Neural Shrub-Leaves

July 10, 2019

1 Neural Shrub - Leaves

In [1]:
```
import time
import os, sys
import string

from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score

from keras.utils import np_utils
from sklearn.preprocessing import LabelEncoder
from keras import Sequential
from keras import layers

import pandas as pd
import numpy as np
```

```
/home/shashwati/anaconda3/envs/py35/lib/python3.5/site-packages/h5py/__init__.py:36: FutureWarn
  from ._conv import register_converters as _register_converters
Using TensorFlow backend.
```

In [2]:
```
def load_data(dataset):
    if os.path.isfile(dataset):
        print("Loading ", dataset, " dataset ...")
        data = pd.read_csv(dataset)
        print("\nDataset loaded successfully\n\n")
        return data
    else:
        print('File not found')
        print('\n\nExiting...')
        sys.exit()
```

In [3]:
```
#The column names are [a, b, c, ..., z, A, B, C, ..., W]
columnNames = list(string.ascii_lowercase) \
              + list(string.ascii_uppercase)[:23]
```

In [4]:
```
def get_data():
    train_dataset = load_data('./sensIT_train.csv')
    label_train = train_dataset['result']
    train = train_dataset[columnNames]

    test_dataset = load_data('./sensIT_test.csv')
    label_test = test_dataset['result']
    test = test_dataset[columnNames]

    return train, label_train, test, label_test
```

In [5]:
```
from sklearn.tree._tree import TREE_LEAF

def prune_index(inner_tree, index, threshold):
    if inner_tree.value[index].min() < threshold:
        # turn node into a leaf by "unlinking" its children
        inner_tree.children_left[index] = TREE_LEAF
        inner_tree.children_right[index] = TREE_LEAF
    # if there are shildren, visit them as well
    if inner_tree.children_left[index] != TREE_LEAF:
        prune_index(inner_tree, inner_tree.children_left[index], threshold)
        prune_index(inner_tree, inner_tree.children_right[index], threshold)
```

In [6]:
```
# Makes the decision tree
def decision_tree(train, label):
    dt = DecisionTreeClassifier(max_depth = 8, min_samples_leaf=500, random_state = 1)
    dt.fit(train, label)
    prune_index(dt.tree_, 0, 5)
    return dt
```

In [7]:
```
# Class_data: list of instances belonging to a class
# Each instance consists of the predictor_values and the actual class
def neural_network(class_data):
    nn_train = []
    nn_label = []

    for instance in class_data:
        nn_train.append(instance[0]) # predictor
        nn_label.append(instance[1]) # actual class

    nn_train = np.array(nn_train)
    nn_label = np.array(nn_label)

    # Preprocessing
    encoder = LabelEncoder()
    encoder.fit(nn_label)
    nn_label = encoder.transform(nn_label)
    nn_label = np_utils.to_categorical(nn_label)
```

```
        print(nn_train.shape, nn_label.shape)

        out = nn_label.shape
        print(out[1])
        exit()
        # Neural network structure
        model = Sequential()
        model.add(layers.Dense(30,init = 'uniform', activation = 'relu', input_dim = 49))
        model.add(layers.Dense(10,init = 'uniform', activation = 'relu'))
        model.add(layers.Dense(out[1], init = 'uniform', activation = 'softmax'))

        model.compile(loss='categorical_crossentropy', metrics=['accuracy'], optimizer='ada
        model.fit(nn_train, nn_label, epochs=15, batch_size=500)

        return model
```

In [8]:
```
# builds the neural shrub
def neural_shrubs(tree, train, label):
    train = np.array(train)
    label = np.array(label)

    # leave_id: index of the leaf that cantains the instance
    leave_id = tree.apply(train)

    classes = dict()

    for x in range(len(train)):
        leaf = leave_id[x]

        # Gets the class for each leaf
        #.value: contains value of all the tree nodes
        #.value[leaf]: returns the value of the leaf
        #idx = tree.tree_.value[leaf][0][0]

        # insert the instance into the class
        if leaf in classes.keys():
            classes[leaf].append([train[x], label[x]])
        else:
            classes[leaf] = [[train[x], label[x]]]

    # stores the neural network for each class
    nn_models = dict()

    #stores the max time taken to build a neural network
    max_time = 0;

    for key in classes.keys():
```

```
                start = time.time()
                model = neural_network(classes[key])
                end = time.time()

                time_taken = end - start
                if max_time < time_taken:
                    max_time = time_taken

                nn_models[key] = model

            # returns a neural network for each class and the max
            # time taken to build the neural network
            return nn_models, max_time
```

In [9]:
```
# The algorithm to build the neural shrub
train, train_label, test, test_label = get_data()

dt_start = time.time()
tree = decision_tree(train, train_label)
dt_end = time.time()

shrubs, max_time = neural_shrubs(tree, train, train_label)
```

```
Loading  ./sensIT_train.csv  dataset ...

Dataset loaded successfully


Loading  ./sensIT_test.csv  dataset ...

Dataset loaded successfully


(3289, 49) (3289, 3)
3


/home/shashwati/anaconda3/envs/py35/lib/python3.5/site-packages/ipykernel_launcher.py:27: UserW
/home/shashwati/anaconda3/envs/py35/lib/python3.5/site-packages/ipykernel_launcher.py:28: UserW
/home/shashwati/anaconda3/envs/py35/lib/python3.5/site-packages/ipykernel_launcher.py:29: UserW


Epoch 1/15
3289/3289 [==============================] - 0s 119us/step - loss: 1.0974 - acc: 0.4044
Epoch 2/15
3289/3289 [==============================] - 0s 13us/step - loss: 1.0944 - acc: 0.4099
Epoch 3/15
3289/3289 [==============================] - 0s 15us/step - loss: 1.0904 - acc: 0.4099
```

```
Epoch 4/15
3289/3289 [==============================] - 0s 13us/step - loss: 1.0845 - acc: 0.4099
Epoch 5/15
3289/3289 [==============================] - 0s 11us/step - loss: 1.0767 - acc: 0.4099
Epoch 6/15
3289/3289 [==============================] - 0s 13us/step - loss: 1.0664 - acc: 0.4099
Epoch 7/15
3289/3289 [==============================] - 0s 10us/step - loss: 1.0545 - acc: 0.4099
Epoch 8/15
3289/3289 [==============================] - 0s 12us/step - loss: 1.0436 - acc: 0.4099
Epoch 9/15
3289/3289 [==============================] - 0s 18us/step - loss: 1.0381 - acc: 0.4099
Epoch 10/15
3289/3289 [==============================] - 0s 14us/step - loss: 1.0367 - acc: 0.4099
Epoch 11/15
3289/3289 [==============================] - 0s 14us/step - loss: 1.0364 - acc: 0.4099
Epoch 12/15
3289/3289 [==============================] - 0s 14us/step - loss: 1.0355 - acc: 0.4099
Epoch 13/15
3289/3289 [==============================] - 0s 19us/step - loss: 1.0348 - acc: 0.4099
Epoch 14/15
3289/3289 [==============================] - 0s 12us/step - loss: 1.0344 - acc: 0.4099
Epoch 15/15
3289/3289 [==============================] - 0s 16us/step - loss: 1.0339 - acc: 0.4099
(3145, 49) (3145, 3)
3
Epoch 1/15
3145/3145 [==============================] - 0s 141us/step - loss: 1.0976 - acc: 0.4909
Epoch 2/15
3145/3145 [==============================] - 0s 15us/step - loss: 1.0947 - acc: 0.4909
Epoch 3/15
3145/3145 [==============================] - 0s 13us/step - loss: 1.0910 - acc: 0.4909
Epoch 4/15
3145/3145 [==============================] - 0s 15us/step - loss: 1.0862 - acc: 0.4909
Epoch 5/15
3145/3145 [==============================] - 0s 14us/step - loss: 1.0797 - acc: 0.4909
Epoch 6/15
3145/3145 [==============================] - 0s 18us/step - loss: 1.0712 - acc: 0.4909
Epoch 7/15
3145/3145 [==============================] - 0s 15us/step - loss: 1.0608 - acc: 0.4909
Epoch 8/15
3145/3145 [==============================] - 0s 13us/step - loss: 1.0508 - acc: 0.4909
Epoch 9/15
3145/3145 [==============================] - 0s 12us/step - loss: 1.0439 - acc: 0.4909
Epoch 10/15
3145/3145 [==============================] - 0s 11us/step - loss: 1.0407 - acc: 0.4909
Epoch 11/15
3145/3145 [==============================] - 0s 13us/step - loss: 1.0403 - acc: 0.4909
```

```
Epoch 12/15
3145/3145 [==============================] - 0s 11us/step - loss: 1.0395 - acc: 0.4909
Epoch 13/15
3145/3145 [==============================] - 0s 15us/step - loss: 1.0389 - acc: 0.4909
Epoch 14/15
3145/3145 [==============================] - 0s 13us/step - loss: 1.0389 - acc: 0.4909
Epoch 15/15
3145/3145 [==============================] - 0s 15us/step - loss: 1.0385 - acc: 0.4909
(567, 49) (567, 3)
3
Epoch 1/15
567/567 [==============================] - 0s 697us/step - loss: 1.0986 - acc: 0.3492
Epoch 2/15
567/567 [==============================] - 0s 45us/step - loss: 1.0974 - acc: 0.5785
Epoch 3/15
567/567 [==============================] - 0s 54us/step - loss: 1.0962 - acc: 0.5785
Epoch 4/15
567/567 [==============================] - 0s 21us/step - loss: 1.0950 - acc: 0.5785
Epoch 5/15
567/567 [==============================] - 0s 42us/step - loss: 1.0938 - acc: 0.5785
Epoch 6/15
567/567 [==============================] - 0s 32us/step - loss: 1.0925 - acc: 0.5785
Epoch 7/15
567/567 [==============================] - 0s 31us/step - loss: 1.0911 - acc: 0.5785
Epoch 8/15
567/567 [==============================] - 0s 36us/step - loss: 1.0897 - acc: 0.5785
Epoch 9/15
567/567 [==============================] - 0s 28us/step - loss: 1.0881 - acc: 0.5785
Epoch 10/15
567/567 [==============================] - 0s 31us/step - loss: 1.0864 - acc: 0.5785
Epoch 11/15
567/567 [==============================] - 0s 34us/step - loss: 1.0846 - acc: 0.5785
Epoch 12/15
567/567 [==============================] - 0s 27us/step - loss: 1.0825 - acc: 0.5785
Epoch 13/15
567/567 [==============================] - 0s 23us/step - loss: 1.0804 - acc: 0.5785
Epoch 14/15
567/567 [==============================] - 0s 38us/step - loss: 1.0779 - acc: 0.5785
Epoch 15/15
567/567 [==============================] - 0s 31us/step - loss: 1.0752 - acc: 0.5785
(8968, 49) (8968, 3)
3
Epoch 1/15
8968/8968 [==============================] - 0s 52us/step - loss: 1.0853 - acc: 0.9444
Epoch 2/15
8968/8968 [==============================] - 0s 9us/step - loss: 1.0474 - acc: 0.9960
Epoch 3/15
8968/8968 [==============================] - 0s 9us/step - loss: 0.9715 - acc: 0.9960
```

```
Epoch 4/15
8968/8968 [==============================] - 0s 10us/step - loss: 0.8172 - acc: 0.9960
Epoch 5/15
8968/8968 [==============================] - 0s 8us/step - loss: 0.5784 - acc: 0.9960
Epoch 6/15
8968/8968 [==============================] - 0s 9us/step - loss: 0.3356 - acc: 0.9960
Epoch 7/15
8968/8968 [==============================] - 0s 8us/step - loss: 0.1747 - acc: 0.9960
Epoch 8/15
8968/8968 [==============================] - 0s 10us/step - loss: 0.0959 - acc: 0.9960
Epoch 9/15
8968/8968 [==============================] - 0s 10us/step - loss: 0.0623 - acc: 0.9960
Epoch 10/15
8968/8968 [==============================] - 0s 9us/step - loss: 0.0478 - acc: 0.9960
Epoch 11/15
8968/8968 [==============================] - 0s 8us/step - loss: 0.0406 - acc: 0.9960
Epoch 12/15
8968/8968 [==============================] - 0s 9us/step - loss: 0.0368 - acc: 0.9960
Epoch 13/15
8968/8968 [==============================] - 0s 7us/step - loss: 0.0343 - acc: 0.9960
Epoch 14/15
8968/8968 [==============================] - 0s 8us/step - loss: 0.0328 - acc: 0.9960
Epoch 15/15
8968/8968 [==============================] - 0s 9us/step - loss: 0.0317 - acc: 0.9960
(2029, 49) (2029, 3)
3
Epoch 1/15
2029/2029 [==============================] - 0s 216us/step - loss: 1.0964 - acc: 0.7723
Epoch 2/15
2029/2029 [==============================] - 0s 10us/step - loss: 1.0882 - acc: 0.9887
Epoch 3/15
2029/2029 [==============================] - 0s 16us/step - loss: 1.0788 - acc: 0.9887
Epoch 4/15
2029/2029 [==============================] - 0s 13us/step - loss: 1.0678 - acc: 0.9887
Epoch 5/15
2029/2029 [==============================] - 0s 12us/step - loss: 1.0546 - acc: 0.9887
Epoch 6/15
2029/2029 [==============================] - 0s 17us/step - loss: 1.0381 - acc: 0.9887
Epoch 7/15
2029/2029 [==============================] - 0s 13us/step - loss: 1.0170 - acc: 0.9887
Epoch 8/15
2029/2029 [==============================] - 0s 11us/step - loss: 0.9900 - acc: 0.9887
Epoch 9/15
2029/2029 [==============================] - 0s 16us/step - loss: 0.9552 - acc: 0.9887
Epoch 10/15
2029/2029 [==============================] - 0s 16us/step - loss: 0.9113 - acc: 0.9887
Epoch 11/15
2029/2029 [==============================] - 0s 18us/step - loss: 0.8568 - acc: 0.9887
```

```
Epoch 12/15
2029/2029 [==============================] - 0s 13us/step - loss: 0.7919 - acc: 0.9887
Epoch 13/15
2029/2029 [==============================] - 0s 17us/step - loss: 0.7163 - acc: 0.9887
Epoch 14/15
2029/2029 [==============================] - 0s 13us/step - loss: 0.6330 - acc: 0.9887
Epoch 15/15
2029/2029 [==============================] - 0s 19us/step - loss: 0.5464 - acc: 0.9887
(3479, 49) (3479, 3)
3
Epoch 1/15
3479/3479 [==============================] - 0s 129us/step - loss: 1.0935 - acc: 0.9129
Epoch 2/15
3479/3479 [==============================] - 0s 8us/step - loss: 1.0805 - acc: 0.9825
Epoch 3/15
3479/3479 [==============================] - 0s 11us/step - loss: 1.0644 - acc: 0.9825
Epoch 4/15
3479/3479 [==============================] - 0s 9us/step - loss: 1.0433 - acc: 0.9825
Epoch 5/15
3479/3479 [==============================] - 0s 10us/step - loss: 1.0144 - acc: 0.9825
Epoch 6/15
3479/3479 [==============================] - 0s 11us/step - loss: 0.9742 - acc: 0.9825
Epoch 7/15
3479/3479 [==============================] - 0s 10us/step - loss: 0.9189 - acc: 0.9825
Epoch 8/15
3479/3479 [==============================] - 0s 11us/step - loss: 0.8459 - acc: 0.9825
Epoch 9/15
3479/3479 [==============================] - 0s 8us/step - loss: 0.7545 - acc: 0.9825
Epoch 10/15
3479/3479 [==============================] - 0s 9us/step - loss: 0.6503 - acc: 0.9825
Epoch 11/15
3479/3479 [==============================] - 0s 7us/step - loss: 0.5419 - acc: 0.9825
Epoch 12/15
3479/3479 [==============================] - 0s 9us/step - loss: 0.4419 - acc: 0.9825
Epoch 13/15
3479/3479 [==============================] - 0s 9us/step - loss: 0.3586 - acc: 0.9825
Epoch 14/15
3479/3479 [==============================] - 0s 10us/step - loss: 0.2932 - acc: 0.9825
Epoch 15/15
3479/3479 [==============================] - 0s 10us/step - loss: 0.2442 - acc: 0.9825
(500, 49) (500, 3)
3
Epoch 1/15
500/500 [==============================] - 0s 899us/step - loss: 1.0984 - acc: 0.5280
Epoch 2/15
500/500 [==============================] - 0s 24us/step - loss: 1.0978 - acc: 0.5260
Epoch 3/15
500/500 [==============================] - 0s 11us/step - loss: 1.0971 - acc: 0.5260
```

```
Epoch 4/15
500/500 [==============================] - 0s 18us/step - loss: 1.0964 - acc: 0.5260
Epoch 5/15
500/500 [==============================] - 0s 10us/step - loss: 1.0957 - acc: 0.5260
Epoch 6/15
500/500 [==============================] - 0s 17us/step - loss: 1.0950 - acc: 0.5260
Epoch 7/15
500/500 [==============================] - 0s 12us/step - loss: 1.0943 - acc: 0.5260
Epoch 8/15
500/500 [==============================] - 0s 26us/step - loss: 1.0936 - acc: 0.5260
Epoch 9/15
500/500 [==============================] - 0s 19us/step - loss: 1.0928 - acc: 0.5260
Epoch 10/15
500/500 [==============================] - 0s 9us/step - loss: 1.0920 - acc: 0.5260
Epoch 11/15
500/500 [==============================] - 0s 20us/step - loss: 1.0911 - acc: 0.5260
Epoch 12/15
500/500 [==============================] - 0s 14us/step - loss: 1.0903 - acc: 0.5260
Epoch 13/15
500/500 [==============================] - 0s 8us/step - loss: 1.0894 - acc: 0.5260
Epoch 14/15
500/500 [==============================] - 0s 17us/step - loss: 1.0884 - acc: 0.5260
Epoch 15/15
500/500 [==============================] - 0s 11us/step - loss: 1.0874 - acc: 0.5260
(852, 49) (852, 3)
3
Epoch 1/15
852/852 [==============================] - 0s 573us/step - loss: 1.0984 - acc: 0.3709
Epoch 2/15
852/852 [==============================] - 0s 21us/step - loss: 1.0974 - acc: 0.5035
Epoch 3/15
852/852 [==============================] - 0s 21us/step - loss: 1.0963 - acc: 0.5035
Epoch 4/15
852/852 [==============================] - 0s 9us/step - loss: 1.0953 - acc: 0.5035
Epoch 5/15
852/852 [==============================] - 0s 21us/step - loss: 1.0942 - acc: 0.5035
Epoch 6/15
852/852 [==============================] - 0s 19us/step - loss: 1.0930 - acc: 0.5035
Epoch 7/15
852/852 [==============================] - 0s 21us/step - loss: 1.0918 - acc: 0.5035
Epoch 8/15
852/852 [==============================] - 0s 22us/step - loss: 1.0904 - acc: 0.5035
Epoch 9/15
852/852 [==============================] - 0s 18us/step - loss: 1.0890 - acc: 0.5035
Epoch 10/15
852/852 [==============================] - 0s 20us/step - loss: 1.0873 - acc: 0.5035
Epoch 11/15
852/852 [==============================] - 0s 17us/step - loss: 1.0857 - acc: 0.5035
```

```
Epoch 12/15
852/852 [==============================] - 0s 18us/step - loss: 1.0837 - acc: 0.5035
Epoch 13/15
852/852 [==============================] - 0s 21us/step - loss: 1.0817 - acc: 0.5035
Epoch 14/15
852/852 [==============================] - 0s 20us/step - loss: 1.0794 - acc: 0.5035
Epoch 15/15
852/852 [==============================] - 0s 16us/step - loss: 1.0769 - acc: 0.5035
(500, 49) (500, 3)
3
Epoch 1/15
500/500 [==============================] - 0s 986us/step - loss: 1.0988 - acc: 0.0540
Epoch 2/15
500/500 [==============================] - 0s 20us/step - loss: 1.0974 - acc: 0.9460
Epoch 3/15
500/500 [==============================] - 0s 15us/step - loss: 1.0960 - acc: 0.9460
Epoch 4/15
500/500 [==============================] - 0s 21us/step - loss: 1.0947 - acc: 0.9460
Epoch 5/15
500/500 [==============================] - 0s 15us/step - loss: 1.0933 - acc: 0.9460
Epoch 6/15
500/500 [==============================] - 0s 14us/step - loss: 1.0919 - acc: 0.9460
Epoch 7/15
500/500 [==============================] - 0s 14us/step - loss: 1.0905 - acc: 0.9460
Epoch 8/15
500/500 [==============================] - 0s 18us/step - loss: 1.0890 - acc: 0.9460
Epoch 9/15
500/500 [==============================] - 0s 23us/step - loss: 1.0876 - acc: 0.9460
Epoch 10/15
500/500 [==============================] - 0s 13us/step - loss: 1.0860 - acc: 0.9460
Epoch 11/15
500/500 [==============================] - 0s 18us/step - loss: 1.0845 - acc: 0.9460
Epoch 12/15
500/500 [==============================] - 0s 13us/step - loss: 1.0829 - acc: 0.9460
Epoch 13/15
500/500 [==============================] - 0s 22us/step - loss: 1.0812 - acc: 0.9460
Epoch 14/15
500/500 [==============================] - 0s 12us/step - loss: 1.0795 - acc: 0.9460
Epoch 15/15
500/500 [==============================] - 0s 8us/step - loss: 1.0778 - acc: 0.9460
(1193, 49) (1193, 3)
3
Epoch 1/15
1193/1193 [==============================] - 1s 434us/step - loss: 1.0974 - acc: 0.8533
Epoch 2/15
1193/1193 [==============================] - 0s 16us/step - loss: 1.0931 - acc: 0.9832
Epoch 3/15
1193/1193 [==============================] - 0s 16us/step - loss: 1.0887 - acc: 0.9832
```

```
Epoch 4/15
1193/1193 [==============================] - 0s 24us/step - loss: 1.0841 - acc: 0.9832
Epoch 5/15
1193/1193 [==============================] - 0s 17us/step - loss: 1.0792 - acc: 0.9832
Epoch 6/15
1193/1193 [==============================] - 0s 13us/step - loss: 1.0739 - acc: 0.9832
Epoch 7/15
1193/1193 [==============================] - 0s 21us/step - loss: 1.0680 - acc: 0.9832
Epoch 8/15
1193/1193 [==============================] - 0s 15us/step - loss: 1.0615 - acc: 0.9832
Epoch 9/15
1193/1193 [==============================] - 0s 18us/step - loss: 1.0539 - acc: 0.9832
Epoch 10/15
1193/1193 [==============================] - 0s 17us/step - loss: 1.0452 - acc: 0.9832
Epoch 11/15
1193/1193 [==============================] - 0s 15us/step - loss: 1.0351 - acc: 0.9832
Epoch 12/15
1193/1193 [==============================] - 0s 21us/step - loss: 1.0233 - acc: 0.9832
Epoch 13/15
1193/1193 [==============================] - 0s 16us/step - loss: 1.0094 - acc: 0.9832
Epoch 14/15
1193/1193 [==============================] - 0s 22us/step - loss: 0.9931 - acc: 0.9832
Epoch 15/15
1193/1193 [==============================] - 0s 17us/step - loss: 0.9742 - acc: 0.9832
(1016, 49) (1016, 3)
3
Epoch 1/15
1016/1016 [==============================] - 1s 536us/step - loss: 1.0977 - acc: 0.5787
Epoch 2/15
1016/1016 [==============================] - 0s 18us/step - loss: 1.0930 - acc: 0.9685
Epoch 3/15
1016/1016 [==============================] - 0s 25us/step - loss: 1.0883 - acc: 0.9685
Epoch 4/15
1016/1016 [==============================] - 0s 16us/step - loss: 1.0834 - acc: 0.9685
Epoch 5/15
1016/1016 [==============================] - 0s 14us/step - loss: 1.0783 - acc: 0.9685
Epoch 6/15
1016/1016 [==============================] - 0s 20us/step - loss: 1.0728 - acc: 0.9685
Epoch 7/15
1016/1016 [==============================] - 0s 19us/step - loss: 1.0669 - acc: 0.9685
Epoch 8/15
1016/1016 [==============================] - 0s 19us/step - loss: 1.0605 - acc: 0.9685
Epoch 9/15
1016/1016 [==============================] - 0s 26us/step - loss: 1.0534 - acc: 0.9685
Epoch 10/15
1016/1016 [==============================] - 0s 26us/step - loss: 1.0456 - acc: 0.9685
Epoch 11/15
1016/1016 [==============================] - 0s 19us/step - loss: 1.0369 - acc: 0.9685
```

```
Epoch 12/15
1016/1016 [==============================] - 0s 14us/step - loss: 1.0271 - acc: 0.9685
Epoch 13/15
1016/1016 [==============================] - 0s 20us/step - loss: 1.0160 - acc: 0.9685
Epoch 14/15
1016/1016 [==============================] - 0s 15us/step - loss: 1.0033 - acc: 0.9685
Epoch 15/15
1016/1016 [==============================] - 0s 19us/step - loss: 0.9887 - acc: 0.9685
(520, 49) (520, 3)
3
Epoch 1/15
520/520 [==============================] - 1s 1ms/step - loss: 1.0984 - acc: 0.7327
Epoch 2/15
520/520 [==============================] - 0s 30us/step - loss: 1.0956 - acc: 0.9096
Epoch 3/15
520/520 [==============================] - 0s 22us/step - loss: 1.0926 - acc: 0.9096
Epoch 4/15
520/520 [==============================] - 0s 23us/step - loss: 1.0895 - acc: 0.9096
Epoch 5/15
520/520 [==============================] - 0s 27us/step - loss: 1.0862 - acc: 0.9096
Epoch 6/15
520/520 [==============================] - 0s 26us/step - loss: 1.0827 - acc: 0.9096
Epoch 7/15
520/520 [==============================] - 0s 25us/step - loss: 1.0789 - acc: 0.9096
Epoch 8/15
520/520 [==============================] - 0s 23us/step - loss: 1.0747 - acc: 0.9096
Epoch 9/15
520/520 [==============================] - 0s 32us/step - loss: 1.0701 - acc: 0.9096
Epoch 10/15
520/520 [==============================] - 0s 27us/step - loss: 1.0649 - acc: 0.9096
Epoch 11/15
520/520 [==============================] - 0s 17us/step - loss: 1.0593 - acc: 0.9096
Epoch 12/15
520/520 [==============================] - 0s 34us/step - loss: 1.0530 - acc: 0.9096
Epoch 13/15
520/520 [==============================] - 0s 29us/step - loss: 1.0459 - acc: 0.9096
Epoch 14/15
520/520 [==============================] - 0s 26us/step - loss: 1.0378 - acc: 0.9096
Epoch 15/15
520/520 [==============================] - 0s 18us/step - loss: 1.0288 - acc: 0.9096
(1869, 49) (1869, 3)
3
Epoch 1/15
1869/1869 [==============================] - 1s 316us/step - loss: 1.0961 - acc: 0.9187
Epoch 2/15
1869/1869 [==============================] - 0s 12us/step - loss: 1.0897 - acc: 0.9588
Epoch 3/15
1869/1869 [==============================] - 0s 14us/step - loss: 1.0825 - acc: 0.9588
```

```
Epoch 4/15
1869/1869 [==============================] - 0s 8us/step - loss: 1.0743 - acc: 0.9588
Epoch 5/15
1869/1869 [==============================] - 0s 10us/step - loss: 1.0644 - acc: 0.9588
Epoch 6/15
1869/1869 [==============================] - 0s 14us/step - loss: 1.0523 - acc: 0.9588
Epoch 7/15
1869/1869 [==============================] - 0s 17us/step - loss: 1.0371 - acc: 0.9588
Epoch 8/15
1869/1869 [==============================] - 0s 12us/step - loss: 1.0180 - acc: 0.9588
Epoch 9/15
1869/1869 [==============================] - 0s 16us/step - loss: 0.9940 - acc: 0.9588
Epoch 10/15
1869/1869 [==============================] - 0s 14us/step - loss: 0.9639 - acc: 0.9588
Epoch 11/15
1869/1869 [==============================] - 0s 11us/step - loss: 0.9266 - acc: 0.9588
Epoch 12/15
1869/1869 [==============================] - 0s 17us/step - loss: 0.8817 - acc: 0.9588
Epoch 13/15
1869/1869 [==============================] - 0s 20us/step - loss: 0.8287 - acc: 0.9588
Epoch 14/15
1869/1869 [==============================] - 0s 13us/step - loss: 0.7683 - acc: 0.9588
Epoch 15/15
1869/1869 [==============================] - 0s 15us/step - loss: 0.7010 - acc: 0.9588
(733, 49) (733, 3)
3
Epoch 1/15
733/733 [==============================] - 1s 823us/step - loss: 1.0980 - acc: 0.6016
Epoch 2/15
733/733 [==============================] - 0s 17us/step - loss: 1.0951 - acc: 0.8690
Epoch 3/15
733/733 [==============================] - 0s 19us/step - loss: 1.0921 - acc: 0.8690
Epoch 4/15
733/733 [==============================] - 0s 21us/step - loss: 1.0890 - acc: 0.8690
Epoch 5/15
733/733 [==============================] - 0s 19us/step - loss: 1.0857 - acc: 0.8690
Epoch 6/15
733/733 [==============================] - 0s 14us/step - loss: 1.0821 - acc: 0.8690
Epoch 7/15
733/733 [==============================] - 0s 23us/step - loss: 1.0782 - acc: 0.8690
Epoch 8/15
733/733 [==============================] - 0s 21us/step - loss: 1.0740 - acc: 0.8690
Epoch 9/15
733/733 [==============================] - 0s 16us/step - loss: 1.0693 - acc: 0.8690
Epoch 10/15
733/733 [==============================] - 0s 27us/step - loss: 1.0641 - acc: 0.8690
Epoch 11/15
733/733 [==============================] - 0s 23us/step - loss: 1.0584 - acc: 0.8690
```

```
Epoch 12/15
733/733 [==============================] - 0s 18us/step - loss: 1.0518 - acc: 0.8690
Epoch 13/15
733/733 [==============================] - 0s 14us/step - loss: 1.0447 - acc: 0.8690
Epoch 14/15
733/733 [==============================] - 0s 19us/step - loss: 1.0367 - acc: 0.8690
Epoch 15/15
733/733 [==============================] - 0s 24us/step - loss: 1.0277 - acc: 0.8690
(804, 49) (804, 3)
3
Epoch 1/15
804/804 [==============================] - 1s 781us/step - loss: 1.0985 - acc: 0.3271
Epoch 2/15
804/804 [==============================] - 0s 19us/step - loss: 1.0973 - acc: 0.5970
Epoch 3/15
804/804 [==============================] - 0s 17us/step - loss: 1.0962 - acc: 0.5970
Epoch 4/15
804/804 [==============================] - 0s 20us/step - loss: 1.0950 - acc: 0.5970
Epoch 5/15
804/804 [==============================] - 0s 13us/step - loss: 1.0937 - acc: 0.5970
Epoch 6/15
804/804 [==============================] - 0s 27us/step - loss: 1.0925 - acc: 0.5970
Epoch 7/15
804/804 [==============================] - 0s 18us/step - loss: 1.0911 - acc: 0.5970
Epoch 8/15
804/804 [==============================] - 0s 20us/step - loss: 1.0897 - acc: 0.5970
Epoch 9/15
804/804 [==============================] - 0s 23us/step - loss: 1.0881 - acc: 0.5970
Epoch 10/15
804/804 [==============================] - 0s 15us/step - loss: 1.0864 - acc: 0.5970
Epoch 11/15
804/804 [==============================] - 0s 19us/step - loss: 1.0845 - acc: 0.5970
Epoch 12/15
804/804 [==============================] - 0s 23us/step - loss: 1.0824 - acc: 0.5970
Epoch 13/15
804/804 [==============================] - 0s 21us/step - loss: 1.0801 - acc: 0.5970
Epoch 14/15
804/804 [==============================] - 0s 20us/step - loss: 1.0773 - acc: 0.5970
Epoch 15/15
804/804 [==============================] - 0s 20us/step - loss: 1.0743 - acc: 0.5970
(1599, 49) (1599, 3)
3
Epoch 1/15
1599/1599 [==============================] - 1s 405us/step - loss: 1.0968 - acc: 0.7742
Epoch 2/15
1599/1599 [==============================] - 0s 19us/step - loss: 1.0905 - acc: 0.9769
Epoch 3/15
1599/1599 [==============================] - 0s 15us/step - loss: 1.0833 - acc: 0.9769
```

```
Epoch 4/15
1599/1599 [==============================] - 0s 17us/step - loss: 1.0752 - acc: 0.9769
Epoch 5/15
1599/1599 [==============================] - 0s 10us/step - loss: 1.0659 - acc: 0.9769
Epoch 6/15
1599/1599 [==============================] - 0s 13us/step - loss: 1.0549 - acc: 0.9769
Epoch 7/15
1599/1599 [==============================] - 0s 16us/step - loss: 1.0416 - acc: 0.9769
Epoch 8/15
1599/1599 [==============================] - 0s 16us/step - loss: 1.0255 - acc: 0.9769
Epoch 9/15
1599/1599 [==============================] - 0s 16us/step - loss: 1.0057 - acc: 0.9769
Epoch 10/15
1599/1599 [==============================] - 0s 17us/step - loss: 0.9814 - acc: 0.9769
Epoch 11/15
1599/1599 [==============================] - 0s 19us/step - loss: 0.9524 - acc: 0.9769
Epoch 12/15
1599/1599 [==============================] - 0s 15us/step - loss: 0.9171 - acc: 0.9769
Epoch 13/15
1599/1599 [==============================] - 0s 15us/step - loss: 0.8760 - acc: 0.9769
Epoch 14/15
1599/1599 [==============================] - 0s 15us/step - loss: 0.8283 - acc: 0.9769
Epoch 15/15
1599/1599 [==============================] - 0s 16us/step - loss: 0.7741 - acc: 0.9769
(887, 49) (887, 3)
3
Epoch 1/15
887/887 [==============================] - 1s 741us/step - loss: 1.0981 - acc: 0.5660
Epoch 2/15
887/887 [==============================] - 0s 16us/step - loss: 1.0957 - acc: 0.8703
Epoch 3/15
887/887 [==============================] - 0s 15us/step - loss: 1.0933 - acc: 0.8703
Epoch 4/15
887/887 [==============================] - 0s 21us/step - loss: 1.0909 - acc: 0.8703
Epoch 5/15
887/887 [==============================] - 0s 19us/step - loss: 1.0884 - acc: 0.8703
Epoch 6/15
887/887 [==============================] - 0s 16us/step - loss: 1.0857 - acc: 0.8703
Epoch 7/15
887/887 [==============================] - 0s 23us/step - loss: 1.0830 - acc: 0.8703
Epoch 8/15
887/887 [==============================] - 0s 19us/step - loss: 1.0800 - acc: 0.8703
Epoch 9/15
887/887 [==============================] - 0s 19us/step - loss: 1.0770 - acc: 0.8703
Epoch 10/15
887/887 [==============================] - 0s 18us/step - loss: 1.0737 - acc: 0.8703
Epoch 11/15
887/887 [==============================] - 0s 18us/step - loss: 1.0702 - acc: 0.8703
```

```
Epoch 12/15
887/887 [==============================] - 0s 18us/step - loss: 1.0664 - acc: 0.8703
Epoch 13/15
887/887 [==============================] - 0s 16us/step - loss: 1.0623 - acc: 0.8703
Epoch 14/15
887/887 [==============================] - 0s 20us/step - loss: 1.0578 - acc: 0.8703
Epoch 15/15
887/887 [==============================] - 0s 22us/step - loss: 1.0528 - acc: 0.8703
(541, 49) (541, 3)
3
Epoch 1/15
541/541 [==============================] - 1s 1ms/step - loss: 1.0985 - acc: 0.5194
Epoch 2/15
541/541 [==============================] - 0s 31us/step - loss: 1.0967 - acc: 0.7098
Epoch 3/15
541/541 [==============================] - 0s 22us/step - loss: 1.0949 - acc: 0.7098
Epoch 4/15
541/541 [==============================] - 0s 19us/step - loss: 1.0929 - acc: 0.7098
Epoch 5/15
541/541 [==============================] - 0s 26us/step - loss: 1.0909 - acc: 0.7098
Epoch 6/15
541/541 [==============================] - 0s 24us/step - loss: 1.0888 - acc: 0.7098
Epoch 7/15
541/541 [==============================] - 0s 27us/step - loss: 1.0865 - acc: 0.7098
Epoch 8/15
541/541 [==============================] - 0s 30us/step - loss: 1.0841 - acc: 0.7098
Epoch 9/15
541/541 [==============================] - 0s 23us/step - loss: 1.0814 - acc: 0.7098
Epoch 10/15
541/541 [==============================] - 0s 19us/step - loss: 1.0785 - acc: 0.7098
Epoch 11/15
541/541 [==============================] - 0s 29us/step - loss: 1.0753 - acc: 0.7098
Epoch 12/15
541/541 [==============================] - 0s 29us/step - loss: 1.0718 - acc: 0.7098
Epoch 13/15
541/541 [==============================] - 0s 24us/step - loss: 1.0680 - acc: 0.7098
Epoch 14/15
541/541 [==============================] - 0s 34us/step - loss: 1.0636 - acc: 0.7098
Epoch 15/15
541/541 [==============================] - 0s 31us/step - loss: 1.0589 - acc: 0.7098
(652, 49) (652, 3)
3
Epoch 1/15
652/652 [==============================] - 1s 1ms/step - loss: 1.0982 - acc: 0.5844
Epoch 2/15
652/652 [==============================] - 0s 17us/step - loss: 1.0952 - acc: 0.9831
Epoch 3/15
652/652 [==============================] - 0s 15us/step - loss: 1.0922 - acc: 0.9831
```

```
Epoch 4/15
652/652 [==============================] - 0s 27us/step - loss: 1.0890 - acc: 0.9831
Epoch 5/15
652/652 [==============================] - 0s 23us/step - loss: 1.0857 - acc: 0.9831
Epoch 6/15
652/652 [==============================] - 0s 25us/step - loss: 1.0822 - acc: 0.9831
Epoch 7/15
652/652 [==============================] - 0s 16us/step - loss: 1.0784 - acc: 0.9831
Epoch 8/15
652/652 [==============================] - 0s 26us/step - loss: 1.0744 - acc: 0.9831
Epoch 9/15
652/652 [==============================] - 0s 24us/step - loss: 1.0700 - acc: 0.9831
Epoch 10/15
652/652 [==============================] - 0s 28us/step - loss: 1.0652 - acc: 0.9831
Epoch 11/15
652/652 [==============================] - 0s 17us/step - loss: 1.0599 - acc: 0.9831
Epoch 12/15
652/652 [==============================] - 0s 29us/step - loss: 1.0541 - acc: 0.9831
Epoch 13/15
652/652 [==============================] - 0s 27us/step - loss: 1.0477 - acc: 0.9831
Epoch 14/15
652/652 [==============================] - 0s 27us/step - loss: 1.0405 - acc: 0.9831
Epoch 15/15
652/652 [==============================] - 0s 25us/step - loss: 1.0325 - acc: 0.9831
(505, 49) (505, 3)
3
Epoch 1/15
505/505 [==============================] - 1s 1ms/step - loss: 1.0986 - acc: 0.4198
Epoch 2/15
505/505 [==============================] - 0s 32us/step - loss: 1.0960 - acc: 0.9010
Epoch 3/15
505/505 [==============================] - 0s 19us/step - loss: 1.0934 - acc: 0.9010
Epoch 4/15
505/505 [==============================] - 0s 21us/step - loss: 1.0909 - acc: 0.9010
Epoch 5/15
505/505 [==============================] - 0s 30us/step - loss: 1.0883 - acc: 0.9010
Epoch 6/15
505/505 [==============================] - 0s 38us/step - loss: 1.0856 - acc: 0.9010
Epoch 7/15
505/505 [==============================] - 0s 27us/step - loss: 1.0827 - acc: 0.9010
Epoch 8/15
505/505 [==============================] - 0s 20us/step - loss: 1.0797 - acc: 0.9010
Epoch 9/15
505/505 [==============================] - 0s 22us/step - loss: 1.0764 - acc: 0.9010
Epoch 10/15
505/505 [==============================] - 0s 37us/step - loss: 1.0730 - acc: 0.9010
Epoch 11/15
505/505 [==============================] - 0s 33us/step - loss: 1.0693 - acc: 0.9010
```

```
Epoch 12/15
505/505 [==============================] - 0s 32us/step - loss: 1.0653 - acc: 0.9010
Epoch 13/15
505/505 [==============================] - 0s 25us/step - loss: 1.0610 - acc: 0.9010
Epoch 14/15
505/505 [==============================] - 0s 23us/step - loss: 1.0563 - acc: 0.9010
Epoch 15/15
505/505 [==============================] - 0s 33us/step - loss: 1.0511 - acc: 0.9010
(980, 49) (980, 3)
3
Epoch 1/15
980/980 [==============================] - 1s 763us/step - loss: 1.0982 - acc: 0.4714
Epoch 2/15
980/980 [==============================] - 0s 21us/step - loss: 1.0961 - acc: 0.7980
Epoch 3/15
980/980 [==============================] - 0s 10us/step - loss: 1.0941 - acc: 0.7980
Epoch 4/15
980/980 [==============================] - 0s 14us/step - loss: 1.0920 - acc: 0.7980
Epoch 5/15
980/980 [==============================] - 0s 16us/step - loss: 1.0898 - acc: 0.7980
Epoch 6/15
980/980 [==============================] - 0s 18us/step - loss: 1.0876 - acc: 0.7980
Epoch 7/15
980/980 [==============================] - 0s 21us/step - loss: 1.0853 - acc: 0.7980
Epoch 8/15
980/980 [==============================] - 0s 13us/step - loss: 1.0829 - acc: 0.7980
Epoch 9/15
980/980 [==============================] - 0s 20us/step - loss: 1.0803 - acc: 0.7980
Epoch 10/15
980/980 [==============================] - 0s 20us/step - loss: 1.0777 - acc: 0.7980
Epoch 11/15
980/980 [==============================] - 0s 19us/step - loss: 1.0748 - acc: 0.7980
Epoch 12/15
980/980 [==============================] - 0s 15us/step - loss: 1.0717 - acc: 0.7980
Epoch 13/15
980/980 [==============================] - 0s 18us/step - loss: 1.0684 - acc: 0.7980
Epoch 14/15
980/980 [==============================] - 0s 18us/step - loss: 1.0648 - acc: 0.7980
Epoch 15/15
980/980 [==============================] - 0s 19us/step - loss: 1.0609 - acc: 0.7980
(523, 49) (523, 3)
3
Epoch 1/15
523/523 [==============================] - 1s 1ms/step - loss: 1.0986 - acc: 0.5832
Epoch 2/15
523/523 [==============================] - 0s 30us/step - loss: 1.0972 - acc: 0.6367
Epoch 3/15
523/523 [==============================] - 0s 32us/step - loss: 1.0957 - acc: 0.6367
```

```
Epoch 4/15
523/523 [==============================] - 0s 25us/step - loss: 1.0942 - acc: 0.6367
Epoch 5/15
523/523 [==============================] - 0s 27us/step - loss: 1.0926 - acc: 0.6367
Epoch 6/15
523/523 [==============================] - 0s 25us/step - loss: 1.0910 - acc: 0.6367
Epoch 7/15
523/523 [==============================] - 0s 32us/step - loss: 1.0892 - acc: 0.6367
Epoch 8/15
523/523 [==============================] - 0s 36us/step - loss: 1.0873 - acc: 0.6367
Epoch 9/15
523/523 [==============================] - 0s 34us/step - loss: 1.0853 - acc: 0.6367
Epoch 10/15
523/523 [==============================] - 0s 17us/step - loss: 1.0831 - acc: 0.6367
Epoch 11/15
523/523 [==============================] - 0s 20us/step - loss: 1.0807 - acc: 0.6367
Epoch 12/15
523/523 [==============================] - 0s 19us/step - loss: 1.0781 - acc: 0.6367
Epoch 13/15
523/523 [==============================] - 0s 32us/step - loss: 1.0753 - acc: 0.6367
Epoch 14/15
523/523 [==============================] - 0s 28us/step - loss: 1.0721 - acc: 0.6367
Epoch 15/15
523/523 [==============================] - 0s 26us/step - loss: 1.0687 - acc: 0.6367
(948, 49) (948, 3)
3
Epoch 1/15
948/948 [==============================] - 1s 852us/step - loss: 1.0984 - acc: 0.4262
Epoch 2/15
948/948 [==============================] - 0s 17us/step - loss: 1.0974 - acc: 0.4694
Epoch 3/15
948/948 [==============================] - 0s 19us/step - loss: 1.0964 - acc: 0.4652
Epoch 4/15
948/948 [==============================] - 0s 16us/step - loss: 1.0953 - acc: 0.4652
Epoch 5/15
948/948 [==============================] - 0s 15us/step - loss: 1.0941 - acc: 0.4652
Epoch 6/15
948/948 [==============================] - 0s 18us/step - loss: 1.0928 - acc: 0.4652
Epoch 7/15
948/948 [==============================] - 0s 16us/step - loss: 1.0915 - acc: 0.4652
Epoch 8/15
948/948 [==============================] - 0s 12us/step - loss: 1.0898 - acc: 0.4652
Epoch 9/15
948/948 [==============================] - 0s 14us/step - loss: 1.0881 - acc: 0.4652
Epoch 10/15
948/948 [==============================] - 0s 22us/step - loss: 1.0862 - acc: 0.4652
Epoch 11/15
948/948 [==============================] - 0s 18us/step - loss: 1.0839 - acc: 0.4652
```

```
Epoch 12/15
948/948 [==============================] - 0s 16us/step - loss: 1.0815 - acc: 0.4652
Epoch 13/15
948/948 [==============================] - 0s 16us/step - loss: 1.0787 - acc: 0.4652
Epoch 14/15
948/948 [==============================] - 0s 16us/step - loss: 1.0756 - acc: 0.4652
Epoch 15/15
948/948 [==============================] - 0s 21us/step - loss: 1.0722 - acc: 0.4652
(964, 49) (964, 3)
3
Epoch 1/15
964/964 [==============================] - 1s 852us/step - loss: 1.0984 - acc: 0.4357
Epoch 2/15
964/964 [==============================] - 0s 15us/step - loss: 1.0973 - acc: 0.5643
Epoch 3/15
964/964 [==============================] - 0s 17us/step - loss: 1.0964 - acc: 0.5643
Epoch 4/15
964/964 [==============================] - 0s 20us/step - loss: 1.0953 - acc: 0.5643
Epoch 5/15
964/964 [==============================] - 0s 16us/step - loss: 1.0940 - acc: 0.5643
Epoch 6/15
964/964 [==============================] - 0s 20us/step - loss: 1.0928 - acc: 0.5643
Epoch 7/15
964/964 [==============================] - 0s 17us/step - loss: 1.0913 - acc: 0.5643
Epoch 8/15
964/964 [==============================] - 0s 18us/step - loss: 1.0897 - acc: 0.5643
Epoch 9/15
964/964 [==============================] - 0s 15us/step - loss: 1.0880 - acc: 0.5643
Epoch 10/15
964/964 [==============================] - 0s 17us/step - loss: 1.0860 - acc: 0.5643
Epoch 11/15
964/964 [==============================] - 0s 13us/step - loss: 1.0839 - acc: 0.5643
Epoch 12/15
964/964 [==============================] - 0s 17us/step - loss: 1.0814 - acc: 0.5643
Epoch 13/15
964/964 [==============================] - 0s 17us/step - loss: 1.0786 - acc: 0.5643
Epoch 14/15
964/964 [==============================] - 0s 17us/step - loss: 1.0753 - acc: 0.5643
Epoch 15/15
964/964 [==============================] - 0s 18us/step - loss: 1.0716 - acc: 0.5643
(952, 49) (952, 3)
3
Epoch 1/15
952/952 [==============================] - 1s 883us/step - loss: 1.0981 - acc: 0.5914
Epoch 2/15
952/952 [==============================] - 0s 12us/step - loss: 1.0964 - acc: 0.7069
Epoch 3/15
952/952 [==============================] - 0s 13us/step - loss: 1.0946 - acc: 0.7069
```

```
Epoch 4/15
952/952 [==============================] - 0s 15us/step - loss: 1.0926 - acc: 0.7069
Epoch 5/15
952/952 [==============================] - 0s 14us/step - loss: 1.0904 - acc: 0.7069
Epoch 6/15
952/952 [==============================] - 0s 20us/step - loss: 1.0881 - acc: 0.7069
Epoch 7/15
952/952 [==============================] - 0s 16us/step - loss: 1.0855 - acc: 0.7069
Epoch 8/15
952/952 [==============================] - 0s 18us/step - loss: 1.0827 - acc: 0.7069
Epoch 9/15
952/952 [==============================] - 0s 14us/step - loss: 1.0795 - acc: 0.7069
Epoch 10/15
952/952 [==============================] - 0s 12us/step - loss: 1.0759 - acc: 0.7069
Epoch 11/15
952/952 [==============================] - 0s 17us/step - loss: 1.0719 - acc: 0.7069
Epoch 12/15
952/952 [==============================] - 0s 11us/step - loss: 1.0672 - acc: 0.7069
Epoch 13/15
952/952 [==============================] - 0s 15us/step - loss: 1.0620 - acc: 0.7069
Epoch 14/15
952/952 [==============================] - 0s 12us/step - loss: 1.0562 - acc: 0.7069
Epoch 15/15
952/952 [==============================] - 0s 23us/step - loss: 1.0496 - acc: 0.7069
(5707, 49) (5707, 3)
3
Epoch 1/15
5707/5707 [==============================] - 1s 157us/step - loss: 1.0934 - acc: 0.7156
Epoch 2/15
5707/5707 [==============================] - 0s 11us/step - loss: 1.0784 - acc: 0.7757
Epoch 3/15
5707/5707 [==============================] - 0s 9us/step - loss: 1.0536 - acc: 0.7757
Epoch 4/15
5707/5707 [==============================] - 0s 10us/step - loss: 1.0081 - acc: 0.7757
Epoch 5/15
5707/5707 [==============================] - 0s 8us/step - loss: 0.9333 - acc: 0.7757
Epoch 6/15
5707/5707 [==============================] - 0s 9us/step - loss: 0.8313 - acc: 0.7757
Epoch 7/15
5707/5707 [==============================] - 0s 9us/step - loss: 0.7368 - acc: 0.7757
Epoch 8/15
5707/5707 [==============================] - 0s 10us/step - loss: 0.6943 - acc: 0.7757
Epoch 9/15
5707/5707 [==============================] - 0s 10us/step - loss: 0.6895 - acc: 0.7757
Epoch 10/15
5707/5707 [==============================] - 0s 9us/step - loss: 0.6872 - acc: 0.7757
Epoch 11/15
5707/5707 [==============================] - 0s 10us/step - loss: 0.6847 - acc: 0.7757
```

```
Epoch 12/15
5707/5707 [==============================] - 0s 9us/step - loss: 0.6831 - acc: 0.7757
Epoch 13/15
5707/5707 [==============================] - 0s 11us/step - loss: 0.6815 - acc: 0.7757
Epoch 14/15
5707/5707 [==============================] - 0s 10us/step - loss: 0.6801 - acc: 0.7757
Epoch 15/15
5707/5707 [==============================] - 0s 10us/step - loss: 0.6783 - acc: 0.7785
(1727, 49) (1727, 3)
3
Epoch 1/15
1727/1727 [==============================] - 1s 521us/step - loss: 1.0977 - acc: 0.5182
Epoch 2/15
1727/1727 [==============================] - 0s 12us/step - loss: 1.0947 - acc: 0.6885
Epoch 3/15
1727/1727 [==============================] - 0s 17us/step - loss: 1.0916 - acc: 0.6885
Epoch 4/15
1727/1727 [==============================] - 0s 13us/step - loss: 1.0883 - acc: 0.6885
Epoch 5/15
1727/1727 [==============================] - 0s 13us/step - loss: 1.0848 - acc: 0.6885
Epoch 6/15
1727/1727 [==============================] - 0s 14us/step - loss: 1.0807 - acc: 0.6885
Epoch 7/15
1727/1727 [==============================] - 0s 15us/step - loss: 1.0762 - acc: 0.6885
Epoch 8/15
1727/1727 [==============================] - 0s 17us/step - loss: 1.0708 - acc: 0.6885
Epoch 9/15
1727/1727 [==============================] - 0s 18us/step - loss: 1.0646 - acc: 0.6885
Epoch 10/15
1727/1727 [==============================] - 0s 19us/step - loss: 1.0571 - acc: 0.6885
Epoch 11/15
1727/1727 [==============================] - 0s 20us/step - loss: 1.0481 - acc: 0.6885
Epoch 12/15
1727/1727 [==============================] - 0s 20us/step - loss: 1.0377 - acc: 0.6885
Epoch 13/15
1727/1727 [==============================] - 0s 17us/step - loss: 1.0249 - acc: 0.6885
Epoch 14/15
1727/1727 [==============================] - 0s 18us/step - loss: 1.0105 - acc: 0.6885
Epoch 15/15
1727/1727 [==============================] - 0s 18us/step - loss: 0.9938 - acc: 0.6885
(853, 49) (853, 3)
3
Epoch 1/15
853/853 [==============================] - 1s 1ms/step - loss: 1.0985 - acc: 0.3857
Epoch 2/15
853/853 [==============================] - 0s 18us/step - loss: 1.0979 - acc: 0.4560
Epoch 3/15
853/853 [==============================] - 0s 21us/step - loss: 1.0974 - acc: 0.4560
```

```
Epoch 4/15
853/853 [==============================] - 0s 19us/step - loss: 1.0968 - acc: 0.4560
Epoch 5/15
853/853 [==============================] - 0s 20us/step - loss: 1.0962 - acc: 0.4560
Epoch 6/15
853/853 [==============================] - 0s 23us/step - loss: 1.0956 - acc: 0.4560
Epoch 7/15
853/853 [==============================] - 0s 16us/step - loss: 1.0949 - acc: 0.4560
Epoch 8/15
853/853 [==============================] - 0s 20us/step - loss: 1.0942 - acc: 0.4560
Epoch 9/15
853/853 [==============================] - 0s 21us/step - loss: 1.0935 - acc: 0.4560
Epoch 10/15
853/853 [==============================] - 0s 24us/step - loss: 1.0927 - acc: 0.4560
Epoch 11/15
853/853 [==============================] - 0s 19us/step - loss: 1.0919 - acc: 0.4560
Epoch 12/15
853/853 [==============================] - 0s 14us/step - loss: 1.0910 - acc: 0.4560
Epoch 13/15
853/853 [==============================] - 0s 27us/step - loss: 1.0900 - acc: 0.4560
Epoch 14/15
853/853 [==============================] - 0s 23us/step - loss: 1.0889 - acc: 0.4560
Epoch 15/15
853/853 [==============================] - 0s 20us/step - loss: 1.0878 - acc: 0.4560
(1709, 49) (1709, 3)
3
Epoch 1/15
1709/1709 [==============================] - 1s 549us/step - loss: 1.0977 - acc: 0.6056
Epoch 2/15
1709/1709 [==============================] - 0s 15us/step - loss: 1.0950 - acc: 0.6214
Epoch 3/15
1709/1709 [==============================] - 0s 15us/step - loss: 1.0919 - acc: 0.6214
Epoch 4/15
1709/1709 [==============================] - 0s 12us/step - loss: 1.0884 - acc: 0.6214
Epoch 5/15
1709/1709 [==============================] - 0s 13us/step - loss: 1.0844 - acc: 0.6214
Epoch 6/15
1709/1709 [==============================] - 0s 12us/step - loss: 1.0795 - acc: 0.6214
Epoch 7/15
1709/1709 [==============================] - 0s 16us/step - loss: 1.0737 - acc: 0.6214
Epoch 8/15
1709/1709 [==============================] - 0s 15us/step - loss: 1.0666 - acc: 0.6214
Epoch 9/15
1709/1709 [==============================] - 0s 15us/step - loss: 1.0579 - acc: 0.6214
Epoch 10/15
1709/1709 [==============================] - 0s 19us/step - loss: 1.0475 - acc: 0.6214
Epoch 11/15
1709/1709 [==============================] - 0s 16us/step - loss: 1.0349 - acc: 0.6214
```

```
Epoch 12/15
1709/1709 [==============================] - 0s 18us/step - loss: 1.0208 - acc: 0.6214
Epoch 13/15
1709/1709 [==============================] - 0s 14us/step - loss: 1.0042 - acc: 0.6214
Epoch 14/15
1709/1709 [==============================] - 0s 12us/step - loss: 0.9867 - acc: 0.6214
Epoch 15/15
1709/1709 [==============================] - 0s 12us/step - loss: 0.9693 - acc: 0.6214
(900, 49) (900, 3)
3
Epoch 1/15
900/900 [==============================] - 1s 1ms/step - loss: 1.0985 - acc: 0.2622
Epoch 2/15
900/900 [==============================] - 0s 18us/step - loss: 1.0974 - acc: 0.5411
Epoch 3/15
900/900 [==============================] - 0s 18us/step - loss: 1.0965 - acc: 0.5344
Epoch 4/15
900/900 [==============================] - 0s 20us/step - loss: 1.0955 - acc: 0.5344
Epoch 5/15
900/900 [==============================] - 0s 18us/step - loss: 1.0945 - acc: 0.5344
Epoch 6/15
900/900 [==============================] - 0s 12us/step - loss: 1.0934 - acc: 0.5344
Epoch 7/15
900/900 [==============================] - 0s 13us/step - loss: 1.0923 - acc: 0.5344
Epoch 8/15
900/900 [==============================] - 0s 23us/step - loss: 1.0911 - acc: 0.5344
Epoch 9/15
900/900 [==============================] - 0s 18us/step - loss: 1.0899 - acc: 0.5344
Epoch 10/15
900/900 [==============================] - 0s 17us/step - loss: 1.0885 - acc: 0.5344
Epoch 11/15
900/900 [==============================] - 0s 17us/step - loss: 1.0871 - acc: 0.5344
Epoch 12/15
900/900 [==============================] - 0s 21us/step - loss: 1.0855 - acc: 0.5344
Epoch 13/15
900/900 [==============================] - 0s 27us/step - loss: 1.0838 - acc: 0.5344
Epoch 14/15
900/900 [==============================] - 0s 23us/step - loss: 1.0819 - acc: 0.5344
Epoch 15/15
900/900 [==============================] - 0s 19us/step - loss: 1.0798 - acc: 0.5344
(523, 49) (523, 3)
3
Epoch 1/15
523/523 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.1491
Epoch 2/15
523/523 [==============================] - 0s 27us/step - loss: 1.0977 - acc: 0.4264
Epoch 3/15
523/523 [==============================] - 0s 21us/step - loss: 1.0969 - acc: 0.4340
```

```
Epoch 4/15
523/523 [==============================] - 0s 26us/step - loss: 1.0960 - acc: 0.4302
Epoch 5/15
523/523 [==============================] - 0s 34us/step - loss: 1.0951 - acc: 0.4226
Epoch 6/15
523/523 [==============================] - 0s 32us/step - loss: 1.0943 - acc: 0.4226
Epoch 7/15
523/523 [==============================] - 0s 41us/step - loss: 1.0933 - acc: 0.4226
Epoch 8/15
523/523 [==============================] - 0s 21us/step - loss: 1.0924 - acc: 0.4226
Epoch 9/15
523/523 [==============================] - 0s 25us/step - loss: 1.0914 - acc: 0.4226
Epoch 10/15
523/523 [==============================] - 0s 24us/step - loss: 1.0903 - acc: 0.4226
Epoch 11/15
523/523 [==============================] - 0s 28us/step - loss: 1.0890 - acc: 0.4226
Epoch 12/15
523/523 [==============================] - 0s 27us/step - loss: 1.0877 - acc: 0.4226
Epoch 13/15
523/523 [==============================] - 0s 20us/step - loss: 1.0862 - acc: 0.4245
Epoch 14/15
523/523 [==============================] - 0s 25us/step - loss: 1.0846 - acc: 0.4245
Epoch 15/15
523/523 [==============================] - 0s 38us/step - loss: 1.0828 - acc: 0.4359
(576, 49) (576, 3)
3
Epoch 1/15
576/576 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.2205
Epoch 2/15
576/576 [==============================] - 0s 37us/step - loss: 1.0980 - acc: 0.4514
Epoch 3/15
576/576 [==============================] - 0s 14us/step - loss: 1.0974 - acc: 0.4514
Epoch 4/15
576/576 [==============================] - 0s 19us/step - loss: 1.0968 - acc: 0.4514
Epoch 5/15
576/576 [==============================] - 0s 19us/step - loss: 1.0962 - acc: 0.4514
Epoch 6/15
576/576 [==============================] - 0s 33us/step - loss: 1.0955 - acc: 0.4514
Epoch 7/15
576/576 [==============================] - 0s 26us/step - loss: 1.0948 - acc: 0.4514
Epoch 8/15
576/576 [==============================] - 0s 34us/step - loss: 1.0941 - acc: 0.4514
Epoch 9/15
576/576 [==============================] - 0s 32us/step - loss: 1.0933 - acc: 0.4514
Epoch 10/15
576/576 [==============================] - 0s 26us/step - loss: 1.0925 - acc: 0.4514
Epoch 11/15
576/576 [==============================] - 0s 27us/step - loss: 1.0916 - acc: 0.4514
```

```
Epoch 12/15
576/576 [==============================] - 0s 29us/step - loss: 1.0906 - acc: 0.4514
Epoch 13/15
576/576 [==============================] - 0s 34us/step - loss: 1.0895 - acc: 0.4514
Epoch 14/15
576/576 [==============================] - 0s 46us/step - loss: 1.0882 - acc: 0.4514
Epoch 15/15
576/576 [==============================] - 0s 28us/step - loss: 1.0870 - acc: 0.4514
(515, 49) (515, 3)
3
Epoch 1/15
515/515 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.3204
Epoch 2/15
515/515 [==============================] - 0s 39us/step - loss: 1.0973 - acc: 0.5689
Epoch 3/15
515/515 [==============================] - 0s 33us/step - loss: 1.0961 - acc: 0.5689
Epoch 4/15
515/515 [==============================] - 0s 42us/step - loss: 1.0948 - acc: 0.5689
Epoch 5/15
515/515 [==============================] - 0s 36us/step - loss: 1.0934 - acc: 0.5689
Epoch 6/15
515/515 [==============================] - 0s 24us/step - loss: 1.0919 - acc: 0.5689
Epoch 7/15
515/515 [==============================] - 0s 36us/step - loss: 1.0903 - acc: 0.5689
Epoch 8/15
515/515 [==============================] - 0s 34us/step - loss: 1.0885 - acc: 0.5689
Epoch 9/15
515/515 [==============================] - 0s 73us/step - loss: 1.0865 - acc: 0.5689
Epoch 10/15
515/515 [==============================] - 0s 38us/step - loss: 1.0842 - acc: 0.5689
Epoch 11/15
515/515 [==============================] - 0s 26us/step - loss: 1.0817 - acc: 0.5689
Epoch 12/15
515/515 [==============================] - 0s 30us/step - loss: 1.0788 - acc: 0.5689
Epoch 13/15
515/515 [==============================] - 0s 31us/step - loss: 1.0756 - acc: 0.5689
Epoch 14/15
515/515 [==============================] - 0s 28us/step - loss: 1.0721 - acc: 0.5689
Epoch 15/15
515/515 [==============================] - 0s 41us/step - loss: 1.0682 - acc: 0.5689
(548, 49) (548, 3)
3
Epoch 1/15
548/548 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.2701
Epoch 2/15
548/548 [==============================] - 0s 22us/step - loss: 1.0980 - acc: 0.4726
Epoch 3/15
548/548 [==============================] - 0s 17us/step - loss: 1.0974 - acc: 0.4726
```

```
Epoch 4/15
548/548 [==============================] - 0s 22us/step - loss: 1.0967 - acc: 0.4726
Epoch 5/15
548/548 [==============================] - 0s 20us/step - loss: 1.0961 - acc: 0.4726
Epoch 6/15
548/548 [==============================] - 0s 24us/step - loss: 1.0954 - acc: 0.4726
Epoch 7/15
548/548 [==============================] - 0s 24us/step - loss: 1.0947 - acc: 0.4726
Epoch 8/15
548/548 [==============================] - 0s 23us/step - loss: 1.0939 - acc: 0.4726
Epoch 9/15
548/548 [==============================] - 0s 19us/step - loss: 1.0931 - acc: 0.4726
Epoch 10/15
548/548 [==============================] - 0s 17us/step - loss: 1.0922 - acc: 0.4726
Epoch 11/15
548/548 [==============================] - 0s 25us/step - loss: 1.0912 - acc: 0.4726
Epoch 12/15
548/548 [==============================] - 0s 25us/step - loss: 1.0902 - acc: 0.4726
Epoch 13/15
548/548 [==============================] - 0s 25us/step - loss: 1.0890 - acc: 0.4726
Epoch 14/15
548/548 [==============================] - 0s 25us/step - loss: 1.0877 - acc: 0.4726
Epoch 15/15
548/548 [==============================] - 0s 20us/step - loss: 1.0862 - acc: 0.4726
(657, 49) (657, 3)
3
Epoch 1/15
657/657 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.2435
Epoch 2/15
657/657 [==============================] - 0s 20us/step - loss: 1.0977 - acc: 0.4307
Epoch 3/15
657/657 [==============================] - 0s 21us/step - loss: 1.0970 - acc: 0.4353
Epoch 4/15
657/657 [==============================] - 0s 17us/step - loss: 1.0961 - acc: 0.4353
Epoch 5/15
657/657 [==============================] - 0s 20us/step - loss: 1.0954 - acc: 0.4353
Epoch 6/15
657/657 [==============================] - 0s 24us/step - loss: 1.0945 - acc: 0.4353
Epoch 7/15
657/657 [==============================] - 0s 24us/step - loss: 1.0937 - acc: 0.4353
Epoch 8/15
657/657 [==============================] - 0s 21us/step - loss: 1.0927 - acc: 0.4353
Epoch 9/15
657/657 [==============================] - 0s 19us/step - loss: 1.0918 - acc: 0.4353
Epoch 10/15
657/657 [==============================] - 0s 17us/step - loss: 1.0908 - acc: 0.4353
Epoch 11/15
657/657 [==============================] - 0s 17us/step - loss: 1.0897 - acc: 0.4353
```

```
Epoch 12/15
657/657 [==============================] - 0s 17us/step - loss: 1.0886 - acc: 0.4353
Epoch 13/15
657/657 [==============================] - 0s 17us/step - loss: 1.0873 - acc: 0.4353
Epoch 14/15
657/657 [==============================] - 0s 20us/step - loss: 1.0860 - acc: 0.4353
Epoch 15/15
657/657 [==============================] - 0s 21us/step - loss: 1.0846 - acc: 0.4353
(551, 49) (551, 3)
3
Epoch 1/15
551/551 [==============================] - 1s 2ms/step - loss: 1.0985 - acc: 0.4374
Epoch 2/15
551/551 [==============================] - 0s 19us/step - loss: 1.0971 - acc: 0.6044
Epoch 3/15
551/551 [==============================] - 0s 19us/step - loss: 1.0957 - acc: 0.6044
Epoch 4/15
551/551 [==============================] - 0s 19us/step - loss: 1.0943 - acc: 0.6044
Epoch 5/15
551/551 [==============================] - 0s 24us/step - loss: 1.0927 - acc: 0.6044
Epoch 6/15
551/551 [==============================] - 0s 21us/step - loss: 1.0911 - acc: 0.6044
Epoch 7/15
551/551 [==============================] - 0s 21us/step - loss: 1.0893 - acc: 0.6044
Epoch 8/15
551/551 [==============================] - 0s 22us/step - loss: 1.0873 - acc: 0.6044
Epoch 9/15
551/551 [==============================] - 0s 24us/step - loss: 1.0852 - acc: 0.6044
Epoch 10/15
551/551 [==============================] - 0s 25us/step - loss: 1.0829 - acc: 0.6044
Epoch 11/15
551/551 [==============================] - 0s 20us/step - loss: 1.0803 - acc: 0.6044
Epoch 12/15
551/551 [==============================] - 0s 21us/step - loss: 1.0775 - acc: 0.6044
Epoch 13/15
551/551 [==============================] - 0s 22us/step - loss: 1.0742 - acc: 0.6044
Epoch 14/15
551/551 [==============================] - 0s 27us/step - loss: 1.0706 - acc: 0.6044
Epoch 15/15
551/551 [==============================] - 0s 24us/step - loss: 1.0667 - acc: 0.6044
(507, 49) (507, 3)
3
Epoch 1/15
507/507 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.2880
Epoch 2/15
507/507 [==============================] - 0s 29us/step - loss: 1.0967 - acc: 0.7416
Epoch 3/15
507/507 [==============================] - 0s 23us/step - loss: 1.0947 - acc: 0.7416
```

```
Epoch 4/15
507/507 [==============================] - 0s 18us/step - loss: 1.0926 - acc: 0.7416
Epoch 5/15
507/507 [==============================] - 0s 22us/step - loss: 1.0904 - acc: 0.7416
Epoch 6/15
507/507 [==============================] - 0s 24us/step - loss: 1.0880 - acc: 0.7416
Epoch 7/15
507/507 [==============================] - 0s 23us/step - loss: 1.0854 - acc: 0.7416
Epoch 8/15
507/507 [==============================] - 0s 26us/step - loss: 1.0826 - acc: 0.7416
Epoch 9/15
507/507 [==============================] - 0s 25us/step - loss: 1.0795 - acc: 0.7416
Epoch 10/15
507/507 [==============================] - 0s 24us/step - loss: 1.0760 - acc: 0.7416
Epoch 11/15
507/507 [==============================] - 0s 18us/step - loss: 1.0722 - acc: 0.7416
Epoch 12/15
507/507 [==============================] - 0s 22us/step - loss: 1.0678 - acc: 0.7416
Epoch 13/15
507/507 [==============================] - 0s 25us/step - loss: 1.0630 - acc: 0.7416
Epoch 14/15
507/507 [==============================] - 0s 24us/step - loss: 1.0576 - acc: 0.7416
Epoch 15/15
507/507 [==============================] - 0s 27us/step - loss: 1.0517 - acc: 0.7416
(569, 49) (569, 3)
3
Epoch 1/15
569/569 [==============================] - 1s 2ms/step - loss: 1.0984 - acc: 0.5888
Epoch 2/15
569/569 [==============================] - 0s 24us/step - loss: 1.0972 - acc: 0.5993
Epoch 3/15
569/569 [==============================] - 0s 17us/step - loss: 1.0958 - acc: 0.5993
Epoch 4/15
569/569 [==============================] - 0s 22us/step - loss: 1.0944 - acc: 0.5993
Epoch 5/15
569/569 [==============================] - 0s 22us/step - loss: 1.0928 - acc: 0.5993
Epoch 6/15
569/569 [==============================] - 0s 24us/step - loss: 1.0912 - acc: 0.5993
Epoch 7/15
569/569 [==============================] - 0s 22us/step - loss: 1.0894 - acc: 0.5993
Epoch 8/15
569/569 [==============================] - 0s 19us/step - loss: 1.0873 - acc: 0.5993
Epoch 9/15
569/569 [==============================] - 0s 37us/step - loss: 1.0852 - acc: 0.5993
Epoch 10/15
569/569 [==============================] - 0s 29us/step - loss: 1.0827 - acc: 0.5993
Epoch 11/15
569/569 [==============================] - 0s 17us/step - loss: 1.0801 - acc: 0.5993
```

```
Epoch 12/15
569/569 [==============================] - 0s 23us/step - loss: 1.0769 - acc: 0.5993
Epoch 13/15
569/569 [==============================] - 0s 27us/step - loss: 1.0736 - acc: 0.5993
Epoch 14/15
569/569 [==============================] - 0s 24us/step - loss: 1.0699 - acc: 0.5993
Epoch 15/15
569/569 [==============================] - 0s 17us/step - loss: 1.0658 - acc: 0.5993
(595, 49) (595, 3)
3
Epoch 1/15
595/595 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.3681
Epoch 2/15
595/595 [==============================] - 0s 24us/step - loss: 1.0985 - acc: 0.3597
Epoch 3/15
595/595 [==============================] - 0s 60us/step - loss: 1.0983 - acc: 0.3597
Epoch 4/15
595/595 [==============================] - 0s 39us/step - loss: 1.0982 - acc: 0.3597
Epoch 5/15
595/595 [==============================] - 0s 26us/step - loss: 1.0981 - acc: 0.3597
Epoch 6/15
595/595 [==============================] - 0s 44us/step - loss: 1.0980 - acc: 0.3597
Epoch 7/15
595/595 [==============================] - 0s 33us/step - loss: 1.0979 - acc: 0.3597
Epoch 8/15
595/595 [==============================] - 0s 26us/step - loss: 1.0977 - acc: 0.3597
Epoch 9/15
595/595 [==============================] - 0s 20us/step - loss: 1.0975 - acc: 0.3597
Epoch 10/15
595/595 [==============================] - 0s 25us/step - loss: 1.0973 - acc: 0.3597
Epoch 11/15
595/595 [==============================] - 0s 25us/step - loss: 1.0970 - acc: 0.3597
Epoch 12/15
595/595 [==============================] - 0s 24us/step - loss: 1.0967 - acc: 0.3597
Epoch 13/15
595/595 [==============================] - 0s 28us/step - loss: 1.0964 - acc: 0.3597
Epoch 14/15
595/595 [==============================] - 0s 24us/step - loss: 1.0959 - acc: 0.3597
Epoch 15/15
595/595 [==============================] - 0s 26us/step - loss: 1.0954 - acc: 0.3597
(2167, 49) (2167, 3)
3
Epoch 1/15
2167/2167 [==============================] - 1s 634us/step - loss: 1.0975 - acc: 0.5565
Epoch 2/15
2167/2167 [==============================] - 0s 12us/step - loss: 1.0943 - acc: 0.5981
Epoch 3/15
2167/2167 [==============================] - 0s 13us/step - loss: 1.0907 - acc: 0.5981
```

```
Epoch 4/15
2167/2167 [==============================] - 0s 14us/step - loss: 1.0868 - acc: 0.5981
Epoch 5/15
2167/2167 [==============================] - 0s 23us/step - loss: 1.0821 - acc: 0.5981
Epoch 6/15
2167/2167 [==============================] - 0s 26us/step - loss: 1.0764 - acc: 0.5981
Epoch 7/15
2167/2167 [==============================] - 0s 20us/step - loss: 1.0694 - acc: 0.5981
Epoch 8/15
2167/2167 [==============================] - 0s 17us/step - loss: 1.0611 - acc: 0.5981
Epoch 9/15
2167/2167 [==============================] - 0s 15us/step - loss: 1.0510 - acc: 0.5981
Epoch 10/15
2167/2167 [==============================] - 0s 17us/step - loss: 1.0385 - acc: 0.5981
Epoch 11/15
2167/2167 [==============================] - 0s 20us/step - loss: 1.0244 - acc: 0.5981
Epoch 12/15
2167/2167 [==============================] - 0s 18us/step - loss: 1.0087 - acc: 0.5981
Epoch 13/15
2167/2167 [==============================] - 0s 27us/step - loss: 0.9922 - acc: 0.5981
Epoch 14/15
2167/2167 [==============================] - 0s 18us/step - loss: 0.9764 - acc: 0.5981
Epoch 15/15
2167/2167 [==============================] - 0s 27us/step - loss: 0.9626 - acc: 0.5981
(799, 49) (799, 3)
3
Epoch 1/15
799/799 [==============================] - 2s 2ms/step - loss: 1.0985 - acc: 0.4305
Epoch 2/15
799/799 [==============================] - 0s 36us/step - loss: 1.0978 - acc: 0.4343
Epoch 3/15
799/799 [==============================] - 0s 56us/step - loss: 1.0971 - acc: 0.4343
Epoch 4/15
799/799 [==============================] - 0s 27us/step - loss: 1.0964 - acc: 0.4343
Epoch 5/15
799/799 [==============================] - 0s 32us/step - loss: 1.0957 - acc: 0.4343
Epoch 6/15
799/799 [==============================] - 0s 26us/step - loss: 1.0949 - acc: 0.4343
Epoch 7/15
799/799 [==============================] - 0s 24us/step - loss: 1.0942 - acc: 0.4343
Epoch 8/15
799/799 [==============================] - 0s 22us/step - loss: 1.0934 - acc: 0.4343
Epoch 9/15
799/799 [==============================] - 0s 28us/step - loss: 1.0925 - acc: 0.4343
Epoch 10/15
799/799 [==============================] - 0s 41us/step - loss: 1.0916 - acc: 0.4343
Epoch 11/15
799/799 [==============================] - 0s 25us/step - loss: 1.0905 - acc: 0.4343
```

```
Epoch 12/15
799/799 [==============================] - 0s 18us/step - loss: 1.0895 - acc: 0.4343
Epoch 13/15
799/799 [==============================] - 0s 35us/step - loss: 1.0883 - acc: 0.4343
Epoch 14/15
799/799 [==============================] - 0s 25us/step - loss: 1.0870 - acc: 0.4343
Epoch 15/15
799/799 [==============================] - 0s 28us/step - loss: 1.0857 - acc: 0.4343
(2057, 49) (2057, 3)
3
Epoch 1/15
2057/2057 [==============================] - 1s 699us/step - loss: 1.0981 - acc: 0.4273
Epoch 2/15
2057/2057 [==============================] - 0s 11us/step - loss: 1.0962 - acc: 0.4993
Epoch 3/15
2057/2057 [==============================] - 0s 11us/step - loss: 1.0943 - acc: 0.4993
Epoch 4/15
2057/2057 [==============================] - 0s 14us/step - loss: 1.0920 - acc: 0.4993
Epoch 5/15
2057/2057 [==============================] - 0s 16us/step - loss: 1.0895 - acc: 0.4993
Epoch 6/15
2057/2057 [==============================] - 0s 14us/step - loss: 1.0865 - acc: 0.4993
Epoch 7/15
2057/2057 [==============================] - 0s 13us/step - loss: 1.0830 - acc: 0.4993
Epoch 8/15
2057/2057 [==============================] - 0s 15us/step - loss: 1.0790 - acc: 0.4993
Epoch 9/15
2057/2057 [==============================] - 0s 13us/step - loss: 1.0741 - acc: 0.4993
Epoch 10/15
2057/2057 [==============================] - 0s 14us/step - loss: 1.0686 - acc: 0.4993
Epoch 11/15
2057/2057 [==============================] - 0s 15us/step - loss: 1.0619 - acc: 0.4993
Epoch 12/15
2057/2057 [==============================] - 0s 13us/step - loss: 1.0548 - acc: 0.4993
Epoch 13/15
2057/2057 [==============================] - 0s 15us/step - loss: 1.0472 - acc: 0.4993
Epoch 14/15
2057/2057 [==============================] - 0s 15us/step - loss: 1.0397 - acc: 0.4993
Epoch 15/15
2057/2057 [==============================] - 0s 13us/step - loss: 1.0326 - acc: 0.4993
(2454, 49) (2454, 3)
3
Epoch 1/15
2454/2454 [==============================] - 1s 560us/step - loss: 1.0981 - acc: 0.4283
Epoch 2/15
2454/2454 [==============================] - 0s 21us/step - loss: 1.0965 - acc: 0.4821
Epoch 3/15
2454/2454 [==============================] - 0s 15us/step - loss: 1.0950 - acc: 0.4821
```

```
Epoch 4/15
2454/2454 [==============================] - 0s 15us/step - loss: 1.0935 - acc: 0.4821
Epoch 5/15
2454/2454 [==============================] - 0s 18us/step - loss: 1.0917 - acc: 0.4821
Epoch 6/15
2454/2454 [==============================] - 0s 17us/step - loss: 1.0898 - acc: 0.4821
Epoch 7/15
2454/2454 [==============================] - 0s 13us/step - loss: 1.0875 - acc: 0.4821
Epoch 8/15
2454/2454 [==============================] - 0s 13us/step - loss: 1.0849 - acc: 0.4821
Epoch 9/15
2454/2454 [==============================] - 0s 13us/step - loss: 1.0817 - acc: 0.4821
Epoch 10/15
2454/2454 [==============================] - 0s 10us/step - loss: 1.0777 - acc: 0.4821
Epoch 11/15
2454/2454 [==============================] - 0s 11us/step - loss: 1.0730 - acc: 0.4821
Epoch 12/15
2454/2454 [==============================] - 0s 11us/step - loss: 1.0673 - acc: 0.4821
Epoch 13/15
2454/2454 [==============================] - 0s 13us/step - loss: 1.0614 - acc: 0.4821
Epoch 14/15
2454/2454 [==============================] - 0s 10us/step - loss: 1.0545 - acc: 0.4821
Epoch 15/15
2454/2454 [==============================] - 0s 11us/step - loss: 1.0487 - acc: 0.4821
(500, 49) (500, 3)
3
Epoch 1/15
500/500 [==============================] - 1s 3ms/step - loss: 1.0986 - acc: 0.2080
Epoch 2/15
500/500 [==============================] - 0s 16us/step - loss: 1.0984 - acc: 0.4060
Epoch 3/15
500/500 [==============================] - 0s 14us/step - loss: 1.0981 - acc: 0.4060
Epoch 4/15
500/500 [==============================] - 0s 11us/step - loss: 1.0978 - acc: 0.4060
Epoch 5/15
500/500 [==============================] - 0s 11us/step - loss: 1.0976 - acc: 0.4060
Epoch 6/15
500/500 [==============================] - 0s 15us/step - loss: 1.0973 - acc: 0.4060
Epoch 7/15
500/500 [==============================] - 0s 19us/step - loss: 1.0970 - acc: 0.4060
Epoch 8/15
500/500 [==============================] - 0s 14us/step - loss: 1.0967 - acc: 0.4060
Epoch 9/15
500/500 [==============================] - 0s 16us/step - loss: 1.0964 - acc: 0.4060
Epoch 10/15
500/500 [==============================] - 0s 14us/step - loss: 1.0961 - acc: 0.4060
Epoch 11/15
500/500 [==============================] - 0s 19us/step - loss: 1.0958 - acc: 0.4060
```

```
Epoch 12/15
500/500 [==============================] - 0s 14us/step - loss: 1.0955 - acc: 0.4060
Epoch 13/15
500/500 [==============================] - 0s 14us/step - loss: 1.0952 - acc: 0.4060
Epoch 14/15
500/500 [==============================] - 0s 23us/step - loss: 1.0949 - acc: 0.4060
Epoch 15/15
500/500 [==============================] - 0s 18us/step - loss: 1.0946 - acc: 0.4060
(752, 49) (752, 3)
3
Epoch 1/15
752/752 [==============================] - 1s 2ms/step - loss: 1.0985 - acc: 0.3125
Epoch 2/15
752/752 [==============================] - 0s 20us/step - loss: 1.0976 - acc: 0.5239
Epoch 3/15
752/752 [==============================] - 0s 18us/step - loss: 1.0968 - acc: 0.5239
Epoch 4/15
752/752 [==============================] - 0s 16us/step - loss: 1.0959 - acc: 0.5239
Epoch 5/15
752/752 [==============================] - 0s 18us/step - loss: 1.0950 - acc: 0.5239
Epoch 6/15
752/752 [==============================] - 0s 18us/step - loss: 1.0940 - acc: 0.5239
Epoch 7/15
752/752 [==============================] - 0s 21us/step - loss: 1.0930 - acc: 0.5239
Epoch 8/15
752/752 [==============================] - 0s 15us/step - loss: 1.0918 - acc: 0.5239
Epoch 9/15
752/752 [==============================] - 0s 14us/step - loss: 1.0906 - acc: 0.5239
Epoch 10/15
752/752 [==============================] - 0s 17us/step - loss: 1.0892 - acc: 0.5239
Epoch 11/15
752/752 [==============================] - 0s 21us/step - loss: 1.0879 - acc: 0.5239
Epoch 12/15
752/752 [==============================] - 0s 17us/step - loss: 1.0862 - acc: 0.5239
Epoch 13/15
752/752 [==============================] - 0s 15us/step - loss: 1.0845 - acc: 0.5239
Epoch 14/15
752/752 [==============================] - 0s 20us/step - loss: 1.0826 - acc: 0.5239
Epoch 15/15
752/752 [==============================] - 0s 18us/step - loss: 1.0805 - acc: 0.5239
(911, 49) (911, 3)
3
Epoch 1/15
911/911 [==============================] - 1s 2ms/step - loss: 1.0984 - acc: 0.3568
Epoch 2/15
911/911 [==============================] - 0s 16us/step - loss: 1.0975 - acc: 0.5357
Epoch 3/15
911/911 [==============================] - 0s 19us/step - loss: 1.0966 - acc: 0.5401
```

```
Epoch 4/15
911/911 [==============================] - 0s 15us/step - loss: 1.0956 - acc: 0.5543
Epoch 5/15
911/911 [==============================] - 0s 14us/step - loss: 1.0947 - acc: 0.5686
Epoch 6/15
911/911 [==============================] - 0s 13us/step - loss: 1.0937 - acc: 0.5785
Epoch 7/15
911/911 [==============================] - 0s 14us/step - loss: 1.0927 - acc: 0.5642
Epoch 8/15
911/911 [==============================] - 0s 10us/step - loss: 1.0917 - acc: 0.5401
Epoch 9/15
911/911 [==============================] - 0s 17us/step - loss: 1.0906 - acc: 0.5236
Epoch 10/15
911/911 [==============================] - 0s 42us/step - loss: 1.0895 - acc: 0.5488
Epoch 11/15
911/911 [==============================] - 0s 31us/step - loss: 1.0883 - acc: 0.5686
Epoch 12/15
911/911 [==============================] - 0s 37us/step - loss: 1.0871 - acc: 0.5730
Epoch 13/15
911/911 [==============================] - 0s 25us/step - loss: 1.0857 - acc: 0.5829
Epoch 14/15
911/911 [==============================] - 0s 15us/step - loss: 1.0844 - acc: 0.5752
Epoch 15/15
911/911 [==============================] - 0s 16us/step - loss: 1.0829 - acc: 0.5752
(1091, 49) (1091, 3)
3
Epoch 1/15
1091/1091 [==============================] - 1s 1ms/step - loss: 1.0983 - acc: 0.3932
Epoch 2/15
1091/1091 [==============================] - 0s 15us/step - loss: 1.0967 - acc: 0.5811
Epoch 3/15
1091/1091 [==============================] - 0s 19us/step - loss: 1.0950 - acc: 0.5811
Epoch 4/15
1091/1091 [==============================] - 0s 12us/step - loss: 1.0932 - acc: 0.5811
Epoch 5/15
1091/1091 [==============================] - 0s 15us/step - loss: 1.0914 - acc: 0.5811
Epoch 6/15
1091/1091 [==============================] - 0s 17us/step - loss: 1.0894 - acc: 0.5811
Epoch 7/15
1091/1091 [==============================] - 0s 23us/step - loss: 1.0874 - acc: 0.5811
Epoch 8/15
1091/1091 [==============================] - 0s 18us/step - loss: 1.0852 - acc: 0.5811
Epoch 9/15
1091/1091 [==============================] - 0s 20us/step - loss: 1.0827 - acc: 0.5811
Epoch 10/15
1091/1091 [==============================] - 0s 13us/step - loss: 1.0801 - acc: 0.5811
Epoch 11/15
1091/1091 [==============================] - 0s 13us/step - loss: 1.0771 - acc: 0.5811
```

```
Epoch 12/15
1091/1091 [==============================] - 0s 16us/step - loss: 1.0738 - acc: 0.5811
Epoch 13/15
1091/1091 [==============================] - 0s 16us/step - loss: 1.0701 - acc: 0.5811
Epoch 14/15
1091/1091 [==============================] - 0s 15us/step - loss: 1.0659 - acc: 0.5811
Epoch 15/15
1091/1091 [==============================] - 0s 16us/step - loss: 1.0613 - acc: 0.5811
(580, 49) (580, 3)
3
Epoch 1/15
580/580 [==============================] - 1s 2ms/step - loss: 1.0984 - acc: 0.6759
Epoch 2/15
580/580 [==============================] - 0s 33us/step - loss: 1.0969 - acc: 0.6759
Epoch 3/15
580/580 [==============================] - 0s 17us/step - loss: 1.0953 - acc: 0.6759
Epoch 4/15
580/580 [==============================] - 0s 19us/step - loss: 1.0937 - acc: 0.6759
Epoch 5/15
580/580 [==============================] - 0s 25us/step - loss: 1.0919 - acc: 0.6759
Epoch 6/15
580/580 [==============================] - 0s 22us/step - loss: 1.0902 - acc: 0.6759
Epoch 7/15
580/580 [==============================] - 0s 21us/step - loss: 1.0883 - acc: 0.6759
Epoch 8/15
580/580 [==============================] - 0s 26us/step - loss: 1.0863 - acc: 0.6759
Epoch 9/15
580/580 [==============================] - 0s 22us/step - loss: 1.0841 - acc: 0.6759
Epoch 10/15
580/580 [==============================] - 0s 27us/step - loss: 1.0818 - acc: 0.6759
Epoch 11/15
580/580 [==============================] - 0s 23us/step - loss: 1.0792 - acc: 0.6759
Epoch 12/15
580/580 [==============================] - 0s 19us/step - loss: 1.0765 - acc: 0.6759
Epoch 13/15
580/580 [==============================] - 0s 24us/step - loss: 1.0734 - acc: 0.6759
Epoch 14/15
580/580 [==============================] - 0s 19us/step - loss: 1.0703 - acc: 0.6759
Epoch 15/15
580/580 [==============================] - 0s 25us/step - loss: 1.0667 - acc: 0.6759
(502, 49) (502, 3)
3
Epoch 1/15
502/502 [==============================] - 1s 3ms/step - loss: 1.0986 - acc: 0.2231
Epoch 2/15
502/502 [==============================] - 0s 28us/step - loss: 1.0978 - acc: 0.5378
Epoch 3/15
502/502 [==============================] - 0s 27us/step - loss: 1.0970 - acc: 0.5378
```

```
Epoch 4/15
502/502 [==============================] - 0s 24us/step - loss: 1.0962 - acc: 0.5378
Epoch 5/15
502/502 [==============================] - 0s 22us/step - loss: 1.0956 - acc: 0.5378
Epoch 6/15
502/502 [==============================] - 0s 23us/step - loss: 1.0950 - acc: 0.5378
Epoch 7/15
502/502 [==============================] - 0s 27us/step - loss: 1.0942 - acc: 0.5378
Epoch 8/15
502/502 [==============================] - 0s 20us/step - loss: 1.0935 - acc: 0.5378
Epoch 9/15
502/502 [==============================] - 0s 24us/step - loss: 1.0928 - acc: 0.5378
Epoch 10/15
502/502 [==============================] - 0s 27us/step - loss: 1.0920 - acc: 0.5378
Epoch 11/15
502/502 [==============================] - 0s 32us/step - loss: 1.0913 - acc: 0.5378
Epoch 12/15
502/502 [==============================] - 0s 27us/step - loss: 1.0907 - acc: 0.5378
Epoch 13/15
502/502 [==============================] - 0s 21us/step - loss: 1.0902 - acc: 0.5378
Epoch 14/15
502/502 [==============================] - 0s 27us/step - loss: 1.0896 - acc: 0.5378
Epoch 15/15
502/502 [==============================] - 0s 26us/step - loss: 1.0890 - acc: 0.5378
(694, 49) (694, 3)
3
Epoch 1/15
694/694 [==============================] - 1s 2ms/step - loss: 1.0986 - acc: 0.2406
Epoch 2/15
694/694 [==============================] - 0s 18us/step - loss: 1.0977 - acc: 0.5418
Epoch 3/15
694/694 [==============================] - 0s 17us/step - loss: 1.0968 - acc: 0.5418
Epoch 4/15
694/694 [==============================] - 0s 19us/step - loss: 1.0959 - acc: 0.5418
Epoch 5/15
694/694 [==============================] - 0s 17us/step - loss: 1.0951 - acc: 0.5418
Epoch 6/15
694/694 [==============================] - 0s 21us/step - loss: 1.0943 - acc: 0.5418
Epoch 7/15
694/694 [==============================] - 0s 19us/step - loss: 1.0934 - acc: 0.5418
Epoch 8/15
694/694 [==============================] - 0s 21us/step - loss: 1.0925 - acc: 0.5418
Epoch 9/15
694/694 [==============================] - 0s 21us/step - loss: 1.0917 - acc: 0.5418
Epoch 10/15
694/694 [==============================] - 0s 18us/step - loss: 1.0907 - acc: 0.5418
Epoch 11/15
694/694 [==============================] - 0s 17us/step - loss: 1.0898 - acc: 0.5418
```

```
Epoch 12/15
694/694 [==============================] - 0s 20us/step - loss: 1.0888 - acc: 0.5418
Epoch 13/15
694/694 [==============================] - 0s 16us/step - loss: 1.0877 - acc: 0.5418
Epoch 14/15
694/694 [==============================] - 0s 19us/step - loss: 1.0866 - acc: 0.5418
Epoch 15/15
694/694 [==============================] - 0s 21us/step - loss: 1.0855 - acc: 0.5418
(506, 49) (506, 3)
3
Epoch 1/15
506/506 [==============================] - 1s 3ms/step - loss: 1.0985 - acc: 0.4269
Epoch 2/15
506/506 [==============================] - 0s 26us/step - loss: 1.0979 - acc: 0.4368
Epoch 3/15
506/506 [==============================] - 0s 16us/step - loss: 1.0974 - acc: 0.4170
Epoch 4/15
506/506 [==============================] - 0s 20us/step - loss: 1.0968 - acc: 0.4170
Epoch 5/15
506/506 [==============================] - 0s 25us/step - loss: 1.0963 - acc: 0.4170
Epoch 6/15
506/506 [==============================] - 0s 31us/step - loss: 1.0958 - acc: 0.4170
Epoch 7/15
506/506 [==============================] - 0s 21us/step - loss: 1.0953 - acc: 0.4170
Epoch 8/15
506/506 [==============================] - 0s 23us/step - loss: 1.0948 - acc: 0.4170
Epoch 9/15
506/506 [==============================] - 0s 23us/step - loss: 1.0944 - acc: 0.4170
Epoch 10/15
506/506 [==============================] - 0s 21us/step - loss: 1.0940 - acc: 0.4170
Epoch 11/15
506/506 [==============================] - 0s 30us/step - loss: 1.0935 - acc: 0.4170
Epoch 12/15
506/506 [==============================] - 0s 21us/step - loss: 1.0929 - acc: 0.4170
Epoch 13/15
506/506 [==============================] - 0s 19us/step - loss: 1.0923 - acc: 0.4170
Epoch 14/15
506/506 [==============================] - 0s 25us/step - loss: 1.0916 - acc: 0.4170
Epoch 15/15
506/506 [==============================] - 0s 27us/step - loss: 1.0908 - acc: 0.4170
(676, 49) (676, 3)
3
Epoch 1/15
676/676 [==============================] - 2s 2ms/step - loss: 1.0981 - acc: 0.9172
Epoch 2/15
676/676 [==============================] - 0s 18us/step - loss: 1.0953 - acc: 0.9172
Epoch 3/15
676/676 [==============================] - 0s 19us/step - loss: 1.0924 - acc: 0.9172
```

```
Epoch 4/15
676/676 [==============================] - 0s 18us/step - loss: 1.0894 - acc: 0.9172
Epoch 5/15
676/676 [==============================] - 0s 18us/step - loss: 1.0863 - acc: 0.9172
Epoch 6/15
676/676 [==============================] - 0s 18us/step - loss: 1.0831 - acc: 0.9172
Epoch 7/15
676/676 [==============================] - 0s 17us/step - loss: 1.0797 - acc: 0.9172
Epoch 8/15
676/676 [==============================] - 0s 18us/step - loss: 1.0760 - acc: 0.9172
Epoch 9/15
676/676 [==============================] - 0s 18us/step - loss: 1.0721 - acc: 0.9172
Epoch 10/15
676/676 [==============================] - 0s 14us/step - loss: 1.0680 - acc: 0.9172
Epoch 11/15
676/676 [==============================] - 0s 20us/step - loss: 1.0635 - acc: 0.9172
Epoch 12/15
676/676 [==============================] - 0s 21us/step - loss: 1.0585 - acc: 0.9172
Epoch 13/15
676/676 [==============================] - 0s 23us/step - loss: 1.0532 - acc: 0.9172
Epoch 14/15
676/676 [==============================] - 0s 17us/step - loss: 1.0474 - acc: 0.9172
Epoch 15/15
676/676 [==============================] - 0s 18us/step - loss: 1.0410 - acc: 0.9172
(604, 49) (604, 3)
3
Epoch 1/15
604/604 [==============================] - 1s 2ms/step - loss: 1.0984 - acc: 0.4338
Epoch 2/15
604/604 [==============================] - 0s 20us/step - loss: 1.0962 - acc: 0.8377
Epoch 3/15
604/604 [==============================] - 0s 34us/step - loss: 1.0940 - acc: 0.8377
Epoch 4/15
604/604 [==============================] - 0s 22us/step - loss: 1.0916 - acc: 0.8377
Epoch 5/15
604/604 [==============================] - 0s 20us/step - loss: 1.0889 - acc: 0.8377
Epoch 6/15
604/604 [==============================] - 0s 16us/step - loss: 1.0861 - acc: 0.8377
Epoch 7/15
604/604 [==============================] - 0s 14us/step - loss: 1.0832 - acc: 0.8377
Epoch 8/15
604/604 [==============================] - 0s 17us/step - loss: 1.0800 - acc: 0.8377
Epoch 9/15
604/604 [==============================] - 0s 24us/step - loss: 1.0766 - acc: 0.8377
Epoch 10/15
604/604 [==============================] - 0s 23us/step - loss: 1.0728 - acc: 0.8377
Epoch 11/15
604/604 [==============================] - 0s 17us/step - loss: 1.0687 - acc: 0.8377
```

```
Epoch 12/15
604/604 [==============================] - 0s 20us/step - loss: 1.0640 - acc: 0.8377
Epoch 13/15
604/604 [==============================] - 0s 20us/step - loss: 1.0589 - acc: 0.8377
Epoch 14/15
604/604 [==============================] - 0s 17us/step - loss: 1.0532 - acc: 0.8377
Epoch 15/15
604/604 [==============================] - 0s 19us/step - loss: 1.0468 - acc: 0.8377
(529, 49) (529, 3)
3
Epoch 1/15
529/529 [==============================] - 2s 3ms/step - loss: 1.0985 - acc: 0.3233
Epoch 2/15
529/529 [==============================] - 0s 26us/step - loss: 1.0970 - acc: 0.6786
Epoch 3/15
529/529 [==============================] - 0s 24us/step - loss: 1.0955 - acc: 0.6786
Epoch 4/15
529/529 [==============================] - 0s 25us/step - loss: 1.0939 - acc: 0.6786
Epoch 5/15
529/529 [==============================] - 0s 21us/step - loss: 1.0922 - acc: 0.6786
Epoch 6/15
529/529 [==============================] - 0s 31us/step - loss: 1.0905 - acc: 0.6786
Epoch 7/15
529/529 [==============================] - 0s 24us/step - loss: 1.0887 - acc: 0.6786
Epoch 8/15
529/529 [==============================] - 0s 22us/step - loss: 1.0868 - acc: 0.6786
Epoch 9/15
529/529 [==============================] - 0s 21us/step - loss: 1.0848 - acc: 0.6786
Epoch 10/15
529/529 [==============================] - 0s 22us/step - loss: 1.0826 - acc: 0.6786
Epoch 11/15
529/529 [==============================] - 0s 25us/step - loss: 1.0803 - acc: 0.6786
Epoch 12/15
529/529 [==============================] - 0s 19us/step - loss: 1.0777 - acc: 0.6786
Epoch 13/15
529/529 [==============================] - 0s 25us/step - loss: 1.0750 - acc: 0.6786
Epoch 14/15
529/529 [==============================] - 0s 25us/step - loss: 1.0721 - acc: 0.6786
Epoch 15/15
529/529 [==============================] - 0s 24us/step - loss: 1.0689 - acc: 0.6786
(2583, 49) (2583, 3)
3
Epoch 1/15
2583/2583 [==============================] - 2s 596us/step - loss: 1.0977 - acc: 0.4262
Epoch 2/15
2583/2583 [==============================] - 0s 12us/step - loss: 1.0951 - acc: 0.4262
Epoch 3/15
2583/2583 [==============================] - 0s 14us/step - loss: 1.0920 - acc: 0.4262
```

```
Epoch 4/15
2583/2583 [==============================] - 0s 10us/step - loss: 1.0886 - acc: 0.4262
Epoch 5/15
2583/2583 [==============================] - 0s 11us/step - loss: 1.0843 - acc: 0.4262
Epoch 6/15
2583/2583 [==============================] - 0s 13us/step - loss: 1.0789 - acc: 0.4262
Epoch 7/15
2583/2583 [==============================] - 0s 13us/step - loss: 1.0720 - acc: 0.4262
Epoch 8/15
2583/2583 [==============================] - 0s 14us/step - loss: 1.0632 - acc: 0.4262
Epoch 9/15
2583/2583 [==============================] - 0s 13us/step - loss: 1.0525 - acc: 0.4262
Epoch 10/15
2583/2583 [==============================] - 0s 12us/step - loss: 1.0406 - acc: 0.4262
Epoch 11/15
2583/2583 [==============================] - 0s 13us/step - loss: 1.0274 - acc: 0.4262
Epoch 12/15
2583/2583 [==============================] - 0s 14us/step - loss: 1.0163 - acc: 0.4262
Epoch 13/15
2583/2583 [==============================] - 0s 12us/step - loss: 1.0088 - acc: 0.4262
Epoch 14/15
2583/2583 [==============================] - 0s 12us/step - loss: 1.0056 - acc: 0.4262
Epoch 15/15
2583/2583 [==============================] - 0s 14us/step - loss: 1.0048 - acc: 0.4352
(559, 49) (559, 3)
3
Epoch 1/15
559/559 [==============================] - 2s 3ms/step - loss: 1.0985 - acc: 0.2880
Epoch 2/15
559/559 [==============================] - 0s 21us/step - loss: 1.0972 - acc: 0.6637
Epoch 3/15
559/559 [==============================] - 0s 20us/step - loss: 1.0958 - acc: 0.6637
Epoch 4/15
559/559 [==============================] - 0s 22us/step - loss: 1.0945 - acc: 0.6637
Epoch 5/15
559/559 [==============================] - 0s 22us/step - loss: 1.0931 - acc: 0.6637
Epoch 6/15
559/559 [==============================] - 0s 21us/step - loss: 1.0918 - acc: 0.6637
Epoch 7/15
559/559 [==============================] - 0s 18us/step - loss: 1.0903 - acc: 0.6637
Epoch 8/15
559/559 [==============================] - 0s 28us/step - loss: 1.0889 - acc: 0.6637
Epoch 9/15
559/559 [==============================] - 0s 23us/step - loss: 1.0874 - acc: 0.6637
Epoch 10/15
559/559 [==============================] - 0s 25us/step - loss: 1.0859 - acc: 0.6637
Epoch 11/15
559/559 [==============================] - 0s 21us/step - loss: 1.0843 - acc: 0.6637
```

```
Epoch 12/15
559/559 [==============================] - 0s 17us/step - loss: 1.0826 - acc: 0.6637
Epoch 13/15
559/559 [==============================] - 0s 27us/step - loss: 1.0809 - acc: 0.6637
Epoch 14/15
559/559 [==============================] - 0s 33us/step - loss: 1.0791 - acc: 0.6637
Epoch 15/15
559/559 [==============================] - 0s 24us/step - loss: 1.0773 - acc: 0.6637
(884, 49) (884, 3)
3
Epoch 1/15
884/884 [==============================] - 2s 2ms/step - loss: 1.0983 - acc: 0.3575
Epoch 2/15
884/884 [==============================] - 0s 16us/step - loss: 1.0965 - acc: 0.7059
Epoch 3/15
884/884 [==============================] - 0s 17us/step - loss: 1.0948 - acc: 0.7059
Epoch 4/15
884/884 [==============================] - 0s 14us/step - loss: 1.0930 - acc: 0.7059
Epoch 5/15
884/884 [==============================] - 0s 14us/step - loss: 1.0912 - acc: 0.7059
Epoch 6/15
884/884 [==============================] - 0s 19us/step - loss: 1.0893 - acc: 0.7059
Epoch 7/15
884/884 [==============================] - 0s 14us/step - loss: 1.0874 - acc: 0.7059
Epoch 8/15
884/884 [==============================] - 0s 18us/step - loss: 1.0855 - acc: 0.7059
Epoch 9/15
884/884 [==============================] - 0s 16us/step - loss: 1.0834 - acc: 0.7059
Epoch 10/15
884/884 [==============================] - 0s 20us/step - loss: 1.0814 - acc: 0.7059
Epoch 11/15
884/884 [==============================] - 0s 19us/step - loss: 1.0791 - acc: 0.7059
Epoch 12/15
884/884 [==============================] - 0s 14us/step - loss: 1.0769 - acc: 0.7059
Epoch 13/15
884/884 [==============================] - 0s 16us/step - loss: 1.0745 - acc: 0.7059
Epoch 14/15
884/884 [==============================] - 0s 18us/step - loss: 1.0719 - acc: 0.7059
Epoch 15/15
884/884 [==============================] - 0s 14us/step - loss: 1.0693 - acc: 0.7059
(567, 49) (567, 3)
3
Epoch 1/15
567/567 [==============================] - 2s 3ms/step - loss: 1.0987 - acc: 0.3069
Epoch 2/15
567/567 [==============================] - 0s 21us/step - loss: 1.0969 - acc: 0.7019
Epoch 3/15
567/567 [==============================] - 0s 24us/step - loss: 1.0952 - acc: 0.7019
```

```
Epoch 4/15
567/567 [==============================] - 0s 26us/step - loss: 1.0935 - acc: 0.7019
Epoch 5/15
567/567 [==============================] - 0s 18us/step - loss: 1.0918 - acc: 0.7019
Epoch 6/15
567/567 [==============================] - 0s 24us/step - loss: 1.0900 - acc: 0.7019
Epoch 7/15
567/567 [==============================] - 0s 24us/step - loss: 1.0882 - acc: 0.7019
Epoch 8/15
567/567 [==============================] - 0s 25us/step - loss: 1.0862 - acc: 0.7019
Epoch 9/15
567/567 [==============================] - 0s 25us/step - loss: 1.0843 - acc: 0.7019
Epoch 10/15
567/567 [==============================] - 0s 28us/step - loss: 1.0822 - acc: 0.7019
Epoch 11/15
567/567 [==============================] - 0s 26us/step - loss: 1.0800 - acc: 0.7019
Epoch 12/15
567/567 [==============================] - 0s 20us/step - loss: 1.0777 - acc: 0.7019
Epoch 13/15
567/567 [==============================] - 0s 27us/step - loss: 1.0752 - acc: 0.7019
Epoch 14/15
567/567 [==============================] - 0s 27us/step - loss: 1.0727 - acc: 0.7019
Epoch 15/15
567/567 [==============================] - 0s 18us/step - loss: 1.0698 - acc: 0.7019
(516, 49) (516, 3)
3
Epoch 1/15
516/516 [==============================] - 2s 3ms/step - loss: 1.0986 - acc: 0.0465
Epoch 2/15
516/516 [==============================] - 0s 22us/step - loss: 1.0966 - acc: 0.8275
Epoch 3/15
516/516 [==============================] - 0s 26us/step - loss: 1.0946 - acc: 0.8275
Epoch 4/15
516/516 [==============================] - 0s 25us/step - loss: 1.0924 - acc: 0.8275
Epoch 5/15
516/516 [==============================] - 0s 25us/step - loss: 1.0901 - acc: 0.8275
Epoch 6/15
516/516 [==============================] - 0s 23us/step - loss: 1.0877 - acc: 0.8275
Epoch 7/15
516/516 [==============================] - 0s 21us/step - loss: 1.0852 - acc: 0.8275
Epoch 8/15
516/516 [==============================] - 0s 22us/step - loss: 1.0825 - acc: 0.8275
Epoch 9/15
516/516 [==============================] - 0s 25us/step - loss: 1.0796 - acc: 0.8275
Epoch 10/15
516/516 [==============================] - 0s 26us/step - loss: 1.0766 - acc: 0.8275
Epoch 11/15
516/516 [==============================] - 0s 25us/step - loss: 1.0733 - acc: 0.8275
```

```
Epoch 12/15
516/516 [==============================] - 0s 20us/step - loss: 1.0698 - acc: 0.8275
Epoch 13/15
516/516 [==============================] - 0s 31us/step - loss: 1.0660 - acc: 0.8275
Epoch 14/15
516/516 [==============================] - 0s 23us/step - loss: 1.0618 - acc: 0.8275
Epoch 15/15
516/516 [==============================] - 0s 26us/step - loss: 1.0572 - acc: 0.8275
(2598, 49) (2598, 3)
3
Epoch 1/15
2598/2598 [==============================] - 2s 633us/step - loss: 1.0974 - acc: 0.5216
Epoch 2/15
2598/2598 [==============================] - 0s 11us/step - loss: 1.0933 - acc: 0.6012
Epoch 3/15
2598/2598 [==============================] - 0s 14us/step - loss: 1.0887 - acc: 0.6012
Epoch 4/15
2598/2598 [==============================] - 0s 14us/step - loss: 1.0826 - acc: 0.6012
Epoch 5/15
2598/2598 [==============================] - 0s 11us/step - loss: 1.0748 - acc: 0.6012
Epoch 6/15
2598/2598 [==============================] - 0s 14us/step - loss: 1.0640 - acc: 0.6012
Epoch 7/15
2598/2598 [==============================] - 0s 11us/step - loss: 1.0498 - acc: 0.6012
Epoch 8/15
2598/2598 [==============================] - 0s 14us/step - loss: 1.0320 - acc: 0.6012
Epoch 9/15
2598/2598 [==============================] - 0s 12us/step - loss: 1.0104 - acc: 0.6012
Epoch 10/15
2598/2598 [==============================] - 0s 12us/step - loss: 0.9883 - acc: 0.6012
Epoch 11/15
2598/2598 [==============================] - 0s 11us/step - loss: 0.9659 - acc: 0.6012
Epoch 12/15
2598/2598 [==============================] - 0s 14us/step - loss: 0.9510 - acc: 0.6012
Epoch 13/15
2598/2598 [==============================] - 0s 13us/step - loss: 0.9437 - acc: 0.6012
Epoch 14/15
2598/2598 [==============================] - 0s 13us/step - loss: 0.9420 - acc: 0.6012
Epoch 15/15
2598/2598 [==============================] - 0s 11us/step - loss: 0.9398 - acc: 0.6012
(515, 49) (515, 3)
3
Epoch 1/15
515/515 [==============================] - 2s 3ms/step - loss: 1.0985 - acc: 0.4330
Epoch 2/15
515/515 [==============================] - 0s 28us/step - loss: 1.0974 - acc: 0.4757
Epoch 3/15
515/515 [==============================] - 0s 24us/step - loss: 1.0963 - acc: 0.4757
```

```
Epoch 4/15
515/515 [==============================] - 0s 21us/step - loss: 1.0952 - acc: 0.4757
Epoch 5/15
515/515 [==============================] - 0s 26us/step - loss: 1.0940 - acc: 0.4757
Epoch 6/15
515/515 [==============================] - 0s 29us/step - loss: 1.0927 - acc: 0.4757
Epoch 7/15
515/515 [==============================] - 0s 21us/step - loss: 1.0914 - acc: 0.4757
Epoch 8/15
515/515 [==============================] - 0s 29us/step - loss: 1.0901 - acc: 0.4757
Epoch 9/15
515/515 [==============================] - 0s 24us/step - loss: 1.0887 - acc: 0.4757
Epoch 10/15
515/515 [==============================] - 0s 19us/step - loss: 1.0872 - acc: 0.4757
Epoch 11/15
515/515 [==============================] - 0s 21us/step - loss: 1.0856 - acc: 0.4757
Epoch 12/15
515/515 [==============================] - 0s 20us/step - loss: 1.0838 - acc: 0.4757
Epoch 13/15
515/515 [==============================] - 0s 23us/step - loss: 1.0820 - acc: 0.4757
Epoch 14/15
515/515 [==============================] - 0s 23us/step - loss: 1.0799 - acc: 0.4757
Epoch 15/15
515/515 [==============================] - 0s 34us/step - loss: 1.0778 - acc: 0.4757
(579, 49) (579, 3)
3
Epoch 1/15
579/579 [==============================] - 2s 3ms/step - loss: 1.0985 - acc: 0.4404
Epoch 2/15
579/579 [==============================] - 0s 25us/step - loss: 1.0973 - acc: 0.4421
Epoch 3/15
579/579 [==============================] - 0s 22us/step - loss: 1.0961 - acc: 0.4421
Epoch 4/15
579/579 [==============================] - 0s 28us/step - loss: 1.0949 - acc: 0.4404
Epoch 5/15
579/579 [==============================] - 0s 29us/step - loss: 1.0936 - acc: 0.4404
Epoch 6/15
579/579 [==============================] - 0s 23us/step - loss: 1.0922 - acc: 0.4404
Epoch 7/15
579/579 [==============================] - 0s 20us/step - loss: 1.0907 - acc: 0.4404
Epoch 8/15
579/579 [==============================] - 0s 16us/step - loss: 1.0890 - acc: 0.4404
Epoch 9/15
579/579 [==============================] - 0s 27us/step - loss: 1.0872 - acc: 0.4404
Epoch 10/15
579/579 [==============================] - 0s 18us/step - loss: 1.0851 - acc: 0.4404
Epoch 11/15
579/579 [==============================] - 0s 25us/step - loss: 1.0829 - acc: 0.4404
```

```
Epoch 12/15
579/579 [==============================] - 0s 24us/step - loss: 1.0803 - acc: 0.4404
Epoch 13/15
579/579 [==============================] - 0s 20us/step - loss: 1.0774 - acc: 0.4404
Epoch 14/15
579/579 [==============================] - 0s 28us/step - loss: 1.0742 - acc: 0.4404
Epoch 15/15
579/579 [==============================] - 0s 17us/step - loss: 1.0706 - acc: 0.4404
(525, 49) (525, 3)
3
Epoch 1/15
525/525 [==============================] - 2s 3ms/step - loss: 1.0985 - acc: 0.5695
Epoch 2/15
525/525 [==============================] - 0s 25us/step - loss: 1.0975 - acc: 0.5695
Epoch 3/15
525/525 [==============================] - 0s 25us/step - loss: 1.0964 - acc: 0.5695
Epoch 4/15
525/525 [==============================] - 0s 26us/step - loss: 1.0953 - acc: 0.5695
Epoch 5/15
525/525 [==============================] - 0s 24us/step - loss: 1.0942 - acc: 0.5695
Epoch 6/15
525/525 [==============================] - 0s 24us/step - loss: 1.0930 - acc: 0.5695
Epoch 7/15
525/525 [==============================] - 0s 26us/step - loss: 1.0918 - acc: 0.5695
Epoch 8/15
525/525 [==============================] - 0s 43us/step - loss: 1.0905 - acc: 0.5695
Epoch 9/15
525/525 [==============================] - 0s 35us/step - loss: 1.0891 - acc: 0.5695
Epoch 10/15
525/525 [==============================] - 0s 19us/step - loss: 1.0875 - acc: 0.5695
Epoch 11/15
525/525 [==============================] - 0s 19us/step - loss: 1.0859 - acc: 0.5695
Epoch 12/15
525/525 [==============================] - 0s 29us/step - loss: 1.0842 - acc: 0.5695
Epoch 13/15
525/525 [==============================] - 0s 25us/step - loss: 1.0822 - acc: 0.5695
Epoch 14/15
525/525 [==============================] - 0s 33us/step - loss: 1.0801 - acc: 0.5695
Epoch 15/15
525/525 [==============================] - 0s 63us/step - loss: 1.0778 - acc: 0.5695
(723, 49) (723, 3)
3
Epoch 1/15
723/723 [==============================] - 2s 3ms/step - loss: 1.0984 - acc: 0.3956
Epoch 2/15
723/723 [==============================] - 0s 22us/step - loss: 1.0970 - acc: 0.6432
Epoch 3/15
723/723 [==============================] - 0s 15us/step - loss: 1.0955 - acc: 0.6432
```

```
Epoch 4/15
723/723 [==============================] - 0s 24us/step - loss: 1.0940 - acc: 0.6432
Epoch 5/15
723/723 [==============================] - 0s 16us/step - loss: 1.0925 - acc: 0.6432
Epoch 6/15
723/723 [==============================] - 0s 25us/step - loss: 1.0908 - acc: 0.6432
Epoch 7/15
723/723 [==============================] - 0s 17us/step - loss: 1.0891 - acc: 0.6432
Epoch 8/15
723/723 [==============================] - 0s 22us/step - loss: 1.0873 - acc: 0.6432
Epoch 9/15
723/723 [==============================] - 0s 22us/step - loss: 1.0853 - acc: 0.6432
Epoch 10/15
723/723 [==============================] - 0s 22us/step - loss: 1.0832 - acc: 0.6432
Epoch 11/15
723/723 [==============================] - 0s 47us/step - loss: 1.0808 - acc: 0.6432
Epoch 12/15
723/723 [==============================] - 0s 43us/step - loss: 1.0782 - acc: 0.6432
Epoch 13/15
723/723 [==============================] - 0s 41us/step - loss: 1.0754 - acc: 0.6432
Epoch 14/15
723/723 [==============================] - 0s 36us/step - loss: 1.0723 - acc: 0.6432
Epoch 15/15
723/723 [==============================] - 0s 38us/step - loss: 1.0688 - acc: 0.6432
```

```
In [10]: def neural_shrub_predict(tree, nn_model, test, label):
             label_test = np.array(label)
             test = np.array(test)

             #row - actual; col - pred
             confusion_matrix = np.array([[0, 0, 0], [0, 0, 0], [0, 0, 0]])
             correct = 0

             for i in range(len(test)):
                 x = test[i]
                 pred_leaf = tree.apply([x])
                 x = np.array([x])
                 nn_model_class = nn_model[pred_leaf[0]]
                 pred = np.argmax(nn_model_class.predict(x))+1

                 confusion_matrix[label[i]-1][pred-1] = confusion_matrix[label[i]-1][pred-1] +
                 if pred == label[i]: correct = correct + 1

             acc_score = correct/len(test)

             return confusion_matrix, acc_score
```

```
In [11]: # Predicting
```

```
        cm, acc_score = neural_shrub_predict(tree, shrubs, test, test_label)
        print("Confusion Matrix:\n\n", cm)
```

```
Confusion Matrix:

 [[3030 1338  235]
 [1278 3167  865]
 [ 833 1669 7290]]
```

```
In [12]: def metrics(cm, cls, size):
             cm = np.array(cm)
             tp = cm[cls][cls]
             fp = sum(cm[x, cls] for x in range(3))-cm[cls][cls]
             fn = sum(cm[cls, x] for x in range(3))-cm[cls][cls]
             tn = size - tp - fp - fn
             precision = tp/(tp+fp)
             recall = tp/(tp+fn)
             fmeasure = 2*(precision*recall)/(precision + recall)
             accuracy = (tp + tn)/size

             return precision, recall, fmeasure, accuracy
```

```
In [13]: # Class 1
         precision0, recall0, f0, acc0 = metrics(cm, 0, len(test))
         print("        Precision Recall F-measure Accuracy")
         print("Class 1: ", round(precision0, 3), "  ", round(recall0, 3), \
               " ", round(f0, 3), "   ", round(acc0,3))
```

```
        Precision Recall F-measure Accuracy
Class 1:  0.589    0.658   0.622     0.813
```

```
In [14]: # Class 2
         precision1, recall1, f1, acc1 = metrics(cm, 1, len(test))
         print("        Precision Recall F-measure Accuracy")
         print("Class 2: ", round(precision1, 3), "  ", round(recall1, 3), \
               " ", round(f1, 3), "   ", round(acc1,3))
```

```
        Precision Recall F-measure Accuracy
Class 2:  0.513    0.596   0.552     0.739
```

```
In [15]: # Class 3
         precision2, recall2, f2, acc2 = metrics(cm, 2, len(test))
         print("        Precision Recall F-measure Accuracy")
         print("Class 3: ", round(precision2, 3), "  ", round(recall2, 3), \
               " ", round(f2, 3), "   ", round(acc2,3))
```

```
        Precision Recall F-measure Accuracy
Class 3:  0.869    0.744   0.802     0.817
```

```
In [16]: avg_p = (precision0 + precision1 + precision2)/3.0
         avg_r = (recall0 + recall1 + recall2) / 3.0
         avg_f = (f0 + f1 + f2) / 3.0
         avg_a = (acc0 + acc1 + acc2)/ 3.0
         print("        Precision Recall F-measure Accuracy")
         print("Average: ", round(avg_p, 3), "  ", round(avg_r, 3), \
               " ", round(avg_f, 3), "   ", round(avg_a,3))
```

```
        Precision Recall F-measure Accuracy
Average:  0.657    0.666   0.658     0.79
```

```
In [17]: # Number of instances correctly classified
         print("Accuracy_score: ", round(acc_score, 4))
         total_time_taken = dt_end - dt_start + max_time
         print("Training Time: %s secs" % round(total_time_taken, 3))
```

```
Accuracy_score:  0.6844
Training Time: 5.764 secs
```