nn_classification_terrain_50

November 11, 2021

[ ]:
```
import numpy as np
from sklearn.utils import shuffle
from keras.utils import np_utils

terrains = ('Plano', 'Bordes',
            'Cráter pequeño', 'Cráter profundo', 'Colina', 'Montaña')

x = np.load(f'terrain_data.npy')
y = np.load(f'terrain_data_labels.npy')
y = y-1

x, y = shuffle(x, y)

x_train, x_val, x_test = np.split(
    np.array(x), [int(len(x)*0.7), int(len(x)*0.85)])
y_train, y_val, y_test = np.split(
    np.array(y), [int(len(y)*0.7), int(len(y)*0.85)])

# Create output variables from original labels
# This is only required in multiclass problems
y_train = np_utils.to_categorical(y_train)
y_val = np_utils.to_categorical(y_val)
y_test = np_utils.to_categorical(y_test)

n_clases = len(terrains)
n_features = 17

print(np.unique(y, return_counts=True))
print(len(x_train))
print(len(y_train))
print(len(x_val))
print(len(y_val))
print(len(x_test))
print(len(y_test))
print(n_clases)
print(n_features)
```

```
2021-11-11 16:58:52.726865: I
```

```
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1

(array([0, 1, 2, 3, 4, 5]), array([1369,  197,  192,   96,  361,  246]))
1722
1722
369
369
370
370
6
17
```

[ ]:
```
from keras.models import Sequential
from keras.layers import Dense
from keras.utils import np_utils
from keras import backend

# We want to make sure we start from the start when training our model␣
 ↪everytime we run it.
backend.clear_session()


# Define MLP model
model = Sequential()
model.add(Dense(256, input_dim=n_features, activation='relu'))
model.add(Dense(64, activation='relu'))
model.add(Dense(32, activation='relu'))
model.add(Dense(n_clases, activation='softmax'))
```

```
2021-11-11 16:58:53.883406: I tensorflow/compiler/jit/xla_cpu_device.cc:41] Not
creating XLA devices, tf_xla_enable_xla_devices not set
2021-11-11 16:58:53.896356: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcuda.so.1
2021-11-11 16:58:54.219334: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.219385: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with
properties:
pciBusID: 0000:01:00.0 name: NVIDIA GeForce RTX 2080 with Max-Q Design
computeCapability: 7.5
coreClock: 1.215GHz coreCount: 46 deviceMemorySize: 8.00GiB
deviceMemoryBandwidth: 357.69GiB/s
2021-11-11 16:58:54.219459: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
```

```
opened dynamic library libcudart.so.10.1
2021-11-11 16:58:54.220917: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-11 16:58:54.220990: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-11 16:58:54.222554: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-11-11 16:58:54.222781: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-11-11 16:58:54.224093: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-11 16:58:54.224869: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-11 16:58:54.228326: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-11 16:58:54.229298: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.230134: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.230154: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-11 16:58:54.231197: I tensorflow/core/platform/cpu_feature_guard.cc:142]
This TensorFlow binary is optimized with oneAPI Deep Neural Network Library
(oneDNN) to use the following CPU instructions in performance-critical
operations:  SSE4.1 SSE4.2 AVX AVX2 FMA
To enable them in other operations, rebuild TensorFlow with the appropriate
compiler flags.
2021-11-11 16:58:54.233731: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.233767: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1720] Found device 0 with
properties:
pciBusID: 0000:01:00.0 name: NVIDIA GeForce RTX 2080 with Max-Q Design
computeCapability: 7.5
```

```
coreClock: 1.215GHz coreCount: 46 deviceMemorySize: 8.00GiB
deviceMemoryBandwidth: 357.69GiB/s
2021-11-11 16:58:54.233812: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-11 16:58:54.233840: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10
2021-11-11 16:58:54.233855: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublasLt.so.10
2021-11-11 16:58:54.233868: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcufft.so.10
2021-11-11 16:58:54.233880: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcurand.so.10
2021-11-11 16:58:54.233893: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusolver.so.10
2021-11-11 16:58:54.233907: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcusparse.so.10
2021-11-11 16:58:54.233920: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudnn.so.7
2021-11-11 16:58:54.234642: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.235371: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:54.235388: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1862] Adding visible gpu
devices: 0
2021-11-11 16:58:54.235443: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcudart.so.10.1
2021-11-11 16:58:55.070436: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1261] Device interconnect
StreamExecutor with strength 1 edge matrix:
2021-11-11 16:58:55.070469: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1267]      0
2021-11-11 16:58:55.070482: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1280] 0:   N
2021-11-11 16:58:55.071488: E
```

```
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:55.071508: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1489] Could not identify NUMA
node of platform GPU id 0, defaulting to 0.  Your kernel may not have been built
with NUMA support.
2021-11-11 16:58:55.072065: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:55.072585: E
tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:927] could not open file to
read NUMA node: /sys/bus/pci/devices/0000:01:00.0/numa_node
Your kernel may have been built without NUMA support.
2021-11-11 16:58:55.072647: I
tensorflow/core/common_runtime/gpu/gpu_device.cc:1406] Created TensorFlow device
(/job:localhost/replica:0/task:0/device:GPU:0 with 6575 MB memory) -> physical
GPU (device: 0, name: NVIDIA GeForce RTX 2080 with Max-Q Design, pci bus id:
0000:01:00.0, compute capability: 7.5)
2021-11-11 16:58:55.073085: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not
creating XLA devices, tf_xla_enable_xla_devices not set
```

[ ]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 128)               2304
_________________________________________________________________
dense_1 (Dense)              (None, 256)               33024
_________________________________________________________________
dense_2 (Dense)              (None, 512)               131584
_________________________________________________________________
dense_3 (Dense)              (None, 256)               131328
_________________________________________________________________
dense_4 (Dense)              (None, 128)               32896
_________________________________________________________________
dense_5 (Dense)              (None, 64)                8256
_________________________________________________________________
dense_6 (Dense)              (None, 32)                2080
_________________________________________________________________
dense_7 (Dense)              (None, 16)                528
_________________________________________________________________
dense_8 (Dense)              (None, 6)                 102
=================================================================
Total params: 342,102
```

```
Trainable params: 342,102
Non-trainable params: 0
_________________________________________________________________
```

[ ]:
```
# Compile model
model.compile(loss='categorical_crossentropy',
              optimizer='adam', metrics=['accuracy'])
```

[ ]:
```
from keras.callbacks import EarlyStopping
from sklearn.utils import class_weight
es = EarlyStopping(monitor='val_acc', mode='min', verbose=1, patience=10)
# Fit model
class_weights = class_weight.compute_class_weight('balanced',
                                                  np.unique(y),
                                                  y)
history = model.fit(x_train, y_train, validation_data=(x_val, y_val),␣
 ↪class_weight=(
    dict(zip(np.unique(y), class_weights))), epochs=150, batch_size=6)
```

```
/home/hivini/anaconda3/envs/tf-gpu/lib/python3.9/site-
packages/sklearn/utils/validation.py:67: FutureWarning: Pass classes=[0 1 2 3 4
5], y=[0 2 4 … 4 0 5] as keyword args. From version 0.25 passing these as
positional arguments will result in an error
  warnings.warn("Pass {} as keyword args. From version 0.25 "
2021-11-11 16:58:55.780036: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the MLIR
optimization passes are enabled (registered 2)
2021-11-11 16:58:55.780478: I
tensorflow/core/platform/profile_utils/cpu_utils.cc:112] CPU Frequency:
2208005000 Hz

Epoch 1/150

2021-11-11 16:58:56.254405: I
tensorflow/stream_executor/platform/default/dso_loader.cc:49] Successfully
opened dynamic library libcublas.so.10

287/287 [==============================] - 3s 7ms/step - loss: 3.5824 -
accuracy: 0.2127 - val_loss: 1.8388 - val_accuracy: 0.3306
Epoch 2/150
287/287 [==============================] - 2s 7ms/step - loss: 1.9532 -
accuracy: 0.3170 - val_loss: 1.7244 - val_accuracy: 0.4363
Epoch 3/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6892 -
accuracy: 0.3857 - val_loss: 2.1100 - val_accuracy: 0.1355
Epoch 4/150
287/287 [==============================] - 2s 7ms/step - loss: 1.7214 -
accuracy: 0.2308 - val_loss: 1.6958 - val_accuracy: 0.1057
Epoch 5/150
```

```
287/287 [==============================] - 2s 7ms/step - loss: 1.6445 -
accuracy: 0.1726 - val_loss: 1.6763 - val_accuracy: 0.1057
Epoch 6/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6417 -
accuracy: 0.1863 - val_loss: 1.6246 - val_accuracy: 0.1599
Epoch 7/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6276 -
accuracy: 0.1442 - val_loss: 1.6687 - val_accuracy: 0.1653
Epoch 8/150
287/287 [==============================] - 2s 7ms/step - loss: 1.5298 -
accuracy: 0.2208 - val_loss: 1.5409 - val_accuracy: 0.3523
Epoch 9/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6519 -
accuracy: 0.2213 - val_loss: 1.5993 - val_accuracy: 0.1897
Epoch 10/150
287/287 [==============================] - 2s 7ms/step - loss: 1.7493 -
accuracy: 0.1850 - val_loss: 1.7132 - val_accuracy: 0.1328
Epoch 11/150
287/287 [==============================] - 2s 8ms/step - loss: 1.6643 -
accuracy: 0.1810 - val_loss: 1.6996 - val_accuracy: 0.3415
Epoch 12/150
287/287 [==============================] - 2s 8ms/step - loss: 1.8058 -
accuracy: 0.2137 - val_loss: 1.7094 - val_accuracy: 0.0867
Epoch 13/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6521 -
accuracy: 0.1442 - val_loss: 1.5331 - val_accuracy: 0.2791
Epoch 14/150
287/287 [==============================] - 2s 8ms/step - loss: 1.7250 -
accuracy: 0.3059 - val_loss: 1.5874 - val_accuracy: 0.1843
Epoch 15/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6267 -
accuracy: 0.3499 - val_loss: 1.5022 - val_accuracy: 0.3686
Epoch 16/150
287/287 [==============================] - 2s 8ms/step - loss: 1.6338 -
accuracy: 0.2873 - val_loss: 1.5776 - val_accuracy: 0.2466
Epoch 17/150
287/287 [==============================] - 2s 8ms/step - loss: 1.6093 -
accuracy: 0.3267 - val_loss: 1.6581 - val_accuracy: 0.2195
Epoch 18/150
287/287 [==============================] - 2s 7ms/step - loss: 1.6156 -
accuracy: 0.3636 - val_loss: 1.6147 - val_accuracy: 0.2547
Epoch 19/150
287/287 [==============================] - 2s 6ms/step - loss: 1.5994 -
accuracy: 0.2659 - val_loss: 1.5146 - val_accuracy: 0.3469
Epoch 20/150
287/287 [==============================] - 2s 7ms/step - loss: 1.5082 -
accuracy: 0.2927 - val_loss: 1.5852 - val_accuracy: 0.2683
Epoch 21/150
```

```
287/287 [==============================] - 2s 7ms/step - loss: 1.4947 -
accuracy: 0.3772 - val_loss: 1.6160 - val_accuracy: 0.2412
Epoch 22/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4437 -
accuracy: 0.3823 - val_loss: 1.4016 - val_accuracy: 0.4770
Epoch 23/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4744 -
accuracy: 0.4906 - val_loss: 1.5252 - val_accuracy: 0.3902
Epoch 24/150
287/287 [==============================] - 2s 7ms/step - loss: 1.4654 -
accuracy: 0.4470 - val_loss: 1.5548 - val_accuracy: 0.3469
Epoch 25/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4208 -
accuracy: 0.4761 - val_loss: 1.6876 - val_accuracy: 0.2358
Epoch 26/150
287/287 [==============================] - 2s 7ms/step - loss: 1.5032 -
accuracy: 0.3658 - val_loss: 2.3490 - val_accuracy: 0.3659
Epoch 27/150
287/287 [==============================] - 2s 6ms/step - loss: 1.8886 -
accuracy: 0.3821 - val_loss: 1.5499 - val_accuracy: 0.3659
Epoch 28/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4698 -
accuracy: 0.3888 - val_loss: 1.5048 - val_accuracy: 0.3631
Epoch 29/150
287/287 [==============================] - 2s 7ms/step - loss: 1.5649 -
accuracy: 0.3859 - val_loss: 1.4558 - val_accuracy: 0.4011
Epoch 30/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3935 -
accuracy: 0.4476 - val_loss: 1.5399 - val_accuracy: 0.3794
Epoch 31/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4496 -
accuracy: 0.4394 - val_loss: 1.5067 - val_accuracy: 0.3794
Epoch 32/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4066 -
accuracy: 0.4870 - val_loss: 1.5192 - val_accuracy: 0.3767
Epoch 33/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3998 -
accuracy: 0.4299 - val_loss: 1.3844 - val_accuracy: 0.4553
Epoch 34/150
287/287 [==============================] - 2s 7ms/step - loss: 1.3879 -
accuracy: 0.4799 - val_loss: 1.3791 - val_accuracy: 0.4824
Epoch 35/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2815 -
accuracy: 0.5055 - val_loss: 1.4885 - val_accuracy: 0.3659
Epoch 36/150
287/287 [==============================] - 2s 7ms/step - loss: 1.3987 -
accuracy: 0.4235 - val_loss: 1.3018 - val_accuracy: 0.5230
Epoch 37/150
```

```
287/287 [==============================] - 2s 8ms/step - loss: 1.3934 -
accuracy: 0.4958 - val_loss: 1.3304 - val_accuracy: 0.4715
Epoch 38/150
287/287 [==============================] - 2s 8ms/step - loss: 1.4170 -
accuracy: 0.4975 - val_loss: 1.4619 - val_accuracy: 0.3604
Epoch 39/150
287/287 [==============================] - 2s 7ms/step - loss: 1.4187 -
accuracy: 0.4786 - val_loss: 1.3991 - val_accuracy: 0.4390
Epoch 40/150
287/287 [==============================] - 2s 6ms/step - loss: 1.3546 -
accuracy: 0.4658 - val_loss: 1.3590 - val_accuracy: 0.5312
Epoch 41/150
287/287 [==============================] - 2s 7ms/step - loss: 1.4031 -
accuracy: 0.5118 - val_loss: 1.4834 - val_accuracy: 0.4228
Epoch 42/150
287/287 [==============================] - 2s 7ms/step - loss: 1.4269 -
accuracy: 0.4020 - val_loss: 1.7214 - val_accuracy: 0.3957
Epoch 43/150
287/287 [==============================] - 2s 7ms/step - loss: 1.4509 -
accuracy: 0.3896 - val_loss: 1.4369 - val_accuracy: 0.4444
Epoch 44/150
287/287 [==============================] - 2s 7ms/step - loss: 1.3139 -
accuracy: 0.5340 - val_loss: 1.4081 - val_accuracy: 0.4661
Epoch 45/150
287/287 [==============================] - 2s 7ms/step - loss: 1.3584 -
accuracy: 0.5031 - val_loss: 1.4187 - val_accuracy: 0.5041
Epoch 46/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2851 -
accuracy: 0.5458 - val_loss: 1.4047 - val_accuracy: 0.4282
Epoch 47/150
287/287 [==============================] - 2s 7ms/step - loss: 1.3263 -
accuracy: 0.4681 - val_loss: 1.3303 - val_accuracy: 0.5339
Epoch 48/150
287/287 [==============================] - 3s 9ms/step - loss: 1.2443 -
accuracy: 0.5360 - val_loss: 1.4589 - val_accuracy: 0.3767
Epoch 49/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3438 -
accuracy: 0.4956 - val_loss: 1.4138 - val_accuracy: 0.4201
Epoch 50/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3479 -
accuracy: 0.5175 - val_loss: 1.5356 - val_accuracy: 0.4092
Epoch 51/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3305 -
accuracy: 0.4530 - val_loss: 1.6915 - val_accuracy: 0.4444
Epoch 52/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2773 -
accuracy: 0.4874 - val_loss: 1.5111 - val_accuracy: 0.4011
Epoch 53/150
```

```
287/287 [==============================] - 2s 8ms/step - loss: 1.3660 -
accuracy: 0.5077 - val_loss: 1.3639 - val_accuracy: 0.5122
Epoch 54/150
287/287 [==============================] - 2s 8ms/step - loss: 1.5020 -
accuracy: 0.4428 - val_loss: 1.5434 - val_accuracy: 0.4444
Epoch 55/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3295 -
accuracy: 0.5079 - val_loss: 1.2915 - val_accuracy: 0.5366
Epoch 56/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2687 -
accuracy: 0.5249 - val_loss: 1.3684 - val_accuracy: 0.4661
Epoch 57/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3540 -
accuracy: 0.4872 - val_loss: 1.3731 - val_accuracy: 0.5014
Epoch 58/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2977 -
accuracy: 0.4922 - val_loss: 1.3497 - val_accuracy: 0.5176
Epoch 59/150
287/287 [==============================] - 3s 9ms/step - loss: 1.3741 -
accuracy: 0.4692 - val_loss: 1.3361 - val_accuracy: 0.5068
Epoch 60/150
287/287 [==============================] - 3s 9ms/step - loss: 1.2691 -
accuracy: 0.5628 - val_loss: 1.3842 - val_accuracy: 0.5312
Epoch 61/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2463 -
accuracy: 0.5465 - val_loss: 1.3474 - val_accuracy: 0.5041
Epoch 62/150
287/287 [==============================] - 3s 9ms/step - loss: 1.2505 -
accuracy: 0.5156 - val_loss: 1.5329 - val_accuracy: 0.3821
Epoch 63/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2188 -
accuracy: 0.5153 - val_loss: 1.4415 - val_accuracy: 0.4472
Epoch 64/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2729 -
accuracy: 0.5014 - val_loss: 1.3056 - val_accuracy: 0.5149
Epoch 65/150
287/287 [==============================] - 3s 9ms/step - loss: 1.2873 -
accuracy: 0.4917 - val_loss: 1.4764 - val_accuracy: 0.4255
Epoch 66/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2362 -
accuracy: 0.4818 - val_loss: 1.3038 - val_accuracy: 0.5420
Epoch 67/150
287/287 [==============================] - 2s 6ms/step - loss: 1.2883 -
accuracy: 0.5029 - val_loss: 1.5703 - val_accuracy: 0.3686
Epoch 68/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2015 -
accuracy: 0.5166 - val_loss: 1.4224 - val_accuracy: 0.4201
Epoch 69/150
```

```
287/287 [==============================] - 2s 8ms/step - loss: 1.2672 -
accuracy: 0.5228 - val_loss: 1.6827 - val_accuracy: 0.3794
Epoch 70/150
287/287 [==============================] - 2s 9ms/step - loss: 1.2091 -
accuracy: 0.5145 - val_loss: 1.2993 - val_accuracy: 0.5312
Epoch 71/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2118 -
accuracy: 0.5291 - val_loss: 1.3852 - val_accuracy: 0.5122
Epoch 72/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1917 -
accuracy: 0.5519 - val_loss: 1.3734 - val_accuracy: 0.5041
Epoch 73/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1755 -
accuracy: 0.5270 - val_loss: 1.3761 - val_accuracy: 0.4607
Epoch 74/150
287/287 [==============================] - 3s 9ms/step - loss: 1.3063 -
accuracy: 0.4549 - val_loss: 1.6561 - val_accuracy: 0.2385
Epoch 75/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2799 -
accuracy: 0.3812 - val_loss: 1.4081 - val_accuracy: 0.5312
Epoch 76/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2578 -
accuracy: 0.4963 - val_loss: 1.4359 - val_accuracy: 0.4201
Epoch 77/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1729 -
accuracy: 0.5234 - val_loss: 1.4469 - val_accuracy: 0.4580
Epoch 78/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0802 -
accuracy: 0.5472 - val_loss: 1.4017 - val_accuracy: 0.5285
Epoch 79/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1039 -
accuracy: 0.5810 - val_loss: 1.4603 - val_accuracy: 0.5122
Epoch 80/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1059 -
accuracy: 0.5787 - val_loss: 1.6810 - val_accuracy: 0.4065
Epoch 81/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2101 -
accuracy: 0.5087 - val_loss: 1.5242 - val_accuracy: 0.4824
Epoch 82/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1843 -
accuracy: 0.5414 - val_loss: 1.5375 - val_accuracy: 0.4959
Epoch 83/150
287/287 [==============================] - 2s 7ms/step - loss: 1.8184 -
accuracy: 0.5391 - val_loss: 1.4891 - val_accuracy: 0.4309
Epoch 84/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1414 -
accuracy: 0.5110 - val_loss: 1.4032 - val_accuracy: 0.4770
Epoch 85/150
```

```
287/287 [==============================] - 2s 7ms/step - loss: 1.1702 -
accuracy: 0.5330 - val_loss: 1.4105 - val_accuracy: 0.4607
Epoch 86/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1542 -
accuracy: 0.5095 - val_loss: 1.5184 - val_accuracy: 0.4715
Epoch 87/150
287/287 [==============================] - 2s 6ms/step - loss: 1.2202 -
accuracy: 0.5245 - val_loss: 1.5938 - val_accuracy: 0.4146
Epoch 88/150
287/287 [==============================] - 2s 6ms/step - loss: 1.1530 -
accuracy: 0.5012 - val_loss: 1.5151 - val_accuracy: 0.4932
Epoch 89/150
287/287 [==============================] - 2s 8ms/step - loss: 1.3027 -
accuracy: 0.5204 - val_loss: 1.7218 - val_accuracy: 0.3225
Epoch 90/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2285 -
accuracy: 0.4671 - val_loss: 1.6486 - val_accuracy: 0.4499
Epoch 91/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1573 -
accuracy: 0.5725 - val_loss: 1.3618 - val_accuracy: 0.4932
Epoch 92/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0598 -
accuracy: 0.5723 - val_loss: 1.4711 - val_accuracy: 0.4580
Epoch 93/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1649 -
accuracy: 0.5172 - val_loss: 1.5212 - val_accuracy: 0.3984
Epoch 94/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0768 -
accuracy: 0.5056 - val_loss: 1.4368 - val_accuracy: 0.4986
Epoch 95/150
287/287 [==============================] - 2s 9ms/step - loss: 1.1160 -
accuracy: 0.5180 - val_loss: 1.3555 - val_accuracy: 0.5393
Epoch 96/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1155 -
accuracy: 0.4897 - val_loss: 1.5348 - val_accuracy: 0.5176
Epoch 97/150
287/287 [==============================] - 2s 9ms/step - loss: 1.2686 -
accuracy: 0.5711 - val_loss: 1.3249 - val_accuracy: 0.5691
Epoch 98/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1444 -
accuracy: 0.5706 - val_loss: 1.4831 - val_accuracy: 0.4688
Epoch 99/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1036 -
accuracy: 0.5103 - val_loss: 1.6590 - val_accuracy: 0.4824
Epoch 100/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1611 -
accuracy: 0.5409 - val_loss: 1.6722 - val_accuracy: 0.4417
Epoch 101/150
```

```
287/287 [==============================] - 2s 8ms/step - loss: 1.2464 -
accuracy: 0.5435 - val_loss: 1.4860 - val_accuracy: 0.4824
Epoch 102/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1012 -
accuracy: 0.5572 - val_loss: 1.4010 - val_accuracy: 0.5041
Epoch 103/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1462 -
accuracy: 0.5406 - val_loss: 1.4585 - val_accuracy: 0.4878
Epoch 104/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1691 -
accuracy: 0.5790 - val_loss: 1.4858 - val_accuracy: 0.4770
Epoch 105/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1474 -
accuracy: 0.5501 - val_loss: 1.5701 - val_accuracy: 0.4607
Epoch 106/150
287/287 [==============================] - 2s 7ms/step - loss: 1.1506 -
accuracy: 0.5359 - val_loss: 1.6817 - val_accuracy: 0.4986
Epoch 107/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1582 -
accuracy: 0.5276 - val_loss: 1.4264 - val_accuracy: 0.5501
Epoch 108/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0928 -
accuracy: 0.5487 - val_loss: 1.5251 - val_accuracy: 0.4743
Epoch 109/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0379 -
accuracy: 0.5642 - val_loss: 1.4050 - val_accuracy: 0.5393
Epoch 110/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0891 -
accuracy: 0.5366 - val_loss: 1.3681 - val_accuracy: 0.5393
Epoch 111/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0984 -
accuracy: 0.5446 - val_loss: 1.6760 - val_accuracy: 0.4661
Epoch 112/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0772 -
accuracy: 0.5470 - val_loss: 1.4789 - val_accuracy: 0.4986
Epoch 113/150
287/287 [==============================] - 2s 7ms/step - loss: 1.2007 -
accuracy: 0.5410 - val_loss: 1.5818 - val_accuracy: 0.4932
Epoch 114/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0419 -
accuracy: 0.5882 - val_loss: 1.5846 - val_accuracy: 0.4499
Epoch 115/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0066 -
accuracy: 0.5583 - val_loss: 1.6346 - val_accuracy: 0.4824
Epoch 116/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0928 -
accuracy: 0.5628 - val_loss: 1.6213 - val_accuracy: 0.4011
Epoch 117/150
```

```
287/287 [==============================] - 2s 9ms/step - loss: 1.0880 -
accuracy: 0.5544 - val_loss: 1.3742 - val_accuracy: 0.5501
Epoch 118/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0531 -
accuracy: 0.5634 - val_loss: 1.3103 - val_accuracy: 0.5420
Epoch 119/150
287/287 [==============================] - 3s 9ms/step - loss: 1.0654 -
accuracy: 0.5848 - val_loss: 1.4691 - val_accuracy: 0.4580
Epoch 120/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0145 -
accuracy: 0.5554 - val_loss: 1.6064 - val_accuracy: 0.4553
Epoch 121/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0838 -
accuracy: 0.5377 - val_loss: 1.4463 - val_accuracy: 0.4743
Epoch 122/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0735 -
accuracy: 0.5840 - val_loss: 1.4141 - val_accuracy: 0.4878
Epoch 123/150
287/287 [==============================] - 2s 9ms/step - loss: 1.0616 -
accuracy: 0.5571 - val_loss: 1.5397 - val_accuracy: 0.4634
Epoch 124/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0554 -
accuracy: 0.5746 - val_loss: 1.4828 - val_accuracy: 0.4932
Epoch 125/150
287/287 [==============================] - 2s 8ms/step - loss: 0.9930 -
accuracy: 0.5751 - val_loss: 1.5573 - val_accuracy: 0.4390
Epoch 126/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0666 -
accuracy: 0.5387 - val_loss: 1.4954 - val_accuracy: 0.5393
Epoch 127/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0576 -
accuracy: 0.5806 - val_loss: 1.5307 - val_accuracy: 0.5176
Epoch 128/150
287/287 [==============================] - 2s 9ms/step - loss: 0.9537 -
accuracy: 0.5793 - val_loss: 1.7680 - val_accuracy: 0.3957
Epoch 129/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0020 -
accuracy: 0.5884 - val_loss: 1.7770 - val_accuracy: 0.3957
Epoch 130/150
287/287 [==============================] - 2s 8ms/step - loss: 0.9634 -
accuracy: 0.5593 - val_loss: 1.5949 - val_accuracy: 0.4851
Epoch 131/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0062 -
accuracy: 0.5623 - val_loss: 1.4216 - val_accuracy: 0.5312
Epoch 132/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0575 -
accuracy: 0.5813 - val_loss: 1.4989 - val_accuracy: 0.5339
Epoch 133/150
```

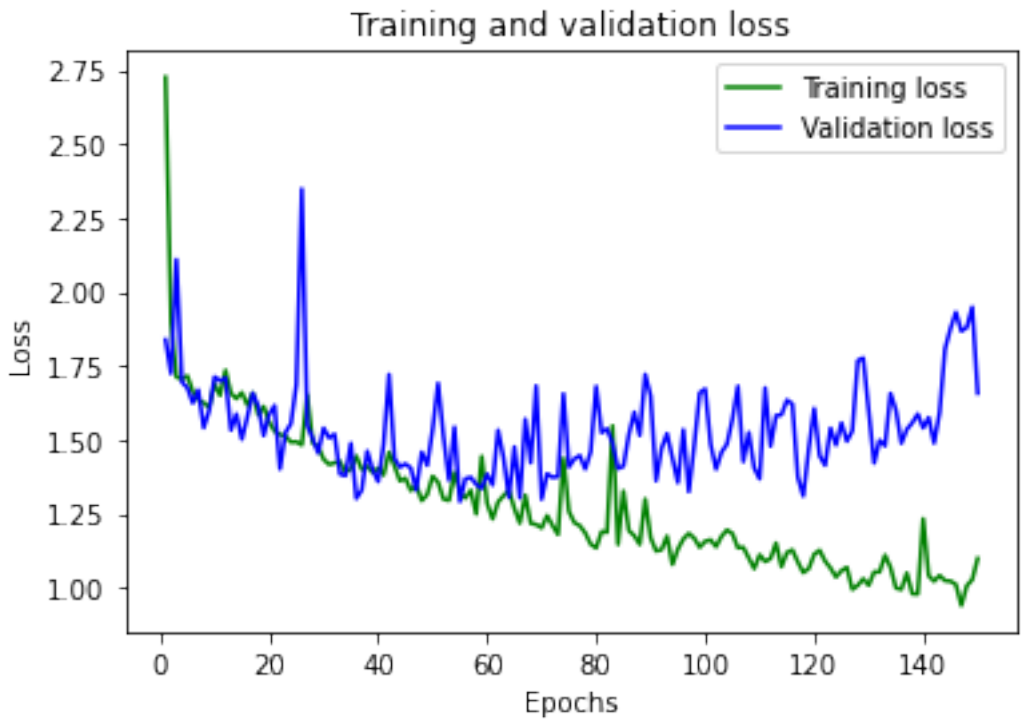
```
287/287 [==============================] - 2s 7ms/step - loss: 1.0365 -
accuracy: 0.5923 - val_loss: 1.4799 - val_accuracy: 0.4743
Epoch 134/150
287/287 [==============================] - 2s 8ms/step - loss: 1.2186 -
accuracy: 0.5283 - val_loss: 1.6572 - val_accuracy: 0.5230
Epoch 135/150
287/287 [==============================] - 2s 8ms/step - loss: 0.9818 -
accuracy: 0.5940 - val_loss: 1.6005 - val_accuracy: 0.5041
Epoch 136/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9724 -
accuracy: 0.6262 - val_loss: 1.4887 - val_accuracy: 0.5095
Epoch 137/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0591 -
accuracy: 0.5821 - val_loss: 1.5358 - val_accuracy: 0.5122
Epoch 138/150
287/287 [==============================] - 2s 8ms/step - loss: 0.9444 -
accuracy: 0.6237 - val_loss: 1.5579 - val_accuracy: 0.4797
Epoch 139/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9818 -
accuracy: 0.5791 - val_loss: 1.5874 - val_accuracy: 0.4824
Epoch 140/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1725 -
accuracy: 0.5816 - val_loss: 1.5405 - val_accuracy: 0.4986
Epoch 141/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9776 -
accuracy: 0.5870 - val_loss: 1.5757 - val_accuracy: 0.5285
Epoch 142/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0405 -
accuracy: 0.6023 - val_loss: 1.4893 - val_accuracy: 0.5014
Epoch 143/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9602 -
accuracy: 0.5815 - val_loss: 1.5920 - val_accuracy: 0.5149
Epoch 144/150
287/287 [==============================] - 2s 8ms/step - loss: 1.0980 -
accuracy: 0.5673 - val_loss: 1.8072 - val_accuracy: 0.4770
Epoch 145/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9872 -
accuracy: 0.5741 - val_loss: 1.8760 - val_accuracy: 0.4851
Epoch 146/150
287/287 [==============================] - 2s 7ms/step - loss: 1.0448 -
accuracy: 0.5881 - val_loss: 1.9315 - val_accuracy: 0.5068
Epoch 147/150
287/287 [==============================] - 2s 7ms/step - loss: 0.9138 -
accuracy: 0.6227 - val_loss: 1.8678 - val_accuracy: 0.4743
Epoch 148/150
287/287 [==============================] - 2s 7ms/step - loss: 0.8713 -
accuracy: 0.6074 - val_loss: 1.8803 - val_accuracy: 0.4553
Epoch 149/150
```

```
287/287 [==============================] - 2s 8ms/step - loss: 1.0279 -
accuracy: 0.5781 - val_loss: 1.9491 - val_accuracy: 0.3902
Epoch 150/150
287/287 [==============================] - 2s 8ms/step - loss: 1.1611 -
accuracy: 0.5228 - val_loss: 1.6579 - val_accuracy: 0.4851
```

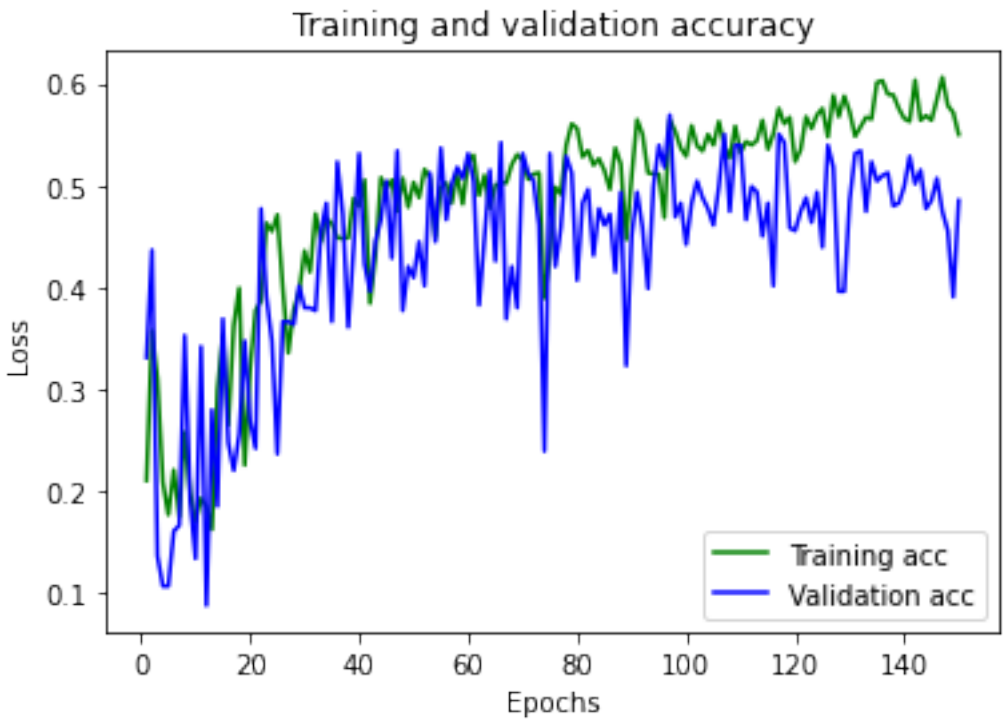
[ ]:
```python
test_loss, test_acc = model.evaluate(x_test, y_test)
print("Loss on test set: ", test_loss)
print("Accuracy on test set: ", test_acc)
```

```
12/12 [==============================] - 0s 9ms/step - loss: 1.5854 - accuracy:
0.5000
Loss on test set:  1.5854191780090332
Accuracy on test set:  0.5
```

[ ]:
```python
import matplotlib.pyplot as plt

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)
# bo is for blue dot.
plt.plot(epochs, loss, 'g', label='Training loss')
# b is for solid blue line
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



[ ]:
```
plt.clf()

plt.plot(epochs, acc, 'g', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```


Training and validation accuracy
Loss
Epochs
Training acc
Validation acc
0.1
0.2
0.3
0.4
0.5
0.6
0
20
40
60
80
100
120
140