FINAL PROJECT - DOG BREED DETECTION

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IMPORTS

In [45]:
```
import tensorflow as tf
from tensorflow.keras import layers
from tensorflow.python.client import device_lib

import cv2
import re
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import os
from time import time
import shutil
import sys
from IPython.display import display, Image

from sklearn.metrics import auc
from sklearn.metrics import roc_curve


from keras import layers
from keras import models
from keras import optimizers
from keras.preprocessing.image import ImageDataGenerator


from tensorflow.keras.callbacks import TensorBoard
from tensorflow.python.eager import context

from keras.preprocessing import image
from keras.utils import layer_utils
from keras.utils.data_utils import get_file
from keras.applications.imagenet_utils import preprocess_input
from keras.callbacks import TensorBoard

from keras.layers import Input, Dense, Activation, ZeroPadding2D, BatchNormalizat
from keras.layers import AveragePooling2D, MaxPooling2D, Dropout
from keras.models import Model, Sequential
from keras.optimizers import Adam,RMSprop,SGD
from sklearn.metrics import roc_curve, auc, precision_recall_curve, average_preci
from sklearn.metrics import confusion_matrix, classification_report, precision_re

from keras import backend as K
if K.backend()=='tensorflow':
    K.set_image_data_format('channels_last')

# Config the matlotlib backend as plotting inline in IPython
%matplotlib inline

print("Tensorflow is installed and is version: ",  tf.__version__)
print("Keras is installed and is version: ", tf.keras.__version__)

with tf.device('/gpu:0'):
    a = tf.constant([1.0, 2.0, 3.0, 4.0, 5.0, 6.0], shape=[2, 3], name='a')
    b = tf.constant([1.0, 2.0, 3.0, 4.0, 5.0, 6.0], shape=[3, 2], name='b')
    c = tf.matmul(a, b)
```

```
with tf.Session() as sess:
    print (sess.run(c))

print(sys.version)
print(device_lib.list_local_devices())

# special matplotlib command for global plot configuration
from matplotlib import rcParams
import matplotlib.cm as cm
import matplotlib as mpl
from matplotlib.colors import ListedColormap
from mpl_toolkits.mplot3d import Axes3D

dark2_colors = [(0.10588235294117647, 0.6196078431372549, 0.4666666666666667),
                (0.9058823529411765, 0.1607843137254902, 0.5411764705882353),
                (0.8509803921568627, 0.37254901960784315, 0.00784313725490196),
                (0.4588235294117647, 0.4392156862745098, 0.7019607843137254),
                (0.4, 0.6509803921568628, 0.11764705882352941),
                (0.9019607843137255, 0.6705882352941176, 0.00784313725490196),
                (0.6509803921568628, 0.4627450980392157, 0.11372549019607843)]

cmap_set1 = ListedColormap(['#e41a1c', '#377eb8', '#4daf4a'])
dark2_cmap=ListedColormap(dark2_colors)

def set_mpl_params():
    rcParams['figure.figsize'] = (12, 6)
    rcParams['figure.dpi'] = 100
    rcParams['axes.prop_cycle'].by_key()['color'][1]
    rcParams['lines.linewidth'] = 2
    rcParams['axes.facecolor'] = 'white'
    rcParams['font.size'] = 14
    rcParams['patch.edgecolor'] = 'white'
    rcParams['patch.facecolor'] = dark2_colors[0]
    rcParams['font.family'] = 'StixGeneral'

set_mpl_params()
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)
<ipython-input-45-e3c6cc03a758> in <module>()
      3 from tensorflow.python.client import device_lib
      4
----> 5 import cv2
      6 import re
      7 import matplotlib.pyplot as plt

ModuleNotFoundError: No module named 'cv2'
```

Some General Functions used in various places

In [43]:
```
# TO CREATE THE LOGS FOR TENSOR BOARD
class TrainValTensorBoard(TensorBoard):
    def __init__(self, log_dir='./logs', **kwargs):
        # Make the original `TensorBoard` log to a subdirectory 'training'
        training_log_dir = os.path.join(log_dir, 'training')
        super(TrainValTensorBoard, self).__init__(training_log_dir, **kwargs)

        # Log the validation metrics to a separate subdirectory
        self.val_log_dir = os.path.join(log_dir, 'validation')

    def set_model(self, model):
        # Setup writer for validation metrics
        self.val_writer = tf.summary.FileWriter(self.val_log_dir)
        super(TrainValTensorBoard, self).set_model(model)

    def on_epoch_end(self, epoch, logs=None):
        # Pop the validation logs and handle them separately with
        # `self.val_writer`. Also rename the keys so that they can
        # be plotted on the same figure with the training metrics
        logs = logs or {}
        val_logs = {k.replace('val_', ''): v for k, v in logs.items() if k.starts
        for name, value in val_logs.items():
            summary = tf.Summary()
            summary_value = summary.value.add()
            summary_value.simple_value = value.item()
            summary_value.tag = name
            self.val_writer.add_summary(summary, epoch)
        self.val_writer.flush()

        # Pass the remaining logs to `TensorBoard.on_epoch_end`
        logs = {k: v for k, v in logs.items() if not k.startswith('val_')}
        super(TrainValTensorBoard, self).on_epoch_end(epoch, logs)

    def on_train_end(self, logs=None):
        super(TrainValTensorBoard, self).on_train_end(logs)
        self.val_writer.close()

# PLOT ACCURACY AND LOSS CHARTS FOR THE MODELS AS THEY TRAIN
def plot_accuracies_loss(history):
    acc = history.history['acc']
    val_acc = history.history['val_acc']
    loss = history.history['loss']
    val_loss = history.history['val_loss']

    epochs = range(len(acc))

    plt.plot(epochs, acc, 'g-', label='Training acc', color = 'brown')
    plt.plot(epochs, val_acc, 'g-', label='Validation acc', color = 'orange')
    plt.xlabel("Num of Epochs")
    plt.ylabel("Accuracy")
    plt.title('Training and validation accuracy')
    plt.legend()

    plt.figure()

    plt.plot(epochs, loss, 'g-', label='Training loss', color = 'brown')
```

```
    plt.plot(epochs, val_loss, 'g-', label='Validation loss', color = 'orange')
    plt.xlabel("Num of Epochs")
    plt.ylabel("Loss")
    plt.title('Training and validation loss')
    plt.legend()
    plt.show()



# TO SHOW CONFUSION MATRIX
def show_confusion_matrix(cm, target_names):
    plt.figure(figsize=(10, 10))
    plt.imshow(cm, interpolation='nearest', cmap=plt.cm.binary)
    plt.title('Confusion matrix')
    plt.set_cmap('Blues')
    plt.colorbar()
    tick_marks = np.arange(len(target_names))
    plt.xticks(tick_marks, target_names, rotation=90)
    plt.yticks(tick_marks, target_names)
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.show()

# SHOW RESULTS OF CLASSIFICATION
def show_results(model, test_generator):
    # GET ACCURACY SCORE ON THE TEST SET
    test_loss, test_acc = model.evaluate_generator(test_generator, steps=100)
    print('\nTEST accuracy:', test_acc)
    print('TEST loss:', test_loss)
    predictions = []
    labels = []
    indexes = []

    i = 0

    for data_batch, labels_batch in test_generator:
        labels.extend(labels_batch)
        predictions.extend(model.predict_classes(data_batch))
        i = i + 1
        if i==len(test_generator):
            break

    for i in range (len(test_generator)):
        indexes.extend(next(test_generator.index_generator))

    labels = [np.where(r==1)[0][0] for r in labels]
    #print("Lables:")
    #print(labels)
    #print("Predictions:")
    #print(predictions)
    print('\nConfusion Matrix')
    cm = confusion_matrix(labels, predictions)
    print(cm)
    print('\nClassification Report')
    target_names = [*test_generator.class_indices.keys()]
    print(classification_report(labels, predictions, target_names=target_names))
    show_confusion_matrix(cm, target_names)
```

```
# FUNCTION TO CHANGE THE DIRECTORY NAMES
def change_directory_names (path, change = False):
    files = os.listdir(path)
    for f in files:
        # check if the file name has numbers
        has_number = re.search(r'\d+', f)
        if has_number != None:
            src = os.path.join(path,f)
            print("\nSrc:%s"%src)

            f_prime = "-".join(f.split("-")[1:])
            if f_prime != "":
                dst = os.path.join(path,f_prime)
            else:
                dst = os.path.join(path,f)
            print("dst : %s\n"%dst)
            if change == True:
                print("Changing directory Name")
                shutil.move(src,dst)
        else :
            print("no numbers --> %s"%f)
    return


# Function to zoom into an image to improve accuracy scores
def resize_image(filename):
    img_org = cv2.imread(filename)
    #read in as black and white for processing
    img = cv2.imread(filename, 0)

    #gray = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
    gray = cv2.medianBlur(img,5)

    corners = cv2.goodFeaturesToTrack(gray,25,0.01,10)
    corners = np.int0(corners)

    xmin = 0
    ymin = 0
    xmax = 0
    ymax = 0
    for i in corners:
        x,y = i.ravel()
        if (xmin == 0): xmin = x
        if (x < xmin): xmin = x

        if (ymin == 0): ymin = y
        if (y < ymin): ymin = y

        if (xmax == 0): xmax = x
        if (x > xmax): xmax = x

        if (ymax == 0): ymax = y
        if (y > ymax): ymax = y

    crop_img = img_org[ymin:ymax, xmin:xmax]
```

```
    return crop_img
```

In [4]:
```
# CHANGING NAMES OF THE DIRECTORIES AND GETTING THE VALUES FOR THE DICT ENTRY
change_directory_names("./dog_images_all", change = True)
```

```
no numbers --> Doberman
no numbers --> schipperke
no numbers --> Border_terrier
no numbers --> Airedale
no numbers --> Old_English_sheepdog
no numbers --> Australian_terrier
no numbers --> Ibizan_hound
no numbers --> Scottish_deerhound
no numbers --> beagle
no numbers --> miniature_poodle
no numbers --> briard
no numbers --> Shih-Tzu
no numbers --> Irish_setter
no numbers --> toy_terrier
no numbers --> borzoi
no numbers --> Lhasa
no numbers --> American_Staffordshire_terrier
no numbers --> Border_collie
no numbers --> Pomeranian
```

Create Dog Directories and split train, validation & test

In [61]:

```
# CREATES THE DIRECTORY STRUCTURES WITH THE PROPER TRAINING, VALIDATION AND TEST S
def create_dog_images_dirs (base_images, dir_split_list):

    # Check if a list of dogs where provided if not return
    if (len(dir_split_list)) == 0:
        return

    # Create the basic directory paths for the three main dirs
    testval_dirs = os.path.join(os.path.dirname(base_images) ,'testval_dogs')
    train_d = os.path.join(testval_dirs,'train')
    val_d = os.path.join(testval_dirs,'validation')
    test_d = os.path.join(testval_dirs,'test')

    # Remove the old directories.
    if os.path.exists(testval_dirs):
            shutil.rmtree(testval_dirs)

    # Create new directories.
    os.makedirs(testval_dirs)
    os.makedirs(train_d)
    os.makedirs(val_d)
    os.makedirs(test_d)

    # Iterate through each dog
    for dog in dir_split_list:

        # Get the dogs name
        name = dog['name']

        # Create dirs with the name of the dog
        dog_train_dst = os.path.join(train_d, name)
        dog_val_dst = os.path.join(val_d, name)
        dog_test_dst = os.path.join(test_d, name)

        os.makedirs(dog_train_dst)
        os.makedirs(dog_val_dst)
        os.makedirs(dog_test_dst)

        # Collect info about this dogs directory and calculate the split numbers
        path, dirs, files = os.walk(os.path.join(base_images, name)).__next__()
        file_count = len(files)
        train_count = int(file_count * dog['train'])
        val_count = int(file_count * dog['val'])
        test_count = file_count - train_count - val_count

        # Copy the files
        for i, file in enumerate(files, start =1):
            if i <= train_count:
                shutil.copy(os.path.join(path, file),os.path.join(dog_train_dst,
            if i <= val_count:
                shutil.copy(os.path.join(path, file),os.path.join(dog_val_dst, fi
            if i <= test_count:
                shutil.copy(os.path.join(path, file),os.path.join(dog_test_dst, f
```

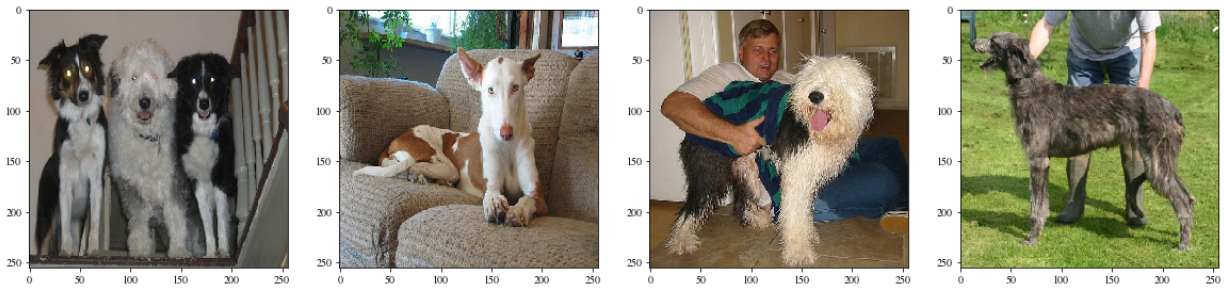
```
    return train_d, val_d, test_d



# Returns a dict of dogs. the number of dogs depends on count
def return_dict(path, trn, vl, tst, count):
    lst_dict = []
    files = os.listdir(path)
    for i, f in enumerate(files) :
        lst_dict.append({'name': f, 'train': trn, 'val': vl, 'test': tst})
        if i == (count-1):
            break
    return lst_dict


def dog_dict_list(path, trn, vl, tst, number_of_dogs):

    dogs_count = return_dict(path, trn, vl, tst, number_of_dogs)

    # ELSE NUM OF DOGS IS USED TO CHOOSE BETWEEN 2, 4, 8
    dogs2 = [{'name': 'golden_retriever', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'curly-coated_retriever', 'train': trn, 'val': vl, 'test':
            ]

    dogs4 = [{'name': 'golden_retriever', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'curly-coated_retriever', 'train': trn, 'val': vl, 'test':
             {'name': 'Japanese_spaniel', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'Chihuahua', 'train': trn, 'val': vl, 'test': tst}
            ]

    dogs8 = [{'name': 'golden_retriever', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'curly-coated_retriever', 'train': trn, 'val': vl, 'test':
             {'name': 'Australian_terrier', 'train': trn, 'val': vl, 'test': tst}
             {'name': 'Chihuahua', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'German_shepherd', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'Japanese_spaniel', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'Tibetan_mastiff', 'train': trn, 'val': vl, 'test': tst},
             {'name': 'toy_poodle', 'train': trn, 'val': vl, 'test': tst}
            ]


    if number_of_dogs == (2 | 4 | 8 ):
        if number_of_dogs == 2:
             dogs  = dogs2
        elif number_of_dogs == 4:
             dogs  = dogs4
        elif number_of_dogs== 8:
             dogs  = dogs8
    else:
        dogs  = dogs_count
    return dogs


def create_data_generatores(train_dir, validation_dir, test_dir):
    image_X = 128
    image_Y = 128
    # All images will be rescaled by 1./255
```

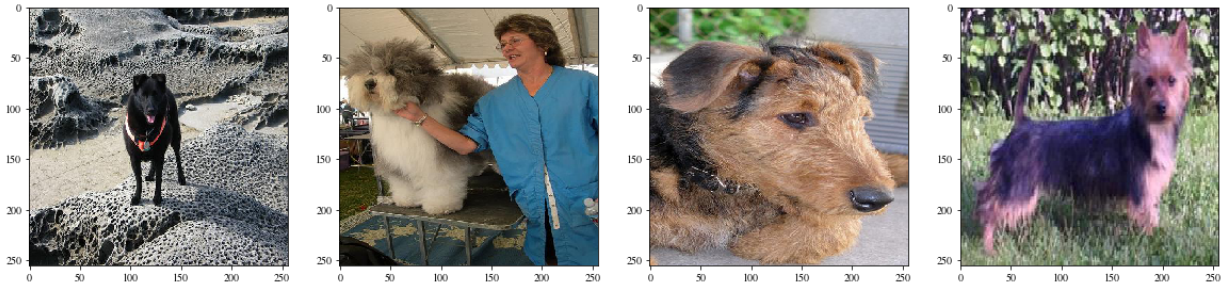
```
    datagen = ImageDataGenerator(rescale=1./255)

    # generator for the training data
    train_generator = datagen.flow_from_directory(
        # This is the target directory
        train_dir,
        # All images will be resized to 64x64
        target_size=(image_X , image_Y),
        batch_size=8,
        # Since we use binary_crossentropy loss, we need binary labels
        class_mode='categorical')

    # generator for the validation data
    validation_generator = datagen.flow_from_directory(
        validation_dir,
        target_size=(image_X , image_Y),
        batch_size=8,
        class_mode='categorical')

    # generator for the test data
    test_generator = datagen.flow_from_directory(
        test_dir,
        target_size=(image_X , image_Y),
        # NO shuffle for the test set to be able to track the file names
        shuffle = False,
        batch_size=8,  # this just makes sure it gets through memory
        class_mode='categorical')
    return train_generator, validation_generator, test_generator
```

AN INITIAL LOOK AT WHAT THE DOG IMAGES LOOK LIKE

In [55]:
```
# CREATE THE DIRECTORIES
train_dir, validation_dir, test_dir = create_dog_images_dirs ('./dog_images_all',

# THEN CREATE THE DATA GENERATORS
train_generator, validation_generator, test_generator = create_data_generatores(t

data_batch, labels_batch = train_generator[0]
plt.rcParams['figure.figsize'] = (20.0, 20.0)
f, ax = plt.subplots(nrows=2, ncols=4)

j=0
i=0
for image in data_batch:
        ax[j, i].imshow(image)
        i = i + 1
        if i == 4 :
            j = j+1
            i = 0
```

```
Found 1021 images belonging to 8 classes.
Found 216 images belonging to 8 classes.
Found 226 images belonging to 8 classes.
```





FINAL CNN MODEL USED

In [65]:
```
K.clear_session()

def CNN_model_create(train_generator, num_of_dogs):
    for data_batch, labels_batch in train_generator:
        print('data batch shape:', data_batch.shape)
        print('labels batch shape:', labels_batch.shape)
        break
    #data_batch, labels_batch = train_generator[0]
    batch_size = len(labels_batch)
    print("Batch Size: %d"%batch_size)

    model = Sequential(name='FiveLayerModel')
    model.add(Conv2D(batch_size, (3, 3), padding='same', activation='relu',
                             input_shape=data_batch.shape[1:], name = 'conv1'))
    model.add(MaxPooling2D((2, 2), name='max_pool1'))
    model.add(Dropout(rate=0.2))
    model.add(Conv2D(64, (3, 3), padding='same', activation='relu', name = 'conv2
    model.add(MaxPooling2D((2, 2), name='max_pool2'))
    model.add(Dropout(rate=0.2))
    model.add(Conv2D(128, (3, 3), padding='same', activation='relu', name = 'conv
    model.add(MaxPooling2D((2, 2), name='max_pool3'))
    model.add(Dropout(rate=0.2))
    model.add(Conv2D(128, (3, 3), padding='same', activation='relu', name = 'conv
    model.add(MaxPooling2D((2, 2), name='max_pool4'))
    model.add(Conv2D(256, (3, 3), padding='same', activation='relu', name = 'conv
    model.add(Conv2D(512,(3, 3), padding='same', activation='relu', name = 'conv6
    model.add(MaxPooling2D((2, 2), name='max_pool5'))
    model.add(Flatten())
    model.add(Dense(512, kernel_initializer='glorot_uniform', activation='relu',
    model.add(Dense(NUM_OF_DOGS, kernel_initializer='glorot_uniform', activation=

    model.compile(loss='categorical_crossentropy',
                  optimizer = 'rmsprop',
                  #optimizer=optimizers.RMSprop(lr=1e-4),
                  metrics=['acc'])
    #model.compile(optimizer="adam", loss="binary_crossentropy", metrics = ["accu
    return model



# Fit model
def fit_model(model, train_generator, validation_generator, epoc):
    history_model = model.fit_generator(
        train_generator,
        steps_per_epoch=100,
        epochs=epoc,
        validation_data=validation_generator,
        validation_steps=50,
        verbose=1,
        callbacks=[TrainValTensorBoard("logs/{}".format(time()), write_graph=True
    return history_model
```

Function to train the model and display result on

test set

In [30]:
```
PATH = './dog_images_all'
TRN = 0.70  # Training data percentage
VL = 0.15   # Validation data percentage
TST = 0.15  # Test data percentage.

def run_CNN_pipeline(num_of_dogs, epoc):
    # CREATE THE DIRECTORIES
    train_dir, validation_dir, test_dir = create_dog_images_dirs (PATH, dog_dict_

    # THEN CREATE THE DATA GENERATORS
    train_generator, validation_generator, test_generator = create_data_generator

    # CREATE THE MODEL
    MODEL = CNN_model_create(train_generator, NUM_OF_DOGS)

    # GET A SUMMARY FOR THE MODEL
    MODEL .summary()

    # FIT MODEL
    history = fit_model(MODEL, train_generator, validation_generator, epoc)

    # PLOT ACCURACIES DURING TRAINING
    plot_accuracies_loss(history)

    # SHOW RESULTS ON TEST SET
    show_results(MODEL, test_generator)
    return
```

CNN MODEL: Classification between 8 dog breeds.

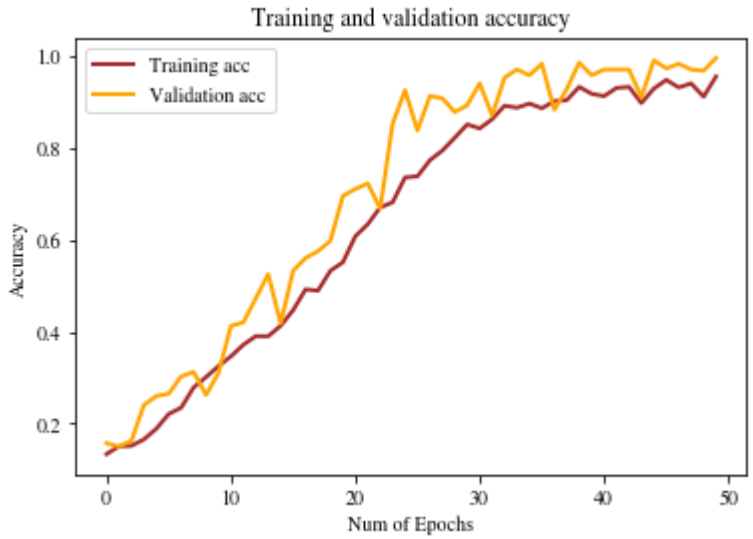
In [7]:
```
NUM_OF_DOGS = 8
EPOC = 50
run_CNN_pipeline(NUM_OF_DOGS, EPOC)
```

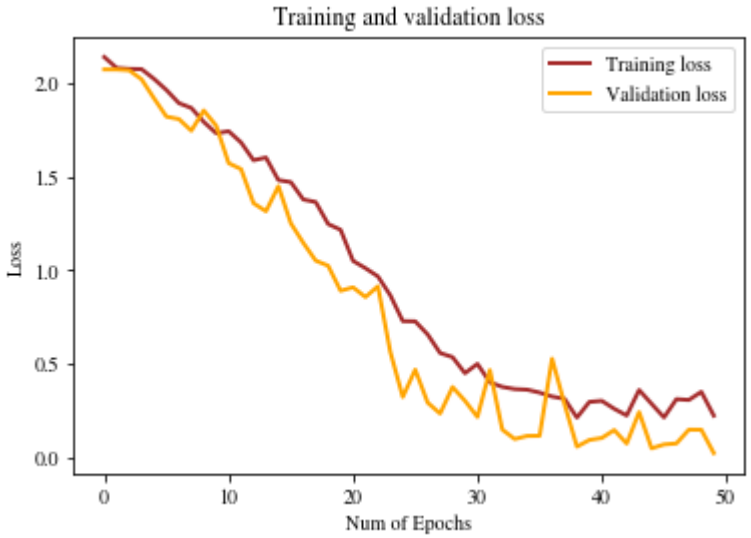
```
Found 1021 images belonging to 8 classes.
Found 216 images belonging to 8 classes.
Found 226 images belonging to 8 classes.
data batch shape: (8, 64, 64, 3)
labels batch shape: (8, 8)
Batch Size: 8
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv1 (Conv2D)               (None, 64, 64, 8)         224
_________________________________________________________________
max_pool1 (MaxPooling2D)     (None, 32, 32, 8)         0
_________________________________________________________________
dropout_1 (Dropout)          (None, 32, 32, 8)         0
_________________________________________________________________
conv2 (Conv2D)               (None, 32, 32, 64)        4672
_________________________________________________________________
max_pool2 (MaxPooling2D)     (None, 16, 16, 64)        0
_________________________________________________________________
dropout_2 (Dropout)          (None, 16, 16, 64)        0
_________________________________________________________________
conv3 (Conv2D)               (None, 16, 16, 128)       73856
_________________________________________________________________
max_pool3 (MaxPooling2D)     (None, 8, 8, 128)         0
_________________________________________________________________
dropout_3 (Dropout)          (None, 8, 8, 128)         0
_________________________________________________________________
conv4 (Conv2D)               (None, 8, 8, 128)         147584
_________________________________________________________________
max_pool4 (MaxPooling2D)     (None, 4, 4, 128)         0
_________________________________________________________________
conv5 (Conv2D)               (None, 4, 4, 256)         295168
_________________________________________________________________
conv6 (Conv2D)               (None, 4, 4, 512)         1180160
_________________________________________________________________
max_pool5 (MaxPooling2D)     (None, 2, 2, 512)         0
_________________________________________________________________
flatten_1 (Flatten)          (None, 2048)              0
_________________________________________________________________
fc1 (Dense)                  (None, 512)               1049088
_________________________________________________________________
fc2 (Dense)                  (None, 8)                 4104
=================================================================
Total params: 2,754,856
Trainable params: 2,754,856
Non-trainable params: 0
_________________________________________________________________
Epoch 1/50
100/100 [==============================] - 5s 50ms/step - loss: 2.1409 - acc:
0.1337 - val_loss: 2.0747 - val_acc: 0.1575
Epoch 2/50
100/100 [==============================] - 4s 38ms/step - loss: 2.0820 - acc:
0.1507 - val_loss: 2.0744 - val_acc: 0.1500
```

```
Epoch 3/50
100/100 [==============================] - 4s 37ms/step - loss: 2.0774 - acc:
0.1527 - val_loss: 2.0702 - val_acc: 0.1625
Epoch 4/50
100/100 [==============================] - 4s 36ms/step - loss: 2.0760 - acc:
0.1657 - val_loss: 2.0217 - val_acc: 0.2400
Epoch 5/50
100/100 [==============================] - 4s 35ms/step - loss: 2.0241 - acc:
0.1888 - val_loss: 1.9200 - val_acc: 0.2600
Epoch 6/50
100/100 [==============================] - 4s 37ms/step - loss: 1.9652 - acc:
0.2200 - val_loss: 1.8221 - val_acc: 0.2650
Epoch 7/50
100/100 [==============================] - 4s 37ms/step - loss: 1.8942 - acc:
0.2338 - val_loss: 1.8091 - val_acc: 0.3025
Epoch 8/50
100/100 [==============================] - 4s 37ms/step - loss: 1.8685 - acc:
0.2783 - val_loss: 1.7469 - val_acc: 0.3125
Epoch 9/50
100/100 [==============================] - 4s 37ms/step - loss: 1.7938 - acc:
0.3015 - val_loss: 1.8551 - val_acc: 0.2625
Epoch 10/50
100/100 [==============================] - 4s 37ms/step - loss: 1.7332 - acc:
0.3250 - val_loss: 1.7735 - val_acc: 0.3100
Epoch 11/50
100/100 [==============================] - 4s 36ms/step - loss: 1.7449 - acc:
0.3472 - val_loss: 1.5733 - val_acc: 0.4125
Epoch 12/50
100/100 [==============================] - 4s 38ms/step - loss: 1.6832 - acc:
0.3708 - val_loss: 1.5411 - val_acc: 0.4200
Epoch 13/50
100/100 [==============================] - 4s 38ms/step - loss: 1.5898 - acc:
0.3888 - val_loss: 1.3590 - val_acc: 0.4725
Epoch 14/50
100/100 [==============================] - 4s 39ms/step - loss: 1.6031 - acc:
0.3900 - val_loss: 1.3158 - val_acc: 0.5250
Epoch 15/50
100/100 [==============================] - 4s 36ms/step - loss: 1.4814 - acc:
0.4135 - val_loss: 1.4499 - val_acc: 0.4175
Epoch 16/50
100/100 [==============================] - 4s 35ms/step - loss: 1.4723 - acc:
0.4458 - val_loss: 1.2514 - val_acc: 0.5325
Epoch 17/50
100/100 [==============================] - 4s 37ms/step - loss: 1.3818 - acc:
0.4908 - val_loss: 1.1468 - val_acc: 0.5600
Epoch 18/50
100/100 [==============================] - 4s 37ms/step - loss: 1.3700 - acc:
0.4897 - val_loss: 1.0519 - val_acc: 0.5750
Epoch 19/50
100/100 [==============================] - 4s 36ms/step - loss: 1.2475 - acc:
0.5325 - val_loss: 1.0244 - val_acc: 0.5975
Epoch 20/50
100/100 [==============================] - 4s 35ms/step - loss: 1.2177 - acc:
0.5503 - val_loss: 0.8906 - val_acc: 0.6950
Epoch 21/50
100/100 [==============================] - 4s 35ms/step - loss: 1.0524 - acc:
0.6073 - val_loss: 0.9088 - val_acc: 0.7100
```

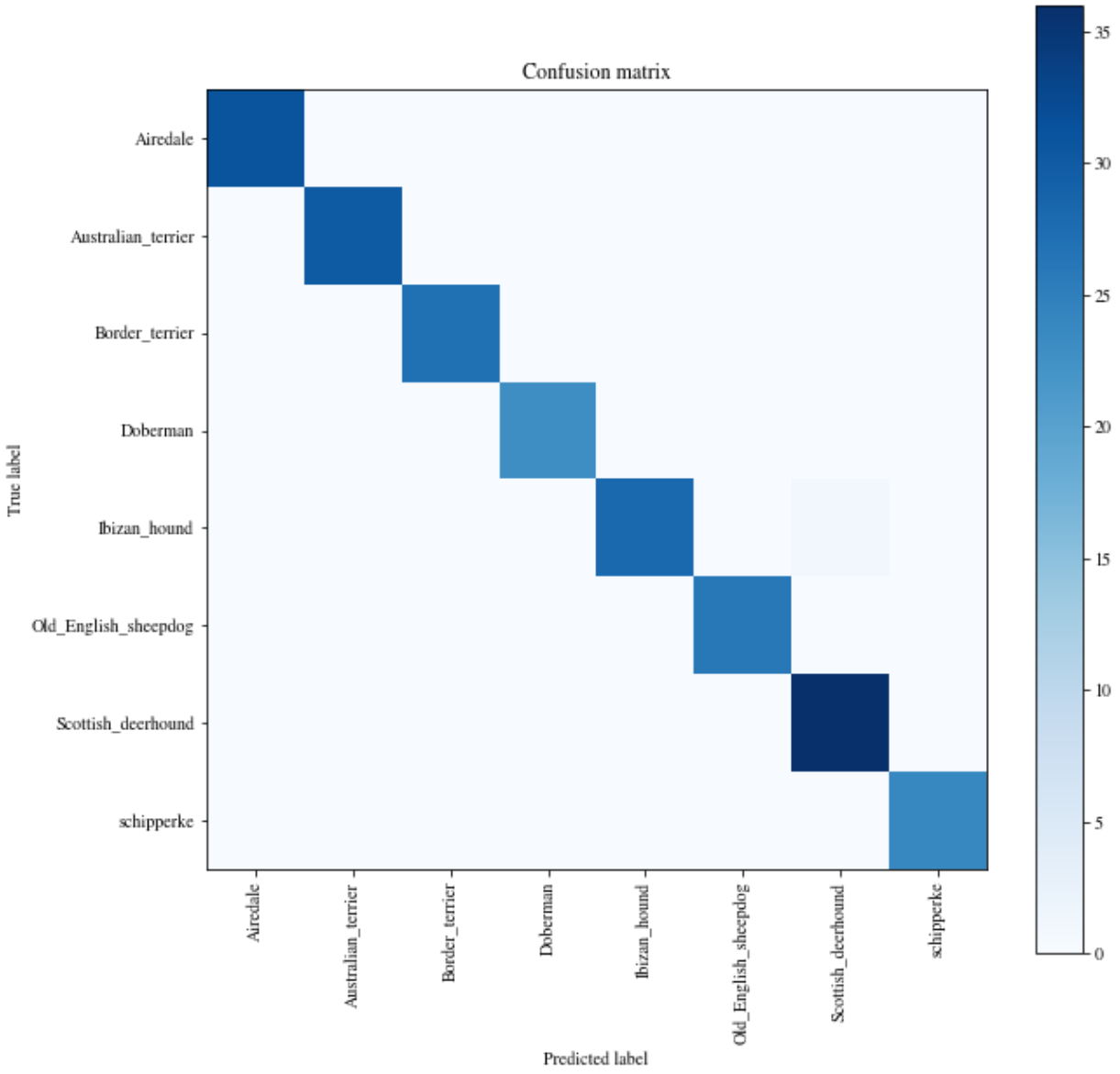
```
Epoch 22/50
100/100 [==============================] - 4s 36ms/step - loss: 1.0107 - acc:
0.6335 - val_loss: 0.8570 - val_acc: 0.7225
Epoch 23/50
100/100 [==============================] - 4s 36ms/step - loss: 0.9674 - acc:
0.6700 - val_loss: 0.9142 - val_acc: 0.6675
Epoch 24/50
100/100 [==============================] - 4s 37ms/step - loss: 0.8673 - acc:
0.6810 - val_loss: 0.5625 - val_acc: 0.8525
Epoch 25/50
100/100 [==============================] - 4s 37ms/step - loss: 0.7299 - acc:
0.7340 - val_loss: 0.3225 - val_acc: 0.9250
Epoch 26/50
100/100 [==============================] - 4s 35ms/step - loss: 0.7256 - acc:
0.7387 - val_loss: 0.4684 - val_acc: 0.8375
Epoch 27/50
100/100 [==============================] - 4s 37ms/step - loss: 0.6545 - acc:
0.7737 - val_loss: 0.2921 - val_acc: 0.9125
Epoch 28/50
100/100 [==============================] - 4s 36ms/step - loss: 0.5576 - acc:
0.7938 - val_loss: 0.2337 - val_acc: 0.9075
Epoch 29/50
100/100 [==============================] - 4s 36ms/step - loss: 0.5339 - acc:
0.8225 - val_loss: 0.3755 - val_acc: 0.8775
Epoch 30/50
100/100 [==============================] - 4s 36ms/step - loss: 0.4480 - acc:
0.8512 - val_loss: 0.3018 - val_acc: 0.8925
Epoch 31/50
100/100 [==============================] - 3s 35ms/step - loss: 0.4982 - acc:
0.8425 - val_loss: 0.2155 - val_acc: 0.9400
Epoch 32/50
100/100 [==============================] - 4s 37ms/step - loss: 0.3999 - acc:
0.8618 - val_loss: 0.4662 - val_acc: 0.8700
Epoch 33/50
100/100 [==============================] - 4s 35ms/step - loss: 0.3765 - acc:
0.8912 - val_loss: 0.1477 - val_acc: 0.9525
Epoch 34/50
100/100 [==============================] - 4s 37ms/step - loss: 0.3633 - acc:
0.8875 - val_loss: 0.0974 - val_acc: 0.9700
Epoch 35/50
100/100 [==============================] - 4s 36ms/step - loss: 0.3602 - acc:
0.8962 - val_loss: 0.1142 - val_acc: 0.9575
Epoch 36/50
100/100 [==============================] - 4s 35ms/step - loss: 0.3447 - acc:
0.8862 - val_loss: 0.1149 - val_acc: 0.9825
Epoch 37/50
100/100 [==============================] - 4s 37ms/step - loss: 0.3248 - acc:
0.9012 - val_loss: 0.5275 - val_acc: 0.8825
Epoch 38/50
100/100 [==============================] - 4s 36ms/step - loss: 0.3167 - acc:
0.9023 - val_loss: 0.2851 - val_acc: 0.9275
Epoch 39/50
100/100 [==============================] - 4s 39ms/step - loss: 0.2130 - acc:
0.9318 - val_loss: 0.0567 - val_acc: 0.9850
Epoch 40/50
100/100 [==============================] - 4s 35ms/step - loss: 0.2951 - acc:
0.9175 - val_loss: 0.0924 - val_acc: 0.9575
```

```
Epoch 41/50
100/100 [==============================] - 4s 35ms/step - loss: 0.3024 - acc:
0.9118 - val_loss: 0.1031 - val_acc: 0.9700
Epoch 42/50
100/100 [==============================] - 4s 36ms/step - loss: 0.2592 - acc:
0.9300 - val_loss: 0.1454 - val_acc: 0.9700
Epoch 43/50
100/100 [==============================] - 4s 38ms/step - loss: 0.2225 - acc:
0.9325 - val_loss: 0.0733 - val_acc: 0.9700
Epoch 44/50
100/100 [==============================] - 4s 37ms/step - loss: 0.3583 - acc:
0.8975 - val_loss: 0.2415 - val_acc: 0.9100
Epoch 45/50
100/100 [==============================] - 4s 37ms/step - loss: 0.2848 - acc:
0.9287 - val_loss: 0.0477 - val_acc: 0.9900
Epoch 46/50
100/100 [==============================] - 4s 35ms/step - loss: 0.2130 - acc:
0.9475 - val_loss: 0.0684 - val_acc: 0.9725
Epoch 47/50
100/100 [==============================] - 4s 36ms/step - loss: 0.3096 - acc:
0.9312 - val_loss: 0.0738 - val_acc: 0.9825
Epoch 48/50
100/100 [==============================] - 4s 36ms/step - loss: 0.3054 - acc:
0.9400 - val_loss: 0.1476 - val_acc: 0.9700
Epoch 49/50
100/100 [==============================] - 4s 38ms/step - loss: 0.3487 - acc:
0.9112 - val_loss: 0.1472 - val_acc: 0.9675
Epoch 50/50
100/100 [==============================] - 4s 37ms/step - loss: 0.2221 - acc:
0.9550 - val_loss: 0.0222 - val_acc: 0.9950
```






```
TEST accuracy: 0.9961636828644501
TEST loss: 0.020793873896913104

Confusion Matrix
[[31  0  0  0  0  0  0  0]
 [ 0 30  0  0  0  0  0  0]
 [ 0  0 27  0  0  0  0  0]
 [ 0  0  0 23  0  0  0  0]
 [ 0  0  0  0 28  0  1  0]
 [ 0  0  0  0  0 26  0  0]
 [ 0  0  0  0  0  0 36  0]
 [ 0  0  0  0  0  0  0 24]]

Classification Report
                     precision    recall  f1-score   support

            Airedale       1.00      1.00      1.00        31
  Australian_terrier       1.00      1.00      1.00        30
      Border_terrier       1.00      1.00      1.00        27
            Doberman       1.00      1.00      1.00        23
        Ibizan_hound       1.00      0.97      0.98        29
Old_English_sheepdog       1.00      1.00      1.00        26
  Scottish_deerhound       0.97      1.00      0.99        36
          schipperke       1.00      1.00      1.00        24

         avg / total       1.00      1.00      1.00       226
```



CNN MODEL : Classification between 16 dog breeds.

In [8]:
```
NUM_OF_DOGS = 16
EPOC = 70
run_CNN_pipeline(NUM_OF_DOGS, EPOC)
```

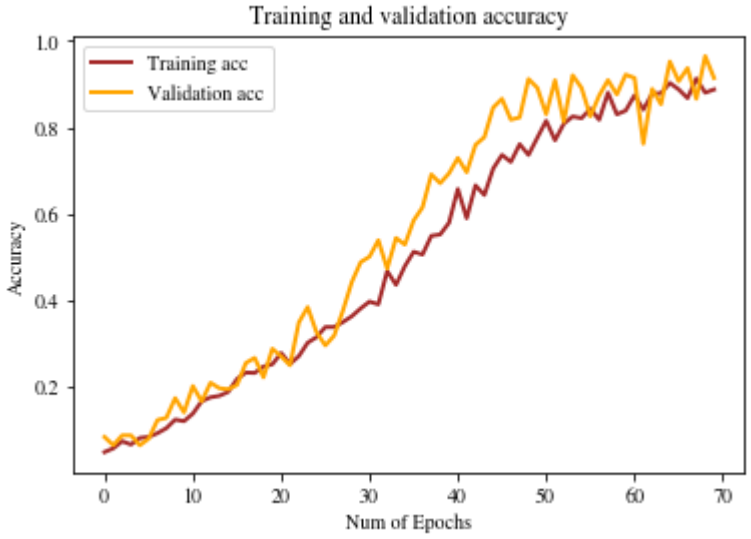
```
Found 1983 images belonging to 16 classes.
Found 419 images belonging to 16 classes.
Found 441 images belonging to 16 classes.
data batch shape: (8, 64, 64, 3)
labels batch shape: (8, 16)
Batch Size: 8
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv1 (Conv2D)               (None, 64, 64, 8)         224
_________________________________________________________________
max_pool1 (MaxPooling2D)     (None, 32, 32, 8)         0
_________________________________________________________________
dropout_4 (Dropout)          (None, 32, 32, 8)         0
_________________________________________________________________
conv2 (Conv2D)               (None, 32, 32, 64)        4672
_________________________________________________________________
max_pool2 (MaxPooling2D)     (None, 16, 16, 64)        0
_________________________________________________________________
dropout_5 (Dropout)          (None, 16, 16, 64)        0
_________________________________________________________________
conv3 (Conv2D)               (None, 16, 16, 128)       73856
_________________________________________________________________
max_pool3 (MaxPooling2D)     (None, 8, 8, 128)         0
_________________________________________________________________
dropout_6 (Dropout)          (None, 8, 8, 128)         0
_________________________________________________________________
conv4 (Conv2D)               (None, 8, 8, 128)         147584
_________________________________________________________________
max_pool4 (MaxPooling2D)     (None, 4, 4, 128)         0
_________________________________________________________________
conv5 (Conv2D)               (None, 4, 4, 256)         295168
_________________________________________________________________
conv6 (Conv2D)               (None, 4, 4, 512)         1180160
_________________________________________________________________
max_pool5 (MaxPooling2D)     (None, 2, 2, 512)         0
_________________________________________________________________
flatten_2 (Flatten)          (None, 2048)              0
_________________________________________________________________
fc1 (Dense)                  (None, 512)               1049088
_________________________________________________________________
fc2 (Dense)                  (None, 16)                8208
=================================================================
Total params: 2,758,960
Trainable params: 2,758,960
Non-trainable params: 0
_________________________________________________________________
Epoch 1/70
100/100 [==============================] - 4s 41ms/step - loss: 2.8789 - acc:
0.0500 - val_loss: 2.7683 - val_acc: 0.0850
Epoch 2/70
100/100 [==============================] - 4s 37ms/step - loss: 2.7719 - acc:
0.0587 - val_loss: 2.7699 - val_acc: 0.0658
```

```
Epoch 3/70
100/100 [==============================] - 4s 35ms/step - loss: 2.7693 - acc:
0.0750 - val_loss: 2.7621 - val_acc: 0.0886
Epoch 4/70
100/100 [==============================] - 4s 36ms/step - loss: 2.7717 - acc:
0.0675 - val_loss: 2.7637 - val_acc: 0.0886
Epoch 5/70
100/100 [==============================] - 3s 34ms/step - loss: 2.7629 - acc:
0.0827 - val_loss: 2.7733 - val_acc: 0.0658
Epoch 6/70
100/100 [==============================] - 4s 37ms/step - loss: 2.7797 - acc:
0.0850 - val_loss: 2.7418 - val_acc: 0.0810
Epoch 7/70
100/100 [==============================] - 3s 35ms/step - loss: 2.7544 - acc:
0.0938 - val_loss: 2.7129 - val_acc: 0.1241
Epoch 8/70
100/100 [==============================] - 4s 36ms/step - loss: 2.7149 - acc:
0.1052 - val_loss: 2.6328 - val_acc: 0.1291
Epoch 9/70
100/100 [==============================] - 4s 37ms/step - loss: 2.6529 - acc:
0.1250 - val_loss: 2.5184 - val_acc: 0.1747
Epoch 10/70
100/100 [==============================] - 4s 37ms/step - loss: 2.6273 - acc:
0.1213 - val_loss: 2.5681 - val_acc: 0.1418
Epoch 11/70
100/100 [==============================] - 4s 36ms/step - loss: 2.5789 - acc:
0.1388 - val_loss: 2.4780 - val_acc: 0.2025
Epoch 12/70
100/100 [==============================] - 4s 37ms/step - loss: 2.5638 - acc:
0.1675 - val_loss: 2.5154 - val_acc: 0.1671
Epoch 13/70
100/100 [==============================] - 4s 35ms/step - loss: 2.5290 - acc:
0.1763 - val_loss: 2.3894 - val_acc: 0.2101
Epoch 14/70
100/100 [==============================] - 4s 36ms/step - loss: 2.5354 - acc:
0.1800 - val_loss: 2.4378 - val_acc: 0.1975
Epoch 15/70
100/100 [==============================] - 4s 35ms/step - loss: 2.5008 - acc:
0.1893 - val_loss: 2.4453 - val_acc: 0.1949
Epoch 16/70
100/100 [==============================] - 3s 35ms/step - loss: 2.4250 - acc:
0.2188 - val_loss: 2.3764 - val_acc: 0.2051
Epoch 17/70
100/100 [==============================] - 4s 38ms/step - loss: 2.4155 - acc:
0.2338 - val_loss: 2.2321 - val_acc: 0.2557
Epoch 18/70
100/100 [==============================] - 4s 37ms/step - loss: 2.3688 - acc:
0.2327 - val_loss: 2.2887 - val_acc: 0.2675
Epoch 19/70
100/100 [==============================] - 3s 35ms/step - loss: 2.3030 - acc:
0.2475 - val_loss: 2.3929 - val_acc: 0.2228
Epoch 20/70
100/100 [==============================] - 4s 37ms/step - loss: 2.3339 - acc:
0.2530 - val_loss: 2.1909 - val_acc: 0.2886
Epoch 21/70
100/100 [==============================] - 4s 37ms/step - loss: 2.2329 - acc:
0.2787 - val_loss: 2.2344 - val_acc: 0.2709
```

```
Epoch 22/70
100/100 [==============================] - 4s 36ms/step - loss: 2.2691 - acc:
0.2537 - val_loss: 2.1784 - val_acc: 0.2506
Epoch 23/70
100/100 [==============================] - 4s 36ms/step - loss: 2.1435 - acc:
0.2716 - val_loss: 2.0118 - val_acc: 0.3494
Epoch 24/70
100/100 [==============================] - 4s 37ms/step - loss: 2.1759 - acc:
0.3025 - val_loss: 1.9322 - val_acc: 0.3848
Epoch 25/70
100/100 [==============================] - 4s 36ms/step - loss: 2.1374 - acc:
0.3155 - val_loss: 2.0857 - val_acc: 0.3266
Epoch 26/70
100/100 [==============================] - 4s 35ms/step - loss: 2.0093 - acc:
0.3387 - val_loss: 2.1321 - val_acc: 0.2962
Epoch 27/70
100/100 [==============================] - 4s 37ms/step - loss: 2.0400 - acc:
0.3387 - val_loss: 2.0387 - val_acc: 0.3190
Epoch 28/70
100/100 [==============================] - 4s 35ms/step - loss: 1.9850 - acc:
0.3504 - val_loss: 1.8488 - val_acc: 0.3772
Epoch 29/70
100/100 [==============================] - 4s 37ms/step - loss: 1.9282 - acc:
0.3638 - val_loss: 1.7394 - val_acc: 0.4430
Epoch 30/70
100/100 [==============================] - 4s 36ms/step - loss: 1.8890 - acc:
0.3814 - val_loss: 1.4875 - val_acc: 0.4886
Epoch 31/70
100/100 [==============================] - 3s 34ms/step - loss: 1.7372 - acc:
0.3975 - val_loss: 1.5301 - val_acc: 0.5013
Epoch 32/70
100/100 [==============================] - 4s 36ms/step - loss: 1.8493 - acc:
0.3912 - val_loss: 1.4751 - val_acc: 0.5392
Epoch 33/70
100/100 [==============================] - 4s 36ms/step - loss: 1.6307 - acc:
0.4680 - val_loss: 1.6226 - val_acc: 0.4734
Epoch 34/70
100/100 [==============================] - 3s 34ms/step - loss: 1.7090 - acc:
0.4363 - val_loss: 1.3958 - val_acc: 0.5443
Epoch 35/70
100/100 [==============================] - 4s 37ms/step - loss: 1.5332 - acc:
0.4796 - val_loss: 1.4199 - val_acc: 0.5291
Epoch 36/70
100/100 [==============================] - 4s 36ms/step - loss: 1.4994 - acc:
0.5125 - val_loss: 1.2905 - val_acc: 0.5850
Epoch 37/70
100/100 [==============================] - 4s 36ms/step - loss: 1.4850 - acc:
0.5062 - val_loss: 1.1493 - val_acc: 0.6152
Epoch 38/70
100/100 [==============================] - 3s 35ms/step - loss: 1.3187 - acc:
0.5491 - val_loss: 0.9143 - val_acc: 0.6911
Epoch 39/70
100/100 [==============================] - 4s 36ms/step - loss: 1.3808 - acc:
0.5525 - val_loss: 0.9697 - val_acc: 0.6709
Epoch 40/70
100/100 [==============================] - 4s 36ms/step - loss: 1.2631 - acc:
0.5796 - val_loss: 0.9176 - val_acc: 0.6937
```

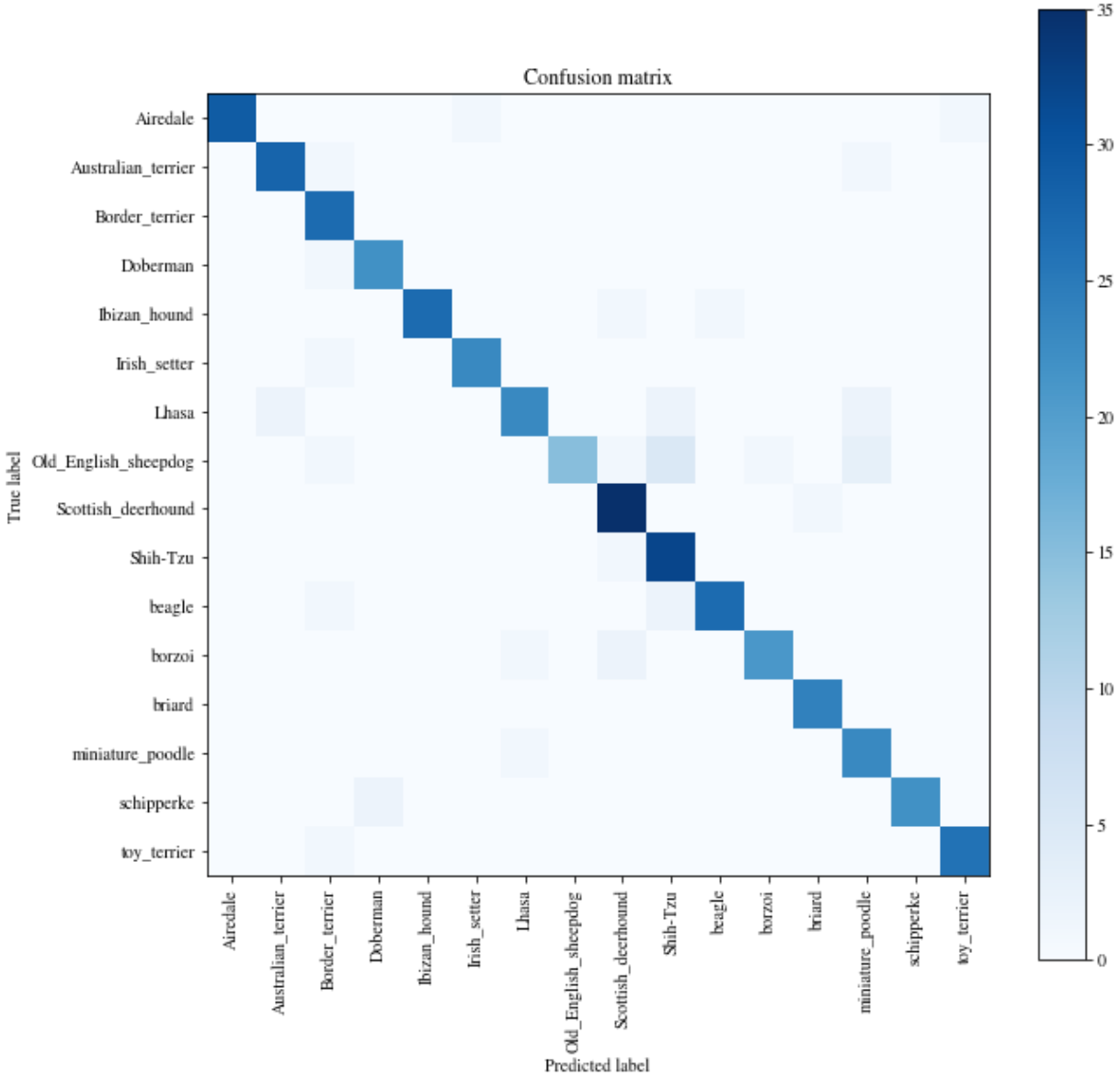
```
Epoch 41/70
100/100 [==============================] - 4s 37ms/step - loss: 1.0650 - acc:
0.6575 - val_loss: 0.8254 - val_acc: 0.7291
Epoch 42/70
100/100 [==============================] - 4s 36ms/step - loss: 1.2736 - acc:
0.5900 - val_loss: 0.9785 - val_acc: 0.6962
Epoch 43/70
100/100 [==============================] - 3s 35ms/step - loss: 0.9363 - acc:
0.6654 - val_loss: 0.6941 - val_acc: 0.7595
Epoch 44/70
100/100 [==============================] - 4s 36ms/step - loss: 1.0380 - acc:
0.6437 - val_loss: 0.7798 - val_acc: 0.7772
Epoch 45/70
100/100 [==============================] - 4s 37ms/step - loss: 0.9387 - acc:
0.7048 - val_loss: 0.5444 - val_acc: 0.8456
Epoch 46/70
100/100 [==============================] - 4s 36ms/step - loss: 0.8147 - acc:
0.7362 - val_loss: 0.4587 - val_acc: 0.8658
Epoch 47/70
100/100 [==============================] - 4s 36ms/step - loss: 0.8466 - acc:
0.7200 - val_loss: 0.5367 - val_acc: 0.8177
Epoch 48/70
100/100 [==============================] - 4s 36ms/step - loss: 0.6919 - acc:
0.7607 - val_loss: 0.5515 - val_acc: 0.8228
Epoch 49/70
100/100 [==============================] - 4s 37ms/step - loss: 0.8317 - acc:
0.7362 - val_loss: 0.4075 - val_acc: 0.9114
Epoch 50/70
100/100 [==============================] - 4s 36ms/step - loss: 0.6716 - acc:
0.7755 - val_loss: 0.3736 - val_acc: 0.8911
Epoch 51/70
100/100 [==============================] - 4s 37ms/step - loss: 0.5718 - acc:
0.8150 - val_loss: 0.5318 - val_acc: 0.8304
Epoch 52/70
100/100 [==============================] - 4s 37ms/step - loss: 0.7091 - acc:
0.7700 - val_loss: 0.3384 - val_acc: 0.9089
Epoch 53/70
100/100 [==============================] - 4s 36ms/step - loss: 0.6114 - acc:
0.8084 - val_loss: 0.6660 - val_acc: 0.8127
Epoch 54/70
100/100 [==============================] - 4s 37ms/step - loss: 0.5997 - acc:
0.8250 - val_loss: 0.2976 - val_acc: 0.9200
Epoch 55/70
100/100 [==============================] - 4s 36ms/step - loss: 0.5972 - acc:
0.8212 - val_loss: 0.2908 - val_acc: 0.8911
Epoch 56/70
100/100 [==============================] - 4s 37ms/step - loss: 0.5048 - acc:
0.8425 - val_loss: 0.5362 - val_acc: 0.8253
Epoch 57/70
100/100 [==============================] - 4s 37ms/step - loss: 0.6285 - acc:
0.8175 - val_loss: 0.4039 - val_acc: 0.8734
Epoch 58/70
100/100 [==============================] - 4s 35ms/step - loss: 0.4196 - acc:
0.8798 - val_loss: 0.2902 - val_acc: 0.9089
Epoch 59/70
100/100 [==============================] - 4s 35ms/step - loss: 0.5333 - acc:
0.8300 - val_loss: 0.4254 - val_acc: 0.8759
```

```
Epoch 60/70
100/100 [==============================] - 4s 36ms/step - loss: 0.5067 - acc:
0.8386 - val_loss: 0.2401 - val_acc: 0.9215
Epoch 61/70
100/100 [==============================] - 4s 37ms/step - loss: 0.4159 - acc:
0.8738 - val_loss: 0.3183 - val_acc: 0.9139
Epoch 62/70
100/100 [==============================] - 4s 38ms/step - loss: 0.4931 - acc:
0.8407 - val_loss: 0.8865 - val_acc: 0.7620
Epoch 63/70
100/100 [==============================] - 4s 37ms/step - loss: 0.4475 - acc:
0.8775 - val_loss: 0.3130 - val_acc: 0.8886
Epoch 64/70
100/100 [==============================] - 4s 38ms/step - loss: 0.4580 - acc:
0.8787 - val_loss: 0.4334 - val_acc: 0.8532
Epoch 65/70
100/100 [==============================] - 4s 37ms/step - loss: 0.3490 - acc:
0.9025 - val_loss: 0.1863 - val_acc: 0.9519
Epoch 66/70
100/100 [==============================] - 4s 36ms/step - loss: 0.3804 - acc:
0.8875 - val_loss: 0.2401 - val_acc: 0.9063
Epoch 67/70
100/100 [==============================] - 4s 35ms/step - loss: 0.4580 - acc:
0.8675 - val_loss: 0.2045 - val_acc: 0.9367
Epoch 68/70
100/100 [==============================] - 4s 36ms/step - loss: 0.3147 - acc:
0.9125 - val_loss: 0.3851 - val_acc: 0.8658
Epoch 69/70
100/100 [==============================] - 4s 37ms/step - loss: 0.4401 - acc:
0.8800 - val_loss: 0.1538 - val_acc: 0.9646
Epoch 70/70
100/100 [==============================] - 4s 36ms/step - loss: 0.3517 - acc:
0.8873 - val_loss: 0.3331 - val_acc: 0.9139
```




```
TEST accuracy: 0.9117276166456494
TEST loss: 0.3380481972444854

Confusion Matrix
[[29  0  0  0  0  1  0  0  0  0  0  0  0  0  0  1]
 [ 0 28  1  0  0  0  0  0  0  0  0  0  0  1  0  0]
 [ 0  0 27  0  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  1 22  0  0  0  0  0  0  0  0  0  0  0  0]
 [ 0  0  0  0 27  0  0  0  1  0  1  0  0  0  0  0]
 [ 0  0  1  0  0 23  0  0  0  0  0  0  0  0  0  0]
 [ 0  2  0  0  0  0 23  0  0  2  0  0  0  2  0  0]
 [ 0  0  1  0  0  0  0 15  1  5  0  1  0  3  0  0]
 [ 0  0  0  0  0  0  0  0 35  0  0  0  1  0  0  0]
 [ 0  0  0  0  0  0  0  0  1 32  0  0  0  0  0  0]
 [ 0  0  1  0  0  0  0  0  0  2 27  0  0  0  0  0]
 [ 0  0  0  0  0  0  1  0  2  0  0 21  0  0  0  0]
 [ 0  0  0  0  0  0  0  0  0  0  0  0 24  0  0  0]
 [ 0  0  0  0  0  0  1  0  0  0  0  0  0 23  0  0]
 [ 0  0  0  2  0  0  0  0  0  0  0  0  0  0 22  0]
 [ 0  0  1  0  0  0  0  0  0  0  0  0  0  0  0 26]]

Classification Report
                      precision    recall  f1-score   support

             Airedale       1.00      0.94      0.97        31
  Australian_terrier        0.93      0.93      0.93        30
      Border_terrier        0.82      1.00      0.90        27
            Doberman        0.92      0.96      0.94        23
        Ibizan_hound        1.00      0.93      0.96        29
        Irish_setter        0.96      0.96      0.96        24
               Lhasa        0.92      0.79      0.85        29
Old_English_sheepdog        1.00      0.58      0.73        26
  Scottish_deerhound        0.88      0.97      0.92        36
            Shih-Tzu        0.78      0.97      0.86        33
              beagle        0.96      0.90      0.93        30
              borzoi        0.95      0.88      0.91        24
              briard        0.96      1.00      0.98        24
    miniature_poodle        0.79      0.96      0.87        24
          schipperke        1.00      0.92      0.96        24
```

toy_terrier	0.96	0.96	0.96	27
avg / total	0.93	0.92	0.91	441



CNN MODEL: Classification between 32 dog breeds.

In [9]:
```
NUM_OF_DOGS = 32
EPOC = 100
run_CNN_pipeline(NUM_OF_DOGS, EPOC)
```

```
Found 3956 images belonging to 32 classes.
Found 836 images belonging to 32 classes.
Found 881 images belonging to 32 classes.
data batch shape: (8, 64, 64, 3)
labels batch shape: (8, 32)
Batch Size: 8
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv1 (Conv2D)               (None, 64, 64, 8)         224
_________________________________________________________________
max_pool1 (MaxPooling2D)     (None, 32, 32, 8)         0
_________________________________________________________________
dropout_7 (Dropout)          (None, 32, 32, 8)         0
_________________________________________________________________
conv2 (Conv2D)               (None, 32, 32, 64)        4672
_________________________________________________________________
max_pool2 (MaxPooling2D)     (None, 16, 16, 64)        0
_________________________________________________________________
dropout_8 (Dropout)          (None, 16, 16, 64)        0
_________________________________________________________________
conv3 (Conv2D)               (None, 16, 16, 128)       73856
_________________________________________________________________
max_pool3 (MaxPooling2D)     (None, 8, 8, 128)         0
_________________________________________________________________
dropout_9 (Dropout)          (None, 8, 8, 128)         0
_________________________________________________________________
conv4 (Conv2D)               (None, 8, 8, 128)         147584
_________________________________________________________________
max_pool4 (MaxPooling2D)     (None, 4, 4, 128)         0
_________________________________________________________________
conv5 (Conv2D)               (None, 4, 4, 256)         295168
_________________________________________________________________
conv6 (Conv2D)               (None, 4, 4, 512)         1180160
_________________________________________________________________
max_pool5 (MaxPooling2D)     (None, 2, 2, 512)         0
_________________________________________________________________
flatten_3 (Flatten)          (None, 2048)              0
_________________________________________________________________
fc1 (Dense)                  (None, 512)               1049088
_________________________________________________________________
fc2 (Dense)                  (None, 32)                16416
=================================================================
Total params: 2,767,168
Trainable params: 2,767,168
Non-trainable params: 0
_________________________________________________________________
Epoch 1/100
100/100 [==============================] - 4s 40ms/step - loss: 3.6221 - acc:
0.0238 - val_loss: 3.4644 - val_acc: 0.0275
Epoch 2/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4663 - acc:
0.0387 - val_loss: 3.4605 - val_acc: 0.0600
```

```
Epoch 3/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4812 - acc:
0.0400 - val_loss: 3.4619 - val_acc: 0.0455
Epoch 4/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4659 - acc:
0.0312 - val_loss: 3.4571 - val_acc: 0.0400
Epoch 5/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4649 - acc:
0.0375 - val_loss: 3.4728 - val_acc: 0.0328
Epoch 6/100
100/100 [==============================] - 4s 37ms/step - loss: 3.4618 - acc:
0.0288 - val_loss: 3.4572 - val_acc: 0.0450
Epoch 7/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4672 - acc:
0.0325 - val_loss: 3.4634 - val_acc: 0.0303
Epoch 8/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4629 - acc:
0.0350 - val_loss: 3.4556 - val_acc: 0.0550
Epoch 9/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4620 - acc:
0.0325 - val_loss: 3.4658 - val_acc: 0.0429
Epoch 10/100
100/100 [==============================] - 4s 37ms/step - loss: 3.4613 - acc:
0.0437 - val_loss: 3.4583 - val_acc: 0.0575
Epoch 11/100
100/100 [==============================] - 4s 37ms/step - loss: 3.4650 - acc:
0.0338 - val_loss: 3.4813 - val_acc: 0.0354
Epoch 12/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4512 - acc:
0.0488 - val_loss: 3.4653 - val_acc: 0.0325
Epoch 13/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4655 - acc:
0.0375 - val_loss: 3.4603 - val_acc: 0.0303
Epoch 14/100
100/100 [==============================] - 3s 34ms/step - loss: 3.4701 - acc:
0.0300 - val_loss: 3.4473 - val_acc: 0.0400
Epoch 15/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4396 - acc:
0.0425 - val_loss: 3.4199 - val_acc: 0.0606
Epoch 16/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4295 - acc:
0.0563 - val_loss: 3.3972 - val_acc: 0.0650
Epoch 17/100
100/100 [==============================] - 4s 36ms/step - loss: 3.4290 - acc:
0.0663 - val_loss: 3.4158 - val_acc: 0.0707
Epoch 18/100
100/100 [==============================] - 4s 35ms/step - loss: 3.4146 - acc:
0.0575 - val_loss: 3.4008 - val_acc: 0.0525
Epoch 19/100
100/100 [==============================] - 4s 39ms/step - loss: 3.4048 - acc:
0.0488 - val_loss: 3.3389 - val_acc: 0.0657
Epoch 20/100
100/100 [==============================] - 3s 34ms/step - loss: 3.3980 - acc:
0.0575 - val_loss: 3.3882 - val_acc: 0.0575
Epoch 21/100
100/100 [==============================] - 4s 36ms/step - loss: 3.3877 - acc:
0.0563 - val_loss: 3.3379 - val_acc: 0.0808
```

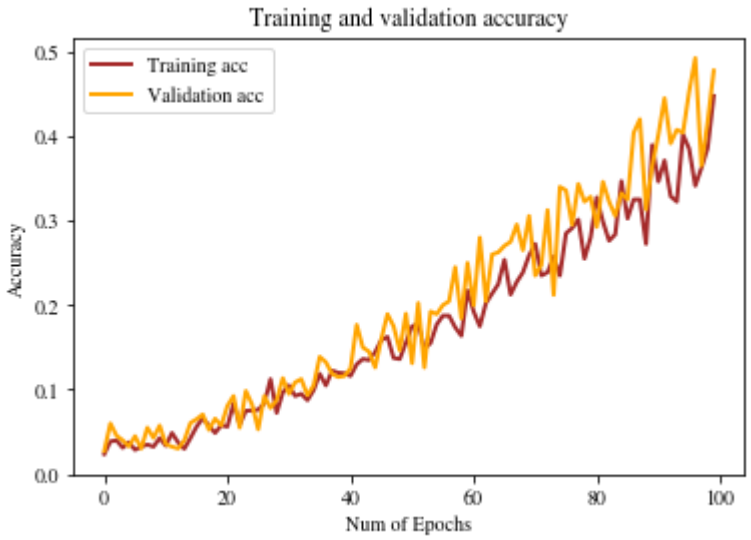
```
Epoch 22/100
100/100 [==============================] - 4s 36ms/step - loss: 3.3598 - acc:
0.0838 - val_loss: 3.3048 - val_acc: 0.0925
Epoch 23/100
100/100 [==============================] - 3s 34ms/step - loss: 3.3561 - acc:
0.0587 - val_loss: 3.3738 - val_acc: 0.0550
Epoch 24/100
100/100 [==============================] - 4s 36ms/step - loss: 3.3390 - acc:
0.0750 - val_loss: 3.2837 - val_acc: 0.0985
Epoch 25/100
100/100 [==============================] - 4s 35ms/step - loss: 3.3416 - acc:
0.0750 - val_loss: 3.2297 - val_acc: 0.0825
Epoch 26/100
100/100 [==============================] - 4s 36ms/step - loss: 3.2802 - acc:
0.0762 - val_loss: 3.2983 - val_acc: 0.0530
Epoch 27/100
100/100 [==============================] - 4s 35ms/step - loss: 3.2981 - acc:
0.0838 - val_loss: 3.2033 - val_acc: 0.0925
Epoch 28/100
100/100 [==============================] - 4s 37ms/step - loss: 3.2461 - acc:
0.1125 - val_loss: 3.3122 - val_acc: 0.0783
Epoch 29/100
100/100 [==============================] - 3s 34ms/step - loss: 3.3078 - acc:
0.0725 - val_loss: 3.2242 - val_acc: 0.0875
Epoch 30/100
100/100 [==============================] - 3s 35ms/step - loss: 3.2484 - acc:
0.0975 - val_loss: 3.1757 - val_acc: 0.1136
Epoch 31/100
100/100 [==============================] - 4s 38ms/step - loss: 3.2108 - acc:
0.1050 - val_loss: 3.2617 - val_acc: 0.0950
Epoch 32/100
100/100 [==============================] - 3s 34ms/step - loss: 3.2615 - acc:
0.0925 - val_loss: 3.1742 - val_acc: 0.1086
Epoch 33/100
100/100 [==============================] - 4s 37ms/step - loss: 3.1986 - acc:
0.0950 - val_loss: 3.1259 - val_acc: 0.1125
Epoch 34/100
100/100 [==============================] - 4s 35ms/step - loss: 3.2074 - acc:
0.0875 - val_loss: 3.1651 - val_acc: 0.0934
Epoch 35/100
100/100 [==============================] - 4s 36ms/step - loss: 3.2048 - acc:
0.1000 - val_loss: 3.1419 - val_acc: 0.1050
Epoch 36/100
100/100 [==============================] - 4s 35ms/step - loss: 3.1129 - acc:
0.1188 - val_loss: 3.0411 - val_acc: 0.1389
Epoch 37/100
100/100 [==============================] - 4s 37ms/step - loss: 3.1834 - acc:
0.1050 - val_loss: 3.1067 - val_acc: 0.1325
Epoch 38/100
100/100 [==============================] - 4s 37ms/step - loss: 3.1514 - acc:
0.1225 - val_loss: 3.0866 - val_acc: 0.1187
Epoch 39/100
100/100 [==============================] - 4s 36ms/step - loss: 3.1369 - acc:
0.1200 - val_loss: 3.0453 - val_acc: 0.1150
Epoch 40/100
100/100 [==============================] - 4s 36ms/step - loss: 3.1532 - acc:
0.1200 - val_loss: 3.0578 - val_acc: 0.1162
```

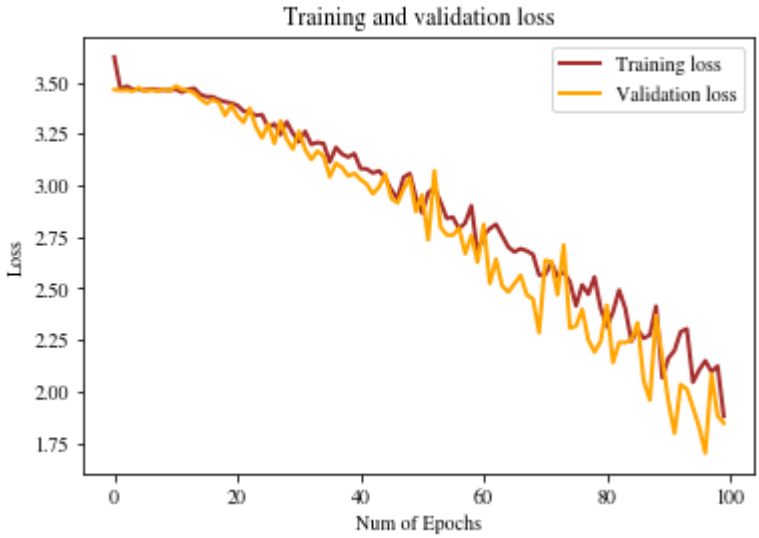
```
Epoch 41/100
100/100 [==============================] - 4s 36ms/step - loss: 3.0812 - acc:
0.1163 - val_loss: 3.0282 - val_acc: 0.1250
Epoch 42/100
100/100 [==============================] - 4s 37ms/step - loss: 3.0791 - acc:
0.1300 - val_loss: 3.0060 - val_acc: 0.1768
Epoch 43/100
100/100 [==============================] - 4s 36ms/step - loss: 3.0595 - acc:
0.1363 - val_loss: 2.9588 - val_acc: 0.1500
Epoch 44/100
100/100 [==============================] - 4s 36ms/step - loss: 3.0700 - acc:
0.1350 - val_loss: 2.9912 - val_acc: 0.1450
Epoch 45/100
100/100 [==============================] - 4s 37ms/step - loss: 3.0355 - acc:
0.1450 - val_loss: 3.0544 - val_acc: 0.1263
Epoch 46/100
100/100 [==============================] - 4s 37ms/step - loss: 2.9781 - acc:
0.1588 - val_loss: 2.9358 - val_acc: 0.1600
Epoch 47/100
100/100 [==============================] - 4s 36ms/step - loss: 2.9357 - acc:
0.1625 - val_loss: 2.9150 - val_acc: 0.1894
Epoch 48/100
100/100 [==============================] - 4s 37ms/step - loss: 3.0388 - acc:
0.1375 - val_loss: 2.9833 - val_acc: 0.1750
Epoch 49/100
100/100 [==============================] - 4s 36ms/step - loss: 3.0570 - acc:
0.1363 - val_loss: 3.0370 - val_acc: 0.1465
Epoch 50/100
100/100 [==============================] - 4s 36ms/step - loss: 2.9396 - acc:
0.1562 - val_loss: 2.8721 - val_acc: 0.1900
Epoch 51/100
100/100 [==============================] - 4s 37ms/step - loss: 2.8659 - acc:
0.1750 - val_loss: 2.9533 - val_acc: 0.1313
Epoch 52/100
100/100 [==============================] - 4s 36ms/step - loss: 2.9644 - acc:
0.1775 - val_loss: 2.7357 - val_acc: 0.2025
Epoch 53/100
100/100 [==============================] - 3s 35ms/step - loss: 2.9871 - acc:
0.1487 - val_loss: 3.0703 - val_acc: 0.1263
Epoch 54/100
100/100 [==============================] - 4s 36ms/step - loss: 2.9183 - acc:
0.1550 - val_loss: 2.7964 - val_acc: 0.1925
Epoch 55/100
100/100 [==============================] - 4s 36ms/step - loss: 2.8445 - acc:
0.1763 - val_loss: 2.7594 - val_acc: 0.1894
Epoch 56/100
100/100 [==============================] - 4s 36ms/step - loss: 2.8447 - acc:
0.1875 - val_loss: 2.7579 - val_acc: 0.2000
Epoch 57/100
100/100 [==============================] - 4s 35ms/step - loss: 2.7892 - acc:
0.1875 - val_loss: 2.7935 - val_acc: 0.2045
Epoch 58/100
100/100 [==============================] - 4s 35ms/step - loss: 2.8174 - acc:
0.1737 - val_loss: 2.6684 - val_acc: 0.2450
Epoch 59/100
100/100 [==============================] - 4s 36ms/step - loss: 2.9007 - acc:
0.1638 - val_loss: 2.7570 - val_acc: 0.1843
```

```
Epoch 60/100
100/100 [==============================] - 4s 37ms/step - loss: 2.6734 - acc:
0.2163 - val_loss: 2.6272 - val_acc: 0.2500
Epoch 61/100
100/100 [==============================] - 4s 36ms/step - loss: 2.7569 - acc:
0.1925 - val_loss: 2.8107 - val_acc: 0.1995
Epoch 62/100
100/100 [==============================] - 3s 35ms/step - loss: 2.7897 - acc:
0.1750 - val_loss: 2.5239 - val_acc: 0.2800
Epoch 63/100
100/100 [==============================] - 4s 36ms/step - loss: 2.8109 - acc:
0.2025 - val_loss: 2.6414 - val_acc: 0.2045
Epoch 64/100
100/100 [==============================] - 4s 38ms/step - loss: 2.7551 - acc:
0.2138 - val_loss: 2.5126 - val_acc: 0.2600
Epoch 65/100
100/100 [==============================] - 4s 37ms/step - loss: 2.7009 - acc:
0.2250 - val_loss: 2.4819 - val_acc: 0.2625
Epoch 66/100
100/100 [==============================] - 4s 36ms/step - loss: 2.6769 - acc:
0.2537 - val_loss: 2.5225 - val_acc: 0.2702
Epoch 67/100
100/100 [==============================] - 3s 35ms/step - loss: 2.6926 - acc:
0.2125 - val_loss: 2.5631 - val_acc: 0.2750
Epoch 68/100
100/100 [==============================] - 4s 37ms/step - loss: 2.6818 - acc:
0.2275 - val_loss: 2.4690 - val_acc: 0.2955
Epoch 69/100
100/100 [==============================] - 4s 37ms/step - loss: 2.6646 - acc:
0.2387 - val_loss: 2.4492 - val_acc: 0.2650
Epoch 70/100
100/100 [==============================] - 3s 35ms/step - loss: 2.5652 - acc:
0.2575 - val_loss: 2.2852 - val_acc: 0.3056
Epoch 71/100
100/100 [==============================] - 4s 37ms/step - loss: 2.5661 - acc:
0.2725 - val_loss: 2.6357 - val_acc: 0.2350
Epoch 72/100
100/100 [==============================] - 4s 37ms/step - loss: 2.6241 - acc:
0.2350 - val_loss: 2.6295 - val_acc: 0.2475
Epoch 73/100
100/100 [==============================] - 3s 34ms/step - loss: 2.5570 - acc:
0.2387 - val_loss: 2.4687 - val_acc: 0.3125
Epoch 74/100
100/100 [==============================] - 3s 35ms/step - loss: 2.5800 - acc:
0.2575 - val_loss: 2.7102 - val_acc: 0.2121
Epoch 75/100
100/100 [==============================] - 4s 37ms/step - loss: 2.5317 - acc:
0.2338 - val_loss: 2.3074 - val_acc: 0.3400
Epoch 76/100
100/100 [==============================] - 3s 35ms/step - loss: 2.4154 - acc:
0.2850 - val_loss: 2.3169 - val_acc: 0.3359
Epoch 77/100
100/100 [==============================] - 4s 35ms/step - loss: 2.5170 - acc:
0.2913 - val_loss: 2.3982 - val_acc: 0.2950
Epoch 78/100
100/100 [==============================] - 4s 36ms/step - loss: 2.4715 - acc:
0.3013 - val_loss: 2.2491 - val_acc: 0.3434
```

```
Epoch 79/100
100/100 [==============================] - 4s 36ms/step - loss: 2.5554 - acc:
0.2550 - val_loss: 2.1916 - val_acc: 0.3225
Epoch 80/100
100/100 [==============================] - 4s 38ms/step - loss: 2.3996 - acc:
0.2800 - val_loss: 2.2420 - val_acc: 0.3283
Epoch 81/100
100/100 [==============================] - 4s 36ms/step - loss: 2.3139 - acc:
0.3275 - val_loss: 2.4184 - val_acc: 0.2925
Epoch 82/100
100/100 [==============================] - 3s 35ms/step - loss: 2.3845 - acc:
0.2987 - val_loss: 2.1397 - val_acc: 0.3460
Epoch 83/100
100/100 [==============================] - 4s 36ms/step - loss: 2.4918 - acc:
0.2762 - val_loss: 2.2373 - val_acc: 0.3225
Epoch 84/100
100/100 [==============================] - 3s 34ms/step - loss: 2.4028 - acc:
0.2838 - val_loss: 2.2370 - val_acc: 0.3056
Epoch 85/100
100/100 [==============================] - 4s 36ms/step - loss: 2.2431 - acc:
0.3463 - val_loss: 2.2491 - val_acc: 0.3325
Epoch 86/100
100/100 [==============================] - 4s 35ms/step - loss: 2.3011 - acc:
0.3025 - val_loss: 2.3333 - val_acc: 0.3250
Epoch 87/100
100/100 [==============================] - 4s 37ms/step - loss: 2.2575 - acc:
0.3250 - val_loss: 2.0511 - val_acc: 0.4040
Epoch 88/100
100/100 [==============================] - 3s 35ms/step - loss: 2.2738 - acc:
0.3250 - val_loss: 1.9583 - val_acc: 0.4200
Epoch 89/100
100/100 [==============================] - 4s 37ms/step - loss: 2.4136 - acc:
0.2725 - val_loss: 2.3690 - val_acc: 0.3131
Epoch 90/100
100/100 [==============================] - 4s 35ms/step - loss: 2.0712 - acc:
0.3875 - val_loss: 2.1649 - val_acc: 0.3650
Epoch 91/100
100/100 [==============================] - 4s 36ms/step - loss: 2.1611 - acc:
0.3463 - val_loss: 1.9521 - val_acc: 0.4015
Epoch 92/100
100/100 [==============================] - 4s 36ms/step - loss: 2.1989 - acc:
0.3713 - val_loss: 1.7969 - val_acc: 0.4450
Epoch 93/100
100/100 [==============================] - 4s 36ms/step - loss: 2.2899 - acc:
0.3287 - val_loss: 2.0332 - val_acc: 0.3914
Epoch 94/100
100/100 [==============================] - 4s 36ms/step - loss: 2.3035 - acc:
0.3225 - val_loss: 2.0113 - val_acc: 0.4075
Epoch 95/100
100/100 [==============================] - 4s 37ms/step - loss: 2.0472 - acc:
0.4013 - val_loss: 1.9209 - val_acc: 0.4040
Epoch 96/100
100/100 [==============================] - 4s 38ms/step - loss: 2.1040 - acc:
0.3850 - val_loss: 1.8276 - val_acc: 0.4525
Epoch 97/100
100/100 [==============================] - 4s 36ms/step - loss: 2.1488 - acc:
0.3412 - val_loss: 1.7008 - val_acc: 0.4924
```

```
Epoch 98/100
100/100 [==============================] - 4s 36ms/step - loss: 2.0949 - acc:
0.3625 - val_loss: 2.0844 - val_acc: 0.3650
Epoch 99/100
100/100 [==============================] - 4s 35ms/step - loss: 2.1211 - acc:
0.3862 - val_loss: 1.8829 - val_acc: 0.4167
Epoch 100/100
100/100 [==============================] - 4s 37ms/step - loss: 1.8801 - acc:
0.4475 - val_loss: 1.8459 - val_acc: 0.4775
```

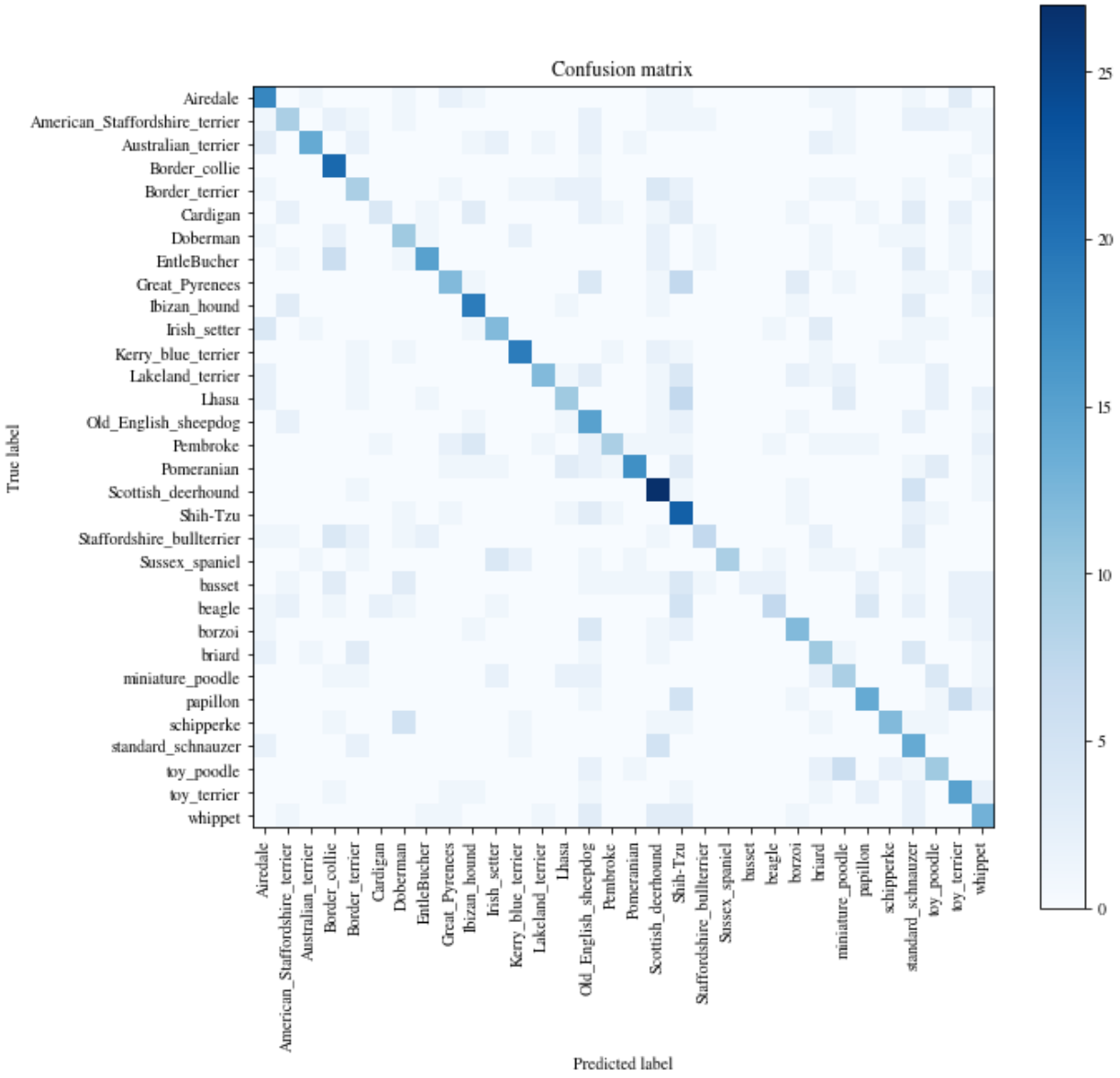





```
TEST accuracy: 0.46125
TEST loss: 1.861013078689575

Confusion Matrix
[[18  0  1 ...  0  3  0]
 [ 1  9  0 ...  2  1  1]
 [ 3  0 14 ...  0  0  1]
 ...
 [ 0  0  0 ... 10  0  0]
 [ 0  0  0 ...  0 15  2]
 [ 0  1  0 ...  0  0 13]]
```

Classification Report

	precision	recall	f1-score	support
Airedale	0.46	0.58	0.51	31
American_Staffordshire_terrier	0.41	0.35	0.38	26
Australian_terrier	0.78	0.47	0.58	30
Border_collie	0.50	0.91	0.65	23
Border_terrier	0.36	0.33	0.35	27
Cardigan	0.57	0.17	0.26	24
Doberman	0.40	0.43	0.42	23
EntleBucher	0.71	0.48	0.58	31
Great_Pyrenees	0.57	0.36	0.44	33
Ibizan_hound	0.56	0.66	0.60	29
Irish_setter	0.55	0.50	0.52	24
Kerry_blue_terrier	0.73	0.68	0.70	28
Lakeland_terrier	0.75	0.39	0.51	31
Lhasa	0.48	0.34	0.40	29
Old_English_sheepdog	0.28	0.58	0.38	26
Pembroke	0.64	0.32	0.43	28
Pomeranian	0.77	0.50	0.61	34
Scottish_deerhound	0.46	0.75	0.57	36
Shih-Tzu	0.29	0.67	0.40	33
Staffordshire_bullterrier	0.64	0.29	0.40	24
Sussex_spaniel	1.00	0.38	0.55	24
basset	1.00	0.07	0.14	27
beagle	0.58	0.23	0.33	30
borzoi	0.50	0.50	0.50	24
briard	0.32	0.42	0.36	24
miniature_poodle	0.32	0.38	0.35	24
papillon	0.58	0.47	0.52	30
schipperke	0.71	0.50	0.59	24
standard_schnauzer	0.24	0.58	0.34	24
toy_poodle	0.36	0.42	0.38	24
toy_terrier	0.43	0.56	0.48	27
whippet	0.34	0.45	0.39	29
avg / total	0.54	0.46	0.46	881



TRANSFER LEARNING USING ResNet50, Xception & InceptionResNetV2

In [67]:
```
K.clear_session()

from keras.applications import InceptionResNetV2
from keras.applications.resnet50 import ResNet50
from keras.applications.xception import Xception


def Transfer_model_create(train_generator, num_of_dogs):
    for data_batch, labels_batch in train_generator:
        print('data batch shape:', data_batch.shape)
        print('labels batch shape:', labels_batch.shape)
        break
    #data_batch, labels_batch = train_generator[0]
    batch_size = len(labels_batch)
    print("Batch Size: %d"%batch_size)
    print(data_batch.shape[1:])

   # conv_base = ResNet50(weights = 'imagenet', include_top= False, input_shape =
    #conv_base = InceptionResNetV2(weights = 'imagenet', include_top= False, inpu
    conv_base = Xception(weights= 'imagenet', include_top= False, input_shape = d
    #conv_base.trainable = False

    print("Number of Trainable weights:", len(conv_base.trainable_weights))

    for layer in conv_base.layers[:80]:
        layer.trainable = False #False
    for layer in conv_base.layers[80:]:
        layer.trainable = True
    print("Number of Trainable weights:", len(conv_base.trainable_weights))

    model = Sequential(name='TransferModel')
    model.add(conv_base)

    model.add(Conv2D(256,(1,1), padding='same',activation='relu'))

    #model.add(Conv2D(256,(3,3), padding='same',activation='relu'))
    model.add(MaxPooling2D(pool_size=(2,2)))
    model.add(BatchNormalization())

    model.add(Flatten())


    model.add(Dense(NUM_OF_DOGS, kernel_initializer='glorot_uniform', activation=

    model.compile(loss='categorical_crossentropy',
                  #optimizer = 'rmsprop',
                  optimizer = 'adam',
                  #optimizer=optimizers.RMSprop(lr=2e-5),
                  metrics=['acc'])
    #model.compile(optimizer="adam", loss="binary_crossentropy", metrics = ["accu
    return model

# CREATE THE DIRECTORIES
train_dir, validation_dir, test_dir = create_dog_images_dirs (PATH, dog_dict_list

# THEN CREATE THE DATA GENERATORS
```

```
train_generator, validation_generator, test_generator = create_data_generatores(t

TRANSFER_model = Transfer_model_create(train_generator, 32)
TRANSFER_model.summary()
```

```
Found 1021 images belonging to 8 classes.
Found 216 images belonging to 8 classes.
Found 226 images belonging to 8 classes.
data batch shape: (8, 128, 128, 3)
labels batch shape: (8, 8)
Batch Size: 8
(128, 128, 3)
Number of Trainable weights: 154
Number of Trainable weights: 63
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
xception (Model)             (None, 4, 4, 2048)        20861480
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 4, 4, 256)         524544
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 2, 2, 256)         0
_________________________________________________________________
batch_normalization_5 (Batch (None, 2, 2, 256)         1024
_________________________________________________________________
flatten_1 (Flatten)          (None, 1024)              0
_________________________________________________________________
fc2 (Dense)                  (None, 115)               117875
=================================================================
Total params: 21,504,923
Trainable params: 13,349,227
Non-trainable params: 8,155,696
_________________________________________________________________
```

In [68]:
```
PATH = './dog_images_all'
TRN = 0.70  # Training data percentage
VL = 0.15   # Validation data percentage
TST = 0.15  # Test data percentage.

def run_Transfer_pipeline(num_of_dogs, epoc):
    # CREATE THE DIRECTORIES
    train_dir, validation_dir, test_dir = create_dog_images_dirs (PATH, dog_dict_

    # THEN CREATE THE DATA GENERATORS
    train_generator, validation_generator, test_generator = create_data_generator

    # CREATE THE MODEL
    MODEL = Transfer_model_create(train_generator, NUM_OF_DOGS)

    # GET A SUMMARY FOR THE MODEL
    MODEL .summary()

    # FIT MODEL
    history = fit_model(MODEL, train_generator, validation_generator, epoc)

    # PLOT ACCURACIES DURING TRAINING
    plot_accuracies_loss(history)

    # SHOW RESULTS ON TEST SET
    show_results(MODEL, test_generator)
    return
```

TRANSFER LEARNING MODEL: Classification with 32 Dog Breeds

In [110]:
```
NUM_OF_DOGS = 32
EPOC = 200
run_Transfer_pipeline(NUM_OF_DOGS, EPOC)
```

```
Found 3956 images belonging to 32 classes.
Found 836 images belonging to 32 classes.
Found 881 images belonging to 32 classes.
data batch shape: (8, 75, 75, 3)
labels batch shape: (8, 32)
Batch Size: 8
(75, 75, 3)
Number of Trainable weights: 154
Number of Trainable weights: 154
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
xception (Model)             (None, 3, 3, 2048)        20861480
_________________________________________________________________
flatten_2 (Flatten)          (None, 18432)             0
_________________________________________________________________
fc2 (Dense)                  (None, 32)                589856
=================================================================
Total params: 21,451,336
Trainable params: 21,396,808
Non-trainable params: 54,528
_________________________________________________________________
Epoch 1/200
100/100 [==============================] - 19s 187ms/step - loss: 3.6739 - acc:
0.0412 - val_loss: 3.9035 - val_acc: 0.0450
Epoch 2/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4701 - acc:
0.0250 - val_loss: 3.4852 - val_acc: 0.0375
Epoch 3/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4681 - acc:
0.0500 - val_loss: 3.4575 - val_acc: 0.0303
Epoch 4/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4778 - acc:
0.0425 - val_loss: 4.0104 - val_acc: 0.0375
Epoch 5/200
100/100 [==============================] - 13s 127ms/step - loss: 3.4645 - acc:
0.0363 - val_loss: 3.4599 - val_acc: 0.0404
Epoch 6/200
100/100 [==============================] - 13s 127ms/step - loss: 3.4566 - acc:
0.0475 - val_loss: 3.5272 - val_acc: 0.0625
Epoch 7/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4711 - acc:
0.0462 - val_loss: 3.6018 - val_acc: 0.0278
Epoch 8/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4475 - acc:
0.0425 - val_loss: 5.1878 - val_acc: 0.0625
Epoch 9/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4362 - acc:
0.0525 - val_loss: 4.0046 - val_acc: 0.0505
Epoch 10/200
100/100 [==============================] - 13s 125ms/step - loss: 3.4594 - acc:
0.0475 - val_loss: 4.2398 - val_acc: 0.0475
Epoch 11/200
```

```
100/100 [==============================] - 13s 126ms/step - loss: 3.4244 - acc:
0.0663 - val_loss: 4.8333 - val_acc: 0.0833
Epoch 12/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4876 - acc:
0.0638 - val_loss: 5.4431 - val_acc: 0.0575
Epoch 13/200
100/100 [==============================] - 13s 126ms/step - loss: 3.4559 - acc:
0.0800 - val_loss: 4.7952 - val_acc: 0.0429
Epoch 14/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3736 - acc:
0.0887 - val_loss: 3.5641 - val_acc: 0.1025
Epoch 15/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3857 - acc:
0.0662 - val_loss: 3.7269 - val_acc: 0.0934
Epoch 16/200
100/100 [==============================] - 13s 127ms/step - loss: 3.3405 - acc:
0.0650 - val_loss: 7.3978 - val_acc: 0.0650
Epoch 17/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3423 - acc:
0.0738 - val_loss: 4.4713 - val_acc: 0.0808
Epoch 18/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3993 - acc:
0.0813 - val_loss: 3.5933 - val_acc: 0.0350
Epoch 19/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3091 - acc:
0.0813 - val_loss: 3.9808 - val_acc: 0.0682
Epoch 20/200
100/100 [==============================] - 13s 126ms/step - loss: 3.3019 - acc:
0.0813 - val_loss: 3.3312 - val_acc: 0.0650
Epoch 21/200
100/100 [==============================] - 13s 126ms/step - loss: 3.1450 - acc:
0.0938 - val_loss: 3.1956 - val_acc: 0.1035
Epoch 22/200
100/100 [==============================] - 13s 127ms/step - loss: 3.1774 - acc:
0.0925 - val_loss: 5.7792 - val_acc: 0.0625
Epoch 23/200
100/100 [==============================] - 13s 126ms/step - loss: 3.1421 - acc:
0.0938 - val_loss: 4.4545 - val_acc: 0.0650
Epoch 24/200
100/100 [==============================] - 13s 127ms/step - loss: 3.0799 - acc:
0.1087 - val_loss: 3.4720 - val_acc: 0.1364
Epoch 25/200
100/100 [==============================] - 13s 126ms/step - loss: 3.1040 - acc:
0.1163 - val_loss: 3.1893 - val_acc: 0.1125
Epoch 26/200
100/100 [==============================] - 13s 126ms/step - loss: 3.0730 - acc:
0.1150 - val_loss: 3.5754 - val_acc: 0.0960
Epoch 27/200
100/100 [==============================] - 13s 126ms/step - loss: 3.0658 - acc:
0.1212 - val_loss: 5.1152 - val_acc: 0.0950
Epoch 28/200
100/100 [==============================] - 13s 126ms/step - loss: 3.0941 - acc:
0.1013 - val_loss: 3.9360 - val_acc: 0.0884
Epoch 29/200
100/100 [==============================] - 13s 126ms/step - loss: 3.0206 - acc:
0.1075 - val_loss: 3.1551 - val_acc: 0.1100
Epoch 30/200
```

```
100/100 [==============================] - 13s 126ms/step - loss: 2.9452 - acc:
0.1500 - val_loss: 3.1226 - val_acc: 0.1187
Epoch 31/200
100/100 [==============================] - 13s 126ms/step - loss: 2.8767 - acc:
0.1612 - val_loss: 2.8932 - val_acc: 0.1400
Epoch 32/200
100/100 [==============================] - 13s 126ms/step - loss: 2.8309 - acc:
0.1200 - val_loss: 2.7395 - val_acc: 0.1389
Epoch 33/200
100/100 [==============================] - 13s 126ms/step - loss: 2.7857 - acc:
0.1625 - val_loss: 2.6782 - val_acc: 0.1875
Epoch 34/200
100/100 [==============================] - 13s 127ms/step - loss: 2.8487 - acc:
0.1537 - val_loss: 3.2970 - val_acc: 0.0783
Epoch 35/200
100/100 [==============================] - 13s 126ms/step - loss: 2.8324 - acc:
0.1663 - val_loss: 2.7926 - val_acc: 0.1825
Epoch 36/200
100/100 [==============================] - 13s 126ms/step - loss: 2.5843 - acc:
0.2188 - val_loss: 2.3618 - val_acc: 0.2778
Epoch 37/200
100/100 [==============================] - 13s 126ms/step - loss: 2.5903 - acc:
0.2125 - val_loss: 2.8474 - val_acc: 0.1650
Epoch 38/200
100/100 [==============================] - 13s 126ms/step - loss: 2.5374 - acc:
0.2200 - val_loss: 2.7258 - val_acc: 0.1970
Epoch 39/200
100/100 [==============================] - 13s 127ms/step - loss: 2.6376 - acc:
0.1938 - val_loss: 2.5364 - val_acc: 0.2325
Epoch 40/200
100/100 [==============================] - 13s 126ms/step - loss: 2.4067 - acc:
0.2725 - val_loss: 2.3652 - val_acc: 0.2601
Epoch 41/200
100/100 [==============================] - 13s 126ms/step - loss: 2.3699 - acc:
0.2863 - val_loss: 2.4652 - val_acc: 0.2350
Epoch 42/200
100/100 [==============================] - 13s 126ms/step - loss: 2.3295 - acc:
0.2662 - val_loss: 2.5200 - val_acc: 0.2702
Epoch 43/200
100/100 [==============================] - 13s 126ms/step - loss: 2.3552 - acc:
0.2525 - val_loss: 2.0599 - val_acc: 0.3650
Epoch 44/200
100/100 [==============================] - 13s 126ms/step - loss: 2.4043 - acc:
0.2725 - val_loss: 3.4549 - val_acc: 0.1625
Epoch 45/200
100/100 [==============================] - 13s 126ms/step - loss: 2.1609 - acc:
0.3150 - val_loss: 2.1073 - val_acc: 0.3611
Epoch 46/200
100/100 [==============================] - 13s 126ms/step - loss: 2.0114 - acc:
0.3612 - val_loss: 3.7519 - val_acc: 0.1650
Epoch 47/200
100/100 [==============================] - 13s 126ms/step - loss: 2.0886 - acc:
0.3438 - val_loss: 2.2068 - val_acc: 0.3182
Epoch 48/200
100/100 [==============================] - 13s 126ms/step - loss: 2.1419 - acc:
0.3237 - val_loss: 2.0541 - val_acc: 0.3450
Epoch 49/200
```

```
100/100 [==============================] - 13s 126ms/step - loss: 2.0867 - acc:
0.3438 - val_loss: 2.4936 - val_acc: 0.2980
Epoch 50/200
100/100 [==============================] - 13s 126ms/step - loss: 1.9860 - acc:
0.3650 - val_loss: 1.9990 - val_acc: 0.3450
Epoch 51/200
100/100 [==============================] - 13s 126ms/step - loss: 1.7908 - acc:
0.4263 - val_loss: 2.4102 - val_acc: 0.3056
Epoch 52/200
100/100 [==============================] - 13s 126ms/step - loss: 1.7951 - acc:
0.4175 - val_loss: 1.6308 - val_acc: 0.4850
Epoch 53/200
100/100 [==============================] - 13s 126ms/step - loss: 1.7906 - acc:
0.4288 - val_loss: 1.7018 - val_acc: 0.4444
Epoch 54/200
100/100 [==============================] - 13s 126ms/step - loss: 1.8923 - acc:
0.4088 - val_loss: 1.7126 - val_acc: 0.4675
Epoch 55/200
100/100 [==============================] - 13s 126ms/step - loss: 1.6224 - acc:
0.4913 - val_loss: 1.3039 - val_acc: 0.5354
Epoch 56/200
100/100 [==============================] - 13s 126ms/step - loss: 1.4211 - acc:
0.5212 - val_loss: 1.3828 - val_acc: 0.5200
Epoch 57/200
100/100 [==============================] - 13s 127ms/step - loss: 1.4845 - acc:
0.5250 - val_loss: 1.8750 - val_acc: 0.4066
Epoch 58/200
100/100 [==============================] - 13s 127ms/step - loss: 1.5310 - acc:
0.4913 - val_loss: 1.1861 - val_acc: 0.5900
Epoch 59/200
100/100 [==============================] - 13s 127ms/step - loss: 1.6537 - acc:
0.4738 - val_loss: 1.1027 - val_acc: 0.6162
Epoch 60/200
100/100 [==============================] - 13s 126ms/step - loss: 1.2892 - acc:
0.5737 - val_loss: 1.1260 - val_acc: 0.6025
Epoch 61/200
100/100 [==============================] - 13s 126ms/step - loss: 1.2410 - acc:
0.5800 - val_loss: 1.3696 - val_acc: 0.5429
Epoch 62/200
100/100 [==============================] - 13s 127ms/step - loss: 1.3125 - acc:
0.5625 - val_loss: 1.4621 - val_acc: 0.5275
Epoch 63/200
100/100 [==============================] - 13s 126ms/step - loss: 1.2875 - acc:
0.5687 - val_loss: 0.9152 - val_acc: 0.7020
Epoch 64/200
100/100 [==============================] - 13s 126ms/step - loss: 1.4209 - acc:
0.5175 - val_loss: 1.4611 - val_acc: 0.5450
Epoch 65/200
100/100 [==============================] - 13s 126ms/step - loss: 1.2015 - acc:
0.6125 - val_loss: 1.4393 - val_acc: 0.5400
Epoch 66/200
100/100 [==============================] - 13s 126ms/step - loss: 1.0091 - acc:
0.6600 - val_loss: 0.7127 - val_acc: 0.7626
Epoch 67/200
100/100 [==============================] - 13s 126ms/step - loss: 1.0592 - acc:
0.6625 - val_loss: 1.3461 - val_acc: 0.5500
Epoch 68/200
```

```
100/100 [==============================] - 13s 126ms/step - loss: 1.0128 - acc:
0.6613 - val_loss: 1.2867 - val_acc: 0.5833
Epoch 69/200
100/100 [==============================] - 13s 127ms/step - loss: 1.0272 - acc:
0.6388 - val_loss: 0.7048 - val_acc: 0.7625
Epoch 70/200
100/100 [==============================] - 13s 125ms/step - loss: 0.8230 - acc:
0.7263 - val_loss: 0.5993 - val_acc: 0.8333
Epoch 71/200
100/100 [==============================] - 13s 126ms/step - loss: 0.8348 - acc:
0.7313 - val_loss: 0.8508 - val_acc: 0.7200
Epoch 72/200
100/100 [==============================] - 13s 126ms/step - loss: 0.8922 - acc:
0.7013 - val_loss: 0.7737 - val_acc: 0.7273
Epoch 73/200
100/100 [==============================] - 13s 126ms/step - loss: 0.9038 - acc:
0.6887 - val_loss: 0.6407 - val_acc: 0.7800
Epoch 74/200
100/100 [==============================] - 13s 126ms/step - loss: 0.8129 - acc:
0.7262 - val_loss: 0.7339 - val_acc: 0.7525
Epoch 75/200
100/100 [==============================] - 13s 126ms/step - loss: 0.6900 - acc:
0.7900 - val_loss: 0.4718 - val_acc: 0.8525
Epoch 76/200
100/100 [==============================] - 13s 126ms/step - loss: 0.6100 - acc:
0.7963 - val_loss: 0.8226 - val_acc: 0.7500
Epoch 77/200
100/100 [==============================] - 13s 127ms/step - loss: 0.6719 - acc:
0.7550 - val_loss: 0.7880 - val_acc: 0.7275
Epoch 78/200
100/100 [==============================] - 13s 127ms/step - loss: 0.7043 - acc:
0.7575 - val_loss: 0.8299 - val_acc: 0.7374
Epoch 79/200
100/100 [==============================] - 13s 127ms/step - loss: 0.7018 - acc:
0.7613 - val_loss: 0.5804 - val_acc: 0.7750
Epoch 80/200
100/100 [==============================] - 13s 126ms/step - loss: 0.5507 - acc:
0.8200 - val_loss: 0.5713 - val_acc: 0.7980
Epoch 81/200
100/100 [==============================] - 13s 126ms/step - loss: 0.5068 - acc:
0.8263 - val_loss: 0.3411 - val_acc: 0.8925
Epoch 82/200
100/100 [==============================] - 13s 126ms/step - loss: 0.6388 - acc:
0.7775 - val_loss: 0.7541 - val_acc: 0.7677
Epoch 83/200
100/100 [==============================] - 13s 126ms/step - loss: 0.6061 - acc:
0.8063 - val_loss: 0.3303 - val_acc: 0.8875
Epoch 84/200
100/100 [==============================] - 13s 126ms/step - loss: 0.5516 - acc:
0.8263 - val_loss: 0.4591 - val_acc: 0.8460
Epoch 85/200
100/100 [==============================] - 13s 126ms/step - loss: 0.5211 - acc:
0.8163 - val_loss: 0.7321 - val_acc: 0.7550
Epoch 86/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4163 - acc:
0.8538 - val_loss: 0.5318 - val_acc: 0.8450
Epoch 87/200
```

```
100/100 [==============================] - 13s 126ms/step - loss: 0.4782 - acc:
0.8363 - val_loss: 0.7448 - val_acc: 0.7424
Epoch 88/200
100/100 [==============================] - 13s 127ms/step - loss: 0.5534 - acc:
0.7963 - val_loss: 0.3467 - val_acc: 0.8625
Epoch 89/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4646 - acc:
0.8500 - val_loss: 0.3060 - val_acc: 0.9015
Epoch 90/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4315 - acc:
0.8713 - val_loss: 0.4234 - val_acc: 0.8475
Epoch 91/200
100/100 [==============================] - 13s 127ms/step - loss: 0.4129 - acc:
0.8688 - val_loss: 0.3851 - val_acc: 0.8586
Epoch 92/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4285 - acc:
0.8650 - val_loss: 0.2600 - val_acc: 0.9125
Epoch 93/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4610 - acc:
0.8525 - val_loss: 0.4484 - val_acc: 0.8510
Epoch 94/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4377 - acc:
0.8713 - val_loss: 0.2876 - val_acc: 0.9125
Epoch 95/200
100/100 [==============================] - 13s 126ms/step - loss: 0.3173 - acc:
0.8950 - val_loss: 0.4225 - val_acc: 0.8586
Epoch 96/200
100/100 [==============================] - 13s 127ms/step - loss: 0.3413 - acc:
0.9062 - val_loss: 0.2155 - val_acc: 0.9225
Epoch 97/200
100/100 [==============================] - 13s 126ms/step - loss: 0.3635 - acc:
0.8637 - val_loss: 0.2342 - val_acc: 0.9343
Epoch 98/200
100/100 [==============================] - 13s 126ms/step - loss: 0.4494 - acc:
0.8500 - val_loss: 0.3024 - val_acc: 0.9100
Epoch 99/200
100/100 [==============================] - 13s 127ms/step - loss: 0.3565 - acc:
0.8775 - val_loss: 0.2516 - val_acc: 0.9141
Epoch 100/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2822 - acc:
0.8937 - val_loss: 0.3031 - val_acc: 0.8800
Epoch 101/200
100/100 [==============================] - 13s 126ms/step - loss: 0.3414 - acc:
0.8787 - val_loss: 0.2073 - val_acc: 0.9268
Epoch 102/200
100/100 [==============================] - 13s 126ms/step - loss: 0.3179 - acc:
0.8875 - val_loss: 1.0270 - val_acc: 0.7300
Epoch 103/200
100/100 [==============================] - 13s 127ms/step - loss: 0.4059 - acc:
0.8588 - val_loss: 0.2068 - val_acc: 0.9419
Epoch 104/200
100/100 [==============================] - 13s 126ms/step - loss: 0.3336 - acc:
0.8938 - val_loss: 0.2825 - val_acc: 0.9000
Epoch 105/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2818 - acc:
0.9062 - val_loss: 0.1856 - val_acc: 0.9419
Epoch 106/200
```

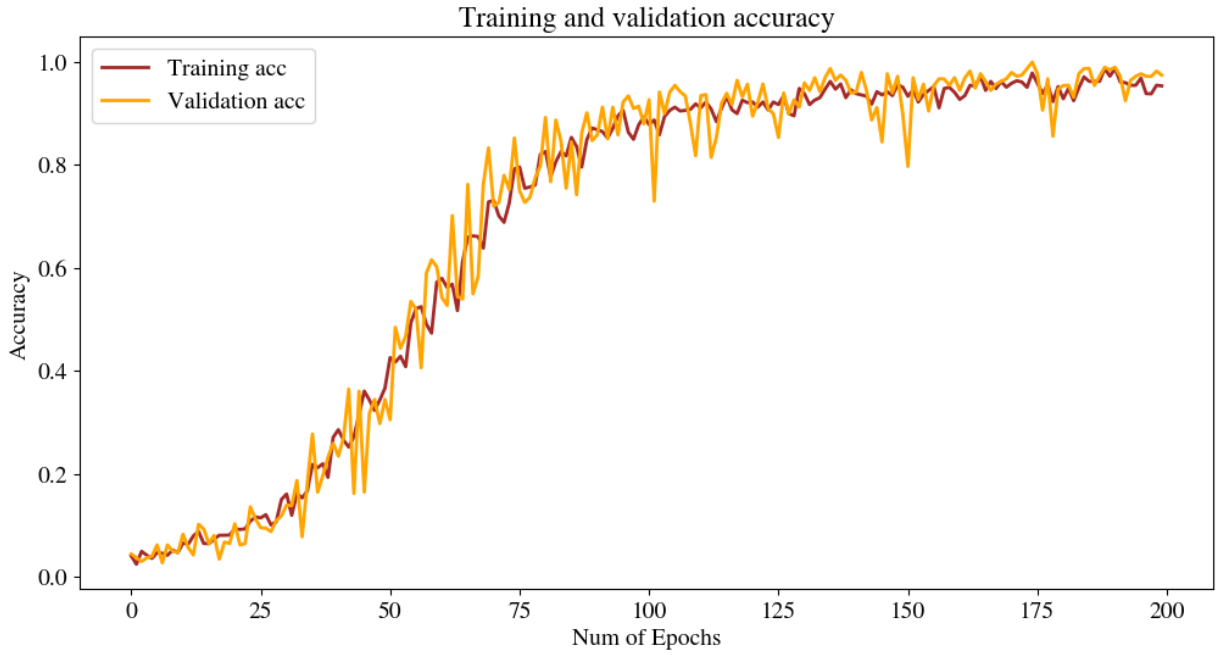
```
100/100 [==============================] - 13s 126ms/step - loss: 0.2755 - acc:
0.9125 - val_loss: 0.1500 - val_acc: 0.9550
Epoch 107/200
100/100 [==============================] - 13s 127ms/step - loss: 0.2755 - acc:
0.9050 - val_loss: 0.2156 - val_acc: 0.9425
Epoch 108/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2896 - acc:
0.9062 - val_loss: 0.1803 - val_acc: 0.9343
Epoch 109/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2857 - acc:
0.9087 - val_loss: 0.3905 - val_acc: 0.8800
Epoch 110/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2642 - acc:
0.9188 - val_loss: 0.5283 - val_acc: 0.8182
Epoch 111/200
100/100 [==============================] - 13s 127ms/step - loss: 0.2531 - acc:
0.9113 - val_loss: 0.1608 - val_acc: 0.9350
Epoch 112/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2381 - acc:
0.9225 - val_loss: 0.1942 - val_acc: 0.9369

Epoch 113/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2815 - acc:
0.9087 - val_loss: 0.6261 - val_acc: 0.8150
Epoch 114/200
100/100 [==============================] - 13s 127ms/step - loss: 0.3429 - acc:
0.8838 - val_loss: 0.5086 - val_acc: 0.8535
Epoch 115/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2795 - acc:
0.9100 - val_loss: 0.2158 - val_acc: 0.9200
Epoch 116/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2127 - acc:
0.9338 - val_loss: 0.1639 - val_acc: 0.9394
Epoch 117/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2884 - acc:
0.9075 - val_loss: 0.2143 - val_acc: 0.9175
Epoch 118/200
100/100 [==============================] - 13s 127ms/step - loss: 0.2857 - acc:
0.9000 - val_loss: 0.1044 - val_acc: 0.9646
Epoch 119/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2048 - acc:
0.9250 - val_loss: 0.1705 - val_acc: 0.9325
Epoch 120/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2144 - acc:
0.9213 - val_loss: 0.1607 - val_acc: 0.9571
Epoch 121/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2270 - acc:
0.9225 - val_loss: 0.3017 - val_acc: 0.8950
Epoch 122/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2737 - acc:
0.9125 - val_loss: 0.2305 - val_acc: 0.9217
Epoch 123/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2411 - acc:
0.9225 - val_loss: 0.1810 - val_acc: 0.9575
Epoch 124/200
100/100 [==============================] - 13s 125ms/step - loss: 0.2720 - acc:
0.9063 - val_loss: 0.3123 - val_acc: 0.9091
```

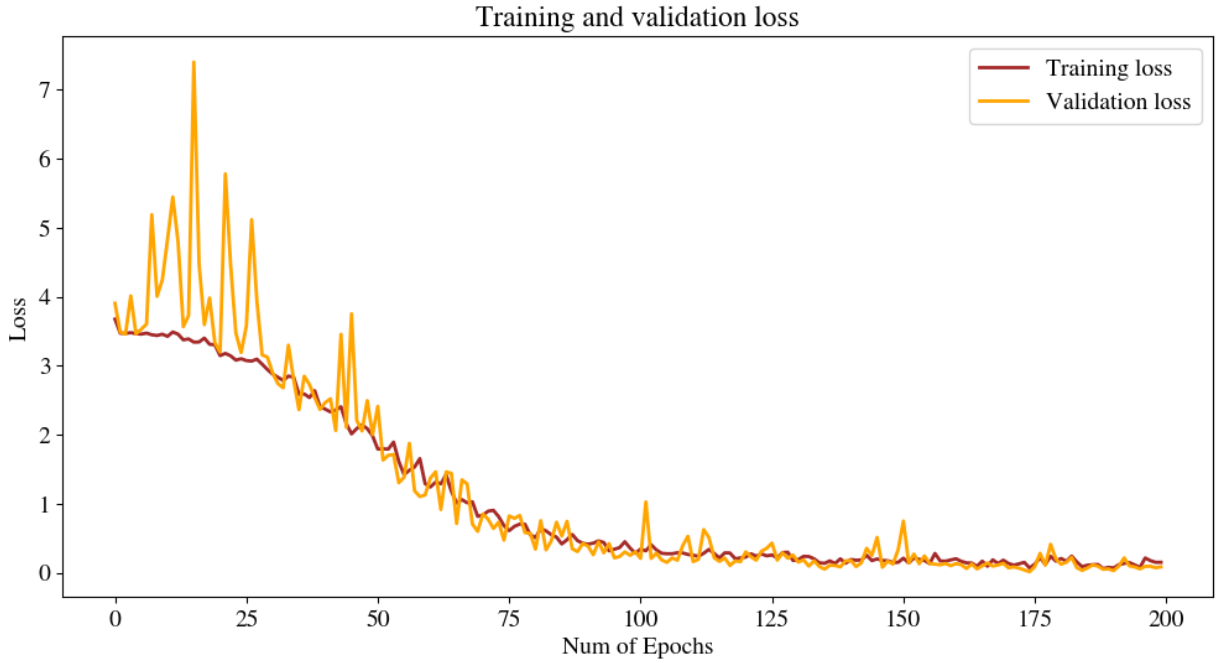
```
Epoch 125/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2447 - acc:
0.9225 - val_loss: 0.3542 - val_acc: 0.9000
Epoch 126/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2576 - acc:
0.9175 - val_loss: 0.4300 - val_acc: 0.8535
Epoch 127/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2139 - acc:
0.9350 - val_loss: 0.1819 - val_acc: 0.9400
Epoch 128/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2914 - acc:
0.9000 - val_loss: 0.2888 - val_acc: 0.9000
Epoch 129/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2982 - acc:
0.8950 - val_loss: 0.2100 - val_acc: 0.9268
Epoch 130/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1769 - acc:
0.9488 - val_loss: 0.2566 - val_acc: 0.9125
Epoch 131/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1901 - acc:
0.9387 - val_loss: 0.1532 - val_acc: 0.9596
Epoch 132/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2372 - acc:
0.9175 - val_loss: 0.1862 - val_acc: 0.9450
Epoch 133/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2348 - acc:
0.9262 - val_loss: 0.0953 - val_acc: 0.9697
Epoch 134/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2017 - acc:
0.9312 - val_loss: 0.1732 - val_acc: 0.9425
Epoch 135/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1442 - acc:
0.9475 - val_loss: 0.0910 - val_acc: 0.9697
Epoch 136/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1365 - acc:
0.9625 - val_loss: 0.0512 - val_acc: 0.9875
Epoch 137/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1718 - acc:
0.9475 - val_loss: 0.1083 - val_acc: 0.9646
Epoch 138/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1334 - acc:
0.9575 - val_loss: 0.1041 - val_acc: 0.9750
Epoch 139/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2089 - acc:
0.9300 - val_loss: 0.0842 - val_acc: 0.9646
Epoch 140/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1369 - acc:
0.9463 - val_loss: 0.1733 - val_acc: 0.9400
Epoch 141/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1919 - acc:
0.9387 - val_loss: 0.1776 - val_acc: 0.9419
Epoch 142/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1808 - acc:
0.9363 - val_loss: 0.0884 - val_acc: 0.9800
Epoch 143/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1849 - acc:
0.9338 - val_loss: 0.1431 - val_acc: 0.9444
```

```
Epoch 144/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2518 - acc:
0.9187 - val_loss: 0.3538 - val_acc: 0.8875
Epoch 145/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1755 - acc:
0.9425 - val_loss: 0.2493 - val_acc: 0.9116
Epoch 146/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1997 - acc:
0.9363 - val_loss: 0.5125 - val_acc: 0.8450
Epoch 147/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1772 - acc:
0.9425 - val_loss: 0.0787 - val_acc: 0.9773
Epoch 148/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1741 - acc:
0.9350 - val_loss: 0.1680 - val_acc: 0.9400
Epoch 149/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1476 - acc:
0.9562 - val_loss: 0.1244 - val_acc: 0.9725
Epoch 150/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1502 - acc:
0.9513 - val_loss: 0.3337 - val_acc: 0.8990
Epoch 151/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2111 - acc:
0.9338 - val_loss: 0.7490 - val_acc: 0.7975
Epoch 152/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1409 - acc:
0.9463 - val_loss: 0.1413 - val_acc: 0.9697
Epoch 153/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2152 - acc:
0.9225 - val_loss: 0.2710 - val_acc: 0.9275
Epoch 154/200
100/100 [==============================] - 13s 125ms/step - loss: 0.1929 - acc:
0.9375 - val_loss: 0.1292 - val_acc: 0.9571
Epoch 155/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1773 - acc:
0.9450 - val_loss: 0.2433 - val_acc: 0.9050
Epoch 156/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1324 - acc:
0.9525 - val_loss: 0.1338 - val_acc: 0.9545
Epoch 157/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2794 - acc:
0.9113 - val_loss: 0.1231 - val_acc: 0.9675
Epoch 158/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1703 - acc:
0.9488 - val_loss: 0.1142 - val_acc: 0.9672
Epoch 159/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1677 - acc:
0.9512 - val_loss: 0.1333 - val_acc: 0.9550
Epoch 160/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1843 - acc:
0.9412 - val_loss: 0.1013 - val_acc: 0.9697
Epoch 161/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2025 - acc:
0.9275 - val_loss: 0.1322 - val_acc: 0.9450
Epoch 162/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1655 - acc:
0.9350 - val_loss: 0.1159 - val_acc: 0.9697
```

```
Epoch 163/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1424 - acc:
0.9550 - val_loss: 0.0601 - val_acc: 0.9825
Epoch 164/200
100/100 [==============================] - 13s 125ms/step - loss: 0.1390 - acc:
0.9537 - val_loss: 0.1268 - val_acc: 0.9495
Epoch 165/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0925 - acc:
0.9725 - val_loss: 0.0548 - val_acc: 0.9775
Epoch 166/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1677 - acc:
0.9450 - val_loss: 0.0986 - val_acc: 0.9621
Epoch 167/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0944 - acc:
0.9625 - val_loss: 0.1415 - val_acc: 0.9450
Epoch 168/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1868 - acc:
0.9488 - val_loss: 0.0955 - val_acc: 0.9571
Epoch 169/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1327 - acc:
0.9625 - val_loss: 0.1117 - val_acc: 0.9625
Epoch 170/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1821 - acc:
0.9513 - val_loss: 0.1359 - val_acc: 0.9675
Epoch 171/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1335 - acc:
0.9587 - val_loss: 0.0700 - val_acc: 0.9798
Epoch 172/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1104 - acc:
0.9637 - val_loss: 0.0838 - val_acc: 0.9725
Epoch 173/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1294 - acc:
0.9613 - val_loss: 0.0658 - val_acc: 0.9747
Epoch 174/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1503 - acc:
0.9512 - val_loss: 0.0400 - val_acc: 0.9875
Epoch 175/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0688 - acc:
0.9788 - val_loss: 0.0137 - val_acc: 1.0000
Epoch 176/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1250 - acc:
0.9587 - val_loss: 0.0885 - val_acc: 0.9775
Epoch 177/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2187 - acc:
0.9387 - val_loss: 0.2824 - val_acc: 0.9066
Epoch 178/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1205 - acc:
0.9562 - val_loss: 0.1086 - val_acc: 0.9675
Epoch 179/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2430 - acc:
0.9225 - val_loss: 0.4121 - val_acc: 0.8561
Epoch 180/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1689 - acc:
0.9525 - val_loss: 0.2000 - val_acc: 0.9475
Epoch 181/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2066 - acc:
0.9287 - val_loss: 0.1230 - val_acc: 0.9545
```

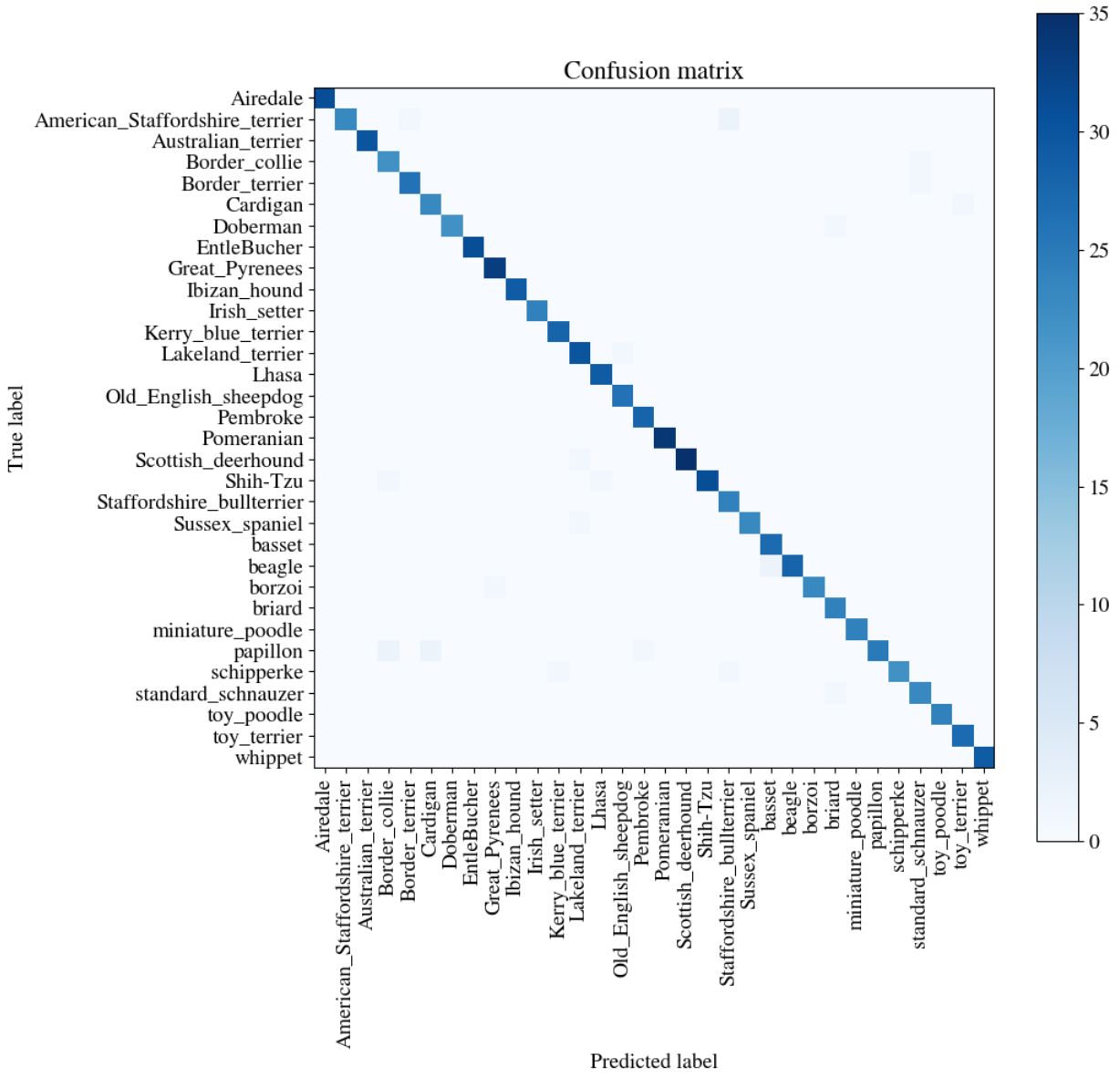
```
Epoch 182/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1655 - acc:
0.9488 - val_loss: 0.1510 - val_acc: 0.9550
Epoch 183/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2411 - acc:
0.9250 - val_loss: 0.2237 - val_acc: 0.9318
Epoch 184/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1616 - acc:
0.9488 - val_loss: 0.0727 - val_acc: 0.9775
Epoch 185/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0874 - acc:
0.9712 - val_loss: 0.0333 - val_acc: 0.9874
Epoch 186/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1089 - acc:
0.9625 - val_loss: 0.0676 - val_acc: 0.9875
Epoch 187/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1164 - acc:
0.9625 - val_loss: 0.1144 - val_acc: 0.9545
Epoch 188/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1192 - acc:
0.9625 - val_loss: 0.0941 - val_acc: 0.9725
Epoch 189/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0592 - acc:
0.9875 - val_loss: 0.0492 - val_acc: 0.9899
Epoch 190/200
100/100 [==============================] - 13s 127ms/step - loss: 0.0777 - acc:
0.9725 - val_loss: 0.0552 - val_acc: 0.9850
Epoch 191/200
100/100 [==============================] - 13s 127ms/step - loss: 0.0689 - acc:
0.9875 - val_loss: 0.0297 - val_acc: 0.9900
Epoch 192/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1165 - acc:
0.9613 - val_loss: 0.0973 - val_acc: 0.9722
Epoch 193/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1351 - acc:
0.9600 - val_loss: 0.2154 - val_acc: 0.9250
Epoch 194/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1466 - acc:
0.9550 - val_loss: 0.0982 - val_acc: 0.9646
Epoch 195/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1134 - acc:
0.9550 - val_loss: 0.0837 - val_acc: 0.9725
Epoch 196/200
100/100 [==============================] - 13s 126ms/step - loss: 0.0764 - acc:
0.9688 - val_loss: 0.0552 - val_acc: 0.9773
Epoch 197/200
100/100 [==============================] - 13s 126ms/step - loss: 0.2141 - acc:
0.9387 - val_loss: 0.0922 - val_acc: 0.9725
Epoch 198/200
100/100 [==============================] - 13s 125ms/step - loss: 0.1750 - acc:
0.9387 - val_loss: 0.0932 - val_acc: 0.9722
Epoch 199/200
100/100 [==============================] - 13s 126ms/step - loss: 0.1506 - acc:
0.9550 - val_loss: 0.0720 - val_acc: 0.9825
Epoch 200/200
100/100 [==============================] - 13s 127ms/step - loss: 0.1508 - acc:
0.9537 - val_loss: 0.0842 - val_acc: 0.9747
```






```
TEST accuracy: 0.97125
TEST loss: 0.08361115617914948

Confusion Matrix
[[31  0  0 ...  0  0  0]
 [ 0 23  0 ...  0  0  0]
 [ 0  0 30 ...  0  0  0]
 ...
 [ 0  0  0 ... 24  0  0]
 [ 0  0  0 ...  0 27  0]
 [ 0  0  0 ...  0  0 29]]

Classification Report
                              precision    recall  f1-score   support
```

Airedale	1.00	1.00	1.00	31
American_Staffordshire_terrier	1.00	0.88	0.94	26
Australian_terrier	1.00	1.00	1.00	30
Border_collie	0.88	0.96	0.92	23
Border_terrier	0.96	0.96	0.96	27
Cardigan	0.92	0.96	0.94	24
Doberman	1.00	0.96	0.98	23
EntleBucher	1.00	1.00	1.00	31
Great_Pyrenees	0.97	1.00	0.99	33
Ibizan_hound	1.00	1.00	1.00	29
Irish_setter	1.00	1.00	1.00	24
Kerry_blue_terrier	0.97	1.00	0.98	28
Lakeland_terrier	0.94	0.97	0.95	31
Lhasa	0.97	1.00	0.98	29
Old_English_sheepdog	0.96	1.00	0.98	26
Pembroke	0.97	1.00	0.98	28
Pomeranian	1.00	1.00	1.00	34
Scottish_deerhound	1.00	0.97	0.99	36
Shih-Tzu	1.00	0.94	0.97	33
Staffordshire_bullterrier	0.89	1.00	0.94	24
Sussex_spaniel	1.00	0.96	0.98	24
basset	0.93	1.00	0.96	27
beagle	1.00	0.93	0.97	30
borzoi	1.00	0.96	0.98	24
briard	0.92	1.00	0.96	24
miniature_poodle	1.00	1.00	1.00	24
papillon	1.00	0.83	0.91	30
schipperke	1.00	0.92	0.96	24
standard_schnauzer	0.92	0.96	0.94	24
toy_poodle	1.00	1.00	1.00	24
toy_terrier	0.96	1.00	0.98	27
whippet	1.00	1.00	1.00	29
avg / total	0.98	0.97	0.97	881


Confusion matrix
True label
Predicted label
Airedale
American_Staffordshire_terrier
Australian_terrier
Border_collie
Border_terrier
Cardigan
Doberman
EntleBucher
Great_Pyrenees
Ibizan_hound
Irish_setter
Kerry_blue_terrier
Lakeland_terrier
Lhasa
Old_English_sheepdog
Pembroke
Pomeranian
Scottish_deerhound
Shih-Tzu
Staffordshire_bullterrier
Sussex_spaniel
basset
beagle
borzoi
briard
miniature_poodle
papillon
schipperke
standard_schnauzer
toy_poodle
toy_terrier
whippet
35
30
25
20
15
10
5
0

In [69]:
```
NUM_OF_DOGS = 115
EPOC = 250
run_Transfer_pipeline(NUM_OF_DOGS, EPOC)
```

```
Found 13758 images belonging to 115 classes.
Found 2899 images belonging to 115 classes.
Found 3067 images belonging to 115 classes.
data batch shape: (8, 128, 128, 3)
labels batch shape: (8, 115)
Batch Size: 8
(128, 128, 3)
Number of Trainable weights: 154
Number of Trainable weights: 63
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
xception (Model)             (None, 4, 4, 2048)        20861480
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 4, 4, 256)         524544
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 2, 2, 256)         0
_________________________________________________________________
batch_normalization_10 (Batc (None, 2, 2, 256)         1024
_________________________________________________________________
flatten_2 (Flatten)          (None, 1024)              0
_________________________________________________________________
fc2 (Dense)                  (None, 115)               117875
=================================================================
Total params: 21,504,923
Trainable params: 13,349,227
Non-trainable params: 8,155,696
_________________________________________________________________
Epoch 1/250
100/100 [==============================] - 14s 143ms/step - loss: 5.3017 - acc:
0.0187 - val_loss: 10.0489 - val_acc: 0.0000e+00
Epoch 2/250
100/100 [==============================] - 11s 109ms/step - loss: 5.1748 - acc:
0.0112 - val_loss: 8.3714 - val_acc: 0.0075
Epoch 3/250
100/100 [==============================] - 11s 109ms/step - loss: 5.1202 - acc:
0.0213 - val_loss: 6.0795 - val_acc: 0.0225
Epoch 4/250
100/100 [==============================] - 11s 109ms/step - loss: 4.9667 - acc:
0.0187 - val_loss: 6.8518 - val_acc: 0.0125
Epoch 5/250
100/100 [==============================] - 11s 109ms/step - loss: 4.9943 - acc:
0.0163 - val_loss: 4.7413 - val_acc: 0.0125
Epoch 6/250
100/100 [==============================] - 11s 109ms/step - loss: 4.9352 - acc:
0.0075 - val_loss: 6.8075 - val_acc: 0.0150
Epoch 7/250
100/100 [==============================] - 11s 109ms/step - loss: 4.9185 - acc:
0.0150 - val_loss: 6.8909 - val_acc: 0.0175
Epoch 8/250
100/100 [==============================] - 11s 109ms/step - loss: 4.8276 - acc:
0.0175 - val_loss: 6.2703 - val_acc: 0.0152
Epoch 9/250
```

```
100/100 [==============================] - 11s 109ms/step - loss: 4.8518 - acc:
0.0075 - val_loss: 5.6993 - val_acc: 0.0175
Epoch 10/250
100/100 [==============================] - 11s 110ms/step - loss: 4.7941 - acc:
0.0187 - val_loss: 5.3305 - val_acc: 0.0000e+00
Epoch 11/250
100/100 [==============================] - 11s 110ms/step - loss: 4.7702 - acc:
0.0187 - val_loss: 4.6838 - val_acc: 0.0150
Epoch 12/250
100/100 [==============================] - 11s 110ms/step - loss: 4.6823 - acc:
0.0187 - val_loss: 5.3140 - val_acc: 0.0125
Epoch 13/250
100/100 [==============================] - 11s 110ms/step - loss: 4.7115 - acc:
0.0213 - val_loss: 5.3296 - val_acc: 0.0250
Epoch 14/250
100/100 [==============================] - 11s 110ms/step - loss: 4.7090 - acc:
0.0213 - val_loss: 5.6953 - val_acc: 0.0275
Epoch 15/250
100/100 [==============================] - 11s 111ms/step - loss: 4.6118 - acc:
0.0250 - val_loss: 5.9081 - val_acc: 0.0152
Epoch 16/250
100/100 [==============================] - 11s 110ms/step - loss: 4.5910 - acc:
0.0400 - val_loss: 5.0737 - val_acc: 0.0200
Epoch 17/250
100/100 [==============================] - 11s 110ms/step - loss: 4.5547 - acc:
0.0362 - val_loss: 4.7150 - val_acc: 0.0400
Epoch 18/250
100/100 [==============================] - 11s 110ms/step - loss: 4.5193 - acc:
0.0400 - val_loss: 4.5390 - val_acc: 0.0375
Epoch 19/250
100/100 [==============================] - 11s 110ms/step - loss: 4.4615 - acc:
0.0275 - val_loss: 4.8613 - val_acc: 0.0450
Epoch 20/250
100/100 [==============================] - 11s 110ms/step - loss: 4.2709 - acc:
0.0512 - val_loss: 4.6401 - val_acc: 0.0700
Epoch 21/250
100/100 [==============================] - 11s 110ms/step - loss: 4.2066 - acc:
0.0587 - val_loss: 4.4708 - val_acc: 0.0550
Epoch 22/250
100/100 [==============================] - 11s 110ms/step - loss: 4.2209 - acc:
0.0550 - val_loss: 4.8670 - val_acc: 0.0734
Epoch 23/250
100/100 [==============================] - 11s 110ms/step - loss: 4.1501 - acc:
0.0438 - val_loss: 4.1771 - val_acc: 0.0725
Epoch 24/250
100/100 [==============================] - 11s 110ms/step - loss: 4.0542 - acc:
0.0625 - val_loss: 4.1150 - val_acc: 0.0900
Epoch 25/250
100/100 [==============================] - 11s 110ms/step - loss: 3.9511 - acc:
0.0712 - val_loss: 3.9903 - val_acc: 0.1075
Epoch 26/250
100/100 [==============================] - 11s 110ms/step - loss: 3.9080 - acc:
0.0925 - val_loss: 3.9527 - val_acc: 0.1100
Epoch 27/250
100/100 [==============================] - 11s 110ms/step - loss: 3.9795 - acc:
0.0900 - val_loss: 4.1949 - val_acc: 0.0650
Epoch 28/250
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100/100 [==============================] - 11s 110ms/step - loss: 3.9944 - acc:
0.0712 - val_loss: 3.8276 - val_acc: 0.1100
Epoch 29/250
100/100 [==============================] - 11s 111ms/step - loss: 3.9589 - acc:
0.0887 - val_loss: 3.7464 - val_acc: 0.1175
Epoch 30/250
100/100 [==============================] - 11s 111ms/step - loss: 3.8227 - acc:
0.1037 - val_loss: 3.9254 - val_acc: 0.1392
Epoch 31/250
100/100 [==============================] - 11s 111ms/step - loss: 3.7751 - acc:
0.0975 - val_loss: 4.7963 - val_acc: 0.1025
Epoch 32/250
100/100 [==============================] - 11s 111ms/step - loss: 3.7628 - acc:
0.1075 - val_loss: 3.9808 - val_acc: 0.1200
Epoch 33/250
100/100 [==============================] - 11s 110ms/step - loss: 3.7418 - acc:
0.0988 - val_loss: 3.6556 - val_acc: 0.1200
Epoch 34/250
100/100 [==============================] - 11s 110ms/step - loss: 3.5843 - acc:
0.1300 - val_loss: 3.6450 - val_acc: 0.1400
Epoch 35/250
100/100 [==============================] - 11s 111ms/step - loss: 3.5126 - acc:
0.1425 - val_loss: 3.3374 - val_acc: 0.1725
Epoch 36/250
100/100 [==============================] - 11s 111ms/step - loss: 3.4423 - acc:
0.1550 - val_loss: 3.1359 - val_acc: 0.1875
Epoch 37/250
100/100 [==============================] - 11s 110ms/step - loss: 3.4572 - acc:
0.1525 - val_loss: 3.0642 - val_acc: 0.2101
Epoch 38/250
100/100 [==============================] - 11s 110ms/step - loss: 3.4309 - acc:
0.1313 - val_loss: 3.3118 - val_acc: 0.1875
Epoch 39/250
100/100 [==============================] - 11s 110ms/step - loss: 3.3677 - acc:
0.1612 - val_loss: 3.3676 - val_acc: 0.1700
Epoch 40/250
100/100 [==============================] - 11s 110ms/step - loss: 3.4611 - acc:
0.1300 - val_loss: 3.0695 - val_acc: 0.2200
Epoch 41/250
100/100 [==============================] - 11s 111ms/step - loss: 3.3666 - acc:
0.1687 - val_loss: 3.0389 - val_acc: 0.2025
Epoch 42/250
100/100 [==============================] - 11s 110ms/step - loss: 3.2413 - acc:
0.1888 - val_loss: 3.2131 - val_acc: 0.2125
Epoch 43/250
100/100 [==============================] - 11s 110ms/step - loss: 3.3405 - acc:
0.1550 - val_loss: 3.1036 - val_acc: 0.1950
Epoch 44/250
100/100 [==============================] - 11s 110ms/step - loss: 3.2059 - acc:
0.1825 - val_loss: 3.1774 - val_acc: 0.2253
Epoch 45/250
100/100 [==============================] - 11s 110ms/step - loss: 3.1579 - acc:
0.2138 - val_loss: 2.8091 - val_acc: 0.2725
Epoch 46/250
100/100 [==============================] - 11s 110ms/step - loss: 3.2147 - acc:
0.1812 - val_loss: 2.7079 - val_acc: 0.2850
Epoch 47/250
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100/100 [==============================] - 11s 110ms/step - loss: 3.1986 - acc:
0.1825 - val_loss: 2.7950 - val_acc: 0.2550
Epoch 48/250
100/100 [==============================] - 11s 110ms/step - loss: 3.1503 - acc:
0.1862 - val_loss: 2.8464 - val_acc: 0.2625
Epoch 49/250
100/100 [==============================] - 11s 111ms/step - loss: 3.0958 - acc:
0.1925 - val_loss: 2.8098 - val_acc: 0.2875
Epoch 50/250

100/100 [==============================] - 11s 110ms/step - loss: 3.0998 - acc:
0.2487 - val_loss: 2.8511 - val_acc: 0.2525
Epoch 51/250
100/100 [==============================] - 11s 110ms/step - loss: 2.9922 - acc:
0.2325 - val_loss: 2.7821 - val_acc: 0.2380
Epoch 52/250
100/100 [==============================] - 11s 110ms/step - loss: 2.9827 - acc:
0.2308 - val_loss: 2.8903 - val_acc: 0.2575
Epoch 53/250
100/100 [==============================] - 11s 111ms/step - loss: 2.7036 - acc:
0.2913 - val_loss: 2.5978 - val_acc: 0.3100
Epoch 54/250
100/100 [==============================] - 11s 111ms/step - loss: 2.7391 - acc:
0.2563 - val_loss: 2.6746 - val_acc: 0.2725
Epoch 55/250
100/100 [==============================] - 11s 111ms/step - loss: 2.8235 - acc:
0.2587 - val_loss: 2.3931 - val_acc: 0.3325
Epoch 56/250
100/100 [==============================] - 11s 110ms/step - loss: 2.7668 - acc:
0.2537 - val_loss: 2.4474 - val_acc: 0.3250
Epoch 57/250
100/100 [==============================] - 11s 111ms/step - loss: 2.9147 - acc:
0.2300 - val_loss: 2.7683 - val_acc: 0.2675
Epoch 58/250
100/100 [==============================] - 11s 111ms/step - loss: 2.7382 - acc:
0.2650 - val_loss: 2.5340 - val_acc: 0.3175
Epoch 59/250
100/100 [==============================] - 11s 110ms/step - loss: 2.8712 - acc:
0.2600 - val_loss: 2.3965 - val_acc: 0.3646
Epoch 60/250
100/100 [==============================] - 11s 110ms/step - loss: 2.8129 - acc:
0.2737 - val_loss: 2.5634 - val_acc: 0.3350
Epoch 61/250
100/100 [==============================] - 11s 110ms/step - loss: 2.7341 - acc:
0.3025 - val_loss: 2.5987 - val_acc: 0.2800
Epoch 62/250
100/100 [==============================] - 11s 110ms/step - loss: 2.7299 - acc:
0.2888 - val_loss: 2.5211 - val_acc: 0.3075
Epoch 63/250
100/100 [==============================] - 11s 110ms/step - loss: 2.6301 - acc:
0.2888 - val_loss: 2.4247 - val_acc: 0.3350
Epoch 64/250
100/100 [==============================] - 11s 110ms/step - loss: 2.6893 - acc:
0.2825 - val_loss: 2.4628 - val_acc: 0.3325
Epoch 65/250
100/100 [==============================] - 11s 111ms/step - loss: 2.7960 - acc:
0.2712 - val_loss: 2.4131 - val_acc: 0.3275
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Epoch 66/250
100/100 [==============================] - 11s 110ms/step - loss: 2.6673 - acc:
0.2863 - val_loss: 2.3892 - val_acc: 0.3696
Epoch 67/250
100/100 [==============================] - 11s 110ms/step - loss: 2.7015 - acc:
0.2812 - val_loss: 2.2069 - val_acc: 0.3850
Epoch 68/250
100/100 [==============================] - 11s 111ms/step - loss: 2.5983 - acc:
0.2950 - val_loss: 2.2257 - val_acc: 0.3975
Epoch 69/250
100/100 [==============================] - 11s 110ms/step - loss: 2.5798 - acc:
0.3117 - val_loss: 2.2257 - val_acc: 0.4125
Epoch 70/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2971 - acc:
0.3537 - val_loss: 2.2005 - val_acc: 0.3825
Epoch 71/250
100/100 [==============================] - 11s 110ms/step - loss: 2.3048 - acc:
0.3713 - val_loss: 1.9850 - val_acc: 0.4050
Epoch 72/250
100/100 [==============================] - 11s 110ms/step - loss: 2.1931 - acc:
0.3800 - val_loss: 2.0512 - val_acc: 0.4100
Epoch 73/250
100/100 [==============================] - 11s 110ms/step - loss: 2.3133 - acc:
0.3537 - val_loss: 2.0583 - val_acc: 0.4278
Epoch 74/250
100/100 [==============================] - 11s 111ms/step - loss: 2.2353 - acc:
0.3750 - val_loss: 1.9918 - val_acc: 0.4200
Epoch 75/250
100/100 [==============================] - 11s 110ms/step - loss: 2.3305 - acc:
0.3625 - val_loss: 2.0497 - val_acc: 0.4050
Epoch 76/250
100/100 [==============================] - 11s 110ms/step - loss: 2.3188 - acc:
0.3575 - val_loss: 2.1055 - val_acc: 0.4150
Epoch 77/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2389 - acc:
0.3875 - val_loss: 2.0285 - val_acc: 0.4325
Epoch 78/250
100/100 [==============================] - 11s 110ms/step - loss: 2.3168 - acc:
0.3525 - val_loss: 2.0321 - val_acc: 0.4350
Epoch 79/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2084 - acc:
0.3875 - val_loss: 2.0880 - val_acc: 0.4225
Epoch 80/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2325 - acc:
0.3713 - val_loss: 1.9343 - val_acc: 0.4734
Epoch 81/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2636 - acc:
0.3713 - val_loss: 1.9455 - val_acc: 0.4475
Epoch 82/250
100/100 [==============================] - 11s 110ms/step - loss: 2.1986 - acc:
0.4025 - val_loss: 2.0705 - val_acc: 0.4425
Epoch 83/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2094 - acc:
0.3925 - val_loss: 1.8207 - val_acc: 0.4750
Epoch 84/250
100/100 [==============================] - 11s 110ms/step - loss: 2.2432 - acc:
0.3963 - val_loss: 1.9681 - val_acc: 0.4450
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Epoch 85/250
100/100 [==============================] - 11s 111ms/step - loss: 2.2339 - acc:
0.3750 - val_loss: 1.9073 - val_acc: 0.4275
Epoch 86/250
100/100 [==============================] - 11s 110ms/step - loss: 2.1249 - acc:
0.3854 - val_loss: 1.8421 - val_acc: 0.4575
Epoch 87/250
100/100 [==============================] - 11s 110ms/step - loss: 1.7704 - acc:
0.4825 - val_loss: 1.8112 - val_acc: 0.4850
Epoch 88/250
100/100 [==============================] - 11s 110ms/step - loss: 1.7086 - acc:
0.4900 - val_loss: 1.7390 - val_acc: 0.4987
Epoch 89/250
100/100 [==============================] - 11s 111ms/step - loss: 1.6846 - acc:
0.5125 - val_loss: 1.6820 - val_acc: 0.5225
Epoch 90/250
100/100 [==============================] - 11s 111ms/step - loss: 1.7948 - acc:
0.4625 - val_loss: 2.0509 - val_acc: 0.4125
Epoch 91/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8352 - acc:
0.4925 - val_loss: 1.7752 - val_acc: 0.5075
Epoch 92/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8700 - acc:
0.4550 - val_loss: 1.6329 - val_acc: 0.5175
Epoch 93/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8439 - acc:
0.4725 - val_loss: 1.9798 - val_acc: 0.4450
Epoch 94/250
100/100 [==============================] - 11s 110ms/step - loss: 1.9173 - acc:
0.4525 - val_loss: 1.6324 - val_acc: 0.5425
Epoch 95/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8568 - acc:
0.4700 - val_loss: 1.6797 - val_acc: 0.5139
Epoch 96/250
100/100 [==============================] - 11s 110ms/step - loss: 1.7147 - acc:
0.5000 - val_loss: 1.7183 - val_acc: 0.4850
Epoch 97/250
100/100 [==============================] - 11s 110ms/step - loss: 1.7903 - acc:
0.4612 - val_loss: 1.8171 - val_acc: 0.4875
Epoch 98/250
100/100 [==============================] - 11s 110ms/step - loss: 1.9323 - acc:
0.4525 - val_loss: 1.5411 - val_acc: 0.5450
Epoch 99/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8748 - acc:
0.4588 - val_loss: 1.7732 - val_acc: 0.4850
Epoch 100/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8310 - acc:
0.4738 - val_loss: 1.6055 - val_acc: 0.5425
Epoch 101/250
100/100 [==============================] - 11s 111ms/step - loss: 1.8730 - acc:
0.4438 - val_loss: 1.3349 - val_acc: 0.5900
Epoch 102/250
100/100 [==============================] - 11s 110ms/step - loss: 1.8799 - acc:
0.4700 - val_loss: 1.6857 - val_acc: 0.4835
Epoch 103/250
100/100 [==============================] - 11s 110ms/step - loss: 1.7860 - acc:
0.4825 - val_loss: 1.5901 - val_acc: 0.5450
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Epoch 104/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4486 - acc:
0.5771 - val_loss: 1.5055 - val_acc: 0.5875
Epoch 105/250
100/100 [==============================] - 11s 110ms/step - loss: 1.3340 - acc:
0.5850 - val_loss: 1.4914 - val_acc: 0.5375
Epoch 106/250
100/100 [==============================] - 11s 110ms/step - loss: 1.3607 - acc:
0.5750 - val_loss: 1.4361 - val_acc: 0.5675
Epoch 107/250
100/100 [==============================] - 11s 110ms/step - loss: 1.3830 - acc:
0.5713 - val_loss: 1.5286 - val_acc: 0.5375
Epoch 108/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4265 - acc:
0.5787 - val_loss: 1.4502 - val_acc: 0.5700
Epoch 109/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4123 - acc:
0.5662 - val_loss: 1.4061 - val_acc: 0.5823

Epoch 110/250
100/100 [==============================] - 11s 110ms/step - loss: 1.3643 - ac
c: 0.5925 - val_loss: 1.5278 - val_acc: 0.5400
Epoch 111/250
100/100 [==============================] - 11s 111ms/step - loss: 1.3580 - ac
c: 0.5837 - val_loss: 1.3640 - val_acc: 0.6025
Epoch 112/250
100/100 [==============================] - 11s 110ms/step - loss: 1.3538 - ac
c: 0.5850 - val_loss: 1.4959 - val_acc: 0.5300
Epoch 113/250
100/100 [==============================] - 11s 110ms/step - loss: 1.5203 - ac
c: 0.5413 - val_loss: 1.6288 - val_acc: 0.5100
Epoch 114/250
100/100 [==============================] - 11s 111ms/step - loss: 1.4391 - ac
c: 0.5812 - val_loss: 1.2614 - val_acc: 0.6525
Epoch 115/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4612 - ac
c: 0.5513 - val_loss: 1.3019 - val_acc: 0.6325
Epoch 116/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4690 - ac
c: 0.5675 - val_loss: 1.3753 - val_acc: 0.6100
Epoch 117/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4193 - ac
c: 0.6025 - val_loss: 1.1274 - val_acc: 0.6456
Epoch 118/250
100/100 [==============================] - 11s 111ms/step - loss: 1.4511 - ac
c: 0.5537 - val_loss: 1.2289 - val_acc: 0.6275
Epoch 119/250
100/100 [==============================] - 11s 111ms/step - loss: 1.6054 - ac
c: 0.5138 - val_loss: 1.2250 - val_acc: 0.6300
Epoch 120/250
100/100 [==============================] - 11s 110ms/step - loss: 1.4925 - ac
c: 0.5713 - val_loss: 1.2575 - val_acc: 0.5725
Epoch 121/250
100/100 [==============================] - 11s 110ms/step - loss: 1.1796 - ac
c: 0.6229 - val_loss: 1.1977 - val_acc: 0.6625
Epoch 122/250
100/100 [==============================] - 11s 111ms/step - loss: 0.9416 - ac
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c: 0.7262 - val_loss: 1.2938 - val_acc: 0.5950
Epoch 123/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8816 - ac
c: 0.7225 - val_loss: 1.1658 - val_acc: 0.6425
Epoch 124/250
100/100 [==============================] - 11s 110ms/step - loss: 0.9631 - ac
c: 0.6875 - val_loss: 1.2814 - val_acc: 0.6304
Epoch 125/250
100/100 [==============================] - 11s 111ms/step - loss: 0.9499 - ac
c: 0.7013 - val_loss: 1.1954 - val_acc: 0.6300
Epoch 126/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0109 - ac
c: 0.6787 - val_loss: 1.0410 - val_acc: 0.7000
Epoch 127/250
100/100 [==============================] - 11s 111ms/step - loss: 0.9745 - ac
c: 0.6912 - val_loss: 1.2620 - val_acc: 0.6525
Epoch 128/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0918 - ac
c: 0.6600 - val_loss: 1.1900 - val_acc: 0.6400
Epoch 129/250
100/100 [==============================] - 11s 111ms/step - loss: 1.1071 - ac
c: 0.6538 - val_loss: 1.1860 - val_acc: 0.6400
Epoch 130/250
100/100 [==============================] - 11s 111ms/step - loss: 1.1032 - ac
c: 0.6663 - val_loss: 1.1730 - val_acc: 0.6350
Epoch 131/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0659 - ac
c: 0.6650 - val_loss: 1.1270 - val_acc: 0.6253
Epoch 132/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0441 - ac
c: 0.6813 - val_loss: 1.1745 - val_acc: 0.6225
Epoch 133/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0746 - ac
c: 0.6700 - val_loss: 1.1204 - val_acc: 0.6475
Epoch 134/250
100/100 [==============================] - 11s 110ms/step - loss: 1.2336 - ac
c: 0.6162 - val_loss: 1.0810 - val_acc: 0.6550
Epoch 135/250
100/100 [==============================] - 11s 111ms/step - loss: 1.1120 - ac
c: 0.6613 - val_loss: 0.9900 - val_acc: 0.7000
Epoch 136/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0522 - ac
c: 0.6538 - val_loss: 1.0676 - val_acc: 0.6650
Epoch 137/250
100/100 [==============================] - 11s 110ms/step - loss: 1.1332 - ac
c: 0.6375 - val_loss: 1.3975 - val_acc: 0.6200
Epoch 138/250
100/100 [==============================] - 11s 110ms/step - loss: 1.0800 - ac
c: 0.6771 - val_loss: 0.9452 - val_acc: 0.7013
Epoch 139/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6488 - ac
c: 0.7938 - val_loss: 1.0372 - val_acc: 0.6525
Epoch 140/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7294 - ac
c: 0.7512 - val_loss: 0.9964 - val_acc: 0.6900
Epoch 141/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6710 - ac
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c: 0.7875 - val_loss: 1.1758 - val_acc: 0.6500
Epoch 142/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6720 - ac
c: 0.7738 - val_loss: 1.0357 - val_acc: 0.6550
Epoch 143/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7629 - ac
c: 0.7562 - val_loss: 1.1051 - val_acc: 0.7075
Epoch 144/250
100/100 [==============================] - 11s 111ms/step - loss: 0.7734 - ac
c: 0.7450 - val_loss: 0.8969 - val_acc: 0.7300
Epoch 145/250
100/100 [==============================] - 11s 111ms/step - loss: 0.7250 - ac
c: 0.7562 - val_loss: 0.8174 - val_acc: 0.7525
Epoch 146/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7449 - ac
c: 0.7700 - val_loss: 0.9550 - val_acc: 0.7266
Epoch 147/250
100/100 [==============================] - 11s 111ms/step - loss: 0.8459 - ac
c: 0.7362 - val_loss: 1.0871 - val_acc: 0.6600
Epoch 148/250
100/100 [==============================] - 11s 111ms/step - loss: 0.8829 - ac
c: 0.7288 - val_loss: 1.2599 - val_acc: 0.6625
Epoch 149/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8719 - ac
c: 0.7325 - val_loss: 1.0012 - val_acc: 0.6875
Epoch 150/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8666 - ac
c: 0.7338 - val_loss: 0.9269 - val_acc: 0.7225
Epoch 151/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8341 - ac
c: 0.7313 - val_loss: 0.9347 - val_acc: 0.7250
Epoch 152/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8111 - ac
c: 0.7387 - val_loss: 0.9946 - val_acc: 0.6800
Epoch 153/250
100/100 [==============================] - 11s 110ms/step - loss: 0.8437 - ac
c: 0.7362 - val_loss: 0.8969 - val_acc: 0.7367
Epoch 154/250
100/100 [==============================] - 11s 111ms/step - loss: 0.8555 - ac
c: 0.7300 - val_loss: 0.9016 - val_acc: 0.7225
Epoch 155/250
100/100 [==============================] - 11s 111ms/step - loss: 0.8386 - ac
c: 0.7267 - val_loss: 0.8751 - val_acc: 0.7450
Epoch 156/250
100/100 [==============================] - 11s 111ms/step - loss: 0.5021 - ac
c: 0.8475 - val_loss: 0.7569 - val_acc: 0.7825
Epoch 157/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4762 - ac
c: 0.8588 - val_loss: 0.7824 - val_acc: 0.7625
Epoch 158/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4328 - ac
c: 0.8625 - val_loss: 0.8448 - val_acc: 0.7325
Epoch 159/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5054 - ac
c: 0.8475 - val_loss: 1.0737 - val_acc: 0.6875
Epoch 160/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5809 - ac
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c: 0.8250 - val_loss: 0.9799 - val_acc: 0.6962
Epoch 161/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5404 - ac
c: 0.8312 - val_loss: 0.8335 - val_acc: 0.7525
Epoch 162/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6039 - ac
c: 0.8100 - val_loss: 0.7426 - val_acc: 0.7625
Epoch 163/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5929 - ac
c: 0.7900 - val_loss: 0.9154 - val_acc: 0.7000
Epoch 164/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5774 - ac
c: 0.8000 - val_loss: 0.8663 - val_acc: 0.7350
Epoch 165/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5884 - ac
c: 0.7963 - val_loss: 0.8487 - val_acc: 0.7400
Epoch 166/250
100/100 [==============================] - 11s 111ms/step - loss: 0.6183 - ac
c: 0.7800 - val_loss: 0.8984 - val_acc: 0.7225
Epoch 167/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7024 - ac
c: 0.7687 - val_loss: 0.8010 - val_acc: 0.7646
Epoch 168/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7205 - ac
c: 0.8000 - val_loss: 0.8687 - val_acc: 0.7150
Epoch 169/250

100/100 [==============================] - 11s 110ms/step - loss: 0.8506 - ac
c: 0.7412 - val_loss: 0.9631 - val_acc: 0.7000
Epoch 170/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6194 - ac
c: 0.7950 - val_loss: 0.8701 - val_acc: 0.7425
Epoch 171/250
100/100 [==============================] - 11s 110ms/step - loss: 0.7710 - ac
c: 0.7537 - val_loss: 0.7823 - val_acc: 0.7550
Epoch 172/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6240 - ac
c: 0.8000 - val_loss: 0.7625 - val_acc: 0.7525
Epoch 173/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3991 - ac
c: 0.8762 - val_loss: 0.8861 - val_acc: 0.7225
Epoch 174/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3535 - ac
c: 0.8875 - val_loss: 0.8550 - val_acc: 0.7375
Epoch 175/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4024 - ac
c: 0.8812 - val_loss: 0.7857 - val_acc: 0.7620
Epoch 176/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3762 - ac
c: 0.8625 - val_loss: 0.6222 - val_acc: 0.8175
Epoch 177/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4421 - ac
c: 0.8425 - val_loss: 0.6697 - val_acc: 0.7800
Epoch 178/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4684 - ac
c: 0.8500 - val_loss: 1.0072 - val_acc: 0.7200
Epoch 179/250
```
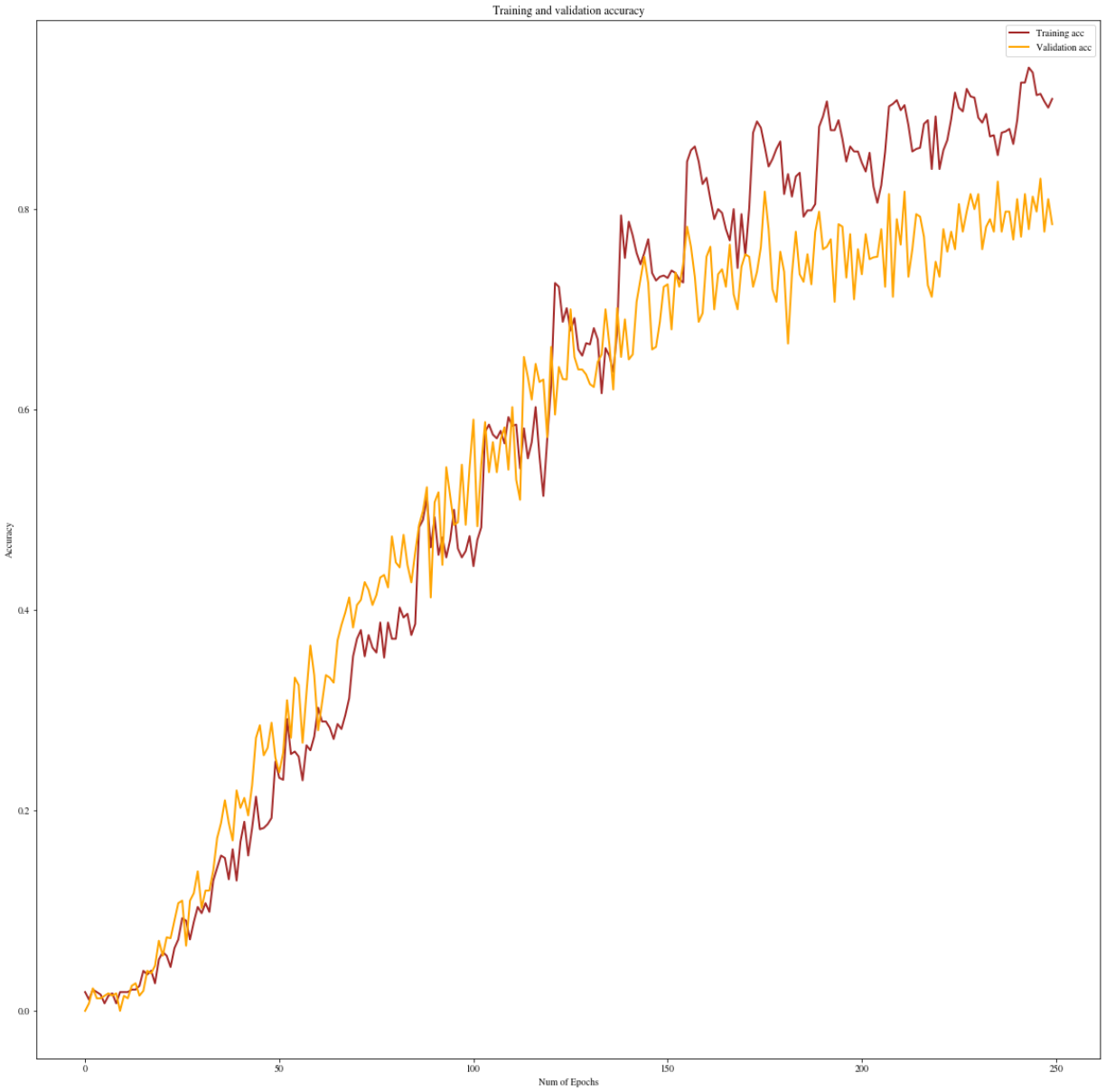
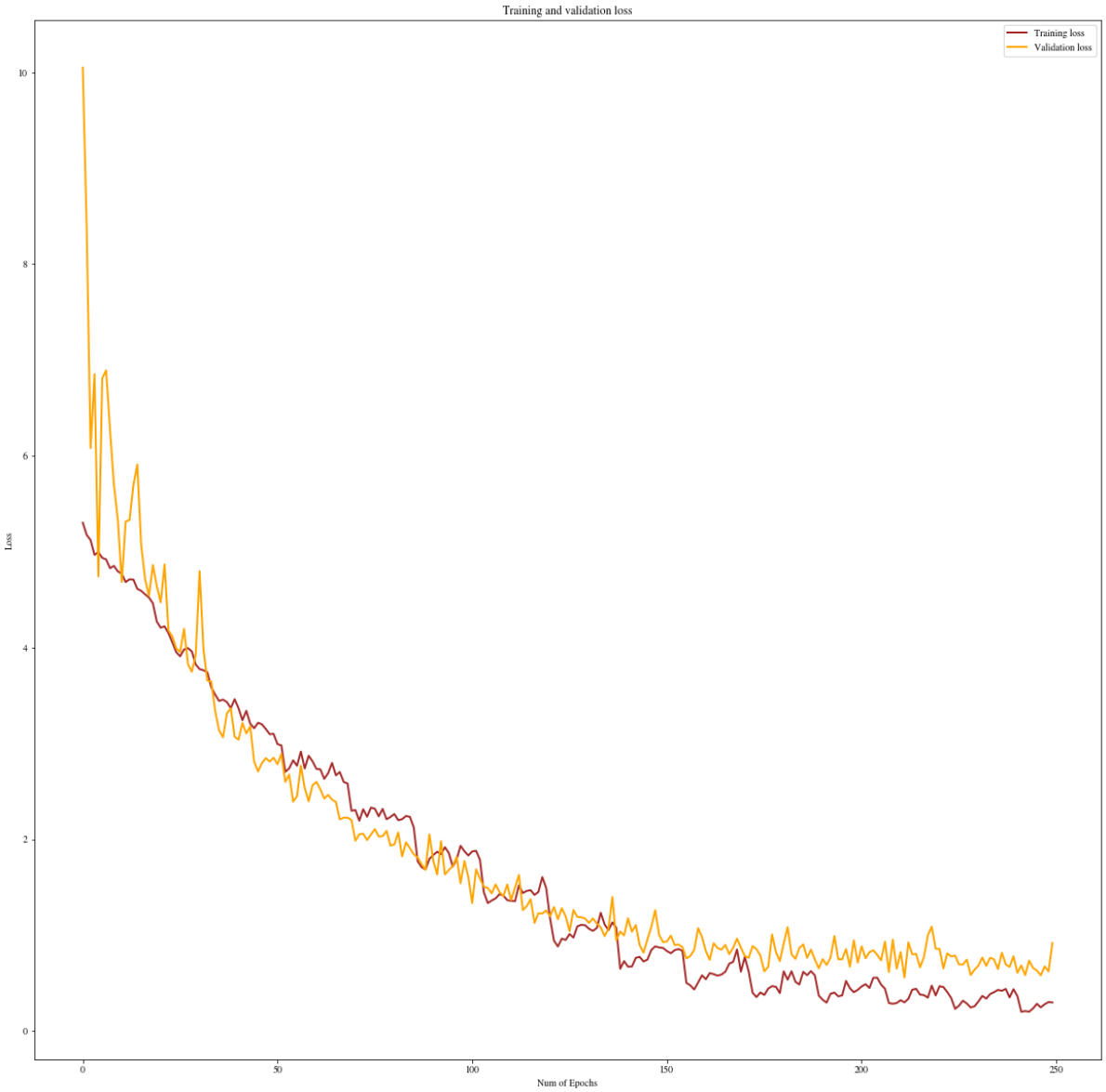

```
100/100 [==============================] - 11s 110ms/step - loss: 0.4609 - ac
c: 0.8600 - val_loss: 0.8235 - val_acc: 0.7075
Epoch 180/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3954 - ac
c: 0.8675 - val_loss: 0.7286 - val_acc: 0.7575
Epoch 181/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6222 - ac
c: 0.8150 - val_loss: 0.9126 - val_acc: 0.7375
Epoch 182/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5351 - ac
c: 0.8350 - val_loss: 1.0834 - val_acc: 0.6658
Epoch 183/250
100/100 [==============================] - 11s 111ms/step - loss: 0.6232 - ac
c: 0.8125 - val_loss: 0.7997 - val_acc: 0.7350
Epoch 184/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5134 - ac
c: 0.8325 - val_loss: 0.7519 - val_acc: 0.7775
Epoch 185/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4850 - ac
c: 0.8363 - val_loss: 0.8663 - val_acc: 0.7350
Epoch 186/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6174 - ac
c: 0.7925 - val_loss: 0.9032 - val_acc: 0.7275
Epoch 187/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5828 - ac
c: 0.7987 - val_loss: 0.7631 - val_acc: 0.7550
Epoch 188/250
100/100 [==============================] - 11s 110ms/step - loss: 0.6244 - ac
c: 0.7987 - val_loss: 0.8494 - val_acc: 0.7250
Epoch 189/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5800 - ac
c: 0.8050 - val_loss: 0.7458 - val_acc: 0.7772
Epoch 190/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3711 - ac
c: 0.8813 - val_loss: 0.6534 - val_acc: 0.7975
Epoch 191/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3263 - ac
c: 0.8925 - val_loss: 0.7499 - val_acc: 0.7600
Epoch 192/250
100/100 [==============================] - 11s 111ms/step - loss: 0.2956 - ac
c: 0.9075 - val_loss: 0.6887 - val_acc: 0.7625
Epoch 193/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3882 - ac
c: 0.8787 - val_loss: 0.7646 - val_acc: 0.7700
Epoch 194/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4005 - ac
c: 0.8787 - val_loss: 0.9911 - val_acc: 0.7075
Epoch 195/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3617 - ac
c: 0.8888 - val_loss: 0.7491 - val_acc: 0.7850
Epoch 196/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3714 - ac
c: 0.8700 - val_loss: 0.7477 - val_acc: 0.7825
Epoch 197/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5223 - ac
c: 0.8475 - val_loss: 0.8551 - val_acc: 0.7316
Epoch 198/250
```

```
100/100 [==============================] - 11s 110ms/step - loss: 0.4461 - ac
c: 0.8625 - val_loss: 0.6704 - val_acc: 0.7750
Epoch 199/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4046 - ac
c: 0.8575 - val_loss: 0.9467 - val_acc: 0.7100
Epoch 200/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4291 - ac
c: 0.8575 - val_loss: 0.7124 - val_acc: 0.7600
Epoch 201/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4650 - ac
c: 0.8462 - val_loss: 0.8837 - val_acc: 0.7350
Epoch 202/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4890 - ac
c: 0.8375 - val_loss: 0.7587 - val_acc: 0.7750
Epoch 203/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4488 - ac
c: 0.8563 - val_loss: 0.8225 - val_acc: 0.7500
Epoch 204/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5550 - ac
c: 0.8225 - val_loss: 0.8420 - val_acc: 0.7519
Epoch 205/250
100/100 [==============================] - 11s 110ms/step - loss: 0.5564 - ac
c: 0.8063 - val_loss: 0.7947 - val_acc: 0.7525
Epoch 206/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4848 - ac
c: 0.8238 - val_loss: 0.7367 - val_acc: 0.7800
Epoch 207/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4404 - ac
c: 0.8567 - val_loss: 0.9324 - val_acc: 0.7225
Epoch 208/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2916 - ac
c: 0.9025 - val_loss: 0.6155 - val_acc: 0.8150
Epoch 209/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2839 - ac
c: 0.9050 - val_loss: 0.9531 - val_acc: 0.7125
Epoch 210/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2919 - ac
c: 0.9087 - val_loss: 0.6499 - val_acc: 0.7900
Epoch 211/250
100/100 [==============================] - 11s 111ms/step - loss: 0.3211 - ac
c: 0.8988 - val_loss: 0.8245 - val_acc: 0.7646
Epoch 212/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2988 - ac
c: 0.9038 - val_loss: 0.5584 - val_acc: 0.8175
Epoch 213/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3362 - ac
c: 0.8838 - val_loss: 0.9245 - val_acc: 0.7325
Epoch 214/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4307 - ac
c: 0.8575 - val_loss: 0.8000 - val_acc: 0.7600
Epoch 215/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4404 - ac
c: 0.8600 - val_loss: 0.8049 - val_acc: 0.7950
Epoch 216/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3796 - ac
c: 0.8612 - val_loss: 0.6637 - val_acc: 0.7925
Epoch 217/250
```

```
100/100 [==============================] - 11s 111ms/step - loss: 0.3740 - ac
c: 0.8850 - val_loss: 0.7721 - val_acc: 0.7725
Epoch 218/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3478 - ac
c: 0.8888 - val_loss: 0.9980 - val_acc: 0.7241
Epoch 219/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4734 - ac
c: 0.8400 - val_loss: 1.0883 - val_acc: 0.7125
Epoch 220/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3707 - ac
c: 0.8925 - val_loss: 0.8584 - val_acc: 0.7475
Epoch 221/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4674 - ac
c: 0.8400 - val_loss: 0.8559 - val_acc: 0.7325
Epoch 222/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4585 - ac
c: 0.8588 - val_loss: 0.6523 - val_acc: 0.7800
Epoch 223/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4063 - ac
c: 0.8688 - val_loss: 0.8104 - val_acc: 0.7575
Epoch 224/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3442 - ac
c: 0.8896 - val_loss: 0.7774 - val_acc: 0.7775
Epoch 225/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2313 - ac
c: 0.9163 - val_loss: 0.7870 - val_acc: 0.7600
Epoch 226/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2643 - ac
c: 0.9012 - val_loss: 0.6947 - val_acc: 0.8051
Epoch 227/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3163 - ac
c: 0.8975 - val_loss: 0.6932 - val_acc: 0.7775
Epoch 228/250

100/100 [==============================] - 11s 110ms/step - loss: 0.2870 - ac
c: 0.9200 - val_loss: 0.7446 - val_acc: 0.7975
Epoch 229/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2448 - ac
c: 0.9125 - val_loss: 0.5844 - val_acc: 0.8150
Epoch 230/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2581 - ac
c: 0.9113 - val_loss: 0.6393 - val_acc: 0.8000
Epoch 231/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3086 - ac
c: 0.8912 - val_loss: 0.6832 - val_acc: 0.8150
Epoch 232/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3665 - ac
c: 0.8863 - val_loss: 0.7665 - val_acc: 0.7600
Epoch 233/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3377 - ac
c: 0.8950 - val_loss: 0.6797 - val_acc: 0.7823
Epoch 234/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3855 - ac
c: 0.8725 - val_loss: 0.7638 - val_acc: 0.7900
Epoch 235/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4050 - ac
c: 0.8738 - val_loss: 0.7464 - val_acc: 0.7775
```

```
Epoch 236/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4290 - ac
c: 0.8538 - val_loss: 0.6465 - val_acc: 0.8275
Epoch 237/250
100/100 [==============================] - 11s 111ms/step - loss: 0.4197 - ac
c: 0.8762 - val_loss: 0.8164 - val_acc: 0.7775
Epoch 238/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4390 - ac
c: 0.8775 - val_loss: 0.6945 - val_acc: 0.7975
Epoch 239/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3504 - ac
c: 0.8800 - val_loss: 0.6688 - val_acc: 0.7975
Epoch 240/250
100/100 [==============================] - 11s 110ms/step - loss: 0.4365 - ac
c: 0.8650 - val_loss: 0.7802 - val_acc: 0.7696
Epoch 241/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3638 - ac
c: 0.8887 - val_loss: 0.6065 - val_acc: 0.8100
Epoch 242/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2006 - ac
c: 0.9262 - val_loss: 0.6840 - val_acc: 0.7725
Epoch 243/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2083 - ac
c: 0.9262 - val_loss: 0.5823 - val_acc: 0.8150
Epoch 244/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2008 - ac
c: 0.9412 - val_loss: 0.7348 - val_acc: 0.7800
Epoch 245/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2345 - ac
c: 0.9363 - val_loss: 0.6582 - val_acc: 0.8125
Epoch 246/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2838 - ac
c: 0.9137 - val_loss: 0.6303 - val_acc: 0.7975
Epoch 247/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2467 - ac
c: 0.9150 - val_loss: 0.5811 - val_acc: 0.8304
Epoch 248/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2790 - ac
c: 0.9075 - val_loss: 0.6736 - val_acc: 0.7775
Epoch 249/250
100/100 [==============================] - 11s 110ms/step - loss: 0.3016 - ac
c: 0.9012 - val_loss: 0.6217 - val_acc: 0.8100
Epoch 250/250
100/100 [==============================] - 11s 110ms/step - loss: 0.2974 - ac
c: 0.9100 - val_loss: 0.9179 - val_acc: 0.7850
```

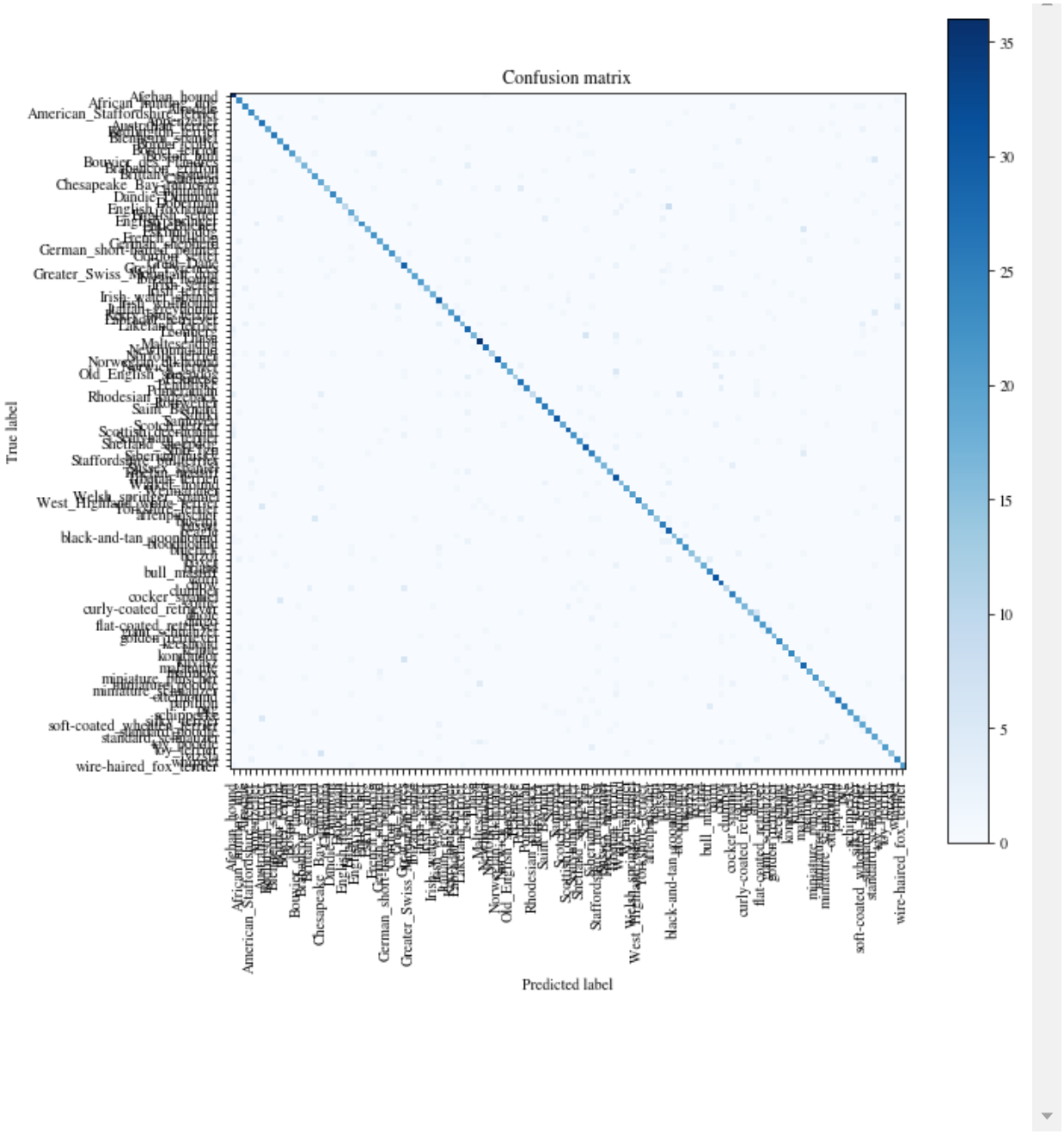

Training and validation accuracy
Training acc
Validation acc
Accuracy
0.0
0.2
0.4
0.6
0.8
0
50
100
150
200
250
Num of Epochs




```
TEST accuracy: 0.77875
TEST loss: 0.7941587169488775

Confusion Matrix
[[36  0  0 ...  0  0  0]
 [ 0 24  0 ...  0  1  0]
 [ 0  0 24 ...  0  0  0]
 ...
 [ 0  0  0 ... 15  0  0]
 [ 0  0  0 ...  0 24  0]
 [ 1  0  0 ...  0  0 20]]

Classification Report
                              precision    recall  f1-score   support

                Afghan_hound       0.57      0.97      0.72        37
            African_hunting_dog       0.67      0.92      0.77        26
                    Airedale       0.83      0.77      0.80        31
American_Staffordshire_terrier       0.67      0.92      0.77        26
```

Appenzeller	0.73	0.79	0.76	24
Australian_terrier	0.63	0.90	0.74	30
Bedlington_terrier	1.00	0.68	0.81	28
Blenheim_spaniel	0.90	0.90	0.90	29
Border_collie	0.64	0.91	0.75	23
Border_terrier	0.93	0.93	0.93	27
Boston_bull	1.00	0.75	0.86	28
Bouvier_des_Flandres	0.92	0.52	0.67	23
Brabancon_griffon	0.89	0.71	0.79	24
Brittany_spaniel	0.84	0.67	0.74	24
Cardigan	0.62	0.88	0.72	24
Chesapeake_Bay_retriever	0.56	0.73	0.63	26
Chihuahua	0.93	0.58	0.72	24
Dandie_Dinmont	0.89	0.86	0.87	28
Doberman	1.00	0.78	0.88	23
English_foxhound	1.00	0.40	0.57	25
English_setter	0.61	0.76	0.68	25
English_springer	0.88	0.56	0.68	25
EntleBucher	1.00	0.74	0.85	31
Eskimo_dog	0.89	0.74	0.81	23
French_bulldog	0.76	0.88	0.81	25
German_shepherd	0.68	0.79	0.73	24
German_short-haired_pointer	0.95	0.88	0.91	24
Gordon_setter	0.96	0.92	0.94	24
Great_Dane	0.75	0.50	0.60	24
Great_Pyrenees	0.64	0.88	0.74	33
Greater_Swiss_Mountain_dog	0.82	0.69	0.75	26
Ibizan_hound	0.91	0.69	0.78	29
Irish_setter	0.88	0.88	0.88	24
Irish_terrier	1.00	0.62	0.76	26
Irish_water_spaniel	0.86	0.78	0.82	23
Irish_wolfhound	0.60	0.88	0.71	34
Italian_greyhound	1.00	0.50	0.67	28
Kerry_blue_terrier	1.00	0.75	0.86	28
Labrador_retriever	0.73	0.89	0.80	27
Lakeland_terrier	0.89	0.55	0.68	31
Leonberg	0.56	0.88	0.68	32
Lhasa	0.81	0.59	0.68	29
Maltese_dog	0.75	0.92	0.83	39
Newfoundland	0.87	0.90	0.89	30
Norfolk_terrier	0.92	0.44	0.60	27
Norwegian_elkhound	0.88	1.00	0.94	30
Norwich_terrier	0.84	0.72	0.78	29
Old_English_sheepdog	0.95	0.69	0.80	26
Pekinese	0.93	0.57	0.70	23
Pembroke	0.69	0.96	0.81	28
Pomeranian	0.96	0.71	0.81	34
Rhodesian_ridgeback	1.00	0.33	0.50	27
Rottweiler	0.92	1.00	0.96	24
Saint_Bernard	0.76	0.96	0.85	27
Saluki	0.92	0.73	0.81	30
Samoyed	0.88	0.88	0.88	34
Scotch_terrier	0.90	0.76	0.83	25
Scottish_deerhound	0.76	0.81	0.78	36
Sealyham_terrier	0.96	0.71	0.81	31
Shetland_sheepdog	0.71	0.88	0.79	25
Shih-Tzu	0.65	0.91	0.76	33

Siberian_husky	0.62	0.83	0.71	30
Staffordshire_bullterrier	0.69	0.75	0.72	24
Sussex_spaniel	1.00	0.71	0.83	24
Tibetan_mastiff	0.95	0.75	0.84	24
Tibetan_terrier	0.53	0.97	0.69	32
Walker_hound	0.89	0.67	0.76	24
Weimaraner	0.90	0.79	0.84	24
Welsh_springer_spaniel	0.80	0.87	0.83	23
West_Highland_white_terrier	0.89	0.92	0.91	26
Yorkshire_terrier	1.00	0.62	0.76	26
affenpinscher	0.91	0.87	0.89	23
basenji	0.93	0.44	0.60	32
basset	0.64	0.93	0.76	27
beagle	0.54	0.97	0.69	30
black-and-tan_coonhound	0.94	0.64	0.76	25
bloodhound	0.84	0.72	0.78	29
bluetick	0.72	0.85	0.78	27
borzoi	1.00	0.62	0.77	24
boxer	1.00	0.54	0.70	24
briard	1.00	0.75	0.86	24
bull_mastiff	0.71	1.00	0.83	24
cairn	0.72	1.00	0.84	31
chow	0.60	0.97	0.74	30
clumber	1.00	0.43	0.61	23
cocker_spaniel	0.61	1.00	0.76	25
collie	0.72	0.75	0.73	24
curly-coated_retriever	0.94	0.71	0.81	24
dhole	0.83	0.65	0.73	23
dingo	0.54	0.88	0.67	24
flat-coated_retriever	0.88	0.88	0.88	24
giant_schnauzer	0.76	0.88	0.81	25
golden_retriever	0.81	0.74	0.77	23
keeshond	0.96	0.96	0.96	25
kelpie	0.85	0.71	0.77	24
komondor	0.86	1.00	0.92	24
kuvasz	1.00	0.57	0.72	23
malamute	0.65	1.00	0.79	28
malinois	0.86	0.78	0.82	23
miniature_pinscher	1.00	0.72	0.84	29
miniature_poodle	0.78	0.58	0.67	24
miniature_schnauzer	0.79	0.92	0.85	24
otterhound	0.90	0.75	0.82	24
papillon	0.90	0.90	0.90	30
pug	1.00	0.83	0.91	30
schipperke	1.00	0.83	0.91	24
silky_terrier	0.77	0.71	0.74	28
soft-coated_wheaten_terrier	0.59	0.79	0.68	24
standard_poodle	0.87	0.80	0.83	25
standard_schnauzer	0.57	0.83	0.68	24
toy_poodle	0.92	0.50	0.65	24
toy_terrier	1.00	0.78	0.88	27
vizsla	0.94	0.62	0.75	24
whippet	0.49	0.83	0.62	29
wire-haired_fox_terrier	0.87	0.80	0.83	25
avg / total	0.82	0.78	0.78	3067


Confusion matrix
True label
Predicted label
35
30
25
20
15
10
5
0

In [ ]: