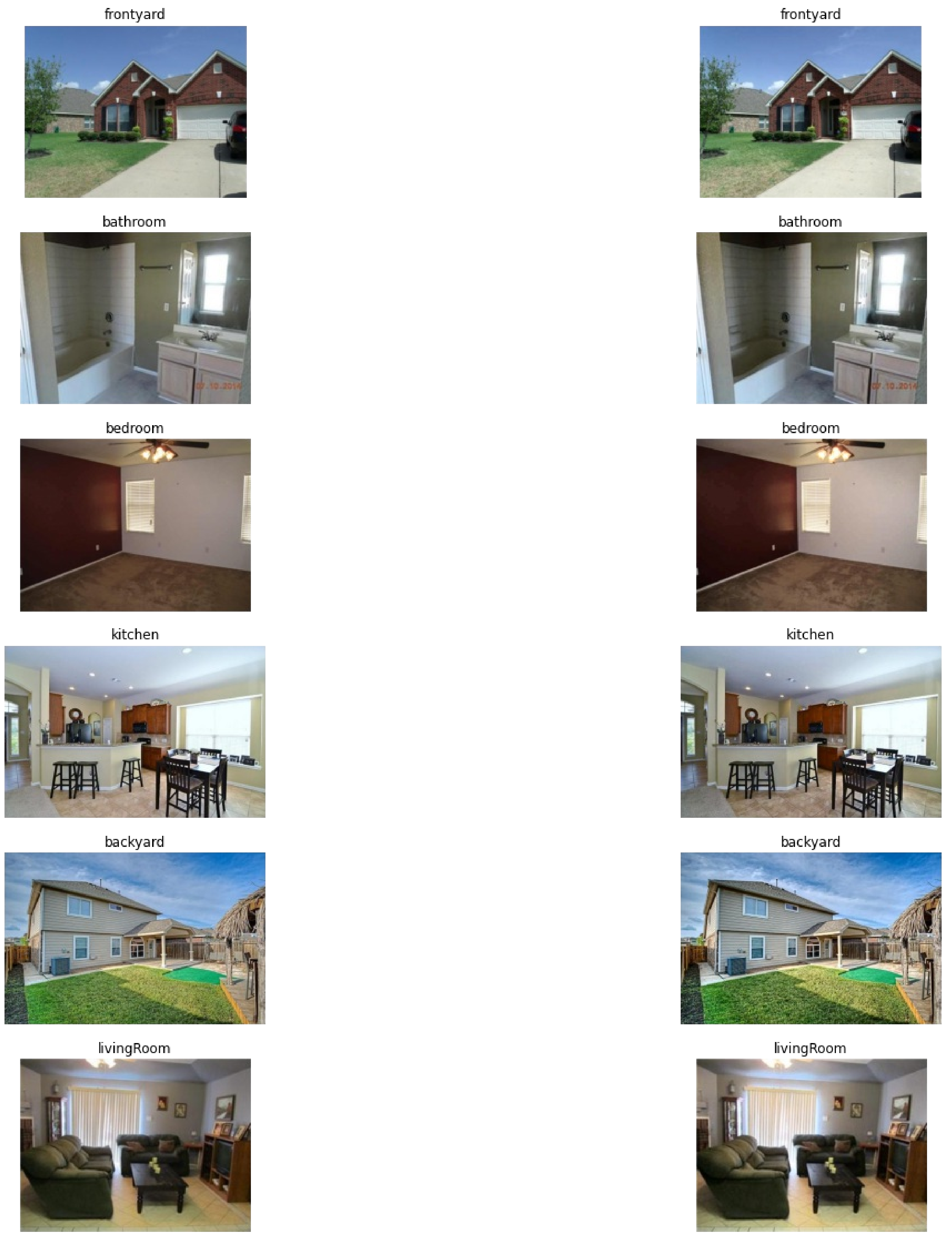
In [ ]:

Experiment: Seeing the difference b/w enhanced image and normal image

- enhancing the image using CLAHE

In [ ]:

```
def plot_img(image,label,cnt,gray=False):
    plt.subplot(6, 2, cnt)
    plt.grid(False)
    plt.axis('off')
    plt.title(label)
    if gray==True:
      plt.imshow(image, cmap='gray', vmin=0, vmax=255)
    else:
      plt.imshow(image)

#image_df
fig = plt.figure(figsize =(20, 20))

import random
cnt=0
for index,label in enumerate(labels):
  #print(index,label)
  paths= image_df[image_df['label']==label]['file_path'].values
  lt = paths[random.sample(range(0, 650), 1)]
  for img_path in lt:

    image = cv2.imread(img_path)
    image1 = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    cnt=cnt+1
    #fig = plt.figure(figsize =(6, 4))

    plot_img(image1,label,cnt)
    '''
    grayscale_img = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    cnt=cnt+1
    plot_img(grayscale_img,label,cnt,gray=True)
    '''


    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=1,tileGridSize=(1,1))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    cnt=cnt+1
    plot_img(enhanced_img,label,cnt,gray=False)
    '''
    enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    cnt=cnt+1
    plot_img(enhanced_grayscale_img,label,cnt,gray=True)
    '''


plt.show()
```



In [ ]:

```
def plot_img(image,label,cnt,gray=False):
    plt.subplot(6, 2, cnt)
    plt.grid(False)
    plt.axis('off')
    plt.title(label)
    if gray==True:
      plt.imshow(image, cmap='gray', vmin=0, vmax=255)
    else:
      plt.imshow(image)

#image_df
fig = plt.figure(figsize =(20, 20))

import random
cnt=0
for index,label in enumerate(labels):
  #print(index,label)
  paths= image_df[image_df['label']==label]['file_path'].values
  lt = paths[random.sample(range(0, 650), 1)]
  for img_path in lt:

    image = cv2.imread(img_path)
    image1 = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
    cnt=cnt+1
    #fig = plt.figure(figsize =(6, 4))

    plot_img(image1,label,cnt)
    '''
    grayscale_img = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    cnt=cnt+1
    plot_img(grayscale_img,label,cnt,gray=True)
    '''


    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(8,8))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    cnt=cnt+1
    plot_img(enhanced_img,label,cnt,gray=False)
    '''
    enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    cnt=cnt+1
    plot_img(enhanced_grayscale_img,label,cnt,gray=True)
    '''



plt.show()
```

frontyard

frontyard

bathroom

bathroom

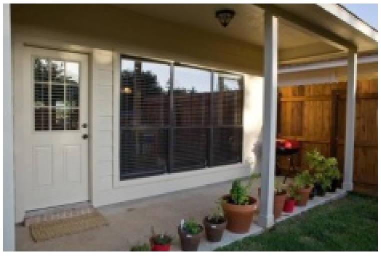
bedroom

bedroom

kitchen

kitchen

backyard



backyard

livingRoom

livingRoom

In [ ]:

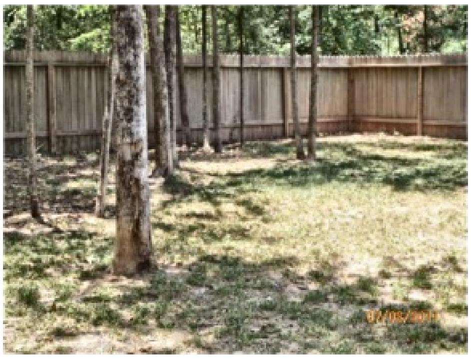
In [ ]:

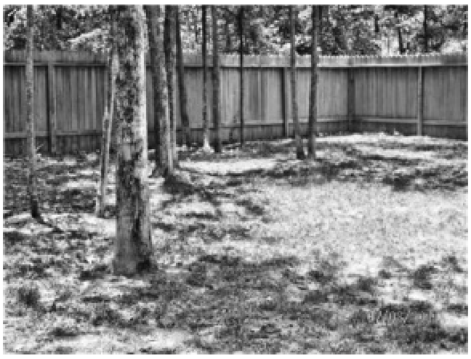
difference is clearly observed in living room images

In [ ]:

```
bgr = cv2.imread("/content/REI-Dataset_/backyard/backyard (1).jpeg")
RGB_img = cv2.cvtColor(bgr, cv2.COLOR_BGR2RGB)
```

```
plt.imshow(RGB_img)
plt.grid(False)
plt.axis('off')
plt.show()
grayscale = cv2.cvtColor(bgr, cv2.COLOR_BGR2GRAY)
plt.imshow(grayscale, cmap='gray', vmin=0, vmax=255)
plt.grid(False)
plt.axis('off')
plt.show()

lab = cv2.cvtColor(bgr, cv2.COLOR_BGR2LAB)

lab_planes = cv2.split(lab)

clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(16,16))

lab_planes[0] = clahe.apply(lab_planes[0])

lab = cv2.merge(lab_planes)

bgr = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
plt.imshow(bgr)
plt.grid(False)
plt.axis('off')
plt.show()
grayscale = cv2.cvtColor(bgr, cv2.COLOR_BGR2GRAY)
plt.imshow(grayscale, cmap='gray', vmin=0, vmax=255)
plt.grid(False)
plt.axis('off')
plt.show()

'''
from google.colab.patches import cv2_imshow
cv2_imshow(bgr)
'''
#test
```





Out[ ]:

```
'\nfrom google.colab.patches import cv2_imshow\ncv2_imshow(bgr)\n'
```

In [ ]:

```
bgr = cv2.imread("/content/REI-Dataset_/backyard/backyard (1).jpeg")
RGB_img = cv2.cvtColor(bgr, cv2.COLOR_BGR2RGB)
plt.imshow(RGB_img)
plt.grid(False)
plt.axis('off')
plt.show()
grayscale = cv2.cvtColor(bgr, cv2.COLOR_BGR2GRAY)
plt.imshow(grayscale, cmap='gray', vmin=0, vmax=255)
plt.grid(False)
plt.axis('off')
plt.show()

lab = cv2.cvtColor(bgr, cv2.COLOR_BGR2LAB)

lab_planes = cv2.split(lab)

clahe = cv2.createCLAHE(clipLimit=1.0,tileGridSize=(1,1))
```

```
lab_planes[0] = clahe.apply(lab_planes[0])

lab = cv2.merge(lab_planes)

bgr = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
plt.imshow(bgr)
plt.grid(False)
plt.axis('off')
plt.show()
grayscale = cv2.cvtColor(bgr, cv2.COLOR_BGR2GRAY)
plt.imshow(grayscale, cmap='gray', vmin=0, vmax=255)
plt.grid(False)
plt.axis('off')
plt.show()

'''
from google.colab.patches import cv2_imshow
cv2_imshow(bgr)
'''
#test
```

Out[ ]:

```
'\nfrom google.colab.patches import cv2_imshow\ncv2_imshow(bgr)\n'
```

Observation:

- By using CLAHE , we can extra imformation in grayscale image

In [ ]:

```
#!zip -r '/content/REI-Dataset_train.zip' '/content/REI-Dataset_train'
```

In [ ]:

Grayscale LSTM Model:

In [ ]:

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

```
Mounted at /content/drive
```

In [ ]:

```
import matplotlib.pyplot as plt
%matplotlib inline
# import seaborn as sns
import pandas as pd
import re
import tensorflow as tf
from tensorflow.keras.layers import Embedding, LSTM, Dense
from tensorflow.keras.models import Model
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
import numpy as np
```

Data Pre processing:

In [ ]:

```
!gdown --id 1s3JydD_s4sR_HOwyH7FhzKGqXlWrhpAs
```

```
/usr/local/lib/python3.7/dist-packages/gdown/cli.py:131: FutureWarning: Option `--id` was deprecated in versio
n 4.3.1 and will be removed in 5.0. You don't need to pass it anymore to use a file ID.
  category=FutureWarning,
Downloading...
From: https://drive.google.com/uc?id=1s3JydD_s4sR_HOwyH7FhzKGqXlWrhpAs
To: /content/Train_Test_Data.zip
100% 302M/302M [00:01<00:00, 217MB/s]
```

In [ ]:

```
!unzip '/content/Train_Test_Data.zip'
```

In [ ]:

```
test_data_path  = '/content/Train_Test_Data/REI-Dataset_test'
train_data_path = '/content/Train_Test_Data/REI-Dataset_train'

labels=[]

for (root,dirs,files) in os.walk(train_data_path, topdown=True):
  if(len(files)>0):

    labels.append(root[root.rfind('/')+1:])
labels
```

Out[ ]:

```
['backyard', 'kitchen', 'frontyard', 'bedroom', 'livingRoom', 'bathroom']
```

In [ ]:

```
from tqdm.notebook import tqdm_notebook
```

Appling CLAHE on image to enhance image and converting it to grayscale image

Train data:

In [ ]:

```
for label in labels:

  path = train_data_path + '/' + label
  files = os.listdir(path)

  for file in tqdm_notebook(files):
    img_path = os.path.join(path, file)

    image = cv2.imread(img_path)    # reading the image

    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(16,16))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    filename = os.path.join(path,'enh_gray_'+file)

    cv2.imwrite(filename, enhanced_grayscale_img)   # saving the gray scale image
    os.remove(img_path)
```

Test Data:

In [ ]:

```
for label in labels:

  path = test_data_path + '/' + label
  files = os.listdir(path)

  for file in tqdm_notebook(files):
    img_path = os.path.join(path, file)

    image = cv2.imread(img_path)

    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(16,16))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    filename = os.path.join(path,'enh_gray_'+file)

    cv2.imwrite(filename, enhanced_grayscale_img)
    os.remove(img_path)
```

In [ ]:

```
!zip -r '/content/REI-Dataset_pp_train_test.zip' '/content/Train_Test_Data'
```

In [ ]:

Modeling:

In [ ]:

```
class LSTM_network(tf.keras.Model):
    '''
    LSTM_network model -- That takes a input sequence and returns output sequence
    '''

    def __init__(self,lstm_units):
        super().__init__()

        #Initialize Embedding layer
        #Intialize Decoder LSTM layer
        self.lstm_initial_h = 0
        self.lstm_initial_c = 0

        self.h_lstm_output = 0
        self.h_lstm_final_state_h = 0
        self.h_lstm_final_state_c  = 0

        self.v_lstm_output = 0
        self.v_lstm_final_state_h = 0
        self.v_lstm_final_state_c  = 0

        self.lstm_units = lstm_units

        self.h_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="h_LSTM")

        self.v_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="v_LSTM")

    def call(self,input_sequence,initial_states):
        '''
          This function takes a sequence input and the initial states of the lstm.
          Pass the input_sequence input to the Embedding layer, Pass the embedding layer ouput to decoder_lst

          returns -- decoder_output,decoder_final_state_h,decoder_final_state_c
        '''
        #print(' input shape : ',input_sequence.shape)

        input_sequence = tf.squeeze(input_sequence, axis=-1, name=None)
        #print(' input shape : ',input_sequence.shape)

        v_input_sequence = tf.transpose( input_sequence, perm=[0, 2, 1], name='transpose')
        #print(' v_input_sequence shape : ',v_input_sequence.shape)
        #print(' initial_states shape : ',initial_states[0].shape,initial_states[1].shape)
        self.lstm_initial_h = initial_states[0]
        self.lstm_initial_c = initial_states[1]

        self.h_lstm_output , self.h_lstm_final_state_h , self.h_lstm_final_state_c = self.h_lstm_layer(input_

        self.v_lstm_output , self.v_lstm_final_state_h , self.v_lstm_final_state_c = self.v_lstm_layer(v_inpu


        #print(' h_lstm_final_state_h output shape : ',self.h_lstm_final_state_h.shape)
        #print(' h_lstm_final_state_c output shape : ',self.h_lstm_final_state_c.shape)



        return self.h_lstm_output , self.v_lstm_output

    def initialize_states(self,batch_size):
      '''
      Given a batch size it will return intial hidden state and intial cell state.
      If batch size is 32- Hidden state is zeros of size [32,lstm_units], cell state zeros is of size [32,lst
      '''

      self.lstm_state_h = tf.zeros((batch_size,self.lstm_units))
      self.lstm_state_c = tf.zeros((batch_size,self.lstm_units))

      return self.lstm_state_h,self.lstm_state_c


    def get_config(self):
        return {'lstm_units': self.lstm_units}

    @classmethod
    def from_config(cls, config):
        return cls(**config)
```

In [ ]:

```
def grader_lstm_nw():
    '''
        verifying the LSTM_network class

        input_row_length: rows of image,
        lstm_units: LSTM units,
        batch_size
    '''

    input_row_length=128
    input_col_length = 256
    lstm_units=32
    batch_size=64

    input_seq=tf.random.uniform(shape=(batch_size,input_row_length,input_col_length,1),maxval=10,minval=0,dty



    state_h=tf.random.uniform(shape=[batch_size,lstm_units],dtype=tf.float32)
    state_c=tf.random.uniform(shape=[batch_size,lstm_units],dtype=tf.float32)
    states=[state_h,state_c]
    lstm= LSTM_network(lstm_units)
    states = lstm.initialize_states(batch_size)
    h_lstm,v_lstm=lstm(input_seq, states)
    print(h_lstm.shape)
    print(v_lstm.shape)
    assert(h_lstm.shape==(batch_size,lstm_units))
    return True
print(grader_lstm_nw())
```

```
(64, 32)
(64, 32)
True
```

In [ ]:

```
class main_framwork(tf.keras.Model):

    def __init__(self,lstm_units,output_class_cnt,batch_size):
        super().__init__()

        self.lstm_units         =     lstm_units
        self.output_class_cnt   =     output_class_cnt
        self.batch_size         =     batch_size

        self.lstm_network = LSTM_network(self.lstm_units)

        self.dense_layer_1 = Dense(128, activation='relu',kernel_initializer = tf.keras.initializers.GlorotNo
        #self.dense_layer_2 = Dense(128, activation='relu',kernel_initializer = tf.keras.initializers.GlorotN
        self.dense_layer_3 = Dense(64, activation='relu',kernel_initializer = tf.keras.initializers.GlorotNor

        self.output_layer = Dense(self.output_class_cnt, activation='softmax')



    def call(self,input_data):


        #print(input_data.shape)
        '''
        print(input_data.shape)
        print(output_data.shape)
        '''

        #print('--------------------------------')

        initial_states =  self.lstm_network.initialize_states(batch_size = self.batch_size)
        h_lstm_output,v_lstm_output = self.lstm_network(input_data,initial_states)
        '''
        print(h_lstm_output.shape)
        print(v_lstm_output.shape)
        '''
        lstm_output = tf.concat([h_lstm_output, v_lstm_output], 1)

        #print(lstm_output.shape)

        dense_1 = self.dense_layer_1(lstm_output)
        #dense_2 = self.dense_layer_2(dense_1)
        dense_3 = self.dense_layer_3(dense_1)
        dense_output = self.output_layer(dense_3)

        #print('dense output shape : ',dense_output.shape)

        return dense_output

    def get_config(self):
        return {'lstm_units'   : self.lstm_units    ,
                'output_class_cnt'     : self.output_class_cnt ,
                'batch_size'    : self.batch_size
                }

    @classmethod
    def from_config(cls, config):
        return cls(**config)
```

In [ ]:

```
'''
 X_train  shape : (4980, 7)
 X_test shape : (879, 7)
 y_train shape : (4980,)
 y_test  shape : (879,)
'''
```

In [ ]:

```
labels
```

Out[ ]:

```
['backyard', 'kitchen', 'frontyard', 'bedroom', 'livingRoom', 'bathroom']
```

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range=15, width_shift_range=0.2,rescale=
                                                            height_shift_range=0.2, horizontal_flip=True)

ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size=
                                                     class_mode = 'categorical', color_mode = 'grayscale' )
```

```
test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_s
                                                         class_mode = 'categorical', color_mode = 'grayscale')
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
```

Fitting model1:

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range=5, width_shift_range=0.1,rescale=1
                                                            height_shift_range=0.1, horizontal_flip=True)

ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size=
                                                     class_mode = 'categorical', color_mode = 'grayscale' )


test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_s
                                                         class_mode = 'categorical', color_mode = 'grayscale')
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
```

In [ ]:

```
lstm_units        = 64
output_class_cnt  = len(labels)
batch_size        = 10

model = main_framwork(lstm_units,output_class_cnt,batch_size)

optimizer = tf.keras.optimizers.Adam(learning_rate=0.0001)
loss_func= tf.keras.losses.CategoricalCrossentropy()#tf.keras.losses.SparseCategoricalCrossentropy()

model.compile(optimizer=optimizer,loss=loss_func,metrics=['accuracy'])

train_steps   =     4980//batch_size
valid_steps   =     879//batch_size

NAME = "model_1"
tensorboard = tf.keras.callbacks.TensorBoard(log_dir="logs/{}".format(NAME),histogram_freq=1,write_images=True

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboard
```

```
Epoch 1/100
498/498 [==============================] - 35s 59ms/step - loss: 1.6327 - accuracy: 0.3382 - val_loss: 1.5417
- val_accuracy: 0.3713
Epoch 2/100
498/498 [==============================] - 21s 42ms/step - loss: 1.5218 - accuracy: 0.3886 - val_loss: 1.4910
- val_accuracy: 0.3966
Epoch 3/100
498/498 [==============================] - 20s 40ms/step - loss: 1.4801 - accuracy: 0.3986 - val_loss: 1.4645
- val_accuracy: 0.3989
Epoch 4/100
498/498 [==============================] - 20s 40ms/step - loss: 1.4365 - accuracy: 0.4169 - val_loss: 1.4043
- val_accuracy: 0.4322
Epoch 5/100
498/498 [==============================] - 22s 43ms/step - loss: 1.4161 - accuracy: 0.4323 - val_loss: 1.3832
- val_accuracy: 0.4402
Epoch 6/100
498/498 [==============================] - 20s 41ms/step - loss: 1.3859 - accuracy: 0.4506 - val_loss: 1.3725
- val_accuracy: 0.4747
Epoch 7/100
498/498 [==============================] - 20s 41ms/step - loss: 1.3557 - accuracy: 0.4528 - val_loss: 1.3376
- val_accuracy: 0.4805
Epoch 8/100
498/498 [==============================] - 21s 42ms/step - loss: 1.3332 - accuracy: 0.4620 - val_loss: 1.3381
- val_accuracy: 0.4586
Epoch 9/100
498/498 [==============================] - 23s 46ms/step - loss: 1.3142 - accuracy: 0.4703 - val_loss: 1.2841
- val_accuracy: 0.5046
Epoch 10/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3184 - accuracy: 0.4685 - val_loss: 1.2707
```

```
498/498 [==============================] - 21s 43ms/step - loss: 1.3184 - accuracy: 0.4685 - val_loss: 1.2707
- val_accuracy: 0.5149
Epoch 11/100
498/498 [==============================] - 20s 41ms/step - loss: 1.2899 - accuracy: 0.4902 - val_loss: 1.2681
- val_accuracy: 0.5345
Epoch 12/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2824 - accuracy: 0.4910 - val_loss: 1.2363
- val_accuracy: 0.5333
Epoch 13/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2566 - accuracy: 0.5036 - val_loss: 1.2588
- val_accuracy: 0.5253
Epoch 14/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2524 - accuracy: 0.4998 - val_loss: 1.2468
- val_accuracy: 0.5437
Epoch 15/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2371 - accuracy: 0.5050 - val_loss: 1.2031
- val_accuracy: 0.5345
Epoch 16/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2282 - accuracy: 0.5137 - val_loss: 1.2158
- val_accuracy: 0.5356
Epoch 17/100
498/498 [==============================] - 20s 40ms/step - loss: 1.2161 - accuracy: 0.5239 - val_loss: 1.2120
- val_accuracy: 0.5345
Epoch 18/100
498/498 [==============================] - 20s 41ms/step - loss: 1.2098 - accuracy: 0.5173 - val_loss: 1.1754
- val_accuracy: 0.5575
Epoch 19/100
498/498 [==============================] - 20s 41ms/step - loss: 1.1872 - accuracy: 0.5317 - val_loss: 1.1962
- val_accuracy: 0.5437
Epoch 20/100
498/498 [==============================] - 20s 40ms/step - loss: 1.1866 - accuracy: 0.5343 - val_loss: 1.1652
- val_accuracy: 0.5690
Epoch 21/100
498/498 [==============================] - 21s 42ms/step - loss: 1.1655 - accuracy: 0.5323 - val_loss: 1.1365
- val_accuracy: 0.5759
Epoch 22/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1592 - accuracy: 0.5442 - val_loss: 1.1537
- val_accuracy: 0.5621
Epoch 23/100
498/498 [==============================] - 20s 41ms/step - loss: 1.1747 - accuracy: 0.5373 - val_loss: 1.1456
- val_accuracy: 0.5690
Epoch 24/100
498/498 [==============================] - 20s 41ms/step - loss: 1.1349 - accuracy: 0.5470 - val_loss: 1.1134
- val_accuracy: 0.5724
Epoch 25/100
498/498 [==============================] - 20s 41ms/step - loss: 1.1203 - accuracy: 0.5538 - val_loss: 1.0791
- val_accuracy: 0.5782
Epoch 26/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1240 - accuracy: 0.5492 - val_loss: 1.0929
- val_accuracy: 0.5931
Epoch 27/100
498/498 [==============================] - 21s 42ms/step - loss: 1.1170 - accuracy: 0.5594 - val_loss: 1.0919
- val_accuracy: 0.5839
Epoch 28/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1128 - accuracy: 0.5610 - val_loss: 1.0702
- val_accuracy: 0.6046
Epoch 29/100
498/498 [==============================] - 21s 41ms/step - loss: 1.0990 - accuracy: 0.5667 - val_loss: 1.0937
- val_accuracy: 0.5897
Epoch 30/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1069 - accuracy: 0.5618 - val_loss: 1.0760
- val_accuracy: 0.6069
Epoch 31/100
498/498 [==============================] - 21s 43ms/step - loss: 1.0939 - accuracy: 0.5675 - val_loss: 1.0290
- val_accuracy: 0.6172
Epoch 32/100
498/498 [==============================] - 21s 43ms/step - loss: 1.0778 - accuracy: 0.5737 - val_loss: 1.0237
- val_accuracy: 0.5989
Epoch 33/100
498/498 [==============================] - 20s 41ms/step - loss: 1.0622 - accuracy: 0.5827 - val_loss: 1.0184
- val_accuracy: 0.6149
Epoch 34/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0739 - accuracy: 0.5811 - val_loss: 1.0385
- val_accuracy: 0.6299
Epoch 35/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0629 - accuracy: 0.5759 - val_loss: 1.0419
- val_accuracy: 0.6023
Epoch 36/100
Epoch 36/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0514 - accuracy: 0.5910 - val_loss: 1.0666
- val_accuracy: 0.5920
Epoch 37/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0571 - accuracy: 0.5831 - val_loss: 0.9992
- val_accuracy: 0.6287
Epoch 38/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0446 - accuracy: 0.5876 - val_loss: 1.0189
- val_accuracy: 0.6172
Epoch 39/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0530 - accuracy: 0.5867 - val_loss: 1.0066
- val_accuracy: 0.6264
Epoch 40/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0353 - accuracy: 0.5908 - val_loss: 0.9897
- val_accuracy: 0.6241
Epoch 41/100
498/498 [==============================] - 21s 43ms/step - loss: 1.0358 - accuracy: 0.5936 - val_loss: 0.9907
- val_accuracy: 0.6241
Epoch 42/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0185 - accuracy: 0.6030 - val_loss: 1.0362
- val_accuracy: 0.5943
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 1.0125 - accuracy: 0.5940 - val_loss: 0.9786
- val_accuracy: 0.6276
Epoch 44/100
498/498 [==============================] - 21s 43ms/step - loss: 1.0148 - accuracy: 0.5980 - val_loss: 0.9834
- val_accuracy: 0.6287
Epoch 45/100
498/498 [==============================] - 21s 42ms/step - loss: 1.0108 - accuracy: 0.6004 - val_loss: 0.9698
- val_accuracy: 0.6184
Epoch 46/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9910 - accuracy: 0.6161 - val_loss: 0.9657
- val_accuracy: 0.6356
Epoch 47/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9946 - accuracy: 0.6020 - val_loss: 0.9357
- val_accuracy: 0.6552
Epoch 48/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9825 - accuracy: 0.6131 - val_loss: 0.9348
- val_accuracy: 0.6563
Epoch 49/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9749 - accuracy: 0.6163 - val_loss: 0.9463
- val_accuracy: 0.6368
Epoch 50/100
498/498 [==============================] - 21s 41ms/step - loss: 0.9724 - accuracy: 0.6137 - val_loss: 0.9412
- val_accuracy: 0.6621
Epoch 51/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9723 - accuracy: 0.6199 - val_loss: 0.9363
- val_accuracy: 0.6506
Epoch 52/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9649 - accuracy: 0.6231 - val_loss: 0.9659
- val_accuracy: 0.6345
Epoch 53/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9702 - accuracy: 0.6205 - val_loss: 0.9766
- val_accuracy: 0.6299
Epoch 54/100
498/498 [==============================] - 20s 41ms/step - loss: 0.9602 - accuracy: 0.6239 - val_loss: 0.9565
- val_accuracy: 0.6437
Epoch 55/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9614 - accuracy: 0.6239 - val_loss: 0.9846
- val_accuracy: 0.6310
Epoch 56/100
498/498 [==============================] - 20s 41ms/step - loss: 0.9562 - accuracy: 0.6245 - val_loss: 0.9803
- val_accuracy: 0.6310
Epoch 57/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9409 - accuracy: 0.6263 - val_loss: 0.9684
- val_accuracy: 0.6402
Epoch 58/100
498/498 [==============================] - 21s 41ms/step - loss: 0.9441 - accuracy: 0.6277 - val_loss: 0.9151
- val_accuracy: 0.6621
Epoch 59/100
498/498 [==============================] - 21s 41ms/step - loss: 0.9583 - accuracy: 0.6195 - val_loss: 0.9302
- val_accuracy: 0.6609
Epoch 60/100
498/498 [==============================] - 22s 45ms/step - loss: 0.9291 - accuracy: 0.6436 - val_loss: 0.9491
- val_accuracy: 0.6483
Epoch 61/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9303 - accuracy: 0.6367 - val_loss: 0.9865
- val_accuracy: 0.6264
- val_accuracy: 0.6264
Epoch 62/100
498/498 [==============================] - 22s 45ms/step - loss: 0.9197 - accuracy: 0.6378 - val_loss: 0.9316
- val_accuracy: 0.6529
Epoch 63/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9296 - accuracy: 0.6307 - val_loss: 0.9151
- val_accuracy: 0.6644
Epoch 64/100
498/498 [==============================] - 22s 45ms/step - loss: 0.9265 - accuracy: 0.6414 - val_loss: 0.9003
- val_accuracy: 0.6644
Epoch 65/100
498/498 [==============================] - 20s 41ms/step - loss: 0.9082 - accuracy: 0.6434 - val_loss: 0.9265
- val_accuracy: 0.6529
Epoch 66/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9028 - accuracy: 0.6394 - val_loss: 0.9102
- val_accuracy: 0.6437
Epoch 67/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9067 - accuracy: 0.6464 - val_loss: 0.9158
- val_accuracy: 0.6529
Epoch 68/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9023 - accuracy: 0.6528 - val_loss: 0.9182
- val_accuracy: 0.6540
Epoch 69/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9011 - accuracy: 0.6530 - val_loss: 0.9869
- val_accuracy: 0.6103
Epoch 70/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8917 - accuracy: 0.6448 - val_loss: 0.9052
- val_accuracy: 0.6632
Epoch 71/100
498/498 [==============================] - 25s 51ms/step - loss: 0.8959 - accuracy: 0.6514 - val_loss: 0.9209
- val_accuracy: 0.6621
Epoch 72/100
498/498 [==============================] - 32s 65ms/step - loss: 0.9081 - accuracy: 0.6510 - val_loss: 0.8990
- val_accuracy: 0.6540
Epoch 73/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8915 - accuracy: 0.6526 - val_loss: 0.9063
- val_accuracy: 0.6644
Epoch 74/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8801 - accuracy: 0.6550 - val_loss: 0.9161
- val_accuracy: 0.6621
Epoch 75/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8712 - accuracy: 0.6556 - val_loss: 0.8892
- val_accuracy: 0.6701
Epoch 76/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8747 - accuracy: 0.6572 - val_loss: 0.8943
- val_accuracy: 0.6598
Epoch 77/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8722 - accuracy: 0.6564 - val_loss: 0.8902
- val_accuracy: 0.6632
Epoch 78/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8574 - accuracy: 0.6608 - val_loss: 0.9260
- val_accuracy: 0.6609
Epoch 79/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8658 - accuracy: 0.6598 - val_loss: 0.9203
- val_accuracy: 0.6552
Epoch 80/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8516 - accuracy: 0.6665 - val_loss: 0.8870
- val_accuracy: 0.6678
Epoch 81/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8534 - accuracy: 0.6689 - val_loss: 0.8884
- val_accuracy: 0.6517
Epoch 82/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8588 - accuracy: 0.6610 - val_loss: 0.8974
- val_accuracy: 0.6598
Epoch 83/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8562 - accuracy: 0.6633 - val_loss: 0.8716
- val_accuracy: 0.6759
Epoch 84/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8543 - accuracy: 0.6618 - val_loss: 0.8559
- val_accuracy: 0.6782
Epoch 85/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8543 - accuracy: 0.6715 - val_loss: 0.9034
- val_accuracy: 0.6678
Epoch 86/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8372 - accuracy: 0.6765 - val_loss: 0.9824
- val_accuracy: 0.6529
Epoch 87/100
```

```
498/498 [==============================] - 21s 42ms/step - loss: 0.8403 - accuracy: 0.6743 - val_loss: 0.8955
- val_accuracy: 0.6621
Epoch 88/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8374 - accuracy: 0.6801 - val_loss: 0.8650
- val_accuracy: 0.6678
Epoch 89/100
498/498 [==============================] - 20s 40ms/step - loss: 0.8404 - accuracy: 0.6649 - val_loss: 0.8995
- val_accuracy: 0.6552
Epoch 90/100
498/498 [==============================] - 22s 45ms/step - loss: 0.8370 - accuracy: 0.6719 - val_loss: 0.9002
- val_accuracy: 0.6770
Epoch 91/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8288 - accuracy: 0.6793 - val_loss: 0.8991
- val_accuracy: 0.6598
Epoch 92/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8282 - accuracy: 0.6801 - val_loss: 0.8676
- val_accuracy: 0.6770
Epoch 93/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8248 - accuracy: 0.6801 - val_loss: 0.9297
- val_accuracy: 0.6632
Epoch 94/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8311 - accuracy: 0.6811 - val_loss: 0.8506
- val_accuracy: 0.6874
Epoch 95/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8105 - accuracy: 0.6819 - val_loss: 0.8627
- val_accuracy: 0.6759
Epoch 96/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8337 - accuracy: 0.6701 - val_loss: 0.8727
- val_accuracy: 0.6759
Epoch 97/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8130 - accuracy: 0.6803 - val_loss: 0.8551
- val_accuracy: 0.6839
Epoch 98/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8151 - accuracy: 0.6825 - val_loss: 0.8863
- val_accuracy: 0.6701
Epoch 99/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8109 - accuracy: 0.6833 - val_loss: 0.8456
- val_accuracy: 0.6862
Epoch 100/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8121 - accuracy: 0.6855 - val_loss: 0.8787
- val_accuracy: 0.6667
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd95a9dc8d0>
```

In [ ]:

```
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Epoch 1/100
498/498 [==============================] - 22s 45ms/step - loss: 0.8004 - accuracy: 0.6819 - val_loss: 0.8913
- val_accuracy: 0.6770
Epoch 2/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8104 - accuracy: 0.6837 - val_loss: 0.8554
- val_accuracy: 0.6908
Epoch 3/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8241 - accuracy: 0.6755 - val_loss: 0.8856
- val_accuracy: 0.6632
Epoch 4/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8087 - accuracy: 0.6825 - val_loss: 0.8631
- val_accuracy: 0.6701
Epoch 5/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7961 - accuracy: 0.6811 - val_loss: 0.8685
- val_accuracy: 0.6805
Epoch 6/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7946 - accuracy: 0.6865 - val_loss: 0.9083
- val_accuracy: 0.6563
Epoch 7/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7951 - accuracy: 0.6873 - val_loss: 0.8566
- val_accuracy: 0.6839
Epoch 8/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7884 - accuracy: 0.6867 - val_loss: 0.9197
- val_accuracy: 0.6805
Epoch 9/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7984 - accuracy: 0.6863 - val_loss: 0.8628
- val_accuracy: 0.6678
Epoch 10/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7895 - accuracy: 0.6936 - val_loss: 0.8519
- val_accuracy: 0.6839
```

```
Epoch 11/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7918 - accuracy: 0.6861 - val_loss: 0.8430
- val_accuracy: 0.6839
Epoch 12/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7847 - accuracy: 0.6928 - val_loss: 0.8765
- val_accuracy: 0.6793
Epoch 13/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7698 - accuracy: 0.6930 - val_loss: 0.8636
- val_accuracy: 0.6828
Epoch 14/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7635 - accuracy: 0.7014 - val_loss: 0.8604
- val_accuracy: 0.6782
Epoch 15/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7707 - accuracy: 0.7018 - val_loss: 0.8531
- val_accuracy: 0.6736
Epoch 16/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7717 - accuracy: 0.6970 - val_loss: 0.9053
- val_accuracy: 0.6644
Epoch 17/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7586 - accuracy: 0.7036 - val_loss: 0.9171
- val_accuracy: 0.6690
Epoch 18/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7697 - accuracy: 0.6928 - val_loss: 0.8746
- val_accuracy: 0.6724
Epoch 19/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7757 - accuracy: 0.6934 - val_loss: 0.8280
- val_accuracy: 0.6805
Epoch 20/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7698 - accuracy: 0.6984 - val_loss: 0.8224
- val_accuracy: 0.6862
Epoch 21/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7596 - accuracy: 0.7050 - val_loss: 0.8312
- val_accuracy: 0.6874
Epoch 22/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7554 - accuracy: 0.7008 - val_loss: 0.8484
- val_accuracy: 0.6862
Epoch 23/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7699 - accuracy: 0.6954 - val_loss: 0.8319
- val_accuracy: 0.6805
Epoch 24/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7613 - accuracy: 0.7020 - val_loss: 0.8258
- val_accuracy: 0.6828
Epoch 25/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7546 - accuracy: 0.7030 - val_loss: 0.8585
- val_accuracy: 0.6805
Epoch 26/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7512 - accuracy: 0.7028 - val_loss: 0.8386
- val_accuracy: 0.6828
Epoch 27/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7602 - accuracy: 0.7028 - val_loss: 0.8360
- val_accuracy: 0.6943
Epoch 28/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7598 - accuracy: 0.7054 - val_loss: 0.8118
- val_accuracy: 0.6943
Epoch 29/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7477 - accuracy: 0.7082 - val_loss: 0.8664
- val_accuracy: 0.6770
Epoch 30/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7372 - accuracy: 0.7169 - val_loss: 0.8367
- val_accuracy: 0.6897
Epoch 31/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7410 - accuracy: 0.7066 - val_loss: 0.8389
- val_accuracy: 0.6920
Epoch 32/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7486 - accuracy: 0.7096 - val_loss: 0.8881
- val_accuracy: 0.6632
Epoch 33/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7311 - accuracy: 0.7074 - val_loss: 0.8434
- val_accuracy: 0.6920
Epoch 34/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7467 - accuracy: 0.7036 - val_loss: 0.8734
- val_accuracy: 0.6793
Epoch 35/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7324 - accuracy: 0.7080 - val_loss: 0.8293
- val_accuracy: 0.6828
Epoch 36/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7223 - accuracy: 0.7118 - val_loss: 0.8358
```

```
- val_accuracy: 0.6908
Epoch 37/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7329 - accuracy: 0.7127 - val_loss: 0.8113
- val_accuracy: 0.6954
Epoch 38/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7424 - accuracy: 0.7074 - val_loss: 0.8751
- val_accuracy: 0.6690
Epoch 39/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7328 - accuracy: 0.7141 - val_loss: 0.8369
- val_accuracy: 0.6805
Epoch 40/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7291 - accuracy: 0.7118 - val_loss: 0.8851
- val_accuracy: 0.6632
Epoch 41/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7302 - accuracy: 0.7145 - val_loss: 0.8806
- val_accuracy: 0.6644
Epoch 42/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7250 - accuracy: 0.7153 - val_loss: 0.8573
- val_accuracy: 0.6770
Epoch 43/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7124 - accuracy: 0.7221 - val_loss: 0.8736
- val_accuracy: 0.6851
Epoch 44/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7071 - accuracy: 0.7247 - val_loss: 0.8692
- val_accuracy: 0.6736
Epoch 45/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7343 - accuracy: 0.7127 - val_loss: 0.8469
- val_accuracy: 0.6885
Epoch 46/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7042 - accuracy: 0.7279 - val_loss: 0.8686
- val_accuracy: 0.6851
Epoch 47/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7103 - accuracy: 0.7231 - val_loss: 0.8615
- val_accuracy: 0.6747
Epoch 48/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7041 - accuracy: 0.7255 - val_loss: 0.8462
- val_accuracy: 0.6759
Epoch 49/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7079 - accuracy: 0.7247 - val_loss: 0.8405
- val_accuracy: 0.6851
Epoch 50/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6997 - accuracy: 0.7263 - val_loss: 0.9028
- val_accuracy: 0.6759
Epoch 51/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6959 - accuracy: 0.7281 - val_loss: 0.8461
- val_accuracy: 0.6908
Epoch 52/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6960 - accuracy: 0.7299 - val_loss: 0.8799
- val_accuracy: 0.6839
Epoch 53/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6956 - accuracy: 0.7341 - val_loss: 0.8176
- val_accuracy: 0.6931
Epoch 54/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6905 - accuracy: 0.7291 - val_loss: 0.8392
- val_accuracy: 0.6920
Epoch 55/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6948 - accuracy: 0.7261 - val_loss: 0.8334
- val_accuracy: 0.7057
Epoch 56/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6877 - accuracy: 0.7331 - val_loss: 0.8772
- val_accuracy: 0.6816
Epoch 57/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7049 - accuracy: 0.7223 - val_loss: 0.8534
- val_accuracy: 0.6874
Epoch 58/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6867 - accuracy: 0.7382 - val_loss: 0.8404
- val_accuracy: 0.6943
Epoch 59/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7017 - accuracy: 0.7307 - val_loss: 0.8583
- val_accuracy: 0.6782
Epoch 60/100
498/498 [==============================] - 23s 45ms/step - loss: 0.6790 - accuracy: 0.7339 - val_loss: 0.8643
- val_accuracy: 0.6805
Epoch 61/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6981 - accuracy: 0.7257 - val_loss: 0.8472
- val_accuracy: 0.6908
Epoch 62/100
```

```
498/498 [==============================] - 21s 42ms/step - loss: 0.6798 - accuracy: 0.7343 - val_loss: 0.8515
- val_accuracy: 0.6851
Epoch 63/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6867 - accuracy: 0.7271 - val_loss: 0.8262
- val_accuracy: 0.6851
Epoch 64/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6894 - accuracy: 0.7329 - val_loss: 0.8853
- val_accuracy: 0.6805
Epoch 65/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6797 - accuracy: 0.7337 - val_loss: 0.8629
- val_accuracy: 0.6816
Epoch 66/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6741 - accuracy: 0.7404 - val_loss: 0.8451
- val_accuracy: 0.6931
Epoch 67/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6720 - accuracy: 0.7406 - val_loss: 0.8748
- val_accuracy: 0.6816
Epoch 68/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6641 - accuracy: 0.7466 - val_loss: 0.8079
- val_accuracy: 0.6989
Epoch 69/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6710 - accuracy: 0.7380 - val_loss: 0.8675
- val_accuracy: 0.6862
Epoch 70/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6742 - accuracy: 0.7408 - val_loss: 0.8588
- val_accuracy: 0.6874
Epoch 71/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6696 - accuracy: 0.7440 - val_loss: 0.9022
- val_accuracy: 0.6713
Epoch 72/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6474 - accuracy: 0.7482 - val_loss: 0.8889
- val_accuracy: 0.6759
Epoch 73/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6595 - accuracy: 0.7396 - val_loss: 0.8485
- val_accuracy: 0.6966
Epoch 74/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6622 - accuracy: 0.7406 - val_loss: 0.8590
- val_accuracy: 0.6828
Epoch 75/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6751 - accuracy: 0.7335 - val_loss: 0.8334
- val_accuracy: 0.6874
Epoch 76/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6663 - accuracy: 0.7442 - val_loss: 0.8424
- val_accuracy: 0.6954
Epoch 77/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6563 - accuracy: 0.7494 - val_loss: 0.8590
- val_accuracy: 0.6770
Epoch 78/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6539 - accuracy: 0.7434 - val_loss: 0.8224
- val_accuracy: 0.6931
Epoch 79/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6714 - accuracy: 0.7394 - val_loss: 0.8354
- val_accuracy: 0.6770
Epoch 80/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6510 - accuracy: 0.7454 - val_loss: 0.8618
- val_accuracy: 0.6736
Epoch 81/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6631 - accuracy: 0.7412 - val_loss: 0.8262
- val_accuracy: 0.6943
Epoch 82/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6573 - accuracy: 0.7394 - val_loss: 0.8490
- val_accuracy: 0.6747
Epoch 83/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6421 - accuracy: 0.7494 - val_loss: 0.8482
- val_accuracy: 0.6954
Epoch 84/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6414 - accuracy: 0.7512 - val_loss: 0.8199
- val_accuracy: 0.6977
Epoch 85/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6299 - accuracy: 0.7586 - val_loss: 0.9014
- val_accuracy: 0.6782
Epoch 86/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6441 - accuracy: 0.7532 - val_loss: 0.8685
- val_accuracy: 0.6954
Epoch 87/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6495 - accuracy: 0.7472 - val_loss: 0.8601
- val accuracy: 0.6966
```

```
Epoch 88/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6505 - accuracy: 0.7422 - val_loss: 0.8273
- val_accuracy: 0.6977
Epoch 89/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6489 - accuracy: 0.7544 - val_loss: 0.8467
- val_accuracy: 0.6805
Epoch 90/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6401 - accuracy: 0.7562 - val_loss: 0.8231
- val_accuracy: 0.7000
Epoch 91/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6386 - accuracy: 0.7570 - val_loss: 0.8380
- val_accuracy: 0.6966
Epoch 92/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6381 - accuracy: 0.7540 - val_loss: 0.8557
- val_accuracy: 0.6885
Epoch 93/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6336 - accuracy: 0.7490 - val_loss: 0.8736
- val_accuracy: 0.6828
Epoch 94/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6331 - accuracy: 0.7504 - val_loss: 0.8615
- val_accuracy: 0.6897
Epoch 95/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6262 - accuracy: 0.7606 - val_loss: 0.8568
- val_accuracy: 0.6770
Epoch 96/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6345 - accuracy: 0.7494 - val_loss: 0.8623
- val_accuracy: 0.6828
Epoch 97/100
498/498 [==============================] - 20s 40ms/step - loss: 0.6329 - accuracy: 0.7540 - val_loss: 0.8834
- val_accuracy: 0.6908
Epoch 98/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6273 - accuracy: 0.7550 - val_loss: 0.8776
- val_accuracy: 0.6885
Epoch 99/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6201 - accuracy: 0.7622 - val_loss: 0.8793
- val_accuracy: 0.6885
Epoch 100/100
498/498 [==============================] - 20s 40ms/step - loss: 0.6140 - accuracy: 0.7588 - val_loss: 0.8574
- val_accuracy: 0.7011
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd9b640cad0>
```

Obsevation of model1:

- Stopped Training as model tend to overfit.
- Details:

  epoch : 200

  Train accuracy: 74.54%

  Test accuracy : 70.11%

Fitting model2:

- Sine the above model is overfitting, In this model I have done change in Data Augmentation elements (ImageDataGenerator(rotation_range =20, width_shift_range=0.2,rescale=1./255 , height_shift_range=0.2 , horizontal_flip=True))

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range =20, width_shift_range=0.2,rescale
                                                             height_shift_range=0.2, horizontal_flip=True)

ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size
                                                      class_mode = 'categorical', color_mode = 'grayscale' )


test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_s
                                                          class_mode = 'categorical', color_mode = 'grayscale',
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
```

In [ ]:

```
lstm_units        = 64
output_class_cnt  = len(labels)
batch_size        = 10

model = main_framwork(lstm_units,output_class_cnt,batch_size)

optimizer = tf.keras.optimizers.Adam(learning_rate=0.0001)
loss_func= tf.keras.losses.CategoricalCrossentropy()#tf.keras.losses.SparseCategoricalCrossentropy()


model.compile(optimizer=optimizer,loss=loss_func,metrics=['accuracy'])

train_steps   =     4980//batch_size
valid_steps   =     879//batch_size

NAME = "model_1"
tensorboard = tf.keras.callbacks.TensorBoard(log_dir="logs/{}".format(NAME),histogram_freq=1,write_images=Tru




model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
Epoch 1/100
498/498 [==============================] - 25s 44ms/step - loss: 1.7281 - accuracy: 0.2791 - val_loss: 1.6734
- val_accuracy: 0.3057
Epoch 2/100
498/498 [==============================] - 22s 44ms/step - loss: 1.6586 - accuracy: 0.3191 - val_loss: 1.6075
- val_accuracy: 0.3345
Epoch 3/100
498/498 [==============================] - 21s 41ms/step - loss: 1.6301 - accuracy: 0.3323 - val_loss: 1.5803
- val_accuracy: 0.3460
Epoch 4/100
498/498 [==============================] - 21s 43ms/step - loss: 1.6110 - accuracy: 0.3406 - val_loss: 1.5673
- val_accuracy: 0.3437
Epoch 5/100
498/498 [==============================] - 22s 44ms/step - loss: 1.5800 - accuracy: 0.3568 - val_loss: 1.5139
- val_accuracy: 0.3736
Epoch 6/100
498/498 [==============================] - 26s 53ms/step - loss: 1.5678 - accuracy: 0.3566 - val_loss: 1.5207
- val_accuracy: 0.3598
Epoch 7/100
498/498 [==============================] - 21s 43ms/step - loss: 1.5412 - accuracy: 0.3685 - val_loss: 1.4905
- val_accuracy: 0.3770
Epoch 8/100
498/498 [==============================] - 24s 48ms/step - loss: 1.5245 - accuracy: 0.3719 - val_loss: 1.4731
- val_accuracy: 0.4184
Epoch 9/100
498/498 [==============================] - 21s 41ms/step - loss: 1.5244 - accuracy: 0.3765 - val_loss: 1.4290
- val_accuracy: 0.4207
Epoch 10/100
498/498 [==============================] - 21s 43ms/step - loss: 1.5130 - accuracy: 0.3924 - val_loss: 1.4165
- val_accuracy: 0.4184
Epoch 11/100
498/498 [==============================] - 21s 42ms/step - loss: 1.5022 - accuracy: 0.3910 - val_loss: 1.4189
- val_accuracy: 0.4264
Epoch 12/100
498/498 [==============================] - 23s 46ms/step - loss: 1.4684 - accuracy: 0.4094 - val_loss: 1.4031
- val_accuracy: 0.4368
Epoch 13/100
498/498 [==============================] - 21s 41ms/step - loss: 1.4924 - accuracy: 0.3910 - val_loss: 1.3620
- val_accuracy: 0.4529
Epoch 14/100
498/498 [==============================] - 21s 43ms/step - loss: 1.4767 - accuracy: 0.3968 - val_loss: 1.3729
- val_accuracy: 0.4448
Epoch 15/100
498/498 [==============================] - 22s 44ms/step - loss: 1.4563 - accuracy: 0.4036 - val_loss: 1.3776
- val_accuracy: 0.4345
Epoch 16/100
498/498 [==============================] - 21s 43ms/step - loss: 1.4454 - accuracy: 0.4114 - val_loss: 1.3865
- val_accuracy: 0.4644
Epoch 17/100
```

```
498/498 [==============================] - 21s 43ms/step - loss: 1.4395 - accuracy: 0.4143 - val_loss: 1.3314
- val_accuracy: 0.4713
Epoch 18/100
498/498 [==============================] - 23s 45ms/step - loss: 1.4293 - accuracy: 0.4229 - val_loss: 1.3339
- val_accuracy: 0.4598
Epoch 19/100
498/498 [==============================] - 21s 43ms/step - loss: 1.4339 - accuracy: 0.4108 - val_loss: 1.3355
- val_accuracy: 0.4747
Epoch 20/100
498/498 [==============================] - 21s 43ms/step - loss: 1.4203 - accuracy: 0.4255 - val_loss: 1.4061
- val_accuracy: 0.4437
Epoch 21/100
498/498 [==============================] - 23s 46ms/step - loss: 1.4085 - accuracy: 0.4297 - val_loss: 1.2875
- val_accuracy: 0.4770
Epoch 22/100
498/498 [==============================] - 20s 41ms/step - loss: 1.4094 - accuracy: 0.4281 - val_loss: 1.3092
- val_accuracy: 0.4793
Epoch 23/100
498/498 [==============================] - 21s 43ms/step - loss: 1.4008 - accuracy: 0.4285 - val_loss: 1.3068
- val_accuracy: 0.4851
Epoch 24/100
498/498 [==============================] - 22s 44ms/step - loss: 1.4075 - accuracy: 0.4339 - val_loss: 1.3035
- val_accuracy: 0.4828
Epoch 25/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3843 - accuracy: 0.4432 - val_loss: 1.2853
- val_accuracy: 0.5000
Epoch 26/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3855 - accuracy: 0.4396 - val_loss: 1.2763
- val_accuracy: 0.4874
Epoch 27/100
498/498 [==============================] - 21s 41ms/step - loss: 1.3836 - accuracy: 0.4365 - val_loss: 1.3201
- val_accuracy: 0.4517
Epoch 28/100
498/498 [==============================] - 23s 46ms/step - loss: 1.3761 - accuracy: 0.4396 - val_loss: 1.2660
- val_accuracy: 0.4885
Epoch 29/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3740 - accuracy: 0.4466 - val_loss: 1.2900
- val_accuracy: 0.4759
Epoch 30/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3692 - accuracy: 0.4454 - val_loss: 1.2536
- val_accuracy: 0.4793
Epoch 31/100
498/498 [==============================] - 22s 44ms/step - loss: 1.3758 - accuracy: 0.4490 - val_loss: 1.2304
- val_accuracy: 0.5115
Epoch 32/100
498/498 [==============================] - 20s 41ms/step - loss: 1.3695 - accuracy: 0.4510 - val_loss: 1.2290
- val_accuracy: 0.4989
Epoch 33/100
498/498 [==============================] - 21s 42ms/step - loss: 1.3543 - accuracy: 0.4556 - val_loss: 1.2586
- val_accuracy: 0.4989
Epoch 34/100
498/498 [==============================] - 23s 46ms/step - loss: 1.3441 - accuracy: 0.4564 - val_loss: 1.2764
- val_accuracy: 0.5000
Epoch 35/100
498/498 [==============================] - 21s 41ms/step - loss: 1.3320 - accuracy: 0.4685 - val_loss: 1.2411
- val_accuracy: 0.4989
Epoch 36/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3395 - accuracy: 0.4554 - val_loss: 1.2130
- val_accuracy: 0.5276
Epoch 37/100
498/498 [==============================] - 22s 45ms/step - loss: 1.3321 - accuracy: 0.4592 - val_loss: 1.2519
- val_accuracy: 0.4851
Epoch 38/100
498/498 [==============================] - 20s 41ms/step - loss: 1.3050 - accuracy: 0.4763 - val_loss: 1.2371
- val_accuracy: 0.4977
Epoch 39/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3155 - accuracy: 0.4606 - val_loss: 1.1955
- val_accuracy: 0.5253
Epoch 40/100
498/498 [==============================] - 20s 41ms/step - loss: 1.3192 - accuracy: 0.4552 - val_loss: 1.2294
- val_accuracy: 0.4943
Epoch 41/100
498/498 [==============================] - 23s 46ms/step - loss: 1.3042 - accuracy: 0.4671 - val_loss: 1.2301
- val_accuracy: 0.5000
Epoch 42/100
498/498 [==============================] - 21s 43ms/step - loss: 1.3011 - accuracy: 0.4771 - val_loss: 1.2082
- val_accuracy: 0.5253
```

```
Epoch 43/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2960 - accuracy: 0.4767 - val_loss: 1.2288
- val_accuracy: 0.5023
Epoch 44/100
498/498 [==============================] - 23s 46ms/step - loss: 1.3088 - accuracy: 0.4763 - val_loss: 1.2109
- val_accuracy: 0.5172
Epoch 45/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2853 - accuracy: 0.4819 - val_loss: 1.1915
- val_accuracy: 0.5103
Epoch 46/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2758 - accuracy: 0.4813 - val_loss: 1.2828
- val_accuracy: 0.4920
Epoch 47/100
498/498 [==============================] - 22s 44ms/step - loss: 1.2895 - accuracy: 0.4783 - val_loss: 1.2289
- val_accuracy: 0.5207
Epoch 48/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2745 - accuracy: 0.4863 - val_loss: 1.1894
- val_accuracy: 0.5184
Epoch 49/100
498/498 [==============================] - 24s 48ms/step - loss: 1.2796 - accuracy: 0.4839 - val_loss: 1.2011
- val_accuracy: 0.5195
Epoch 50/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2677 - accuracy: 0.4910 - val_loss: 1.1862
- val_accuracy: 0.5276
Epoch 51/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2678 - accuracy: 0.4863 - val_loss: 1.1951
- val_accuracy: 0.5230
Epoch 52/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2829 - accuracy: 0.4841 - val_loss: 1.1718
- val_accuracy: 0.5333
Epoch 53/100
498/498 [==============================] - 23s 46ms/step - loss: 1.2607 - accuracy: 0.4960 - val_loss: 1.1436
- val_accuracy: 0.5494
Epoch 54/100
498/498 [==============================] - 21s 42ms/step - loss: 1.2650 - accuracy: 0.4922 - val_loss: 1.1725
- val_accuracy: 0.5126
Epoch 55/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2443 - accuracy: 0.5000 - val_loss: 1.1764
- val_accuracy: 0.5195
Epoch 56/100
498/498 [==============================] - 22s 44ms/step - loss: 1.2519 - accuracy: 0.4972 - val_loss: 1.1507
- val_accuracy: 0.5230
Epoch 57/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2499 - accuracy: 0.4888 - val_loss: 1.1452
- val_accuracy: 0.5402
Epoch 58/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2568 - accuracy: 0.5016 - val_loss: 1.1955
- val_accuracy: 0.5207
Epoch 59/100
498/498 [==============================] - 22s 44ms/step - loss: 1.2400 - accuracy: 0.5018 - val_loss: 1.1285
- val_accuracy: 0.5563
Epoch 60/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2340 - accuracy: 0.4972 - val_loss: 1.1226
- val_accuracy: 0.5586
Epoch 61/100
498/498 [==============================] - 20s 41ms/step - loss: 1.2506 - accuracy: 0.4942 - val_loss: 1.1674
- val_accuracy: 0.5356
Epoch 62/100
498/498 [==============================] - 20s 41ms/step - loss: 1.2202 - accuracy: 0.4994 - val_loss: 1.1122
- val_accuracy: 0.5575
Epoch 63/100
498/498 [==============================] - 22s 44ms/step - loss: 1.2317 - accuracy: 0.5062 - val_loss: 1.1085
- val_accuracy: 0.5552
Epoch 64/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2192 - accuracy: 0.4988 - val_loss: 1.1347
- val_accuracy: 0.5483
Epoch 65/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2241 - accuracy: 0.5086 - val_loss: 1.1292
- val_accuracy: 0.5506
Epoch 66/100
498/498 [==============================] - 23s 46ms/step - loss: 1.2081 - accuracy: 0.5129 - val_loss: 1.1962
- val_accuracy: 0.5195
Epoch 67/100
498/498 [==============================] - 20s 41ms/step - loss: 1.2075 - accuracy: 0.5135 - val_loss: 1.1435
- val_accuracy: 0.5402
Epoch 68/100
498/498 [==============================] - 21s 41ms/step - loss: 1.2119 - accuracy: 0.5139 - val_loss: 1.1296
```

```
- val_accuracy: 0.5345
Epoch 69/100
498/498 [==============================] - 22s 44ms/step - loss: 1.2119 - accuracy: 0.5165 - val_loss: 1.1134
- val_accuracy: 0.5506
Epoch 70/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1896 - accuracy: 0.5098 - val_loss: 1.1529
- val_accuracy: 0.5379
Epoch 71/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2008 - accuracy: 0.5143 - val_loss: 1.1776
- val_accuracy: 0.5218
Epoch 72/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1941 - accuracy: 0.5177 - val_loss: 1.1461
- val_accuracy: 0.5356
Epoch 73/100
498/498 [==============================] - 23s 46ms/step - loss: 1.2087 - accuracy: 0.5137 - val_loss: 1.0704
- val_accuracy: 0.5724
Epoch 74/100
498/498 [==============================] - 21s 43ms/step - loss: 1.2016 - accuracy: 0.5143 - val_loss: 1.1111
- val_accuracy: 0.5402
Epoch 75/100
498/498 [==============================] - 22s 44ms/step - loss: 1.1830 - accuracy: 0.5269 - val_loss: 1.0782
- val_accuracy: 0.5540
Epoch 76/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1828 - accuracy: 0.5261 - val_loss: 1.2556
- val_accuracy: 0.4874
Epoch 77/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1886 - accuracy: 0.5165 - val_loss: 1.1167
- val_accuracy: 0.5517
Epoch 78/100
498/498 [==============================] - 23s 46ms/step - loss: 1.1782 - accuracy: 0.5191 - val_loss: 1.0752
- val_accuracy: 0.5586
Epoch 79/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1827 - accuracy: 0.5167 - val_loss: 1.0720
- val_accuracy: 0.5793
Epoch 80/100
498/498 [==============================] - 24s 48ms/step - loss: 1.1806 - accuracy: 0.5201 - val_loss: 1.1162
- val_accuracy: 0.5506
Epoch 81/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1745 - accuracy: 0.5239 - val_loss: 1.0754
- val_accuracy: 0.5667
Epoch 82/100
498/498 [==============================] - 21s 42ms/step - loss: 1.1767 - accuracy: 0.5191 - val_loss: 1.0574
- val_accuracy: 0.5759
Epoch 83/100
498/498 [==============================] - 22s 44ms/step - loss: 1.1788 - accuracy: 0.5251 - val_loss: 1.0837
- val_accuracy: 0.5598
Epoch 84/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1644 - accuracy: 0.5335 - val_loss: 1.0530
- val_accuracy: 0.5724
Epoch 85/100
498/498 [==============================] - 22s 43ms/step - loss: 1.1656 - accuracy: 0.5271 - val_loss: 1.0800
- val_accuracy: 0.5552
Epoch 86/100
498/498 [==============================] - 22s 44ms/step - loss: 1.1726 - accuracy: 0.5265 - val_loss: 1.0508
- val_accuracy: 0.5828
Epoch 87/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1607 - accuracy: 0.5335 - val_loss: 1.0889
- val_accuracy: 0.5494
Epoch 88/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1532 - accuracy: 0.5311 - val_loss: 1.1686
- val_accuracy: 0.5391
Epoch 89/100
498/498 [==============================] - 22s 45ms/step - loss: 1.1645 - accuracy: 0.5231 - val_loss: 1.0485
- val_accuracy: 0.5839
Epoch 90/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1404 - accuracy: 0.5394 - val_loss: 1.0425
- val_accuracy: 0.5793
Epoch 91/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1379 - accuracy: 0.5484 - val_loss: 1.0333
- val_accuracy: 0.5770
Epoch 92/100
498/498 [==============================] - 23s 46ms/step - loss: 1.1438 - accuracy: 0.5390 - val_loss: 1.0667
- val_accuracy: 0.5690
Epoch 93/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1556 - accuracy: 0.5311 - val_loss: 1.0594
- val_accuracy: 0.5816
Epoch 94/100
```

```
498/498 [==============================] - 20s 41ms/step - loss: 1.1421 - accuracy: 0.5444 - val_loss: 1.0914
- val_accuracy: 0.5609
Epoch 95/100
498/498 [==============================] - 22s 44ms/step - loss: 1.1548 - accuracy: 0.5307 - val_loss: 1.0816
- val_accuracy: 0.5529
Epoch 96/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1521 - accuracy: 0.5355 - val_loss: 1.0177
- val_accuracy: 0.5897
Epoch 97/100
498/498 [==============================] - 21s 43ms/step - loss: 1.1365 - accuracy: 0.5353 - val_loss: 1.0166
- val_accuracy: 0.5828
Epoch 98/100
498/498 [==============================] - 23s 46ms/step - loss: 1.1408 - accuracy: 0.5470 - val_loss: 1.0253
- val_accuracy: 0.5862
Epoch 99/100
498/498 [==============================] - 21s 41ms/step - loss: 1.1422 - accuracy: 0.5464 - val_loss: 1.2151
- val_accuracy: 0.5184
Epoch 100/100
498/498 [==============================] - 21s 42ms/step - loss: 1.1324 - accuracy: 0.5444 - val_loss: 1.0205
- val_accuracy: 0.5782
```

Out[ ]:

```
<keras.callbacks.History at 0x7fe2f5293bd0>
```

epoch cnt:100

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range =20, width_shift_range=0.2,rescale
                                                             height_shift_range=0.2, horizontal_flip=True)

ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size=
                                                      class_mode = 'categorical', color_mode = 'grayscale' )


test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_si
                                                          class_mode = 'categorical', color_mode = 'grayscale')


lstm_units        = 64
output_class_cnt  = len(labels)
batch_size        = 10

train_steps   =     4980//batch_size
valid_steps   =     879//batch_size

model = tf.keras.models.load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model')

NAME = "model_1"
tensorboard = tf.keras.callbacks.TensorBoard(log_dir="logs/{}".format(NAME),histogram_freq=1,write_images=True

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=200,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
Epoch 1/200
498/498 [==============================] - 27s 44ms/step - loss: 1.1308 - accuracy: 0.5432 - val_loss: 1.0295
- val_accuracy: 0.5920
Epoch 2/200
498/498 [==============================] - 23s 46ms/step - loss: 1.1222 - accuracy: 0.5386 - val_loss: 1.0232
- val_accuracy: 0.5851
Epoch 3/200
498/498 [==============================] - 21s 42ms/step - loss: 1.1016 - accuracy: 0.5568 - val_loss: 1.0271
- val_accuracy: 0.5897
Epoch 4/200
498/498 [==============================] - 22s 43ms/step - loss: 1.1211 - accuracy: 0.5500 - val_loss: 1.0714
- val_accuracy: 0.5977
Epoch 5/200
498/498 [==============================] - 22s 45ms/step - loss: 1.1005 - accuracy: 0.5570 - val_loss: 0.9972
- val_accuracy: 0.6011
Epoch 6/200
Epoch 6/200
498/498 [==============================] - 22s 43ms/step - loss: 1.1216 - accuracy: 0.5518 - val_loss: 1.0022
- val_accuracy: 0.5931
Epoch 7/200
498/498 [==============================] - 22s 43ms/step - loss: 1.1290 - accuracy: 0.5496 - val_loss: 0.9957
- val_accuracy: 0.5885
Epoch 8/200
498/498 [==============================] - 23s 46ms/step - loss: 1.1238 - accuracy: 0.5498 - val_loss: 1.0667
- val_accuracy: 0.5759
Epoch 9/200
498/498 [==============================] - 21s 43ms/step - loss: 1.1140 - accuracy: 0.5540 - val_loss: 0.9765
- val_accuracy: 0.6057
Epoch 10/200
498/498 [==============================] - 21s 42ms/step - loss: 1.1100 - accuracy: 0.5512 - val_loss: 1.0334
- val_accuracy: 0.5816
Epoch 11/200
498/498 [==============================] - 23s 46ms/step - loss: 1.1082 - accuracy: 0.5552 - val_loss: 0.9732
- val_accuracy: 0.6000
Epoch 12/200
498/498 [==============================] - 22s 43ms/step - loss: 1.1181 - accuracy: 0.5510 - val_loss: 0.9886
- val_accuracy: 0.5931
Epoch 13/200
498/498 [==============================] - 21s 42ms/step - loss: 1.1117 - accuracy: 0.5534 - val_loss: 1.0294
- val_accuracy: 0.5874
Epoch 14/200
498/498 [==============================] - 24s 49ms/step - loss: 1.1139 - accuracy: 0.5466 - val_loss: 1.0112
- val_accuracy: 0.5966
Epoch 15/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0805 - accuracy: 0.5614 - val_loss: 1.0127
- val_accuracy: 0.6023
Epoch 16/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0988 - accuracy: 0.5586 - val_loss: 0.9836
- val_accuracy: 0.6023
Epoch 17/200
498/498 [==============================] - 23s 45ms/step - loss: 1.1070 - accuracy: 0.5554 - val_loss: 1.0066
- val_accuracy: 0.5908
Epoch 18/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0963 - accuracy: 0.5532 - val_loss: 1.0062
- val_accuracy: 0.5874
Epoch 19/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0892 - accuracy: 0.5590 - val_loss: 0.9854
- val_accuracy: 0.6057
Epoch 20/200
498/498 [==============================] - 24s 49ms/step - loss: 1.0993 - accuracy: 0.5635 - val_loss: 1.0500
- val_accuracy: 0.5529
Epoch 21/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0893 - accuracy: 0.5576 - val_loss: 1.0086
- val_accuracy: 0.5805
Epoch 22/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0871 - accuracy: 0.5661 - val_loss: 0.9550
- val_accuracy: 0.5989
Epoch 23/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0986 - accuracy: 0.5588 - val_loss: 0.9705
- val_accuracy: 0.6057
Epoch 24/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0924 - accuracy: 0.5598 - val_loss: 0.9689
- val_accuracy: 0.6092
Epoch 25/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0876 - accuracy: 0.5675 - val_loss: 1.0389
- val_accuracy: 0.5862
Epoch 26/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0873 - accuracy: 0.5574 - val_loss: 0.9791
- val_accuracy: 0.6046
Epoch 27/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0720 - accuracy: 0.5683 - val_loss: 0.9748
- val_accuracy: 0.6069
Epoch 28/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0815 - accuracy: 0.5697 - val_loss: 0.9675
- val_accuracy: 0.6161
Epoch 29/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0973 - accuracy: 0.5616 - val_loss: 0.9678
- val_accuracy: 0.6138
Epoch 30/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0819 - accuracy: 0.5647 - val_loss: 0.9621
- val_accuracy: 0.6138
Epoch 31/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0904 - accuracy: 0.5582 - val_loss: 1.0408
- val_accuracy: 0.5644
- val_accuracy: 0.5644
Epoch 32/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0936 - accuracy: 0.5622 - val_loss: 0.9694
- val_accuracy: 0.6195
Epoch 33/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0807 - accuracy: 0.5608 - val_loss: 0.9510
- val_accuracy: 0.6184
Epoch 34/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0725 - accuracy: 0.5679 - val_loss: 0.9329
- val_accuracy: 0.6333
Epoch 35/200
498/498 [==============================] - 23s 46ms/step - loss: 1.0819 - accuracy: 0.5631 - val_loss: 0.9471
- val_accuracy: 0.6218
Epoch 36/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0761 - accuracy: 0.5659 - val_loss: 0.9532
- val_accuracy: 0.6241
Epoch 37/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0865 - accuracy: 0.5661 - val_loss: 0.9504
- val_accuracy: 0.6103
Epoch 38/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0589 - accuracy: 0.5787 - val_loss: 0.9613
- val_accuracy: 0.6057
Epoch 39/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0720 - accuracy: 0.5631 - val_loss: 0.9379
- val_accuracy: 0.6172
Epoch 40/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0666 - accuracy: 0.5707 - val_loss: 0.9594
- val_accuracy: 0.6264
Epoch 41/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0757 - accuracy: 0.5673 - val_loss: 0.9656
- val_accuracy: 0.6207
Epoch 42/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0635 - accuracy: 0.5783 - val_loss: 0.9882
- val_accuracy: 0.6057
Epoch 43/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0643 - accuracy: 0.5681 - val_loss: 0.9741
- val_accuracy: 0.6069
Epoch 44/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0769 - accuracy: 0.5649 - val_loss: 0.9289
- val_accuracy: 0.6264
Epoch 45/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0749 - accuracy: 0.5649 - val_loss: 0.9264
- val_accuracy: 0.6345
Epoch 46/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0711 - accuracy: 0.5655 - val_loss: 0.9158
- val_accuracy: 0.6494
Epoch 47/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0496 - accuracy: 0.5761 - val_loss: 0.9371
- val_accuracy: 0.6184
Epoch 48/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0723 - accuracy: 0.5685 - val_loss: 0.9170
- val_accuracy: 0.6368
Epoch 49/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0706 - accuracy: 0.5749 - val_loss: 0.9263
- val_accuracy: 0.6264
Epoch 50/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0590 - accuracy: 0.5715 - val_loss: 0.9200
- val_accuracy: 0.6241
Epoch 51/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0621 - accuracy: 0.5729 - val_loss: 0.9236
- val_accuracy: 0.6241
Epoch 52/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0528 - accuracy: 0.5783 - val_loss: 0.9480
- val_accuracy: 0.6126
Epoch 53/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0553 - accuracy: 0.5695 - val_loss: 0.9063
- val_accuracy: 0.6483
Epoch 54/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0459 - accuracy: 0.5799 - val_loss: 0.8996
- val_accuracy: 0.6379
Epoch 55/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0517 - accuracy: 0.5801 - val_loss: 1.0066
- val_accuracy: 0.5966
Epoch 56/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0484 - accuracy: 0.5759 - val_loss: 0.9367
- val_accuracy: 0.6230
Epoch 57/200
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498/498 [==============================] - 21s 43ms/step - loss: 1.0356 - accuracy: 0.5815 - val_loss: 0.9043
- val_accuracy: 0.6368
Epoch 58/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0432 - accuracy: 0.5823 - val_loss: 0.9035
- val_accuracy: 0.6287
Epoch 59/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0528 - accuracy: 0.5753 - val_loss: 0.9302
- val_accuracy: 0.6310
Epoch 60/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0545 - accuracy: 0.5741 - val_loss: 0.8989
- val_accuracy: 0.6494
Epoch 61/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0427 - accuracy: 0.5884 - val_loss: 0.9127
- val_accuracy: 0.6414
Epoch 62/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0459 - accuracy: 0.5785 - val_loss: 0.9149
- val_accuracy: 0.6368
Epoch 63/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0500 - accuracy: 0.5771 - val_loss: 0.9400
- val_accuracy: 0.6184
Epoch 64/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0434 - accuracy: 0.5815 - val_loss: 0.9549
- val_accuracy: 0.6218
Epoch 65/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0227 - accuracy: 0.5869 - val_loss: 0.9181
- val_accuracy: 0.6172
Epoch 66/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0596 - accuracy: 0.5695 - val_loss: 0.8972
- val_accuracy: 0.6322
Epoch 67/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0360 - accuracy: 0.5797 - val_loss: 0.9682
- val_accuracy: 0.6023
Epoch 68/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0394 - accuracy: 0.5829 - val_loss: 0.9002
- val_accuracy: 0.6425
Epoch 69/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0356 - accuracy: 0.5843 - val_loss: 0.8955
- val_accuracy: 0.6529
Epoch 70/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0427 - accuracy: 0.5823 - val_loss: 0.9779
- val_accuracy: 0.5989
Epoch 71/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0409 - accuracy: 0.5863 - val_loss: 0.8932
- val_accuracy: 0.6264
Epoch 72/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0139 - accuracy: 0.5873 - val_loss: 0.8921
- val_accuracy: 0.6368
Epoch 73/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0240 - accuracy: 0.5904 - val_loss: 0.8880
- val_accuracy: 0.6517
Epoch 74/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0327 - accuracy: 0.5791 - val_loss: 0.8844
- val_accuracy: 0.6552
Epoch 75/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0164 - accuracy: 0.5902 - val_loss: 0.8895
- val_accuracy: 0.6391
Epoch 76/200
498/498 [==============================] - 21s 43ms/step - loss: 1.0280 - accuracy: 0.5855 - val_loss: 0.8745
- val_accuracy: 0.6701
Epoch 77/200
498/498 [==============================] - 23s 45ms/step - loss: 1.0301 - accuracy: 0.5839 - val_loss: 0.9011
- val_accuracy: 0.6540
Epoch 78/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0289 - accuracy: 0.5878 - val_loss: 0.9718
- val_accuracy: 0.6092
Epoch 79/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0301 - accuracy: 0.5795 - val_loss: 0.8940
- val_accuracy: 0.6368
Epoch 80/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0242 - accuracy: 0.5932 - val_loss: 0.9219
- val_accuracy: 0.6276
Epoch 81/200
498/498 [==============================] - 21s 41ms/step - loss: 1.0400 - accuracy: 0.5819 - val_loss: 0.9230
- val_accuracy: 0.6402
Epoch 82/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0187 - accuracy: 0.5910 - val_loss: 0.9019
- val_accuracy: 0.6448
Epoch 83/200
Epoch 83/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0358 - accuracy: 0.5896 - val_loss: 0.8775
- val_accuracy: 0.6529
Epoch 84/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0161 - accuracy: 0.5906 - val_loss: 0.9321
- val_accuracy: 0.6345
Epoch 85/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0350 - accuracy: 0.5757 - val_loss: 0.8778
- val_accuracy: 0.6575
Epoch 86/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0323 - accuracy: 0.5900 - val_loss: 0.8863
- val_accuracy: 0.6483
Epoch 87/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0204 - accuracy: 0.5867 - val_loss: 0.9033
- val_accuracy: 0.6437
Epoch 88/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0169 - accuracy: 0.5888 - val_loss: 0.9195
- val_accuracy: 0.6368
Epoch 89/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0084 - accuracy: 0.5918 - val_loss: 0.9351
- val_accuracy: 0.6356
Epoch 90/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0150 - accuracy: 0.5861 - val_loss: 0.9500
- val_accuracy: 0.6414
Epoch 91/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0051 - accuracy: 0.5976 - val_loss: 0.9349
- val_accuracy: 0.6218
Epoch 92/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0136 - accuracy: 0.5896 - val_loss: 0.8890
- val_accuracy: 0.6563
Epoch 93/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0036 - accuracy: 0.5934 - val_loss: 0.8865
- val_accuracy: 0.6644
Epoch 94/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0049 - accuracy: 0.5978 - val_loss: 0.8649
- val_accuracy: 0.6747
Epoch 95/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9898 - accuracy: 0.5972 - val_loss: 0.8810
- val_accuracy: 0.6575
Epoch 96/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0043 - accuracy: 0.5942 - val_loss: 0.8661
- val_accuracy: 0.6598
Epoch 97/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0002 - accuracy: 0.6028 - val_loss: 0.9240
- val_accuracy: 0.6241
Epoch 98/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0147 - accuracy: 0.5876 - val_loss: 0.8920
- val_accuracy: 0.6471
Epoch 99/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0139 - accuracy: 0.5890 - val_loss: 0.9348
- val_accuracy: 0.6299
Epoch 100/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0060 - accuracy: 0.5934 - val_loss: 0.8721
- val_accuracy: 0.6540
Epoch 101/200
498/498 [==============================] - 22s 44ms/step - loss: 1.0011 - accuracy: 0.6028 - val_loss: 0.8764
- val_accuracy: 0.6609
Epoch 102/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0037 - accuracy: 0.5920 - val_loss: 0.9010
- val_accuracy: 0.6310
Epoch 103/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0166 - accuracy: 0.5884 - val_loss: 0.8790
- val_accuracy: 0.6598
Epoch 104/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9945 - accuracy: 0.6072 - val_loss: 0.8759
- val_accuracy: 0.6483
Epoch 105/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9940 - accuracy: 0.6046 - val_loss: 0.8686
- val_accuracy: 0.6632
Epoch 106/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9992 - accuracy: 0.5980 - val_loss: 0.8433
- val_accuracy: 0.6667
Epoch 107/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9955 - accuracy: 0.5972 - val_loss: 0.8927
- val_accuracy: 0.6586
Epoch 108/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9985 - accuracy: 0.5990 - val_loss: 0.8737
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- val_accuracy: 0.6667
Epoch 109/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9959 - accuracy: 0.6044 - val_loss: 0.8581
- val_accuracy: 0.6609
Epoch 110/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9947 - accuracy: 0.5954 - val_loss: 0.9595
- val_accuracy: 0.6218
Epoch 111/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9995 - accuracy: 0.6036 - val_loss: 0.8718
- val_accuracy: 0.6471
Epoch 112/200
498/498 [==============================] - 21s 42ms/step - loss: 1.0025 - accuracy: 0.6002 - val_loss: 0.8712
- val_accuracy: 0.6552
Epoch 113/200
498/498 [==============================] - 23s 46ms/step - loss: 0.9849 - accuracy: 0.6088 - val_loss: 0.8942
- val_accuracy: 0.6517
Epoch 114/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9809 - accuracy: 0.6080 - val_loss: 0.8427
- val_accuracy: 0.6805
Epoch 115/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9953 - accuracy: 0.5976 - val_loss: 0.8912
- val_accuracy: 0.6494
Epoch 116/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9842 - accuracy: 0.5964 - val_loss: 0.8503
- val_accuracy: 0.6701
Epoch 117/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9997 - accuracy: 0.5996 - val_loss: 0.8531
- val_accuracy: 0.6747
Epoch 118/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9898 - accuracy: 0.6084 - val_loss: 0.8583
- val_accuracy: 0.6563
Epoch 119/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9926 - accuracy: 0.6048 - val_loss: 0.8657
- val_accuracy: 0.6701
Epoch 120/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9778 - accuracy: 0.6048 - val_loss: 0.8771
- val_accuracy: 0.6494
Epoch 121/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9774 - accuracy: 0.6042 - val_loss: 0.8553
- val_accuracy: 0.6644
Epoch 122/200
498/498 [==============================] - 22s 43ms/step - loss: 1.0000 - accuracy: 0.5986 - val_loss: 0.8451
- val_accuracy: 0.6736
Epoch 123/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9652 - accuracy: 0.6135 - val_loss: 0.8541
- val_accuracy: 0.6701
Epoch 124/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9929 - accuracy: 0.5944 - val_loss: 0.8317
- val_accuracy: 0.6655
Epoch 125/200
498/498 [==============================] - 23s 46ms/step - loss: 1.0000 - accuracy: 0.5988 - val_loss: 0.8426
- val_accuracy: 0.6724
Epoch 126/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9874 - accuracy: 0.6032 - val_loss: 0.8651
- val_accuracy: 0.6816
Epoch 127/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9732 - accuracy: 0.6092 - val_loss: 0.8601
- val_accuracy: 0.6667
Epoch 128/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9823 - accuracy: 0.6056 - val_loss: 0.8758
- val_accuracy: 0.6517
Epoch 129/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9795 - accuracy: 0.6018 - val_loss: 0.8474
- val_accuracy: 0.6701
Epoch 130/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9812 - accuracy: 0.6058 - val_loss: 0.8631
- val_accuracy: 0.6540
Epoch 131/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9672 - accuracy: 0.6100 - val_loss: 0.8687
- val_accuracy: 0.6483
Epoch 132/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9657 - accuracy: 0.6054 - val_loss: 0.8372
- val_accuracy: 0.6724
Epoch 133/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9820 - accuracy: 0.6012 - val_loss: 0.8655
- val_accuracy: 0.6632
Epoch 134/200
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498/498 [==============================] - 22s 43ms/step - loss: 0.9655 - accuracy: 0.6068 - val_loss: 0.9099
- val_accuracy: 0.6230
Epoch 135/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9672 - accuracy: 0.6155 - val_loss: 0.8511
- val_accuracy: 0.6529
Epoch 136/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9851 - accuracy: 0.6026 - val_loss: 0.8794
- val_accuracy: 0.6575
Epoch 137/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9722 - accuracy: 0.6060 - val_loss: 0.8314
- val_accuracy: 0.6644
Epoch 138/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9830 - accuracy: 0.6050 - val_loss: 0.8413
- val_accuracy: 0.6621
Epoch 139/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9676 - accuracy: 0.6104 - val_loss: 0.8418
- val_accuracy: 0.6632
Epoch 140/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9657 - accuracy: 0.6100 - val_loss: 0.8373
- val_accuracy: 0.6747
Epoch 141/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9552 - accuracy: 0.6157 - val_loss: 0.8346
- val_accuracy: 0.6770
Epoch 142/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9584 - accuracy: 0.6118 - val_loss: 0.8729
- val_accuracy: 0.6644
Epoch 143/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9640 - accuracy: 0.6163 - val_loss: 0.8725
- val_accuracy: 0.6517
Epoch 144/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9818 - accuracy: 0.6090 - val_loss: 0.8978
- val_accuracy: 0.6310
Epoch 145/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9680 - accuracy: 0.6122 - val_loss: 0.8372
- val_accuracy: 0.6575
Epoch 146/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9729 - accuracy: 0.6098 - val_loss: 0.8575
- val_accuracy: 0.6713
Epoch 147/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9718 - accuracy: 0.6124 - val_loss: 0.8671
- val_accuracy: 0.6575
Epoch 148/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9670 - accuracy: 0.6133 - val_loss: 0.8680
- val_accuracy: 0.6586
Epoch 149/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9709 - accuracy: 0.6143 - val_loss: 0.8299
- val_accuracy: 0.6770
Epoch 150/200
498/498 [==============================] - 23s 46ms/step - loss: 0.9712 - accuracy: 0.6135 - val_loss: 0.8448
- val_accuracy: 0.6391
Epoch 151/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9707 - accuracy: 0.6171 - val_loss: 0.8340
- val_accuracy: 0.6805
Epoch 152/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9405 - accuracy: 0.6217 - val_loss: 0.8290
- val_accuracy: 0.6759
Epoch 153/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9618 - accuracy: 0.6056 - val_loss: 0.8039
- val_accuracy: 0.6874
Epoch 154/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9570 - accuracy: 0.6193 - val_loss: 0.8539
- val_accuracy: 0.6644
Epoch 155/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9746 - accuracy: 0.6052 - val_loss: 0.8230
- val_accuracy: 0.6747
Epoch 156/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9372 - accuracy: 0.6257 - val_loss: 0.8193
- val_accuracy: 0.6782
Epoch 157/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9624 - accuracy: 0.6131 - val_loss: 0.8265
- val_accuracy: 0.6782
Epoch 158/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9565 - accuracy: 0.6084 - val_loss: 0.8536
- val_accuracy: 0.6448
Epoch 159/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9581 - accuracy: 0.6114 - val_loss: 0.8128
- val_accuracy: 0.6805
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Epoch 160/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9574 - accuracy: 0.6122 - val_loss: 0.8469
- val_accuracy: 0.6621
Epoch 161/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9612 - accuracy: 0.6133 - val_loss: 0.8255
- val_accuracy: 0.6678
Epoch 162/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9574 - accuracy: 0.6139 - val_loss: 0.8395
- val_accuracy: 0.6506
Epoch 163/200
498/498 [==============================] - 23s 46ms/step - loss: 0.9439 - accuracy: 0.6191 - val_loss: 0.8203
- val_accuracy: 0.6621
Epoch 164/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9600 - accuracy: 0.6169 - val_loss: 0.8647
- val_accuracy: 0.6471
Epoch 165/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9518 - accuracy: 0.6185 - val_loss: 0.8163
- val_accuracy: 0.6724
Epoch 166/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9400 - accuracy: 0.6275 - val_loss: 0.8733
- val_accuracy: 0.6483
Epoch 167/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9397 - accuracy: 0.6106 - val_loss: 0.7949
- val_accuracy: 0.6897
Epoch 168/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9502 - accuracy: 0.6227 - val_loss: 0.8640
- val_accuracy: 0.6598
Epoch 169/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9454 - accuracy: 0.6094 - val_loss: 0.8083
- val_accuracy: 0.6793
Epoch 170/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9527 - accuracy: 0.6247 - val_loss: 0.8907
- val_accuracy: 0.6437
Epoch 171/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9397 - accuracy: 0.6247 - val_loss: 0.8307
- val_accuracy: 0.6609
Epoch 172/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9391 - accuracy: 0.6243 - val_loss: 0.8209
- val_accuracy: 0.6667
Epoch 173/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9356 - accuracy: 0.6257 - val_loss: 0.8072
- val_accuracy: 0.6793
Epoch 174/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9509 - accuracy: 0.6155 - val_loss: 0.8408
- val_accuracy: 0.6540
Epoch 175/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9364 - accuracy: 0.6217 - val_loss: 0.8083
- val_accuracy: 0.6782
Epoch 176/200
498/498 [==============================] - 23s 46ms/step - loss: 0.9349 - accuracy: 0.6269 - val_loss: 0.8372
- val_accuracy: 0.6575
Epoch 177/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9509 - accuracy: 0.6114 - val_loss: 0.8293
- val_accuracy: 0.6655
Epoch 178/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9474 - accuracy: 0.6189 - val_loss: 0.8113
- val_accuracy: 0.6793
Epoch 179/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9328 - accuracy: 0.6281 - val_loss: 0.9099
- val_accuracy: 0.6299
Epoch 180/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9433 - accuracy: 0.6165 - val_loss: 0.8070
- val_accuracy: 0.6759
Epoch 181/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9299 - accuracy: 0.6275 - val_loss: 0.8212
- val_accuracy: 0.6782
Epoch 182/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9332 - accuracy: 0.6197 - val_loss: 0.8158
- val_accuracy: 0.6655
Epoch 183/200
498/498 [==============================] - 22s 43ms/step - loss: 0.9281 - accuracy: 0.6307 - val_loss: 0.8474
- val_accuracy: 0.6598
Epoch 184/200
498/498 [==============================] - 21s 42ms/step - loss: 0.9512 - accuracy: 0.6163 - val_loss: 0.8310
- val_accuracy: 0.6724
Epoch 185/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9329 - accuracy: 0.6301 - val_loss: 0.8055
```

```
- val_accuracy: 0.6782
Epoch 186/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9328 - accuracy: 0.6251 - val_loss: 0.8484
- val_accuracy: 0.6575
Epoch 187/200
498/498 [==============================] - 22s 45ms/step - loss: 0.9378 - accuracy: 0.6301 - val_loss: 0.8163
- val_accuracy: 0.6736
Epoch 188/200
498/498 [==============================] - 23s 46ms/step - loss: 0.9257 - accuracy: 0.6291 - val_loss: 0.8108
- val_accuracy: 0.6782
Epoch 189/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9319 - accuracy: 0.6269 - val_loss: 0.8227
- val_accuracy: 0.6632
Epoch 190/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9351 - accuracy: 0.6235 - val_loss: 0.8184
- val_accuracy: 0.6632
Epoch 191/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9183 - accuracy: 0.6301 - val_loss: 0.8614
- val_accuracy: 0.6517
Epoch 192/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9403 - accuracy: 0.6179 - val_loss: 0.8480
- val_accuracy: 0.6471
Epoch 193/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9271 - accuracy: 0.6281 - val_loss: 0.8221
- val_accuracy: 0.6690
Epoch 194/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9246 - accuracy: 0.6273 - val_loss: 0.8243
- val_accuracy: 0.6678
Epoch 195/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9189 - accuracy: 0.6343 - val_loss: 0.8066
- val_accuracy: 0.6632
Epoch 196/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9355 - accuracy: 0.6313 - val_loss: 0.8230
- val_accuracy: 0.6713
Epoch 197/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9289 - accuracy: 0.6289 - val_loss: 0.7944
- val_accuracy: 0.6920
Epoch 198/200
498/498 [==============================] - 22s 44ms/step - loss: 0.9206 - accuracy: 0.6291 - val_loss: 0.7920
- val_accuracy: 0.6609
Epoch 199/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9321 - accuracy: 0.6231 - val_loss: 0.8293
- val_accuracy: 0.6506
Epoch 200/200
498/498 [==============================] - 21s 43ms/step - loss: 0.9286 - accuracy: 0.6317 - val_loss: 0.7963
- val_accuracy: 0.6782
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd740ebb550>
```

epoch cnt:300

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd760829150> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd76082fa90> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Epoch 1/100
498/498 [==============================] - 27s 54ms/step - loss: 0.9091 - accuracy: 0.6424 - val_loss: 0.7795
- val_accuracy: 0.6931
Epoch 2/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9171 - accuracy: 0.6406 - val_loss: 0.7999
- val_accuracy: 0.6885
```

```
Epoch 3/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9072 - accuracy: 0.6345 - val_loss: 0.7974
- val_accuracy: 0.6759
Epoch 4/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9294 - accuracy: 0.6295 - val_loss: 0.8059
- val_accuracy: 0.6724
Epoch 5/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9318 - accuracy: 0.6303 - val_loss: 0.8052
- val_accuracy: 0.6770
Epoch 6/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9220 - accuracy: 0.6265 - val_loss: 0.7955
- val_accuracy: 0.6701
Epoch 7/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9134 - accuracy: 0.6271 - val_loss: 0.8162
- val_accuracy: 0.6690
Epoch 8/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9138 - accuracy: 0.6333 - val_loss: 0.8383
- val_accuracy: 0.6575
Epoch 9/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9185 - accuracy: 0.6337 - val_loss: 0.8032
- val_accuracy: 0.6851
Epoch 10/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9102 - accuracy: 0.6285 - val_loss: 0.7851
- val_accuracy: 0.6793
Epoch 11/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9142 - accuracy: 0.6363 - val_loss: 0.8239
- val_accuracy: 0.6575
Epoch 12/100
498/498 [==============================] - 24s 49ms/step - loss: 0.9126 - accuracy: 0.6331 - val_loss: 0.7776
- val_accuracy: 0.6874
Epoch 13/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9185 - accuracy: 0.6263 - val_loss: 0.7791
- val_accuracy: 0.6793
Epoch 14/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9225 - accuracy: 0.6321 - val_loss: 0.7793
- val_accuracy: 0.6759
Epoch 15/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9125 - accuracy: 0.6371 - val_loss: 0.7928
- val_accuracy: 0.6724
Epoch 16/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9246 - accuracy: 0.6329 - val_loss: 0.8141
- val_accuracy: 0.6678
Epoch 17/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9024 - accuracy: 0.6376 - val_loss: 0.7940
- val_accuracy: 0.6690
Epoch 18/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8994 - accuracy: 0.6402 - val_loss: 0.7769
- val_accuracy: 0.6805
Epoch 19/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9064 - accuracy: 0.6309 - val_loss: 0.8091
- val_accuracy: 0.6563
Epoch 20/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9177 - accuracy: 0.6355 - val_loss: 0.7848
- val_accuracy: 0.6793
Epoch 21/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9063 - accuracy: 0.6430 - val_loss: 0.7952
- val_accuracy: 0.6977
Epoch 22/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9087 - accuracy: 0.6291 - val_loss: 0.8375
- val_accuracy: 0.6563
Epoch 23/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9134 - accuracy: 0.6367 - val_loss: 0.8313
- val_accuracy: 0.6690
Epoch 24/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9208 - accuracy: 0.6291 - val_loss: 0.7627
- val_accuracy: 0.6851
Epoch 25/100
498/498 [==============================] - 25s 49ms/step - loss: 0.9107 - accuracy: 0.6337 - val_loss: 0.7546
- val_accuracy: 0.6851
Epoch 26/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8951 - accuracy: 0.6313 - val_loss: 0.7814
- val_accuracy: 0.6747
Epoch 27/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8972 - accuracy: 0.6333 - val_loss: 0.7845
- val_accuracy: 0.6782
Epoch 28/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8996 - accuracy: 0.6492 - val_loss: 0.8095
```

```
- val_accuracy: 0.6632
Epoch 29/100
498/498 [==============================] - 22s 43ms/step - loss: 0.9097 - accuracy: 0.6438 - val_loss: 0.7853
- val_accuracy: 0.6770
Epoch 30/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9076 - accuracy: 0.6380 - val_loss: 0.7972
- val_accuracy: 0.6736
Epoch 31/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9043 - accuracy: 0.6307 - val_loss: 0.8114
- val_accuracy: 0.6690
Epoch 32/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8919 - accuracy: 0.6412 - val_loss: 0.8165
- val_accuracy: 0.6644
Epoch 33/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8995 - accuracy: 0.6390 - val_loss: 0.7940
- val_accuracy: 0.6678
Epoch 34/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9028 - accuracy: 0.6382 - val_loss: 0.7718
- val_accuracy: 0.6805
Epoch 35/100
498/498 [==============================] - 21s 42ms/step - loss: 0.9062 - accuracy: 0.6388 - val_loss: 0.7688
- val_accuracy: 0.6828
Epoch 36/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8920 - accuracy: 0.6494 - val_loss: 0.7608
- val_accuracy: 0.6966
Epoch 37/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9097 - accuracy: 0.6410 - val_loss: 0.8023
- val_accuracy: 0.6724
Epoch 38/100
498/498 [==============================] - 22s 45ms/step - loss: 0.8960 - accuracy: 0.6382 - val_loss: 0.8082
- val_accuracy: 0.6828
Epoch 39/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8967 - accuracy: 0.6452 - val_loss: 0.8339
- val_accuracy: 0.6644
Epoch 40/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8902 - accuracy: 0.6424 - val_loss: 0.7850
- val_accuracy: 0.6759
Epoch 41/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8797 - accuracy: 0.6524 - val_loss: 0.7691
- val_accuracy: 0.7057
Epoch 42/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8977 - accuracy: 0.6426 - val_loss: 0.7599
- val_accuracy: 0.6793
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8816 - accuracy: 0.6470 - val_loss: 0.7907
- val_accuracy: 0.6920
Epoch 44/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8949 - accuracy: 0.6408 - val_loss: 0.7714
- val_accuracy: 0.6851
Epoch 45/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8873 - accuracy: 0.6371 - val_loss: 0.7776
- val_accuracy: 0.6793
Epoch 46/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8818 - accuracy: 0.6514 - val_loss: 0.7662
- val_accuracy: 0.6885
Epoch 47/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8770 - accuracy: 0.6494 - val_loss: 0.7657
- val_accuracy: 0.6954
Epoch 48/100
498/498 [==============================] - 22s 44ms/step - loss: 0.9010 - accuracy: 0.6337 - val_loss: 0.7999
- val_accuracy: 0.6782
Epoch 49/100
498/498 [==============================] - 21s 43ms/step - loss: 0.9016 - accuracy: 0.6412 - val_loss: 0.7773
- val_accuracy: 0.6897
Epoch 50/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8812 - accuracy: 0.6428 - val_loss: 0.7725
- val_accuracy: 0.6908
Epoch 51/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8831 - accuracy: 0.6460 - val_loss: 0.7490
- val_accuracy: 0.6839
Epoch 52/100
498/498 [==============================] - 23s 46ms/step - loss: 0.8801 - accuracy: 0.6476 - val_loss: 0.8292
- val_accuracy: 0.6563
Epoch 53/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8882 - accuracy: 0.6432 - val_loss: 0.7755
- val_accuracy: 0.6851
Epoch 54/100
```

```
498/498 [==============================] - 21s 43ms/step - loss: 0.8981 - accuracy: 0.6452 - val_loss: 0.7802
- val_accuracy: 0.6828
Epoch 55/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8918 - accuracy: 0.6490 - val_loss: 0.7650
- val_accuracy: 0.6977
Epoch 56/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8813 - accuracy: 0.6510 - val_loss: 0.7802
- val_accuracy: 0.6897
Epoch 57/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8859 - accuracy: 0.6470 - val_loss: 0.8193
- val_accuracy: 0.6632
Epoch 58/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8853 - accuracy: 0.6514 - val_loss: 0.7761
- val_accuracy: 0.6816
Epoch 59/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8790 - accuracy: 0.6502 - val_loss: 0.7810
- val_accuracy: 0.6736
Epoch 60/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8799 - accuracy: 0.6452 - val_loss: 0.7613
- val_accuracy: 0.6770
Epoch 61/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8837 - accuracy: 0.6492 - val_loss: 0.7477
- val_accuracy: 0.7000
Epoch 62/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8898 - accuracy: 0.6450 - val_loss: 0.7893
- val_accuracy: 0.6874
Epoch 63/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8796 - accuracy: 0.6520 - val_loss: 0.7519
- val_accuracy: 0.6931
Epoch 64/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8866 - accuracy: 0.6500 - val_loss: 0.7982
- val_accuracy: 0.6805
Epoch 65/100
498/498 [==============================] - 23s 45ms/step - loss: 0.8852 - accuracy: 0.6492 - val_loss: 0.7591
- val_accuracy: 0.6931
Epoch 66/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8850 - accuracy: 0.6460 - val_loss: 0.7917
- val_accuracy: 0.6690
Epoch 67/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8826 - accuracy: 0.6500 - val_loss: 0.8223
- val_accuracy: 0.6598
Epoch 68/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8655 - accuracy: 0.6544 - val_loss: 0.7965
- val_accuracy: 0.6793
Epoch 69/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8698 - accuracy: 0.6512 - val_loss: 0.7549
- val_accuracy: 0.7000
Epoch 70/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8778 - accuracy: 0.6480 - val_loss: 0.7795
- val_accuracy: 0.6862
Epoch 71/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8648 - accuracy: 0.6574 - val_loss: 0.7401
- val_accuracy: 0.6931
Epoch 72/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8738 - accuracy: 0.6474 - val_loss: 0.7774
- val_accuracy: 0.6885
Epoch 73/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8789 - accuracy: 0.6452 - val_loss: 0.7728
- val_accuracy: 0.6816
Epoch 74/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8657 - accuracy: 0.6498 - val_loss: 0.7909
- val_accuracy: 0.6678
Epoch 75/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8742 - accuracy: 0.6416 - val_loss: 0.7726
- val_accuracy: 0.6966
Epoch 76/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8734 - accuracy: 0.6486 - val_loss: 0.7600
- val_accuracy: 0.6943
Epoch 77/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8597 - accuracy: 0.6562 - val_loss: 0.7948
- val_accuracy: 0.6839
Epoch 78/100
498/498 [==============================] - 23s 46ms/step - loss: 0.8707 - accuracy: 0.6536 - val_loss: 0.7533
- val_accuracy: 0.6874
Epoch 79/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8806 - accuracy: 0.6424 - val_loss: 0.7625
- val_accuracy: 0.6805
```

```
Epoch 80/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8726 - accuracy: 0.6524 - val_loss: 0.8266
- val_accuracy: 0.6529
Epoch 81/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8634 - accuracy: 0.6492 - val_loss: 0.7760
- val_accuracy: 0.6885
Epoch 82/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8745 - accuracy: 0.6542 - val_loss: 0.7518
- val_accuracy: 0.6908
Epoch 83/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8495 - accuracy: 0.6622 - val_loss: 0.7688
- val_accuracy: 0.6724
Epoch 84/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8644 - accuracy: 0.6498 - val_loss: 0.7443
- val_accuracy: 0.6931
Epoch 85/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8811 - accuracy: 0.6442 - val_loss: 0.7505
- val_accuracy: 0.6897
Epoch 86/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8686 - accuracy: 0.6512 - val_loss: 0.7705
- val_accuracy: 0.6782
Epoch 87/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8722 - accuracy: 0.6522 - val_loss: 0.7547
- val_accuracy: 0.6908
Epoch 88/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8541 - accuracy: 0.6616 - val_loss: 0.7758
- val_accuracy: 0.6874
Epoch 89/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8639 - accuracy: 0.6532 - val_loss: 0.7918
- val_accuracy: 0.6816
Epoch 90/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8454 - accuracy: 0.6614 - val_loss: 0.7635
- val_accuracy: 0.6805
Epoch 91/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8581 - accuracy: 0.6596 - val_loss: 0.7302
- val_accuracy: 0.7000
Epoch 92/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8684 - accuracy: 0.6598 - val_loss: 0.7775
- val_accuracy: 0.6805
Epoch 93/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8582 - accuracy: 0.6616 - val_loss: 0.7534
- val_accuracy: 0.6920
Epoch 94/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8597 - accuracy: 0.6538 - val_loss: 0.7362
- val_accuracy: 0.6897
Epoch 95/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8628 - accuracy: 0.6532 - val_loss: 0.7325
- val_accuracy: 0.7092
Epoch 96/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8652 - accuracy: 0.6490 - val_loss: 0.7572
- val_accuracy: 0.6989
Epoch 97/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8604 - accuracy: 0.6508 - val_loss: 0.7658
- val_accuracy: 0.6989
Epoch 98/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8652 - accuracy: 0.6508 - val_loss: 0.7482
- val_accuracy: 0.7069
Epoch 99/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8574 - accuracy: 0.6554 - val_loss: 0.7648
- val_accuracy: 0.6931
Epoch 100/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8696 - accuracy: 0.6528 - val_loss: 0.7300
- val_accuracy: 0.7057
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd800162650>
```

epoch cnt:400

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd760829150> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd76082fa90> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
from keras import backend as K
K.set_value(model.optimizer.learning_rate, 0.0001)
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboard
```

```
Epoch 1/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8663 - accuracy: 0.6482 - val_loss: 0.7441
- val_accuracy: 0.6989
Epoch 2/100
498/498 [==============================] - 27s 55ms/step - loss: 0.8383 - accuracy: 0.6669 - val_loss: 0.7407
- val_accuracy: 0.6897
Epoch 3/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8649 - accuracy: 0.6584 - val_loss: 0.7493
- val_accuracy: 0.7011
Epoch 4/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8546 - accuracy: 0.6622 - val_loss: 0.7259
- val_accuracy: 0.7046
Epoch 5/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8506 - accuracy: 0.6596 - val_loss: 0.7369
- val_accuracy: 0.7092
Epoch 6/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8683 - accuracy: 0.6578 - val_loss: 0.7718
- val_accuracy: 0.6851
Epoch 7/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8534 - accuracy: 0.6562 - val_loss: 0.7370
- val_accuracy: 0.6954
Epoch 8/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8369 - accuracy: 0.6645 - val_loss: 0.7562
- val_accuracy: 0.6977
Epoch 9/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8515 - accuracy: 0.6604 - val_loss: 0.7201
- val_accuracy: 0.6966
Epoch 10/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8597 - accuracy: 0.6590 - val_loss: 0.7121
- val_accuracy: 0.6966
Epoch 11/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8484 - accuracy: 0.6671 - val_loss: 0.7522
- val_accuracy: 0.6943
Epoch 12/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8460 - accuracy: 0.6562 - val_loss: 0.7275
- val_accuracy: 0.6966
Epoch 13/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8482 - accuracy: 0.6596 - val_loss: 0.7445
- val_accuracy: 0.6839
Epoch 14/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8621 - accuracy: 0.6544 - val_loss: 0.7511
- val_accuracy: 0.6977
Epoch 15/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8641 - accuracy: 0.6548 - val_loss: 0.7382
- val_accuracy: 0.6897
Epoch 16/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8486 - accuracy: 0.6631 - val_loss: 0.7294
- val_accuracy: 0.7057
Epoch 17/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8440 - accuracy: 0.6596 - val_loss: 0.7365
- val_accuracy: 0.6954
Epoch 18/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8638 - accuracy: 0.6528 - val_loss: 0.7266
- val_accuracy: 0.7046
Epoch 19/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8492 - accuracy: 0.6514 - val_loss: 0.7786
- val_accuracy: 0.6897
Epoch 20/100
```

```
498/498 [==============================] - 20s 41ms/step - loss: 0.8493 - accuracy: 0.6639 - val_loss: 0.7453
- val_accuracy: 0.6943
Epoch 21/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8355 - accuracy: 0.6616 - val_loss: 0.7534
- val_accuracy: 0.6908
Epoch 22/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8393 - accuracy: 0.6633 - val_loss: 0.7376
- val_accuracy: 0.6977
Epoch 23/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8437 - accuracy: 0.6482 - val_loss: 0.7141
- val_accuracy: 0.7149
Epoch 24/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8420 - accuracy: 0.6566 - val_loss: 0.7368
- val_accuracy: 0.6885
Epoch 25/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8286 - accuracy: 0.6635 - val_loss: 0.7447
- val_accuracy: 0.6885
Epoch 26/100
498/498 [==============================] - 23s 46ms/step - loss: 0.8408 - accuracy: 0.6657 - val_loss: 0.7297
- val_accuracy: 0.7138
Epoch 27/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8469 - accuracy: 0.6548 - val_loss: 0.7159
- val_accuracy: 0.7092
Epoch 28/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8396 - accuracy: 0.6657 - val_loss: 0.7292
- val_accuracy: 0.7046
Epoch 29/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8296 - accuracy: 0.6665 - val_loss: 0.7235
- val_accuracy: 0.7069
Epoch 30/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8358 - accuracy: 0.6629 - val_loss: 0.7314
- val_accuracy: 0.6977
Epoch 31/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8324 - accuracy: 0.6709 - val_loss: 0.7802
- val_accuracy: 0.6678
Epoch 32/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8408 - accuracy: 0.6608 - val_loss: 0.7374
- val_accuracy: 0.7011
Epoch 33/100
498/498 [==============================] - 27s 54ms/step - loss: 0.8296 - accuracy: 0.6753 - val_loss: 0.7366
- val_accuracy: 0.7046
Epoch 34/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8422 - accuracy: 0.6681 - val_loss: 0.7044
- val_accuracy: 0.7080
Epoch 35/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8426 - accuracy: 0.6624 - val_loss: 0.7344
- val_accuracy: 0.7011
Epoch 36/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8268 - accuracy: 0.6715 - val_loss: 0.7316
- val_accuracy: 0.7046
Epoch 37/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8247 - accuracy: 0.6707 - val_loss: 0.7358
- val_accuracy: 0.6908
Epoch 38/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8303 - accuracy: 0.6683 - val_loss: 0.7278
- val_accuracy: 0.7195
Epoch 39/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8244 - accuracy: 0.6709 - val_loss: 0.7384
- val_accuracy: 0.6977
Epoch 40/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8269 - accuracy: 0.6673 - val_loss: 0.7134
- val_accuracy: 0.7057
Epoch 41/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8270 - accuracy: 0.6695 - val_loss: 0.7259
- val_accuracy: 0.6943
Epoch 42/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8357 - accuracy: 0.6677 - val_loss: 0.7120
- val_accuracy: 0.7184
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8303 - accuracy: 0.6675 - val_loss: 0.7421
- val_accuracy: 0.6851
Epoch 44/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8283 - accuracy: 0.6709 - val_loss: 0.7027
- val_accuracy: 0.7207
Epoch 45/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8331 - accuracy: 0.6743 - val_loss: 0.7960
- val_accuracy: 0.6736
- val_accuracy: 0.6780
Epoch 46/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8391 - accuracy: 0.6687 - val_loss: 0.7414
- val_accuracy: 0.6908
Epoch 47/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8282 - accuracy: 0.6707 - val_loss: 0.7421
- val_accuracy: 0.6862
Epoch 48/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8207 - accuracy: 0.6635 - val_loss: 0.7609
- val_accuracy: 0.6793
Epoch 49/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8335 - accuracy: 0.6622 - val_loss: 0.7174
- val_accuracy: 0.7218
Epoch 50/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8381 - accuracy: 0.6624 - val_loss: 0.7365
- val_accuracy: 0.6793
Epoch 51/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8194 - accuracy: 0.6741 - val_loss: 0.7936
- val_accuracy: 0.6770
Epoch 52/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8191 - accuracy: 0.6673 - val_loss: 0.7254
- val_accuracy: 0.7034
Epoch 53/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8140 - accuracy: 0.6771 - val_loss: 0.7754
- val_accuracy: 0.6805
Epoch 54/100
498/498 [==============================] - 22s 45ms/step - loss: 0.8128 - accuracy: 0.6781 - val_loss: 0.7348
- val_accuracy: 0.7023
Epoch 55/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8054 - accuracy: 0.6759 - val_loss: 0.7347
- val_accuracy: 0.7069
Epoch 56/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8408 - accuracy: 0.6592 - val_loss: 0.7178
- val_accuracy: 0.7115
Epoch 57/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8120 - accuracy: 0.6757 - val_loss: 0.7070
- val_accuracy: 0.7218
Epoch 58/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8231 - accuracy: 0.6671 - val_loss: 0.7223
- val_accuracy: 0.7138
Epoch 59/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8251 - accuracy: 0.6721 - val_loss: 0.7292
- val_accuracy: 0.6989
Epoch 60/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8036 - accuracy: 0.6827 - val_loss: 0.7049
- val_accuracy: 0.7172
Epoch 61/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8232 - accuracy: 0.6709 - val_loss: 0.7124
- val_accuracy: 0.7126
Epoch 62/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8266 - accuracy: 0.6687 - val_loss: 0.7357
- val_accuracy: 0.6931
Epoch 63/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8240 - accuracy: 0.6631 - val_loss: 0.7338
- val_accuracy: 0.6989
Epoch 64/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8330 - accuracy: 0.6669 - val_loss: 0.7130
- val_accuracy: 0.7080
Epoch 65/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8173 - accuracy: 0.6733 - val_loss: 0.7305
- val_accuracy: 0.7046
Epoch 66/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8087 - accuracy: 0.6769 - val_loss: 0.7496
- val_accuracy: 0.6897
Epoch 67/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8112 - accuracy: 0.6753 - val_loss: 0.7280
- val_accuracy: 0.7149
Epoch 68/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8263 - accuracy: 0.6719 - val_loss: 0.7533
- val_accuracy: 0.6874
Epoch 69/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8232 - accuracy: 0.6747 - val_loss: 0.7184
- val_accuracy: 0.7184
Epoch 70/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8099 - accuracy: 0.6743 - val_loss: 0.7318
- val_accuracy: 0.6989
Epoch 71/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8154 - accuracy: 0.6773 - val_loss: 0.7379
```

```
498/498 [==============================] - 21s 43ms/step - loss: 0.8154 - accuracy: 0.6775 - val_loss: 0.7379
- val_accuracy: 0.7138
Epoch 72/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8143 - accuracy: 0.6799 - val_loss: 0.7153
- val_accuracy: 0.7103
Epoch 73/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8184 - accuracy: 0.6787 - val_loss: 0.7177
- val_accuracy: 0.7207
Epoch 74/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8120 - accuracy: 0.6745 - val_loss: 0.7236
- val_accuracy: 0.6931
Epoch 75/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8168 - accuracy: 0.6739 - val_loss: 0.7177
- val_accuracy: 0.7138
Epoch 76/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8067 - accuracy: 0.6745 - val_loss: 0.7298
- val_accuracy: 0.7069
Epoch 77/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8175 - accuracy: 0.6725 - val_loss: 0.7476
- val_accuracy: 0.6966
Epoch 78/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8024 - accuracy: 0.6771 - val_loss: 0.7146
- val_accuracy: 0.6989
Epoch 79/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8075 - accuracy: 0.6757 - val_loss: 0.7274
- val_accuracy: 0.6977
Epoch 80/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8046 - accuracy: 0.6687 - val_loss: 0.7471
- val_accuracy: 0.6862
Epoch 81/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8045 - accuracy: 0.6743 - val_loss: 0.7217
- val_accuracy: 0.7184
Epoch 82/100
498/498 [==============================] - 23s 46ms/step - loss: 0.8079 - accuracy: 0.6725 - val_loss: 0.7135
- val_accuracy: 0.7138
Epoch 83/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7932 - accuracy: 0.6845 - val_loss: 0.7473
- val_accuracy: 0.6931
Epoch 84/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7969 - accuracy: 0.6807 - val_loss: 0.7239
- val_accuracy: 0.6897
Epoch 85/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8083 - accuracy: 0.6747 - val_loss: 0.7422
- val_accuracy: 0.6977
Epoch 86/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8084 - accuracy: 0.6755 - val_loss: 0.7439
- val_accuracy: 0.7023
Epoch 87/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8075 - accuracy: 0.6797 - val_loss: 0.7139
- val_accuracy: 0.7126
Epoch 88/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7906 - accuracy: 0.6833 - val_loss: 0.7261
- val_accuracy: 0.6908
Epoch 89/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8084 - accuracy: 0.6763 - val_loss: 0.7015
- val_accuracy: 0.7138
Epoch 90/100
498/498 [==============================] - 21s 43ms/step - loss: 0.8073 - accuracy: 0.6795 - val_loss: 0.6975
- val_accuracy: 0.7161
Epoch 91/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8181 - accuracy: 0.6813 - val_loss: 0.7071
- val_accuracy: 0.7092
Epoch 92/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7976 - accuracy: 0.6807 - val_loss: 0.6861
- val_accuracy: 0.7264
Epoch 93/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7935 - accuracy: 0.6886 - val_loss: 0.7578
- val_accuracy: 0.7011
Epoch 94/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7988 - accuracy: 0.6813 - val_loss: 0.6923
- val_accuracy: 0.7264
Epoch 95/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7968 - accuracy: 0.6855 - val_loss: 0.6907
- val_accuracy: 0.7046
Epoch 96/100
498/498 [==============================] - 24s 48ms/step - loss: 0.8032 - accuracy: 0.6813 - val_loss: 0.7073
- val_accuracy: 0.7161
Epoch 97/100
Epoch 97/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8007 - accuracy: 0.6821 - val_loss: 0.7032
- val_accuracy: 0.6943
Epoch 98/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8043 - accuracy: 0.6813 - val_loss: 0.7319
- val_accuracy: 0.7034
Epoch 99/100
498/498 [==============================] - 20s 41ms/step - loss: 0.8128 - accuracy: 0.6783 - val_loss: 0.7537
- val_accuracy: 0.6828
Epoch 100/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7860 - accuracy: 0.6888 - val_loss: 0.7047
- val_accuracy: 0.7103
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd74d157bd0>
```

epoch cnt:500

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd760829150> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd76082fa90> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboard
```

```
Epoch 1/100
498/498 [==============================] - 24s 49ms/step - loss: 0.8140 - accuracy: 0.6745 - val_loss: 0.7088
- val_accuracy: 0.7000
Epoch 2/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8054 - accuracy: 0.6773 - val_loss: 0.7394
- val_accuracy: 0.6977
Epoch 3/100
498/498 [==============================] - 23s 45ms/step - loss: 0.8032 - accuracy: 0.6819 - val_loss: 0.6963
- val_accuracy: 0.7103
Epoch 4/100
498/498 [==============================] - 21s 42ms/step - loss: 0.8054 - accuracy: 0.6825 - val_loss: 0.7386
- val_accuracy: 0.6943
Epoch 5/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7914 - accuracy: 0.6819 - val_loss: 0.6947
- val_accuracy: 0.7080
Epoch 6/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7879 - accuracy: 0.6928 - val_loss: 0.7007
- val_accuracy: 0.7034
Epoch 7/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7974 - accuracy: 0.6845 - val_loss: 0.7360
- val_accuracy: 0.6954
Epoch 8/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7893 - accuracy: 0.6831 - val_loss: 0.7266
- val_accuracy: 0.7000
Epoch 9/100
498/498 [==============================] - 22s 44ms/step - loss: 0.8054 - accuracy: 0.6739 - val_loss: 0.7190
- val_accuracy: 0.7069
Epoch 10/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7935 - accuracy: 0.6876 - val_loss: 0.7039
- val_accuracy: 0.7126
Epoch 11/100
498/498 [==============================] - 21s 41ms/step - loss: 0.8031 - accuracy: 0.6787 - val_loss: 0.7026
- val_accuracy: 0.7138
Epoch 12/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7875 - accuracy: 0.6894 - val_loss: 0.7304
- val_accuracy: 0.7046
Epoch 13/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7953 - accuracy: 0.6845 - val_loss: 0.7456
- val_accuracy: 0.7034
Epoch 14/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7932 - accuracy: 0.6867 - val_loss: 0.6884
```

```
498/498 [==============================] - 21s 43ms/step - loss: 0.79[illegible] - accuracy: [illegible] - val_loss: [illegible]
- val_accuracy: 0.7138
Epoch 15/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7794 - accuracy: 0.6918 - val_loss: 0.7037
- val_accuracy: 0.7046
Epoch 16/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7870 - accuracy: 0.6839 - val_loss: 0.7056
- val_accuracy: 0.7057
Epoch 17/100
498/498 [==============================] - 23s 46ms/step - loss: 0.7928 - accuracy: 0.6890 - val_loss: 0.7029
- val_accuracy: 0.6920
Epoch 18/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7861 - accuracy: 0.6906 - val_loss: 0.6977
- val_accuracy: 0.7046
Epoch 19/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7850 - accuracy: 0.6886 - val_loss: 0.6848
- val_accuracy: 0.7264
Epoch 20/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7916 - accuracy: 0.6910 - val_loss: 0.7054
- val_accuracy: 0.7149
Epoch 21/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7920 - accuracy: 0.6882 - val_loss: 0.7328
- val_accuracy: 0.6931
Epoch 22/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7979 - accuracy: 0.6815 - val_loss: 0.6870
- val_accuracy: 0.7218
Epoch 23/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7895 - accuracy: 0.6851 - val_loss: 0.7166
- val_accuracy: 0.7092
Epoch 24/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7957 - accuracy: 0.6835 - val_loss: 0.6819
- val_accuracy: 0.7368
Epoch 25/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7888 - accuracy: 0.6847 - val_loss: 0.7020
- val_accuracy: 0.7057
Epoch 26/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7908 - accuracy: 0.6803 - val_loss: 0.6923
- val_accuracy: 0.7184
Epoch 27/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7922 - accuracy: 0.6865 - val_loss: 0.7084
- val_accuracy: 0.7069
Epoch 28/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7723 - accuracy: 0.6884 - val_loss: 0.6913
- val_accuracy: 0.7184
Epoch 29/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7725 - accuracy: 0.6894 - val_loss: 0.6885
- val_accuracy: 0.7264
Epoch 30/100
498/498 [==============================] - 22s 43ms/step - loss: 0.8028 - accuracy: 0.6787 - val_loss: 0.7137
- val_accuracy: 0.7149
Epoch 31/100
498/498 [==============================] - 23s 46ms/step - loss: 0.7997 - accuracy: 0.6833 - val_loss: 0.6917
- val_accuracy: 0.7184
Epoch 32/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7672 - accuracy: 0.6952 - val_loss: 0.7023
- val_accuracy: 0.7138
Epoch 33/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7752 - accuracy: 0.6938 - val_loss: 0.7171
- val_accuracy: 0.7126
Epoch 34/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7828 - accuracy: 0.6869 - val_loss: 0.6843
- val_accuracy: 0.7207
Epoch 35/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7777 - accuracy: 0.6972 - val_loss: 0.6771
- val_accuracy: 0.7276
Epoch 36/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7822 - accuracy: 0.6930 - val_loss: 0.6764
- val_accuracy: 0.7287
Epoch 37/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7838 - accuracy: 0.6851 - val_loss: 0.6841
- val_accuracy: 0.7218
Epoch 38/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7781 - accuracy: 0.6886 - val_loss: 0.6872
- val_accuracy: 0.7184
Epoch 39/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7765 - accuracy: 0.6863 - val_loss: 0.6885
- val_accuracy: 0.7103
Epoch 40/100
Epoch 40/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7806 - accuracy: 0.6851 - val_loss: 0.7175
- val_accuracy: 0.6931
Epoch 41/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7789 - accuracy: 0.6902 - val_loss: 0.7181
- val_accuracy: 0.7092
Epoch 42/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7791 - accuracy: 0.6942 - val_loss: 0.6996
- val_accuracy: 0.7161
Epoch 43/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7778 - accuracy: 0.6833 - val_loss: 0.7171
- val_accuracy: 0.6943
Epoch 44/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7659 - accuracy: 0.6956 - val_loss: 0.7056
- val_accuracy: 0.7149
Epoch 45/100
498/498 [==============================] - 23s 46ms/step - loss: 0.7678 - accuracy: 0.6904 - val_loss: 0.7012
- val_accuracy: 0.7149
Epoch 46/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7810 - accuracy: 0.6916 - val_loss: 0.7046
- val_accuracy: 0.7149
Epoch 47/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7699 - accuracy: 0.6914 - val_loss: 0.6787
- val_accuracy: 0.7241
Epoch 48/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7817 - accuracy: 0.6992 - val_loss: 0.6875
- val_accuracy: 0.7218
Epoch 49/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7840 - accuracy: 0.6880 - val_loss: 0.6751
- val_accuracy: 0.7299
Epoch 50/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7617 - accuracy: 0.6972 - val_loss: 0.6901
- val_accuracy: 0.7241
Epoch 51/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7890 - accuracy: 0.6813 - val_loss: 0.6824
- val_accuracy: 0.7230
Epoch 52/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7679 - accuracy: 0.6980 - val_loss: 0.6835
- val_accuracy: 0.7276
Epoch 53/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7798 - accuracy: 0.6916 - val_loss: 0.7282
- val_accuracy: 0.7069
Epoch 54/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7742 - accuracy: 0.6950 - val_loss: 0.6821
- val_accuracy: 0.7195
Epoch 55/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7867 - accuracy: 0.6853 - val_loss: 0.7272
- val_accuracy: 0.6977
Epoch 56/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7690 - accuracy: 0.7010 - val_loss: 0.6960
- val_accuracy: 0.7057
Epoch 57/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7668 - accuracy: 0.6932 - val_loss: 0.6876
- val_accuracy: 0.7218
Epoch 58/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7792 - accuracy: 0.6954 - val_loss: 0.6866
- val_accuracy: 0.7299
Epoch 59/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7705 - accuracy: 0.6932 - val_loss: 0.6922
- val_accuracy: 0.7241
Epoch 60/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7734 - accuracy: 0.6906 - val_loss: 0.7033
- val_accuracy: 0.7092
Epoch 61/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7750 - accuracy: 0.6841 - val_loss: 0.7001
- val_accuracy: 0.6954
Epoch 62/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7649 - accuracy: 0.6944 - val_loss: 0.6855
- val_accuracy: 0.7149
Epoch 63/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7689 - accuracy: 0.6960 - val_loss: 0.6885
- val_accuracy: 0.7149
Epoch 64/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7736 - accuracy: 0.6884 - val_loss: 0.6730
- val_accuracy: 0.7287
Epoch 65/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7755 - accuracy: 0.6914 - val_loss: 0.6632
- val_accuracy: 0.7230
- val_accuracy: 0.7230
Epoch 66/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7797 - accuracy: 0.6865 - val_loss: 0.6857
- val_accuracy: 0.7402
Epoch 67/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7598 - accuracy: 0.6992 - val_loss: 0.6697
- val_accuracy: 0.7207
Epoch 68/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7707 - accuracy: 0.6882 - val_loss: 0.7319
- val_accuracy: 0.7034
Epoch 69/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7633 - accuracy: 0.7032 - val_loss: 0.6897
- val_accuracy: 0.7172
Epoch 70/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7656 - accuracy: 0.6898 - val_loss: 0.7541
- val_accuracy: 0.6862
Epoch 71/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7462 - accuracy: 0.7056 - val_loss: 0.7257
- val_accuracy: 0.7023
Epoch 72/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7525 - accuracy: 0.6922 - val_loss: 0.7339
- val_accuracy: 0.6897
Epoch 73/100
498/498 [==============================] - 23s 47ms/step - loss: 0.7692 - accuracy: 0.6904 - val_loss: 0.6856
- val_accuracy: 0.7218
Epoch 74/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7561 - accuracy: 0.6948 - val_loss: 0.7124
- val_accuracy: 0.7103
Epoch 75/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7605 - accuracy: 0.6924 - val_loss: 0.7171
- val_accuracy: 0.7000
Epoch 76/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7660 - accuracy: 0.6988 - val_loss: 0.6939
- val_accuracy: 0.7034
Epoch 77/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7533 - accuracy: 0.6976 - val_loss: 0.6694
- val_accuracy: 0.7230
Epoch 78/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7705 - accuracy: 0.6894 - val_loss: 0.7288
- val_accuracy: 0.6931
Epoch 79/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7465 - accuracy: 0.7056 - val_loss: 0.6947
- val_accuracy: 0.7172
Epoch 80/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7620 - accuracy: 0.6994 - val_loss: 0.6983
- val_accuracy: 0.7069
Epoch 81/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7524 - accuracy: 0.7072 - val_loss: 0.7290
- val_accuracy: 0.6954
Epoch 82/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7710 - accuracy: 0.6972 - val_loss: 0.6922
- val_accuracy: 0.7138
Epoch 83/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7605 - accuracy: 0.6922 - val_loss: 0.6731
- val_accuracy: 0.7264
Epoch 84/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7637 - accuracy: 0.6948 - val_loss: 0.7040
- val_accuracy: 0.7115
Epoch 85/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7585 - accuracy: 0.7000 - val_loss: 0.6793
- val_accuracy: 0.7126
Epoch 86/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7513 - accuracy: 0.6972 - val_loss: 0.6961
- val_accuracy: 0.7149
Epoch 87/100
498/498 [==============================] - 22s 45ms/step - loss: 0.7490 - accuracy: 0.7034 - val_loss: 0.6776
- val_accuracy: 0.7184
Epoch 88/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7372 - accuracy: 0.7096 - val_loss: 0.6675
- val_accuracy: 0.7299
Epoch 89/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7620 - accuracy: 0.6952 - val_loss: 0.6758
- val_accuracy: 0.7218
Epoch 90/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7626 - accuracy: 0.6994 - val_loss: 0.7198
- val_accuracy: 0.7103
Epoch 91/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7486 - accuracy: 0.6996 - val_loss: 0.6813
```

```
498/498 [==============================] - 21s 42ms/step - loss: 0.7486 - accuracy: 0.6996 - val_loss: 0.6815
- val_accuracy: 0.7126
Epoch 92/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7609 - accuracy: 0.6912 - val_loss: 0.6782
- val_accuracy: 0.7149
Epoch 93/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7690 - accuracy: 0.6966 - val_loss: 0.6749
- val_accuracy: 0.7184
Epoch 94/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7524 - accuracy: 0.6970 - val_loss: 0.7225
- val_accuracy: 0.6943
Epoch 95/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7598 - accuracy: 0.6980 - val_loss: 0.6715
- val_accuracy: 0.7207
Epoch 96/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7522 - accuracy: 0.7076 - val_loss: 0.6886
- val_accuracy: 0.7310
Epoch 97/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7591 - accuracy: 0.6970 - val_loss: 0.6828
- val_accuracy: 0.7115
Epoch 98/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7330 - accuracy: 0.7118 - val_loss: 0.6495
- val_accuracy: 0.7379
Epoch 99/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7580 - accuracy: 0.6918 - val_loss: 0.6765
- val_accuracy: 0.7230
Epoch 100/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7438 - accuracy: 0.7052 - val_loss: 0.6892
- val_accuracy: 0.7184
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd80007dc90>
```

epoch cnt:600

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd760829150> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd76082fa90> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
model= tf.keras.models.load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model')
```

In [ ]:

```
from keras import backend as K
K.set_value(model.optimizer.learning_rate, 0.000001)
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                   validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Epoch 1/100
498/498 [==============================] - 23s 42ms/step - loss: 0.7500 - accuracy: 0.6950 - val_loss: 0.6653
- val_accuracy: 0.7333
Epoch 2/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7269 - accuracy: 0.7084 - val_loss: 0.6694
- val_accuracy: 0.7322
Epoch 3/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7203 - accuracy: 0.7133 - val_loss: 0.6686
- val_accuracy: 0.7287
Epoch 4/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7326 - accuracy: 0.7110 - val_loss: 0.6642
- val_accuracy: 0.7264
Epoch 5/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7103 - accuracy: 0.7213 - val_loss: 0.6584
- val_accuracy: 0.7322
Epoch 6/100
498/498 [==============================] - 22s 45ms/step - loss: 0.7094 - accuracy: 0.7179 - val_loss: 0.6628
- val_accuracy: 0.7333
Epoch 7/100
```

```
498/498 [==============================] - 21s 43ms/step - loss: 0.7200 - accuracy: 0.7173 - val_loss: 0.6589
- val_accuracy: 0.7333
Epoch 8/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7206 - accuracy: 0.7169 - val_loss: 0.6516
- val_accuracy: 0.7368
Epoch 9/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7150 - accuracy: 0.7187 - val_loss: 0.6596
- val_accuracy: 0.7322
Epoch 10/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7211 - accuracy: 0.7165 - val_loss: 0.6544
- val_accuracy: 0.7345
Epoch 11/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7103 - accuracy: 0.7171 - val_loss: 0.6557
- val_accuracy: 0.7322
Epoch 12/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7072 - accuracy: 0.7167 - val_loss: 0.6545
- val_accuracy: 0.7333
Epoch 13/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7089 - accuracy: 0.7175 - val_loss: 0.6570
- val_accuracy: 0.7287
Epoch 14/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7150 - accuracy: 0.7163 - val_loss: 0.6562
- val_accuracy: 0.7276
Epoch 15/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7175 - accuracy: 0.7120 - val_loss: 0.6547
- val_accuracy: 0.7322
Epoch 16/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6879 - accuracy: 0.7257 - val_loss: 0.6487
- val_accuracy: 0.7276
Epoch 17/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7003 - accuracy: 0.7191 - val_loss: 0.6530
- val_accuracy: 0.7276
Epoch 18/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7168 - accuracy: 0.7088 - val_loss: 0.6553
- val_accuracy: 0.7264
Epoch 19/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6898 - accuracy: 0.7205 - val_loss: 0.6531
- val_accuracy: 0.7333
Epoch 20/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7107 - accuracy: 0.7275 - val_loss: 0.6488
- val_accuracy: 0.7310
Epoch 21/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6950 - accuracy: 0.7291 - val_loss: 0.6540
- val_accuracy: 0.7287
Epoch 22/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6958 - accuracy: 0.7247 - val_loss: 0.6570
- val_accuracy: 0.7230
Epoch 23/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7237 - accuracy: 0.7205 - val_loss: 0.6565
- val_accuracy: 0.7264
Epoch 24/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7068 - accuracy: 0.7193 - val_loss: 0.6525
- val_accuracy: 0.7264
Epoch 25/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7030 - accuracy: 0.7257 - val_loss: 0.6524
- val_accuracy: 0.7310
Epoch 26/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7013 - accuracy: 0.7219 - val_loss: 0.6488
- val_accuracy: 0.7333
Epoch 27/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7049 - accuracy: 0.7191 - val_loss: 0.6473
- val_accuracy: 0.7310
Epoch 28/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7057 - accuracy: 0.7233 - val_loss: 0.6387
- val_accuracy: 0.7345
Epoch 29/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7038 - accuracy: 0.7163 - val_loss: 0.6507
- val_accuracy: 0.7276
Epoch 30/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6920 - accuracy: 0.7237 - val_loss: 0.6519
- val_accuracy: 0.7253
Epoch 31/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7057 - accuracy: 0.7203 - val_loss: 0.6493
- val_accuracy: 0.7241
Epoch 32/100
498/498 [==============================] - 20s 40ms/step - loss: 0.7144 - accuracy: 0.7185 - val_loss: 0.6546
- val_accuracy: 0.7218
```

```
Epoch 33/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6982 - accuracy: 0.7201 - val_loss: 0.6552
- val_accuracy: 0.7241
Epoch 34/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7070 - accuracy: 0.7185 - val_loss: 0.6524
- val_accuracy: 0.7264
Epoch 35/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7093 - accuracy: 0.7219 - val_loss: 0.6498
- val_accuracy: 0.7253
Epoch 36/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6905 - accuracy: 0.7297 - val_loss: 0.6520
- val_accuracy: 0.7253
Epoch 37/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6953 - accuracy: 0.7261 - val_loss: 0.6528
- val_accuracy: 0.7264
Epoch 38/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6922 - accuracy: 0.7315 - val_loss: 0.6513
- val_accuracy: 0.7253
Epoch 39/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7062 - accuracy: 0.7159 - val_loss: 0.6522
- val_accuracy: 0.7241
Epoch 40/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7005 - accuracy: 0.7205 - val_loss: 0.6496
- val_accuracy: 0.7264
Epoch 41/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7111 - accuracy: 0.7135 - val_loss: 0.6526
- val_accuracy: 0.7264
Epoch 42/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7138 - accuracy: 0.7171 - val_loss: 0.6515
- val_accuracy: 0.7264
Epoch 43/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6951 - accuracy: 0.7263 - val_loss: 0.6474
- val_accuracy: 0.7276
Epoch 44/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7065 - accuracy: 0.7227 - val_loss: 0.6475
- val_accuracy: 0.7287
Epoch 45/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7216 - accuracy: 0.7159 - val_loss: 0.6540
- val_accuracy: 0.7276
Epoch 46/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6956 - accuracy: 0.7269 - val_loss: 0.6491
- val_accuracy: 0.7264
Epoch 47/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6986 - accuracy: 0.7181 - val_loss: 0.6462
- val_accuracy: 0.7287
Epoch 48/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7023 - accuracy: 0.7237 - val_loss: 0.6519
- val_accuracy: 0.7287
Epoch 49/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6917 - accuracy: 0.7327 - val_loss: 0.6467
- val_accuracy: 0.7322
Epoch 50/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7098 - accuracy: 0.7179 - val_loss: 0.6496
- val_accuracy: 0.7287
Epoch 51/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7017 - accuracy: 0.7151 - val_loss: 0.6541
- val_accuracy: 0.7230
Epoch 52/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7093 - accuracy: 0.7201 - val_loss: 0.6540
- val_accuracy: 0.7253
Epoch 53/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7019 - accuracy: 0.7281 - val_loss: 0.6535
- val_accuracy: 0.7241
Epoch 54/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6915 - accuracy: 0.7223 - val_loss: 0.6508
- val_accuracy: 0.7253
Epoch 55/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7000 - accuracy: 0.7223 - val_loss: 0.6549
- val_accuracy: 0.7264
Epoch 56/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7009 - accuracy: 0.7201 - val_loss: 0.6533
- val_accuracy: 0.7253
Epoch 57/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6898 - accuracy: 0.7249 - val_loss: 0.6567
- val_accuracy: 0.7230
Epoch 58/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6945 - accuracy: 0.7209 - val_loss: 0.6545
```

```
- val_accuracy: 0.7230
Epoch 59/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6883 - accuracy: 0.7271 - val_loss: 0.6529
- val_accuracy: 0.7241
Epoch 60/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6924 - accuracy: 0.7259 - val_loss: 0.6558
- val_accuracy: 0.7241
Epoch 61/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7045 - accuracy: 0.7137 - val_loss: 0.6500
- val_accuracy: 0.7264
Epoch 62/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6992 - accuracy: 0.7219 - val_loss: 0.6517
- val_accuracy: 0.7241
Epoch 63/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7109 - accuracy: 0.7122 - val_loss: 0.6548
- val_accuracy: 0.7230
Epoch 64/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6966 - accuracy: 0.7195 - val_loss: 0.6490
- val_accuracy: 0.7253
Epoch 65/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6925 - accuracy: 0.7263 - val_loss: 0.6535
- val_accuracy: 0.7218
Epoch 66/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7038 - accuracy: 0.7249 - val_loss: 0.6537
- val_accuracy: 0.7264
Epoch 67/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6838 - accuracy: 0.7241 - val_loss: 0.6505
- val_accuracy: 0.7241
Epoch 68/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6941 - accuracy: 0.7185 - val_loss: 0.6500
- val_accuracy: 0.7276
Epoch 69/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6967 - accuracy: 0.7213 - val_loss: 0.6506
- val_accuracy: 0.7264
Epoch 70/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6882 - accuracy: 0.7243 - val_loss: 0.6531
- val_accuracy: 0.7264
Epoch 71/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6859 - accuracy: 0.7303 - val_loss: 0.6514
- val_accuracy: 0.7241
Epoch 72/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7048 - accuracy: 0.7251 - val_loss: 0.6525
- val_accuracy: 0.7264
Epoch 73/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6912 - accuracy: 0.7255 - val_loss: 0.6508
- val_accuracy: 0.7276
Epoch 74/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6972 - accuracy: 0.7269 - val_loss: 0.6518
- val_accuracy: 0.7287
Epoch 75/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6993 - accuracy: 0.7187 - val_loss: 0.6506
- val_accuracy: 0.7276
Epoch 76/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6951 - accuracy: 0.7273 - val_loss: 0.6490
- val_accuracy: 0.7299
Epoch 77/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6952 - accuracy: 0.7255 - val_loss: 0.6489
- val_accuracy: 0.7310
Epoch 78/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6964 - accuracy: 0.7311 - val_loss: 0.6523
- val_accuracy: 0.7299
Epoch 79/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6993 - accuracy: 0.7225 - val_loss: 0.6484
- val_accuracy: 0.7287
Epoch 80/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7068 - accuracy: 0.7141 - val_loss: 0.6514
- val_accuracy: 0.7287
Epoch 81/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7028 - accuracy: 0.7217 - val_loss: 0.6518
- val_accuracy: 0.7276
Epoch 82/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7047 - accuracy: 0.7241 - val_loss: 0.6516
- val_accuracy: 0.7287
Epoch 83/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6933 - accuracy: 0.7245 - val_loss: 0.6467
- val_accuracy: 0.7264
Epoch 84/100
Epoch 84/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6922 - accuracy: 0.7303 - val_loss: 0.6495
- val_accuracy: 0.7310
Epoch 85/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6881 - accuracy: 0.7271 - val_loss: 0.6489
- val_accuracy: 0.7287
Epoch 86/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7015 - accuracy: 0.7239 - val_loss: 0.6470
- val_accuracy: 0.7322
Epoch 87/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6957 - accuracy: 0.7291 - val_loss: 0.6465
- val_accuracy: 0.7322
Epoch 88/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6924 - accuracy: 0.7241 - val_loss: 0.6490
- val_accuracy: 0.7287
Epoch 89/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7174 - accuracy: 0.7157 - val_loss: 0.6474
- val_accuracy: 0.7299
Epoch 90/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6967 - accuracy: 0.7253 - val_loss: 0.6478
- val_accuracy: 0.7310
Epoch 91/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6923 - accuracy: 0.7219 - val_loss: 0.6516
- val_accuracy: 0.7276
Epoch 92/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7087 - accuracy: 0.7145 - val_loss: 0.6485
- val_accuracy: 0.7287
Epoch 93/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6819 - accuracy: 0.7303 - val_loss: 0.6500
- val_accuracy: 0.7310
Epoch 94/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6924 - accuracy: 0.7217 - val_loss: 0.6503
- val_accuracy: 0.7299
Epoch 95/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6940 - accuracy: 0.7259 - val_loss: 0.6502
- val_accuracy: 0.7299
Epoch 96/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6979 - accuracy: 0.7249 - val_loss: 0.6517
- val_accuracy: 0.7241
Epoch 97/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6854 - accuracy: 0.7225 - val_loss: 0.6475
- val_accuracy: 0.7287
Epoch 98/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7046 - accuracy: 0.7225 - val_loss: 0.6485
- val_accuracy: 0.7287
Epoch 99/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7049 - accuracy: 0.7179 - val_loss: 0.6501
- val_accuracy: 0.7299
Epoch 100/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6933 - accuracy: 0.7197 - val_loss: 0.6512
- val_accuracy: 0.7276
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd787add990>
```

epoch cnt:700

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model2',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model2/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model2/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd8000aab90> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd8000ca050> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
model = tf.keras.models.load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model')
```

In [ ]:

```
from keras import backend as K
```

```
K.set_value(model.optimizer.learning_rate, 0.00005)
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboard
```

```
Epoch 1/100
498/498 [==============================] - 22s 41ms/step - loss: 0.7268 - accuracy: 0.7062 - val_loss: 0.6803
- val_accuracy: 0.7253
Epoch 2/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7224 - accuracy: 0.7145 - val_loss: 0.6564
- val_accuracy: 0.7379
Epoch 3/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7165 - accuracy: 0.7141 - val_loss: 0.6678
- val_accuracy: 0.7287
Epoch 4/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7207 - accuracy: 0.7127 - val_loss: 0.6600
- val_accuracy: 0.7310
Epoch 5/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7181 - accuracy: 0.7120 - val_loss: 0.6654
- val_accuracy: 0.7310
Epoch 6/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7055 - accuracy: 0.7139 - val_loss: 0.6545
- val_accuracy: 0.7368
Epoch 7/100
498/498 [==============================] - 22s 45ms/step - loss: 0.7210 - accuracy: 0.7110 - val_loss: 0.6610
- val_accuracy: 0.7218
Epoch 8/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7107 - accuracy: 0.7153 - val_loss: 0.6621
- val_accuracy: 0.7345
Epoch 9/100
498/498 [==============================] - 23s 46ms/step - loss: 0.7308 - accuracy: 0.7082 - val_loss: 0.6755
- val_accuracy: 0.7299
Epoch 10/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7159 - accuracy: 0.7149 - val_loss: 0.6682
- val_accuracy: 0.7207
Epoch 11/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7063 - accuracy: 0.7173 - val_loss: 0.6398
- val_accuracy: 0.7345
Epoch 12/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7280 - accuracy: 0.7084 - val_loss: 0.6937
- val_accuracy: 0.7207
Epoch 13/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7197 - accuracy: 0.7108 - val_loss: 0.6658
- val_accuracy: 0.7253
Epoch 14/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7128 - accuracy: 0.7147 - val_loss: 0.6981
- val_accuracy: 0.7057
Epoch 15/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7066 - accuracy: 0.7213 - val_loss: 0.6576
- val_accuracy: 0.7230
Epoch 16/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7030 - accuracy: 0.7120 - val_loss: 0.6536
- val_accuracy: 0.7264
Epoch 17/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7180 - accuracy: 0.7205 - val_loss: 0.6819
- val_accuracy: 0.7184
Epoch 18/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7222 - accuracy: 0.7155 - val_loss: 0.6597
- val_accuracy: 0.7379
Epoch 19/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7064 - accuracy: 0.7235 - val_loss: 0.6798
- val_accuracy: 0.7356
Epoch 20/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7072 - accuracy: 0.7213 - val_loss: 0.6498
- val_accuracy: 0.7345
Epoch 21/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7107 - accuracy: 0.7175 - val_loss: 0.6672
- val_accuracy: 0.7310
Epoch 22/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7029 - accuracy: 0.7175 - val_loss: 0.6638
- val_accuracy: 0.7368
Epoch 23/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7068 - accuracy: 0.7211 - val_loss: 0.6772
- val_accuracy: 0.7264
Epoch 24/100
498/498 [==============================] - 22s 45ms/step - loss: 0.7340 - accuracy: 0.7056 - val_loss: 0.6987
- val_accuracy: 0.7069
Epoch 25/100
```

```
498/498 [==============================] - 21s 42ms/step - loss: 0.7131 - accuracy: 0.7114 - val_loss: 0.6925
- val_accuracy: 0.7115
Epoch 26/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7136 - accuracy: 0.7223 - val_loss: 0.6552
- val_accuracy: 0.7299
Epoch 27/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7117 - accuracy: 0.7163 - val_loss: 0.6434
- val_accuracy: 0.7310
Epoch 28/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7005 - accuracy: 0.7217 - val_loss: 0.6491
- val_accuracy: 0.7287
Epoch 29/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7170 - accuracy: 0.7159 - val_loss: 0.6716
- val_accuracy: 0.7310
Epoch 30/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7045 - accuracy: 0.7229 - val_loss: 0.6693
- val_accuracy: 0.7230
Epoch 31/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7131 - accuracy: 0.7151 - val_loss: 0.6538
- val_accuracy: 0.7310
Epoch 32/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7148 - accuracy: 0.7241 - val_loss: 0.6681
- val_accuracy: 0.7172
Epoch 33/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7112 - accuracy: 0.7179 - val_loss: 0.6533
- val_accuracy: 0.7391
Epoch 34/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7077 - accuracy: 0.7165 - val_loss: 0.6543
- val_accuracy: 0.7333
Epoch 35/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6953 - accuracy: 0.7229 - val_loss: 0.6568
- val_accuracy: 0.7368
Epoch 36/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7142 - accuracy: 0.7161 - val_loss: 0.6585
- val_accuracy: 0.7276
Epoch 37/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7103 - accuracy: 0.7245 - val_loss: 0.6431
- val_accuracy: 0.7379
Epoch 38/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7192 - accuracy: 0.7084 - val_loss: 0.6436
- val_accuracy: 0.7402
Epoch 39/100
498/498 [==============================] - 24s 48ms/step - loss: 0.7127 - accuracy: 0.7205 - val_loss: 0.6454
- val_accuracy: 0.7368
Epoch 40/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7122 - accuracy: 0.7205 - val_loss: 0.6505
- val_accuracy: 0.7368
Epoch 41/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7223 - accuracy: 0.7114 - val_loss: 0.6491
- val_accuracy: 0.7402
Epoch 42/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7132 - accuracy: 0.7145 - val_loss: 0.6566
- val_accuracy: 0.7299
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7009 - accuracy: 0.7193 - val_loss: 0.6630
- val_accuracy: 0.7345
Epoch 44/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6880 - accuracy: 0.7261 - val_loss: 0.6869
- val_accuracy: 0.7115
Epoch 45/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7136 - accuracy: 0.7135 - val_loss: 0.6543
- val_accuracy: 0.7276
Epoch 46/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7118 - accuracy: 0.7209 - val_loss: 0.6753
- val_accuracy: 0.7287
Epoch 47/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7087 - accuracy: 0.7137 - val_loss: 0.6793
- val_accuracy: 0.7276
Epoch 48/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6896 - accuracy: 0.7229 - val_loss: 0.6521
- val_accuracy: 0.7322
Epoch 49/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7070 - accuracy: 0.7211 - val_loss: 0.6338
- val_accuracy: 0.7356
Epoch 50/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7031 - accuracy: 0.7165 - val_loss: 0.6534
- val_accuracy: 0.7333
```

```
Epoch 51/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7089 - accuracy: 0.7255 - val_loss: 0.6563
- val_accuracy: 0.7287
Epoch 52/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7064 - accuracy: 0.7181 - val_loss: 0.6659
- val_accuracy: 0.7241
Epoch 53/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6941 - accuracy: 0.7173 - val_loss: 0.6563
- val_accuracy: 0.7218
Epoch 54/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7134 - accuracy: 0.7104 - val_loss: 0.6670
- val_accuracy: 0.7161
Epoch 55/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6946 - accuracy: 0.7177 - val_loss: 0.6823
- val_accuracy: 0.7103
Epoch 56/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6945 - accuracy: 0.7259 - val_loss: 0.6780
- val_accuracy: 0.7253
Epoch 57/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7125 - accuracy: 0.7133 - val_loss: 0.6560
- val_accuracy: 0.7287
Epoch 58/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6966 - accuracy: 0.7193 - val_loss: 0.6529
- val_accuracy: 0.7241
Epoch 59/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6999 - accuracy: 0.7179 - val_loss: 0.6490
- val_accuracy: 0.7276
Epoch 60/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7164 - accuracy: 0.7201 - val_loss: 0.6811
- val_accuracy: 0.7241
Epoch 61/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7181 - accuracy: 0.7167 - val_loss: 0.6551
- val_accuracy: 0.7345
Epoch 62/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6991 - accuracy: 0.7189 - val_loss: 0.6554
- val_accuracy: 0.7356
Epoch 63/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7123 - accuracy: 0.7145 - val_loss: 0.6593
- val_accuracy: 0.7379
Epoch 64/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7025 - accuracy: 0.7227 - val_loss: 0.6711
- val_accuracy: 0.7264
Epoch 65/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7106 - accuracy: 0.7149 - val_loss: 0.6645
- val_accuracy: 0.7368
Epoch 66/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6902 - accuracy: 0.7217 - val_loss: 0.6424
- val_accuracy: 0.7402
Epoch 67/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6969 - accuracy: 0.7243 - val_loss: 0.6580
- val_accuracy: 0.7299
Epoch 68/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7045 - accuracy: 0.7171 - val_loss: 0.6606
- val_accuracy: 0.7276
Epoch 69/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7028 - accuracy: 0.7183 - val_loss: 0.6542
- val_accuracy: 0.7402
Epoch 70/100
498/498 [==============================] - 23s 46ms/step - loss: 0.7065 - accuracy: 0.7193 - val_loss: 0.6603
- val_accuracy: 0.7218
Epoch 71/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6937 - accuracy: 0.7311 - val_loss: 0.6475
- val_accuracy: 0.7287
Epoch 72/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6935 - accuracy: 0.7263 - val_loss: 0.6412
- val_accuracy: 0.7345
Epoch 73/100
498/498 [==============================] - 20s 41ms/step - loss: 0.7117 - accuracy: 0.7175 - val_loss: 0.6374
- val_accuracy: 0.7414
Epoch 74/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6953 - accuracy: 0.7247 - val_loss: 0.6556
- val_accuracy: 0.7310
Epoch 75/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7013 - accuracy: 0.7291 - val_loss: 0.6542
- val_accuracy: 0.7287
Epoch 76/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7014 - accuracy: 0.7139 - val_loss: 0.6703
```

```
- val_accuracy: 0.7172
Epoch 77/100
498/498 [==============================] - 21s 41ms/step - loss: 0.7030 - accuracy: 0.7249 - val_loss: 0.6521
- val_accuracy: 0.7276
Epoch 78/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7107 - accuracy: 0.7157 - val_loss: 0.6524
- val_accuracy: 0.7471
Epoch 79/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7087 - accuracy: 0.7185 - val_loss: 0.6642
- val_accuracy: 0.7368
Epoch 80/100
498/498 [==============================] - 22s 43ms/step - loss: 0.7039 - accuracy: 0.7175 - val_loss: 0.6428
- val_accuracy: 0.7322
Epoch 81/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7033 - accuracy: 0.7165 - val_loss: 0.6759
- val_accuracy: 0.7195
Epoch 82/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6994 - accuracy: 0.7247 - val_loss: 0.6451
- val_accuracy: 0.7425
Epoch 83/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7023 - accuracy: 0.7207 - val_loss: 0.6408
- val_accuracy: 0.7356
Epoch 84/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6973 - accuracy: 0.7245 - val_loss: 0.6566
- val_accuracy: 0.7379
Epoch 85/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6754 - accuracy: 0.7325 - val_loss: 0.6804
- val_accuracy: 0.7207
Epoch 86/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7006 - accuracy: 0.7161 - val_loss: 0.6388
- val_accuracy: 0.7437
Epoch 87/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6872 - accuracy: 0.7311 - val_loss: 0.6493
- val_accuracy: 0.7368
Epoch 88/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7020 - accuracy: 0.7263 - val_loss: 0.6562
- val_accuracy: 0.7241
Epoch 89/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6933 - accuracy: 0.7269 - val_loss: 0.6857
- val_accuracy: 0.7195
Epoch 90/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6873 - accuracy: 0.7323 - val_loss: 0.6559
- val_accuracy: 0.7333
Epoch 91/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6968 - accuracy: 0.7269 - val_loss: 0.6514
- val_accuracy: 0.7322
Epoch 92/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6827 - accuracy: 0.7317 - val_loss: 0.6696
- val_accuracy: 0.7161
Epoch 93/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7023 - accuracy: 0.7161 - val_loss: 0.6834
- val_accuracy: 0.7161
Epoch 94/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6998 - accuracy: 0.7195 - val_loss: 0.6595
- val_accuracy: 0.7264
Epoch 95/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6958 - accuracy: 0.7227 - val_loss: 0.6490
- val_accuracy: 0.7356
Epoch 96/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7012 - accuracy: 0.7163 - val_loss: 0.6411
- val_accuracy: 0.7333
Epoch 97/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6814 - accuracy: 0.7277 - val_loss: 0.6780
- val_accuracy: 0.7241
Epoch 98/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6955 - accuracy: 0.7261 - val_loss: 0.6432
- val_accuracy: 0.7276
Epoch 99/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6914 - accuracy: 0.7273 - val_loss: 0.6479
- val_accuracy: 0.7356
Epoch 100/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6950 - accuracy: 0.7259 - val_loss: 0.6406
- val_accuracy: 0.7494
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd789889550>
```

epoch cnt:800

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd7246ba510> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd7246c14d0> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
def scheduler(epoch, lr):
  if epoch < 10:
    return lr
  else:
    return lr * tf.math.exp(-0.01)

lr_scheduler = tf.keras.callbacks.LearningRateScheduler(scheduler)

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboar
```

```
Epoch 1/100
498/498 [==============================] - 22s 44ms/step - loss: 0.7039 - accuracy: 0.7199 - val_loss: 0.6544
- val_accuracy: 0.7322 - lr: 5.0000e-05
Epoch 2/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6893 - accuracy: 0.7253 - val_loss: 0.6712
- val_accuracy: 0.7310 - lr: 5.0000e-05
Epoch 3/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6864 - accuracy: 0.7249 - val_loss: 0.6631
- val_accuracy: 0.7149 - lr: 5.0000e-05
Epoch 4/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7017 - accuracy: 0.7255 - val_loss: 0.6839
- val_accuracy: 0.7276 - lr: 5.0000e-05
Epoch 5/100
498/498 [==============================] - 21s 42ms/step - loss: 0.7039 - accuracy: 0.7175 - val_loss: 0.6573
- val_accuracy: 0.7333 - lr: 5.0000e-05
Epoch 6/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6899 - accuracy: 0.7325 - val_loss: 0.6442
- val_accuracy: 0.7310 - lr: 5.0000e-05
Epoch 7/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6808 - accuracy: 0.7261 - val_loss: 0.6576
- val_accuracy: 0.7310 - lr: 5.0000e-05
Epoch 8/100
498/498 [==============================] - 24s 49ms/step - loss: 0.6943 - accuracy: 0.7251 - val_loss: 0.6459
- val_accuracy: 0.7368 - lr: 5.0000e-05
Epoch 9/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6884 - accuracy: 0.7279 - val_loss: 0.6747
- val_accuracy: 0.7069 - lr: 5.0000e-05
Epoch 10/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6860 - accuracy: 0.7201 - val_loss: 0.6441
- val_accuracy: 0.7345 - lr: 5.0000e-05
Epoch 11/100
498/498 [==============================] - 21s 43ms/step - loss: 0.7087 - accuracy: 0.7120 - val_loss: 0.6810
- val_accuracy: 0.7195 - lr: 4.9502e-05
Epoch 12/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6874 - accuracy: 0.7283 - val_loss: 0.6312
- val_accuracy: 0.7425 - lr: 4.9010e-05
Epoch 13/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6851 - accuracy: 0.7243 - val_loss: 0.6597
- val_accuracy: 0.7414 - lr: 4.8522e-05
Epoch 14/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6931 - accuracy: 0.7221 - val_loss: 0.6434
- val_accuracy: 0.7391 - lr: 4.8039e-05
Epoch 15/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6874 - accuracy: 0.7295 - val_loss: 0.6831
- val_accuracy: 0.7161 - lr: 4.7561e-05
Epoch 16/100
```

```
498/498 [==============================] - 21s 41ms/step - loss: 0.6984 - accuracy: 0.7173 - val_loss: 0.6716
- val_accuracy: 0.7161 - lr: 4.7088e-05
Epoch 17/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6911 - accuracy: 0.7279 - val_loss: 0.6639
- val_accuracy: 0.7149 - lr: 4.6620e-05
Epoch 18/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6850 - accuracy: 0.7243 - val_loss: 0.6613
- val_accuracy: 0.7276 - lr: 4.6156e-05
Epoch 19/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6916 - accuracy: 0.7277 - val_loss: 0.6520
- val_accuracy: 0.7299 - lr: 4.5697e-05
Epoch 20/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6890 - accuracy: 0.7223 - val_loss: 0.6826
- val_accuracy: 0.7172 - lr: 4.5242e-05
Epoch 21/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6915 - accuracy: 0.7265 - val_loss: 0.6554
- val_accuracy: 0.7253 - lr: 4.4792e-05
Epoch 22/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6816 - accuracy: 0.7337 - val_loss: 0.6542
- val_accuracy: 0.7287 - lr: 4.4346e-05
Epoch 23/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6919 - accuracy: 0.7295 - val_loss: 0.6496
- val_accuracy: 0.7218 - lr: 4.3905e-05
Epoch 24/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6747 - accuracy: 0.7293 - val_loss: 0.6472
- val_accuracy: 0.7230 - lr: 4.3468e-05
Epoch 25/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6822 - accuracy: 0.7315 - val_loss: 0.6511
- val_accuracy: 0.7333 - lr: 4.3035e-05
Epoch 26/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6822 - accuracy: 0.7331 - val_loss: 0.6649
- val_accuracy: 0.7230 - lr: 4.2607e-05
Epoch 27/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6838 - accuracy: 0.7341 - val_loss: 0.6589
- val_accuracy: 0.7207 - lr: 4.2183e-05
Epoch 28/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6752 - accuracy: 0.7281 - val_loss: 0.6636
- val_accuracy: 0.7218 - lr: 4.1764e-05
Epoch 29/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6836 - accuracy: 0.7225 - val_loss: 0.6611
- val_accuracy: 0.7322 - lr: 4.1348e-05
Epoch 30/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6816 - accuracy: 0.7257 - val_loss: 0.6682
- val_accuracy: 0.7276 - lr: 4.0937e-05
Epoch 31/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6974 - accuracy: 0.7185 - val_loss: 0.6504
- val_accuracy: 0.7368 - lr: 4.0529e-05
Epoch 32/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6897 - accuracy: 0.7217 - val_loss: 0.6465
- val_accuracy: 0.7310 - lr: 4.0126e-05
Epoch 33/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6716 - accuracy: 0.7341 - val_loss: 0.6447
- val_accuracy: 0.7437 - lr: 3.9727e-05
Epoch 34/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6826 - accuracy: 0.7255 - val_loss: 0.6813
- val_accuracy: 0.7092 - lr: 3.9331e-05
Epoch 35/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6704 - accuracy: 0.7309 - val_loss: 0.6482
- val_accuracy: 0.7253 - lr: 3.8940e-05
Epoch 36/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6826 - accuracy: 0.7203 - val_loss: 0.6639
- val_accuracy: 0.7287 - lr: 3.8553e-05
Epoch 37/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6833 - accuracy: 0.7297 - val_loss: 0.6631
- val_accuracy: 0.7287 - lr: 3.8169e-05
Epoch 38/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6595 - accuracy: 0.7448 - val_loss: 0.6636
- val_accuracy: 0.7230 - lr: 3.7789e-05
Epoch 39/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6717 - accuracy: 0.7418 - val_loss: 0.6671
- val_accuracy: 0.7172 - lr: 3.7413e-05
Epoch 40/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6665 - accuracy: 0.7345 - val_loss: 0.6546
- val_accuracy: 0.7276 - lr: 3.7041e-05
Epoch 41/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6759 - accuracy: 0.7325 - val_loss: 0.6665
- val accuracv: 0.7115 - lr: 3.6672e-05
```

```
Epoch 42/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6829 - accuracy: 0.7329 - val_loss: 0.6602
- val_accuracy: 0.7414 - lr: 3.6307e-05
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6745 - accuracy: 0.7291 - val_loss: 0.6510
- val_accuracy: 0.7368 - lr: 3.5946e-05
Epoch 44/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6740 - accuracy: 0.7279 - val_loss: 0.6558
- val_accuracy: 0.7310 - lr: 3.5589e-05
Epoch 45/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6824 - accuracy: 0.7263 - val_loss: 0.6436
- val_accuracy: 0.7402 - lr: 3.5234e-05
Epoch 46/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6725 - accuracy: 0.7361 - val_loss: 0.6359
- val_accuracy: 0.7345 - lr: 3.4884e-05
Epoch 47/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6805 - accuracy: 0.7253 - val_loss: 0.6449
- val_accuracy: 0.7356 - lr: 3.4537e-05
Epoch 48/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6767 - accuracy: 0.7351 - val_loss: 0.6634
- val_accuracy: 0.7218 - lr: 3.4193e-05
Epoch 49/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6666 - accuracy: 0.7307 - val_loss: 0.6357
- val_accuracy: 0.7391 - lr: 3.3853e-05
Epoch 50/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6789 - accuracy: 0.7339 - val_loss: 0.6508
- val_accuracy: 0.7253 - lr: 3.3516e-05
Epoch 51/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6794 - accuracy: 0.7325 - val_loss: 0.6563
- val_accuracy: 0.7230 - lr: 3.3183e-05
Epoch 52/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6637 - accuracy: 0.7384 - val_loss: 0.6412
- val_accuracy: 0.7356 - lr: 3.2852e-05
Epoch 53/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6874 - accuracy: 0.7197 - val_loss: 0.6394
- val_accuracy: 0.7402 - lr: 3.2525e-05
Epoch 54/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6806 - accuracy: 0.7281 - val_loss: 0.6357
- val_accuracy: 0.7437 - lr: 3.2202e-05
Epoch 55/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6612 - accuracy: 0.7367 - val_loss: 0.6585
- val_accuracy: 0.7322 - lr: 3.1881e-05
Epoch 56/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6748 - accuracy: 0.7287 - val_loss: 0.6506
- val_accuracy: 0.7299 - lr: 3.1564e-05
Epoch 57/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6579 - accuracy: 0.7363 - val_loss: 0.6360
- val_accuracy: 0.7345 - lr: 3.1250e-05
Epoch 58/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6816 - accuracy: 0.7319 - val_loss: 0.6550
- val_accuracy: 0.7391 - lr: 3.0939e-05
Epoch 59/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6593 - accuracy: 0.7353 - val_loss: 0.6483
- val_accuracy: 0.7402 - lr: 3.0631e-05
Epoch 60/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6590 - accuracy: 0.7325 - val_loss: 0.6664
- val_accuracy: 0.7299 - lr: 3.0327e-05
Epoch 61/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6694 - accuracy: 0.7317 - val_loss: 0.6554
- val_accuracy: 0.7322 - lr: 3.0025e-05
Epoch 62/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6688 - accuracy: 0.7363 - val_loss: 0.6460
- val_accuracy: 0.7322 - lr: 2.9726e-05
Epoch 63/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6691 - accuracy: 0.7273 - val_loss: 0.6379
- val_accuracy: 0.7333 - lr: 2.9430e-05
Epoch 64/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6688 - accuracy: 0.7343 - val_loss: 0.6438
- val_accuracy: 0.7333 - lr: 2.9137e-05
Epoch 65/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6614 - accuracy: 0.7357 - val_loss: 0.6503
- val_accuracy: 0.7345 - lr: 2.8847e-05
Epoch 66/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6763 - accuracy: 0.7265 - val_loss: 0.6507
- val_accuracy: 0.7414 - lr: 2.8560e-05
Epoch 67/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6766 - accuracy: 0.7325 - val_loss: 0.6449
```

```
- val_accuracy: 0.7448 - lr: 2.8276e-05
Epoch 68/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6653 - accuracy: 0.7363 - val_loss: 0.6399
- val_accuracy: 0.7368 - lr: 2.7995e-05
Epoch 69/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6587 - accuracy: 0.7307 - val_loss: 0.6586
- val_accuracy: 0.7322 - lr: 2.7716e-05
Epoch 70/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6634 - accuracy: 0.7410 - val_loss: 0.6341
- val_accuracy: 0.7425 - lr: 2.7441e-05
Epoch 71/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6689 - accuracy: 0.7402 - val_loss: 0.6538
- val_accuracy: 0.7322 - lr: 2.7168e-05
Epoch 72/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6559 - accuracy: 0.7335 - val_loss: 0.6601
- val_accuracy: 0.7310 - lr: 2.6897e-05
Epoch 73/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6717 - accuracy: 0.7357 - val_loss: 0.6509
- val_accuracy: 0.7276 - lr: 2.6630e-05
Epoch 74/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6709 - accuracy: 0.7303 - val_loss: 0.6407
- val_accuracy: 0.7310 - lr: 2.6365e-05
Epoch 75/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6638 - accuracy: 0.7398 - val_loss: 0.6667
- val_accuracy: 0.7345 - lr: 2.6102e-05
Epoch 76/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6673 - accuracy: 0.7355 - val_loss: 0.6413
- val_accuracy: 0.7483 - lr: 2.5843e-05
Epoch 77/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6620 - accuracy: 0.7353 - val_loss: 0.6370
- val_accuracy: 0.7517 - lr: 2.5585e-05
Epoch 78/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6619 - accuracy: 0.7428 - val_loss: 0.6444
- val_accuracy: 0.7414 - lr: 2.5331e-05
Epoch 79/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6539 - accuracy: 0.7434 - val_loss: 0.6367
- val_accuracy: 0.7494 - lr: 2.5079e-05
Epoch 80/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6645 - accuracy: 0.7309 - val_loss: 0.6560
- val_accuracy: 0.7379 - lr: 2.4829e-05
Epoch 81/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6639 - accuracy: 0.7325 - val_loss: 0.6392
- val_accuracy: 0.7402 - lr: 2.4582e-05
Epoch 82/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6648 - accuracy: 0.7355 - val_loss: 0.6277
- val_accuracy: 0.7448 - lr: 2.4338e-05
Epoch 83/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6616 - accuracy: 0.7341 - val_loss: 0.6505
- val_accuracy: 0.7506 - lr: 2.4095e-05
Epoch 84/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6715 - accuracy: 0.7305 - val_loss: 0.6379
- val_accuracy: 0.7437 - lr: 2.3856e-05
Epoch 85/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6496 - accuracy: 0.7446 - val_loss: 0.6456
- val_accuracy: 0.7345 - lr: 2.3618e-05
Epoch 86/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6481 - accuracy: 0.7408 - val_loss: 0.6419
- val_accuracy: 0.7310 - lr: 2.3383e-05
Epoch 87/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6474 - accuracy: 0.7404 - val_loss: 0.6452
- val_accuracy: 0.7391 - lr: 2.3151e-05
Epoch 88/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6552 - accuracy: 0.7363 - val_loss: 0.6536
- val_accuracy: 0.7253 - lr: 2.2920e-05
Epoch 89/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6596 - accuracy: 0.7424 - val_loss: 0.6535
- val_accuracy: 0.7310 - lr: 2.2692e-05
Epoch 90/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6643 - accuracy: 0.7315 - val_loss: 0.6438
- val_accuracy: 0.7345 - lr: 2.2466e-05
Epoch 91/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6548 - accuracy: 0.7434 - val_loss: 0.6467
- val_accuracy: 0.7299 - lr: 2.2243e-05
Epoch 92/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6638 - accuracy: 0.7361 - val_loss: 0.6484
- val_accuracy: 0.7310 - lr: 2.2022e-05
Epoch 93/100
Epoch 93/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6585 - accuracy: 0.7341 - val_loss: 0.6542
- val_accuracy: 0.7391 - lr: 2.1802e-05
Epoch 94/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6653 - accuracy: 0.7355 - val_loss: 0.6477
- val_accuracy: 0.7425 - lr: 2.1586e-05
Epoch 95/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6613 - accuracy: 0.7369 - val_loss: 0.6424
- val_accuracy: 0.7356 - lr: 2.1371e-05
Epoch 96/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6677 - accuracy: 0.7365 - val_loss: 0.6499
- val_accuracy: 0.7402 - lr: 2.1158e-05
Epoch 97/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6566 - accuracy: 0.7331 - val_loss: 0.6741
- val_accuracy: 0.7172 - lr: 2.0948e-05
Epoch 98/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6578 - accuracy: 0.7349 - val_loss: 0.6548
- val_accuracy: 0.7391 - lr: 2.0739e-05
Epoch 99/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6639 - accuracy: 0.7349 - val_loss: 0.6534
- val_accuracy: 0.7368 - lr: 2.0533e-05
Epoch 100/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6544 - accuracy: 0.7418 - val_loss: 0.6496
- val_accuracy: 0.7322 - lr: 2.0328e-05
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd7783cc490>
```

epoch cnt:900

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

```
WARNING:absl:Found untraced functions such as dense_12_layer_call_fn, dense_12_layer_call_and_return_condition
al_losses, dense_13_layer_call_fn, dense_13_layer_call_and_return_conditional_losses, dense_14_layer_call_fn w
hile saving (showing 5 of 10). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
INFO:tensorflow:Assets written to: /content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model/assets
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd7246ba510> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
WARNING:absl:<keras.layers.recurrent.LSTMCell object at 0x7fd7246c14d0> has the same name 'LSTMCell' as a buil
t-in Keras object. Consider renaming <class 'keras.layers.recurrent.LSTMCell'> to avoid naming conflicts when
loading with `tf.keras.models.load_model`. If renaming is not possible, pass the object in the `custom_objects
` parameter of the load function.
```

In [ ]:

```
from keras import backend as K
K.set_value(model.optimizer.learning_rate, 0.00005)


def scheduler(epoch, lr):
  if epoch < 10:
    return lr
  else:
    return lr * tf.math.exp(-0.01)

lr_scheduler = tf.keras.callbacks.LearningRateScheduler(scheduler)

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [tensorboard
```

```
Epoch 1/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6699 - accuracy: 0.7410 - val_loss: 0.6884
- val_accuracy: 0.7195 - lr: 5.0000e-05
Epoch 2/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6594 - accuracy: 0.7420 - val_loss: 0.6419
- val_accuracy: 0.7425 - lr: 5.0000e-05
Epoch 3/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6768 - accuracy: 0.7359 - val_loss: 0.6452
- val_accuracy: 0.7379 - lr: 5.0000e-05
Epoch 4/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6874 - accuracy: 0.7237 - val_loss: 0.6491
- val_accuracy: 0.7414 - lr: 5.0000e-05
Epoch 5/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6844 - accuracy: 0.7273 - val_loss: 0.6446
- val_accuracy: 0.7264 - lr: 5.0000e-05
Epoch 6/100
```

```
498/498 [==============================] - 20s 41ms/step - loss: 0.6639 - accuracy: 0.7373 - val_loss: 0.6386
- val_accuracy: 0.7609 - lr: 5.0000e-05
Epoch 7/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6697 - accuracy: 0.7327 - val_loss: 0.6544
- val_accuracy: 0.7437 - lr: 5.0000e-05
Epoch 8/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6574 - accuracy: 0.7394 - val_loss: 0.6616
- val_accuracy: 0.7310 - lr: 5.0000e-05
Epoch 9/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6810 - accuracy: 0.7313 - val_loss: 0.6858
- val_accuracy: 0.7287 - lr: 5.0000e-05
Epoch 10/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6660 - accuracy: 0.7307 - val_loss: 0.6586
- val_accuracy: 0.7402 - lr: 5.0000e-05
Epoch 11/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6760 - accuracy: 0.7367 - val_loss: 0.6673
- val_accuracy: 0.7264 - lr: 4.9502e-05
Epoch 12/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6606 - accuracy: 0.7384 - val_loss: 0.6561
- val_accuracy: 0.7345 - lr: 4.9010e-05
Epoch 13/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6804 - accuracy: 0.7265 - val_loss: 0.6554
- val_accuracy: 0.7299 - lr: 4.8522e-05
Epoch 14/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6558 - accuracy: 0.7313 - val_loss: 0.6474
- val_accuracy: 0.7253 - lr: 4.8039e-05
Epoch 15/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6521 - accuracy: 0.7436 - val_loss: 0.6639
- val_accuracy: 0.7287 - lr: 4.7561e-05
Epoch 16/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6673 - accuracy: 0.7408 - val_loss: 0.6750
- val_accuracy: 0.7253 - lr: 4.7088e-05
Epoch 17/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6612 - accuracy: 0.7341 - val_loss: 0.6420
- val_accuracy: 0.7333 - lr: 4.6620e-05
Epoch 18/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6793 - accuracy: 0.7265 - val_loss: 0.6626
- val_accuracy: 0.7299 - lr: 4.6156e-05
Epoch 19/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6770 - accuracy: 0.7285 - val_loss: 0.6401
- val_accuracy: 0.7425 - lr: 4.5697e-05
Epoch 20/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6627 - accuracy: 0.7359 - val_loss: 0.6494
- val_accuracy: 0.7391 - lr: 4.5242e-05
Epoch 21/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6720 - accuracy: 0.7329 - val_loss: 0.6454
- val_accuracy: 0.7299 - lr: 4.4792e-05
Epoch 22/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6808 - accuracy: 0.7349 - val_loss: 0.6396
- val_accuracy: 0.7471 - lr: 4.4346e-05
Epoch 23/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6831 - accuracy: 0.7293 - val_loss: 0.6473
- val_accuracy: 0.7391 - lr: 4.3905e-05
Epoch 24/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6797 - accuracy: 0.7365 - val_loss: 0.6301
- val_accuracy: 0.7471 - lr: 4.3468e-05
Epoch 25/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6688 - accuracy: 0.7337 - val_loss: 0.6571
- val_accuracy: 0.7345 - lr: 4.3035e-05
Epoch 26/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6590 - accuracy: 0.7382 - val_loss: 0.6594
- val_accuracy: 0.7322 - lr: 4.2607e-05
Epoch 27/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6686 - accuracy: 0.7349 - val_loss: 0.6433
- val_accuracy: 0.7471 - lr: 4.2183e-05
Epoch 28/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6728 - accuracy: 0.7335 - val_loss: 0.6616
- val_accuracy: 0.7287 - lr: 4.1764e-05
Epoch 29/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6730 - accuracy: 0.7392 - val_loss: 0.6275
- val_accuracy: 0.7448 - lr: 4.1348e-05
Epoch 30/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6647 - accuracy: 0.7327 - val_loss: 0.6354
- val_accuracy: 0.7391 - lr: 4.0937e-05
Epoch 31/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6581 - accuracy: 0.7398 - val_loss: 0.6364
- val_accuracy: 0.7425 - lr: 4.0529e-05
Epoch 32/100
Epoch 32/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6630 - accuracy: 0.7299 - val_loss: 0.6478
- val_accuracy: 0.7402 - lr: 4.0126e-05
Epoch 33/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6756 - accuracy: 0.7291 - val_loss: 0.6576
- val_accuracy: 0.7333 - lr: 3.9727e-05
Epoch 34/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6528 - accuracy: 0.7390 - val_loss: 0.6551
- val_accuracy: 0.7356 - lr: 3.9331e-05
Epoch 35/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6510 - accuracy: 0.7420 - val_loss: 0.6696
- val_accuracy: 0.7287 - lr: 3.8940e-05
Epoch 36/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6667 - accuracy: 0.7307 - val_loss: 0.6761
- val_accuracy: 0.7241 - lr: 3.8553e-05
Epoch 37/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6630 - accuracy: 0.7317 - val_loss: 0.6726
- val_accuracy: 0.7230 - lr: 3.8169e-05
Epoch 38/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6657 - accuracy: 0.7349 - val_loss: 0.6674
- val_accuracy: 0.7310 - lr: 3.7789e-05
Epoch 39/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6682 - accuracy: 0.7351 - val_loss: 0.6513
- val_accuracy: 0.7448 - lr: 3.7413e-05
Epoch 40/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6641 - accuracy: 0.7339 - val_loss: 0.6467
- val_accuracy: 0.7425 - lr: 3.7041e-05
Epoch 41/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6708 - accuracy: 0.7363 - val_loss: 0.6434
- val_accuracy: 0.7437 - lr: 3.6672e-05
Epoch 42/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6514 - accuracy: 0.7353 - val_loss: 0.6365
- val_accuracy: 0.7322 - lr: 3.6307e-05
Epoch 43/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6664 - accuracy: 0.7331 - val_loss: 0.6276
- val_accuracy: 0.7391 - lr: 3.5946e-05
Epoch 44/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6727 - accuracy: 0.7259 - val_loss: 0.6523
- val_accuracy: 0.7402 - lr: 3.5589e-05
Epoch 45/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6536 - accuracy: 0.7410 - val_loss: 0.6429
- val_accuracy: 0.7494 - lr: 3.5234e-05
Epoch 46/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6693 - accuracy: 0.7369 - val_loss: 0.6577
- val_accuracy: 0.7184 - lr: 3.4884e-05
Epoch 47/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6555 - accuracy: 0.7406 - val_loss: 0.6449
- val_accuracy: 0.7414 - lr: 3.4537e-05
Epoch 48/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6570 - accuracy: 0.7353 - val_loss: 0.6461
- val_accuracy: 0.7437 - lr: 3.4193e-05
Epoch 49/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6652 - accuracy: 0.7319 - val_loss: 0.6649
- val_accuracy: 0.7218 - lr: 3.3853e-05
Epoch 50/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6625 - accuracy: 0.7384 - val_loss: 0.6442
- val_accuracy: 0.7195 - lr: 3.3516e-05
Epoch 51/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6543 - accuracy: 0.7432 - val_loss: 0.6398
- val_accuracy: 0.7379 - lr: 3.3183e-05
Epoch 52/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6551 - accuracy: 0.7428 - val_loss: 0.6518
- val_accuracy: 0.7322 - lr: 3.2852e-05
Epoch 53/100
498/498 [==============================] - 20s 41ms/step - loss: 0.6620 - accuracy: 0.7353 - val_loss: 0.6367
- val_accuracy: 0.7379 - lr: 3.2525e-05
Epoch 54/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6612 - accuracy: 0.7373 - val_loss: 0.6492
- val_accuracy: 0.7322 - lr: 3.2202e-05
Epoch 55/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6808 - accuracy: 0.7285 - val_loss: 0.6367
- val_accuracy: 0.7356 - lr: 3.1881e-05
Epoch 56/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6552 - accuracy: 0.7335 - val_loss: 0.6538
- val_accuracy: 0.7333 - lr: 3.1564e-05
Epoch 57/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6597 - accuracy: 0.7357 - val_loss: 0.6394
```

```
- val_accuracy: 0.7241 - lr: 3.1250e-05
Epoch 58/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6405 - accuracy: 0.7518 - val_loss: 0.6349
- val_accuracy: 0.7402 - lr: 3.0939e-05
Epoch 59/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6409 - accuracy: 0.7430 - val_loss: 0.6357
- val_accuracy: 0.7333 - lr: 3.0631e-05
Epoch 60/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6604 - accuracy: 0.7357 - val_loss: 0.6257
- val_accuracy: 0.7379 - lr: 3.0327e-05
Epoch 61/100
498/498 [==============================] - 22s 44ms/step - loss: 0.6476 - accuracy: 0.7432 - val_loss: 0.6527
- val_accuracy: 0.7207 - lr: 3.0025e-05
Epoch 62/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6520 - accuracy: 0.7410 - val_loss: 0.6319
- val_accuracy: 0.7322 - lr: 2.9726e-05
Epoch 63/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6508 - accuracy: 0.7474 - val_loss: 0.6700
- val_accuracy: 0.7207 - lr: 2.9430e-05
Epoch 64/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6459 - accuracy: 0.7462 - val_loss: 0.6256
- val_accuracy: 0.7471 - lr: 2.9137e-05
Epoch 65/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6446 - accuracy: 0.7373 - val_loss: 0.6309
- val_accuracy: 0.7379 - lr: 2.8847e-05
Epoch 66/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6376 - accuracy: 0.7380 - val_loss: 0.6256
- val_accuracy: 0.7379 - lr: 2.8560e-05
Epoch 67/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6450 - accuracy: 0.7456 - val_loss: 0.6414
- val_accuracy: 0.7253 - lr: 2.8276e-05
Epoch 68/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6467 - accuracy: 0.7430 - val_loss: 0.6269
- val_accuracy: 0.7437 - lr: 2.7995e-05
Epoch 69/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6554 - accuracy: 0.7424 - val_loss: 0.6401
- val_accuracy: 0.7379 - lr: 2.7716e-05
Epoch 70/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6262 - accuracy: 0.7494 - val_loss: 0.6481
- val_accuracy: 0.7345 - lr: 2.7441e-05
Epoch 71/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6485 - accuracy: 0.7466 - val_loss: 0.6301
- val_accuracy: 0.7379 - lr: 2.7168e-05
Epoch 72/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6513 - accuracy: 0.7440 - val_loss: 0.6237
- val_accuracy: 0.7414 - lr: 2.6897e-05
Epoch 73/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6490 - accuracy: 0.7404 - val_loss: 0.6314
- val_accuracy: 0.7379 - lr: 2.6630e-05
Epoch 74/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6577 - accuracy: 0.7466 - val_loss: 0.6525
- val_accuracy: 0.7230 - lr: 2.6365e-05
Epoch 75/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6479 - accuracy: 0.7438 - val_loss: 0.6301
- val_accuracy: 0.7391 - lr: 2.6102e-05
Epoch 76/100
498/498 [==============================] - 22s 45ms/step - loss: 0.6591 - accuracy: 0.7365 - val_loss: 0.6501
- val_accuracy: 0.7310 - lr: 2.5843e-05
Epoch 77/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6632 - accuracy: 0.7386 - val_loss: 0.6371
- val_accuracy: 0.7345 - lr: 2.5585e-05
Epoch 78/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6537 - accuracy: 0.7396 - val_loss: 0.6410
- val_accuracy: 0.7333 - lr: 2.5331e-05
Epoch 79/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6429 - accuracy: 0.7474 - val_loss: 0.6391
- val_accuracy: 0.7402 - lr: 2.5079e-05
Epoch 80/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6428 - accuracy: 0.7452 - val_loss: 0.6278
- val_accuracy: 0.7322 - lr: 2.4829e-05
Epoch 81/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6441 - accuracy: 0.7430 - val_loss: 0.6449
- val_accuracy: 0.7276 - lr: 2.4582e-05
Epoch 82/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6352 - accuracy: 0.7367 - val_loss: 0.6309
- val_accuracy: 0.7356 - lr: 2.4338e-05
Epoch 83/100
```

```
498/498 [==============================] - 21s 43ms/step - loss: 0.6573 - accuracy: 0.7400 - val_loss: 0.6476
- val_accuracy: 0.7356 - lr: 2.4095e-05
Epoch 84/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6560 - accuracy: 0.7347 - val_loss: 0.6347
- val_accuracy: 0.7414 - lr: 2.3856e-05
Epoch 85/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6612 - accuracy: 0.7408 - val_loss: 0.6399
- val_accuracy: 0.7310 - lr: 2.3618e-05
Epoch 86/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6490 - accuracy: 0.7424 - val_loss: 0.6466
- val_accuracy: 0.7333 - lr: 2.3383e-05
Epoch 87/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6241 - accuracy: 0.7502 - val_loss: 0.6507
- val_accuracy: 0.7287 - lr: 2.3151e-05
Epoch 88/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6430 - accuracy: 0.7460 - val_loss: 0.6591
- val_accuracy: 0.7310 - lr: 2.2920e-05
Epoch 89/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6359 - accuracy: 0.7484 - val_loss: 0.6287
- val_accuracy: 0.7483 - lr: 2.2692e-05
Epoch 90/100
498/498 [==============================] - 23s 46ms/step - loss: 0.6460 - accuracy: 0.7384 - val_loss: 0.6443
- val_accuracy: 0.7345 - lr: 2.2466e-05
Epoch 91/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6493 - accuracy: 0.7458 - val_loss: 0.6393
- val_accuracy: 0.7264 - lr: 2.2243e-05
Epoch 92/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6462 - accuracy: 0.7428 - val_loss: 0.6373
- val_accuracy: 0.7345 - lr: 2.2022e-05
Epoch 93/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6246 - accuracy: 0.7546 - val_loss: 0.6383
- val_accuracy: 0.7437 - lr: 2.1802e-05
Epoch 94/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6541 - accuracy: 0.7339 - val_loss: 0.6447
- val_accuracy: 0.7287 - lr: 2.1586e-05
Epoch 95/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6428 - accuracy: 0.7462 - val_loss: 0.6515
- val_accuracy: 0.7287 - lr: 2.1371e-05
Epoch 96/100
498/498 [==============================] - 21s 43ms/step - loss: 0.6382 - accuracy: 0.7506 - val_loss: 0.6675
- val_accuracy: 0.7322 - lr: 2.1158e-05
Epoch 97/100
498/498 [==============================] - 21s 41ms/step - loss: 0.6468 - accuracy: 0.7442 - val_loss: 0.6278
- val_accuracy: 0.7379 - lr: 2.0948e-05
Epoch 98/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6374 - accuracy: 0.7446 - val_loss: 0.6507
- val_accuracy: 0.7333 - lr: 2.0739e-05
Epoch 99/100
498/498 [==============================] - 21s 42ms/step - loss: 0.6306 - accuracy: 0.7566 - val_loss: 0.6434
- val_accuracy: 0.7402 - lr: 2.0533e-05
Epoch 100/100
498/498 [==============================] - 22s 43ms/step - loss: 0.6457 - accuracy: 0.7394 - val_loss: 0.6362
- val_accuracy: 0.7299 - lr: 2.0328e-05
```

Out[ ]:

```
<keras.callbacks.History at 0x7fd786b63290>
```

epoch cnt:1000

In [ ]:

```
model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

In [ ]:

```
model = tf.keras.models.load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model')
```

In [ ]:

```
from keras import backend as K
K.set_value(model.optimizer.learning_rate, 0.00001)

batch_size        = 10
train_steps   =     4980//batch_size
valid_steps   =     879//batch_size

def scheduler(epoch, lr):
  if epoch < 10:
    return lr
  else:
    return lr * tf.math.exp(-0.05)
```

```
lr_scheduler = tf.keras.callbacks.LearningRateScheduler(scheduler)

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [lr_schedule
```

```
Epoch 1/100
498/498 [==============================] - 136s 268ms/step - loss: 0.6444 - accuracy: 0.7504 - val_loss: 0.634
3 - val_accuracy: 0.7414 - lr: 1.0000e-05
Epoch 2/100
498/498 [==============================] - 145s 291ms/step - loss: 0.6388 - accuracy: 0.7458 - val_loss: 0.645
7 - val_accuracy: 0.7379 - lr: 1.0000e-05
Epoch 3/100
498/498 [==============================] - 131s 262ms/step - loss: 0.6450 - accuracy: 0.7430 - val_loss: 0.636
7 - val_accuracy: 0.7368 - lr: 1.0000e-05
Epoch 4/100
498/498 [==============================] - 131s 262ms/step - loss: 0.6246 - accuracy: 0.7576 - val_loss: 0.634
6 - val_accuracy: 0.7356 - lr: 1.0000e-05
Epoch 5/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6316 - accuracy: 0.7506 - val_loss: 0.637
9 - val_accuracy: 0.7356 - lr: 1.0000e-05
Epoch 6/100
498/498 [==============================] - 130s 262ms/step - loss: 0.6270 - accuracy: 0.7548 - val_loss: 0.652
9 - val_accuracy: 0.7345 - lr: 1.0000e-05
Epoch 7/100
498/498 [==============================] - 129s 260ms/step - loss: 0.6243 - accuracy: 0.7542 - val_loss: 0.651
0 - val_accuracy: 0.7322 - lr: 1.0000e-05
Epoch 8/100
498/498 [==============================] - 132s 265ms/step - loss: 0.6542 - accuracy: 0.7386 - val_loss: 0.644
9 - val_accuracy: 0.7333 - lr: 1.0000e-05
Epoch 9/100
498/498 [==============================] - 130s 261ms/step - loss: 0.6397 - accuracy: 0.7404 - val_loss: 0.631
1 - val_accuracy: 0.7402 - lr: 1.0000e-05
Epoch 10/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6262 - accuracy: 0.7532 - val_loss: 0.649
2 - val_accuracy: 0.7253 - lr: 1.0000e-05
Epoch 11/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6362 - accuracy: 0.7430 - val_loss: 0.640
1 - val_accuracy: 0.7230 - lr: 9.5123e-06
Epoch 12/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6222 - accuracy: 0.7452 - val_loss: 0.635
7 - val_accuracy: 0.7368 - lr: 9.0484e-06
Epoch 13/100
498/498 [==============================] - 127s 256ms/step - loss: 0.6383 - accuracy: 0.7428 - val_loss: 0.639
0 - val_accuracy: 0.7310 - lr: 8.6071e-06
Epoch 14/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6244 - accuracy: 0.7536 - val_loss: 0.629
7 - val_accuracy: 0.7322 - lr: 8.1873e-06
Epoch 15/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6307 - accuracy: 0.7530 - val_loss: 0.642
0 - val_accuracy: 0.7368 - lr: 7.7880e-06
Epoch 16/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6302 - accuracy: 0.7502 - val_loss: 0.637
2 - val_accuracy: 0.7333 - lr: 7.4082e-06
Epoch 17/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6387 - accuracy: 0.7462 - val_loss: 0.642
4 - val_accuracy: 0.7241 - lr: 7.0469e-06
Epoch 18/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6218 - accuracy: 0.7604 - val_loss: 0.628
5 - val_accuracy: 0.7402 - lr: 6.7032e-06
Epoch 19/100
498/498 [==============================] - 127s 254ms/step - loss: 0.6342 - accuracy: 0.7492 - val_loss: 0.637
4 - val_accuracy: 0.7379 - lr: 6.3763e-06
Epoch 20/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6240 - accuracy: 0.7540 - val_loss: 0.636
4 - val_accuracy: 0.7333 - lr: 6.0653e-06
Epoch 21/100
498/498 [==============================] - 127s 256ms/step - loss: 0.6191 - accuracy: 0.7584 - val_loss: 0.628
8 - val_accuracy: 0.7356 - lr: 5.7695e-06
Epoch 22/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6420 - accuracy: 0.7508 - val_loss: 0.629
5 - val_accuracy: 0.7379 - lr: 5.4881e-06
Epoch 23/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6324 - accuracy: 0.7484 - val_loss: 0.642
2 - val_accuracy: 0.7253 - lr: 5.2205e-06
Epoch 24/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6120 - accuracy: 0.7578 - val_loss: 0.634
```

```
9 - val_accuracy: 0.7322 - lr: 4.9659e-06
Epoch 25/100
498/498 [==============================] - 128s 256ms/step - loss: 0.6292 - accuracy: 0.7518 - val_loss: 0.633
1 - val_accuracy: 0.7333 - lr: 4.7237e-06
Epoch 26/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6353 - accuracy: 0.7506 - val_loss: 0.636
5 - val_accuracy: 0.7299 - lr: 4.4933e-06
Epoch 27/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6212 - accuracy: 0.7552 - val_loss: 0.642
1 - val_accuracy: 0.7276 - lr: 4.2742e-06
Epoch 28/100
498/498 [==============================] - 127s 254ms/step - loss: 0.6265 - accuracy: 0.7502 - val_loss: 0.629
7 - val_accuracy: 0.7402 - lr: 4.0657e-06
Epoch 29/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6345 - accuracy: 0.7484 - val_loss: 0.636
7 - val_accuracy: 0.7345 - lr: 3.8674e-06
Epoch 30/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6342 - accuracy: 0.7460 - val_loss: 0.641
3 - val_accuracy: 0.7287 - lr: 3.6788e-06
Epoch 31/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6244 - accuracy: 0.7462 - val_loss: 0.632
2 - val_accuracy: 0.7368 - lr: 3.4994e-06
Epoch 32/100
498/498 [==============================] - 127s 256ms/step - loss: 0.6149 - accuracy: 0.7552 - val_loss: 0.642
0 - val_accuracy: 0.7333 - lr: 3.3287e-06
Epoch 33/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6263 - accuracy: 0.7518 - val_loss: 0.632
9 - val_accuracy: 0.7356 - lr: 3.1664e-06
Epoch 34/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6375 - accuracy: 0.7512 - val_loss: 0.631
2 - val_accuracy: 0.7379 - lr: 3.0119e-06
Epoch 35/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6375 - accuracy: 0.7426 - val_loss: 0.634
3 - val_accuracy: 0.7333 - lr: 2.8651e-06
Epoch 36/100
498/498 [==============================] - 131s 263ms/step - loss: 0.6202 - accuracy: 0.7586 - val_loss: 0.639
2 - val_accuracy: 0.7299 - lr: 2.7253e-06
Epoch 37/100
498/498 [==============================] - 130s 262ms/step - loss: 0.6211 - accuracy: 0.7606 - val_loss: 0.634
8 - val_accuracy: 0.7391 - lr: 2.5924e-06
Epoch 38/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6254 - accuracy: 0.7548 - val_loss: 0.637
9 - val_accuracy: 0.7322 - lr: 2.4660e-06
Epoch 39/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6267 - accuracy: 0.7514 - val_loss: 0.636
7 - val_accuracy: 0.7322 - lr: 2.3457e-06
Epoch 40/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6337 - accuracy: 0.7438 - val_loss: 0.627
4 - val_accuracy: 0.7402 - lr: 2.2313e-06
Epoch 41/100
498/498 [==============================] - 130s 261ms/step - loss: 0.6327 - accuracy: 0.7450 - val_loss: 0.641
4 - val_accuracy: 0.7287 - lr: 2.1225e-06
Epoch 42/100
498/498 [==============================] - 132s 266ms/step - loss: 0.6368 - accuracy: 0.7398 - val_loss: 0.634
1 - val_accuracy: 0.7299 - lr: 2.0190e-06
Epoch 43/100
498/498 [==============================] - 134s 270ms/step - loss: 0.6295 - accuracy: 0.7552 - val_loss: 0.638
4 - val_accuracy: 0.7310 - lr: 1.9205e-06
Epoch 44/100
498/498 [==============================] - 134s 268ms/step - loss: 0.6272 - accuracy: 0.7520 - val_loss: 0.636
3 - val_accuracy: 0.7333 - lr: 1.8268e-06
Epoch 45/100
498/498 [==============================] - 132s 265ms/step - loss: 0.6239 - accuracy: 0.7512 - val_loss: 0.636
9 - val_accuracy: 0.7356 - lr: 1.7377e-06
Epoch 46/100
498/498 [==============================] - 131s 262ms/step - loss: 0.6306 - accuracy: 0.7550 - val_loss: 0.639
7 - val_accuracy: 0.7322 - lr: 1.6530e-06
Epoch 47/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6279 - accuracy: 0.7544 - val_loss: 0.629
5 - val_accuracy: 0.7356 - lr: 1.5724e-06
Epoch 48/100
498/498 [==============================] - 131s 262ms/step - loss: 0.6308 - accuracy: 0.7482 - val_loss: 0.635
3 - val_accuracy: 0.7356 - lr: 1.4957e-06
Epoch 49/100
498/498 [==============================] - 130s 261ms/step - loss: 0.6225 - accuracy: 0.7490 - val_loss: 0.630
4 - val_accuracy: 0.7345 - lr: 1.4227e-06
Epoch 50/100
```

```
498/498 [==============================] - 131s 263ms/step - loss: 0.6119 - accuracy: 0.7556 - val_loss: 0.641
0 - val_accuracy: 0.7299 - lr: 1.3534e-06
Epoch 51/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6170 - accuracy: 0.7516 - val_loss: 0.632
7 - val_accuracy: 0.7368 - lr: 1.2874e-06
Epoch 52/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6102 - accuracy: 0.7610 - val_loss: 0.636
3 - val_accuracy: 0.7287 - lr: 1.2246e-06
Epoch 53/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6411 - accuracy: 0.7470 - val_loss: 0.635
9 - val_accuracy: 0.7299 - lr: 1.1648e-06
Epoch 54/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6458 - accuracy: 0.7500 - val_loss: 0.635
7 - val_accuracy: 0.7345 - lr: 1.1080e-06
Epoch 55/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6057 - accuracy: 0.7536 - val_loss: 0.634
5 - val_accuracy: 0.7345 - lr: 1.0540e-06
Epoch 56/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6310 - accuracy: 0.7532 - val_loss: 0.636
2 - val_accuracy: 0.7368 - lr: 1.0026e-06
Epoch 57/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6366 - accuracy: 0.7470 - val_loss: 0.636
5 - val_accuracy: 0.7368 - lr: 9.5369e-07
Epoch 58/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6405 - accuracy: 0.7452 - val_loss: 0.638
6 - val_accuracy: 0.7333 - lr: 9.0718e-07
Epoch 59/100
498/498 [==============================] - 131s 264ms/step - loss: 0.6383 - accuracy: 0.7418 - val_loss: 0.632
9 - val_accuracy: 0.7414 - lr: 8.6294e-07
Epoch 60/100
498/498 [==============================] - 131s 263ms/step - loss: 0.6238 - accuracy: 0.7526 - val_loss: 0.633
9 - val_accuracy: 0.7379 - lr: 8.2085e-07
Epoch 61/100
498/498 [==============================] - 132s 266ms/step - loss: 0.6374 - accuracy: 0.7476 - val_loss: 0.634
6 - val_accuracy: 0.7345 - lr: 7.8082e-07
Epoch 62/100
498/498 [==============================] - 128s 256ms/step - loss: 0.6211 - accuracy: 0.7538 - val_loss: 0.640
9 - val_accuracy: 0.7322 - lr: 7.4274e-07
Epoch 63/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6184 - accuracy: 0.7538 - val_loss: 0.636
4 - val_accuracy: 0.7333 - lr: 7.0651e-07
Epoch 64/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6286 - accuracy: 0.7500 - val_loss: 0.635
9 - val_accuracy: 0.7345 - lr: 6.7206e-07
Epoch 65/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6339 - accuracy: 0.7492 - val_loss: 0.636
3 - val_accuracy: 0.7345 - lr: 6.3928e-07
Epoch 66/100
498/498 [==============================] - 130s 262ms/step - loss: 0.6316 - accuracy: 0.7474 - val_loss: 0.634
8 - val_accuracy: 0.7368 - lr: 6.0810e-07
Epoch 67/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6304 - accuracy: 0.7536 - val_loss: 0.630
5 - val_accuracy: 0.7356 - lr: 5.7844e-07
Epoch 68/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6282 - accuracy: 0.7448 - val_loss: 0.635
0 - val_accuracy: 0.7379 - lr: 5.5023e-07
Epoch 69/100
498/498 [==============================] - 127s 256ms/step - loss: 0.6236 - accuracy: 0.7586 - val_loss: 0.635
8 - val_accuracy: 0.7368 - lr: 5.2340e-07
Epoch 70/100
498/498 [==============================] - 127s 254ms/step - loss: 0.6135 - accuracy: 0.7538 - val_loss: 0.634
6 - val_accuracy: 0.7379 - lr: 4.9787e-07
Epoch 71/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6341 - accuracy: 0.7502 - val_loss: 0.632
3 - val_accuracy: 0.7391 - lr: 4.7359e-07
Epoch 72/100
498/498 [==============================] - 127s 255ms/step - loss: 0.6226 - accuracy: 0.7550 - val_loss: 0.631
3 - val_accuracy: 0.7391 - lr: 4.5049e-07
Epoch 73/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6259 - accuracy: 0.7474 - val_loss: 0.634
0 - val_accuracy: 0.7391 - lr: 4.2852e-07
Epoch 74/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6327 - accuracy: 0.7502 - val_loss: 0.633
7 - val_accuracy: 0.7379 - lr: 4.0762e-07
Epoch 75/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6213 - accuracy: 0.7524 - val_loss: 0.635
4 - val_accuracy: 0.7368 - lr: 3.8774e-07
```

```
Epoch 76/100
498/498 [==============================] - 128s 256ms/step - loss: 0.6214 - accuracy: 0.7506 - val_loss: 0.634
5 - val_accuracy: 0.7414 - lr: 3.6883e-07
Epoch 77/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6231 - accuracy: 0.7560 - val_loss: 0.635
2 - val_accuracy: 0.7379 - lr: 3.5084e-07
Epoch 78/100
498/498 [==============================] - 130s 261ms/step - loss: 0.6220 - accuracy: 0.7598 - val_loss: 0.636
6 - val_accuracy: 0.7356 - lr: 3.3373e-07
Epoch 79/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6198 - accuracy: 0.7554 - val_loss: 0.630
7 - val_accuracy: 0.7391 - lr: 3.1746e-07
Epoch 80/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6362 - accuracy: 0.7446 - val_loss: 0.635
8 - val_accuracy: 0.7402 - lr: 3.0197e-07
Epoch 81/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6273 - accuracy: 0.7496 - val_loss: 0.629
2 - val_accuracy: 0.7414 - lr: 2.8725e-07
Epoch 82/100
498/498 [==============================] - 130s 262ms/step - loss: 0.6189 - accuracy: 0.7582 - val_loss: 0.639
8 - val_accuracy: 0.7356 - lr: 2.7324e-07
Epoch 83/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6309 - accuracy: 0.7478 - val_loss: 0.635
5 - val_accuracy: 0.7379 - lr: 2.5991e-07
Epoch 84/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6262 - accuracy: 0.7496 - val_loss: 0.633
3 - val_accuracy: 0.7402 - lr: 2.4724e-07
Epoch 85/100
498/498 [==============================] - 131s 264ms/step - loss: 0.6257 - accuracy: 0.7520 - val_loss: 0.639
2 - val_accuracy: 0.7368 - lr: 2.3518e-07
Epoch 86/100
498/498 [==============================] - 128s 258ms/step - loss: 0.6382 - accuracy: 0.7516 - val_loss: 0.638
1 - val_accuracy: 0.7379 - lr: 2.2371e-07
Epoch 87/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6249 - accuracy: 0.7546 - val_loss: 0.635
4 - val_accuracy: 0.7379 - lr: 2.1280e-07
Epoch 88/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6237 - accuracy: 0.7486 - val_loss: 0.633
5 - val_accuracy: 0.7368 - lr: 2.0242e-07
Epoch 89/100
498/498 [==============================] - 130s 262ms/step - loss: 0.6420 - accuracy: 0.7478 - val_loss: 0.634
4 - val_accuracy: 0.7379 - lr: 1.9255e-07
Epoch 90/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6293 - accuracy: 0.7534 - val_loss: 0.635
2 - val_accuracy: 0.7368 - lr: 1.8316e-07
Epoch 91/100
498/498 [==============================] - 129s 258ms/step - loss: 0.6145 - accuracy: 0.7516 - val_loss: 0.632
6 - val_accuracy: 0.7402 - lr: 1.7422e-07
Epoch 92/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6328 - accuracy: 0.7516 - val_loss: 0.633
7 - val_accuracy: 0.7391 - lr: 1.6573e-07
Epoch 93/100
498/498 [==============================] - 129s 259ms/step - loss: 0.6255 - accuracy: 0.7496 - val_loss: 0.630
5 - val_accuracy: 0.7402 - lr: 1.5764e-07
Epoch 94/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6095 - accuracy: 0.7614 - val_loss: 0.635
1 - val_accuracy: 0.7391 - lr: 1.4996e-07
Epoch 95/100
498/498 [==============================] - 129s 260ms/step - loss: 0.6281 - accuracy: 0.7456 - val_loss: 0.633
6 - val_accuracy: 0.7368 - lr: 1.4264e-07
Epoch 96/100
498/498 [==============================] - 130s 261ms/step - loss: 0.6240 - accuracy: 0.7524 - val_loss: 0.635
4 - val_accuracy: 0.7391 - lr: 1.3569e-07
Epoch 97/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6272 - accuracy: 0.7542 - val_loss: 0.631
4 - val_accuracy: 0.7402 - lr: 1.2907e-07
Epoch 98/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6304 - accuracy: 0.7560 - val_loss: 0.636
7 - val_accuracy: 0.7379 - lr: 1.2277e-07
Epoch 99/100
498/498 [==============================] - 130s 260ms/step - loss: 0.6327 - accuracy: 0.7542 - val_loss: 0.637
6 - val_accuracy: 0.7379 - lr: 1.1679e-07
Epoch 100/100
498/498 [==============================] - 128s 257ms/step - loss: 0.6257 - accuracy: 0.7522 - val_loss: 0.630
7 - val_accuracy: 0.7414 - lr: 1.1109e-07
```

Out[ ]:

```
<keras.callbacks.History at 0x7f8fddf96790>
```

In [ ]:

```
#model.save('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model',save_format='tf')
```

In [ ]:

```
model = tf.keras.models.load_model('/content/drive/MyDrive/Colab Notebooks/Case_Study_2/lstm_model')
```

In [ ]:

```
y_true=[]
y_pred=[]
cnt=0
for x,y in ImageGenerator_test:
  #print(x.shape)
  #print(y.shape)
  cnt = cnt+1
  if x.shape[0]==10 and cnt<=1000:
    y_pred.extend(list(np.argmax(model.predict(x),axis=1)))
    y_true.extend(np.argmax(y,axis=1))
  else:
    break
```

In [ ]:

```
len(y_pred)
```

Out[ ]:

```
870
```

In [ ]:

```
for x,y in ImageGenerator_test:
  print(x.shape)
  print(type(x))
  print(model.predict(x))
  break
```

In [ ]:

```
''''
  else:
    y_cap=[]
    for i in range(x.shape[0]):
      y_cap.append(np.argmax(model.predict(x[i:i+1,:,:,:])[0]))
    y_pred.extend(y_cap)
    break
'''
```

In [ ]:

```
y_pred
```

Out[ ]:

```
[2, 2, 3, 2, 4, 5, 2, 2, 5, 3]
```

epoch cnt:1077

In [ ]:

```
ImageGenerator_test.class_indices
```

Out[ ]:

```
{'backyard': 0,
 'bathroom': 1,
 'bedroom': 2,
 'frontyard': 3,
 'kitchen': 4,
 'livingRoom': 5}
```

In [ ]:

```
list(ImageGenerator_test.class_indices.keys())
```

Out[ ]:

```
['backyard', 'bathroom', 'bedroom', 'frontyard', 'kitchen', 'livingRoom']
```

In [ ]:

```
y_test.values
```

In [ ]:

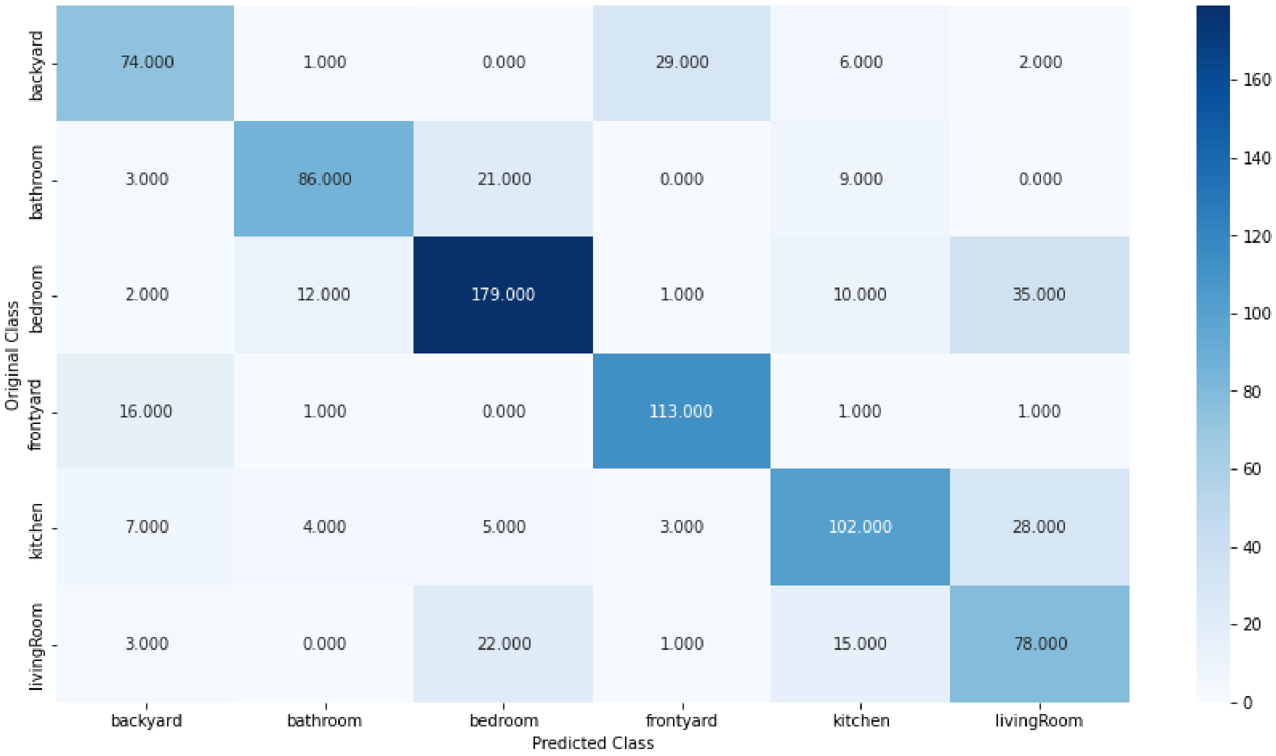
```
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.ConfusionMatrixDisplay.html
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

cm = confusion_matrix(y_true, y_pred, labels=list(ImageGenerator_test.class_indices.values()))

plt.figure(figsize=(15,8))

labels = list(ImageGenerator_test.class_indices.keys())
```

```
sns.heatmap(cm, annot=True, cmap='Blues', fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.show()
```



In [ ]:

```
precision = true_pos = np.diag(cm) /np.sum(cm,axis=0)
recall = true_pos = np.diag(cm) /np.sum(cm,axis=1)
```

In [ ]:

```
from prettytable import PrettyTable

columns = ["label", "Precision", "Recall"]

table = PrettyTable()

# Add Columns
table.add_column(columns[0], labels)
table.add_column(columns[1],list(map(lambda x : round(x,4),precision)))
table.add_column(columns[2], list(map(lambda x : round(x,4),recall)))

print(table)
```

```
+------------+-----------+--------+
|   label    | Precision | Recall |
+------------+-----------+--------+
|  backyard  |   0.7048  | 0.6607 |
|  bathroom  |   0.8269  | 0.7227 |
|  bedroom   |   0.7885  | 0.749  |
| frontyard  |   0.7687  | 0.8561 |
|  kitchen   |   0.7133  | 0.6846 |
| livingRoom |   0.5417  | 0.6555 |
+------------+-----------+--------+
```

Observation:

epoch:1100

Train accuracy: 76.08%

Test accuracy: 74.94%

- stop training due to high training time.
- The precision and recall of bathroom is 0.5417 and 0.655 respectively.

In [ ]:

In [ ]:

RGB LSTM Model:

- The input to this model is RGB image.

In [ ]:

```
import matplotlib.pyplot as plt
%matplotlib inline
# import seaborn as sns
import pandas as pd
import re
import tensorflow as tf
from tensorflow.keras.layers import Embedding, LSTM, Dense
from tensorflow.keras.models import Model
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
import numpy as np
```

pre processing

In [ ]:

```
#!rm -r '/content/logs'
```

In [ ]:

```
!gdown --id 1s3JydD_s4sR_HOwyH7FhzKGqXlWrhpAs
```

```
/usr/local/lib/python3.7/dist-packages/gdown/cli.py:131: FutureWarning: Option `--id` was deprecated in versio
n 4.3.1 and will be removed in 5.0. You don't need to pass it anymore to use a file ID.
  category=FutureWarning,
Downloading...
From: https://drive.google.com/uc?id=1s3JydD_s4sR_HOwyH7FhzKGqXlWrhpAs
To: /content/Train_Test_Data.zip
100% 302M/302M [00:01<00:00, 216MB/s]
```

In [ ]:

```
!unzip '/content/Train_Test_Data.zip'
```

In [ ]:

```
test_data_path  = '/content/Train_Test_Data/REI-Dataset_test'
train_data_path = '/content/Train_Test_Data/REI-Dataset_train'

labels=[]

for (root,dirs,files) in os.walk(train_data_path, topdown=True):
  if(len(files)>0):

    labels.append(root[root.rfind('/')+1:])
labels
```

Out[ ]:

```
['frontyard', 'bathroom', 'bedroom', 'kitchen', 'backyard', 'livingRoom']
```

In [ ]:

```
from tqdm.notebook import tqdm_notebook
```

In [ ]:

```
for label in labels:

  path = train_data_path + '/' + label
  files = os.listdir(path)

  for file in tqdm_notebook(files):
    img_path = os.path.join(path, file)

    image = cv2.imread(img_path)

    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(8,8))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    #enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    filename = os.path.join(path,'enh_'+file)
    cv2.imwrite(filename, enhanced_img)
    os.remove(img_path)
```

In [ ]:

```
for label in labels:

  path = test_data_path + '/' + label
  files = os.listdir(path)

  for file in tqdm_notebook(files):
    img_path = os.path.join(path, file)

    image = cv2.imread(img_path)

    lab = cv2.cvtColor(image, cv2.COLOR_BGR2LAB)
    lab_planes = cv2.split(lab)
    clahe = cv2.createCLAHE(clipLimit=2.0,tileGridSize=(8,8))
    lab_planes[0] = clahe.apply(lab_planes[0])
    lab = cv2.merge(lab_planes)
    enhanced_img = cv2.cvtColor(lab, cv2.COLOR_LAB2RGB)
    #enhanced_grayscale_img = cv2.cvtColor(enhanced_img, cv2.COLOR_RGB2GRAY)
    filename = os.path.join(path,'enh_'+file)

    cv2.imwrite(filename, enhanced_img)
    os.remove(img_path)
```

In [ ]:

```
!zip -r '/content/REI-Dataset_pp_enha_rgb_train_test.zip' '/content/Train_Test_Data'
```

In [ ]:

Modeling:

In [ ]:

```
class RGB_LSTM_network(tf.keras.Model):
    '''
    RGB_LSTM_network model -- That takes a input sequence and returns output sequence
    '''

    def __init__(self,lstm_units):
        super().__init__()

        #Initialize Embedding layer
        #Intialize Decoder LSTM layer
        self.lstm_initial_h = 0
        self.lstm_initial_c = 0

        self.h_lstm_output = 0
        self.h_lstm_final_state_h = 0
        self.h_lstm_final_state_c  = 0

        self.v_lstm_output = 0
        self.v_lstm_final_state_h = 0
        self.v_lstm_final_state_c  = 0

        self.lstm_units = lstm_units

        self.h_r_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="R_h_LSTM'
        self.h_b_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="B_h_LSTM'
        self.h_g_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="G_h_LSTM'

        self.v_r_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="R_v_LSTM'
        self.v_b_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="B_v_LSTM'
        self.v_g_lstm_layer = LSTM(self.lstm_units, return_sequences=False, return_state=True, name="G_v_LSTM'


    def call(self,input_sequence,initial_states):
        '''
          This function takes a RGB sequence input and the initial states of the LSTM.

          returns RGB h lstm and v lstm total 6 outputs
        '''
        #print(' input shape : ',input_sequence.shape)
        #print(input_sequence[:,:,:,0].shape)

        Red_channel_input = input_sequence[:,:,:,0]

        Blue_channel_input = input_sequence[:,:,:,1]

        Green_channel_input = input_sequence[:,:,:,2]
        '''
        print(' Red_channel_input shape : ',Red_channel_input.shape)
        print(' Blue_channel_input shape : ',Blue_channel_input.shape)
        print(' Green_channel_input shape : ',Green_channel_input.shape)
       '''

        v_Red_channel_input   = tf.transpose( Red_channel_input, perm=[0, 2, 1], name='transpose')
        v_Blue_channel_input  = tf.transpose( Blue_channel_input, perm=[0, 2, 1], name='transpose')
        v_Green_channel_input = tf.transpose( Green_channel_input, perm=[0, 2, 1], name='transpose')
        '''
        print(' v_Red_channel_input shape : ',v_Red_channel_input.shape)
        print(' v_Blue_channel_input shape : ',v_Blue_channel_input.shape)
        print(' v_Green_channel_input shape : ',v_Green_channel_input.shape)
        print(' initial_states shape : ',initial_states[0].shape,initial_states[1].shape)
        '''

        self.lstm_initial_h = initial_states[0]
        self.lstm_initial_c = initial_states[1]

        self.h_R_lstm_output , self.h_R_lstm_final_state_h , self.h_R_lstm_final_state_c = self.h_r_lstm_layer

        self.h_B_lstm_output , self.h_B_lstm_final_state_h , self.h_B_lstm_final_state_c = self.h_b_lstm_layer

        self.h_G_lstm_output , self.h_G_lstm_final_state_h , self.h_G_lstm_final_state_c = self.h_g_lstm_layer


        self.v_R_lstm_output , self.v_R_lstm_final_state_h , self.v_R_lstm_final_state_c = self.v_r_lstm_layer

        self.v_B_lstm_output , self.v_B_lstm_final_state_h , self.v_B_lstm_final_state_c = self.v_b_lstm_layer

        self.v_G_lstm_output , self.v_G_lstm_final_state_h , self.v_G_lstm_final_state_c = self.v_g_lstm_layer


        #print(' h_lstm_final_state_h output shape : ',self.h_lstm_final_state_h.shape)
        #print(' h_lstm_final_state_c output shape : ',self.h_lstm_final_state_c.shape)



        return self.h_R_lstm_output,self.h_B_lstm_output,self.h_G_lstm_output,self.v_R_lstm_output,self.v_B_ls


    def initialize_states(self,batch_size):
      '''
      Given a batch size it will return intial hidden state and intial cell state.
      If batch size is 32- Hidden state is zeros of size [32,lstm_units], cell state zeros is of size [32,lst
      '''

      self.lstm_state_h = tf.zeros((batch_size,self.lstm_units))
      self.lstm_state_c = tf.zeros((batch_size,self.lstm_units))

      return self.lstm_state_h,self.lstm_state_c


    def get_config(self):
        return {'lstm_units': self.lstm_units}

    @classmethod
    def from_config(cls, config):
        return cls(**config)
```

In [ ]:

```
def grader_RGB_LSTM_network():
    '''
        verifying theRGB_LSTM_network class

    '''

    input_row_length=128
    input_row_length=256
    channels=3
    lstm_units=32
    batch_size=64

    input_seq=tf.random.uniform(shape=(batch_size,input_row_length,input_row_length,channels),maxval=10,minval


    state_h=tf.random.uniform(shape=[batch_size,lstm_units],dtype=tf.float32)
    state_c=tf.random.uniform(shape=[batch_size,lstm_units],dtype=tf.float32)
    states=[state_h,state_c]
    lstm= RGB_LSTM_network(lstm_units)
    states = lstm.initialize_states(batch_size)
    h_lstm,_,_,v_lstm,_,_=lstm(input_seq, states)
    print(h_lstm.shape)
    print(v_lstm.shape)
    assert(h_lstm.shape==(batch_size,lstm_units))
    return True
print(grader_RGB_LSTM_network())
```

In [ ]:

```
class main_RGB_framwork(tf.keras.Model):

    def __init__(self,lstm_units,output_class_cnt,batch_size):
        super().__init__()

        self.lstm_units         =     lstm_units
        self.output_class_cnt   =     output_class_cnt
        self.batch_size         =     batch_size



        self.lstm_network = RGB_LSTM_network(self.lstm_units)

        self.dense_layer_1 = Dense(256, activation='relu',kernel_initializer = tf.keras.initializers.GlorotNor
        #self.dense_layer_2 = Dense(128, activation='relu',kernel_initializer = tf.keras.initializers.GlorotNo
        self.dense_layer_3 = Dense(64, activation='relu',kernel_initializer = tf.keras.initializers.GlorotNorm

        self.output_layer = Dense(self.output_class_cnt, activation='softmax')



    def call(self,input_data):

        '''
        print(input_data.shape)
        print(output_data.shape)
        '''

        initial_states =  self.lstm_network.initialize_states(batch_size = self.batch_size)
        h_r_lstm_output,h_b_lstm_output,h_g_lstm_output,v_r_lstm_output,v_b_lstm_output,v_g_lstm_output = sel
        '''
        print(h_lstm_output.shape)
        print(v_lstm_output.shape)
        '''
        lstm_output = tf.concat([ h_r_lstm_output,h_b_lstm_output,h_g_lstm_output,v_r_lstm_output,v_b_lstm_out

        #print(lstm_output.shape)

        dense_1 = self.dense_layer_1(lstm_output)
        #dense_2 = self.dense_layer_2(dense_1)
        dense_3 = self.dense_layer_3(dense_1)
        dense_output = self.output_layer(dense_3)

        #print('dense output shape : ',dense_output.shape)

        return dense_output

    def get_config(self):
        return {'lstm_units'    : self.lstm_units    ,
                'output_class_cnt'      : self.output_class_cnt ,
                'batch_size'     : self.batch_size
                }

    @classmethod
    def from_config(cls, config):
        return cls(**config)
```

In [ ]:

```
train_data_path='/content/Train_Test_Data/REI-Dataset_train'
test_data_path='/content/Train_Test_Data/REI-Dataset_test'
ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator( rotation_range=15, width_shift_range=0.2,rescale=
                                                            height_shift_range=0.2, horizontal_flip=True)

ImageGenerator_train = ImageFlow.flow_from_directory(train_data_path,target_size=(128,128),seed=10,batch_size=
                                                     class_mode = 'categorical', color_mode = 'rgb' )


test_ImageFlow = tf.keras.preprocessing.image.ImageDataGenerator(rescale=1./255)

ImageGenerator_test = test_ImageFlow.flow_from_directory(test_data_path,target_size=(128,128),seed=10,batch_si
                                                         class_mode = 'categorical', color_mode = 'rgb')
```

```
Found 4980 images belonging to 6 classes.
Found 879 images belonging to 6 classes.
```

Fitting the model:

In [ ]:

```
lstm_units        = 64
output_class_cnt  = len(labels)
batch_size        = 10

model = main_RGB_framwork(lstm_units,output_class_cnt,batch_size)

optimizer = tf.keras.optimizers.Adam(learning_rate=0.001)
loss_func= tf.keras.losses.CategoricalCrossentropy()#tf.keras.losses.SparseCategoricalCrossentropy()

model.compile(optimizer=optimizer,loss=loss_func,metrics=['accuracy'])

train_steps   =     4980//batch_size
valid_steps   =     879//batch_size

def scheduler(epoch, lr):
  if epoch < 10:
    return lr
  else:
    return lr * tf.math.exp(-0.005)

lr_scheduler = tf.keras.callbacks.LearningRateScheduler(scheduler)

model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                    validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [lr_schedule
```

```
Epoch 1/100
498/498 [==============================] - 90s 113ms/step - loss: 1.6503 - accuracy: 0.3082 - val_loss: 1.5942
- val_accuracy: 0.3161 - lr: 0.0010
Epoch 2/100
498/498 [==============================] - 53s 107ms/step - loss: 1.4729 - accuracy: 0.3709 - val_loss: 1.3658
- val_accuracy: 0.4322 - lr: 0.0010
Epoch 3/100
498/498 [==============================] - 54s 109ms/step - loss: 1.3584 - accuracy: 0.4205 - val_loss: 1.4248
- val_accuracy: 0.3816 - lr: 0.0010
Epoch 4/100
498/498 [==============================] - 54s 108ms/step - loss: 1.2984 - accuracy: 0.4464 - val_loss: 1.2509
- val_accuracy: 0.4425 - lr: 0.0010
Epoch 5/100
498/498 [==============================] - 56s 113ms/step - loss: 1.2749 - accuracy: 0.4548 - val_loss: 1.1645
- val_accuracy: 0.4736 - lr: 0.0010
Epoch 6/100
498/498 [==============================] - 53s 107ms/step - loss: 1.2474 - accuracy: 0.4610 - val_loss: 1.2125
- val_accuracy: 0.4920 - lr: 0.0010
Epoch 7/100
498/498 [==============================] - 53s 106ms/step - loss: 1.2015 - accuracy: 0.4865 - val_loss: 1.1183
- val_accuracy: 0.5264 - lr: 0.0010
Epoch 8/100
498/498 [==============================] - 53s 106ms/step - loss: 1.2090 - accuracy: 0.4869 - val_loss: 1.1809
- val_accuracy: 0.4839 - lr: 0.0010
Epoch 9/100
498/498 [==============================] - 53s 106ms/step - loss: 1.2029 - accuracy: 0.4906 - val_loss: 1.1738
- val_accuracy: 0.5126 - lr: 0.0010
Epoch 10/100
Epoch 10/100
498/498 [==============================] - 53s 106ms/step - loss: 1.1743 - accuracy: 0.5030 - val_loss: 1.0874
- val_accuracy: 0.5483 - lr: 0.0010
Epoch 11/100
498/498 [==============================] - 54s 108ms/step - loss: 1.1411 - accuracy: 0.5122 - val_loss: 1.1321
- val_accuracy: 0.5425 - lr: 9.9501e-04
Epoch 12/100
498/498 [==============================] - 52s 105ms/step - loss: 1.1603 - accuracy: 0.5074 - val_loss: 1.0843
- val_accuracy: 0.5379 - lr: 9.9005e-04
Epoch 13/100
498/498 [==============================] - 52s 105ms/step - loss: 1.1468 - accuracy: 0.5086 - val_loss: 1.0972
- val_accuracy: 0.5322 - lr: 9.8511e-04
Epoch 14/100
498/498 [==============================] - 52s 105ms/step - loss: 1.1172 - accuracy: 0.5271 - val_loss: 1.0293
- val_accuracy: 0.5793 - lr: 9.8020e-04
Epoch 15/100
498/498 [==============================] - 52s 104ms/step - loss: 1.1027 - accuracy: 0.5394 - val_loss: 1.0217
- val_accuracy: 0.5598 - lr: 9.7531e-04
Epoch 16/100
498/498 [==============================] - 52s 104ms/step - loss: 1.1013 - accuracy: 0.5307 - val_loss: 1.0511
- val_accuracy: 0.5552 - lr: 9.7045e-04
Epoch 17/100
498/498 [==============================] - 55s 109ms/step - loss: 1.0958 - accuracy: 0.5430 - val_loss: 1.0269
- val_accuracy: 0.5805 - lr: 9.6561e-04
Epoch 18/100
498/498 [==============================] - 53s 106ms/step - loss: 1.0816 - accuracy: 0.5458 - val_loss: 1.0343
- val_accuracy: 0.5552 - lr: 9.6079e-04
Epoch 19/100
498/498 [==============================] - 52s 105ms/step - loss: 1.0770 - accuracy: 0.5430 - val_loss: 1.0855
- val_accuracy: 0.5460 - lr: 9.5600e-04
Epoch 20/100
498/498 [==============================] - 52s 105ms/step - loss: 1.0949 - accuracy: 0.5384 - val_loss: 1.0150
- val_accuracy: 0.5874 - lr: 9.5123e-04
Epoch 21/100
498/498 [==============================] - 53s 106ms/step - loss: 1.0636 - accuracy: 0.5558 - val_loss: 1.0224
- val_accuracy: 0.5713 - lr: 9.4649e-04
Epoch 22/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0577 - accuracy: 0.5544 - val_loss: 1.0044
- val_accuracy: 0.6000 - lr: 9.4177e-04
Epoch 23/100
498/498 [==============================] - 53s 105ms/step - loss: 1.0552 - accuracy: 0.5616 - val_loss: 1.0322
- val_accuracy: 0.5563 - lr: 9.3707e-04
Epoch 24/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0507 - accuracy: 0.5566 - val_loss: 0.9565
- val_accuracy: 0.6103 - lr: 9.3239e-04
Epoch 25/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0390 - accuracy: 0.5614 - val_loss: 0.9667
- val_accuracy: 0.5920 - lr: 9.2774e-04
Epoch 26/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0426 - accuracy: 0.5618 - val_loss: 0.9400
- val_accuracy: 0.6000 - lr: 9.2312e-04
Epoch 27/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0444 - accuracy: 0.5596 - val_loss: 0.9748
- val_accuracy: 0.5839 - lr: 9.1851e-04
Epoch 28/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0220 - accuracy: 0.5749 - val_loss: 0.9951
- val_accuracy: 0.5874 - lr: 9.1393e-04
Epoch 29/100
498/498 [==============================] - 53s 106ms/step - loss: 1.0404 - accuracy: 0.5661 - val_loss: 0.9610
- val_accuracy: 0.6023 - lr: 9.0937e-04
Epoch 30/100
498/498 [==============================] - 52s 103ms/step - loss: 1.0124 - accuracy: 0.5755 - val_loss: 1.0223
- val_accuracy: 0.5678 - lr: 9.0484e-04
Epoch 31/100
498/498 [==============================] - 51s 103ms/step - loss: 1.0100 - accuracy: 0.5799 - val_loss: 1.0304
- val_accuracy: 0.5713 - lr: 9.0033e-04
Epoch 32/100
498/498 [==============================] - 52s 105ms/step - loss: 1.0258 - accuracy: 0.5759 - val_loss: 0.9072
- val_accuracy: 0.6126 - lr: 8.9584e-04
Epoch 33/100
498/498 [==============================] - 53s 106ms/step - loss: 1.0078 - accuracy: 0.5723 - val_loss: 0.9452
- val_accuracy: 0.6034 - lr: 8.9137e-04
Epoch 34/100
498/498 [==============================] - 52s 104ms/step - loss: 1.0013 - accuracy: 0.5759 - val_loss: 0.9205
- val_accuracy: 0.6069 - lr: 8.8692e-04
Epoch 35/100
498/498 [==============================] - 54s 109ms/step - loss: 0.9948 - accuracy: 0.5819 - val_loss: 0.9565
- val_accuracy: 0.6115 - lr: 8.8250e-04
- val_accuracy: 0.6115 - lr: 8.8250e-04
Epoch 36/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9916 - accuracy: 0.5902 - val_loss: 0.8917
- val_accuracy: 0.6161 - lr: 8.7810e-04
Epoch 37/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9724 - accuracy: 0.5869 - val_loss: 0.8951
- val_accuracy: 0.6207 - lr: 8.7372e-04
Epoch 38/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9824 - accuracy: 0.5871 - val_loss: 0.9385
- val_accuracy: 0.6345 - lr: 8.6936e-04
Epoch 39/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9660 - accuracy: 0.5918 - val_loss: 0.9308
- val_accuracy: 0.6000 - lr: 8.6502e-04
Epoch 40/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9637 - accuracy: 0.5956 - val_loss: 0.9032
- val_accuracy: 0.6276 - lr: 8.6071e-04
Epoch 41/100
498/498 [==============================] - 54s 109ms/step - loss: 0.9673 - accuracy: 0.5912 - val_loss: 0.8909
- val_accuracy: 0.6149 - lr: 8.5642e-04
Epoch 42/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9589 - accuracy: 0.5952 - val_loss: 0.9060
- val_accuracy: 0.6115 - lr: 8.5215e-04
Epoch 43/100
498/498 [==============================] - 54s 108ms/step - loss: 0.9511 - accuracy: 0.6014 - val_loss: 0.8820
- val_accuracy: 0.6264 - lr: 8.4790e-04
Epoch 44/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9576 - accuracy: 0.5966 - val_loss: 0.8564
- val_accuracy: 0.6391 - lr: 8.4367e-04
Epoch 45/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9477 - accuracy: 0.5948 - val_loss: 0.8776
- val_accuracy: 0.6264 - lr: 8.3946e-04
Epoch 46/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9466 - accuracy: 0.6038 - val_loss: 0.8890
- val_accuracy: 0.6230 - lr: 8.3527e-04
Epoch 47/100
498/498 [==============================] - 54s 107ms/step - loss: 0.9506 - accuracy: 0.6034 - val_loss: 0.8591
- val_accuracy: 0.6368 - lr: 8.3111e-04
Epoch 48/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9336 - accuracy: 0.6124 - val_loss: 0.8292
- val_accuracy: 0.6678 - lr: 8.2696e-04
Epoch 49/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9255 - accuracy: 0.6022 - val_loss: 0.8612
- val_accuracy: 0.6494 - lr: 8.2284e-04
Epoch 50/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9140 - accuracy: 0.6124 - val_loss: 0.8643
- val_accuracy: 0.6356 - lr: 8.1873e-04
Epoch 51/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9274 - accuracy: 0.6096 - val_loss: 0.8390
- val_accuracy: 0.6322 - lr: 8.1465e-04
Epoch 52/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9150 - accuracy: 0.6159 - val_loss: 0.8956
- val_accuracy: 0.6207 - lr: 8.1059e-04
Epoch 53/100
498/498 [==============================] - 53s 106ms/step - loss: 0.9124 - accuracy: 0.6141 - val_loss: 0.8408
- val_accuracy: 0.6540 - lr: 8.0654e-04
Epoch 54/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9079 - accuracy: 0.6229 - val_loss: 0.8413
- val_accuracy: 0.6414 - lr: 8.0252e-04
Epoch 55/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8975 - accuracy: 0.6231 - val_loss: 0.8783
- val_accuracy: 0.6345 - lr: 7.9852e-04
Epoch 56/100
498/498 [==============================] - 52s 104ms/step - loss: 0.9112 - accuracy: 0.6169 - val_loss: 0.8239
- val_accuracy: 0.6701 - lr: 7.9454e-04
Epoch 57/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9037 - accuracy: 0.6179 - val_loss: 0.8476
- val_accuracy: 0.6483 - lr: 7.9057e-04
Epoch 58/100
498/498 [==============================] - 52s 105ms/step - loss: 0.9079 - accuracy: 0.6217 - val_loss: 0.8312
- val_accuracy: 0.6529 - lr: 7.8663e-04
Epoch 59/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8878 - accuracy: 0.6313 - val_loss: 0.8279
- val_accuracy: 0.6517 - lr: 7.8271e-04
Epoch 60/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8790 - accuracy: 0.6347 - val_loss: 0.8349
- val_accuracy: 0.6644 - lr: 7.7880e-04
Epoch 61/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8824 - accuracy: 0.6306 - val_loss: 0.8557
```

```
498/498 [==============================] - 52s 104ms/step - loss: 0.8834 - accuracy: 0.6396 - val_loss: 0.8557
- val_accuracy: 0.6586 - lr: 7.7492e-04
Epoch 62/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8879 - accuracy: 0.6321 - val_loss: 0.8100
- val_accuracy: 0.6678 - lr: 7.7105e-04
Epoch 63/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8561 - accuracy: 0.6398 - val_loss: 0.8179
- val_accuracy: 0.6609 - lr: 7.6721e-04
Epoch 64/100
498/498 [==============================] - 53s 107ms/step - loss: 0.8787 - accuracy: 0.6265 - val_loss: 0.8172
- val_accuracy: 0.6632 - lr: 7.6338e-04
Epoch 65/100
498/498 [==============================] - 55s 110ms/step - loss: 0.8769 - accuracy: 0.6404 - val_loss: 0.8100
- val_accuracy: 0.6644 - lr: 7.5957e-04
Epoch 66/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8604 - accuracy: 0.6416 - val_loss: 0.8308
- val_accuracy: 0.6322 - lr: 7.5579e-04
Epoch 67/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8671 - accuracy: 0.6380 - val_loss: 0.8304
- val_accuracy: 0.6621 - lr: 7.5202e-04
Epoch 68/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8658 - accuracy: 0.6418 - val_loss: 0.8065
- val_accuracy: 0.6747 - lr: 7.4827e-04
Epoch 69/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8688 - accuracy: 0.6426 - val_loss: 0.7920
- val_accuracy: 0.6609 - lr: 7.4453e-04
Epoch 70/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8556 - accuracy: 0.6446 - val_loss: 0.8294
- val_accuracy: 0.6506 - lr: 7.4082e-04
Epoch 71/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8498 - accuracy: 0.6544 - val_loss: 0.8102
- val_accuracy: 0.6540 - lr: 7.3713e-04
Epoch 72/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8394 - accuracy: 0.6540 - val_loss: 0.8093
- val_accuracy: 0.6747 - lr: 7.3345e-04
Epoch 73/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8333 - accuracy: 0.6522 - val_loss: 0.7995
- val_accuracy: 0.6747 - lr: 7.2979e-04
Epoch 74/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8527 - accuracy: 0.6444 - val_loss: 0.7786
- val_accuracy: 0.6839 - lr: 7.2615e-04
Epoch 75/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8347 - accuracy: 0.6572 - val_loss: 0.8110
- val_accuracy: 0.6655 - lr: 7.2253e-04
Epoch 76/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8376 - accuracy: 0.6494 - val_loss: 0.8206
- val_accuracy: 0.6759 - lr: 7.1893e-04
Epoch 77/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8197 - accuracy: 0.6681 - val_loss: 0.8213
- val_accuracy: 0.6540 - lr: 7.1534e-04
Epoch 78/100
498/498 [==============================] - 53s 105ms/step - loss: 0.8340 - accuracy: 0.6482 - val_loss: 0.7725
- val_accuracy: 0.6736 - lr: 7.1177e-04
Epoch 79/100
498/498 [==============================] - 52s 104ms/step - loss: 0.8320 - accuracy: 0.6578 - val_loss: 0.7890
- val_accuracy: 0.6667 - lr: 7.0822e-04
Epoch 80/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8355 - accuracy: 0.6550 - val_loss: 0.7601
- val_accuracy: 0.6874 - lr: 7.0469e-04
Epoch 81/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8299 - accuracy: 0.6562 - val_loss: 0.7889
- val_accuracy: 0.6839 - lr: 7.0118e-04
Epoch 82/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8243 - accuracy: 0.6592 - val_loss: 0.7882
- val_accuracy: 0.6782 - lr: 6.9768e-04
Epoch 83/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8194 - accuracy: 0.6657 - val_loss: 0.7504
- val_accuracy: 0.6931 - lr: 6.9420e-04
Epoch 84/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8127 - accuracy: 0.6629 - val_loss: 0.7821
- val_accuracy: 0.6874 - lr: 6.9074e-04
Epoch 85/100
498/498 [==============================] - 54s 107ms/step - loss: 0.8279 - accuracy: 0.6586 - val_loss: 0.7974
- val_accuracy: 0.6529 - lr: 6.8729e-04
Epoch 86/100
498/498 [==============================] - 53s 106ms/step - loss: 0.7982 - accuracy: 0.6743 - val_loss: 0.8267
- val_accuracy: 0.6690 - lr: 6.8386e-04
Epoch 87/100
Epoch 87/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8225 - accuracy: 0.6631 - val_loss: 0.8335
- val_accuracy: 0.6609 - lr: 6.8045e-04
Epoch 88/100
498/498 [==============================] - 53s 106ms/step - loss: 0.8188 - accuracy: 0.6504 - val_loss: 0.7755
- val_accuracy: 0.6632 - lr: 6.7706e-04
Epoch 89/100
498/498 [==============================] - 53s 107ms/step - loss: 0.8065 - accuracy: 0.6761 - val_loss: 0.8038
- val_accuracy: 0.6575 - lr: 6.7368e-04
Epoch 90/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8132 - accuracy: 0.6614 - val_loss: 0.7835
- val_accuracy: 0.6563 - lr: 6.7032e-04
Epoch 91/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8048 - accuracy: 0.6691 - val_loss: 0.7987
- val_accuracy: 0.6690 - lr: 6.6698e-04
Epoch 92/100
498/498 [==============================] - 52s 105ms/step - loss: 0.8058 - accuracy: 0.6649 - val_loss: 0.7748
- val_accuracy: 0.6770 - lr: 6.6365e-04
Epoch 93/100
498/498 [==============================] - 52s 105ms/step - loss: 0.7809 - accuracy: 0.6773 - val_loss: 0.7629
- val_accuracy: 0.6897 - lr: 6.6034e-04
Epoch 94/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7910 - accuracy: 0.6737 - val_loss: 0.7373
- val_accuracy: 0.6920 - lr: 6.5705e-04
Epoch 95/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7922 - accuracy: 0.6811 - val_loss: 0.7674
- val_accuracy: 0.6816 - lr: 6.5377e-04
Epoch 96/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7897 - accuracy: 0.6751 - val_loss: 0.7765
- val_accuracy: 0.6736 - lr: 6.5051e-04
Epoch 97/100
498/498 [==============================] - 53s 106ms/step - loss: 0.7948 - accuracy: 0.6697 - val_loss: 0.7680
- val_accuracy: 0.6632 - lr: 6.4727e-04
Epoch 98/100
498/498 [==============================] - 53s 106ms/step - loss: 0.7941 - accuracy: 0.6723 - val_loss: 0.7511
- val_accuracy: 0.6747 - lr: 6.4404e-04
Epoch 99/100
498/498 [==============================] - 53s 106ms/step - loss: 0.7844 - accuracy: 0.6819 - val_loss: 0.7639
- val_accuracy: 0.6908 - lr: 6.4083e-04
Epoch 100/100
498/498 [==============================] - 53s 106ms/step - loss: 0.7781 - accuracy: 0.6825 - val_loss: 0.7692
- val_accuracy: 0.6805 - lr: 6.3763e-04
```

Out[ ]:

```
<keras.callbacks.History at 0x7f01c2c3ce10>
```

In [ ]:

```
model.save('/content/RGB_lstm_model',save_format='tf')
```

In [ ]:

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

```
Mounted at /content/drive
```

In [ ]:

In [ ]:

```
model.fit(ImageGenerator_train, steps_per_epoch=train_steps, epochs=100,\
                   validation_data=ImageGenerator_test, validation_steps=valid_steps,callbacks = [lr_schedule
```

```
Epoch 1/100
498/498 [==============================] - 58s 116ms/step - loss: 0.7691 - accuracy: 0.6920 - val_loss: 0.7489
- val_accuracy: 0.6954 - lr: 6.3763e-04
Epoch 2/100
498/498 [==============================] - 56s 113ms/step - loss: 0.7740 - accuracy: 0.6789 - val_loss: 0.7499
- val_accuracy: 0.6816 - lr: 6.3763e-04
Epoch 3/100
498/498 [==============================] - 56s 113ms/step - loss: 0.7855 - accuracy: 0.6751 - val_loss: 0.7654
- val_accuracy: 0.6989 - lr: 6.3763e-04
Epoch 4/100
498/498 [==============================] - 56s 112ms/step - loss: 0.7740 - accuracy: 0.6841 - val_loss: 0.7324
- val_accuracy: 0.7103 - lr: 6.3763e-04
Epoch 5/100
498/498 [==============================] - 56s 112ms/step - loss: 0.7796 - accuracy: 0.6775 - val_loss: 0.7667
- val_accuracy: 0.6874 - lr: 6.3763e-04
Epoch 6/100
498/498 [==============================] - 57s 115ms/step - loss: 0.7962 - accuracy: 0.6725 - val_loss: 0.7370
- val_accuracy: 0.6885 - lr: 6.3763e-04
Epoch 7/100
```

```
498/498 [==============================] - 55s 111ms/step - loss: 0.7611 - accuracy: 0.6833 - val_loss: 0.8059
- val_accuracy: 0.6805 - lr: 6.3763e-04
Epoch 8/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7602 - accuracy: 0.6809 - val_loss: 0.7498
- val_accuracy: 0.6851 - lr: 6.3763e-04
Epoch 9/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7613 - accuracy: 0.6873 - val_loss: 0.7264
- val_accuracy: 0.6851 - lr: 6.3763e-04
Epoch 10/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7651 - accuracy: 0.6878 - val_loss: 0.7648
- val_accuracy: 0.6782 - lr: 6.3763e-04
Epoch 11/100
498/498 [==============================] - 56s 112ms/step - loss: 0.7544 - accuracy: 0.6851 - val_loss: 0.7642
- val_accuracy: 0.6816 - lr: 6.3445e-04
Epoch 12/100
498/498 [==============================] - 56s 113ms/step - loss: 0.7514 - accuracy: 0.6948 - val_loss: 0.7568
- val_accuracy: 0.6828 - lr: 6.3129e-04
Epoch 13/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7622 - accuracy: 0.6831 - val_loss: 0.7224
- val_accuracy: 0.6816 - lr: 6.2814e-04
Epoch 14/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7540 - accuracy: 0.6863 - val_loss: 0.7369
- val_accuracy: 0.7023 - lr: 6.2500e-04
Epoch 15/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7556 - accuracy: 0.6916 - val_loss: 0.7893
- val_accuracy: 0.6793 - lr: 6.2189e-04
Epoch 16/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7538 - accuracy: 0.6873 - val_loss: 0.7657
- val_accuracy: 0.6828 - lr: 6.1879e-04
Epoch 17/100
498/498 [==============================] - 53s 107ms/step - loss: 0.7529 - accuracy: 0.6932 - val_loss: 0.7831
- val_accuracy: 0.6724 - lr: 6.1570e-04
Epoch 18/100
498/498 [==============================] - 56s 112ms/step - loss: 0.7503 - accuracy: 0.6922 - val_loss: 0.7235
- val_accuracy: 0.6920 - lr: 6.1263e-04
Epoch 19/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7504 - accuracy: 0.6888 - val_loss: 0.7231
- val_accuracy: 0.7034 - lr: 6.0957e-04
Epoch 20/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7513 - accuracy: 0.6888 - val_loss: 0.7115
- val_accuracy: 0.6931 - lr: 6.0653e-04
Epoch 21/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7355 - accuracy: 0.6980 - val_loss: 0.7541
- val_accuracy: 0.6885 - lr: 6.0351e-04
Epoch 22/100
498/498 [==============================] - 55s 109ms/step - loss: 0.7526 - accuracy: 0.6968 - val_loss: 0.7251
- val_accuracy: 0.6931 - lr: 6.0050e-04
Epoch 23/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7441 - accuracy: 0.6896 - val_loss: 0.7402
- val_accuracy: 0.6874 - lr: 5.9750e-04
Epoch 24/100
498/498 [==============================] - 56s 113ms/step - loss: 0.7323 - accuracy: 0.6992 - val_loss: 0.7484
- val_accuracy: 0.6690 - lr: 5.9452e-04
Epoch 25/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7389 - accuracy: 0.6944 - val_loss: 0.7557
- val_accuracy: 0.6793 - lr: 5.9156e-04
Epoch 26/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7442 - accuracy: 0.6970 - val_loss: 0.7727
- val_accuracy: 0.6851 - lr: 5.8861e-04
Epoch 27/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7309 - accuracy: 0.6956 - val_loss: 0.7274
- val_accuracy: 0.7069 - lr: 5.8567e-04
Epoch 28/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7396 - accuracy: 0.7014 - val_loss: 0.7172
- val_accuracy: 0.6966 - lr: 5.8275e-04
Epoch 29/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7386 - accuracy: 0.6962 - val_loss: 0.7456
- val_accuracy: 0.7092 - lr: 5.7984e-04
Epoch 30/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7272 - accuracy: 0.6976 - val_loss: 0.7464
- val_accuracy: 0.6943 - lr: 5.7695e-04
Epoch 31/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7263 - accuracy: 0.6968 - val_loss: 0.7532
- val_accuracy: 0.7034 - lr: 5.7407e-04
Epoch 32/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7149 - accuracy: 0.7004 - val_loss: 0.7107
- val_accuracy: 0.7195 - lr: 5.7121e-04
- val_accuracy: 0.7190 - lr: 5.7121e-04
Epoch 33/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7404 - accuracy: 0.6982 - val_loss: 0.7018
- val_accuracy: 0.7172 - lr: 5.6836e-04
Epoch 34/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7186 - accuracy: 0.6978 - val_loss: 0.7503
- val_accuracy: 0.6966 - lr: 5.6553e-04
Epoch 35/100
498/498 [==============================] - 53s 107ms/step - loss: 0.7283 - accuracy: 0.6944 - val_loss: 0.7274
- val_accuracy: 0.6782 - lr: 5.6271e-04
Epoch 36/100
498/498 [==============================] - 55s 111ms/step - loss: 0.7174 - accuracy: 0.7056 - val_loss: 0.7611
- val_accuracy: 0.6701 - lr: 5.5990e-04
Epoch 37/100
498/498 [==============================] - 53s 107ms/step - loss: 0.7180 - accuracy: 0.7052 - val_loss: 0.7262
- val_accuracy: 0.6931 - lr: 5.5711e-04
Epoch 38/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7196 - accuracy: 0.7070 - val_loss: 0.7172
- val_accuracy: 0.7115 - lr: 5.5433e-04
Epoch 39/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7234 - accuracy: 0.7094 - val_loss: 0.7474
- val_accuracy: 0.6931 - lr: 5.5157e-04
Epoch 40/100
498/498 [==============================] - 55s 110ms/step - loss: 0.7153 - accuracy: 0.7034 - val_loss: 0.7244
- val_accuracy: 0.6897 - lr: 5.4881e-04
Epoch 41/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7180 - accuracy: 0.7038 - val_loss: 0.7036
- val_accuracy: 0.7172 - lr: 5.4608e-04
Epoch 42/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6977 - accuracy: 0.7159 - val_loss: 0.7428
- val_accuracy: 0.6828 - lr: 5.4335e-04
Epoch 43/100
498/498 [==============================] - 53s 107ms/step - loss: 0.7094 - accuracy: 0.7068 - val_loss: 0.7294
- val_accuracy: 0.7057 - lr: 5.4064e-04
Epoch 44/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7074 - accuracy: 0.7062 - val_loss: 0.7244
- val_accuracy: 0.6966 - lr: 5.3795e-04
Epoch 45/100
498/498 [==============================] - 54s 107ms/step - loss: 0.7026 - accuracy: 0.7118 - val_loss: 0.7388
- val_accuracy: 0.7034 - lr: 5.3526e-04
Epoch 46/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6960 - accuracy: 0.7102 - val_loss: 0.7030
- val_accuracy: 0.7126 - lr: 5.3259e-04
Epoch 47/100
498/498 [==============================] - 54s 108ms/step - loss: 0.7058 - accuracy: 0.7145 - val_loss: 0.7574
- val_accuracy: 0.6862 - lr: 5.2994e-04
Epoch 48/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6899 - accuracy: 0.7161 - val_loss: 0.7237
- val_accuracy: 0.7092 - lr: 5.2730e-04
Epoch 49/100
498/498 [==============================] - 54s 109ms/step - loss: 0.7085 - accuracy: 0.7171 - val_loss: 0.7253
- val_accuracy: 0.6931 - lr: 5.2467e-04
Epoch 50/100
498/498 [==============================] - 55s 110ms/step - loss: 0.6881 - accuracy: 0.7151 - val_loss: 0.7015
- val_accuracy: 0.7080 - lr: 5.2205e-04
Epoch 51/100
498/498 [==============================] - 54s 107ms/step - loss: 0.7139 - accuracy: 0.7018 - val_loss: 0.6990
- val_accuracy: 0.7161 - lr: 5.1944e-04
Epoch 52/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6986 - accuracy: 0.7197 - val_loss: 0.7338
- val_accuracy: 0.6816 - lr: 5.1685e-04
Epoch 53/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6935 - accuracy: 0.7112 - val_loss: 0.7357
- val_accuracy: 0.7069 - lr: 5.1428e-04
Epoch 54/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6943 - accuracy: 0.7137 - val_loss: 0.7084
- val_accuracy: 0.7092 - lr: 5.1171e-04
Epoch 55/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6887 - accuracy: 0.7141 - val_loss: 0.7174
- val_accuracy: 0.7046 - lr: 5.0916e-04
Epoch 56/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6841 - accuracy: 0.7169 - val_loss: 0.7674
- val_accuracy: 0.6644 - lr: 5.0662e-04
Epoch 57/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6938 - accuracy: 0.7159 - val_loss: 0.7011
- val_accuracy: 0.7057 - lr: 5.0409e-04
Epoch 58/100
498/498 [==============================] - 55s 110ms/step - loss: 0.6881 - accuracy: 0.7213 - val_loss: 0.7269
```

```
498/498 [==============================] - 55s 110ms/step - loss: 0.6861 - accuracy: 0.7213 - val_loss: 0.7209
- val_accuracy: 0.6989 - lr: 5.0158e-04
Epoch 59/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6766 - accuracy: 0.7269 - val_loss: 0.7394
- val_accuracy: 0.6908 - lr: 4.9908e-04
Epoch 60/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6936 - accuracy: 0.7135 - val_loss: 0.7697
- val_accuracy: 0.6954 - lr: 4.9659e-04
Epoch 61/100
498/498 [==============================] - 56s 112ms/step - loss: 0.7042 - accuracy: 0.7120 - val_loss: 0.6993
- val_accuracy: 0.7241 - lr: 4.9411e-04
Epoch 62/100
498/498 [==============================] - 56s 112ms/step - loss: 0.6829 - accuracy: 0.7265 - val_loss: 0.7045
- val_accuracy: 0.7161 - lr: 4.9165e-04
Epoch 63/100
498/498 [==============================] - 56s 112ms/step - loss: 0.6679 - accuracy: 0.7299 - val_loss: 0.7515
- val_accuracy: 0.6943 - lr: 4.8920e-04
Epoch 64/100
498/498 [==============================] - 55s 110ms/step - loss: 0.6826 - accuracy: 0.7231 - val_loss: 0.7347
- val_accuracy: 0.7057 - lr: 4.8676e-04
Epoch 65/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6732 - accuracy: 0.7159 - val_loss: 0.7053
- val_accuracy: 0.7011 - lr: 4.8433e-04
Epoch 66/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6865 - accuracy: 0.7197 - val_loss: 0.7266
- val_accuracy: 0.6954 - lr: 4.8191e-04
Epoch 67/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6704 - accuracy: 0.7231 - val_loss: 0.7052
- val_accuracy: 0.7299 - lr: 4.7951e-04
Epoch 68/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6771 - accuracy: 0.7229 - val_loss: 0.6849
- val_accuracy: 0.7241 - lr: 4.7712e-04
Epoch 69/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6539 - accuracy: 0.7303 - val_loss: 0.7055
- val_accuracy: 0.7184 - lr: 4.7474e-04
Epoch 70/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6695 - accuracy: 0.7221 - val_loss: 0.7224
- val_accuracy: 0.7000 - lr: 4.7237e-04
Epoch 71/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6587 - accuracy: 0.7235 - val_loss: 0.6852
- val_accuracy: 0.7172 - lr: 4.7001e-04
Epoch 72/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6434 - accuracy: 0.7378 - val_loss: 0.7162
- val_accuracy: 0.7161 - lr: 4.6767e-04
Epoch 73/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6696 - accuracy: 0.7251 - val_loss: 0.6935
- val_accuracy: 0.7195 - lr: 4.6534e-04
Epoch 74/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6671 - accuracy: 0.7275 - val_loss: 0.7223
- val_accuracy: 0.7161 - lr: 4.6302e-04
Epoch 75/100
498/498 [==============================] - 55s 110ms/step - loss: 0.6628 - accuracy: 0.7299 - val_loss: 0.7246
- val_accuracy: 0.6966 - lr: 4.6071e-04
Epoch 76/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6712 - accuracy: 0.7283 - val_loss: 0.7260
- val_accuracy: 0.7011 - lr: 4.5841e-04
Epoch 77/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6678 - accuracy: 0.7275 - val_loss: 0.7305
- val_accuracy: 0.7011 - lr: 4.5612e-04
Epoch 78/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6586 - accuracy: 0.7343 - val_loss: 0.7088
- val_accuracy: 0.7207 - lr: 4.5385e-04
Epoch 79/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6571 - accuracy: 0.7305 - val_loss: 0.7145
- val_accuracy: 0.7103 - lr: 4.5158e-04
Epoch 80/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6499 - accuracy: 0.7305 - val_loss: 0.6917
- val_accuracy: 0.7230 - lr: 4.4933e-04
Epoch 81/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6606 - accuracy: 0.7309 - val_loss: 0.7269
- val_accuracy: 0.7195 - lr: 4.4709e-04
Epoch 82/100
498/498 [==============================] - 53s 107ms/step - loss: 0.6491 - accuracy: 0.7305 - val_loss: 0.7212
- val_accuracy: 0.6931 - lr: 4.4486e-04
Epoch 83/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6597 - accuracy: 0.7301 - val_loss: 0.7192
- val_accuracy: 0.7011 - lr: 4.4264e-04
Epoch 84/100
Epoch 84/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6584 - accuracy: 0.7301 - val_loss: 0.6886
- val_accuracy: 0.7241 - lr: 4.4043e-04
Epoch 85/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6552 - accuracy: 0.7295 - val_loss: 0.6959
- val_accuracy: 0.7253 - lr: 4.3824e-04
Epoch 86/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6603 - accuracy: 0.7309 - val_loss: 0.6956
- val_accuracy: 0.7092 - lr: 4.3605e-04
Epoch 87/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6542 - accuracy: 0.7225 - val_loss: 0.6676
- val_accuracy: 0.7230 - lr: 4.3388e-04
Epoch 88/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6422 - accuracy: 0.7404 - val_loss: 0.6789
- val_accuracy: 0.7230 - lr: 4.3171e-04
Epoch 89/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6389 - accuracy: 0.7428 - val_loss: 0.6944
- val_accuracy: 0.7126 - lr: 4.2956e-04
Epoch 90/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6407 - accuracy: 0.7450 - val_loss: 0.7014
- val_accuracy: 0.7276 - lr: 4.2742e-04
Epoch 91/100
498/498 [==============================] - 54s 109ms/step - loss: 0.6431 - accuracy: 0.7305 - val_loss: 0.7242
- val_accuracy: 0.7034 - lr: 4.2529e-04
Epoch 92/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6484 - accuracy: 0.7345 - val_loss: 0.6759
- val_accuracy: 0.7322 - lr: 4.2317e-04
Epoch 93/100
498/498 [==============================] - 54s 108ms/step - loss: 0.6411 - accuracy: 0.7339 - val_loss: 0.6923
- val_accuracy: 0.7161 - lr: 4.2105e-04
Epoch 94/100
498/498 [==============================] - 55s 111ms/step - loss: 0.6286 - accuracy: 0.7408 - val_loss: 0.6867
- val_accuracy: 0.7230 - lr: 4.1895e-04
Epoch 95/100
104/498 [=====>........................] - ETA: 38s - loss: 0.6371 - accuracy: 0.7413
```

Observation:

epoch:194

Train accuracy: 74.08%

Test accuracy: 72.30%

Observation:

In [1]:

```
from prettytable import PrettyTable

# Specify the Column Names while initializing the Table
Table = PrettyTable(["Sno", "epoch", "Model", "Train accuracy","Test Accuracy"])

# Add rows
Table.add_row(["1", "340", "simple baseline model", "78.83%","79.29%"])
Table.add_row(["2", "200", "Grayscale LSTM model M1", " 74.54%","70.11%"])
Table.add_row(["3", "1100", "Grayscale LSTM model M2", "76.08%","74.94%"])
Table.add_row(["4", "194", "RGB LSTM model", "74.08%","72.30%"])

print(Table)
```

```
+-----+-------+-------------------------+----------------+---------------+
| Sno | epoch |          Model          | Train accuracy | Test Accuracy |
+-----+-------+-------------------------+----------------+---------------+
|  1  |  340  |  simple baseline model  |     78.83%     |     79.29%    |
|  2  |  200  | Grayscale LSTM model M1 |     74.54%     |     70.11%    |
|  3  |  1100 | Grayscale LSTM model M2 |     76.08%     |     74.94%    |
|  4  |  194  |      RGB LSTM model     |     74.08%     |     72.30%    |
+-----+-------+-------------------------+----------------+---------------+
```

- Both Grayscale and RGB LSTM model need to be fine tuned and should be trained for more epoch which may surely results in better results.
- Simple Baseline model was performing good.
- Gray scale LSTM M2 model and Gray scale LSTM M1 are same in architecture, only differ in train data i.e.data augmentation.
- Since the training data is small, which is limiting the model to perform well.