```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from keras.utils.np_utils import to_categorical
from sklearn.model_selection import KFold, cross_val_score,
train_test_split
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
from tensorflow.keras.preprocessing import
image_dataset_from_directory
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Activation,
Flatten, Dense, Dropout, BatchNormalization
from tensorflow.keras.losses import SparseCategoricalCrossentropy
from tensorflow.keras.regularizers import l2
from gc import callbacks

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

Mounted at /content/drive

path="/content/drive/MyDrive/Cancer_data/Full_cancer_data"

x_benign="/content/drive/MyDrive/Full_cancer_data/benign"
x_malignant="/content/drive/MyDrive/Full_cancer_data/malignant"

import cv2 #open cv
import glob

x_benign_images = [cv2.imread(file) for file in
glob.glob(x_benign+'/*.jpg')] #data will be read as a list using
imread
x_malignant_images= [cv2.imread(file) for file in
glob.glob(x_malignant+'/*.jpg')]

print("Number of begnign images =" + str(len(x_benign_images)))
print("Number of malignant images =" + str(len(x_malignant_images)))

Number of begnign images =1800
Number of malignant images =1497

x_benign_images=np.array(x_benign_images) #convert to array of images
x_malignant_images=np.array(x_malignant_images)

print(x_benign_images.shape)
print(x_malignant_images.shape)

(1800, 224, 224, 3)
(1497, 224, 224, 3)
```

```
# Create labels
y_benign = np.zeros(x_benign_images.shape[0]) #target value labels
y_malignant = np.ones(x_malignant_images.shape[0])

y_benign

array([0., 0., 0., ..., 0., 0., 0.])

# Merge data
X = np.concatenate((x_benign_images, x_malignant_images), axis = 0)
y = np.concatenate((y_benign, y_malignant), axis = 0)

type(y)

numpy.ndarray

X.shape

(3297, 224, 224, 3)

y.shape

(3297,)

y=y.astype(np.int64) #change dtype from float to int
y

array([0, 0, 0, ..., 1, 1, 1])

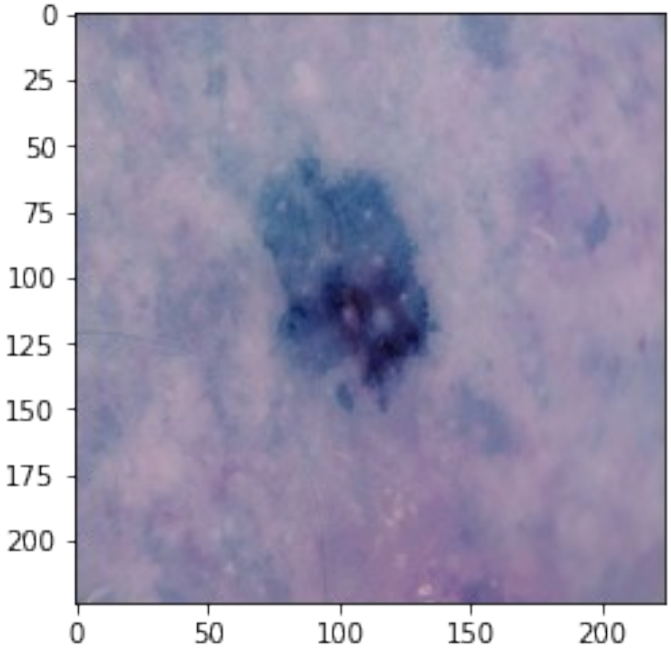
# one hot encoding

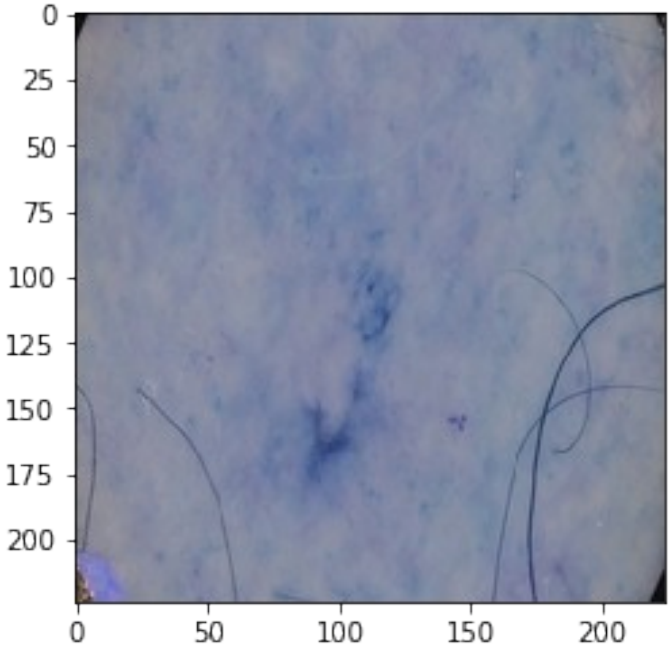
# y = to_categorical(y, num_classes= 2)
# y.dtype

# Shuffle data
s = np.arange(X.shape[0]) #(start, stop, spacing=1(default))
np.random.shuffle(s) #shuffles
X = X[s]
y= y[s] #here x and y both has same s (index)
print(s)
print(y[s])

[2313 1196 2414 ... 1164 2904 1361]
[1 1 0 ... 1 0 0]

for i in range(1, 15):
  plt.imshow(X[i], interpolation='nearest')
  plt.show()
```


0
25
50
75
100
125
150
175
200
0
50
100
150
200


0
25
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100
125
150
175
200
0
50
100
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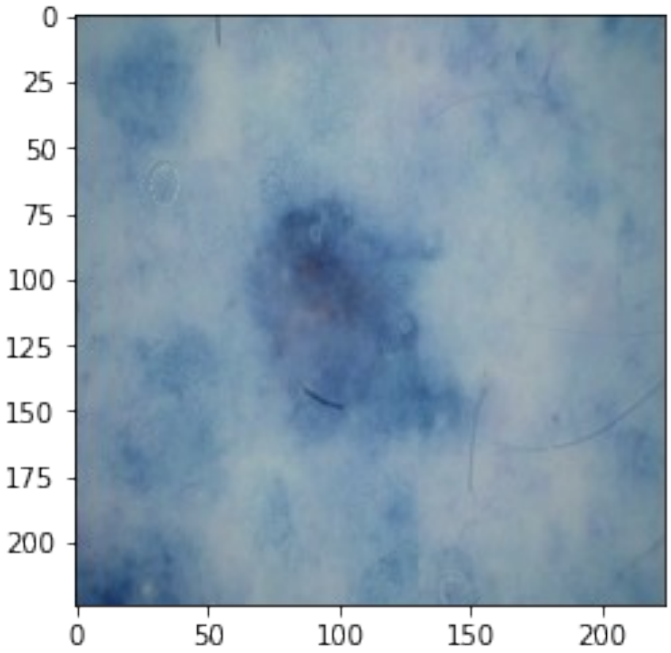
200


0
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125
150
175
200
0
50
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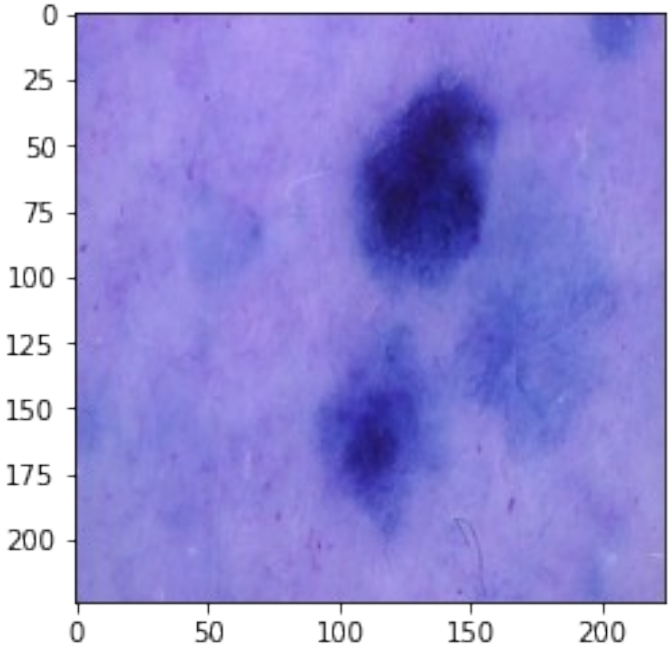
200


0
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150
175
200
0
50
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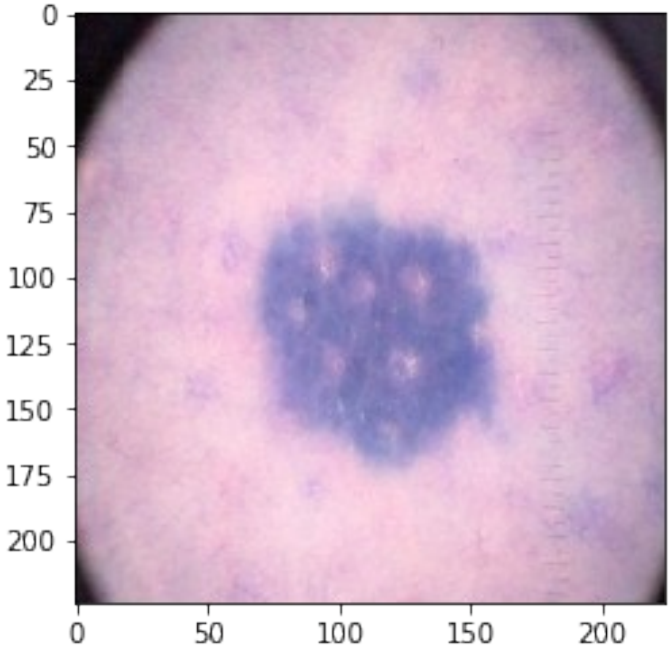
200


0
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150
175
200
0
50
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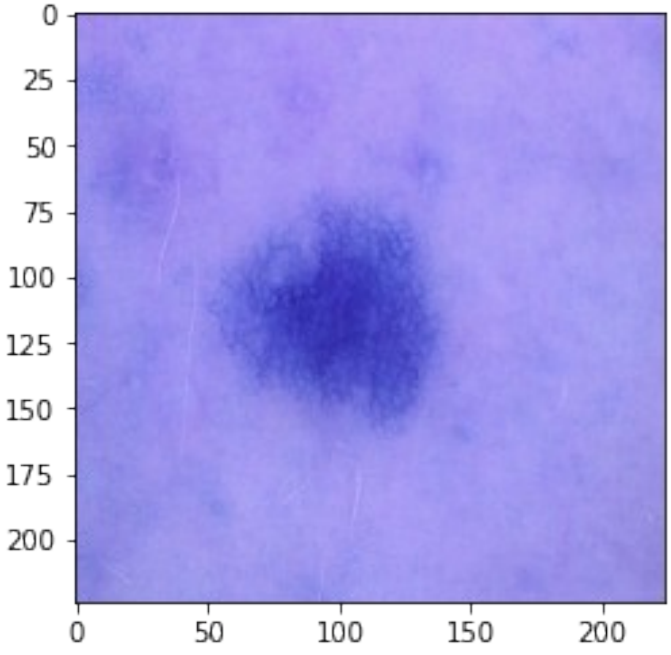
150
200


0
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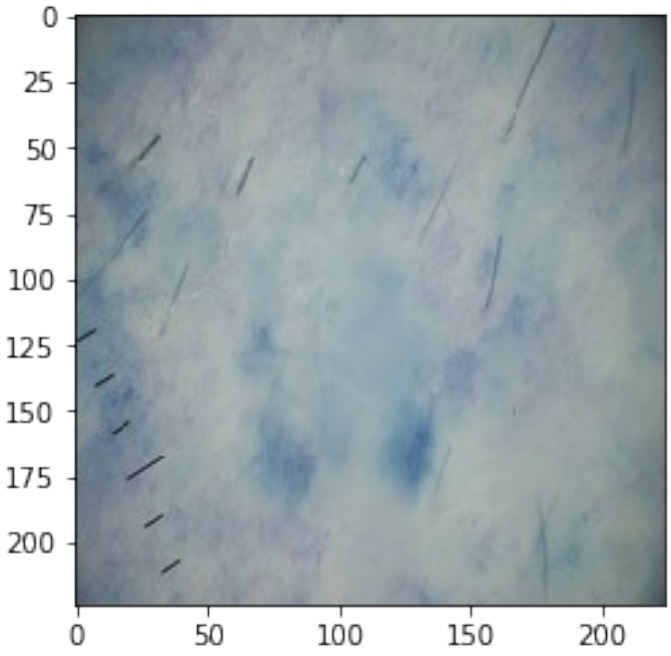
150
175
200
0
50
100
150
200


0
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100
125
150
175
200
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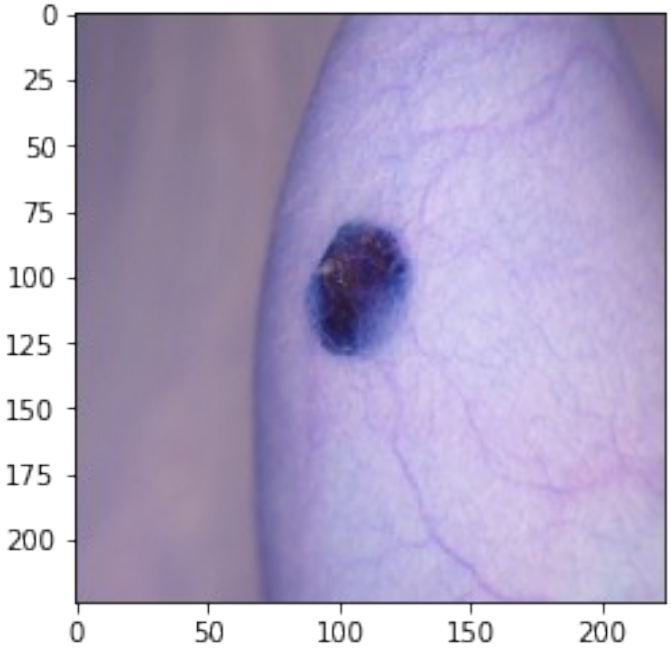
200


0
25
50
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125
150
175
200
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50
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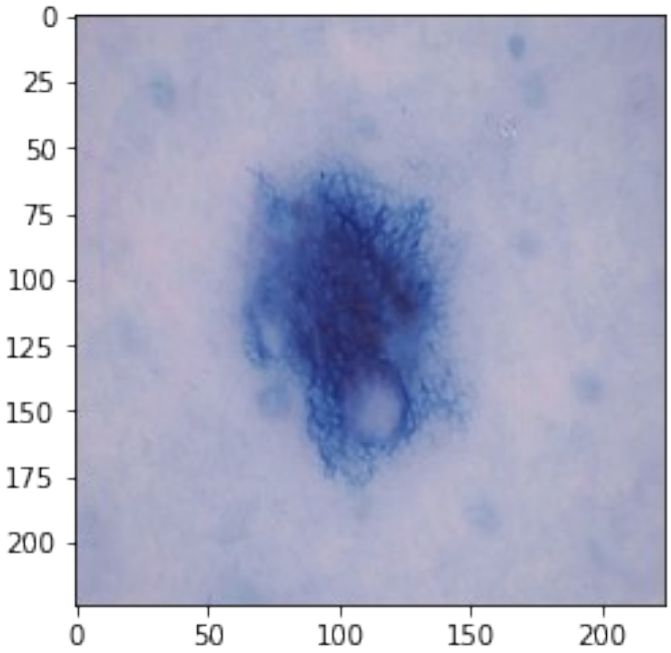
200


0
25
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75
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125
150
175
200
0
50
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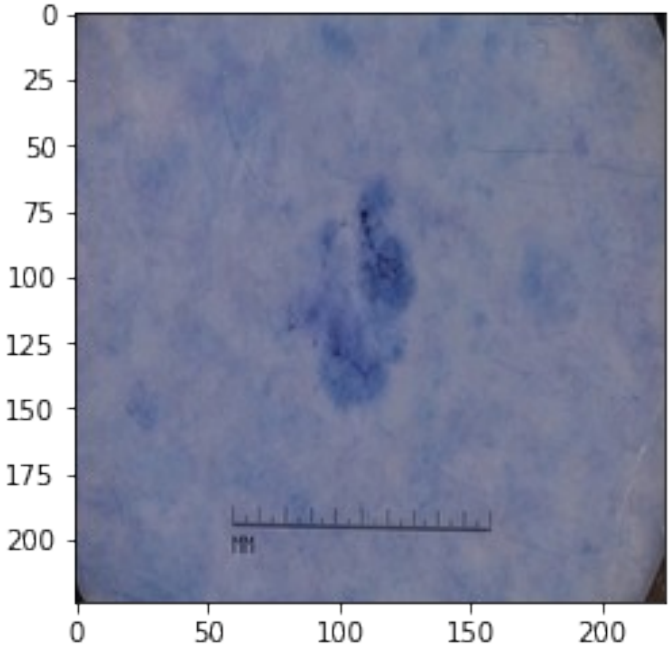
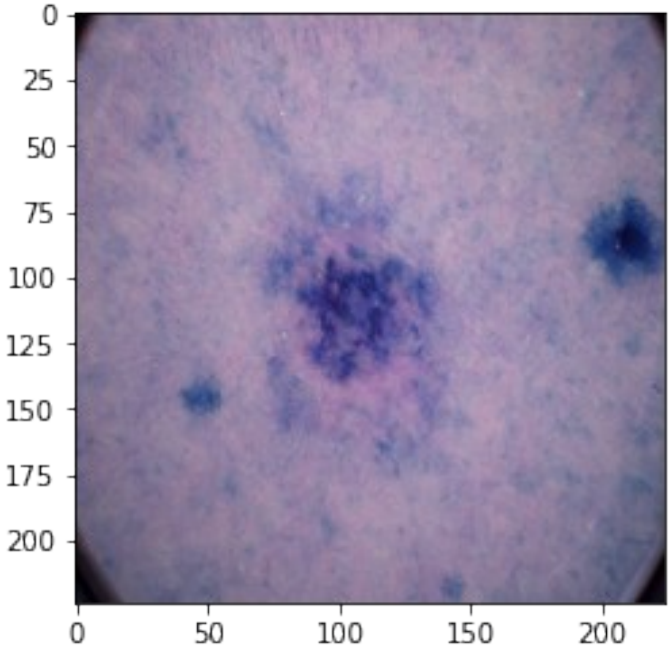
150
200


0
25
50
75
100
125
150
175
200
0
50
100
150
200


0
25
50
75
100
125
150
175
200
0
50
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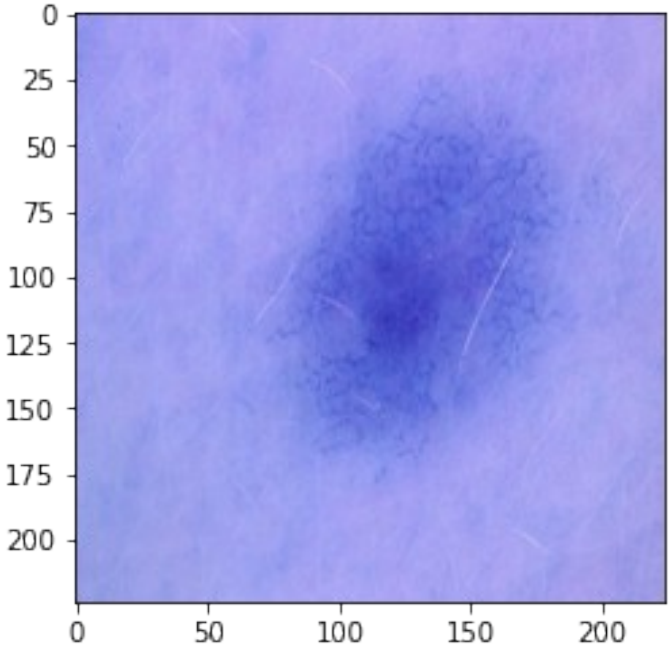
200


0
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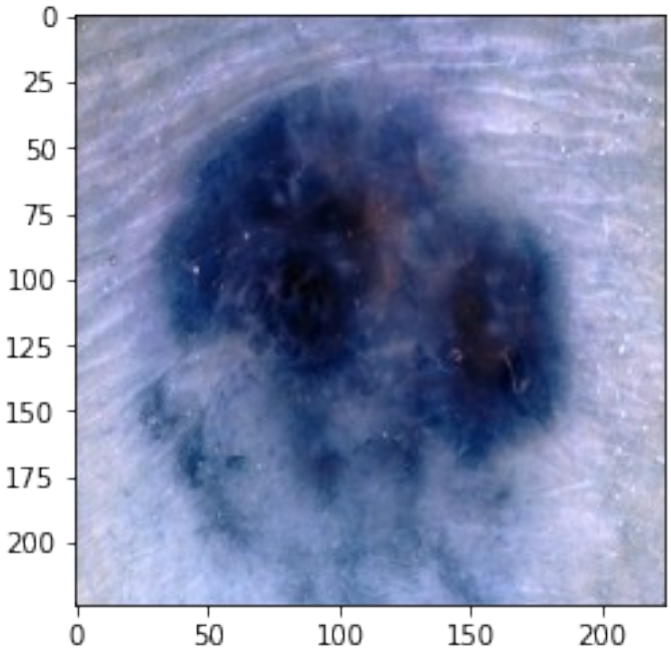
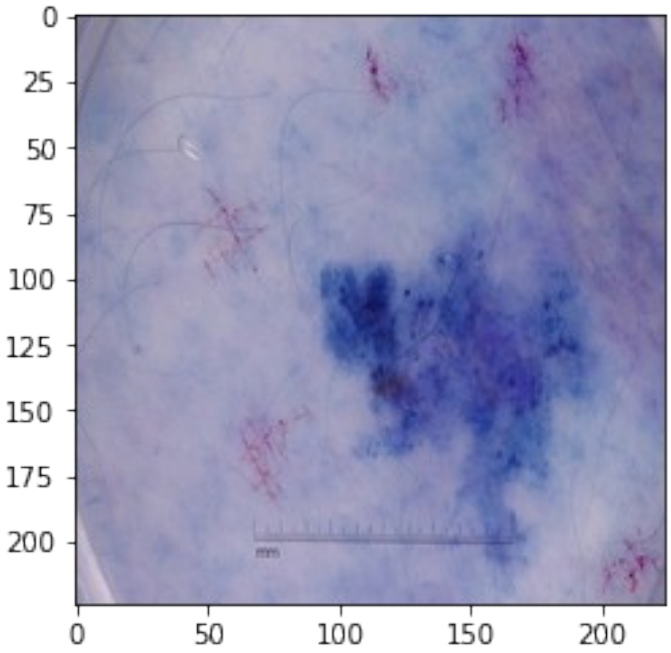




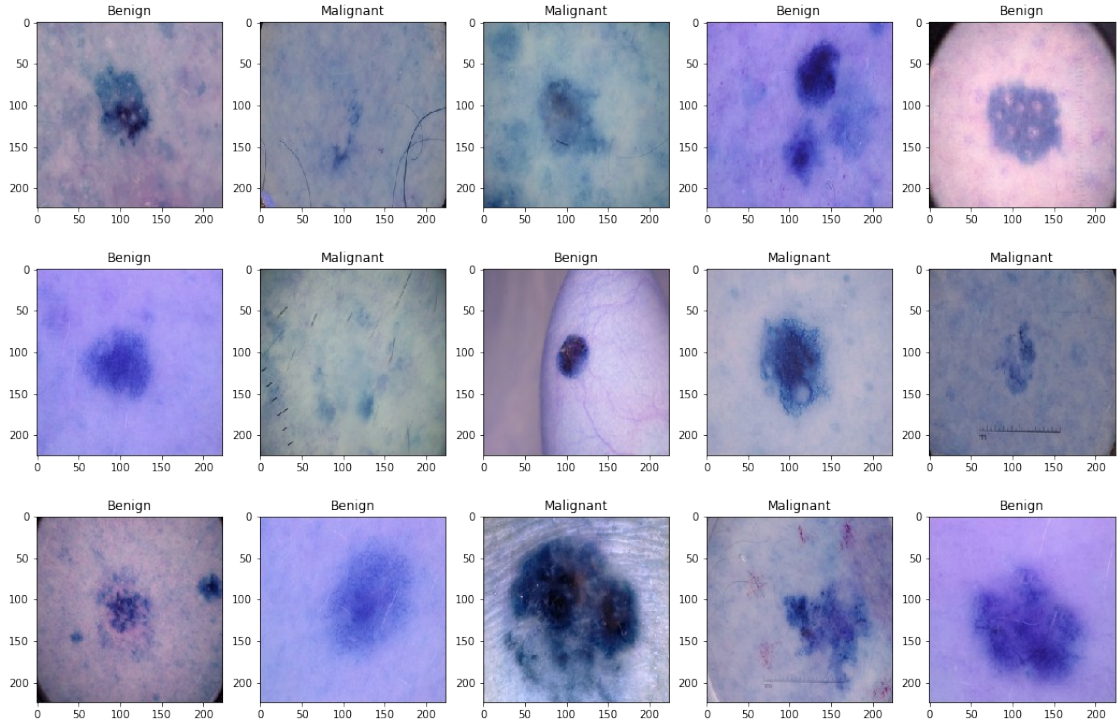

```
X.shape
```

```
(3297, 224, 224, 3)
```

```
fig=plt.figure(figsize=(18, 12))
columns = 5
rows = 3

for i in range(1, columns*rows +1): #1 to 16 range
```

```
    ax = fig.add_subplot(rows, columns, i)
    if y[i] == 0:
        ax.title.set_text('Benign')
    else:
        ax.title.set_text('Malignant')
    plt.imshow(X[i], interpolation='nearest')
plt.show()
```




```
#train test split
X_train, X_test, Y_train, Y_test = train_test_split(X, y,
test_size=0.2)

print("x_train_shape" +str(X_train.shape))
print("x_test_shape" +str(X_test.shape))
print("y_train_shape" +str(Y_train.shape))
print("y_test_shape" +str(Y_test.shape))
```

```
x_train_shape(2637, 224, 224, 3)
x_test_shape(660, 224, 224, 3)
y_train_shape(2637,)
y_test_shape(660,)
```

```
y_unique=np.unique(Y_train, return_counts=True)
y_unique
```

```
(array([0, 1]), array([1436, 1201]))
```

```
y_unique[1][0]
```

```
1436
```

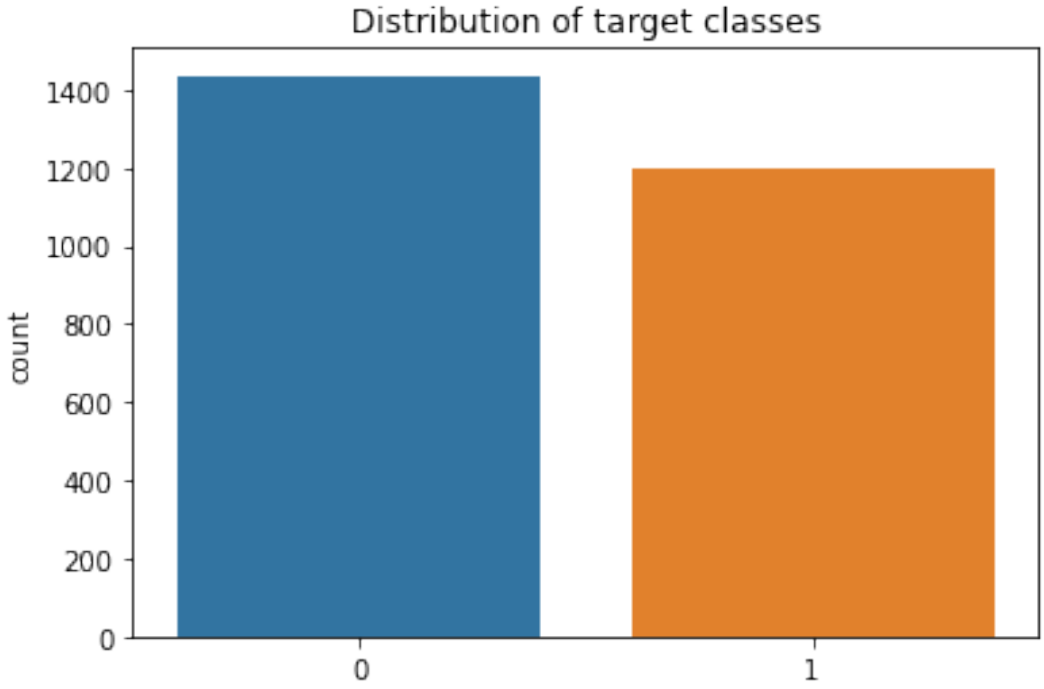
```
y_unique=np.unique(Y_test, return_counts=True)
y_unique
```

```
(array([0, 1]), array([364, 296]))
```

```
plt.title("Distribution of target classes")
sns.countplot(Y_train)
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/_decorators.py:43:
FutureWarning: Pass the following variable as a keyword arg: x. From
version 0.12, the only valid positional argument will be `data`, and
passing other arguments without an explicit keyword will result in an
error or misinterpretation.
  FutureWarning
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f327f079350>
```



Data augmentation

```
# #data augmentation
# y_1=np.where(Y_train==1)#malignant images
# y_1
```

```
# train_ds=np.take(X_train, list(y_1), axis=0) #it applies filter
indices, takes only images from those index value=1
```

```
# train_ds

# train_ds.shape

# data_augmentation = tf.keras.Sequential(
#   [
#     layers.experimental.preprocessing.RandomFlip("horizontal",
input_shape=(224, 224,3)),
#     layers.experimental.preprocessing.RandomRotation(0.1),
#     layers.experimental.preprocessing.RandomZoom(0.1),
#   ]
# )

# diff=abs(y_unique[1][0]-y_unique[1][1]) # the diff between counts of
class 0 and class 1 in Y_train



# lst=[]
# for images in train_ds:
#         augmented_images = data_augmentation(images) #input train_ds
images in data augmentation
#         lst.append(augmented_images)


# lst=np.array(lst, dtype="uint8") #turning images into array like a
vector form

# lst.shape #new malignant images created as to the value equal in
y_train count for malignant images

# augmented_images_final=np.array(lst[0][0:diff]) #go inside the first
dimension and take out the diff (count) number of images, we are not
doing random choice.

# augmented_images_final.shape #final shape

# #generating augmented malignant images

# for i in range(diff):
#   plt.imshow(augmented_images_final[i], interpolation='nearest')
#   plt.title("Malignant")
#   plt.show()

# X_train

# X_train = np.concatenate((X_train, augmented_images_final), axis =
0) #concatenate the actual train data with the new augmented data

# y_augmented = np.ones(augmented_images_final.shape[0])

# Y_train = np.concatenate((Y_train, y_augmented), axis = 0)
```

```
# X_train.shape

# Y_train.shape

#shuffle for randomness before modeling
# s = np.arange(X_train.shape[0]) #(start, stop, spacing=1(default))
# np.random.shuffle(s) #shuffles
# X_train = X_train[s]
# Y_train= Y_train[s] #here x and y both has same s (index)
# print(s)
# print(Y_train[s])

y_unique=np.unique(Y_train, return_counts=True) #the class here
balanced
y_unique
```

```
(array([0, 1]), array([1436, 1201]))
```

```
Y_train=Y_train.astype(np.int64) #
Y_train
```

```
array([1, 0, 1, ..., 0, 1, 1])
```

Tensorspec concept of combining image and its label into a tuple

```
dataset = tf.data.Dataset.range(2) # (x_train, y_train)
def g(x):
  return tf.constant(X_train), tf.constant(Y_train) #change to image
and labels tuple with constants, unchangeable values
result_train = dataset.map(g) #dataset creates empty tuple in which we
explicitly assign image and the lable
result_train.element_spec #spec of every element in the component
```

```
(TensorSpec(shape=(2637, 224, 224, 3), dtype=tf.uint8, name=None),
 TensorSpec(shape=(2637,), dtype=tf.int64, name=None))
```

```
dataset = tf.data.Dataset.range(2) # (x_test, y_test)
def g(x):
  return tf.constant(X_test), tf.constant(Y_test) #change to image and
labels tuple with constants, unchangeable values
result_test = dataset.map(g) #dataset creates empty tuple in which we
explicitly assign image and the lable
result_test.element_spec #spec of every elent in the component
```

```
(TensorSpec(shape=(660, 224, 224, 3), dtype=tf.uint8, name=None),
 TensorSpec(shape=(660,), dtype=tf.int64, name=None))
```

```
ds_train=result_train
ds_test=result_test
```

```
print(ds_train) #ds_train is map dataset and it will not have shape
```

```
<MapDataset element_spec=(TensorSpec(shape=(2637, 224, 224, 3),
dtype=tf.uint8, name=None), TensorSpec(shape=(2637,), dtype=tf.int64,
name=None))>
```

```
print(ds_test)
```

```
<MapDataset element_spec=(TensorSpec(shape=(660, 224, 224, 3),
dtype=tf.uint8, name=None), TensorSpec(shape=(660,), dtype=tf.int64,
name=None))>
```

```
def normalize_img(image, label):
  """Normalizes images: `uint8` -> `float32`."""
  return tf.cast(image, tf.float32) / 255., label

#for train data
ds_train = ds_train.map(
    normalize_img, num_parallel_calls=tf.data.AUTOTUNE) #autotune with
the runtime
ds_train = ds_train.cache() #cache transformation can cache a dataset,
either in memory or on local storage. This will save some operations
(like file opening and data reading) from being executed during each
epoch.
ds_train = ds_train.shuffle(X_train.shape[0]) #reshuffle on train ,
For true randomness, set the shuffle buffer to the full dataset size.
ds_train = ds_train.batch(128) #Batch elements of the dataset after
shuffling to get unique batches at each epoch
ds_train = ds_train.prefetch(tf.data.AUTOTUNE) #This allows later
elements to be prepared while the current element is being processed.

#same for test data
ds_test = ds_test.map(
    normalize_img, num_parallel_calls=tf.data.AUTOTUNE)
ds_test = ds_test.batch(128)
ds_test = ds_test.cache()
ds_test = ds_test.prefetch(tf.data.AUTOTUNE)
```

```
print(ds_train)
```

```
<PrefetchDataset element_spec=(TensorSpec(shape=(None, 2637, 224, 224,
3), dtype=tf.float32, name=None), TensorSpec(shape=(None, 2637),
dtype=tf.int64, name=None))>
```

```
print(ds_test)
```

```
<PrefetchDataset element_spec=(TensorSpec(shape=(None, 660, 224, 224,
3), dtype=tf.float32, name=None), TensorSpec(shape=(None, 660),
dtype=tf.int64, name=None))>
```

```
X_train.shape
```

```
(2637, 224, 224, 3)
```

Modeling

Baseline Model

```
# # Normalizing the image data

X_train=X_train/255.0

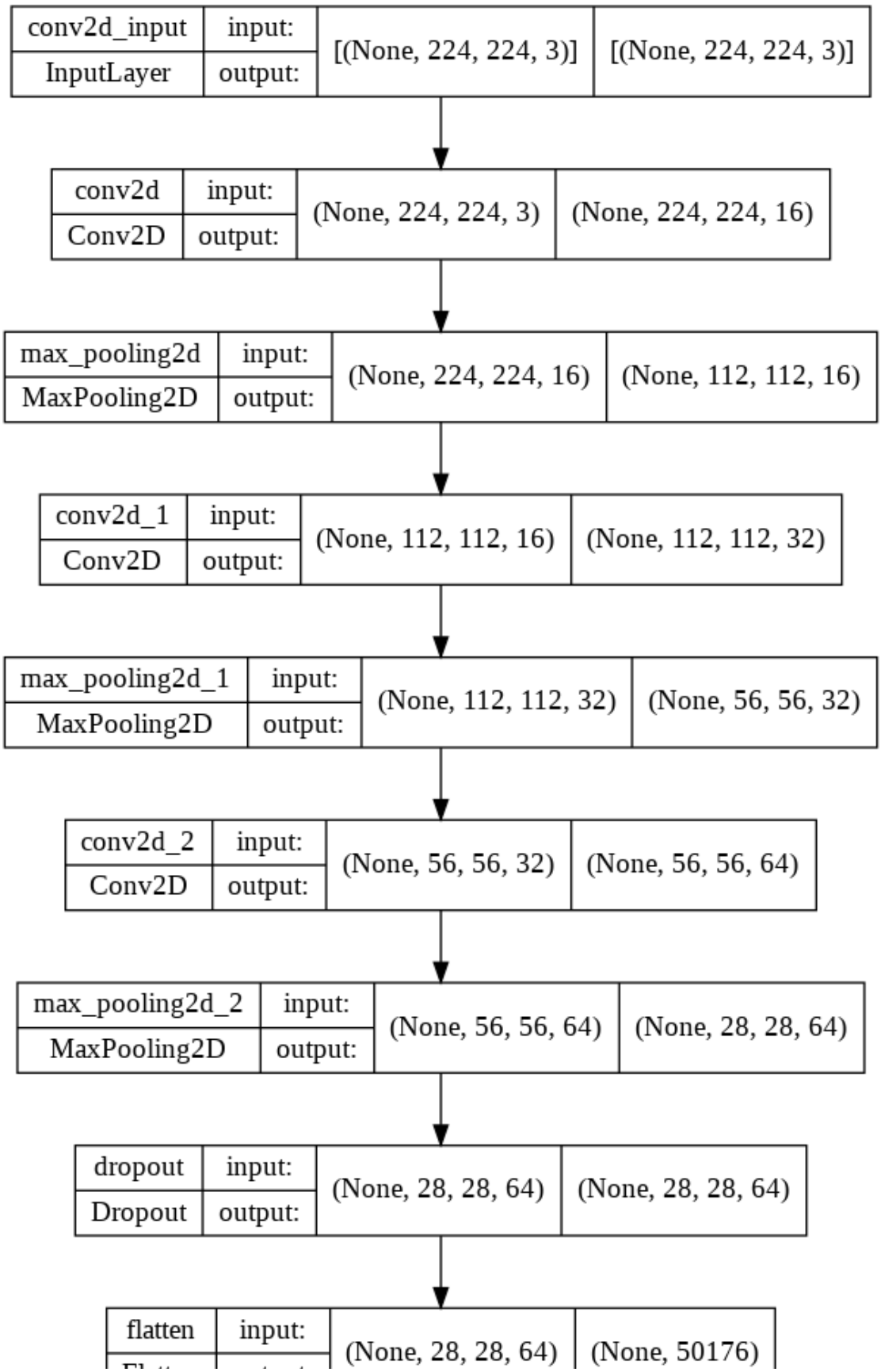
model = Sequential()

#add model layers
model.add(Conv2D(filters=16, kernel_size=(3,3), strides=(1,1),
padding='same', activation="relu", input_shape=(224,224,3)))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Conv2D(filters=32, kernel_size=(3,3), strides=(1,1),
padding='same', activation="relu"))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Conv2D(filters=64, kernel_size=(3,3), strides=(1,1),
padding='same', activation="relu"))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.15))

model.add(Flatten()) #we have two layers after the flatening
model.add(Dense(128, activation="relu"))
model.add(Dense(2, activation="softmax"))

model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

from tensorflow.keras.utils import to_categorical, plot_model
plot_model(model, to_file='cnn-mnist.png', show_shapes=True) #shows
the summary of the model
```


conv2d_input
InputLayer
input:
output:
[(None, 224, 224, 3)]
[(None, 224, 224, 3)]
conv2d
Conv2D
input:
output:
(None, 224, 224, 3)
(None, 224, 224, 16)
max_pooling2d
MaxPooling2D
input:
output:
(None, 224, 224, 16)
(None, 112, 112, 16)
conv2d_1
Conv2D
input:
output:
(None, 112, 112, 16)
(None, 112, 112, 32)
max_pooling2d_1
MaxPooling2D
input:
output:
(None, 112, 112, 32)
(None, 56, 56, 32)
conv2d_2
Conv2D
input:
output:
(None, 56, 56, 32)
(None, 56, 56, 64)
max_pooling2d_2
MaxPooling2D
input:
output:
(None, 56, 56, 64)
(None, 28, 28, 64)
dropout
Dropout
input:
output:
(None, 28, 28, 64)
(None, 28, 28, 64)
flatten
input:
(None, 28, 28, 64)
(None, 50176)

```
from keras.callbacks import EarlyStopping #early stopping
es=EarlyStopping(
    monitor='val_sparse_categorical_accuracy',
    min_delta=0,
    patience=100,
    verbose=1,
    mode='auto',
    baseline=None,
    restore_best_weights=True
)

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 13s 41ms/step - loss: 0.6359
- sparse_categorical_accuracy: 0.6305 - val_loss: 0.5870 -
val_sparse_categorical_accuracy: 0.7121
Epoch 2/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.5578 -
sparse_categorical_accuracy: 0.7100 - val_loss: 0.5465 -
val_sparse_categorical_accuracy: 0.7247
Epoch 3/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.5112 -
sparse_categorical_accuracy: 0.7314 - val_loss: 0.5089 -
val_sparse_categorical_accuracy: 0.7500
Epoch 4/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.4765 -
sparse_categorical_accuracy: 0.7648 - val_loss: 0.4935 -
val_sparse_categorical_accuracy: 0.7247
Epoch 5/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.4524 -
sparse_categorical_accuracy: 0.7724 - val_loss: 0.4803 -
val_sparse_categorical_accuracy: 0.7601
Epoch 6/1000
71/71 [==============================] - 2s 32ms/step - loss: 0.4340 -
sparse_categorical_accuracy: 0.7854 - val_loss: 0.4675 -
val_sparse_categorical_accuracy: 0.7475
Epoch 7/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.4208 -
sparse_categorical_accuracy: 0.7854 - val_loss: 0.4628 -
```

```
val_sparse_categorical_accuracy: 0.7551
Epoch 8/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.4126 -
sparse_categorical_accuracy: 0.7947 - val_loss: 0.4570 -
val_sparse_categorical_accuracy: 0.7677
Epoch 9/1000
71/71 [==============================] - 2s 32ms/step - loss: 0.4086 -
sparse_categorical_accuracy: 0.8019 - val_loss: 0.4612 -
val_sparse_categorical_accuracy: 0.7576
Epoch 10/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.4002 -
sparse_categorical_accuracy: 0.8054 - val_loss: 0.4545 -
val_sparse_categorical_accuracy: 0.7601
Epoch 11/1000
71/71 [==============================] - 2s 32ms/step - loss: 0.3995 -
sparse_categorical_accuracy: 0.8054 - val_loss: 0.4489 -
val_sparse_categorical_accuracy: 0.7626
Epoch 12/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3926 -
sparse_categorical_accuracy: 0.8126 - val_loss: 0.4453 -
val_sparse_categorical_accuracy: 0.7753
Epoch 13/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3844 -
sparse_categorical_accuracy: 0.8108 - val_loss: 0.4611 -
val_sparse_categorical_accuracy: 0.7803
Epoch 14/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3860 -
sparse_categorical_accuracy: 0.8112 - val_loss: 0.4409 -
val_sparse_categorical_accuracy: 0.7803
Epoch 15/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3815 -
sparse_categorical_accuracy: 0.8135 - val_loss: 0.4404 -
val_sparse_categorical_accuracy: 0.7753
Epoch 16/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3800 -
sparse_categorical_accuracy: 0.8166 - val_loss: 0.4364 -
val_sparse_categorical_accuracy: 0.7828
Epoch 17/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3747 -
sparse_categorical_accuracy: 0.8220 - val_loss: 0.4369 -
val_sparse_categorical_accuracy: 0.7904
Epoch 18/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3743 -
sparse_categorical_accuracy: 0.8175 - val_loss: 0.4300 -
val_sparse_categorical_accuracy: 0.7828
Epoch 19/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3698 -
sparse_categorical_accuracy: 0.8264 - val_loss: 0.4309 -
val_sparse_categorical_accuracy: 0.7904
Epoch 20/1000
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71/71 [==============================] - 2s 33ms/step - loss: 0.3688 -
sparse_categorical_accuracy: 0.8246 - val_loss: 0.4301 -
val_sparse_categorical_accuracy: 0.7854
Epoch 21/1000
71/71 [==============================] - 2s 32ms/step - loss: 0.3706 -
sparse_categorical_accuracy: 0.8211 - val_loss: 0.4285 -
val_sparse_categorical_accuracy: 0.7854
Epoch 22/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3629 -
sparse_categorical_accuracy: 0.8318 - val_loss: 0.4580 -
val_sparse_categorical_accuracy: 0.7854
Epoch 23/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3669 -
sparse_categorical_accuracy: 0.8148 - val_loss: 0.4288 -
val_sparse_categorical_accuracy: 0.7879
Epoch 24/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3614 -
sparse_categorical_accuracy: 0.8304 - val_loss: 0.4249 -
val_sparse_categorical_accuracy: 0.7980
Epoch 25/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3603 -
sparse_categorical_accuracy: 0.8362 - val_loss: 0.4225 -
val_sparse_categorical_accuracy: 0.7955
Epoch 26/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3562 -
sparse_categorical_accuracy: 0.8376 - val_loss: 0.4254 -
val_sparse_categorical_accuracy: 0.7904
Epoch 27/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3515 -
sparse_categorical_accuracy: 0.8394 - val_loss: 0.4224 -
val_sparse_categorical_accuracy: 0.8005
Epoch 28/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3505 -
sparse_categorical_accuracy: 0.8376 - val_loss: 0.4196 -
val_sparse_categorical_accuracy: 0.7929
Epoch 29/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3515 -
sparse_categorical_accuracy: 0.8336 - val_loss: 0.4190 -
val_sparse_categorical_accuracy: 0.8005
Epoch 30/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3482 -
sparse_categorical_accuracy: 0.8394 - val_loss: 0.4167 -
val_sparse_categorical_accuracy: 0.8030
Epoch 31/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3449 -
sparse_categorical_accuracy: 0.8407 - val_loss: 0.4242 -
val_sparse_categorical_accuracy: 0.8056
Epoch 32/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3438 -
sparse_categorical_accuracy: 0.8407 - val_loss: 0.4149 -
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val_sparse_categorical_accuracy: 0.8056
Epoch 33/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3397 -
sparse_categorical_accuracy: 0.8429 - val_loss: 0.4111 -
val_sparse_categorical_accuracy: 0.8005
Epoch 34/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3375 -
sparse_categorical_accuracy: 0.8402 - val_loss: 0.4112 -
val_sparse_categorical_accuracy: 0.8030
Epoch 35/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3363 -
sparse_categorical_accuracy: 0.8434 - val_loss: 0.4110 -
val_sparse_categorical_accuracy: 0.8131
Epoch 36/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3366 -
sparse_categorical_accuracy: 0.8478 - val_loss: 0.4075 -
val_sparse_categorical_accuracy: 0.8081
Epoch 37/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3330 -
sparse_categorical_accuracy: 0.8443 - val_loss: 0.4074 -
val_sparse_categorical_accuracy: 0.8081
Epoch 38/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3311 -
sparse_categorical_accuracy: 0.8487 - val_loss: 0.4155 -
val_sparse_categorical_accuracy: 0.7828
Epoch 39/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3334 -
sparse_categorical_accuracy: 0.8501 - val_loss: 0.4053 -
val_sparse_categorical_accuracy: 0.8005
Epoch 40/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3345 -
sparse_categorical_accuracy: 0.8402 - val_loss: 0.4032 -
val_sparse_categorical_accuracy: 0.8005
Epoch 41/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3253 -
sparse_categorical_accuracy: 0.8541 - val_loss: 0.4135 -
val_sparse_categorical_accuracy: 0.7828
Epoch 42/1000
71/71 [==============================] - 3s 35ms/step - loss: 0.3338 -
sparse_categorical_accuracy: 0.8438 - val_loss: 0.4073 -
val_sparse_categorical_accuracy: 0.7879
Epoch 43/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3221 -
sparse_categorical_accuracy: 0.8505 - val_loss: 0.4063 -
val_sparse_categorical_accuracy: 0.7803
Epoch 44/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3235 -
sparse_categorical_accuracy: 0.8505 - val_loss: 0.3988 -
val_sparse_categorical_accuracy: 0.8056
Epoch 45/1000
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71/71 [==============================] - 2s 34ms/step - loss: 0.3223 -
sparse_categorical_accuracy: 0.8559 - val_loss: 0.3983 -
val_sparse_categorical_accuracy: 0.8182
Epoch 46/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3192 -
sparse_categorical_accuracy: 0.8612 - val_loss: 0.3975 -
val_sparse_categorical_accuracy: 0.8081
Epoch 47/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3153 -
sparse_categorical_accuracy: 0.8568 - val_loss: 0.4202 -
val_sparse_categorical_accuracy: 0.7904
Epoch 48/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3268 -
sparse_categorical_accuracy: 0.8523 - val_loss: 0.3974 -
val_sparse_categorical_accuracy: 0.8030
Epoch 49/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3140 -
sparse_categorical_accuracy: 0.8563 - val_loss: 0.3956 -
val_sparse_categorical_accuracy: 0.8106
Epoch 50/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.3131 -
sparse_categorical_accuracy: 0.8608 - val_loss: 0.3989 -
val_sparse_categorical_accuracy: 0.8232
Epoch 51/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3103 -
sparse_categorical_accuracy: 0.8621 - val_loss: 0.3939 -
val_sparse_categorical_accuracy: 0.8106
Epoch 52/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3098 -
sparse_categorical_accuracy: 0.8568 - val_loss: 0.4006 -
val_sparse_categorical_accuracy: 0.8207
Epoch 53/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3078 -
sparse_categorical_accuracy: 0.8621 - val_loss: 0.3957 -
val_sparse_categorical_accuracy: 0.8106
Epoch 54/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3076 -
sparse_categorical_accuracy: 0.8639 - val_loss: 0.3910 -
val_sparse_categorical_accuracy: 0.8182
Epoch 55/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3085 -
sparse_categorical_accuracy: 0.8639 - val_loss: 0.3868 -
val_sparse_categorical_accuracy: 0.8131
Epoch 56/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3036 -
sparse_categorical_accuracy: 0.8684 - val_loss: 0.4183 -
val_sparse_categorical_accuracy: 0.8131
Epoch 57/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.3233 -
sparse_categorical_accuracy: 0.8532 - val_loss: 0.3937 -
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val_sparse_categorical_accuracy: 0.8308
Epoch 58/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3036 -
sparse_categorical_accuracy: 0.8710 - val_loss: 0.3901 -
val_sparse_categorical_accuracy: 0.8005
Epoch 59/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.3033 -
sparse_categorical_accuracy: 0.8701 - val_loss: 0.3855 -
val_sparse_categorical_accuracy: 0.8157
Epoch 60/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2981 -
sparse_categorical_accuracy: 0.8697 - val_loss: 0.3943 -
val_sparse_categorical_accuracy: 0.8308
Epoch 61/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2976 -
sparse_categorical_accuracy: 0.8706 - val_loss: 0.3834 -
val_sparse_categorical_accuracy: 0.8258
Epoch 62/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2955 -
sparse_categorical_accuracy: 0.8652 - val_loss: 0.3847 -
val_sparse_categorical_accuracy: 0.8157
Epoch 63/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2999 -
sparse_categorical_accuracy: 0.8612 - val_loss: 0.3836 -
val_sparse_categorical_accuracy: 0.8182
Epoch 64/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2915 -
sparse_categorical_accuracy: 0.8733 - val_loss: 0.3836 -
val_sparse_categorical_accuracy: 0.8157
Epoch 65/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2946 -
sparse_categorical_accuracy: 0.8670 - val_loss: 0.3829 -
val_sparse_categorical_accuracy: 0.8157
Epoch 66/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2898 -
sparse_categorical_accuracy: 0.8800 - val_loss: 0.3815 -
val_sparse_categorical_accuracy: 0.8207
Epoch 67/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2904 -
sparse_categorical_accuracy: 0.8768 - val_loss: 0.3828 -
val_sparse_categorical_accuracy: 0.8232
Epoch 68/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2882 -
sparse_categorical_accuracy: 0.8746 - val_loss: 0.3808 -
val_sparse_categorical_accuracy: 0.8157
Epoch 69/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2882 -
sparse_categorical_accuracy: 0.8764 - val_loss: 0.3783 -
val_sparse_categorical_accuracy: 0.8258
Epoch 70/1000
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71/71 [==============================] - 2s 33ms/step - loss: 0.2854 -
sparse_categorical_accuracy: 0.8768 - val_loss: 0.3869 -
val_sparse_categorical_accuracy: 0.7955
Epoch 71/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2936 -
sparse_categorical_accuracy: 0.8684 - val_loss: 0.3799 -
val_sparse_categorical_accuracy: 0.8081
Epoch 72/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2826 -
sparse_categorical_accuracy: 0.8728 - val_loss: 0.3799 -
val_sparse_categorical_accuracy: 0.8157
Epoch 73/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2795 -
sparse_categorical_accuracy: 0.8831 - val_loss: 0.3815 -
val_sparse_categorical_accuracy: 0.8030
Epoch 74/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2847 -
sparse_categorical_accuracy: 0.8804 - val_loss: 0.3783 -
val_sparse_categorical_accuracy: 0.8131
Epoch 75/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2781 -
sparse_categorical_accuracy: 0.8822 - val_loss: 0.3766 -
val_sparse_categorical_accuracy: 0.8232
Epoch 76/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2791 -
sparse_categorical_accuracy: 0.8831 - val_loss: 0.3849 -
val_sparse_categorical_accuracy: 0.8258
Epoch 77/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2764 -
sparse_categorical_accuracy: 0.8782 - val_loss: 0.3756 -
val_sparse_categorical_accuracy: 0.8232
Epoch 78/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2769 -
sparse_categorical_accuracy: 0.8835 - val_loss: 0.3729 -
val_sparse_categorical_accuracy: 0.8232
Epoch 79/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2848 -
sparse_categorical_accuracy: 0.8701 - val_loss: 0.3738 -
val_sparse_categorical_accuracy: 0.8056
Epoch 80/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2781 -
sparse_categorical_accuracy: 0.8849 - val_loss: 0.3762 -
val_sparse_categorical_accuracy: 0.8308
Epoch 81/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2719 -
sparse_categorical_accuracy: 0.8813 - val_loss: 0.3799 -
val_sparse_categorical_accuracy: 0.8283
Epoch 82/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2687 -
sparse_categorical_accuracy: 0.8858 - val_loss: 0.3744 -
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val_sparse_categorical_accuracy: 0.8157
Epoch 83/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2758 -
sparse_categorical_accuracy: 0.8791 - val_loss: 0.3742 -
val_sparse_categorical_accuracy: 0.8157
Epoch 84/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2677 -
sparse_categorical_accuracy: 0.8858 - val_loss: 0.3720 -
val_sparse_categorical_accuracy: 0.8207
Epoch 85/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2654 -
sparse_categorical_accuracy: 0.8898 - val_loss: 0.3714 -
val_sparse_categorical_accuracy: 0.8232
Epoch 86/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2633 -
sparse_categorical_accuracy: 0.8902 - val_loss: 0.3820 -
val_sparse_categorical_accuracy: 0.7929
Epoch 87/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2661 -
sparse_categorical_accuracy: 0.8862 - val_loss: 0.3790 -
val_sparse_categorical_accuracy: 0.8333
Epoch 88/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2668 -
sparse_categorical_accuracy: 0.8871 - val_loss: 0.3693 -
val_sparse_categorical_accuracy: 0.8207
Epoch 89/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2620 -
sparse_categorical_accuracy: 0.8898 - val_loss: 0.3700 -
val_sparse_categorical_accuracy: 0.8207
Epoch 90/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2626 -
sparse_categorical_accuracy: 0.8889 - val_loss: 0.3706 -
val_sparse_categorical_accuracy: 0.8258
Epoch 91/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2581 -
sparse_categorical_accuracy: 0.8960 - val_loss: 0.3696 -
val_sparse_categorical_accuracy: 0.8207
Epoch 92/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2597 -
sparse_categorical_accuracy: 0.8898 - val_loss: 0.3697 -
val_sparse_categorical_accuracy: 0.8359
Epoch 93/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2574 -
sparse_categorical_accuracy: 0.8920 - val_loss: 0.3669 -
val_sparse_categorical_accuracy: 0.8258
Epoch 94/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2542 -
sparse_categorical_accuracy: 0.8942 - val_loss: 0.3689 -
val_sparse_categorical_accuracy: 0.8081
Epoch 95/1000
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71/71 [==============================] - 2s 33ms/step - loss: 0.2554 -
sparse_categorical_accuracy: 0.8938 - val_loss: 0.3686 -
val_sparse_categorical_accuracy: 0.8333
Epoch 96/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2526 -
sparse_categorical_accuracy: 0.8960 - val_loss: 0.3695 -
val_sparse_categorical_accuracy: 0.8182
Epoch 97/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2511 -
sparse_categorical_accuracy: 0.8956 - val_loss: 0.3674 -
val_sparse_categorical_accuracy: 0.8232
Epoch 98/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2493 -
sparse_categorical_accuracy: 0.8978 - val_loss: 0.3667 -
val_sparse_categorical_accuracy: 0.8157
Epoch 99/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2513 -
sparse_categorical_accuracy: 0.8956 - val_loss: 0.3657 -
val_sparse_categorical_accuracy: 0.8157
Epoch 100/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2491 -
sparse_categorical_accuracy: 0.8934 - val_loss: 0.3712 -
val_sparse_categorical_accuracy: 0.8409
Epoch 101/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2466 -
sparse_categorical_accuracy: 0.8978 - val_loss: 0.3646 -
val_sparse_categorical_accuracy: 0.8258
Epoch 102/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2496 -
sparse_categorical_accuracy: 0.8983 - val_loss: 0.3653 -
val_sparse_categorical_accuracy: 0.8409
Epoch 103/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2428 -
sparse_categorical_accuracy: 0.9036 - val_loss: 0.3647 -
val_sparse_categorical_accuracy: 0.8258
Epoch 104/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2432 -
sparse_categorical_accuracy: 0.8983 - val_loss: 0.3692 -
val_sparse_categorical_accuracy: 0.8359
Epoch 105/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2424 -
sparse_categorical_accuracy: 0.9000 - val_loss: 0.3704 -
val_sparse_categorical_accuracy: 0.8333
Epoch 106/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2412 -
sparse_categorical_accuracy: 0.8992 - val_loss: 0.3650 -
val_sparse_categorical_accuracy: 0.8359
Epoch 107/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2430 -
sparse_categorical_accuracy: 0.8987 - val_loss: 0.3663 -
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val_sparse_categorical_accuracy: 0.8409
Epoch 108/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2387 -
sparse_categorical_accuracy: 0.9027 - val_loss: 0.3685 -
val_sparse_categorical_accuracy: 0.8081
Epoch 109/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2390 -
sparse_categorical_accuracy: 0.8987 - val_loss: 0.3633 -
val_sparse_categorical_accuracy: 0.8409
Epoch 110/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2337 -
sparse_categorical_accuracy: 0.9076 - val_loss: 0.3616 -
val_sparse_categorical_accuracy: 0.8207
Epoch 111/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2359 -
sparse_categorical_accuracy: 0.9054 - val_loss: 0.3605 -
val_sparse_categorical_accuracy: 0.8207
Epoch 112/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2336 -
sparse_categorical_accuracy: 0.9023 - val_loss: 0.3617 -
val_sparse_categorical_accuracy: 0.8333
Epoch 113/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2349 -
sparse_categorical_accuracy: 0.9018 - val_loss: 0.3610 -
val_sparse_categorical_accuracy: 0.8308
Epoch 114/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2310 -
sparse_categorical_accuracy: 0.9081 - val_loss: 0.3596 -
val_sparse_categorical_accuracy: 0.8182
Epoch 115/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2305 -
sparse_categorical_accuracy: 0.9054 - val_loss: 0.3677 -
val_sparse_categorical_accuracy: 0.8384
Epoch 116/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2330 -
sparse_categorical_accuracy: 0.9014 - val_loss: 0.3645 -
val_sparse_categorical_accuracy: 0.8182
Epoch 117/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2321 -
sparse_categorical_accuracy: 0.9027 - val_loss: 0.3620 -
val_sparse_categorical_accuracy: 0.8308
Epoch 118/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2254 -
sparse_categorical_accuracy: 0.9108 - val_loss: 0.3638 -
val_sparse_categorical_accuracy: 0.8283
Epoch 119/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2316 -
sparse_categorical_accuracy: 0.9041 - val_loss: 0.3618 -
val_sparse_categorical_accuracy: 0.8333
Epoch 120/1000
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71/71 [==============================] - 2s 33ms/step - loss: 0.2278 -
sparse_categorical_accuracy: 0.9067 - val_loss: 0.3676 -
val_sparse_categorical_accuracy: 0.8333
Epoch 121/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2231 -
sparse_categorical_accuracy: 0.9085 - val_loss: 0.3622 -
val_sparse_categorical_accuracy: 0.8232
Epoch 122/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2450 -
sparse_categorical_accuracy: 0.8844 - val_loss: 0.3624 -
val_sparse_categorical_accuracy: 0.8232
Epoch 123/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2256 -
sparse_categorical_accuracy: 0.9072 - val_loss: 0.3627 -
val_sparse_categorical_accuracy: 0.8333
Epoch 124/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2217 -
sparse_categorical_accuracy: 0.9134 - val_loss: 0.3602 -
val_sparse_categorical_accuracy: 0.8283
Epoch 125/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2329 -
sparse_categorical_accuracy: 0.9041 - val_loss: 0.3546 -
val_sparse_categorical_accuracy: 0.8182
Epoch 126/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2209 -
sparse_categorical_accuracy: 0.9112 - val_loss: 0.3653 -
val_sparse_categorical_accuracy: 0.8359
Epoch 127/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2161 -
sparse_categorical_accuracy: 0.9112 - val_loss: 0.3661 -
val_sparse_categorical_accuracy: 0.8283
Epoch 128/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2172 -
sparse_categorical_accuracy: 0.9121 - val_loss: 0.3666 -
val_sparse_categorical_accuracy: 0.8308
Epoch 129/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2181 -
sparse_categorical_accuracy: 0.9099 - val_loss: 0.3644 -
val_sparse_categorical_accuracy: 0.8283
Epoch 130/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2168 -
sparse_categorical_accuracy: 0.9121 - val_loss: 0.3588 -
val_sparse_categorical_accuracy: 0.8333
Epoch 131/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2154 -
sparse_categorical_accuracy: 0.9121 - val_loss: 0.3616 -
val_sparse_categorical_accuracy: 0.8359
Epoch 132/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2155 -
sparse_categorical_accuracy: 0.9121 - val_loss: 0.3633 -
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val_sparse_categorical_accuracy: 0.8283
Epoch 133/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2147 -
sparse_categorical_accuracy: 0.9134 - val_loss: 0.3599 -
val_sparse_categorical_accuracy: 0.8359
Epoch 134/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2108 -
sparse_categorical_accuracy: 0.9143 - val_loss: 0.3627 -
val_sparse_categorical_accuracy: 0.8283
Epoch 135/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2108 -
sparse_categorical_accuracy: 0.9134 - val_loss: 0.3580 -
val_sparse_categorical_accuracy: 0.8333
Epoch 136/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2107 -
sparse_categorical_accuracy: 0.9148 - val_loss: 0.3678 -
val_sparse_categorical_accuracy: 0.8308
Epoch 137/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2080 -
sparse_categorical_accuracy: 0.9161 - val_loss: 0.3556 -
val_sparse_categorical_accuracy: 0.8333
Epoch 138/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2049 -
sparse_categorical_accuracy: 0.9183 - val_loss: 0.3550 -
val_sparse_categorical_accuracy: 0.8258
Epoch 139/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2071 -
sparse_categorical_accuracy: 0.9179 - val_loss: 0.3551 -
val_sparse_categorical_accuracy: 0.8333
Epoch 140/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2045 -
sparse_categorical_accuracy: 0.9201 - val_loss: 0.3647 -
val_sparse_categorical_accuracy: 0.8283
Epoch 141/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2048 -
sparse_categorical_accuracy: 0.9197 - val_loss: 0.3538 -
val_sparse_categorical_accuracy: 0.8333
Epoch 142/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.2038 -
sparse_categorical_accuracy: 0.9232 - val_loss: 0.3520 -
val_sparse_categorical_accuracy: 0.8384
Epoch 143/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2039 -
sparse_categorical_accuracy: 0.9206 - val_loss: 0.3519 -
val_sparse_categorical_accuracy: 0.8409
Epoch 144/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2015 -
sparse_categorical_accuracy: 0.9197 - val_loss: 0.3631 -
val_sparse_categorical_accuracy: 0.8258
Epoch 145/1000
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71/71 [==============================] - 2s 33ms/step - loss: 0.2003 -
sparse_categorical_accuracy: 0.9170 - val_loss: 0.3863 -
val_sparse_categorical_accuracy: 0.8308
Epoch 146/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2015 -
sparse_categorical_accuracy: 0.9188 - val_loss: 0.3614 -
val_sparse_categorical_accuracy: 0.8258
Epoch 147/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1973 -
sparse_categorical_accuracy: 0.9197 - val_loss: 0.3580 -
val_sparse_categorical_accuracy: 0.8308
Epoch 148/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1990 -
sparse_categorical_accuracy: 0.9255 - val_loss: 0.3570 -
val_sparse_categorical_accuracy: 0.8308
Epoch 149/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1981 -
sparse_categorical_accuracy: 0.9192 - val_loss: 0.3526 -
val_sparse_categorical_accuracy: 0.8308
Epoch 150/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1938 -
sparse_categorical_accuracy: 0.9250 - val_loss: 0.3578 -
val_sparse_categorical_accuracy: 0.8333
Epoch 151/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1963 -
sparse_categorical_accuracy: 0.9237 - val_loss: 0.3727 -
val_sparse_categorical_accuracy: 0.8232
Epoch 152/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.2030 -
sparse_categorical_accuracy: 0.9161 - val_loss: 0.3627 -
val_sparse_categorical_accuracy: 0.8409
Epoch 153/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1923 -
sparse_categorical_accuracy: 0.9224 - val_loss: 0.3602 -
val_sparse_categorical_accuracy: 0.8232
Epoch 154/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1955 -
sparse_categorical_accuracy: 0.9255 - val_loss: 0.3757 -
val_sparse_categorical_accuracy: 0.8232
Epoch 155/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1931 -
sparse_categorical_accuracy: 0.9224 - val_loss: 0.3581 -
val_sparse_categorical_accuracy: 0.8333
Epoch 156/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1874 -
sparse_categorical_accuracy: 0.9353 - val_loss: 0.3532 -
val_sparse_categorical_accuracy: 0.8409
Epoch 157/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1914 -
sparse_categorical_accuracy: 0.9219 - val_loss: 0.3543 -
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val_sparse_categorical_accuracy: 0.8384
Epoch 158/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1868 -
sparse_categorical_accuracy: 0.9290 - val_loss: 0.3538 -
val_sparse_categorical_accuracy: 0.8384
Epoch 159/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1863 -
sparse_categorical_accuracy: 0.9299 - val_loss: 0.3685 -
val_sparse_categorical_accuracy: 0.8232
Epoch 160/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1867 -
sparse_categorical_accuracy: 0.9273 - val_loss: 0.3552 -
val_sparse_categorical_accuracy: 0.8434
Epoch 161/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1829 -
sparse_categorical_accuracy: 0.9295 - val_loss: 0.3534 -
val_sparse_categorical_accuracy: 0.8333
Epoch 162/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1840 -
sparse_categorical_accuracy: 0.9277 - val_loss: 0.3516 -
val_sparse_categorical_accuracy: 0.8359
Epoch 163/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1805 -
sparse_categorical_accuracy: 0.9304 - val_loss: 0.3557 -
val_sparse_categorical_accuracy: 0.8384
Epoch 164/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1821 -
sparse_categorical_accuracy: 0.9259 - val_loss: 0.3730 -
val_sparse_categorical_accuracy: 0.8182
Epoch 165/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1786 -
sparse_categorical_accuracy: 0.9322 - val_loss: 0.3550 -
val_sparse_categorical_accuracy: 0.8308
Epoch 166/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1786 -
sparse_categorical_accuracy: 0.9317 - val_loss: 0.3561 -
val_sparse_categorical_accuracy: 0.8384
Epoch 167/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1810 -
sparse_categorical_accuracy: 0.9224 - val_loss: 0.3752 -
val_sparse_categorical_accuracy: 0.8258
Epoch 168/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1826 -
sparse_categorical_accuracy: 0.9273 - val_loss: 0.3593 -
val_sparse_categorical_accuracy: 0.8359
Epoch 169/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1756 -
sparse_categorical_accuracy: 0.9322 - val_loss: 0.3583 -
val_sparse_categorical_accuracy: 0.8460
Epoch 170/1000
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71/71 [==============================] - 2s 34ms/step - loss: 0.1758 -
sparse_categorical_accuracy: 0.9331 - val_loss: 0.3545 -
val_sparse_categorical_accuracy: 0.8409
Epoch 171/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1816 -
sparse_categorical_accuracy: 0.9290 - val_loss: 0.3601 -
val_sparse_categorical_accuracy: 0.8409
Epoch 172/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1773 -
sparse_categorical_accuracy: 0.9349 - val_loss: 0.3564 -
val_sparse_categorical_accuracy: 0.8434
Epoch 173/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1735 -
sparse_categorical_accuracy: 0.9340 - val_loss: 0.3591 -
val_sparse_categorical_accuracy: 0.8258
Epoch 174/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1783 -
sparse_categorical_accuracy: 0.9264 - val_loss: 0.3530 -
val_sparse_categorical_accuracy: 0.8460
Epoch 175/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1710 -
sparse_categorical_accuracy: 0.9371 - val_loss: 0.3554 -
val_sparse_categorical_accuracy: 0.8434
Epoch 176/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1741 -
sparse_categorical_accuracy: 0.9349 - val_loss: 0.3547 -
val_sparse_categorical_accuracy: 0.8359
Epoch 177/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1691 -
sparse_categorical_accuracy: 0.9380 - val_loss: 0.3528 -
val_sparse_categorical_accuracy: 0.8434
Epoch 178/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1768 -
sparse_categorical_accuracy: 0.9313 - val_loss: 0.3509 -
val_sparse_categorical_accuracy: 0.8485
Epoch 179/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1724 -
sparse_categorical_accuracy: 0.9331 - val_loss: 0.3544 -
val_sparse_categorical_accuracy: 0.8434
Epoch 180/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1679 -
sparse_categorical_accuracy: 0.9393 - val_loss: 0.3672 -
val_sparse_categorical_accuracy: 0.8359
Epoch 181/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1668 -
sparse_categorical_accuracy: 0.9366 - val_loss: 0.3602 -
val_sparse_categorical_accuracy: 0.8333
Epoch 182/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1709 -
sparse_categorical_accuracy: 0.9353 - val_loss: 0.3583 -
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val_sparse_categorical_accuracy: 0.8333
Epoch 183/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1657 -
sparse_categorical_accuracy: 0.9384 - val_loss: 0.3571 -
val_sparse_categorical_accuracy: 0.8384
Epoch 184/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1636 -
sparse_categorical_accuracy: 0.9371 - val_loss: 0.3592 -
val_sparse_categorical_accuracy: 0.8434
Epoch 185/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1645 -
sparse_categorical_accuracy: 0.9420 - val_loss: 0.3600 -
val_sparse_categorical_accuracy: 0.8409
Epoch 186/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1636 -
sparse_categorical_accuracy: 0.9366 - val_loss: 0.3664 -
val_sparse_categorical_accuracy: 0.8460
Epoch 187/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1640 -
sparse_categorical_accuracy: 0.9407 - val_loss: 0.3958 -
val_sparse_categorical_accuracy: 0.8258
Epoch 188/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1708 -
sparse_categorical_accuracy: 0.9304 - val_loss: 0.3797 -
val_sparse_categorical_accuracy: 0.8359
Epoch 189/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1612 -
sparse_categorical_accuracy: 0.9415 - val_loss: 0.3549 -
val_sparse_categorical_accuracy: 0.8510
Epoch 190/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1599 -
sparse_categorical_accuracy: 0.9393 - val_loss: 0.3565 -
val_sparse_categorical_accuracy: 0.8485
Epoch 191/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1597 -
sparse_categorical_accuracy: 0.9402 - val_loss: 0.3770 -
val_sparse_categorical_accuracy: 0.8283
Epoch 192/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1577 -
sparse_categorical_accuracy: 0.9380 - val_loss: 0.3606 -
val_sparse_categorical_accuracy: 0.8460
Epoch 193/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1556 -
sparse_categorical_accuracy: 0.9407 - val_loss: 0.3637 -
val_sparse_categorical_accuracy: 0.8333
Epoch 194/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1602 -
sparse_categorical_accuracy: 0.9411 - val_loss: 0.3668 -
val_sparse_categorical_accuracy: 0.8460
Epoch 195/1000
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71/71 [==============================] - 2s 34ms/step - loss: 0.1545 -
sparse_categorical_accuracy: 0.9469 - val_loss: 0.3609 -
val_sparse_categorical_accuracy: 0.8359
Epoch 196/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1527 -
sparse_categorical_accuracy: 0.9473 - val_loss: 0.3851 -
val_sparse_categorical_accuracy: 0.8359
Epoch 197/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1575 -
sparse_categorical_accuracy: 0.9415 - val_loss: 0.3788 -
val_sparse_categorical_accuracy: 0.8359
Epoch 198/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1540 -
sparse_categorical_accuracy: 0.9456 - val_loss: 0.3767 -
val_sparse_categorical_accuracy: 0.8384
Epoch 199/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1509 -
sparse_categorical_accuracy: 0.9420 - val_loss: 0.3705 -
val_sparse_categorical_accuracy: 0.8460
Epoch 200/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1515 -
sparse_categorical_accuracy: 0.9451 - val_loss: 0.3710 -
val_sparse_categorical_accuracy: 0.8535
Epoch 201/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1485 -
sparse_categorical_accuracy: 0.9433 - val_loss: 0.3704 -
val_sparse_categorical_accuracy: 0.8485
Epoch 202/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1520 -
sparse_categorical_accuracy: 0.9407 - val_loss: 0.3623 -
val_sparse_categorical_accuracy: 0.8384
Epoch 203/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1467 -
sparse_categorical_accuracy: 0.9487 - val_loss: 0.3629 -
val_sparse_categorical_accuracy: 0.8510
Epoch 204/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1476 -
sparse_categorical_accuracy: 0.9438 - val_loss: 0.3712 -
val_sparse_categorical_accuracy: 0.8434
Epoch 205/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1470 -
sparse_categorical_accuracy: 0.9456 - val_loss: 0.3840 -
val_sparse_categorical_accuracy: 0.8283
Epoch 206/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1461 -
sparse_categorical_accuracy: 0.9500 - val_loss: 0.3641 -
val_sparse_categorical_accuracy: 0.8485
Epoch 207/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1430 -
sparse_categorical_accuracy: 0.9429 - val_loss: 0.3763 -
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val_sparse_categorical_accuracy: 0.8333
Epoch 208/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1542 -
sparse_categorical_accuracy: 0.9411 - val_loss: 0.3640 -
val_sparse_categorical_accuracy: 0.8460
Epoch 209/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1460 -
sparse_categorical_accuracy: 0.9473 - val_loss: 0.3691 -
val_sparse_categorical_accuracy: 0.8384
Epoch 210/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1425 -
sparse_categorical_accuracy: 0.9487 - val_loss: 0.3672 -
val_sparse_categorical_accuracy: 0.8485
Epoch 211/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1446 -
sparse_categorical_accuracy: 0.9487 - val_loss: 0.3682 -
val_sparse_categorical_accuracy: 0.8409
Epoch 212/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1407 -
sparse_categorical_accuracy: 0.9509 - val_loss: 0.3808 -
val_sparse_categorical_accuracy: 0.8485
Epoch 213/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1382 -
sparse_categorical_accuracy: 0.9527 - val_loss: 0.3684 -
val_sparse_categorical_accuracy: 0.8510
Epoch 214/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1392 -
sparse_categorical_accuracy: 0.9509 - val_loss: 0.3688 -
val_sparse_categorical_accuracy: 0.8409
Epoch 215/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1383 -
sparse_categorical_accuracy: 0.9514 - val_loss: 0.3740 -
val_sparse_categorical_accuracy: 0.8384
Epoch 216/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1412 -
sparse_categorical_accuracy: 0.9491 - val_loss: 0.3729 -
val_sparse_categorical_accuracy: 0.8510
Epoch 217/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1361 -
sparse_categorical_accuracy: 0.9509 - val_loss: 0.3707 -
val_sparse_categorical_accuracy: 0.8434
Epoch 218/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1392 -
sparse_categorical_accuracy: 0.9500 - val_loss: 0.3969 -
val_sparse_categorical_accuracy: 0.8333
Epoch 219/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1392 -
sparse_categorical_accuracy: 0.9487 - val_loss: 0.3731 -
val_sparse_categorical_accuracy: 0.8409
Epoch 220/1000
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71/71 [==============================] - 2s 34ms/step - loss: 0.1347 -
sparse_categorical_accuracy: 0.9523 - val_loss: 0.3740 -
val_sparse_categorical_accuracy: 0.8409
Epoch 221/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1345 -
sparse_categorical_accuracy: 0.9514 - val_loss: 0.3769 -
val_sparse_categorical_accuracy: 0.8333
Epoch 222/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1430 -
sparse_categorical_accuracy: 0.9438 - val_loss: 0.3731 -
val_sparse_categorical_accuracy: 0.8485
Epoch 223/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1339 -
sparse_categorical_accuracy: 0.9527 - val_loss: 0.3767 -
val_sparse_categorical_accuracy: 0.8333
Epoch 224/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1288 -
sparse_categorical_accuracy: 0.9536 - val_loss: 0.3749 -
val_sparse_categorical_accuracy: 0.8308
Epoch 225/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1331 -
sparse_categorical_accuracy: 0.9496 - val_loss: 0.3737 -
val_sparse_categorical_accuracy: 0.8359
Epoch 226/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1303 -
sparse_categorical_accuracy: 0.9514 - val_loss: 0.3787 -
val_sparse_categorical_accuracy: 0.8434
Epoch 227/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1299 -
sparse_categorical_accuracy: 0.9540 - val_loss: 0.3806 -
val_sparse_categorical_accuracy: 0.8485
Epoch 228/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1285 -
sparse_categorical_accuracy: 0.9545 - val_loss: 0.3720 -
val_sparse_categorical_accuracy: 0.8510
Epoch 229/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1271 -
sparse_categorical_accuracy: 0.9558 - val_loss: 0.3760 -
val_sparse_categorical_accuracy: 0.8460
Epoch 230/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1290 -
sparse_categorical_accuracy: 0.9536 - val_loss: 0.3745 -
val_sparse_categorical_accuracy: 0.8510
Epoch 231/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1279 -
sparse_categorical_accuracy: 0.9527 - val_loss: 0.4154 -
val_sparse_categorical_accuracy: 0.8384
Epoch 232/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1248 -
sparse_categorical_accuracy: 0.9585 - val_loss: 0.3789 -
```

```
val_sparse_categorical_accuracy: 0.8485
Epoch 233/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1281 -
sparse_categorical_accuracy: 0.9558 - val_loss: 0.3782 -
val_sparse_categorical_accuracy: 0.8384
Epoch 234/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1325 -
sparse_categorical_accuracy: 0.9505 - val_loss: 0.4027 -
val_sparse_categorical_accuracy: 0.8359
Epoch 235/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1241 -
sparse_categorical_accuracy: 0.9558 - val_loss: 0.3908 -
val_sparse_categorical_accuracy: 0.8460
Epoch 236/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1227 -
sparse_categorical_accuracy: 0.9567 - val_loss: 0.3856 -
val_sparse_categorical_accuracy: 0.8333
Epoch 237/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1424 -
sparse_categorical_accuracy: 0.9442 - val_loss: 0.3811 -
val_sparse_categorical_accuracy: 0.8359
Epoch 238/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1252 -
sparse_categorical_accuracy: 0.9523 - val_loss: 0.3829 -
val_sparse_categorical_accuracy: 0.8409
Epoch 239/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1212 -
sparse_categorical_accuracy: 0.9554 - val_loss: 0.3820 -
val_sparse_categorical_accuracy: 0.8359
Epoch 240/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1212 -
sparse_categorical_accuracy: 0.9594 - val_loss: 0.3921 -
val_sparse_categorical_accuracy: 0.8485
Epoch 241/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1202 -
sparse_categorical_accuracy: 0.9585 - val_loss: 0.3804 -
val_sparse_categorical_accuracy: 0.8460
Epoch 242/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1209 -
sparse_categorical_accuracy: 0.9612 - val_loss: 0.3919 -
val_sparse_categorical_accuracy: 0.8485
Epoch 243/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1220 -
sparse_categorical_accuracy: 0.9554 - val_loss: 0.3926 -
val_sparse_categorical_accuracy: 0.8409
Epoch 244/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1179 -
sparse_categorical_accuracy: 0.9585 - val_loss: 0.4001 -
val_sparse_categorical_accuracy: 0.8485
Epoch 245/1000
```

```
71/71 [==============================] - 2s 34ms/step - loss: 0.1267 -
sparse_categorical_accuracy: 0.9514 - val_loss: 0.3858 -
val_sparse_categorical_accuracy: 0.8434
Epoch 246/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1186 -
sparse_categorical_accuracy: 0.9589 - val_loss: 0.4148 -
val_sparse_categorical_accuracy: 0.8384
Epoch 247/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1212 -
sparse_categorical_accuracy: 0.9581 - val_loss: 0.4233 -
val_sparse_categorical_accuracy: 0.8308
Epoch 248/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1215 -
sparse_categorical_accuracy: 0.9567 - val_loss: 0.3846 -
val_sparse_categorical_accuracy: 0.8485
Epoch 249/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1160 -
sparse_categorical_accuracy: 0.9647 - val_loss: 0.3860 -
val_sparse_categorical_accuracy: 0.8409
Epoch 250/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1164 -
sparse_categorical_accuracy: 0.9594 - val_loss: 0.3860 -
val_sparse_categorical_accuracy: 0.8460
Epoch 251/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1160 -
sparse_categorical_accuracy: 0.9607 - val_loss: 0.3862 -
val_sparse_categorical_accuracy: 0.8434
Epoch 252/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1145 -
sparse_categorical_accuracy: 0.9598 - val_loss: 0.4021 -
val_sparse_categorical_accuracy: 0.8384
Epoch 253/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1277 -
sparse_categorical_accuracy: 0.9554 - val_loss: 0.3907 -
val_sparse_categorical_accuracy: 0.8409
Epoch 254/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1141 -
sparse_categorical_accuracy: 0.9603 - val_loss: 0.3984 -
val_sparse_categorical_accuracy: 0.8485
Epoch 255/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1123 -
sparse_categorical_accuracy: 0.9639 - val_loss: 0.3897 -
val_sparse_categorical_accuracy: 0.8460
Epoch 256/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1119 -
sparse_categorical_accuracy: 0.9621 - val_loss: 0.3968 -
val_sparse_categorical_accuracy: 0.8485
Epoch 257/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1108 -
sparse_categorical_accuracy: 0.9643 - val_loss: 0.3895 -
```

```
val_sparse_categorical_accuracy: 0.8384
Epoch 258/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1110 -
sparse_categorical_accuracy: 0.9585 - val_loss: 0.3980 -
val_sparse_categorical_accuracy: 0.8460
Epoch 259/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1086 -
sparse_categorical_accuracy: 0.9656 - val_loss: 0.4131 -
val_sparse_categorical_accuracy: 0.8485
Epoch 260/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1128 -
sparse_categorical_accuracy: 0.9652 - val_loss: 0.3963 -
val_sparse_categorical_accuracy: 0.8409
Epoch 261/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1082 -
sparse_categorical_accuracy: 0.9625 - val_loss: 0.3967 -
val_sparse_categorical_accuracy: 0.8510
Epoch 262/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1100 -
sparse_categorical_accuracy: 0.9647 - val_loss: 0.4053 -
val_sparse_categorical_accuracy: 0.8460
Epoch 263/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1081 -
sparse_categorical_accuracy: 0.9616 - val_loss: 0.4070 -
val_sparse_categorical_accuracy: 0.8535
Epoch 264/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1079 -
sparse_categorical_accuracy: 0.9612 - val_loss: 0.3933 -
val_sparse_categorical_accuracy: 0.8409
Epoch 265/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1074 -
sparse_categorical_accuracy: 0.9630 - val_loss: 0.3986 -
val_sparse_categorical_accuracy: 0.8434
Epoch 266/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1075 -
sparse_categorical_accuracy: 0.9621 - val_loss: 0.3958 -
val_sparse_categorical_accuracy: 0.8384
Epoch 267/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1092 -
sparse_categorical_accuracy: 0.9639 - val_loss: 0.4026 -
val_sparse_categorical_accuracy: 0.8384
Epoch 268/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1058 -
sparse_categorical_accuracy: 0.9688 - val_loss: 0.3960 -
val_sparse_categorical_accuracy: 0.8384
Epoch 269/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1134 -
sparse_categorical_accuracy: 0.9585 - val_loss: 0.4075 -
val_sparse_categorical_accuracy: 0.8434
Epoch 270/1000
```

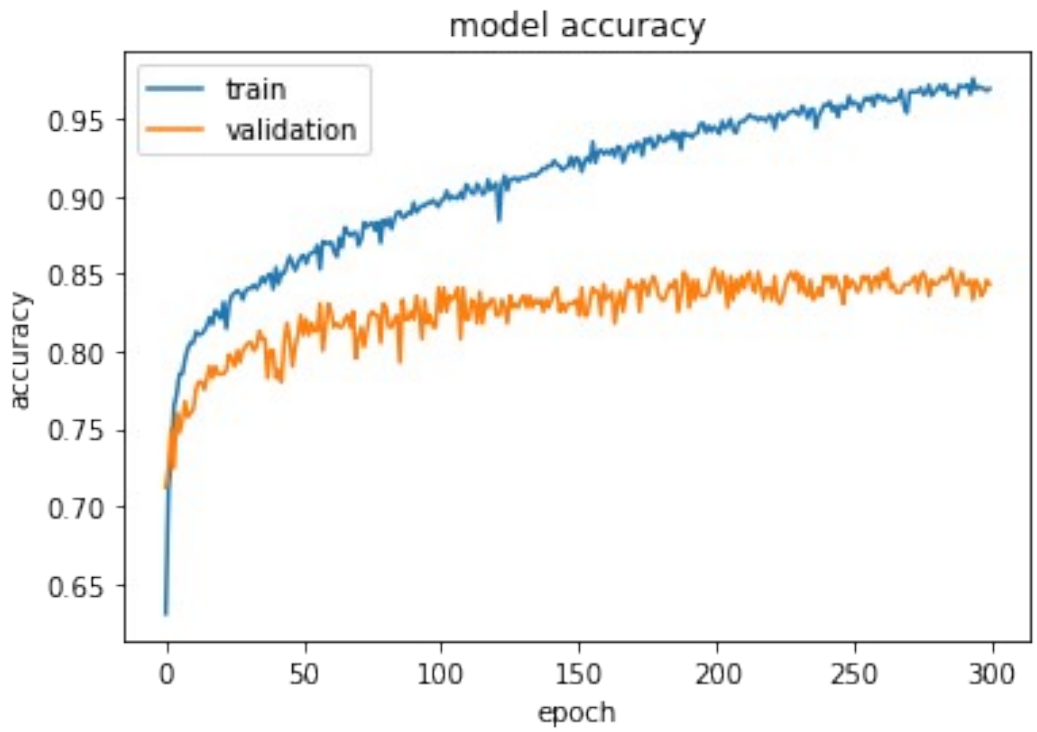
```
71/71 [==============================] - 2s 34ms/step - loss: 0.1148 -
sparse_categorical_accuracy: 0.9540 - val_loss: 0.4110 -
val_sparse_categorical_accuracy: 0.8434
Epoch 271/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1045 -
sparse_categorical_accuracy: 0.9674 - val_loss: 0.4103 -
val_sparse_categorical_accuracy: 0.8434
Epoch 272/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1023 -
sparse_categorical_accuracy: 0.9679 - val_loss: 0.4192 -
val_sparse_categorical_accuracy: 0.8460
Epoch 273/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1019 -
sparse_categorical_accuracy: 0.9674 - val_loss: 0.4032 -
val_sparse_categorical_accuracy: 0.8485
Epoch 274/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1027 -
sparse_categorical_accuracy: 0.9679 - val_loss: 0.4030 -
val_sparse_categorical_accuracy: 0.8384
Epoch 275/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0984 -
sparse_categorical_accuracy: 0.9701 - val_loss: 0.4046 -
val_sparse_categorical_accuracy: 0.8485
Epoch 276/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1033 -
sparse_categorical_accuracy: 0.9656 - val_loss: 0.4150 -
val_sparse_categorical_accuracy: 0.8510
Epoch 277/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0981 -
sparse_categorical_accuracy: 0.9670 - val_loss: 0.4276 -
val_sparse_categorical_accuracy: 0.8460
Epoch 278/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0969 -
sparse_categorical_accuracy: 0.9719 - val_loss: 0.4478 -
val_sparse_categorical_accuracy: 0.8359
Epoch 279/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1009 -
sparse_categorical_accuracy: 0.9652 - val_loss: 0.4180 -
val_sparse_categorical_accuracy: 0.8460
Epoch 280/1000
71/71 [==============================] - 2s 33ms/step - loss: 0.1020 -
sparse_categorical_accuracy: 0.9674 - val_loss: 0.4128 -
val_sparse_categorical_accuracy: 0.8434
Epoch 281/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0952 -
sparse_categorical_accuracy: 0.9692 - val_loss: 0.4073 -
val_sparse_categorical_accuracy: 0.8434
Epoch 282/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0928 -
sparse_categorical_accuracy: 0.9719 - val_loss: 0.4219 -
```

```
val_sparse_categorical_accuracy: 0.8460
Epoch 283/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0945 -
sparse_categorical_accuracy: 0.9688 - val_loss: 0.4087 -
val_sparse_categorical_accuracy: 0.8485
Epoch 284/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0919 -
sparse_categorical_accuracy: 0.9723 - val_loss: 0.4020 -
val_sparse_categorical_accuracy: 0.8460
Epoch 285/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0977 -
sparse_categorical_accuracy: 0.9656 - val_loss: 0.4127 -
val_sparse_categorical_accuracy: 0.8485
Epoch 286/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0916 -
sparse_categorical_accuracy: 0.9674 - val_loss: 0.4302 -
val_sparse_categorical_accuracy: 0.8535
Epoch 287/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0968 -
sparse_categorical_accuracy: 0.9679 - val_loss: 0.4175 -
val_sparse_categorical_accuracy: 0.8460
Epoch 288/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.1073 -
sparse_categorical_accuracy: 0.9643 - val_loss: 0.4094 -
val_sparse_categorical_accuracy: 0.8359
Epoch 289/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0903 -
sparse_categorical_accuracy: 0.9719 - val_loss: 0.4129 -
val_sparse_categorical_accuracy: 0.8434
Epoch 290/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0928 -
sparse_categorical_accuracy: 0.9705 - val_loss: 0.4333 -
val_sparse_categorical_accuracy: 0.8510
Epoch 291/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0929 -
sparse_categorical_accuracy: 0.9710 - val_loss: 0.4077 -
val_sparse_categorical_accuracy: 0.8434
Epoch 292/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0913 -
sparse_categorical_accuracy: 0.9723 - val_loss: 0.4172 -
val_sparse_categorical_accuracy: 0.8434
Epoch 293/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0974 -
sparse_categorical_accuracy: 0.9661 - val_loss: 0.4443 -
val_sparse_categorical_accuracy: 0.8460
Epoch 294/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0881 -
sparse_categorical_accuracy: 0.9763 - val_loss: 0.4227 -
val_sparse_categorical_accuracy: 0.8333
Epoch 295/1000
```

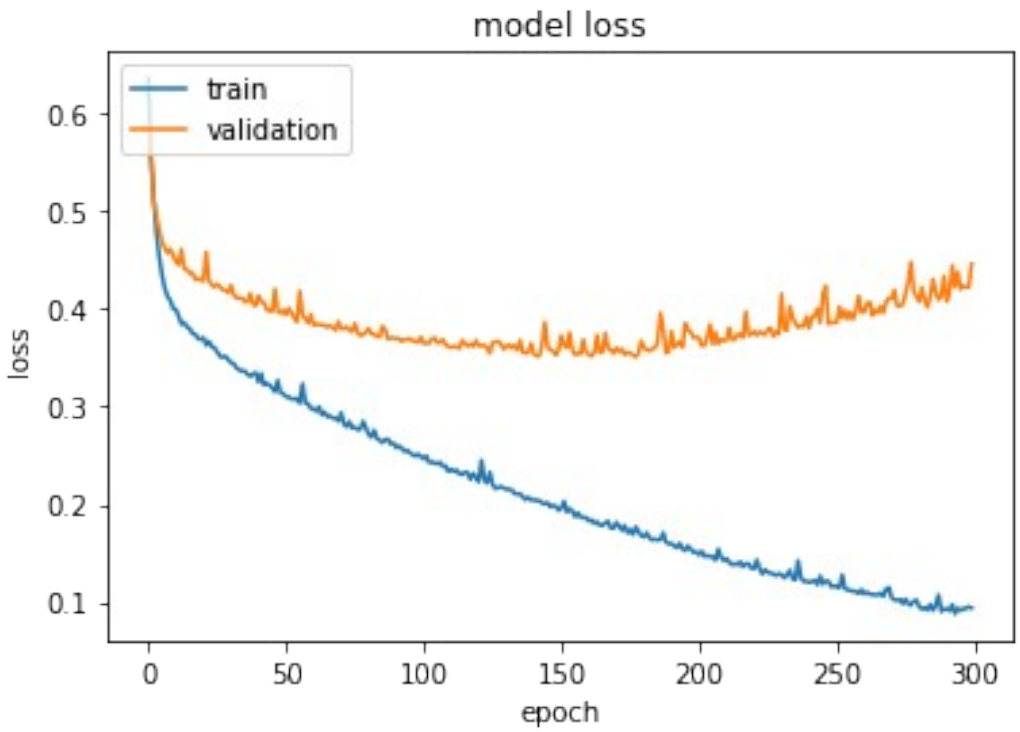
```
71/71 [==============================] - 2s 34ms/step - loss: 0.0936 -
sparse_categorical_accuracy: 0.9692 - val_loss: 0.4375 -
val_sparse_categorical_accuracy: 0.8460
Epoch 296/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0915 -
sparse_categorical_accuracy: 0.9710 - val_loss: 0.4202 -
val_sparse_categorical_accuracy: 0.8434
Epoch 297/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0930 -
sparse_categorical_accuracy: 0.9701 - val_loss: 0.4233 -
val_sparse_categorical_accuracy: 0.8359
Epoch 298/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0938 -
sparse_categorical_accuracy: 0.9697 - val_loss: 0.4220 -
val_sparse_categorical_accuracy: 0.8384
Epoch 299/1000
71/71 [==============================] - 2s 34ms/step - loss: 0.0952 -
sparse_categorical_accuracy: 0.9683 - val_loss: 0.4223 -
val_sparse_categorical_accuracy: 0.8460
Epoch 300/1000
69/71 [============================>.] - ETA: 0s - loss: 0.0936 -
sparse_categorical_accuracy: 0.9701Restoring model weights from the
end of the best epoch: 200.
71/71 [==============================] - 2s 34ms/step - loss: 0.0939 -
sparse_categorical_accuracy: 0.9697 - val_loss: 0.4457 -
val_sparse_categorical_accuracy: 0.8434
Epoch 300: early stopping
```

```
model.save('/content/drive/MyDrive/my_model.h5')
```

```
plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
# np.unique(Y_train)

# Testing model on test data to evaluate
y_pred = model.predict(X_test)
y_pred #it defaulty arranges class 0 prob at index 0 and for class 1
at index 1
```

```
array([[1.0000000e+00, 0.0000000e+00],
       [1.0000000e+00, 0.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       ...,
       [1.0000000e+00, 0.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       [9.7035436e-06, 9.9999034e-01]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
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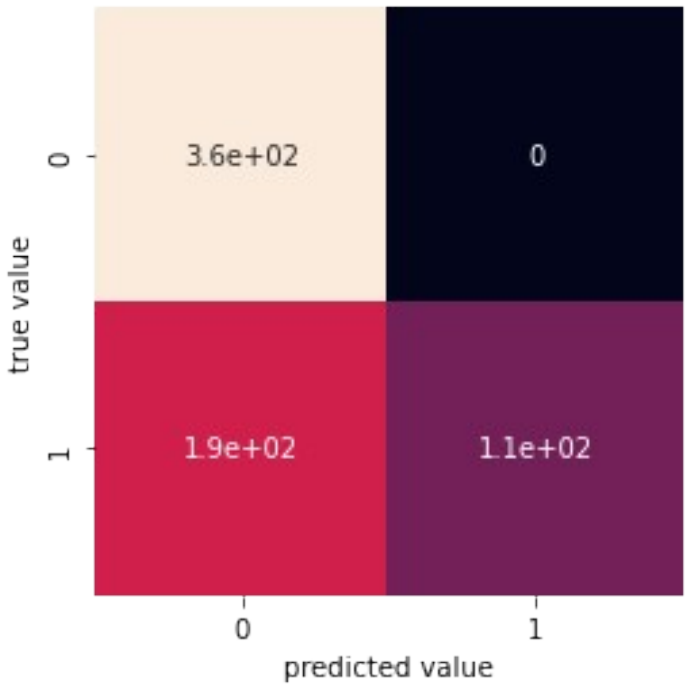
```
# type(Y_test)
```

```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score


print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
```

```
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.715
Precision: 1.000
Recall: 0.365
F1: 0.535
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
baseline_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",baseline_f1_score)
```

```
F1_score: 0.5346534653465346
```

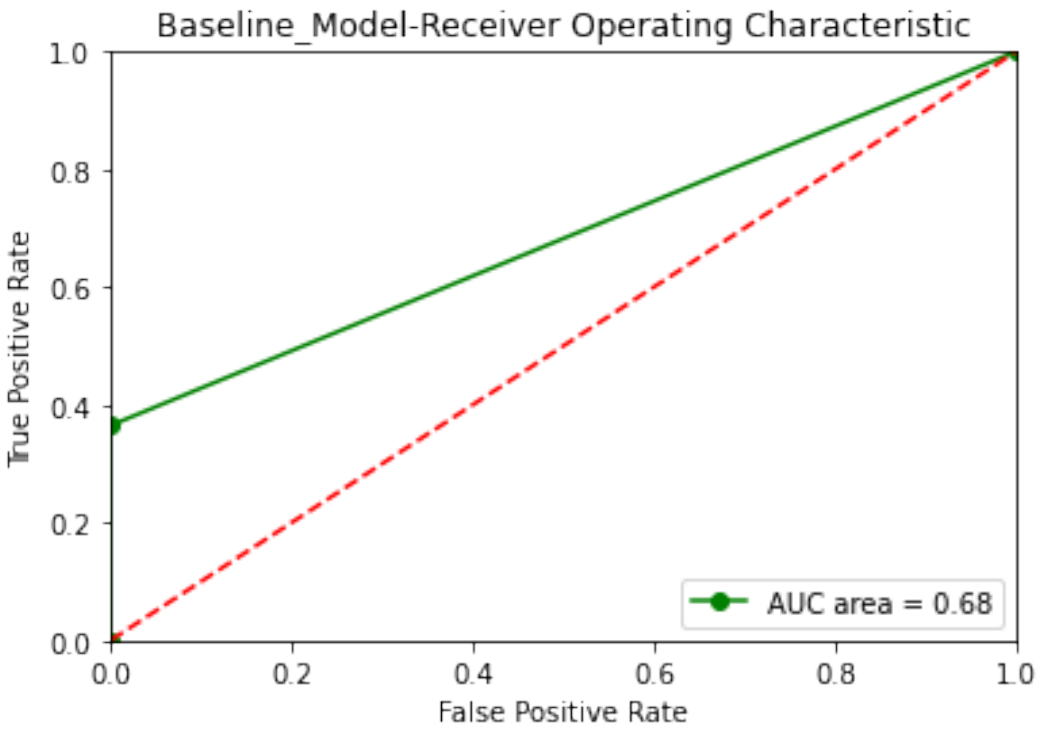
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_baseline = auc(fpr_keras, tpr_keras)
auc_keras_baseline
```

```
0.6824324324324325
```

```
import matplotlib.pyplot as plt
plt.title('Baseline_Model-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_baseline)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```




```
# from tensorflow.keras.models import load_model

# reloaded_model=load_model("/content/drive/My Drive/my_model.h5")
#loading the h5 file model
```

Model-ResNet 50

```
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras import Model

input_shape=(224,224,3)



head_model = ResNet50(include_top=False,
                  weights='imagenet', #random initialization
                  #input_tensor=None,
                  input_shape=input_shape)
                  #pooling='avg',
                  #classes=2)


for layer in head_model.layers:
  layer.trainable = False #trainable are the last three layers until
flatten (the whole set of fully connected layers)
```

```
x = layers.Flatten()(head_model.output) #google: how to cut off a pre
train model resnet and add fully connected layers in tensorflow
x = layers.Dense(1000, activation='relu')(x)
predictions = layers.Dense(2, activation = 'softmax')(x)

model = Model(inputs = head_model.input, outputs = predictions)
```

```
model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/
resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94773248/94765736 [==============================] - 2s 0us/step
94781440/94765736 [==============================] - 2s 0us/step
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 15s 160ms/step - loss: 0.7018
- sparse_categorical_accuracy: 0.5765 - val_loss: 0.6826 -
val_sparse_categorical_accuracy: 0.5556
Epoch 2/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.6695
- sparse_categorical_accuracy: 0.5939 - val_loss: 0.6459 -
val_sparse_categorical_accuracy: 0.5859
Epoch 3/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.6073
- sparse_categorical_accuracy: 0.6756 - val_loss: 0.6071 -
val_sparse_categorical_accuracy: 0.6313
Epoch 4/1000
71/71 [==============================] - 9s 126ms/step - loss: 0.6026
- sparse_categorical_accuracy: 0.6734 - val_loss: 0.6446 -
val_sparse_categorical_accuracy: 0.6010
Epoch 5/1000
71/71 [==============================] - 9s 126ms/step - loss: 0.5975
```

```
- sparse_categorical_accuracy: 0.6894 - val_loss: 0.6659 -
val_sparse_categorical_accuracy: 0.5934
Epoch 6/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.5744
- sparse_categorical_accuracy: 0.6925 - val_loss: 0.5702 -
val_sparse_categorical_accuracy: 0.6995
Epoch 7/1000
71/71 [==============================] - 9s 131ms/step - loss: 0.5585
- sparse_categorical_accuracy: 0.7082 - val_loss: 0.5489 -
val_sparse_categorical_accuracy: 0.7525
Epoch 8/1000
71/71 [==============================] - 9s 127ms/step - loss: 0.5535
- sparse_categorical_accuracy: 0.7113 - val_loss: 0.6626 -
val_sparse_categorical_accuracy: 0.6086
Epoch 9/1000
71/71 [==============================] - 9s 127ms/step - loss: 0.5598
- sparse_categorical_accuracy: 0.7202 - val_loss: 0.5861 -
val_sparse_categorical_accuracy: 0.6768
Epoch 10/1000
71/71 [==============================] - 9s 127ms/step - loss: 0.5260
- sparse_categorical_accuracy: 0.7376 - val_loss: 0.6676 -
val_sparse_categorical_accuracy: 0.6136
Epoch 11/1000
71/71 [==============================] - 9s 127ms/step - loss: 0.5298
- sparse_categorical_accuracy: 0.7327 - val_loss: 0.5227 -
val_sparse_categorical_accuracy: 0.7500
Epoch 12/1000
71/71 [==============================] - 9s 132ms/step - loss: 0.5706
- sparse_categorical_accuracy: 0.7019 - val_loss: 0.5470 -
val_sparse_categorical_accuracy: 0.7601
Epoch 13/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.5174
- sparse_categorical_accuracy: 0.7412 - val_loss: 0.5366 -
val_sparse_categorical_accuracy: 0.7576
Epoch 14/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.5151
- sparse_categorical_accuracy: 0.7332 - val_loss: 0.5523 -
val_sparse_categorical_accuracy: 0.7121
Epoch 15/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.5296
- sparse_categorical_accuracy: 0.7300 - val_loss: 0.6298 -
val_sparse_categorical_accuracy: 0.6490
Epoch 16/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4928
- sparse_categorical_accuracy: 0.7465 - val_loss: 0.5508 -
val_sparse_categorical_accuracy: 0.7576
Epoch 17/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.4864
- sparse_categorical_accuracy: 0.7581 - val_loss: 0.5114 -
val_sparse_categorical_accuracy: 0.7652
```

```
Epoch 18/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.5077
- sparse_categorical_accuracy: 0.7546 - val_loss: 0.6054 -
val_sparse_categorical_accuracy: 0.7197
Epoch 19/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.5015
- sparse_categorical_accuracy: 0.7479 - val_loss: 0.4977 -
val_sparse_categorical_accuracy: 0.7601
Epoch 20/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4923
- sparse_categorical_accuracy: 0.7470 - val_loss: 0.4946 -
val_sparse_categorical_accuracy: 0.7475
Epoch 21/1000
71/71 [==============================] - 9s 132ms/step - loss: 0.4775
- sparse_categorical_accuracy: 0.7671 - val_loss: 0.4985 -
val_sparse_categorical_accuracy: 0.7727
Epoch 22/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4713
- sparse_categorical_accuracy: 0.7680 - val_loss: 0.5688 -
val_sparse_categorical_accuracy: 0.7020
Epoch 23/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4760
- sparse_categorical_accuracy: 0.7657 - val_loss: 0.5030 -
val_sparse_categorical_accuracy: 0.7273
Epoch 24/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.4645
- sparse_categorical_accuracy: 0.7738 - val_loss: 0.5098 -
val_sparse_categorical_accuracy: 0.7778
Epoch 25/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4805
- sparse_categorical_accuracy: 0.7662 - val_loss: 0.5158 -
val_sparse_categorical_accuracy: 0.7121
Epoch 26/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4687
- sparse_categorical_accuracy: 0.7671 - val_loss: 0.6155 -
val_sparse_categorical_accuracy: 0.6818
Epoch 27/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4805
- sparse_categorical_accuracy: 0.7657 - val_loss: 0.5059 -
val_sparse_categorical_accuracy: 0.7778
Epoch 28/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4611
- sparse_categorical_accuracy: 0.7742 - val_loss: 0.4814 -
val_sparse_categorical_accuracy: 0.7576
Epoch 29/1000
71/71 [==============================] - 9s 132ms/step - loss: 0.4673
- sparse_categorical_accuracy: 0.7693 - val_loss: 0.5019 -
val_sparse_categorical_accuracy: 0.7803
Epoch 30/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4543
```

```
- sparse_categorical_accuracy: 0.7796 - val_loss: 0.4916 -
val_sparse_categorical_accuracy: 0.7399
Epoch 31/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4528
- sparse_categorical_accuracy: 0.7805 - val_loss: 0.5219 -
val_sparse_categorical_accuracy: 0.7222
Epoch 32/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4779
- sparse_categorical_accuracy: 0.7546 - val_loss: 0.4869 -
val_sparse_categorical_accuracy: 0.7449
Epoch 33/1000
71/71 [==============================] - 9s 132ms/step - loss: 0.4448
- sparse_categorical_accuracy: 0.7840 - val_loss: 0.4735 -
val_sparse_categorical_accuracy: 0.7854
Epoch 34/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4342
- sparse_categorical_accuracy: 0.7894 - val_loss: 0.6574 -
val_sparse_categorical_accuracy: 0.6667
Epoch 35/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4671
- sparse_categorical_accuracy: 0.7738 - val_loss: 0.4717 -
val_sparse_categorical_accuracy: 0.7475
Epoch 36/1000
71/71 [==============================] - 9s 132ms/step - loss: 0.4331
- sparse_categorical_accuracy: 0.7925 - val_loss: 0.4720 -
val_sparse_categorical_accuracy: 0.7929
Epoch 37/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4458
- sparse_categorical_accuracy: 0.7836 - val_loss: 0.6164 -
val_sparse_categorical_accuracy: 0.7172
Epoch 38/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.4626
- sparse_categorical_accuracy: 0.7791 - val_loss: 0.4725 -
val_sparse_categorical_accuracy: 0.7980
Epoch 39/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4738
- sparse_categorical_accuracy: 0.7680 - val_loss: 0.4724 -
val_sparse_categorical_accuracy: 0.7449
Epoch 40/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.4259
- sparse_categorical_accuracy: 0.7925 - val_loss: 0.5577 -
val_sparse_categorical_accuracy: 0.7576
Epoch 41/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4617
- sparse_categorical_accuracy: 0.7778 - val_loss: 0.4703 -
val_sparse_categorical_accuracy: 0.7500
Epoch 42/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4249
- sparse_categorical_accuracy: 0.7996 - val_loss: 0.6846 -
val_sparse_categorical_accuracy: 0.6919
```

```
Epoch 43/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4841
- sparse_categorical_accuracy: 0.7689 - val_loss: 0.5172 -
val_sparse_categorical_accuracy: 0.7702
Epoch 44/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.4203
- sparse_categorical_accuracy: 0.8081 - val_loss: 0.4703 -
val_sparse_categorical_accuracy: 0.8081
Epoch 45/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4120
- sparse_categorical_accuracy: 0.7983 - val_loss: 0.4886 -
val_sparse_categorical_accuracy: 0.7980
Epoch 46/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4194
- sparse_categorical_accuracy: 0.8046 - val_loss: 0.4649 -
val_sparse_categorical_accuracy: 0.7500
Epoch 47/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4185
- sparse_categorical_accuracy: 0.8086 - val_loss: 0.4576 -
val_sparse_categorical_accuracy: 0.7778
Epoch 48/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4156
- sparse_categorical_accuracy: 0.8126 - val_loss: 0.4693 -
val_sparse_categorical_accuracy: 0.7449
Epoch 49/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4184
- sparse_categorical_accuracy: 0.8050 - val_loss: 0.5044 -
val_sparse_categorical_accuracy: 0.7348
Epoch 50/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4194
- sparse_categorical_accuracy: 0.7979 - val_loss: 0.5793 -
val_sparse_categorical_accuracy: 0.7348
Epoch 51/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4606
- sparse_categorical_accuracy: 0.7742 - val_loss: 0.4933 -
val_sparse_categorical_accuracy: 0.7727
Epoch 52/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4078
- sparse_categorical_accuracy: 0.8139 - val_loss: 0.4661 -
val_sparse_categorical_accuracy: 0.8056
Epoch 53/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4176
- sparse_categorical_accuracy: 0.8032 - val_loss: 0.5961 -
val_sparse_categorical_accuracy: 0.6970
Epoch 54/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4182
- sparse_categorical_accuracy: 0.8028 - val_loss: 0.4749 -
val_sparse_categorical_accuracy: 0.7525
Epoch 55/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4192
```

```
- sparse_categorical_accuracy: 0.7965 - val_loss: 0.7407 -
val_sparse_categorical_accuracy: 0.6540
Epoch 56/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4394
- sparse_categorical_accuracy: 0.7916 - val_loss: 0.7795 -
val_sparse_categorical_accuracy: 0.6540
Epoch 57/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4301
- sparse_categorical_accuracy: 0.7934 - val_loss: 0.5528 -
val_sparse_categorical_accuracy: 0.7146
Epoch 58/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4674
- sparse_categorical_accuracy: 0.7800 - val_loss: 0.4508 -
val_sparse_categorical_accuracy: 0.7929
Epoch 59/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.4032
- sparse_categorical_accuracy: 0.8081 - val_loss: 0.4666 -
val_sparse_categorical_accuracy: 0.8131
Epoch 60/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4095
- sparse_categorical_accuracy: 0.8072 - val_loss: 0.4778 -
val_sparse_categorical_accuracy: 0.8030
Epoch 61/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4009
- sparse_categorical_accuracy: 0.8117 - val_loss: 0.4704 -
val_sparse_categorical_accuracy: 0.8081
Epoch 62/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3962
- sparse_categorical_accuracy: 0.8104 - val_loss: 0.6477 -
val_sparse_categorical_accuracy: 0.6970
Epoch 63/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4237
- sparse_categorical_accuracy: 0.7979 - val_loss: 0.5125 -
val_sparse_categorical_accuracy: 0.7374
Epoch 64/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4180
- sparse_categorical_accuracy: 0.8068 - val_loss: 0.6179 -
val_sparse_categorical_accuracy: 0.7045
Epoch 65/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4547
- sparse_categorical_accuracy: 0.7827 - val_loss: 0.4474 -
val_sparse_categorical_accuracy: 0.8106
Epoch 66/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3824
- sparse_categorical_accuracy: 0.8246 - val_loss: 0.4444 -
val_sparse_categorical_accuracy: 0.7980
Epoch 67/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3925
- sparse_categorical_accuracy: 0.8193 - val_loss: 0.4997 -
val_sparse_categorical_accuracy: 0.7374
```

```
Epoch 68/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4297
- sparse_categorical_accuracy: 0.7943 - val_loss: 0.6737 -
val_sparse_categorical_accuracy: 0.7045
Epoch 69/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4109
- sparse_categorical_accuracy: 0.8072 - val_loss: 0.5760 -
val_sparse_categorical_accuracy: 0.7475
Epoch 70/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4375
- sparse_categorical_accuracy: 0.7903 - val_loss: 0.4436 -
val_sparse_categorical_accuracy: 0.7980
Epoch 71/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.3892
- sparse_categorical_accuracy: 0.8202 - val_loss: 0.4655 -
val_sparse_categorical_accuracy: 0.8157
Epoch 72/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3859
- sparse_categorical_accuracy: 0.8242 - val_loss: 0.5228 -
val_sparse_categorical_accuracy: 0.7652
Epoch 73/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.3977
- sparse_categorical_accuracy: 0.8117 - val_loss: 0.4512 -
val_sparse_categorical_accuracy: 0.8131
Epoch 74/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.3995
- sparse_categorical_accuracy: 0.8135 - val_loss: 0.4477 -
val_sparse_categorical_accuracy: 0.7803
Epoch 75/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3851
- sparse_categorical_accuracy: 0.8264 - val_loss: 0.4681 -
val_sparse_categorical_accuracy: 0.7626
Epoch 76/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3926
- sparse_categorical_accuracy: 0.8166 - val_loss: 0.4832 -
val_sparse_categorical_accuracy: 0.7551
Epoch 77/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3857
- sparse_categorical_accuracy: 0.8286 - val_loss: 0.4409 -
val_sparse_categorical_accuracy: 0.8106
Epoch 78/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3856
- sparse_categorical_accuracy: 0.8135 - val_loss: 0.4579 -
val_sparse_categorical_accuracy: 0.8157
Epoch 79/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3925
- sparse_categorical_accuracy: 0.8188 - val_loss: 0.4443 -
val_sparse_categorical_accuracy: 0.8131
Epoch 80/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3827
```

```
- sparse_categorical_accuracy: 0.8255 - val_loss: 0.6704 -
val_sparse_categorical_accuracy: 0.6894
Epoch 81/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3924
- sparse_categorical_accuracy: 0.8224 - val_loss: 0.4512 -
val_sparse_categorical_accuracy: 0.7753
Epoch 82/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3970
- sparse_categorical_accuracy: 0.8148 - val_loss: 0.5016 -
val_sparse_categorical_accuracy: 0.7449
Epoch 83/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4163
- sparse_categorical_accuracy: 0.8028 - val_loss: 0.4575 -
val_sparse_categorical_accuracy: 0.7677
Epoch 84/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3926
- sparse_categorical_accuracy: 0.8202 - val_loss: 0.6679 -
val_sparse_categorical_accuracy: 0.7172
Epoch 85/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4332
- sparse_categorical_accuracy: 0.7983 - val_loss: 0.4397 -
val_sparse_categorical_accuracy: 0.7879
Epoch 86/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3960
- sparse_categorical_accuracy: 0.8112 - val_loss: 0.4776 -
val_sparse_categorical_accuracy: 0.7854
Epoch 87/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3835
- sparse_categorical_accuracy: 0.8211 - val_loss: 0.5469 -
val_sparse_categorical_accuracy: 0.7652
Epoch 88/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3875
- sparse_categorical_accuracy: 0.8170 - val_loss: 0.5680 -
val_sparse_categorical_accuracy: 0.7475
Epoch 89/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4177
- sparse_categorical_accuracy: 0.8063 - val_loss: 0.4450 -
val_sparse_categorical_accuracy: 0.8157
Epoch 90/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3675
- sparse_categorical_accuracy: 0.8251 - val_loss: 0.5133 -
val_sparse_categorical_accuracy: 0.7727
Epoch 91/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3751
- sparse_categorical_accuracy: 0.8269 - val_loss: 0.5610 -
val_sparse_categorical_accuracy: 0.7500
Epoch 92/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3879
- sparse_categorical_accuracy: 0.8166 - val_loss: 0.4713 -
val_sparse_categorical_accuracy: 0.7551
```

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Epoch 93/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4040
- sparse_categorical_accuracy: 0.8112 - val_loss: 0.4408 -
val_sparse_categorical_accuracy: 0.7879
Epoch 94/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3646
- sparse_categorical_accuracy: 0.8313 - val_loss: 0.5090 -
val_sparse_categorical_accuracy: 0.7702
Epoch 95/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3821
- sparse_categorical_accuracy: 0.8242 - val_loss: 0.4336 -
val_sparse_categorical_accuracy: 0.8157
Epoch 96/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3885
- sparse_categorical_accuracy: 0.8170 - val_loss: 0.6706 -
val_sparse_categorical_accuracy: 0.6894
Epoch 97/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4508
- sparse_categorical_accuracy: 0.7845 - val_loss: 0.5027 -
val_sparse_categorical_accuracy: 0.7778
Epoch 98/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3940
- sparse_categorical_accuracy: 0.8148 - val_loss: 0.4610 -
val_sparse_categorical_accuracy: 0.7677
Epoch 99/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3991
- sparse_categorical_accuracy: 0.8126 - val_loss: 0.4796 -
val_sparse_categorical_accuracy: 0.7803
Epoch 100/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3974
- sparse_categorical_accuracy: 0.8041 - val_loss: 0.5167 -
val_sparse_categorical_accuracy: 0.7500
Epoch 101/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3875
- sparse_categorical_accuracy: 0.8117 - val_loss: 0.5361 -
val_sparse_categorical_accuracy: 0.7374
Epoch 102/1000
71/71 [==============================] - 9s 134ms/step - loss: 0.4402
- sparse_categorical_accuracy: 0.7956 - val_loss: 0.4456 -
val_sparse_categorical_accuracy: 0.8182
Epoch 103/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.3618
- sparse_categorical_accuracy: 0.8425 - val_loss: 0.4294 -
val_sparse_categorical_accuracy: 0.8258
Epoch 104/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3610
- sparse_categorical_accuracy: 0.8291 - val_loss: 0.6458 -
val_sparse_categorical_accuracy: 0.6894
Epoch 105/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3848
```

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- sparse_categorical_accuracy: 0.8228 - val_loss: 0.5465 -
val_sparse_categorical_accuracy: 0.7551
Epoch 106/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4013
- sparse_categorical_accuracy: 0.8090 - val_loss: 0.4403 -
val_sparse_categorical_accuracy: 0.7955
Epoch 107/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3787
- sparse_categorical_accuracy: 0.8197 - val_loss: 0.4466 -
val_sparse_categorical_accuracy: 0.7904
Epoch 108/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3664
- sparse_categorical_accuracy: 0.8344 - val_loss: 0.4418 -
val_sparse_categorical_accuracy: 0.7929
Epoch 109/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3586
- sparse_categorical_accuracy: 0.8344 - val_loss: 0.4963 -
val_sparse_categorical_accuracy: 0.7803
Epoch 110/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3855
- sparse_categorical_accuracy: 0.8197 - val_loss: 0.5238 -
val_sparse_categorical_accuracy: 0.7778
Epoch 111/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3962
- sparse_categorical_accuracy: 0.8135 - val_loss: 0.4260 -
val_sparse_categorical_accuracy: 0.7955
Epoch 112/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3554
- sparse_categorical_accuracy: 0.8371 - val_loss: 0.5590 -
val_sparse_categorical_accuracy: 0.7500
Epoch 113/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3978
- sparse_categorical_accuracy: 0.8090 - val_loss: 0.5456 -
val_sparse_categorical_accuracy: 0.7298
Epoch 114/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3922
- sparse_categorical_accuracy: 0.8090 - val_loss: 0.4252 -
val_sparse_categorical_accuracy: 0.8005
Epoch 115/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3615
- sparse_categorical_accuracy: 0.8295 - val_loss: 0.5657 -
val_sparse_categorical_accuracy: 0.7475
Epoch 116/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3619
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4251 -
val_sparse_categorical_accuracy: 0.8131
Epoch 117/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3708
- sparse_categorical_accuracy: 0.8282 - val_loss: 0.5203 -
val_sparse_categorical_accuracy: 0.7778
```

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Epoch 118/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3772
- sparse_categorical_accuracy: 0.8139 - val_loss: 0.4944 -
val_sparse_categorical_accuracy: 0.7551
Epoch 119/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3766
- sparse_categorical_accuracy: 0.8278 - val_loss: 0.4894 -
val_sparse_categorical_accuracy: 0.7626
Epoch 120/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4062
- sparse_categorical_accuracy: 0.8153 - val_loss: 0.4774 -
val_sparse_categorical_accuracy: 0.7828
Epoch 121/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3620
- sparse_categorical_accuracy: 0.8264 - val_loss: 0.4671 -
val_sparse_categorical_accuracy: 0.7955
Epoch 122/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3546
- sparse_categorical_accuracy: 0.8411 - val_loss: 0.4408 -
val_sparse_categorical_accuracy: 0.8207
Epoch 123/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3806
- sparse_categorical_accuracy: 0.8291 - val_loss: 0.4344 -
val_sparse_categorical_accuracy: 0.8207
Epoch 124/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3642
- sparse_categorical_accuracy: 0.8202 - val_loss: 0.4701 -
val_sparse_categorical_accuracy: 0.7677
Epoch 125/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3739
- sparse_categorical_accuracy: 0.8286 - val_loss: 0.6313 -
val_sparse_categorical_accuracy: 0.7399
Epoch 126/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.4239
- sparse_categorical_accuracy: 0.8023 - val_loss: 0.4724 -
val_sparse_categorical_accuracy: 0.7854
Epoch 127/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4058
- sparse_categorical_accuracy: 0.8166 - val_loss: 0.5237 -
val_sparse_categorical_accuracy: 0.7525
Epoch 128/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3531
- sparse_categorical_accuracy: 0.8286 - val_loss: 0.4309 -
val_sparse_categorical_accuracy: 0.8232
Epoch 129/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3655
- sparse_categorical_accuracy: 0.8295 - val_loss: 0.4446 -
val_sparse_categorical_accuracy: 0.7955
Epoch 130/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3583
```

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- sparse_categorical_accuracy: 0.8255 - val_loss: 0.4457 -
val_sparse_categorical_accuracy: 0.7955
Epoch 131/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3655
- sparse_categorical_accuracy: 0.8313 - val_loss: 0.5860 -
val_sparse_categorical_accuracy: 0.7222
Epoch 132/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3953
- sparse_categorical_accuracy: 0.8144 - val_loss: 0.6572 -
val_sparse_categorical_accuracy: 0.6944
Epoch 133/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4034
- sparse_categorical_accuracy: 0.8112 - val_loss: 0.4221 -
val_sparse_categorical_accuracy: 0.7955
Epoch 134/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3616
- sparse_categorical_accuracy: 0.8300 - val_loss: 0.4210 -
val_sparse_categorical_accuracy: 0.8030
Epoch 135/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3462
- sparse_categorical_accuracy: 0.8438 - val_loss: 0.5760 -
val_sparse_categorical_accuracy: 0.7247
Epoch 136/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3821
- sparse_categorical_accuracy: 0.8184 - val_loss: 0.6346 -
val_sparse_categorical_accuracy: 0.7374
Epoch 137/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3628
- sparse_categorical_accuracy: 0.8340 - val_loss: 0.5444 -
val_sparse_categorical_accuracy: 0.7601
Epoch 138/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3532
- sparse_categorical_accuracy: 0.8411 - val_loss: 0.4636 -
val_sparse_categorical_accuracy: 0.7929
Epoch 139/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3537
- sparse_categorical_accuracy: 0.8349 - val_loss: 0.4387 -
val_sparse_categorical_accuracy: 0.8232
Epoch 140/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3570
- sparse_categorical_accuracy: 0.8331 - val_loss: 0.4321 -
val_sparse_categorical_accuracy: 0.7929
Epoch 141/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3432
- sparse_categorical_accuracy: 0.8358 - val_loss: 0.4472 -
val_sparse_categorical_accuracy: 0.7904
Epoch 142/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3824
- sparse_categorical_accuracy: 0.8233 - val_loss: 0.4589 -
val_sparse_categorical_accuracy: 0.8030
```

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Epoch 143/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3693
- sparse_categorical_accuracy: 0.8264 - val_loss: 0.4386 -
val_sparse_categorical_accuracy: 0.8232
Epoch 144/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3577
- sparse_categorical_accuracy: 0.8264 - val_loss: 0.4444 -
val_sparse_categorical_accuracy: 0.8157
Epoch 145/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3438
- sparse_categorical_accuracy: 0.8425 - val_loss: 0.4408 -
val_sparse_categorical_accuracy: 0.8207
Epoch 146/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3513
- sparse_categorical_accuracy: 0.8269 - val_loss: 0.5502 -
val_sparse_categorical_accuracy: 0.7348
Epoch 147/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3711
- sparse_categorical_accuracy: 0.8318 - val_loss: 0.4204 -
val_sparse_categorical_accuracy: 0.8030
Epoch 148/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3385
- sparse_categorical_accuracy: 0.8465 - val_loss: 0.4360 -
val_sparse_categorical_accuracy: 0.8207
Epoch 149/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3437
- sparse_categorical_accuracy: 0.8496 - val_loss: 0.4809 -
val_sparse_categorical_accuracy: 0.7904
Epoch 150/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3582
- sparse_categorical_accuracy: 0.8322 - val_loss: 0.5646 -
val_sparse_categorical_accuracy: 0.7449
Epoch 151/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3481
- sparse_categorical_accuracy: 0.8438 - val_loss: 0.4814 -
val_sparse_categorical_accuracy: 0.7727
Epoch 152/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3597
- sparse_categorical_accuracy: 0.8340 - val_loss: 0.4236 -
val_sparse_categorical_accuracy: 0.8232
Epoch 153/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3375
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4239 -
val_sparse_categorical_accuracy: 0.8232
Epoch 154/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3844
- sparse_categorical_accuracy: 0.8184 - val_loss: 0.8729 -
val_sparse_categorical_accuracy: 0.6439
Epoch 155/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4856
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- sparse_categorical_accuracy: 0.7885 - val_loss: 0.4537 -
val_sparse_categorical_accuracy: 0.7753
Epoch 156/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.3508
- sparse_categorical_accuracy: 0.8336 - val_loss: 0.4292 -
val_sparse_categorical_accuracy: 0.8283
Epoch 157/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3802
- sparse_categorical_accuracy: 0.8246 - val_loss: 0.4289 -
val_sparse_categorical_accuracy: 0.8283
Epoch 158/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3439
- sparse_categorical_accuracy: 0.8336 - val_loss: 0.4317 -
val_sparse_categorical_accuracy: 0.8207
Epoch 159/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3515
- sparse_categorical_accuracy: 0.8411 - val_loss: 0.4789 -
val_sparse_categorical_accuracy: 0.7904
Epoch 160/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3651
- sparse_categorical_accuracy: 0.8273 - val_loss: 0.4342 -
val_sparse_categorical_accuracy: 0.8207
Epoch 161/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3646
- sparse_categorical_accuracy: 0.8344 - val_loss: 0.4181 -
val_sparse_categorical_accuracy: 0.8056
Epoch 162/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3325
- sparse_categorical_accuracy: 0.8483 - val_loss: 0.4677 -
val_sparse_categorical_accuracy: 0.7929
Epoch 163/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3369
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.5359 -
val_sparse_categorical_accuracy: 0.7424
Epoch 164/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3620
- sparse_categorical_accuracy: 0.8318 - val_loss: 0.4158 -
val_sparse_categorical_accuracy: 0.8056
Epoch 165/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3563
- sparse_categorical_accuracy: 0.8273 - val_loss: 0.5241 -
val_sparse_categorical_accuracy: 0.7803
Epoch 166/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3846
- sparse_categorical_accuracy: 0.8255 - val_loss: 0.4799 -
val_sparse_categorical_accuracy: 0.7753
Epoch 167/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3435
- sparse_categorical_accuracy: 0.8385 - val_loss: 0.4371 -
val_sparse_categorical_accuracy: 0.8182
```

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Epoch 168/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3447
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4216 -
val_sparse_categorical_accuracy: 0.7955
Epoch 169/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3405
- sparse_categorical_accuracy: 0.8434 - val_loss: 0.4301 -
val_sparse_categorical_accuracy: 0.8232
Epoch 170/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3480
- sparse_categorical_accuracy: 0.8380 - val_loss: 0.4213 -
val_sparse_categorical_accuracy: 0.8207
Epoch 171/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3290
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.5832 -
val_sparse_categorical_accuracy: 0.7146
Epoch 172/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3616
- sparse_categorical_accuracy: 0.8206 - val_loss: 0.5171 -
val_sparse_categorical_accuracy: 0.7500
Epoch 173/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3436
- sparse_categorical_accuracy: 0.8402 - val_loss: 0.4784 -
val_sparse_categorical_accuracy: 0.7753
Epoch 174/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3434
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4574 -
val_sparse_categorical_accuracy: 0.8030
Epoch 175/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3600
- sparse_categorical_accuracy: 0.8389 - val_loss: 0.4233 -
val_sparse_categorical_accuracy: 0.8005
Epoch 176/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3350
- sparse_categorical_accuracy: 0.8487 - val_loss: 0.4919 -
val_sparse_categorical_accuracy: 0.7727
Epoch 177/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3424
- sparse_categorical_accuracy: 0.8465 - val_loss: 0.5989 -
val_sparse_categorical_accuracy: 0.7475
Epoch 178/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3522
- sparse_categorical_accuracy: 0.8336 - val_loss: 0.4975 -
val_sparse_categorical_accuracy: 0.7854
Epoch 179/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3469
- sparse_categorical_accuracy: 0.8420 - val_loss: 0.4596 -
val_sparse_categorical_accuracy: 0.7828
Epoch 180/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3637
```

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- sparse_categorical_accuracy: 0.8278 - val_loss: 0.4804 -
val_sparse_categorical_accuracy: 0.7955
Epoch 181/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3619
- sparse_categorical_accuracy: 0.8304 - val_loss: 0.4159 -
val_sparse_categorical_accuracy: 0.8056
Epoch 182/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3580
- sparse_categorical_accuracy: 0.8282 - val_loss: 0.4143 -
val_sparse_categorical_accuracy: 0.8081
Epoch 183/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4169
- sparse_categorical_accuracy: 0.8130 - val_loss: 0.4171 -
val_sparse_categorical_accuracy: 0.8005
Epoch 184/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3261
- sparse_categorical_accuracy: 0.8514 - val_loss: 0.4548 -
val_sparse_categorical_accuracy: 0.7828
Epoch 185/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3984
- sparse_categorical_accuracy: 0.8121 - val_loss: 0.4503 -
val_sparse_categorical_accuracy: 0.7854
Epoch 186/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3490
- sparse_categorical_accuracy: 0.8434 - val_loss: 0.4334 -
val_sparse_categorical_accuracy: 0.8030
Epoch 187/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3315
- sparse_categorical_accuracy: 0.8492 - val_loss: 0.4239 -
val_sparse_categorical_accuracy: 0.8005
Epoch 188/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3384
- sparse_categorical_accuracy: 0.8425 - val_loss: 0.4315 -
val_sparse_categorical_accuracy: 0.8207
Epoch 189/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3321
- sparse_categorical_accuracy: 0.8514 - val_loss: 0.4328 -
val_sparse_categorical_accuracy: 0.8030
Epoch 190/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3429
- sparse_categorical_accuracy: 0.8389 - val_loss: 0.4290 -
val_sparse_categorical_accuracy: 0.8005
Epoch 191/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3375
- sparse_categorical_accuracy: 0.8443 - val_loss: 0.5564 -
val_sparse_categorical_accuracy: 0.7601
Epoch 192/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3533
- sparse_categorical_accuracy: 0.8376 - val_loss: 0.4342 -
val_sparse_categorical_accuracy: 0.8030
```

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Epoch 193/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3296
- sparse_categorical_accuracy: 0.8456 - val_loss: 0.4213 -
val_sparse_categorical_accuracy: 0.8283
Epoch 194/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3401
- sparse_categorical_accuracy: 0.8402 - val_loss: 0.4221 -
val_sparse_categorical_accuracy: 0.8283
Epoch 195/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3703
- sparse_categorical_accuracy: 0.8228 - val_loss: 0.4353 -
val_sparse_categorical_accuracy: 0.8182
Epoch 196/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3454
- sparse_categorical_accuracy: 0.8443 - val_loss: 0.4177 -
val_sparse_categorical_accuracy: 0.8207
Epoch 197/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3376
- sparse_categorical_accuracy: 0.8425 - val_loss: 0.5691 -
val_sparse_categorical_accuracy: 0.7298
Epoch 198/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4021
- sparse_categorical_accuracy: 0.8081 - val_loss: 0.4511 -
val_sparse_categorical_accuracy: 0.7828
Epoch 199/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3375
- sparse_categorical_accuracy: 0.8487 - val_loss: 0.4492 -
val_sparse_categorical_accuracy: 0.8106
Epoch 200/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3298
- sparse_categorical_accuracy: 0.8514 - val_loss: 0.4466 -
val_sparse_categorical_accuracy: 0.7879
Epoch 201/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3357
- sparse_categorical_accuracy: 0.8416 - val_loss: 0.4725 -
val_sparse_categorical_accuracy: 0.7955
Epoch 202/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3383
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.6398 -
val_sparse_categorical_accuracy: 0.7071
Epoch 203/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.4066
- sparse_categorical_accuracy: 0.8090 - val_loss: 0.5553 -
val_sparse_categorical_accuracy: 0.7652
Epoch 204/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3829
- sparse_categorical_accuracy: 0.8170 - val_loss: 0.4709 -
val_sparse_categorical_accuracy: 0.7778
Epoch 205/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3449
```

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- sparse_categorical_accuracy: 0.8429 - val_loss: 0.4203 -
val_sparse_categorical_accuracy: 0.8081
Epoch 206/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3297
- sparse_categorical_accuracy: 0.8461 - val_loss: 0.4296 -
val_sparse_categorical_accuracy: 0.8030
Epoch 207/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3368
- sparse_categorical_accuracy: 0.8452 - val_loss: 0.4249 -
val_sparse_categorical_accuracy: 0.8258
Epoch 208/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3189
- sparse_categorical_accuracy: 0.8505 - val_loss: 0.5023 -
val_sparse_categorical_accuracy: 0.7677
Epoch 209/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3498
- sparse_categorical_accuracy: 0.8340 - val_loss: 0.4801 -
val_sparse_categorical_accuracy: 0.7702
Epoch 210/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3297
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.4170 -
val_sparse_categorical_accuracy: 0.8106
Epoch 211/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3153
- sparse_categorical_accuracy: 0.8594 - val_loss: 0.4355 -
val_sparse_categorical_accuracy: 0.8005
Epoch 212/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3362
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.4261 -
val_sparse_categorical_accuracy: 0.8283
Epoch 213/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3186
- sparse_categorical_accuracy: 0.8505 - val_loss: 0.4531 -
val_sparse_categorical_accuracy: 0.7803
Epoch 214/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3369
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4300 -
val_sparse_categorical_accuracy: 0.8232
Epoch 215/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3289
- sparse_categorical_accuracy: 0.8461 - val_loss: 0.5102 -
val_sparse_categorical_accuracy: 0.7601
Epoch 216/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3391
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.4680 -
val_sparse_categorical_accuracy: 0.8005
Epoch 217/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3964
- sparse_categorical_accuracy: 0.8166 - val_loss: 0.4185 -
val_sparse_categorical_accuracy: 0.8106
```

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Epoch 218/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3298
- sparse_categorical_accuracy: 0.8461 - val_loss: 0.4196 -
val_sparse_categorical_accuracy: 0.8056
Epoch 219/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3244
- sparse_categorical_accuracy: 0.8474 - val_loss: 0.5246 -
val_sparse_categorical_accuracy: 0.7904
Epoch 220/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3596
- sparse_categorical_accuracy: 0.8322 - val_loss: 0.4368 -
val_sparse_categorical_accuracy: 0.8030
Epoch 221/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3221
- sparse_categorical_accuracy: 0.8527 - val_loss: 0.4167 -
val_sparse_categorical_accuracy: 0.8258
Epoch 222/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3164
- sparse_categorical_accuracy: 0.8519 - val_loss: 0.4161 -
val_sparse_categorical_accuracy: 0.8106
Epoch 223/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3375
- sparse_categorical_accuracy: 0.8447 - val_loss: 0.4174 -
val_sparse_categorical_accuracy: 0.8232
Epoch 224/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3299
- sparse_categorical_accuracy: 0.8438 - val_loss: 0.4396 -
val_sparse_categorical_accuracy: 0.8232
Epoch 225/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3239
- sparse_categorical_accuracy: 0.8487 - val_loss: 0.5020 -
val_sparse_categorical_accuracy: 0.7702
Epoch 226/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3434
- sparse_categorical_accuracy: 0.8420 - val_loss: 0.4826 -
val_sparse_categorical_accuracy: 0.7879
Epoch 227/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3190
- sparse_categorical_accuracy: 0.8545 - val_loss: 0.4216 -
val_sparse_categorical_accuracy: 0.8030
Epoch 228/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3400
- sparse_categorical_accuracy: 0.8411 - val_loss: 0.4483 -
val_sparse_categorical_accuracy: 0.7980
Epoch 229/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3153
- sparse_categorical_accuracy: 0.8554 - val_loss: 0.4298 -
val_sparse_categorical_accuracy: 0.8056
Epoch 230/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3125
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- sparse_categorical_accuracy: 0.8545 - val_loss: 0.4213 -
val_sparse_categorical_accuracy: 0.8030
Epoch 231/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3395
- sparse_categorical_accuracy: 0.8456 - val_loss: 0.4829 -
val_sparse_categorical_accuracy: 0.7753
Epoch 232/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3252
- sparse_categorical_accuracy: 0.8483 - val_loss: 0.5597 -
val_sparse_categorical_accuracy: 0.7323
Epoch 233/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3492
- sparse_categorical_accuracy: 0.8362 - val_loss: 0.4797 -
val_sparse_categorical_accuracy: 0.7879
Epoch 234/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3501
- sparse_categorical_accuracy: 0.8389 - val_loss: 0.4329 -
val_sparse_categorical_accuracy: 0.8056
Epoch 235/1000
71/71 [==============================] - 9s 133ms/step - loss: 0.3162
- sparse_categorical_accuracy: 0.8527 - val_loss: 0.4252 -
val_sparse_categorical_accuracy: 0.8333
Epoch 236/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3405
- sparse_categorical_accuracy: 0.8416 - val_loss: 0.6145 -
val_sparse_categorical_accuracy: 0.7500
Epoch 237/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3502
- sparse_categorical_accuracy: 0.8367 - val_loss: 0.5116 -
val_sparse_categorical_accuracy: 0.7601
Epoch 238/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3269
- sparse_categorical_accuracy: 0.8461 - val_loss: 0.4568 -
val_sparse_categorical_accuracy: 0.8106
Epoch 239/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3483
- sparse_categorical_accuracy: 0.8286 - val_loss: 0.4892 -
val_sparse_categorical_accuracy: 0.7778
Epoch 240/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3326
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.4210 -
val_sparse_categorical_accuracy: 0.8081
Epoch 241/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3159
- sparse_categorical_accuracy: 0.8643 - val_loss: 0.4921 -
val_sparse_categorical_accuracy: 0.7778
Epoch 242/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3241
- sparse_categorical_accuracy: 0.8563 - val_loss: 0.4825 -
val_sparse_categorical_accuracy: 0.7727
```

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Epoch 243/1000
71/71 [==============================] - 9s 128ms/step - loss: 0.3340
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.5406 -
val_sparse_categorical_accuracy: 0.7828
Epoch 244/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3567
- sparse_categorical_accuracy: 0.8371 - val_loss: 0.6820 -
val_sparse_categorical_accuracy: 0.7323
Epoch 245/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3637
- sparse_categorical_accuracy: 0.8344 - val_loss: 0.4495 -
val_sparse_categorical_accuracy: 0.8030
Epoch 246/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3342
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.5996 -
val_sparse_categorical_accuracy: 0.7273
Epoch 247/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3828
- sparse_categorical_accuracy: 0.8286 - val_loss: 0.4665 -
val_sparse_categorical_accuracy: 0.8056
Epoch 248/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3338
- sparse_categorical_accuracy: 0.8469 - val_loss: 0.4220 -
val_sparse_categorical_accuracy: 0.8258
Epoch 249/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3348
- sparse_categorical_accuracy: 0.8478 - val_loss: 0.4206 -
val_sparse_categorical_accuracy: 0.8157
Epoch 250/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3196
- sparse_categorical_accuracy: 0.8568 - val_loss: 0.4716 -
val_sparse_categorical_accuracy: 0.8030
Epoch 251/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3167
- sparse_categorical_accuracy: 0.8523 - val_loss: 0.5115 -
val_sparse_categorical_accuracy: 0.7879
Epoch 252/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3281
- sparse_categorical_accuracy: 0.8447 - val_loss: 0.4300 -
val_sparse_categorical_accuracy: 0.8081
Epoch 253/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3127
- sparse_categorical_accuracy: 0.8572 - val_loss: 0.4288 -
val_sparse_categorical_accuracy: 0.8283
Epoch 254/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3519
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4233 -
val_sparse_categorical_accuracy: 0.8030
Epoch 255/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3222
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- sparse_categorical_accuracy: 0.8563 - val_loss: 0.4225 -
val_sparse_categorical_accuracy: 0.8258
Epoch 256/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3251
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.6749 -
val_sparse_categorical_accuracy: 0.7323
Epoch 257/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3590
- sparse_categorical_accuracy: 0.8278 - val_loss: 0.4770 -
val_sparse_categorical_accuracy: 0.8005
Epoch 258/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3223
- sparse_categorical_accuracy: 0.8572 - val_loss: 0.6876 -
val_sparse_categorical_accuracy: 0.7348
Epoch 259/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3515
- sparse_categorical_accuracy: 0.8434 - val_loss: 0.4414 -
val_sparse_categorical_accuracy: 0.8005
Epoch 260/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3207
- sparse_categorical_accuracy: 0.8532 - val_loss: 0.4907 -
val_sparse_categorical_accuracy: 0.7828
Epoch 261/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3946
- sparse_categorical_accuracy: 0.8228 - val_loss: 0.4282 -
val_sparse_categorical_accuracy: 0.8056
Epoch 262/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3101
- sparse_categorical_accuracy: 0.8572 - val_loss: 0.4353 -
val_sparse_categorical_accuracy: 0.8081
Epoch 263/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3164
- sparse_categorical_accuracy: 0.8465 - val_loss: 0.4524 -
val_sparse_categorical_accuracy: 0.8131
Epoch 264/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3189
- sparse_categorical_accuracy: 0.8510 - val_loss: 0.4617 -
val_sparse_categorical_accuracy: 0.7929
Epoch 265/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3278
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.4196 -
val_sparse_categorical_accuracy: 0.8258
Epoch 266/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3120
- sparse_categorical_accuracy: 0.8519 - val_loss: 0.4246 -
val_sparse_categorical_accuracy: 0.8056
Epoch 267/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3198
- sparse_categorical_accuracy: 0.8496 - val_loss: 0.4195 -
val_sparse_categorical_accuracy: 0.8207
```

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Epoch 268/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3275
- sparse_categorical_accuracy: 0.8456 - val_loss: 0.4204 -
val_sparse_categorical_accuracy: 0.8283
Epoch 269/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3335
- sparse_categorical_accuracy: 0.8478 - val_loss: 0.4707 -
val_sparse_categorical_accuracy: 0.7778
Epoch 270/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3347
- sparse_categorical_accuracy: 0.8487 - val_loss: 0.5043 -
val_sparse_categorical_accuracy: 0.7879
Epoch 271/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3221
- sparse_categorical_accuracy: 0.8492 - val_loss: 0.6575 -
val_sparse_categorical_accuracy: 0.7121
Epoch 272/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3266
- sparse_categorical_accuracy: 0.8469 - val_loss: 0.4208 -
val_sparse_categorical_accuracy: 0.8232
Epoch 273/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3106
- sparse_categorical_accuracy: 0.8554 - val_loss: 0.4269 -
val_sparse_categorical_accuracy: 0.8283
Epoch 274/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3176
- sparse_categorical_accuracy: 0.8510 - val_loss: 0.4825 -
val_sparse_categorical_accuracy: 0.7702
Epoch 275/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3172
- sparse_categorical_accuracy: 0.8554 - val_loss: 0.5018 -
val_sparse_categorical_accuracy: 0.7677
Epoch 276/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3244
- sparse_categorical_accuracy: 0.8545 - val_loss: 0.4780 -
val_sparse_categorical_accuracy: 0.7677
Epoch 277/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3139
- sparse_categorical_accuracy: 0.8519 - val_loss: 0.5321 -
val_sparse_categorical_accuracy: 0.7854
Epoch 278/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3475
- sparse_categorical_accuracy: 0.8447 - val_loss: 0.4199 -
val_sparse_categorical_accuracy: 0.8157
Epoch 279/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3239
- sparse_categorical_accuracy: 0.8536 - val_loss: 0.4203 -
val_sparse_categorical_accuracy: 0.8258
Epoch 280/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3246
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- sparse_categorical_accuracy: 0.8505 - val_loss: 0.4248 -
val_sparse_categorical_accuracy: 0.8308
Epoch 281/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3131
- sparse_categorical_accuracy: 0.8590 - val_loss: 0.4318 -
val_sparse_categorical_accuracy: 0.8283
Epoch 282/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3119
- sparse_categorical_accuracy: 0.8572 - val_loss: 0.4342 -
val_sparse_categorical_accuracy: 0.8081
Epoch 283/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3115
- sparse_categorical_accuracy: 0.8519 - val_loss: 0.4283 -
val_sparse_categorical_accuracy: 0.8081
Epoch 284/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3136
- sparse_categorical_accuracy: 0.8536 - val_loss: 0.4198 -
val_sparse_categorical_accuracy: 0.8157
Epoch 285/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3036
- sparse_categorical_accuracy: 0.8550 - val_loss: 0.6351 -
val_sparse_categorical_accuracy: 0.7222
Epoch 286/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3260
- sparse_categorical_accuracy: 0.8492 - val_loss: 0.4567 -
val_sparse_categorical_accuracy: 0.8056
Epoch 287/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3014
- sparse_categorical_accuracy: 0.8612 - val_loss: 0.5949 -
val_sparse_categorical_accuracy: 0.7525
Epoch 288/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3557
- sparse_categorical_accuracy: 0.8402 - val_loss: 0.5660 -
val_sparse_categorical_accuracy: 0.7702
Epoch 289/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3302
- sparse_categorical_accuracy: 0.8505 - val_loss: 0.4201 -
val_sparse_categorical_accuracy: 0.8157
Epoch 290/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3180
- sparse_categorical_accuracy: 0.8523 - val_loss: 0.4594 -
val_sparse_categorical_accuracy: 0.8030
Epoch 291/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3190
- sparse_categorical_accuracy: 0.8545 - val_loss: 0.4811 -
val_sparse_categorical_accuracy: 0.7626
Epoch 292/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3034
- sparse_categorical_accuracy: 0.8612 - val_loss: 0.4298 -
val_sparse_categorical_accuracy: 0.8258
```

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Epoch 293/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3022
- sparse_categorical_accuracy: 0.8630 - val_loss: 0.4276 -
val_sparse_categorical_accuracy: 0.8283
Epoch 294/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3356
- sparse_categorical_accuracy: 0.8389 - val_loss: 0.4965 -
val_sparse_categorical_accuracy: 0.7677
Epoch 295/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3352
- sparse_categorical_accuracy: 0.8465 - val_loss: 0.4339 -
val_sparse_categorical_accuracy: 0.8232
Epoch 296/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3112
- sparse_categorical_accuracy: 0.8599 - val_loss: 0.7741 -
val_sparse_categorical_accuracy: 0.6869
Epoch 297/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3798
- sparse_categorical_accuracy: 0.8309 - val_loss: 0.5142 -
val_sparse_categorical_accuracy: 0.7601
Epoch 298/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3431
- sparse_categorical_accuracy: 0.8367 - val_loss: 0.4381 -
val_sparse_categorical_accuracy: 0.8056
Epoch 299/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3268
- sparse_categorical_accuracy: 0.8532 - val_loss: 0.4319 -
val_sparse_categorical_accuracy: 0.8081
Epoch 300/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3283
- sparse_categorical_accuracy: 0.8550 - val_loss: 0.5855 -
val_sparse_categorical_accuracy: 0.7323
Epoch 301/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3152
- sparse_categorical_accuracy: 0.8559 - val_loss: 0.5055 -
val_sparse_categorical_accuracy: 0.7652
Epoch 302/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3164
- sparse_categorical_accuracy: 0.8501 - val_loss: 0.4239 -
val_sparse_categorical_accuracy: 0.8283
Epoch 303/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3030
- sparse_categorical_accuracy: 0.8585 - val_loss: 0.4448 -
val_sparse_categorical_accuracy: 0.8258
Epoch 304/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3142
- sparse_categorical_accuracy: 0.8536 - val_loss: 0.4409 -
val_sparse_categorical_accuracy: 0.8258
Epoch 305/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3163
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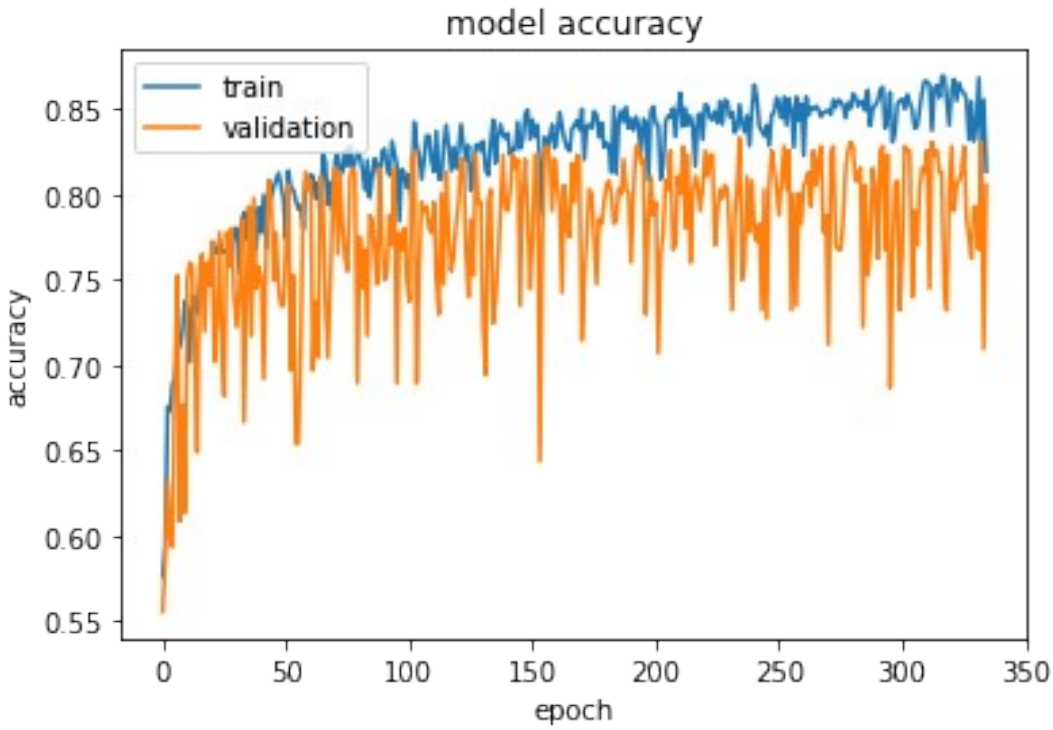
- sparse_categorical_accuracy: 0.8496 - val_loss: 0.5709 -
val_sparse_categorical_accuracy: 0.7399
Epoch 306/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3497
- sparse_categorical_accuracy: 0.8389 - val_loss: 0.5330 -
val_sparse_categorical_accuracy: 0.7904
Epoch 307/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3664
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.5766 -
val_sparse_categorical_accuracy: 0.7702
Epoch 308/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3299
- sparse_categorical_accuracy: 0.8496 - val_loss: 0.4295 -
val_sparse_categorical_accuracy: 0.8030
Epoch 309/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2981
- sparse_categorical_accuracy: 0.8599 - val_loss: 0.4230 -
val_sparse_categorical_accuracy: 0.8157
Epoch 310/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2947
- sparse_categorical_accuracy: 0.8666 - val_loss: 0.4232 -
val_sparse_categorical_accuracy: 0.8131
Epoch 311/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3028
- sparse_categorical_accuracy: 0.8661 - val_loss: 0.4267 -
val_sparse_categorical_accuracy: 0.8258
Epoch 312/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3046
- sparse_categorical_accuracy: 0.8643 - val_loss: 0.5558 -
val_sparse_categorical_accuracy: 0.7449
Epoch 313/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3660
- sparse_categorical_accuracy: 0.8376 - val_loss: 0.4307 -
val_sparse_categorical_accuracy: 0.8308
Epoch 314/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2995
- sparse_categorical_accuracy: 0.8626 - val_loss: 0.4456 -
val_sparse_categorical_accuracy: 0.8232
Epoch 315/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2988
- sparse_categorical_accuracy: 0.8639 - val_loss: 0.4241 -
val_sparse_categorical_accuracy: 0.8258
Epoch 316/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3134
- sparse_categorical_accuracy: 0.8568 - val_loss: 0.4264 -
val_sparse_categorical_accuracy: 0.8131
Epoch 317/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2957
- sparse_categorical_accuracy: 0.8693 - val_loss: 0.4645 -
val_sparse_categorical_accuracy: 0.8131
```

```
Epoch 318/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.2948
- sparse_categorical_accuracy: 0.8693 - val_loss: 0.5702 -
val_sparse_categorical_accuracy: 0.7449
Epoch 319/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3115
- sparse_categorical_accuracy: 0.8550 - val_loss: 0.7277 -
val_sparse_categorical_accuracy: 0.7323
Epoch 320/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3424
- sparse_categorical_accuracy: 0.8407 - val_loss: 0.4497 -
val_sparse_categorical_accuracy: 0.8030
Epoch 321/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2991
- sparse_categorical_accuracy: 0.8621 - val_loss: 0.4325 -
val_sparse_categorical_accuracy: 0.8283
Epoch 322/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2947
- sparse_categorical_accuracy: 0.8675 - val_loss: 0.4775 -
val_sparse_categorical_accuracy: 0.7904
Epoch 323/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3101
- sparse_categorical_accuracy: 0.8550 - val_loss: 0.4574 -
val_sparse_categorical_accuracy: 0.8056
Epoch 324/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3059
- sparse_categorical_accuracy: 0.8652 - val_loss: 0.4377 -
val_sparse_categorical_accuracy: 0.8081
Epoch 325/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2984
- sparse_categorical_accuracy: 0.8608 - val_loss: 0.4667 -
val_sparse_categorical_accuracy: 0.8131
Epoch 326/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3064
- sparse_categorical_accuracy: 0.8594 - val_loss: 0.4307 -
val_sparse_categorical_accuracy: 0.8283
Epoch 327/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3061
- sparse_categorical_accuracy: 0.8559 - val_loss: 0.5271 -
val_sparse_categorical_accuracy: 0.7854
Epoch 328/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3751
- sparse_categorical_accuracy: 0.8322 - val_loss: 0.5573 -
val_sparse_categorical_accuracy: 0.7753
Epoch 329/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3252
- sparse_categorical_accuracy: 0.8545 - val_loss: 0.5917 -
val_sparse_categorical_accuracy: 0.7626
Epoch 330/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3594
```

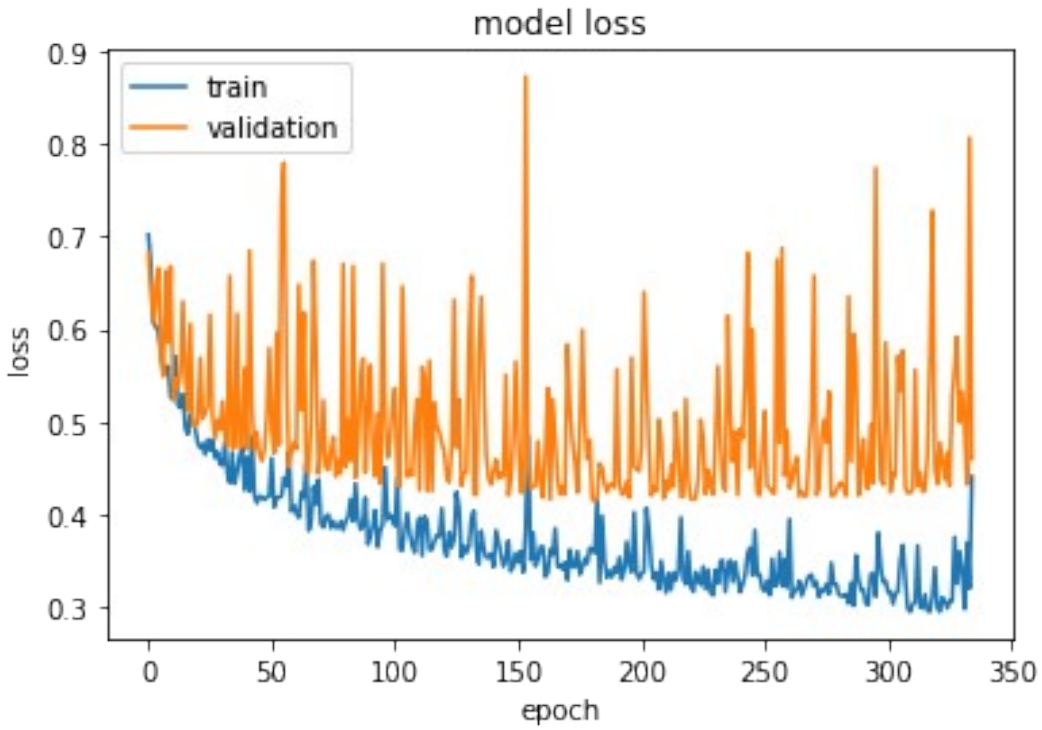
```
- sparse_categorical_accuracy: 0.8313 - val_loss: 0.4989 -
val_sparse_categorical_accuracy: 0.7929
Epoch 331/1000
71/71 [==============================] - 9s 130ms/step - loss: 0.3398
- sparse_categorical_accuracy: 0.8398 - val_loss: 0.5326 -
val_sparse_categorical_accuracy: 0.7929
Epoch 332/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.2976
- sparse_categorical_accuracy: 0.8684 - val_loss: 0.4975 -
val_sparse_categorical_accuracy: 0.7677
Epoch 333/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3695
- sparse_categorical_accuracy: 0.8273 - val_loss: 0.4319 -
val_sparse_categorical_accuracy: 0.8308
Epoch 334/1000
71/71 [==============================] - 9s 129ms/step - loss: 0.3197
- sparse_categorical_accuracy: 0.8554 - val_loss: 0.8066 -
val_sparse_categorical_accuracy: 0.7096
Epoch 335/1000
70/71 [============================>.] - ETA: 0s - loss: 0.4407 -
sparse_categorical_accuracy: 0.8134Restoring model weights from the
end of the best epoch: 235.
71/71 [==============================] - 9s 132ms/step - loss: 0.4405
- sparse_categorical_accuracy: 0.8135 - val_loss: 0.4596 -
val_sparse_categorical_accuracy: 0.8056
Epoch 335: early stopping
```

```
model.save('/content/drive/MyDrive/resnet_model.h5')
```

```
plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
y_pred=model.predict(X_test)
y_pred
```

```
array([[0.0000000e+00, 1.0000000e+00],
       [3.5620572e-11, 1.0000000e+00],
       [7.1390460e-24, 1.0000000e+00],
       ...,
       [1.8190033e-09, 1.0000000e+00],
       [3.4918220e-22, 1.0000000e+00],
       [2.8847701e-36, 1.0000000e+00]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
```

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```
print(Y_train)
```

```
[1 0 1 ... 0 1 1]
```

```
np.unique(Y_train, return_counts=True)
```

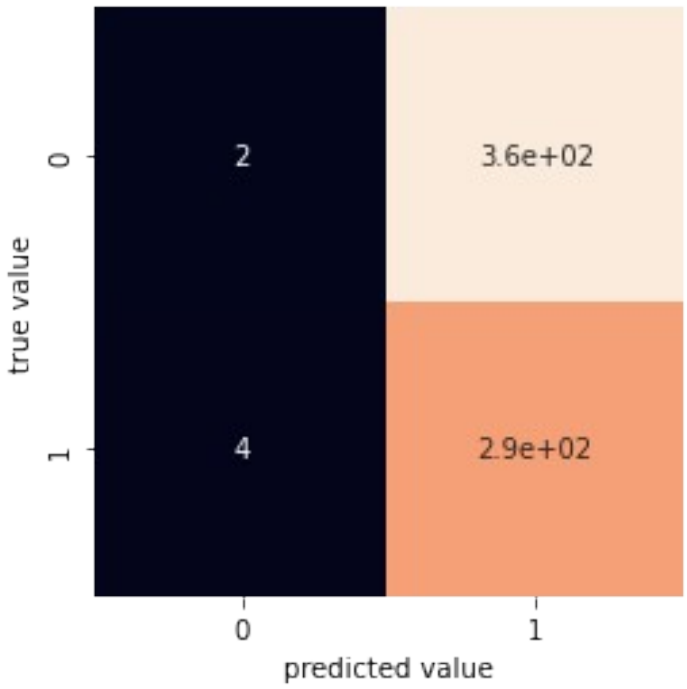
```
(array([0, 1]), array([1436, 1201]))
```

```
np.unique(Y_test, return_counts=True)
```

```
(array([0, 1]), array([364, 296]))
```

```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score
```

```
print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.445
Precision: 0.446
Recall: 0.986
F1: 0.615
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
Resnet_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",Resnet_f1_score)
```

```
F1_score: 0.6147368421052632
```

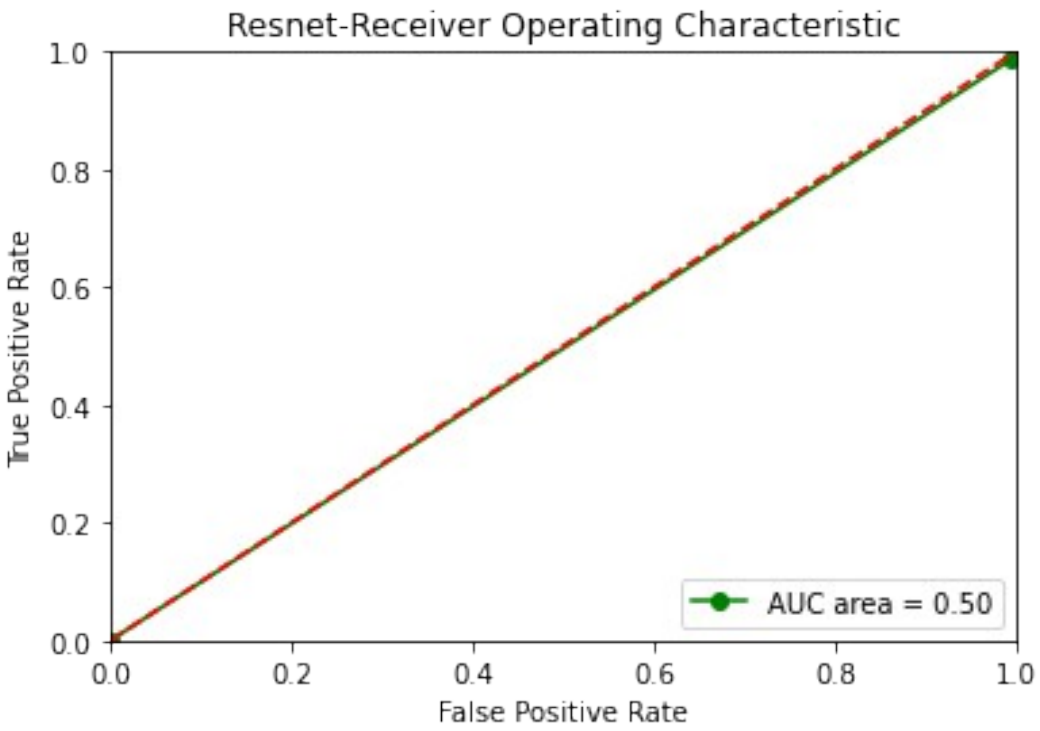
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_ResNet50 = auc(fpr_keras, tpr_keras)
auc_keras_ResNet50 #auc score
```

```
0.495990495990496
```

```
import matplotlib.pyplot as plt
plt.title('Resnet-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_ResNet50)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```



Model-InceptionV3

```
from gc import callbacks
from tensorflow.keras.applications.inception_v3 import InceptionV3

input_shape=(224,224,3)



head_model = InceptionV3(include_top=False,
                 weights='imagenet',
                 #input_tensor=None,
                 input_shape=input_shape)
                 #pooling='avg',
                 #classes=2,
                 #classifier_activation='softmax')

for layer in head_model.layers:
  layer.trainable = False #trainable are the last three layers until
flatten (the whole set of fully connected layers)


x = layers.Flatten()(head_model.output) #google: how to cut off a pre
train model resnet and add fully connected layers in tensorflow
x = layers.Dense(1000, activation='relu')(x)
predictions = layers.Dense(2, activation = 'softmax')(x)
```

```
model = Model(inputs = head_model.input, outputs = predictions)


model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/inception_v3/
inception_v3_weights_tf_dim_ordering_tf_kernels_notop.h5
87916544/87910968 [==============================] - 3s 0us/step
87924736/87910968 [==============================] - 3s 0us/step
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 15s 143ms/step - loss: 0.5565
- sparse_categorical_accuracy: 0.7367 - val_loss: 0.4630 -
val_sparse_categorical_accuracy: 0.7879
Epoch 2/1000
71/71 [==============================] - 7s 97ms/step - loss: 0.2321 -
sparse_categorical_accuracy: 0.9094 - val_loss: 0.4303 -
val_sparse_categorical_accuracy: 0.8207
Epoch 3/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.1352 -
sparse_categorical_accuracy: 0.9661 - val_loss: 0.4318 -
val_sparse_categorical_accuracy: 0.7904
Epoch 4/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0863 -
sparse_categorical_accuracy: 0.9862 - val_loss: 0.4362 -
val_sparse_categorical_accuracy: 0.8056
Epoch 5/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0560 -
sparse_categorical_accuracy: 0.9987 - val_loss: 0.4463 -
val_sparse_categorical_accuracy: 0.8157
Epoch 6/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0417 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4799 -
val_sparse_categorical_accuracy: 0.7929
Epoch 7/1000
```

```
71/71 [==============================] - 7s 94ms/step - loss: 0.0306 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.4563 -
val_sparse_categorical_accuracy: 0.8106
Epoch 8/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0235 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4846 -
val_sparse_categorical_accuracy: 0.8056
Epoch 9/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0190 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5076 -
val_sparse_categorical_accuracy: 0.7955
Epoch 10/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0158 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4746 -
val_sparse_categorical_accuracy: 0.8157
Epoch 11/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0130 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4883 -
val_sparse_categorical_accuracy: 0.8157
Epoch 12/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0109 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4878 -
val_sparse_categorical_accuracy: 0.8030
Epoch 13/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0097 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4904 -
val_sparse_categorical_accuracy: 0.8182
Epoch 14/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0090 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.4999 -
val_sparse_categorical_accuracy: 0.8157
Epoch 15/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0072 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5050 -
val_sparse_categorical_accuracy: 0.8182
Epoch 16/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0063 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5070 -
val_sparse_categorical_accuracy: 0.8157
Epoch 17/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0057 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5124 -
val_sparse_categorical_accuracy: 0.8182
Epoch 18/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0052 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5480 -
val_sparse_categorical_accuracy: 0.8106
Epoch 19/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0062 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5251 -
```

```
val_sparse_categorical_accuracy: 0.8157
Epoch 20/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0047 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5228 -
val_sparse_categorical_accuracy: 0.8157
Epoch 21/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0039 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5333 -
val_sparse_categorical_accuracy: 0.8131
Epoch 22/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0040 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5389 -
val_sparse_categorical_accuracy: 0.8157
Epoch 23/1000
71/71 [==============================] - 7s 96ms/step - loss: 0.0032 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5463 -
val_sparse_categorical_accuracy: 0.8207
Epoch 24/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0031 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5489 -
val_sparse_categorical_accuracy: 0.8157
Epoch 25/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0026 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5600 -
val_sparse_categorical_accuracy: 0.8182
Epoch 26/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0024 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5535 -
val_sparse_categorical_accuracy: 0.8182
Epoch 27/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0023 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5575 -
val_sparse_categorical_accuracy: 0.8157
Epoch 28/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5665 -
val_sparse_categorical_accuracy: 0.8157
Epoch 29/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5734 -
val_sparse_categorical_accuracy: 0.8157
Epoch 30/1000
71/71 [==============================] - 7s 94ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5699 -
val_sparse_categorical_accuracy: 0.8182
Epoch 31/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5729 -
val_sparse_categorical_accuracy: 0.8106
Epoch 32/1000
```

```
71/71 [==============================] - 7s 95ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5770 -
val_sparse_categorical_accuracy: 0.8131
Epoch 33/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5808 -
val_sparse_categorical_accuracy: 0.8182
Epoch 34/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5809 -
val_sparse_categorical_accuracy: 0.8131
Epoch 35/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5870 -
val_sparse_categorical_accuracy: 0.8157
Epoch 36/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5867 -
val_sparse_categorical_accuracy: 0.8207
Epoch 37/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5919 -
val_sparse_categorical_accuracy: 0.8182
Epoch 38/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0011 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5955 -
val_sparse_categorical_accuracy: 0.8157
Epoch 39/1000
71/71 [==============================] - 7s 95ms/step - loss: 0.0010 -
sparse_categorical_accuracy: 1.0000 - val_loss: 0.5967 -
val_sparse_categorical_accuracy: 0.8207
Epoch 40/1000
71/71 [==============================] - 7s 95ms/step - loss: 9.6935e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5989 -
val_sparse_categorical_accuracy: 0.8207
Epoch 41/1000
71/71 [==============================] - 7s 95ms/step - loss: 9.2509e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6023 -
val_sparse_categorical_accuracy: 0.8157
Epoch 42/1000
71/71 [==============================] - 7s 95ms/step - loss: 8.7347e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6050 -
val_sparse_categorical_accuracy: 0.8182
Epoch 43/1000
71/71 [==============================] - 7s 95ms/step - loss: 8.2389e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6054 -
val_sparse_categorical_accuracy: 0.8157
Epoch 44/1000
71/71 [==============================] - 7s 96ms/step - loss: 7.8480e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6124 -
```

```
val_sparse_categorical_accuracy: 0.8081
Epoch 45/1000
71/71 [==============================] - 7s 96ms/step - loss: 7.4135e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6136 -
val_sparse_categorical_accuracy: 0.8182
Epoch 46/1000
71/71 [==============================] - 7s 96ms/step - loss: 6.9420e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6193 -
val_sparse_categorical_accuracy: 0.8157
Epoch 47/1000
71/71 [==============================] - 7s 96ms/step - loss: 6.6240e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6209 -
val_sparse_categorical_accuracy: 0.8157
Epoch 48/1000
71/71 [==============================] - 7s 96ms/step - loss: 6.2608e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6228 -
val_sparse_categorical_accuracy: 0.8182
Epoch 49/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.9322e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6298 -
val_sparse_categorical_accuracy: 0.8182
Epoch 50/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.6540e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6290 -
val_sparse_categorical_accuracy: 0.8182
Epoch 51/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.3675e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6334 -
val_sparse_categorical_accuracy: 0.8182
Epoch 52/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.2077e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6343 -
val_sparse_categorical_accuracy: 0.8207
Epoch 53/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.3321e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6424 -
val_sparse_categorical_accuracy: 0.8106
Epoch 54/1000
71/71 [==============================] - 7s 95ms/step - loss: 4.7035e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6452 -
val_sparse_categorical_accuracy: 0.8131
Epoch 55/1000
71/71 [==============================] - 7s 95ms/step - loss: 4.4044e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6466 -
val_sparse_categorical_accuracy: 0.8157
Epoch 56/1000
71/71 [==============================] - 7s 95ms/step - loss: 4.1630e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6557 -
val_sparse_categorical_accuracy: 0.8157
Epoch 57/1000
```

```
71/71 [==============================] - 7s 95ms/step - loss: 4.0527e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6483 -
val_sparse_categorical_accuracy: 0.8131
Epoch 58/1000
71/71 [==============================] - 7s 95ms/step - loss: 4.0113e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6507 -
val_sparse_categorical_accuracy: 0.8131
Epoch 59/1000
71/71 [==============================] - 7s 95ms/step - loss: 3.7940e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6561 -
val_sparse_categorical_accuracy: 0.8157
Epoch 60/1000
71/71 [==============================] - 7s 95ms/step - loss: 3.4476e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6592 -
val_sparse_categorical_accuracy: 0.8131
Epoch 61/1000
71/71 [==============================] - 7s 95ms/step - loss: 3.2611e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6629 -
val_sparse_categorical_accuracy: 0.8131
Epoch 62/1000
71/71 [==============================] - 7s 95ms/step - loss: 3.1014e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6658 -
val_sparse_categorical_accuracy: 0.8131
Epoch 63/1000
71/71 [==============================] - 7s 95ms/step - loss: 2.9643e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6651 -
val_sparse_categorical_accuracy: 0.8106
Epoch 64/1000
71/71 [==============================] - 7s 95ms/step - loss: 2.8410e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6700 -
val_sparse_categorical_accuracy: 0.8131
Epoch 65/1000
71/71 [==============================] - 7s 95ms/step - loss: 2.6912e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6747 -
val_sparse_categorical_accuracy: 0.8131
Epoch 66/1000
71/71 [==============================] - 7s 95ms/step - loss: 2.5631e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6737 -
val_sparse_categorical_accuracy: 0.8131
Epoch 67/1000
71/71 [==============================] - 7s 96ms/step - loss: 2.4524e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6809 -
val_sparse_categorical_accuracy: 0.8131
Epoch 68/1000
71/71 [==============================] - 7s 96ms/step - loss: 2.3463e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6826 -
val_sparse_categorical_accuracy: 0.8131
Epoch 69/1000
71/71 [==============================] - 7s 96ms/step - loss: 2.2219e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6887 -
```

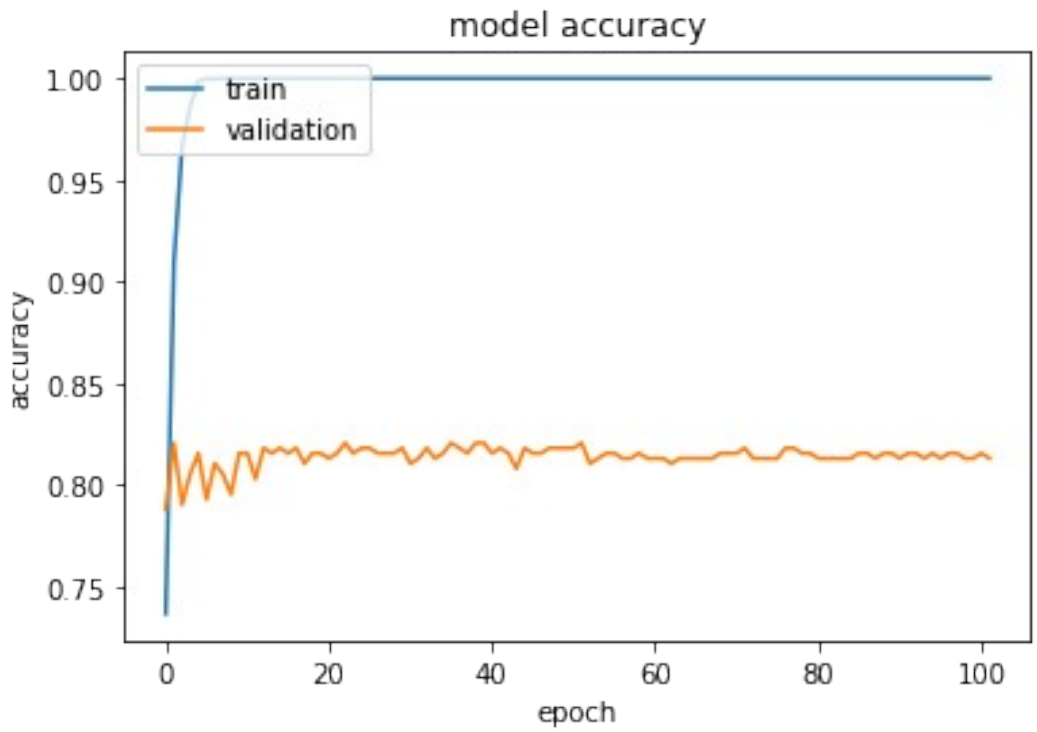
```
val_sparse_categorical_accuracy: 0.8157
Epoch 70/1000
71/71 [==============================] - 7s 96ms/step - loss: 2.1434e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6880 -
val_sparse_categorical_accuracy: 0.8157
Epoch 71/1000
71/71 [==============================] - 7s 95ms/step - loss: 2.0311e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6889 -
val_sparse_categorical_accuracy: 0.8157
Epoch 72/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.9446e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6894 -
val_sparse_categorical_accuracy: 0.8182
Epoch 73/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.8632e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6942 -
val_sparse_categorical_accuracy: 0.8131
Epoch 74/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.7826e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6957 -
val_sparse_categorical_accuracy: 0.8131
Epoch 75/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.7248e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6997 -
val_sparse_categorical_accuracy: 0.8131
Epoch 76/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.6162e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7035 -
val_sparse_categorical_accuracy: 0.8131
Epoch 77/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.6267e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7055 -
val_sparse_categorical_accuracy: 0.8182
Epoch 78/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.4925e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7056 -
val_sparse_categorical_accuracy: 0.8182
Epoch 79/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.4606e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7169 -
val_sparse_categorical_accuracy: 0.8157
Epoch 80/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.3593e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7147 -
val_sparse_categorical_accuracy: 0.8157
Epoch 81/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.3026e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7171 -
val_sparse_categorical_accuracy: 0.8131
Epoch 82/1000
```

```
71/71 [==============================] - 7s 95ms/step - loss: 1.3093e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7218 -
val_sparse_categorical_accuracy: 0.8131
Epoch 83/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.2013e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7245 -
val_sparse_categorical_accuracy: 0.8131
Epoch 84/1000
71/71 [==============================] - 7s 96ms/step - loss: 1.1408e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7284 -
val_sparse_categorical_accuracy: 0.8131
Epoch 85/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.1020e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7296 -
val_sparse_categorical_accuracy: 0.8131
Epoch 86/1000
71/71 [==============================] - 7s 95ms/step - loss: 1.0400e-
04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7350 -
val_sparse_categorical_accuracy: 0.8157
Epoch 87/1000
71/71 [==============================] - 7s 96ms/step - loss: 9.9394e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7412 -
val_sparse_categorical_accuracy: 0.8157
Epoch 88/1000
71/71 [==============================] - 7s 95ms/step - loss: 9.5559e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7396 -
val_sparse_categorical_accuracy: 0.8131
Epoch 89/1000
71/71 [==============================] - 7s 96ms/step - loss: 9.1297e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7399 -
val_sparse_categorical_accuracy: 0.8157
Epoch 90/1000
71/71 [==============================] - 7s 96ms/step - loss: 9.0150e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7406 -
val_sparse_categorical_accuracy: 0.8157
Epoch 91/1000
71/71 [==============================] - 7s 96ms/step - loss: 8.5949e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7450 -
val_sparse_categorical_accuracy: 0.8131
Epoch 92/1000
71/71 [==============================] - 7s 96ms/step - loss: 8.0167e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7531 -
val_sparse_categorical_accuracy: 0.8157
Epoch 93/1000
71/71 [==============================] - 7s 96ms/step - loss: 7.7523e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7537 -
val_sparse_categorical_accuracy: 0.8157
Epoch 94/1000
71/71 [==============================] - 7s 95ms/step - loss: 7.3969e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7532 -
```

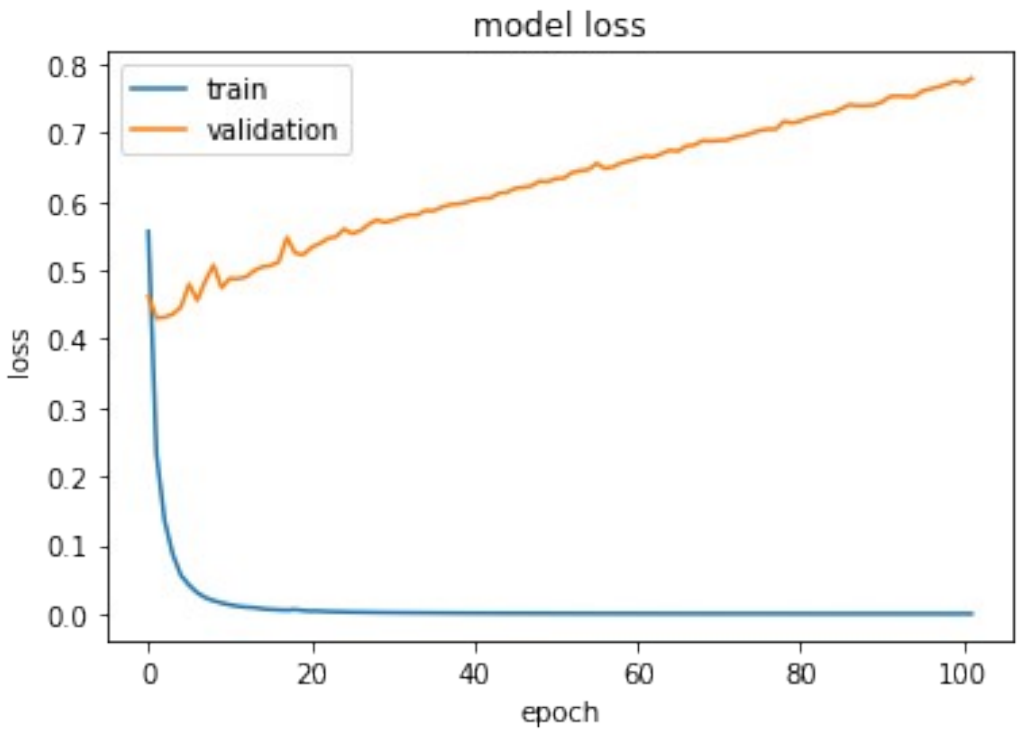
```
val_sparse_categorical_accuracy: 0.8131
Epoch 95/1000
71/71 [==============================] - 7s 95ms/step - loss: 7.0812e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7531 -
val_sparse_categorical_accuracy: 0.8157
Epoch 96/1000
71/71 [==============================] - 7s 95ms/step - loss: 7.0349e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7612 -
val_sparse_categorical_accuracy: 0.8131
Epoch 97/1000
71/71 [==============================] - 7s 95ms/step - loss: 6.9379e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7642 -
val_sparse_categorical_accuracy: 0.8157
Epoch 98/1000
71/71 [==============================] - 7s 95ms/step - loss: 6.2514e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7672 -
val_sparse_categorical_accuracy: 0.8157
Epoch 99/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.9573e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7712 -
val_sparse_categorical_accuracy: 0.8131
Epoch 100/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.7427e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7755 -
val_sparse_categorical_accuracy: 0.8131
Epoch 101/1000
71/71 [==============================] - 7s 95ms/step - loss: 5.4945e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7723 -
val_sparse_categorical_accuracy: 0.8157
Epoch 102/1000
70/71 [============================>.] - ETA: 0s - loss: 5.2301e-05 -
sparse_categorical_accuracy: 1.0000Restoring model weights from the
end of the best epoch: 2.
71/71 [==============================] - 7s 97ms/step - loss: 5.2305e-
05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.7795 -
val_sparse_categorical_accuracy: 0.8131
Epoch 102: early stopping
```

```
model.save('/content/drive/MyDrive/inceptionV3_model.h5')
```

```
plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
y_pred=model.predict(X_test)
y_pred
```

```
array([[0.0000000e+00, 1.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       ...,
       [0.0000000e+00, 1.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       [1.2049965e-32, 1.0000000e+00]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
```

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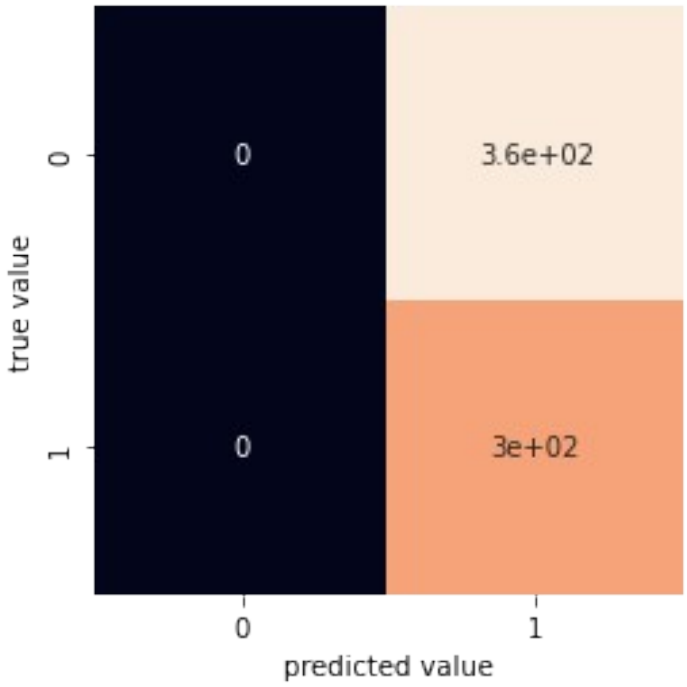
```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score


print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.448
Precision: 0.448
```

```
Recall: 1.000
F1: 0.619
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
InceptionV3_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",InceptionV3_f1_score)
```

```
F1_score: 0.6192468619246861
```

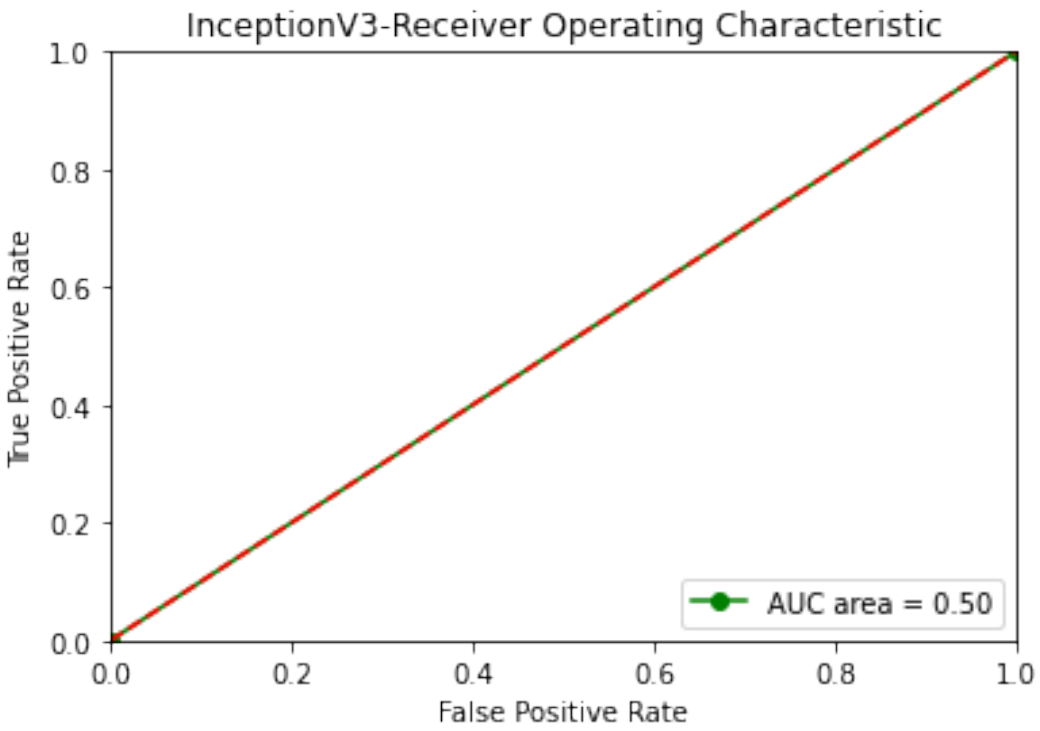
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_InceptionV3 = auc(fpr_keras, tpr_keras)
auc_keras_InceptionV3 #auc score
```

```
0.5
```

```
import matplotlib.pyplot as plt
plt.title('InceptionV3-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_InceptionV3)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```



Model-VGG16

```
from tensorflow.keras.applications.vgg16 import VGG16

input_shape=(224,224,3)



head_model = VGG16(include_top=False,
                   weights='imagenet',
                   #input_tensor=None,
                   input_shape=input_shape)
                   #pooling='avg',
                   #classes=2,
                   #classifier_activation='softmax')


for layer in head_model.layers:
  layer.trainable = False #trainable are the last three layers until
flatten (the whole set of fully connected layers)


x = layers.Flatten()(head_model.output) #google: how to cut off a pre
train model resnet and add fully connected layers in tensorflow
x = layers.Dense(1000, activation='relu')(x)
predictions = layers.Dense(2, activation = 'softmax')(x)
```

```
model = Model(inputs = head_model.input, outputs = predictions)
```

```
model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/vgg16/vgg16_weights_tf_dim_ordering_tf_kernels_notop.h5
58892288/58889256 [==============================] - 1s 0us/step
58900480/58889256 [==============================] - 1s 0us/step
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 19s 225ms/step - loss: 0.5182
- sparse_categorical_accuracy: 0.7390 - val_loss: 0.4915 -
val_sparse_categorical_accuracy: 0.7828
Epoch 2/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.3936
- sparse_categorical_accuracy: 0.8197 - val_loss: 0.4357 -
val_sparse_categorical_accuracy: 0.8131
Epoch 3/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.3527
- sparse_categorical_accuracy: 0.8469 - val_loss: 0.4211 -
val_sparse_categorical_accuracy: 0.8081
Epoch 4/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.3402
- sparse_categorical_accuracy: 0.8532 - val_loss: 0.3744 -
val_sparse_categorical_accuracy: 0.8207
Epoch 5/1000
71/71 [==============================] - 14s 191ms/step - loss: 0.3139
- sparse_categorical_accuracy: 0.8657 - val_loss: 0.3668 -
val_sparse_categorical_accuracy: 0.8409
Epoch 6/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2922
- sparse_categorical_accuracy: 0.8733 - val_loss: 0.3571 -
val_sparse_categorical_accuracy: 0.8409
```

```
Epoch 7/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2884
- sparse_categorical_accuracy: 0.8751 - val_loss: 0.3543 -
val_sparse_categorical_accuracy: 0.8359
Epoch 8/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2701
- sparse_categorical_accuracy: 0.8871 - val_loss: 0.4213 -
val_sparse_categorical_accuracy: 0.8081
Epoch 9/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2724
- sparse_categorical_accuracy: 0.8826 - val_loss: 0.3581 -
val_sparse_categorical_accuracy: 0.8333
Epoch 10/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2494
- sparse_categorical_accuracy: 0.8916 - val_loss: 0.3504 -
val_sparse_categorical_accuracy: 0.8333
Epoch 11/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2382
- sparse_categorical_accuracy: 0.9054 - val_loss: 0.3505 -
val_sparse_categorical_accuracy: 0.8359
Epoch 12/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2301
- sparse_categorical_accuracy: 0.9081 - val_loss: 0.3466 -
val_sparse_categorical_accuracy: 0.8384
Epoch 13/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2177
- sparse_categorical_accuracy: 0.9143 - val_loss: 0.3486 -
val_sparse_categorical_accuracy: 0.8384
Epoch 14/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2149
- sparse_categorical_accuracy: 0.9174 - val_loss: 0.3486 -
val_sparse_categorical_accuracy: 0.8359
Epoch 15/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2055
- sparse_categorical_accuracy: 0.9201 - val_loss: 0.3454 -
val_sparse_categorical_accuracy: 0.8409
Epoch 16/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2008
- sparse_categorical_accuracy: 0.9219 - val_loss: 0.3490 -
val_sparse_categorical_accuracy: 0.8409
Epoch 17/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1940
- sparse_categorical_accuracy: 0.9237 - val_loss: 0.3526 -
val_sparse_categorical_accuracy: 0.8333
Epoch 18/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1896
- sparse_categorical_accuracy: 0.9331 - val_loss: 0.3744 -
val_sparse_categorical_accuracy: 0.8308
Epoch 19/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.2010
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- sparse_categorical_accuracy: 0.9201 - val_loss: 0.3485 -
val_sparse_categorical_accuracy: 0.8384
Epoch 20/1000
71/71 [==============================] - 14s 191ms/step - loss: 0.1965
- sparse_categorical_accuracy: 0.9174 - val_loss: 0.3563 -
val_sparse_categorical_accuracy: 0.8434
Epoch 21/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1970
- sparse_categorical_accuracy: 0.9273 - val_loss: 0.3539 -
val_sparse_categorical_accuracy: 0.8409
Epoch 22/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1710
- sparse_categorical_accuracy: 0.9344 - val_loss: 0.3531 -
val_sparse_categorical_accuracy: 0.8434
Epoch 23/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1652
- sparse_categorical_accuracy: 0.9456 - val_loss: 0.3639 -
val_sparse_categorical_accuracy: 0.8384
Epoch 24/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1612
- sparse_categorical_accuracy: 0.9460 - val_loss: 0.3645 -
val_sparse_categorical_accuracy: 0.8384
Epoch 25/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1613
- sparse_categorical_accuracy: 0.9447 - val_loss: 0.3596 -
val_sparse_categorical_accuracy: 0.8359
Epoch 26/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1534
- sparse_categorical_accuracy: 0.9482 - val_loss: 0.3765 -
val_sparse_categorical_accuracy: 0.8384
Epoch 27/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1517
- sparse_categorical_accuracy: 0.9456 - val_loss: 0.3608 -
val_sparse_categorical_accuracy: 0.8384
Epoch 28/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1472
- sparse_categorical_accuracy: 0.9536 - val_loss: 0.3614 -
val_sparse_categorical_accuracy: 0.8359
Epoch 29/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1436
- sparse_categorical_accuracy: 0.9523 - val_loss: 0.3762 -
val_sparse_categorical_accuracy: 0.8308
Epoch 30/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1399
- sparse_categorical_accuracy: 0.9496 - val_loss: 0.3647 -
val_sparse_categorical_accuracy: 0.8384
Epoch 31/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1414
- sparse_categorical_accuracy: 0.9505 - val_loss: 0.3777 -
val_sparse_categorical_accuracy: 0.8359
```

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Epoch 32/1000
71/71 [==============================] - 14s 191ms/step - loss: 0.1344
- sparse_categorical_accuracy: 0.9576 - val_loss: 0.3654 -
val_sparse_categorical_accuracy: 0.8460
Epoch 33/1000
71/71 [==============================] - 14s 191ms/step - loss: 0.1404
- sparse_categorical_accuracy: 0.9558 - val_loss: 0.3640 -
val_sparse_categorical_accuracy: 0.8485
Epoch 34/1000
71/71 [==============================] - 13s 191ms/step - loss: 0.1335
- sparse_categorical_accuracy: 0.9598 - val_loss: 0.3703 -
val_sparse_categorical_accuracy: 0.8333
Epoch 35/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1256
- sparse_categorical_accuracy: 0.9607 - val_loss: 0.3693 -
val_sparse_categorical_accuracy: 0.8359
Epoch 36/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1207
- sparse_categorical_accuracy: 0.9643 - val_loss: 0.3735 -
val_sparse_categorical_accuracy: 0.8409
Epoch 37/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1167
- sparse_categorical_accuracy: 0.9670 - val_loss: 0.3726 -
val_sparse_categorical_accuracy: 0.8409
Epoch 38/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1134
- sparse_categorical_accuracy: 0.9665 - val_loss: 0.3785 -
val_sparse_categorical_accuracy: 0.8384
Epoch 39/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1180
- sparse_categorical_accuracy: 0.9697 - val_loss: 0.3707 -
val_sparse_categorical_accuracy: 0.8409
Epoch 40/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1138
- sparse_categorical_accuracy: 0.9697 - val_loss: 0.4292 -
val_sparse_categorical_accuracy: 0.8333
Epoch 41/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1126
- sparse_categorical_accuracy: 0.9692 - val_loss: 0.3778 -
val_sparse_categorical_accuracy: 0.8434
Epoch 42/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1047
- sparse_categorical_accuracy: 0.9719 - val_loss: 0.3977 -
val_sparse_categorical_accuracy: 0.8333
Epoch 43/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.1034
- sparse_categorical_accuracy: 0.9728 - val_loss: 0.3755 -
val_sparse_categorical_accuracy: 0.8460
Epoch 44/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1070
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- sparse_categorical_accuracy: 0.9674 - val_loss: 0.3846 -
val_sparse_categorical_accuracy: 0.8333
Epoch 45/1000
71/71 [==============================] - 14s 191ms/step - loss: 0.0986
- sparse_categorical_accuracy: 0.9723 - val_loss: 0.3813 -
val_sparse_categorical_accuracy: 0.8510
Epoch 46/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0982
- sparse_categorical_accuracy: 0.9746 - val_loss: 0.3873 -
val_sparse_categorical_accuracy: 0.8283
Epoch 47/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0938
- sparse_categorical_accuracy: 0.9750 - val_loss: 0.3962 -
val_sparse_categorical_accuracy: 0.8283
Epoch 48/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0921
- sparse_categorical_accuracy: 0.9768 - val_loss: 0.3894 -
val_sparse_categorical_accuracy: 0.8359
Epoch 49/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0896
- sparse_categorical_accuracy: 0.9777 - val_loss: 0.3874 -
val_sparse_categorical_accuracy: 0.8485
Epoch 50/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0943
- sparse_categorical_accuracy: 0.9737 - val_loss: 0.4000 -
val_sparse_categorical_accuracy: 0.8460
Epoch 51/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0855
- sparse_categorical_accuracy: 0.9786 - val_loss: 0.3882 -
val_sparse_categorical_accuracy: 0.8409
Epoch 52/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0846
- sparse_categorical_accuracy: 0.9777 - val_loss: 0.3910 -
val_sparse_categorical_accuracy: 0.8333
Epoch 53/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0889
- sparse_categorical_accuracy: 0.9781 - val_loss: 0.3958 -
val_sparse_categorical_accuracy: 0.8333
Epoch 54/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0795
- sparse_categorical_accuracy: 0.9830 - val_loss: 0.3973 -
val_sparse_categorical_accuracy: 0.8510
Epoch 55/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0907
- sparse_categorical_accuracy: 0.9759 - val_loss: 0.3988 -
val_sparse_categorical_accuracy: 0.8258
Epoch 56/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0759
- sparse_categorical_accuracy: 0.9839 - val_loss: 0.3936 -
val_sparse_categorical_accuracy: 0.8434
```

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Epoch 57/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0749
- sparse_categorical_accuracy: 0.9848 - val_loss: 0.3938 -
val_sparse_categorical_accuracy: 0.8485
Epoch 58/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0725
- sparse_categorical_accuracy: 0.9866 - val_loss: 0.4041 -
val_sparse_categorical_accuracy: 0.8409
Epoch 59/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0785
- sparse_categorical_accuracy: 0.9799 - val_loss: 0.4213 -
val_sparse_categorical_accuracy: 0.8384
Epoch 60/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0703
- sparse_categorical_accuracy: 0.9862 - val_loss: 0.4035 -
val_sparse_categorical_accuracy: 0.8308
Epoch 61/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0766
- sparse_categorical_accuracy: 0.9822 - val_loss: 0.4236 -
val_sparse_categorical_accuracy: 0.8384
Epoch 62/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0671
- sparse_categorical_accuracy: 0.9880 - val_loss: 0.4012 -
val_sparse_categorical_accuracy: 0.8409
Epoch 63/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0650
- sparse_categorical_accuracy: 0.9857 - val_loss: 0.4172 -
val_sparse_categorical_accuracy: 0.8359
Epoch 64/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0628
- sparse_categorical_accuracy: 0.9893 - val_loss: 0.4075 -
val_sparse_categorical_accuracy: 0.8434
Epoch 65/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0784
- sparse_categorical_accuracy: 0.9772 - val_loss: 0.4075 -
val_sparse_categorical_accuracy: 0.8460
Epoch 66/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0653
- sparse_categorical_accuracy: 0.9853 - val_loss: 0.4136 -
val_sparse_categorical_accuracy: 0.8308
Epoch 67/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0582
- sparse_categorical_accuracy: 0.9871 - val_loss: 0.4376 -
val_sparse_categorical_accuracy: 0.8333
Epoch 68/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0582
- sparse_categorical_accuracy: 0.9911 - val_loss: 0.4109 -
val_sparse_categorical_accuracy: 0.8434
Epoch 69/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0580
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- sparse_categorical_accuracy: 0.9906 - val_loss: 0.4166 -
val_sparse_categorical_accuracy: 0.8434
Epoch 70/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0567
- sparse_categorical_accuracy: 0.9915 - val_loss: 0.4112 -
val_sparse_categorical_accuracy: 0.8384
Epoch 71/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0592
- sparse_categorical_accuracy: 0.9888 - val_loss: 0.4199 -
val_sparse_categorical_accuracy: 0.8460
Epoch 72/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0524
- sparse_categorical_accuracy: 0.9920 - val_loss: 0.4347 -
val_sparse_categorical_accuracy: 0.8308
Epoch 73/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0607
- sparse_categorical_accuracy: 0.9866 - val_loss: 0.4270 -
val_sparse_categorical_accuracy: 0.8384
Epoch 74/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0500
- sparse_categorical_accuracy: 0.9933 - val_loss: 0.4287 -
val_sparse_categorical_accuracy: 0.8434
Epoch 75/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0483
- sparse_categorical_accuracy: 0.9929 - val_loss: 0.4235 -
val_sparse_categorical_accuracy: 0.8384
Epoch 76/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0472
- sparse_categorical_accuracy: 0.9938 - val_loss: 0.4355 -
val_sparse_categorical_accuracy: 0.8434
Epoch 77/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0461
- sparse_categorical_accuracy: 0.9933 - val_loss: 0.4342 -
val_sparse_categorical_accuracy: 0.8333
Epoch 78/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0456
- sparse_categorical_accuracy: 0.9933 - val_loss: 0.4276 -
val_sparse_categorical_accuracy: 0.8409
Epoch 79/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0446
- sparse_categorical_accuracy: 0.9946 - val_loss: 0.4502 -
val_sparse_categorical_accuracy: 0.8359
Epoch 80/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0445
- sparse_categorical_accuracy: 0.9946 - val_loss: 0.4323 -
val_sparse_categorical_accuracy: 0.8409
Epoch 81/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0416
- sparse_categorical_accuracy: 0.9946 - val_loss: 0.6276 -
val_sparse_categorical_accuracy: 0.8030
```

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Epoch 82/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.1195
- sparse_categorical_accuracy: 0.9576 - val_loss: 0.4408 -
val_sparse_categorical_accuracy: 0.8434
Epoch 83/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0431
- sparse_categorical_accuracy: 0.9951 - val_loss: 0.4328 -
val_sparse_categorical_accuracy: 0.8510
Epoch 84/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0408
- sparse_categorical_accuracy: 0.9951 - val_loss: 0.4476 -
val_sparse_categorical_accuracy: 0.8359
Epoch 85/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0399
- sparse_categorical_accuracy: 0.9946 - val_loss: 0.4485 -
val_sparse_categorical_accuracy: 0.8434
Epoch 86/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0383
- sparse_categorical_accuracy: 0.9969 - val_loss: 0.4426 -
val_sparse_categorical_accuracy: 0.8510
Epoch 87/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0373
- sparse_categorical_accuracy: 0.9960 - val_loss: 0.4447 -
val_sparse_categorical_accuracy: 0.8409
Epoch 88/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0373
- sparse_categorical_accuracy: 0.9955 - val_loss: 0.4431 -
val_sparse_categorical_accuracy: 0.8510
Epoch 89/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0370
- sparse_categorical_accuracy: 0.9969 - val_loss: 0.4478 -
val_sparse_categorical_accuracy: 0.8485
Epoch 90/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0357
- sparse_categorical_accuracy: 0.9964 - val_loss: 0.4479 -
val_sparse_categorical_accuracy: 0.8460
Epoch 91/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0367
- sparse_categorical_accuracy: 0.9964 - val_loss: 0.4501 -
val_sparse_categorical_accuracy: 0.8434
Epoch 92/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0349
- sparse_categorical_accuracy: 0.9960 - val_loss: 0.4724 -
val_sparse_categorical_accuracy: 0.8409
Epoch 93/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0340
- sparse_categorical_accuracy: 0.9951 - val_loss: 0.4599 -
val_sparse_categorical_accuracy: 0.8434
Epoch 94/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0329
```

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- sparse_categorical_accuracy: 0.9964 - val_loss: 0.4701 -
val_sparse_categorical_accuracy: 0.8434
Epoch 95/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0330
- sparse_categorical_accuracy: 0.9955 - val_loss: 0.4696 -
val_sparse_categorical_accuracy: 0.8409
Epoch 96/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0314
- sparse_categorical_accuracy: 0.9964 - val_loss: 0.4866 -
val_sparse_categorical_accuracy: 0.8359
Epoch 97/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0340
- sparse_categorical_accuracy: 0.9933 - val_loss: 0.4722 -
val_sparse_categorical_accuracy: 0.8409
Epoch 98/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0299
- sparse_categorical_accuracy: 0.9973 - val_loss: 0.4605 -
val_sparse_categorical_accuracy: 0.8485
Epoch 99/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0303
- sparse_categorical_accuracy: 0.9969 - val_loss: 0.4680 -
val_sparse_categorical_accuracy: 0.8485
Epoch 100/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0290
- sparse_categorical_accuracy: 0.9973 - val_loss: 0.4815 -
val_sparse_categorical_accuracy: 0.8359
Epoch 101/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0282
- sparse_categorical_accuracy: 0.9978 - val_loss: 0.4814 -
val_sparse_categorical_accuracy: 0.8359
Epoch 102/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0329
- sparse_categorical_accuracy: 0.9960 - val_loss: 0.5098 -
val_sparse_categorical_accuracy: 0.8283
Epoch 103/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0524
- sparse_categorical_accuracy: 0.9830 - val_loss: 0.4829 -
val_sparse_categorical_accuracy: 0.8485
Epoch 104/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0270
- sparse_categorical_accuracy: 0.9973 - val_loss: 0.4832 -
val_sparse_categorical_accuracy: 0.8460
Epoch 105/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0266
- sparse_categorical_accuracy: 0.9978 - val_loss: 0.4734 -
val_sparse_categorical_accuracy: 0.8485
Epoch 106/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0256
- sparse_categorical_accuracy: 0.9978 - val_loss: 0.4796 -
val_sparse_categorical_accuracy: 0.8460
```

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Epoch 107/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0254
- sparse_categorical_accuracy: 0.9969 - val_loss: 0.4746 -
val_sparse_categorical_accuracy: 0.8434
Epoch 108/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0279
- sparse_categorical_accuracy: 0.9973 - val_loss: 0.4777 -
val_sparse_categorical_accuracy: 0.8409
Epoch 109/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0236
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4927 -
val_sparse_categorical_accuracy: 0.8460
Epoch 110/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0242
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4857 -
val_sparse_categorical_accuracy: 0.8460
Epoch 111/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0223
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4840 -
val_sparse_categorical_accuracy: 0.8460
Epoch 112/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0220
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4933 -
val_sparse_categorical_accuracy: 0.8409
Epoch 113/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0212
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4958 -
val_sparse_categorical_accuracy: 0.8485
Epoch 114/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0214
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4994 -
val_sparse_categorical_accuracy: 0.8460
Epoch 115/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0210
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.4911 -
val_sparse_categorical_accuracy: 0.8409
Epoch 116/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0202
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.4927 -
val_sparse_categorical_accuracy: 0.8460
Epoch 117/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0208
- sparse_categorical_accuracy: 0.9978 - val_loss: 0.4946 -
val_sparse_categorical_accuracy: 0.8460
Epoch 118/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0205
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5057 -
val_sparse_categorical_accuracy: 0.8485
Epoch 119/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0187
```

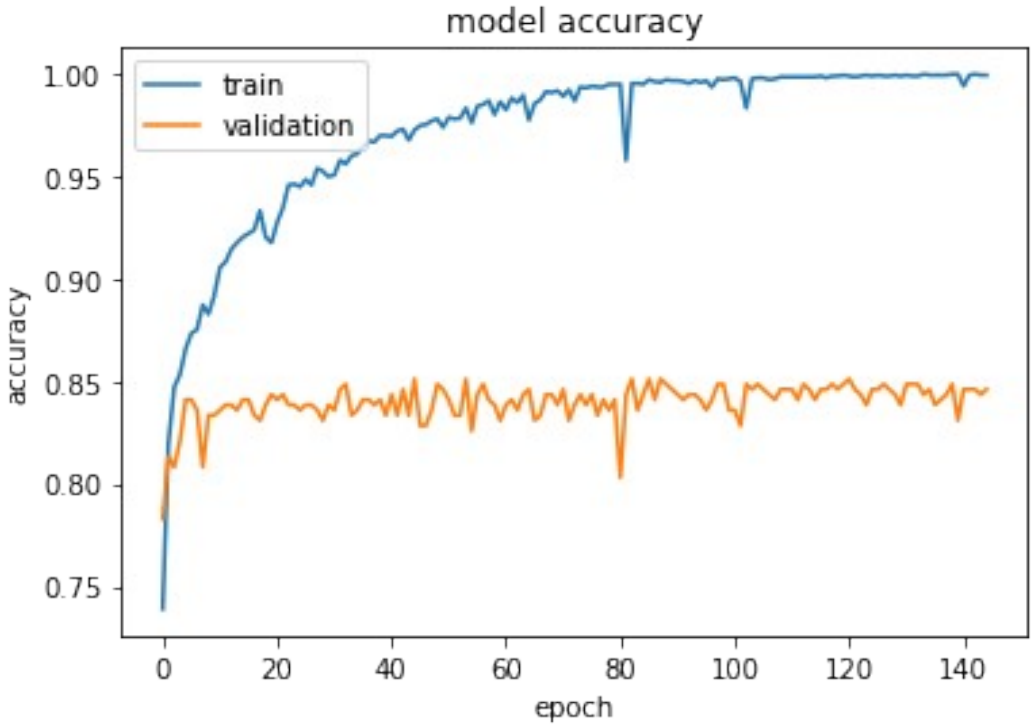
```
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5048 -
val_sparse_categorical_accuracy: 0.8460
Epoch 120/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0183
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5023 -
val_sparse_categorical_accuracy: 0.8485
Epoch 121/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0187
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5120 -
val_sparse_categorical_accuracy: 0.8510
Epoch 122/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0194
- sparse_categorical_accuracy: 0.9982 - val_loss: 0.5123 -
val_sparse_categorical_accuracy: 0.8460
Epoch 123/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0181
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5163 -
val_sparse_categorical_accuracy: 0.8434
Epoch 124/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0197
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5136 -
val_sparse_categorical_accuracy: 0.8384
Epoch 125/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0180
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5216 -
val_sparse_categorical_accuracy: 0.8460
Epoch 126/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0160
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5261 -
val_sparse_categorical_accuracy: 0.8460
Epoch 127/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0161
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5209 -
val_sparse_categorical_accuracy: 0.8485
Epoch 128/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0196
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5419 -
val_sparse_categorical_accuracy: 0.8460
Epoch 129/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0155
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5268 -
val_sparse_categorical_accuracy: 0.8434
Epoch 130/1000
71/71 [==============================] - 13s 190ms/step - loss: 0.0147
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5284 -
val_sparse_categorical_accuracy: 0.8384
Epoch 131/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0147
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5416 -
val_sparse_categorical_accuracy: 0.8485
```

```
Epoch 132/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0142
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5410 -
val_sparse_categorical_accuracy: 0.8485
Epoch 133/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0137
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.5431 -
val_sparse_categorical_accuracy: 0.8485
Epoch 134/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0137
- sparse_categorical_accuracy: 0.9996 - val_loss: 0.5340 -
val_sparse_categorical_accuracy: 0.8434
Epoch 135/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0129
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5561 -
val_sparse_categorical_accuracy: 0.8460
Epoch 136/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0130
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5465 -
val_sparse_categorical_accuracy: 0.8384
Epoch 137/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0123
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5624 -
val_sparse_categorical_accuracy: 0.8409
Epoch 138/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0131
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5424 -
val_sparse_categorical_accuracy: 0.8434
Epoch 139/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0120
- sparse_categorical_accuracy: 0.9996 - val_loss: 0.5434 -
val_sparse_categorical_accuracy: 0.8485
Epoch 140/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0122
- sparse_categorical_accuracy: 0.9996 - val_loss: 0.5709 -
val_sparse_categorical_accuracy: 0.8308
Epoch 141/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0271
- sparse_categorical_accuracy: 0.9938 - val_loss: 0.5619 -
val_sparse_categorical_accuracy: 0.8460
Epoch 142/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0116
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5595 -
val_sparse_categorical_accuracy: 0.8460
Epoch 143/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0107
- sparse_categorical_accuracy: 0.9996 - val_loss: 0.5779 -
val_sparse_categorical_accuracy: 0.8460
Epoch 144/1000
71/71 [==============================] - 13s 189ms/step - loss: 0.0106
```

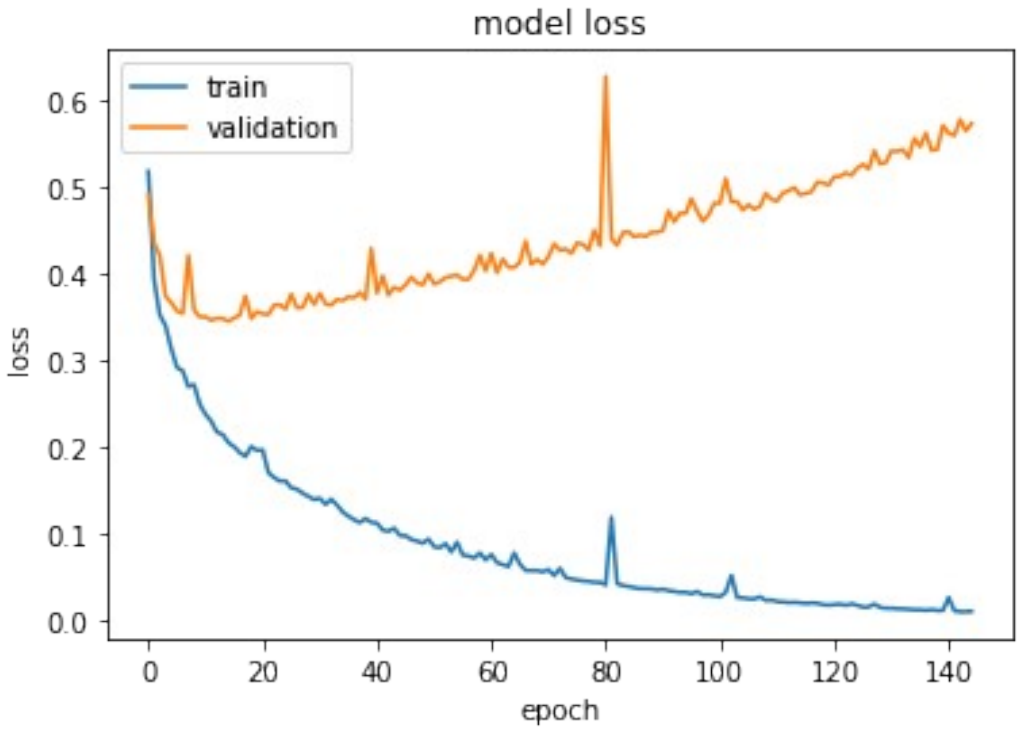
```
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5648 -
val_sparse_categorical_accuracy: 0.8434
Epoch 145/1000
70/71 [============================>.] - ETA: 0s - loss: 0.0111 -
sparse_categorical_accuracy: 0.9991Restoring model weights from the
end of the best epoch: 45.
71/71 [==============================] - 13s 190ms/step - loss: 0.0111
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.5731 -
val_sparse_categorical_accuracy: 0.8460
Epoch 145: early stopping
```

```
model.save('/content/drive/MyDrive/VGG16_model.h5')
```

```
plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
y_pred=model.predict(X_test)
y_pred
```

```
array([[0.0000000e+00, 1.0000000e+00],
       [7.1547079e-28, 1.0000000e+00],
       [0.0000000e+00, 1.0000000e+00],
       ...,
       [1.0000000e+00, 1.1731382e-13],
       [1.0958346e-06, 9.9999893e-01],
       [0.0000000e+00, 1.0000000e+00]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
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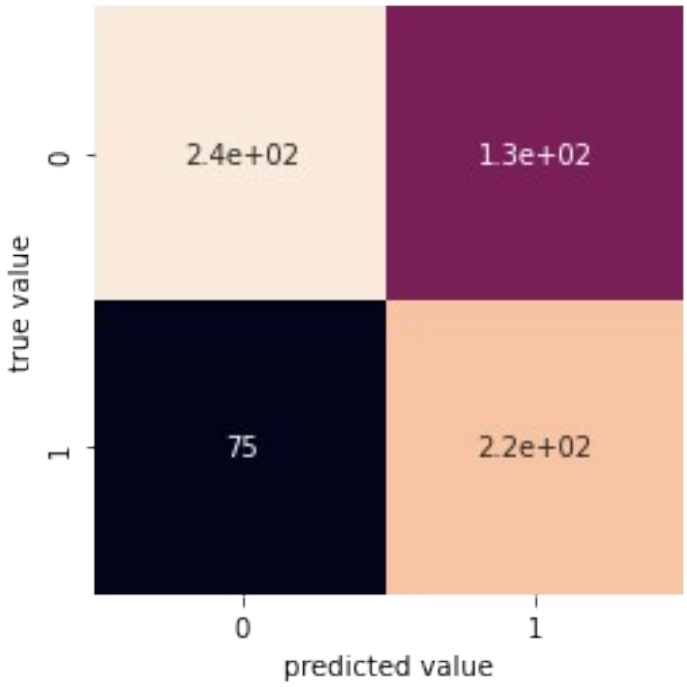
```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score


print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.695
Precision: 0.637
```

```
Recall: 0.747
F1: 0.687
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
VGG16_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",VGG16_f1_score)
```

```
F1_score: 0.687402799377916
```

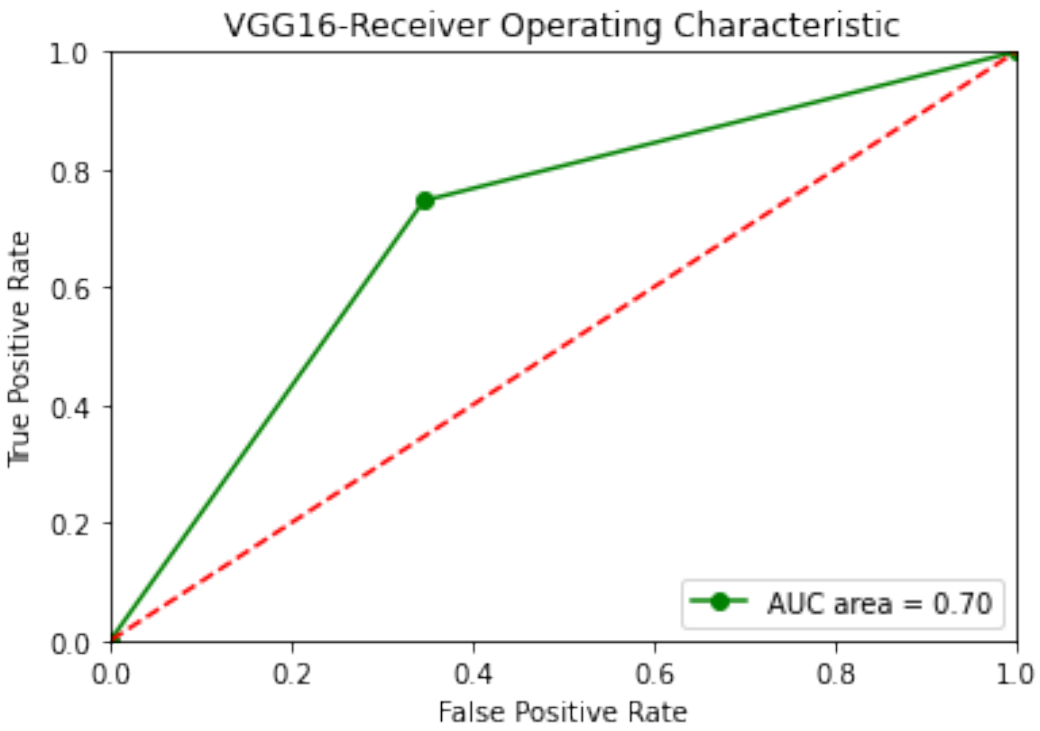
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_VGG16 = auc(fpr_keras, tpr_keras)
auc_keras_VGG16 #auc score
```

```
0.7002338877338876
```

```
import matplotlib.pyplot as plt
plt.title('VGG16-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_VGG16)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```



Model-DenseNet121

```
from tensorflow.keras.applications.densenet import DenseNet121

input_shape=(224,224,3)



head_model = DenseNet121(include_top=False,
                 weights='imagenet',
                 #input_tensor=None,
                 input_shape=input_shape)
                 #pooling='avg',
                 #classes=2)

for layer in head_model.layers:
  layer.trainable = False #trainable are the last three layers until
flatten (the whole set of fully connected layers)


x = layers.Flatten()(head_model.output) #google: how to cut off a pre
train model resnet and add fully connected layers in tensorflow
x = layers.Dense(1000, activation='relu')(x)
predictions = layers.Dense(2, activation = 'softmax')(x)

model = Model(inputs = head_model.input, outputs = predictions)
```

```
model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/densenet/
densenet121_weights_tf_dim_ordering_tf_kernels_notop.h5
29089792/29084464 [==============================] - 0s 0us/step
29097984/29084464 [==============================] - 0s 0us/step
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 21s 181ms/step - loss: 0.4340
- sparse_categorical_accuracy: 0.8041 - val_loss: 0.4573 -
val_sparse_categorical_accuracy: 0.7803
Epoch 2/1000
71/71 [==============================] - 9s 124ms/step - loss: 0.2021
- sparse_categorical_accuracy: 0.9206 - val_loss: 0.3344 -
val_sparse_categorical_accuracy: 0.8636
Epoch 3/1000
71/71 [==============================] - 9s 122ms/step - loss: 0.1255
- sparse_categorical_accuracy: 0.9612 - val_loss: 0.3138 -
val_sparse_categorical_accuracy: 0.8737
Epoch 4/1000
71/71 [==============================] - 8s 119ms/step - loss: 0.0942
- sparse_categorical_accuracy: 0.9768 - val_loss: 0.3072 -
val_sparse_categorical_accuracy: 0.8737
Epoch 5/1000
71/71 [==============================] - 8s 119ms/step - loss: 0.0633
- sparse_categorical_accuracy: 0.9888 - val_loss: 0.3252 -
val_sparse_categorical_accuracy: 0.8662
Epoch 6/1000
71/71 [==============================] - 9s 123ms/step - loss: 0.0527
- sparse_categorical_accuracy: 0.9938 - val_loss: 0.3268 -
```

```
val_sparse_categorical_accuracy: 0.8763
Epoch 7/1000
71/71 [==============================] - 8s 119ms/step - loss: 0.0372
- sparse_categorical_accuracy: 0.9987 - val_loss: 0.3237 -
val_sparse_categorical_accuracy: 0.8687
Epoch 8/1000
71/71 [==============================] - 9s 123ms/step - loss: 0.0345
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.3186 -
val_sparse_categorical_accuracy: 0.8813
Epoch 9/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0263
- sparse_categorical_accuracy: 0.9991 - val_loss: 0.3358 -
val_sparse_categorical_accuracy: 0.8763
Epoch 10/1000
71/71 [==============================] - 9s 124ms/step - loss: 0.0204
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3265 -
val_sparse_categorical_accuracy: 0.8838
Epoch 11/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0170
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3331 -
val_sparse_categorical_accuracy: 0.8813
Epoch 12/1000
71/71 [==============================] - 9s 124ms/step - loss: 0.0149
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3317 -
val_sparse_categorical_accuracy: 0.8864
Epoch 13/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0149
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3383 -
val_sparse_categorical_accuracy: 0.8838
Epoch 14/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0110
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3484 -
val_sparse_categorical_accuracy: 0.8838
Epoch 15/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0101
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3415 -
val_sparse_categorical_accuracy: 0.8838
Epoch 16/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0089
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3496 -
val_sparse_categorical_accuracy: 0.8813
Epoch 17/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0078
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3505 -
val_sparse_categorical_accuracy: 0.8838
Epoch 18/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0078
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3471 -
val_sparse_categorical_accuracy: 0.8838
Epoch 19/1000
```

```
71/71 [==============================] - 9s 121ms/step - loss: 0.0064
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3497 -
val_sparse_categorical_accuracy: 0.8864
Epoch 20/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0057
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3549 -
val_sparse_categorical_accuracy: 0.8813
Epoch 21/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0052
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3605 -
val_sparse_categorical_accuracy: 0.8813
Epoch 22/1000
71/71 [==============================] - 9s 124ms/step - loss: 0.0048
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3586 -
val_sparse_categorical_accuracy: 0.8889
Epoch 23/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0045
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3625 -
val_sparse_categorical_accuracy: 0.8889
Epoch 24/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0048
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3675 -
val_sparse_categorical_accuracy: 0.8864
Epoch 25/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0039
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3726 -
val_sparse_categorical_accuracy: 0.8813
Epoch 26/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0035
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3697 -
val_sparse_categorical_accuracy: 0.8864
Epoch 27/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0032
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3780 -
val_sparse_categorical_accuracy: 0.8838
Epoch 28/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0030
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3779 -
val_sparse_categorical_accuracy: 0.8838
Epoch 29/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0028
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3871 -
val_sparse_categorical_accuracy: 0.8838
Epoch 30/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0026
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3836 -
val_sparse_categorical_accuracy: 0.8838
Epoch 31/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0026
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3848 -
```

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val_sparse_categorical_accuracy: 0.8864
Epoch 32/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0023
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3854 -
val_sparse_categorical_accuracy: 0.8864
Epoch 33/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0021
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3881 -
val_sparse_categorical_accuracy: 0.8864
Epoch 34/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0020
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3966 -
val_sparse_categorical_accuracy: 0.8838
Epoch 35/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0019
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3920 -
val_sparse_categorical_accuracy: 0.8838
Epoch 36/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0018
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3942 -
val_sparse_categorical_accuracy: 0.8813
Epoch 37/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0017
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3990 -
val_sparse_categorical_accuracy: 0.8889
Epoch 38/1000
71/71 [==============================] - 8s 120ms/step - loss: 0.0016
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4007 -
val_sparse_categorical_accuracy: 0.8889
Epoch 39/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0015
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.3983 -
val_sparse_categorical_accuracy: 0.8889
Epoch 40/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0014
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4013 -
val_sparse_categorical_accuracy: 0.8864
Epoch 41/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0013
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4063 -
val_sparse_categorical_accuracy: 0.8864
Epoch 42/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0012
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4064 -
val_sparse_categorical_accuracy: 0.8838
Epoch 43/1000
71/71 [==============================] - 9s 120ms/step - loss: 0.0012
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4083 -
val_sparse_categorical_accuracy: 0.8864
Epoch 44/1000
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71/71 [==============================] - 9s 121ms/step - loss: 0.0011
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4109 -
val_sparse_categorical_accuracy: 0.8864
Epoch 45/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0011
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4138 -
val_sparse_categorical_accuracy: 0.8864
Epoch 46/1000
71/71 [==============================] - 9s 121ms/step - loss: 0.0010
- sparse_categorical_accuracy: 1.0000 - val_loss: 0.4147 -
val_sparse_categorical_accuracy: 0.8864
Epoch 47/1000
71/71 [==============================] - 9s 120ms/step - loss:
9.5527e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4160 -
val_sparse_categorical_accuracy: 0.8864
Epoch 48/1000
71/71 [==============================] - 9s 120ms/step - loss:
9.0323e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4193 -
val_sparse_categorical_accuracy: 0.8889
Epoch 49/1000
71/71 [==============================] - 9s 120ms/step - loss:
8.5988e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4255 -
val_sparse_categorical_accuracy: 0.8813
Epoch 50/1000
71/71 [==============================] - 9s 120ms/step - loss:
8.1650e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4243 -
val_sparse_categorical_accuracy: 0.8889
Epoch 51/1000
71/71 [==============================] - 9s 120ms/step - loss:
7.7729e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4242 -
val_sparse_categorical_accuracy: 0.8864
Epoch 52/1000
71/71 [==============================] - 9s 120ms/step - loss:
7.4192e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4274 -
val_sparse_categorical_accuracy: 0.8838
Epoch 53/1000
71/71 [==============================] - 9s 120ms/step - loss:
7.1264e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4298 -
val_sparse_categorical_accuracy: 0.8864
Epoch 54/1000
71/71 [==============================] - 9s 120ms/step - loss:
6.7134e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4306 -
val_sparse_categorical_accuracy: 0.8889
Epoch 55/1000
71/71 [==============================] - 9s 124ms/step - loss:
6.4515e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4362 -
val_sparse_categorical_accuracy: 0.8914
Epoch 56/1000
71/71 [==============================] - 9s 121ms/step - loss:
6.0937e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4337 -
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val_sparse_categorical_accuracy: 0.8889
Epoch 57/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.7941e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4375 -
val_sparse_categorical_accuracy: 0.8864
Epoch 58/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.5146e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4381 -
val_sparse_categorical_accuracy: 0.8889
Epoch 59/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.4775e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4447 -
val_sparse_categorical_accuracy: 0.8889
Epoch 60/1000
71/71 [==============================] - 9s 120ms/step - loss:
5.0395e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4467 -
val_sparse_categorical_accuracy: 0.8864
Epoch 61/1000
71/71 [==============================] - 9s 120ms/step - loss:
4.9774e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4460 -
val_sparse_categorical_accuracy: 0.8864
Epoch 62/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.5646e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4479 -
val_sparse_categorical_accuracy: 0.8864
Epoch 63/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.3559e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4479 -
val_sparse_categorical_accuracy: 0.8889
Epoch 64/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.1821e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4469 -
val_sparse_categorical_accuracy: 0.8864
Epoch 65/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.9934e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4512 -
val_sparse_categorical_accuracy: 0.8889
Epoch 66/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.7839e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4563 -
val_sparse_categorical_accuracy: 0.8838
Epoch 67/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.6881e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4602 -
val_sparse_categorical_accuracy: 0.8914
Epoch 68/1000
71/71 [==============================] - 8s 120ms/step - loss:
3.5229e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4569 -
val_sparse_categorical_accuracy: 0.8864
Epoch 69/1000
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71/71 [==============================] - 8s 120ms/step - loss:
3.3210e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4616 -
val_sparse_categorical_accuracy: 0.8864
Epoch 70/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.1949e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4583 -
val_sparse_categorical_accuracy: 0.8864
Epoch 71/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.1225e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4593 -
val_sparse_categorical_accuracy: 0.8864
Epoch 72/1000
71/71 [==============================] - 9s 120ms/step - loss:
2.8947e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4598 -
val_sparse_categorical_accuracy: 0.8864
Epoch 73/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.7641e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4683 -
val_sparse_categorical_accuracy: 0.8864
Epoch 74/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.6609e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4670 -
val_sparse_categorical_accuracy: 0.8864
Epoch 75/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.5218e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4708 -
val_sparse_categorical_accuracy: 0.8838
Epoch 76/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.4327e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4704 -
val_sparse_categorical_accuracy: 0.8864
Epoch 77/1000
71/71 [==============================] - 9s 120ms/step - loss:
2.3310e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4711 -
val_sparse_categorical_accuracy: 0.8864
Epoch 78/1000
71/71 [==============================] - 9s 120ms/step - loss:
2.2413e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4727 -
val_sparse_categorical_accuracy: 0.8864
Epoch 79/1000
71/71 [==============================] - 8s 120ms/step - loss:
2.1378e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4787 -
val_sparse_categorical_accuracy: 0.8889
Epoch 80/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.0410e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4762 -
val_sparse_categorical_accuracy: 0.8864
Epoch 81/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.9533e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4783 -
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val_sparse_categorical_accuracy: 0.8864
Epoch 82/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.9042e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4813 -
val_sparse_categorical_accuracy: 0.8889
Epoch 83/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.8853e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4865 -
val_sparse_categorical_accuracy: 0.8889
Epoch 84/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.7176e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4842 -
val_sparse_categorical_accuracy: 0.8864
Epoch 85/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.6940e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4886 -
val_sparse_categorical_accuracy: 0.8889
Epoch 86/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.5759e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4903 -
val_sparse_categorical_accuracy: 0.8889
Epoch 87/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.5113e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4898 -
val_sparse_categorical_accuracy: 0.8864
Epoch 88/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.4350e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4929 -
val_sparse_categorical_accuracy: 0.8889
Epoch 89/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.3822e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4969 -
val_sparse_categorical_accuracy: 0.8838
Epoch 90/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.3209e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4952 -
val_sparse_categorical_accuracy: 0.8864
Epoch 91/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.2702e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.4986 -
val_sparse_categorical_accuracy: 0.8864
Epoch 92/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.2264e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5000 -
val_sparse_categorical_accuracy: 0.8864
Epoch 93/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.1651e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5048 -
val_sparse_categorical_accuracy: 0.8889
Epoch 94/1000
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71/71 [==============================] - 9s 121ms/step - loss:
1.1289e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5061 -
val_sparse_categorical_accuracy: 0.8864
Epoch 95/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.0746e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5075 -
val_sparse_categorical_accuracy: 0.8864
Epoch 96/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.0246e-04 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5094 -
val_sparse_categorical_accuracy: 0.8864
Epoch 97/1000
71/71 [==============================] - 9s 121ms/step - loss:
9.8194e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5078 -
val_sparse_categorical_accuracy: 0.8864
Epoch 98/1000
71/71 [==============================] - 9s 121ms/step - loss:
9.5775e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5106 -
val_sparse_categorical_accuracy: 0.8864
Epoch 99/1000
71/71 [==============================] - 9s 121ms/step - loss:
9.0440e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5108 -
val_sparse_categorical_accuracy: 0.8864
Epoch 100/1000
71/71 [==============================] - 9s 121ms/step - loss:
8.6484e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5171 -
val_sparse_categorical_accuracy: 0.8864
Epoch 101/1000
71/71 [==============================] - 9s 120ms/step - loss:
8.3490e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5206 -
val_sparse_categorical_accuracy: 0.8864
Epoch 102/1000
71/71 [==============================] - 9s 121ms/step - loss:
8.0982e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5163 -
val_sparse_categorical_accuracy: 0.8864
Epoch 103/1000
71/71 [==============================] - 9s 121ms/step - loss:
7.6615e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5239 -
val_sparse_categorical_accuracy: 0.8864
Epoch 104/1000
71/71 [==============================] - 9s 121ms/step - loss:
7.4052e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5223 -
val_sparse_categorical_accuracy: 0.8889
Epoch 105/1000
71/71 [==============================] - 9s 120ms/step - loss:
7.1025e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5228 -
val_sparse_categorical_accuracy: 0.8838
Epoch 106/1000
71/71 [==============================] - 9s 121ms/step - loss:
6.7676e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5223 -
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val_sparse_categorical_accuracy: 0.8889
Epoch 107/1000
71/71 [==============================] - 9s 121ms/step - loss:
6.5196e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5254 -
val_sparse_categorical_accuracy: 0.8864
Epoch 108/1000
71/71 [==============================] - 9s 121ms/step - loss:
6.2591e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5265 -
val_sparse_categorical_accuracy: 0.8838
Epoch 109/1000
71/71 [==============================] - 9s 121ms/step - loss:
6.0050e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5289 -
val_sparse_categorical_accuracy: 0.8864
Epoch 110/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.8203e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5327 -
val_sparse_categorical_accuracy: 0.8914
Epoch 111/1000
71/71 [==============================] - 9s 120ms/step - loss:
5.5588e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5337 -
val_sparse_categorical_accuracy: 0.8864
Epoch 112/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.3425e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5339 -
val_sparse_categorical_accuracy: 0.8889
Epoch 113/1000
71/71 [==============================] - 9s 121ms/step - loss:
5.0836e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5384 -
val_sparse_categorical_accuracy: 0.8914
Epoch 114/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.8919e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5432 -
val_sparse_categorical_accuracy: 0.8889
Epoch 115/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.6990e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5411 -
val_sparse_categorical_accuracy: 0.8914
Epoch 116/1000
71/71 [==============================] - 9s 120ms/step - loss:
4.5822e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5412 -
val_sparse_categorical_accuracy: 0.8864
Epoch 117/1000
71/71 [==============================] - 9s 120ms/step - loss:
4.3036e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5412 -
val_sparse_categorical_accuracy: 0.8889
Epoch 118/1000
71/71 [==============================] - 9s 121ms/step - loss:
4.1547e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5470 -
val_sparse_categorical_accuracy: 0.8914
Epoch 119/1000
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71/71 [==============================] - 9s 120ms/step - loss:
4.0222e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5481 -
val_sparse_categorical_accuracy: 0.8914
Epoch 120/1000
71/71 [==============================] - 9s 121ms/step - loss:
3.8184e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5462 -
val_sparse_categorical_accuracy: 0.8889
Epoch 121/1000
71/71 [==============================] - 9s 121ms/step - loss:
3.6995e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5515 -
val_sparse_categorical_accuracy: 0.8889
Epoch 122/1000
71/71 [==============================] - 9s 121ms/step - loss:
3.5992e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5523 -
val_sparse_categorical_accuracy: 0.8914
Epoch 123/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.4060e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5537 -
val_sparse_categorical_accuracy: 0.8914
Epoch 124/1000
71/71 [==============================] - 9s 121ms/step - loss:
3.2563e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5542 -
val_sparse_categorical_accuracy: 0.8838
Epoch 125/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.1821e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5554 -
val_sparse_categorical_accuracy: 0.8838
Epoch 126/1000
71/71 [==============================] - 9s 120ms/step - loss:
3.0509e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5598 -
val_sparse_categorical_accuracy: 0.8889
Epoch 127/1000
71/71 [==============================] - 9s 120ms/step - loss:
2.9103e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5594 -
val_sparse_categorical_accuracy: 0.8864
Epoch 128/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.8004e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5651 -
val_sparse_categorical_accuracy: 0.8914
Epoch 129/1000
71/71 [==============================] - 9s 120ms/step - loss:
2.7046e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5662 -
val_sparse_categorical_accuracy: 0.8914
Epoch 130/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.5655e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5635 -
val_sparse_categorical_accuracy: 0.8864
Epoch 131/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.6876e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5773 -
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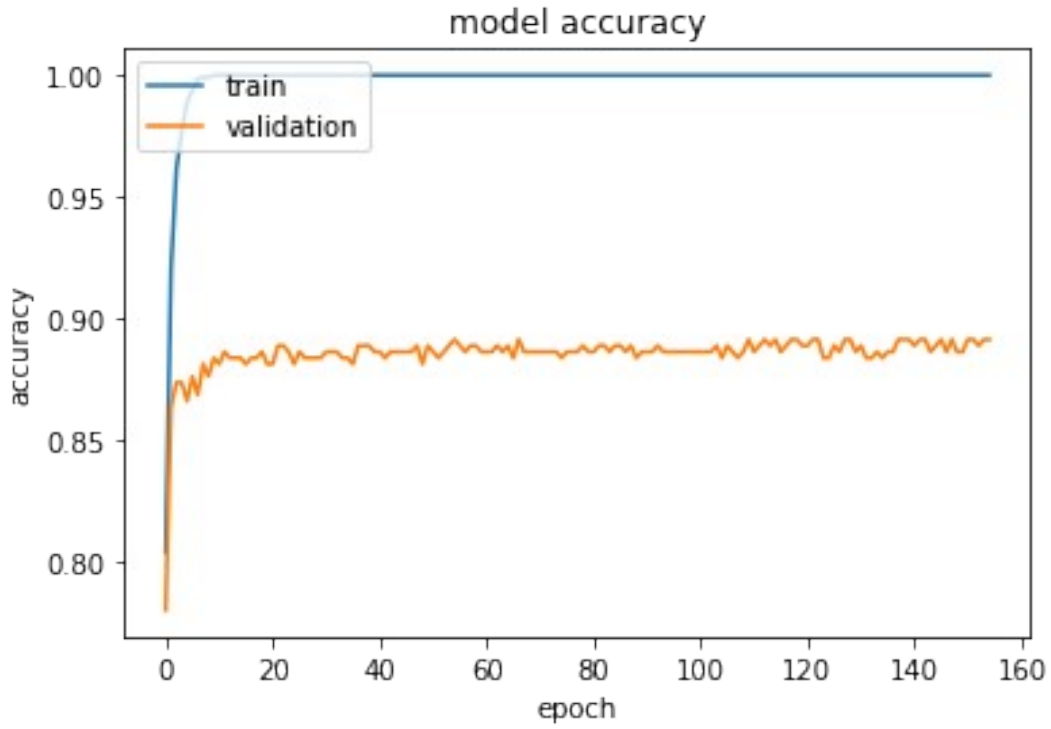
val_sparse_categorical_accuracy: 0.8889
Epoch 132/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.4816e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5732 -
val_sparse_categorical_accuracy: 0.8838
Epoch 133/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.2842e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5703 -
val_sparse_categorical_accuracy: 0.8838
Epoch 134/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.1669e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5720 -
val_sparse_categorical_accuracy: 0.8864
Epoch 135/1000
71/71 [==============================] - 9s 122ms/step - loss:
2.0990e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5769 -
val_sparse_categorical_accuracy: 0.8838
Epoch 136/1000
71/71 [==============================] - 9s 121ms/step - loss:
2.0013e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5773 -
val_sparse_categorical_accuracy: 0.8864
Epoch 137/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.9304e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5796 -
val_sparse_categorical_accuracy: 0.8864
Epoch 138/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.8458e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5835 -
val_sparse_categorical_accuracy: 0.8914
Epoch 139/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.7966e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5869 -
val_sparse_categorical_accuracy: 0.8914
Epoch 140/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.7071e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5868 -
val_sparse_categorical_accuracy: 0.8914
Epoch 141/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.6419e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5872 -
val_sparse_categorical_accuracy: 0.8889
Epoch 142/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.5872e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5888 -
val_sparse_categorical_accuracy: 0.8914
Epoch 143/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.5239e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5917 -
val_sparse_categorical_accuracy: 0.8914
Epoch 144/1000
```

```
71/71 [==============================] - 9s 121ms/step - loss:
1.4656e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5879 -
val_sparse_categorical_accuracy: 0.8864
Epoch 145/1000
71/71 [==============================] - 9s 120ms/step - loss:
1.4111e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5902 -
val_sparse_categorical_accuracy: 0.8889
Epoch 146/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.3670e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5937 -
val_sparse_categorical_accuracy: 0.8914
Epoch 147/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.3021e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5929 -
val_sparse_categorical_accuracy: 0.8864
Epoch 148/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.3514e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5968 -
val_sparse_categorical_accuracy: 0.8914
Epoch 149/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.2073e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5989 -
val_sparse_categorical_accuracy: 0.8864
Epoch 150/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.1612e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.5982 -
val_sparse_categorical_accuracy: 0.8864
Epoch 151/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.1144e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6032 -
val_sparse_categorical_accuracy: 0.8914
Epoch 152/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.0821e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6058 -
val_sparse_categorical_accuracy: 0.8914
Epoch 153/1000
71/71 [==============================] - 9s 121ms/step - loss:
1.0436e-05 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6022 -
val_sparse_categorical_accuracy: 0.8889
Epoch 154/1000
71/71 [==============================] - 9s 122ms/step - loss:
9.9351e-06 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6047 -
val_sparse_categorical_accuracy: 0.8914
Epoch 155/1000
70/71 [============================>.] - ETA: 0s - loss: 9.5911e-06 -
sparse_categorical_accuracy: 1.0000Restoring model weights from the
end of the best epoch: 55.
71/71 [==============================] - 9s 125ms/step - loss:
9.5869e-06 - sparse_categorical_accuracy: 1.0000 - val_loss: 0.6069 -
```

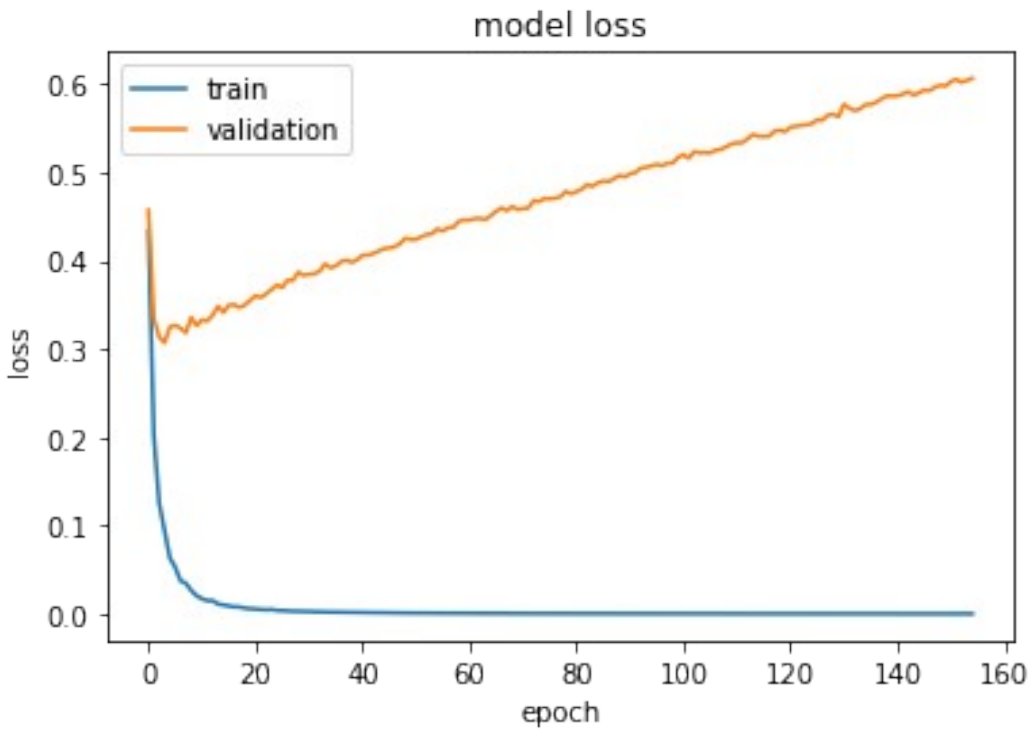
```
val_sparse_categorical_accuracy: 0.8914
Epoch 155: early stopping

model.save('/content/drive/MyDrive/DenseNet121_model.h5')

plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
y_pred=model.predict(X_test)
y_pred
```

```
array([[2.8675307e-08, 1.0000000e+00],
       [9.5230292e-20, 1.0000000e+00],
       [2.2437453e-17, 1.0000000e+00],
       ...,
       [0.0000000e+00, 1.0000000e+00],
       [1.8575976e-18, 1.0000000e+00],
       [1.1458871e-11, 1.0000000e+00]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
```

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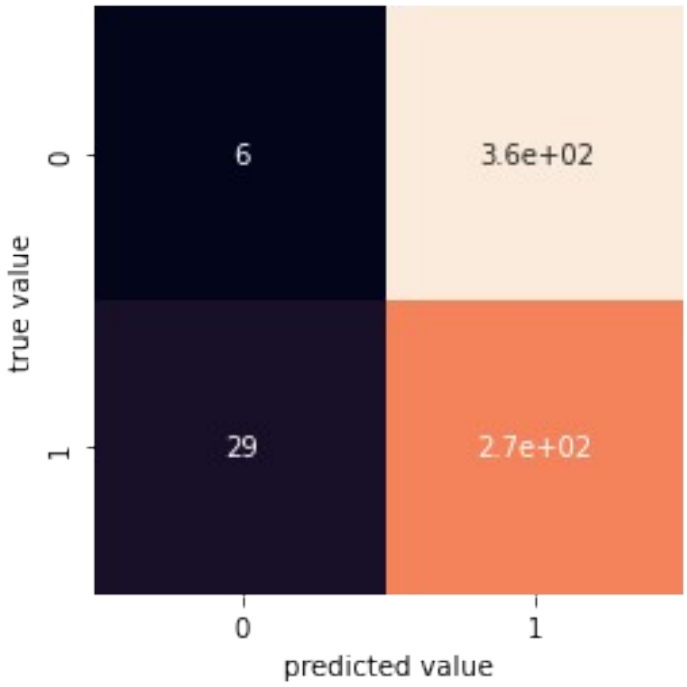
```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score


print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.414
Precision: 0.427
```

```
Recall: 0.902
F1: 0.580
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
DenseNet121_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",DenseNet121_f1_score)
```

```
F1_score: 0.5798045602605864
```

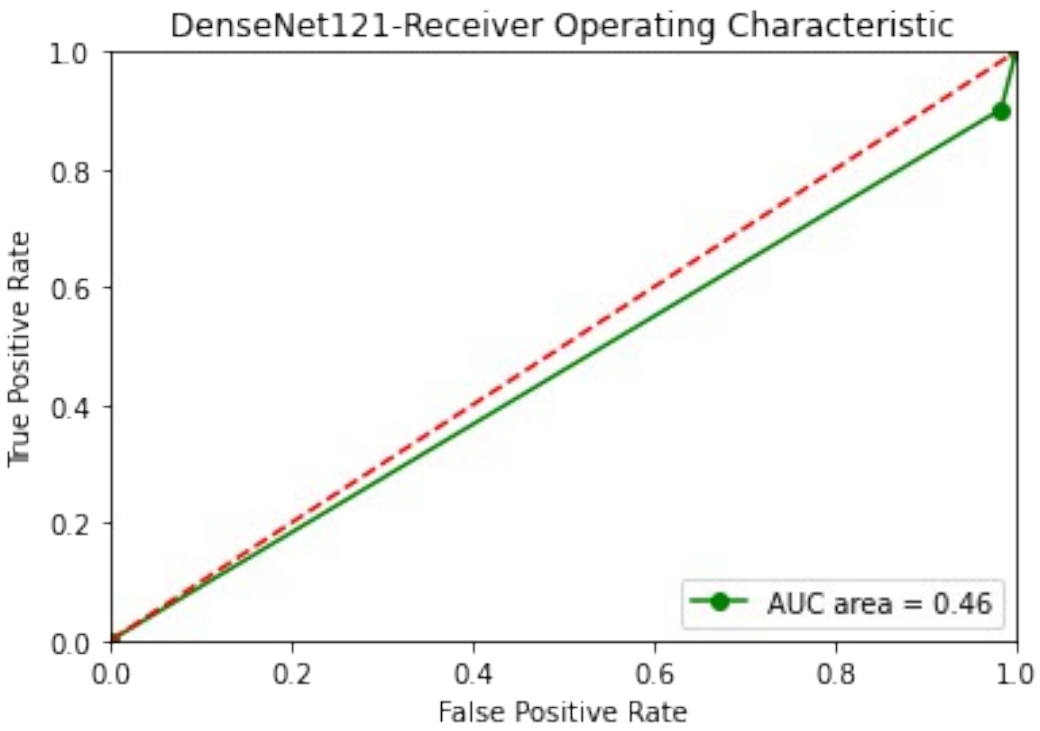
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_DenseNet121 = auc(fpr_keras, tpr_keras)
auc_keras_DenseNet121 #auc score
```

```
0.45925527175527175
```

```
import matplotlib.pyplot as plt
plt.title('DenseNet121-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_DenseNet121)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```



Model-EfficientNetB2

```
from tensorflow.keras.applications.efficientnet import EfficientNetB2

input_shape=(224,224,3)



head_model = EfficientNetB2(include_top=False,
                  weights='imagenet',
                  #input_tensor=None,
                  input_shape=input_shape)
                  #pooling='avg',
                  #classes=2,
                  #classifier_activation='softmax')



for layer in head_model.layers:
  layer.trainable = False #trainable are the last three layers until
flatten (the whole set of fully connected layers)


x = layers.Flatten()(head_model.output) #google: how to cut off a pre
train model resnet and add fully connected layers in tensorflow
x = layers.Dense(1000, activation='relu')(x)
predictions = layers.Dense(2, activation = 'softmax')(x)
```

```
model = Model(inputs = head_model.input, outputs = predictions)
```

```
model.compile(optimizer=tf.keras.optimizers.Adam(0.00001),
              loss=SparseCategoricalCrossentropy(from_logits=True),
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])

history=model.fit(
    X_train,Y_train,
    epochs=1000, #can change the epoch
    validation_split=0.15, verbose=1,callbacks=[es])
```

```
Downloading data from https://storage.googleapis.com/keras-
applications/efficientnetb2_notop.h5
31793152/31790344 [==============================] - 2s 0us/step
31801344/31790344 [==============================] - 2s 0us/step
Epoch 1/1000

/usr/local/lib/python3.7/dist-packages/tensorflow/python/util/
dispatch.py:1082: UserWarning: "`sparse_categorical_crossentropy`
received `from_logits=True`, but the `output` argument was produced by
a sigmoid or softmax activation and thus does not represent logits.
Was this intended?"
  return dispatch_target(*args, **kwargs)

71/71 [==============================] - 21s 171ms/step - loss: 0.8490
- sparse_categorical_accuracy: 0.5078 - val_loss: 0.9522 -
val_sparse_categorical_accuracy: 0.4545
Epoch 2/1000
71/71 [==============================] - 8s 115ms/step - loss: 0.8297
- sparse_categorical_accuracy: 0.5047 - val_loss: 1.4095 -
val_sparse_categorical_accuracy: 0.4545
Epoch 3/1000
71/71 [==============================] - 8s 119ms/step - loss: 0.7882
- sparse_categorical_accuracy: 0.5185 - val_loss: 0.8501 -
val_sparse_categorical_accuracy: 0.5455
Epoch 4/1000
71/71 [==============================] - 8s 115ms/step - loss: 0.7290
- sparse_categorical_accuracy: 0.5065 - val_loss: 0.7502 -
val_sparse_categorical_accuracy: 0.5455
Epoch 5/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7866
- sparse_categorical_accuracy: 0.5176 - val_loss: 1.2078 -
val_sparse_categorical_accuracy: 0.4545
Epoch 6/1000
```

```
71/71 [==============================] - 8s 119ms/step - loss: 0.9234
- sparse_categorical_accuracy: 0.5033 - val_loss: 0.6930 -
val_sparse_categorical_accuracy: 0.6364
Epoch 7/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7276
- sparse_categorical_accuracy: 0.5163 - val_loss: 0.8210 -
val_sparse_categorical_accuracy: 0.5455
Epoch 8/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7409
- sparse_categorical_accuracy: 0.5056 - val_loss: 0.7355 -
val_sparse_categorical_accuracy: 0.4545
Epoch 9/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7443
- sparse_categorical_accuracy: 0.5234 - val_loss: 0.8093 -
val_sparse_categorical_accuracy: 0.5455
Epoch 10/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7718
- sparse_categorical_accuracy: 0.5100 - val_loss: 0.8167 -
val_sparse_categorical_accuracy: 0.5455
Epoch 11/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7253
- sparse_categorical_accuracy: 0.5163 - val_loss: 0.8030 -
val_sparse_categorical_accuracy: 0.5455
Epoch 12/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7430
- sparse_categorical_accuracy: 0.5078 - val_loss: 0.7645 -
val_sparse_categorical_accuracy: 0.4545
Epoch 13/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7390
- sparse_categorical_accuracy: 0.4993 - val_loss: 0.7590 -
val_sparse_categorical_accuracy: 0.4545
Epoch 14/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7466
- sparse_categorical_accuracy: 0.5154 - val_loss: 0.7849 -
val_sparse_categorical_accuracy: 0.4545
Epoch 15/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7647
- sparse_categorical_accuracy: 0.5042 - val_loss: 1.1556 -
val_sparse_categorical_accuracy: 0.4545
Epoch 16/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.9167
- sparse_categorical_accuracy: 0.5083 - val_loss: 0.6961 -
val_sparse_categorical_accuracy: 0.5455
Epoch 17/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7102
- sparse_categorical_accuracy: 0.5199 - val_loss: 1.0466 -
val_sparse_categorical_accuracy: 0.5455
Epoch 18/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7498
- sparse_categorical_accuracy: 0.5154 - val_loss: 0.9006 -
```

```
val_sparse_categorical_accuracy: 0.5455
Epoch 19/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.8083
- sparse_categorical_accuracy: 0.4989 - val_loss: 0.9474 -
val_sparse_categorical_accuracy: 0.4545
Epoch 20/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7687
- sparse_categorical_accuracy: 0.5020 - val_loss: 1.0222 -
val_sparse_categorical_accuracy: 0.4545
Epoch 21/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7646
- sparse_categorical_accuracy: 0.5047 - val_loss: 0.8583 -
val_sparse_categorical_accuracy: 0.4545
Epoch 22/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7836
- sparse_categorical_accuracy: 0.5083 - val_loss: 0.8403 -
val_sparse_categorical_accuracy: 0.5455
Epoch 23/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7633
- sparse_categorical_accuracy: 0.5029 - val_loss: 0.9751 -
val_sparse_categorical_accuracy: 0.5455
Epoch 24/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.8207
- sparse_categorical_accuracy: 0.5100 - val_loss: 0.6962 -
val_sparse_categorical_accuracy: 0.5455
Epoch 25/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7663
- sparse_categorical_accuracy: 0.5266 - val_loss: 0.8271 -
val_sparse_categorical_accuracy: 0.4545
Epoch 26/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7355
- sparse_categorical_accuracy: 0.5083 - val_loss: 0.6965 -
val_sparse_categorical_accuracy: 0.5455
Epoch 27/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7316
- sparse_categorical_accuracy: 0.5038 - val_loss: 1.0037 -
val_sparse_categorical_accuracy: 0.5455
Epoch 28/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8083
- sparse_categorical_accuracy: 0.4868 - val_loss: 0.9011 -
val_sparse_categorical_accuracy: 0.4545
Epoch 29/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7246
- sparse_categorical_accuracy: 0.5207 - val_loss: 0.7981 -
val_sparse_categorical_accuracy: 0.5455
Epoch 30/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7217
- sparse_categorical_accuracy: 0.5203 - val_loss: 0.9915 -
val_sparse_categorical_accuracy: 0.4545
Epoch 31/1000
```

```
71/71 [==============================] - 8s 116ms/step - loss: 0.7802
- sparse_categorical_accuracy: 0.5033 - val_loss: 0.8069 -
val_sparse_categorical_accuracy: 0.5455
Epoch 32/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7623
- sparse_categorical_accuracy: 0.4935 - val_loss: 0.7876 -
val_sparse_categorical_accuracy: 0.4545
Epoch 33/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8164
- sparse_categorical_accuracy: 0.4967 - val_loss: 1.0616 -
val_sparse_categorical_accuracy: 0.4545
Epoch 34/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8052
- sparse_categorical_accuracy: 0.5074 - val_loss: 0.7162 -
val_sparse_categorical_accuracy: 0.5455
Epoch 35/1000
71/71 [==============================] - 8s 118ms/step - loss: 0.7483
- sparse_categorical_accuracy: 0.5105 - val_loss: 0.6883 -
val_sparse_categorical_accuracy: 0.5455
Epoch 36/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7471
- sparse_categorical_accuracy: 0.5091 - val_loss: 0.8847 -
val_sparse_categorical_accuracy: 0.4545
Epoch 37/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7660
- sparse_categorical_accuracy: 0.5167 - val_loss: 1.0650 -
val_sparse_categorical_accuracy: 0.5455
Epoch 38/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7467
- sparse_categorical_accuracy: 0.5029 - val_loss: 0.8792 -
val_sparse_categorical_accuracy: 0.5455
Epoch 39/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7956
- sparse_categorical_accuracy: 0.5181 - val_loss: 0.9085 -
val_sparse_categorical_accuracy: 0.4545
Epoch 40/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7595
- sparse_categorical_accuracy: 0.5033 - val_loss: 0.9629 -
val_sparse_categorical_accuracy: 0.4545
Epoch 41/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7852
- sparse_categorical_accuracy: 0.5033 - val_loss: 0.8233 -
val_sparse_categorical_accuracy: 0.5455
Epoch 42/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7439
- sparse_categorical_accuracy: 0.5105 - val_loss: 0.8769 -
val_sparse_categorical_accuracy: 0.5455
Epoch 43/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7360
- sparse_categorical_accuracy: 0.4993 - val_loss: 0.8057 -
```

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val_sparse_categorical_accuracy: 0.5455
Epoch 44/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7368
- sparse_categorical_accuracy: 0.5051 - val_loss: 0.7030 -
val_sparse_categorical_accuracy: 0.5455
Epoch 45/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7450
- sparse_categorical_accuracy: 0.5212 - val_loss: 1.0699 -
val_sparse_categorical_accuracy: 0.5455
Epoch 46/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7565
- sparse_categorical_accuracy: 0.5167 - val_loss: 0.7044 -
val_sparse_categorical_accuracy: 0.5455
Epoch 47/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7355
- sparse_categorical_accuracy: 0.5123 - val_loss: 0.8247 -
val_sparse_categorical_accuracy: 0.4545
Epoch 48/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8128
- sparse_categorical_accuracy: 0.5127 - val_loss: 0.7902 -
val_sparse_categorical_accuracy: 0.5455
Epoch 49/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7682
- sparse_categorical_accuracy: 0.5181 - val_loss: 0.6880 -
val_sparse_categorical_accuracy: 0.5455
Epoch 50/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8005
- sparse_categorical_accuracy: 0.5065 - val_loss: 0.8025 -
val_sparse_categorical_accuracy: 0.5455
Epoch 51/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7829
- sparse_categorical_accuracy: 0.5038 - val_loss: 1.2446 -
val_sparse_categorical_accuracy: 0.5455
Epoch 52/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8062
- sparse_categorical_accuracy: 0.4859 - val_loss: 0.9100 -
val_sparse_categorical_accuracy: 0.5455
Epoch 53/1000
71/71 [==============================] - 8s 118ms/step - loss: 0.7870
- sparse_categorical_accuracy: 0.5060 - val_loss: 0.7744 -
val_sparse_categorical_accuracy: 0.5455
Epoch 54/1000
71/71 [==============================] - 8s 118ms/step - loss: 0.7155
- sparse_categorical_accuracy: 0.4984 - val_loss: 0.8690 -
val_sparse_categorical_accuracy: 0.5455
Epoch 55/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7274
- sparse_categorical_accuracy: 0.5100 - val_loss: 0.7456 -
val_sparse_categorical_accuracy: 0.5455
Epoch 56/1000
```

```
71/71 [==============================] - 8s 117ms/step - loss: 0.7399
- sparse_categorical_accuracy: 0.5248 - val_loss: 0.6927 -
val_sparse_categorical_accuracy: 0.4545
Epoch 57/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7612
- sparse_categorical_accuracy: 0.5083 - val_loss: 1.1728 -
val_sparse_categorical_accuracy: 0.4545
Epoch 58/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8165
- sparse_categorical_accuracy: 0.5207 - val_loss: 1.4861 -
val_sparse_categorical_accuracy: 0.5455
Epoch 59/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8564
- sparse_categorical_accuracy: 0.4913 - val_loss: 0.7821 -
val_sparse_categorical_accuracy: 0.5455
Epoch 60/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7710
- sparse_categorical_accuracy: 0.5199 - val_loss: 0.6935 -
val_sparse_categorical_accuracy: 0.4545
Epoch 61/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7142
- sparse_categorical_accuracy: 0.5136 - val_loss: 0.7751 -
val_sparse_categorical_accuracy: 0.5455
Epoch 62/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8138
- sparse_categorical_accuracy: 0.5069 - val_loss: 0.7537 -
val_sparse_categorical_accuracy: 0.4545
Epoch 63/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7516
- sparse_categorical_accuracy: 0.5078 - val_loss: 1.0475 -
val_sparse_categorical_accuracy: 0.5455
Epoch 64/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7484
- sparse_categorical_accuracy: 0.5185 - val_loss: 0.8220 -
val_sparse_categorical_accuracy: 0.5455
Epoch 65/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7541
- sparse_categorical_accuracy: 0.5100 - val_loss: 0.7248 -
val_sparse_categorical_accuracy: 0.4545
Epoch 66/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7290
- sparse_categorical_accuracy: 0.5127 - val_loss: 0.7267 -
val_sparse_categorical_accuracy: 0.4545
Epoch 67/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7253
- sparse_categorical_accuracy: 0.5172 - val_loss: 0.8980 -
val_sparse_categorical_accuracy: 0.5455
Epoch 68/1000
71/71 [==============================] - 8s 116ms/step - loss: 0.7843
- sparse_categorical_accuracy: 0.4998 - val_loss: 0.7749 -
```

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val_sparse_categorical_accuracy: 0.4545
Epoch 69/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7549
- sparse_categorical_accuracy: 0.5118 - val_loss: 0.8472 -
val_sparse_categorical_accuracy: 0.4545
Epoch 70/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7761
- sparse_categorical_accuracy: 0.4904 - val_loss: 0.9246 -
val_sparse_categorical_accuracy: 0.5455
Epoch 71/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7431
- sparse_categorical_accuracy: 0.5239 - val_loss: 1.1916 -
val_sparse_categorical_accuracy: 0.4545
Epoch 72/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8063
- sparse_categorical_accuracy: 0.5096 - val_loss: 1.5684 -
val_sparse_categorical_accuracy: 0.5455
Epoch 73/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8207
- sparse_categorical_accuracy: 0.5025 - val_loss: 0.7360 -
val_sparse_categorical_accuracy: 0.4545
Epoch 74/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7631
- sparse_categorical_accuracy: 0.5047 - val_loss: 0.7499 -
val_sparse_categorical_accuracy: 0.4545
Epoch 75/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7466
- sparse_categorical_accuracy: 0.5033 - val_loss: 0.7578 -
val_sparse_categorical_accuracy: 0.4545
Epoch 76/1000
71/71 [==============================] - 8s 118ms/step - loss: 0.7749
- sparse_categorical_accuracy: 0.4980 - val_loss: 0.9213 -
val_sparse_categorical_accuracy: 0.5455
Epoch 77/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7296
- sparse_categorical_accuracy: 0.5149 - val_loss: 0.6877 -
val_sparse_categorical_accuracy: 0.5455
Epoch 78/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7532
- sparse_categorical_accuracy: 0.5038 - val_loss: 0.9298 -
val_sparse_categorical_accuracy: 0.4545
Epoch 79/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7524
- sparse_categorical_accuracy: 0.5154 - val_loss: 0.7104 -
val_sparse_categorical_accuracy: 0.5455
Epoch 80/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7151
- sparse_categorical_accuracy: 0.5252 - val_loss: 0.9056 -
val_sparse_categorical_accuracy: 0.5455
Epoch 81/1000
```

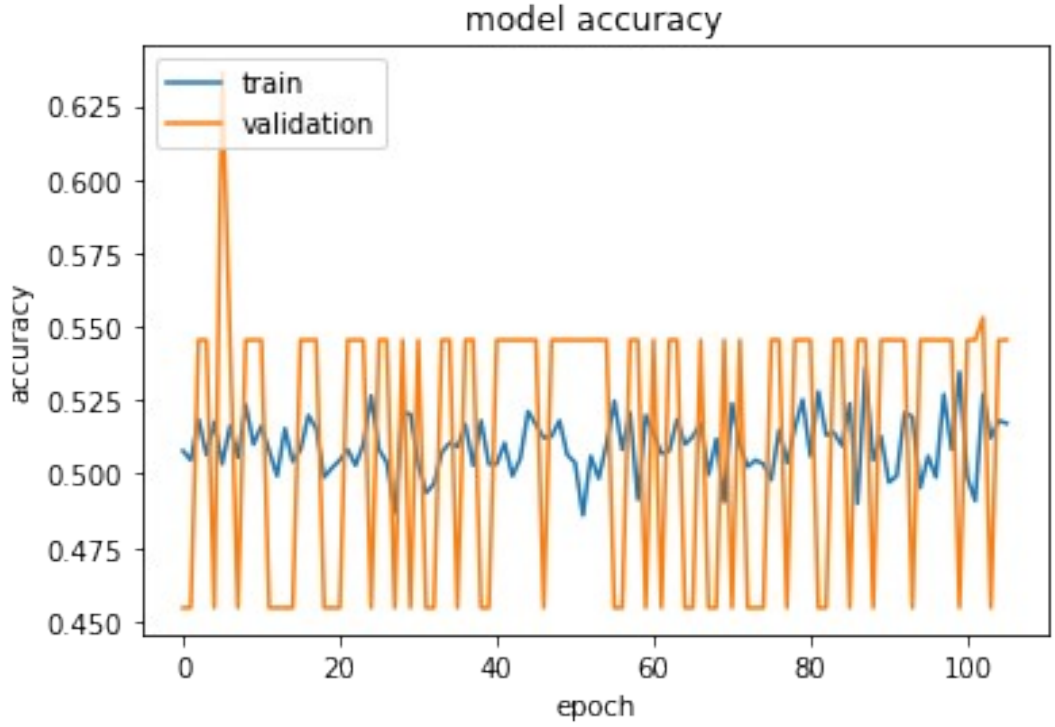
```
71/71 [==============================] - 8s 117ms/step - loss: 0.7732
- sparse_categorical_accuracy: 0.5060 - val_loss: 0.6885 -
val_sparse_categorical_accuracy: 0.5455
Epoch 82/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7138
- sparse_categorical_accuracy: 0.5279 - val_loss: 0.6988 -
val_sparse_categorical_accuracy: 0.4545
Epoch 83/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7510
- sparse_categorical_accuracy: 0.5132 - val_loss: 0.7006 -
val_sparse_categorical_accuracy: 0.4545
Epoch 84/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7255
- sparse_categorical_accuracy: 0.5141 - val_loss: 0.8042 -
val_sparse_categorical_accuracy: 0.5455
Epoch 85/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7502
- sparse_categorical_accuracy: 0.5096 - val_loss: 0.8413 -
val_sparse_categorical_accuracy: 0.5455
Epoch 86/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7428
- sparse_categorical_accuracy: 0.5239 - val_loss: 1.2022 -
val_sparse_categorical_accuracy: 0.4545
Epoch 87/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8205
- sparse_categorical_accuracy: 0.4900 - val_loss: 0.7614 -
val_sparse_categorical_accuracy: 0.5455
Epoch 88/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7065
- sparse_categorical_accuracy: 0.5359 - val_loss: 0.7816 -
val_sparse_categorical_accuracy: 0.5455
Epoch 89/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7443
- sparse_categorical_accuracy: 0.5047 - val_loss: 1.1240 -
val_sparse_categorical_accuracy: 0.4545
Epoch 90/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7996
- sparse_categorical_accuracy: 0.5127 - val_loss: 0.7481 -
val_sparse_categorical_accuracy: 0.5455
Epoch 91/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7208
- sparse_categorical_accuracy: 0.4971 - val_loss: 1.0106 -
val_sparse_categorical_accuracy: 0.5455
Epoch 92/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7772
- sparse_categorical_accuracy: 0.4993 - val_loss: 0.8063 -
val_sparse_categorical_accuracy: 0.5455
Epoch 93/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7177
- sparse_categorical_accuracy: 0.5207 - val_loss: 0.6994 -
```

```
val_sparse_categorical_accuracy: 0.5455
Epoch 94/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7270
- sparse_categorical_accuracy: 0.5194 - val_loss: 0.9005 -
val_sparse_categorical_accuracy: 0.4545
Epoch 95/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7570
- sparse_categorical_accuracy: 0.4953 - val_loss: 1.1767 -
val_sparse_categorical_accuracy: 0.5455
Epoch 96/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7560
- sparse_categorical_accuracy: 0.5060 - val_loss: 0.9138 -
val_sparse_categorical_accuracy: 0.5455
Epoch 97/1000
71/71 [==============================] - 8s 118ms/step - loss: 0.7520
- sparse_categorical_accuracy: 0.4989 - val_loss: 0.9272 -
val_sparse_categorical_accuracy: 0.5455
Epoch 98/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7596
- sparse_categorical_accuracy: 0.5270 - val_loss: 0.9191 -
val_sparse_categorical_accuracy: 0.5455
Epoch 99/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7600
- sparse_categorical_accuracy: 0.5083 - val_loss: 0.7311 -
val_sparse_categorical_accuracy: 0.5455
Epoch 100/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7600
- sparse_categorical_accuracy: 0.5346 - val_loss: 0.8247 -
val_sparse_categorical_accuracy: 0.4545
Epoch 101/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7872
- sparse_categorical_accuracy: 0.4989 - val_loss: 0.7713 -
val_sparse_categorical_accuracy: 0.5455
Epoch 102/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.8215
- sparse_categorical_accuracy: 0.4909 - val_loss: 0.7254 -
val_sparse_categorical_accuracy: 0.5455
Epoch 103/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7295
- sparse_categorical_accuracy: 0.5270 - val_loss: 0.6913 -
val_sparse_categorical_accuracy: 0.5530
Epoch 104/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7273
- sparse_categorical_accuracy: 0.5123 - val_loss: 0.7031 -
val_sparse_categorical_accuracy: 0.4545
Epoch 105/1000
71/71 [==============================] - 8s 117ms/step - loss: 0.7314
- sparse_categorical_accuracy: 0.5181 - val_loss: 0.8623 -
val_sparse_categorical_accuracy: 0.5455
Epoch 106/1000
```

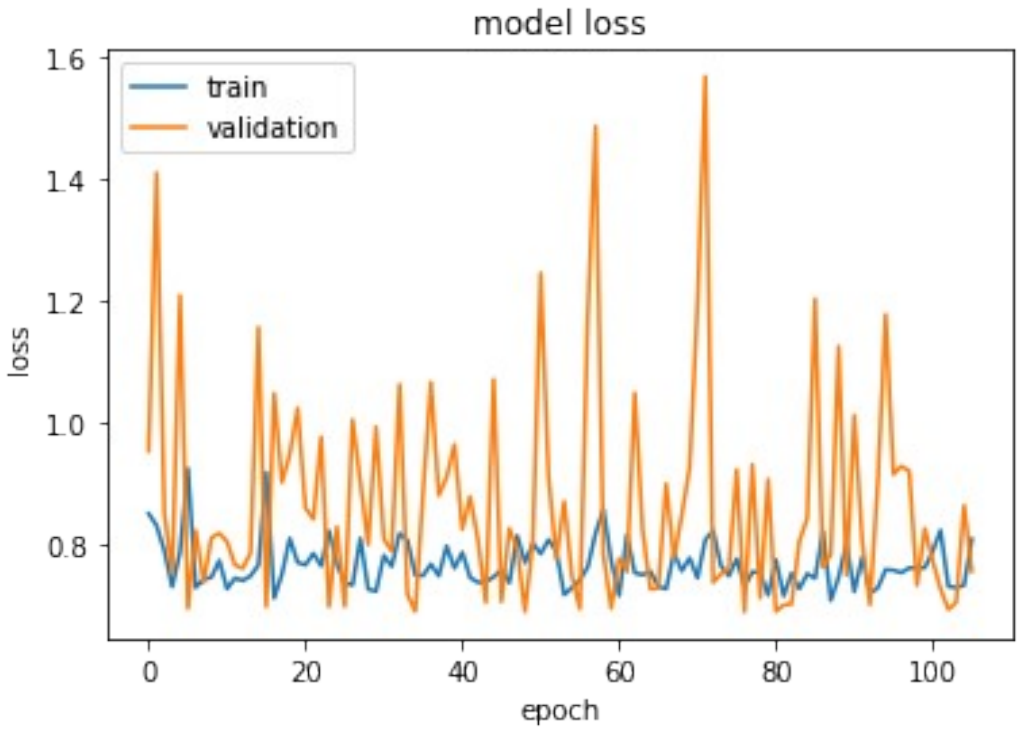
```
70/71 [============================>.] - ETA: 0s - loss: 0.8070 -
sparse_categorical_accuracy: 0.5170Restoring model weights from the
end of the best epoch: 6.
71/71 [==============================] - 9s 120ms/step - loss: 0.8068
- sparse_categorical_accuracy: 0.5172 - val_loss: 0.7545 -
val_sparse_categorical_accuracy: 0.5455
Epoch 106: early stopping
```

```
model.save('/content/drive/MyDrive/EfficientNetB2_model.h5')
```

```
plt.plot(history.history['sparse_categorical_accuracy'])
plt.plot(history.history['val_sparse_categorical_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```




```
y_pred=model.predict(X_test)
y_pred
```

```
array([[0.24647109, 0.75352895],
       [0.07895396, 0.921046  ],
       [0.06984871, 0.93015134],
       ...,
       [0.3486227 , 0.65137726],
       [0.4062755 , 0.5937245 ],
       [0.08687673, 0.9131233 ]], dtype=float32)
```

```
lst=[]

for i in range(0,len(y_pred)):
     k=np.argmax(y_pred[i]) #it gives index value of the highest
probability for each iteration
     print(k)
     lst.append(k)

y_pred_label=np.array(lst)
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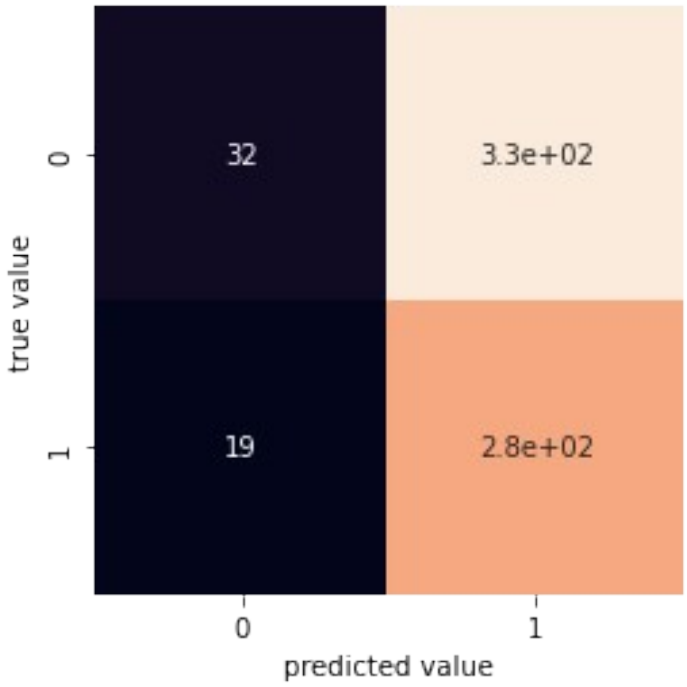
```

```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import plot_confusion_matrix

mat = confusion_matrix(Y_test, y_pred_label) #we dont do this because
we dont get the whole number on the confusion matrixis to fet the
whole number annotation
sns.heatmap(mat, square=True, annot=True, cbar=False)
plt.xlabel('predicted value')
plt.ylabel('true value');
```




```
from sklearn.metrics import accuracy_score, precision_score,
recall_score, f1_score


print('Accuracy: %.3f' % accuracy_score(y_true=Y_test,
y_pred=y_pred_label))
print('Precision: %.3f' % precision_score(y_true=Y_test,
y_pred=y_pred_label))
print('Recall: %.3f' % recall_score(y_true=Y_test,
y_pred=y_pred_label))
print('F1: %.3f' % f1_score(y_true=Y_test, y_pred=y_pred_label))
```

```
Accuracy: 0.468
Precision: 0.455
```

```
Recall: 0.936
F1: 0.612
```

```
from sklearn import metrics

# Model f1_score: how often is the classifier correct?
EfficientNetB2_f1_score=metrics.f1_score(Y_test, y_pred_label)



print("F1_score:",EfficientNetB2_f1_score)
```

```
F1_score: 0.6121546961325968
```

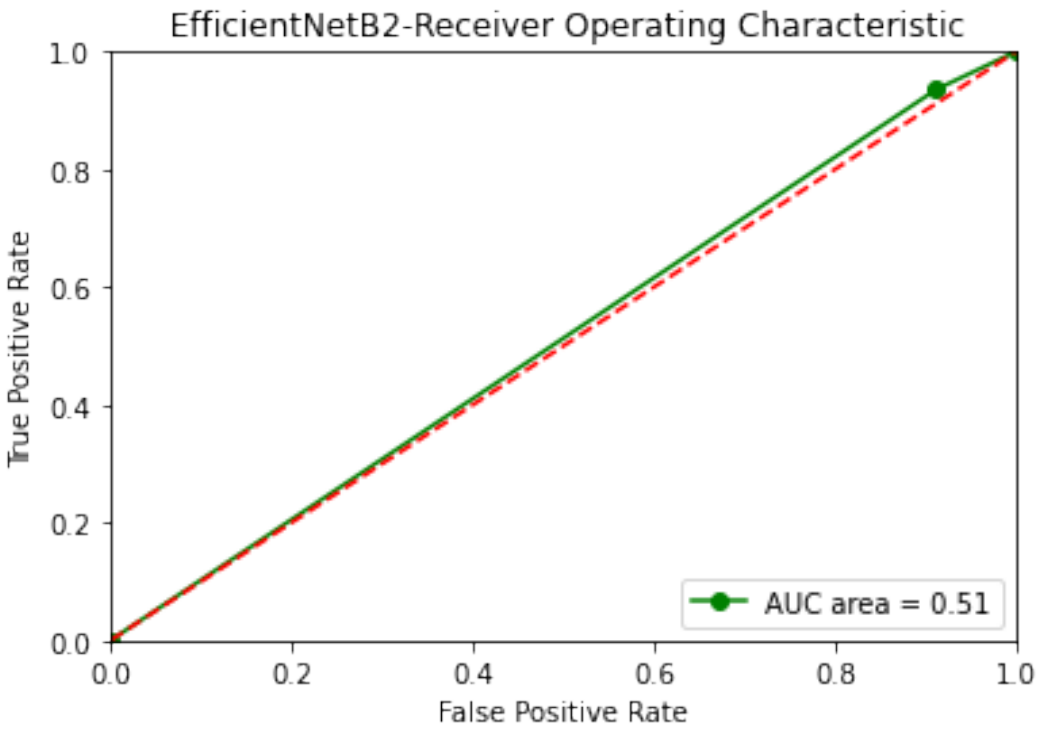
```
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
fpr_keras, tpr_keras, thresholds_keras = roc_curve(Y_test,
y_pred_label)


auc_keras_EfficientNetB2 = auc(fpr_keras, tpr_keras)
auc_keras_EfficientNetB2 #auc score
```

```
0.5118614493614494
```

```
import matplotlib.pyplot as plt
plt.title(' EfficientNetB2-Receiver Operating Characteristic')
plt.plot(fpr_keras, tpr_keras, color='green',marker='o', label = 'AUC
area = %0.2f' % auc_keras_EfficientNetB2)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--') #diagonal line
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
```

```
Text(0.5, 0, 'False Positive Rate')
```

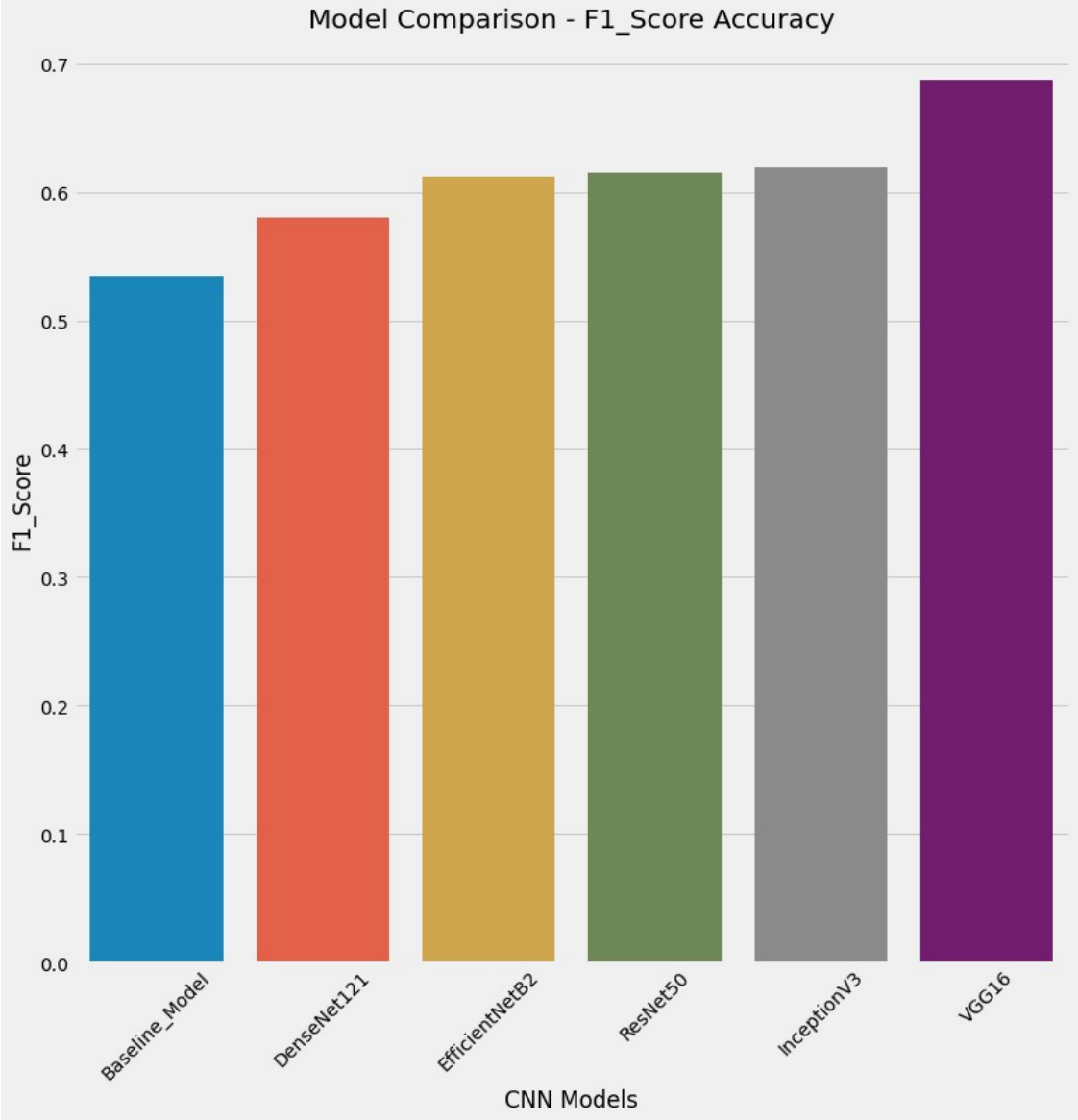


Comparison

```
F1_score_list=[baseline_f1_score,Resnet_f1_score,InceptionV3_f1_score,
VGG16_f1_score,DenseNet121_f1_score,EfficientNetB2_f1_score]
F1_score_list.sort()
print(F1_score_list)
classifier_names_list=["Baseline_Model","DenseNet121","EfficientNetB2"
,"ResNet50","InceptionV3","VGG16"]
```

```
[0.5346534653465346, 0.5798045602605864, 0.6121546961325968,
0.6147368421052632, 0.6192468619246861, 0.687402799377916]
```

```
plt.style.use("fivethirtyeight")
plt.figure(figsize=(12, 12))
sns.barplot(x=classifier_names_list, y=F1_score_list)
plt.xlabel("CNN Models")
plt.ylabel("F1_Score")
plt.xticks(rotation=45)
plt.title("Model Comparison - F1_Score Accuracy")
plt.show()
```


Model Comparison - F1_Score Accuracy
F1_Score
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Baseline_Model
DenseNet121
EfficientNetB2
ResNet50
InceptionV3
VGG16
CNN Models