Syed Ali COSC 750 Pattern Recognition I

Assignment Due May 10th, 2021

1. Problem Statement:

The purpose of this assignment is to understand supervised classification using neural network. From the IRIS data, we need tosplit data into training set and test set. We also need to choose an appropriate architecture for the neural network for three class classifications (Setosa, virginica, versicolor), then:

a. Classify the test data completely and find accuracy of classification on test data

b. Save the neural network model and compute predicted class labels on any 5 test data examples and see if they are classified correctly.

2. Neural architecture and justification:

From the IRIS data I will split the data into training set and test set. In this case I am using Keras and sklearn modules for the three class classifications (Setosa, virginica, versicolor). I will be using Convolutional Neural Network (CNN) architecture type since this type of an architecture allows for automatic detection of important features without any human supervision. I will also be using Keras and sklearn since Keras is a user-friendly API and it is very easy to create neural network models with Keras.

Neural Network classification of IRIS using Keras and sklearn modules

In [1]:

```
# import all the modules and functions
import numpy as np
import matplotlib.pyplot as plt
import keras
from keras.models import Sequential
from keras.layers import Dense
from keras.utils import to_categorical
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn import preprocessing
```

```
Using TensorFlow backend.
```

Load IRIS data

In [2]:
```
iris = load_iris()
```

iris is a python dictionary which has data description, keys, data, target, taget_names etc each of which can be extracted as in the following statements

In [3]:
```
print(iris.keys())
```

```
dict_keys(['data', 'target', 'frame', 'target_names', 'DESCR', 'feature_names', 'filenam
e'])
```

Now knowing the keys, one can get the information about all the using print(iris["name_of_the_key"]) for example if you want feature_names, print(iris["feature_names"])

In [4]:
```
print(iris['DESCR'])
```

```
.. _iris_dataset:

Iris plants dataset
--------------------

**Data Set Characteristics:**

    :Number of Instances: 150 (50 in each of three classes)
    :Number of Attributes: 4 numeric, predictive attributes and the class
    :Attribute Information:
        - sepal length in cm
        - sepal width in cm
        - petal length in cm
        - petal width in cm
        - class:
                - Iris-Setosa
                - Iris-Versicolour
                - Iris-Virginica

    :Summary Statistics:

    ============== ==== ==== ======= ===== ====================
                    Min  Max   Mean    SD   Class Correlation
    ============== ==== ==== ======= ===== ====================
    sepal length:   4.3  7.9   5.84   0.83    0.7826
```

```
    sepal width:    2.0  4.4   3.05   0.43   -0.4194
    petal length:   1.0  6.9   3.76   1.76    0.9490  (high!)
    petal width:    0.1  2.5   1.20   0.76    0.9565  (high!)
    ============== ==== ==== ======= ===== ====================

    :Missing Attribute Values: None
    :Class Distribution: 33.3% for each of 3 classes.
    :Creator: R.A. Fisher
    :Donor: Michael Marshall (MARSHALL%PLU@io.arc.nasa.gov)
    :Date: July, 1988

The famous Iris database, first used by Sir R.A. Fisher. The dataset is taken
from Fisher's paper. Note that it's the same as in R, but not as in the UCI
Machine Learning Repository, which has two wrong data points.

This is perhaps the best known database to be found in the
pattern recognition literature.  Fisher's paper is a classic in the field and
is referenced frequently to this day.  (See Duda & Hart, for example.)  The
data set contains 3 classes of 50 instances each, where each class refers to a
type of iris plant.  One class is linearly separable from the other 2; the
latter are NOT linearly separable from each other.

.. topic:: References

   - Fisher, R.A. "The use of multiple measurements in taxonomic problems"
     Annual Eugenics, 7, Part II, 179-188 (1936); also in "Contributions to
     Mathematical Statistics" (John Wiley, NY, 1950).
   - Duda, R.O., & Hart, P.E. (1973) Pattern Classification and Scene Analysis.
     (Q327.D83) John Wiley & Sons.  ISBN 0-471-22361-1.  See page 218.
   - Dasarathy, B.V. (1980) "Nosing Around the Neighborhood: A New System
     Structure and Classification Rule for Recognition in Partially Exposed
     Environments".  IEEE Transactions on Pattern Analysis and Machine
     Intelligence, Vol. PAMI-2, No. 1, 67-71.
   - Gates, G.W. (1972) "The Reduced Nearest Neighbor Rule".  IEEE Transactions
     on Information Theory, May 1972, 431-433.
   - See also: 1988 MLC Proceedings, 54-64.  Cheeseman et al"s AUTOCLASS II
     conceptual clustering system finds 3 classes in the data.
   - Many, many more ...
```

Now let us get the data from the dictionary iris

In [5]:
```
 X = iris['data']
print(X.shape)
```

```
(150, 4)
```

Extact target from iris and convert the target numbers 1,2,3 to categorical 000,010,001

In [6]:
```
Y = iris['target']
Y = to_categorical(Y)
print(Y.shape)
```

```
(150, 3)
```

In [7]:
```
print(Y)
```

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```

3 a) Test 1: Split the X and Y into training and test sets and let us use a training dataset of 0.6 or 40% using 200 epochs

In [8]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.6)
```

In [9]:
```
print(X_train.shape, X_test.shape)
```

```
(60, 4) (90, 4)
```

Now create a model as shown 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [10]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [11]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 200 epochs and see how it performs on training and test data sets

In [12]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=200)
```

```
Train on 60 samples, validate on 90 samples
Epoch 1/200
60/60 [==============================] - 0s 2ms/step - loss: 1.2047 - accuracy: 0.2833 -
val_loss: 1.0976 - val_accuracy: 0.3667
```

```
Epoch 2/200
60/60 [==============================] - 0s 151us/step - loss: 1.1854 - accuracy: 0.2833
- val_loss: 1.0864 - val_accuracy: 0.3667
Epoch 3/200
60/60 [==============================] - 0s 117us/step - loss: 1.1658 - accuracy: 0.2833
- val_loss: 1.0768 - val_accuracy: 0.3667
Epoch 4/200
60/60 [==============================] - 0s 167us/step - loss: 1.1515 - accuracy: 0.3000
- val_loss: 1.0692 - val_accuracy: 0.3889
Epoch 5/200
60/60 [==============================] - 0s 159us/step - loss: 1.1343 - accuracy: 0.3000
- val_loss: 1.0639 - val_accuracy: 0.4000
Epoch 6/200
60/60 [==============================] - 0s 133us/step - loss: 1.1246 - accuracy: 0.3167
- val_loss: 1.0607 - val_accuracy: 0.4222
Epoch 7/200
60/60 [==============================] - 0s 183us/step - loss: 1.1155 - accuracy: 0.4000
- val_loss: 1.0592 - val_accuracy: 0.5111
Epoch 8/200
60/60 [==============================] - 0s 150us/step - loss: 1.1088 - accuracy: 0.4167
- val_loss: 1.0588 - val_accuracy: 0.5556
Epoch 9/200
60/60 [==============================] - 0s 150us/step - loss: 1.1039 - accuracy: 0.4500
- val_loss: 1.0584 - val_accuracy: 0.5778
Epoch 10/200
60/60 [==============================] - 0s 183us/step - loss: 1.1002 - accuracy: 0.5833
- val_loss: 1.0583 - val_accuracy: 0.6222
Epoch 11/200
60/60 [==============================] - 0s 167us/step - loss: 1.0954 - accuracy: 0.6167
- val_loss: 1.0578 - val_accuracy: 0.6222
Epoch 12/200
60/60 [==============================] - 0s 167us/step - loss: 1.0926 - accuracy: 0.6667
- val_loss: 1.0564 - val_accuracy: 0.6333
Epoch 13/200
60/60 [==============================] - 0s 150us/step - loss: 1.0888 - accuracy: 0.6667
- val_loss: 1.0544 - val_accuracy: 0.6444
Epoch 14/200
60/60 [==============================] - 0s 193us/step - loss: 1.0856 - accuracy: 0.6667
- val_loss: 1.0510 - val_accuracy: 0.6444
Epoch 15/200
60/60 [==============================] - 0s 175us/step - loss: 1.0811 - accuracy: 0.6667
- val_loss: 1.0475 - val_accuracy: 0.6444
Epoch 16/200
60/60 [==============================] - 0s 117us/step - loss: 1.0776 - accuracy: 0.6667
- val_loss: 1.0438 - val_accuracy: 0.6444
Epoch 17/200
60/60 [==============================] - 0s 150us/step - loss: 1.0737 - accuracy: 0.6667
- val_loss: 1.0400 - val_accuracy: 0.6333
Epoch 18/200
60/60 [==============================] - 0s 167us/step - loss: 1.0717 - accuracy: 0.6667
- val_loss: 1.0360 - val_accuracy: 0.6222
Epoch 19/200
60/60 [==============================] - 0s 133us/step - loss: 1.0671 - accuracy: 0.6667
- val_loss: 1.0328 - val_accuracy: 0.6222
Epoch 20/200
60/60 [==============================] - 0s 133us/step - loss: 1.0660 - accuracy: 0.6500
- val_loss: 1.0295 - val_accuracy: 0.6222
Epoch 21/200
60/60 [==============================] - 0s 183us/step - loss: 1.0626 - accuracy: 0.6500
- val_loss: 1.0269 - val_accuracy: 0.6222
Epoch 22/200
60/60 [==============================] - 0s 217us/step - loss: 1.0605 - accuracy: 0.6333
- val_loss: 1.0248 - val_accuracy: 0.6222
Epoch 23/200
60/60 [==============================] - 0s 117us/step - loss: 1.0584 - accuracy: 0.6333
```

```
- val_loss: 1.0229 - val_accuracy: 0.6222
Epoch 24/200
60/60 [==============================] - 0s 176us/step - loss: 1.0565 - accuracy: 0.6500
- val_loss: 1.0215 - val_accuracy: 0.6222
Epoch 25/200
60/60 [==============================] - 0s 176us/step - loss: 1.0549 - accuracy: 0.6500
- val_loss: 1.0202 - val_accuracy: 0.6222
Epoch 26/200
60/60 [==============================] - 0s 117us/step - loss: 1.0525 - accuracy: 0.6500
- val_loss: 1.0194 - val_accuracy: 0.6222
Epoch 27/200
60/60 [==============================] - 0s 150us/step - loss: 1.0503 - accuracy: 0.6667
- val_loss: 1.0183 - val_accuracy: 0.6222
Epoch 28/200
60/60 [==============================] - 0s 183us/step - loss: 1.0489 - accuracy: 0.6667
- val_loss: 1.0174 - val_accuracy: 0.6333
Epoch 29/200
60/60 [==============================] - 0s 133us/step - loss: 1.0472 - accuracy: 0.6667
- val_loss: 1.0159 - val_accuracy: 0.6222
Epoch 30/200
60/60 [==============================] - 0s 183us/step - loss: 1.0452 - accuracy: 0.6667
- val_loss: 1.0145 - val_accuracy: 0.6222
Epoch 31/200
60/60 [==============================] - 0s 217us/step - loss: 1.0435 - accuracy: 0.6667
- val_loss: 1.0134 - val_accuracy: 0.6222
Epoch 32/200
60/60 [==============================] - 0s 175us/step - loss: 1.0420 - accuracy: 0.6667
- val_loss: 1.0118 - val_accuracy: 0.6222
Epoch 33/200
60/60 [==============================] - 0s 133us/step - loss: 1.0402 - accuracy: 0.6667
- val_loss: 1.0108 - val_accuracy: 0.6222
Epoch 34/200
60/60 [==============================] - 0s 192us/step - loss: 1.0383 - accuracy: 0.6667
- val_loss: 1.0095 - val_accuracy: 0.6222
Epoch 35/200
60/60 [==============================] - 0s 167us/step - loss: 1.0371 - accuracy: 0.6667
- val_loss: 1.0079 - val_accuracy: 0.6222
Epoch 36/200
60/60 [==============================] - 0s 117us/step - loss: 1.0351 - accuracy: 0.6667
- val_loss: 1.0065 - val_accuracy: 0.6222
Epoch 37/200
60/60 [==============================] - 0s 166us/step - loss: 1.0333 - accuracy: 0.6667
- val_loss: 1.0052 - val_accuracy: 0.6222
Epoch 38/200
60/60 [==============================] - 0s 183us/step - loss: 1.0318 - accuracy: 0.6667
- val_loss: 1.0036 - val_accuracy: 0.6222
Epoch 39/200
60/60 [==============================] - 0s 134us/step - loss: 1.0299 - accuracy: 0.6667
- val_loss: 1.0021 - val_accuracy: 0.6222
Epoch 40/200
60/60 [==============================] - 0s 117us/step - loss: 1.0285 - accuracy: 0.6667
- val_loss: 1.0002 - val_accuracy: 0.6222
Epoch 41/200
60/60 [==============================] - 0s 150us/step - loss: 1.0266 - accuracy: 0.6667
- val_loss: 0.9989 - val_accuracy: 0.6222
Epoch 42/200
60/60 [==============================] - 0s 133us/step - loss: 1.0249 - accuracy: 0.6667
- val_loss: 0.9974 - val_accuracy: 0.6222
Epoch 43/200
60/60 [==============================] - 0s 183us/step - loss: 1.0233 - accuracy: 0.6667
- val_loss: 0.9957 - val_accuracy: 0.6222
Epoch 44/200
60/60 [==============================] - 0s 200us/step - loss: 1.0217 - accuracy: 0.6667
- val_loss: 0.9936 - val_accuracy: 0.6222
Epoch 45/200
```

```
60/60 [==============================] - 0s 167us/step - loss: 1.0197 - accuracy: 0.6667
- val_loss: 0.9920 - val_accuracy: 0.6222
Epoch 46/200
60/60 [==============================] - 0s 133us/step - loss: 1.0180 - accuracy: 0.6667
- val_loss: 0.9901 - val_accuracy: 0.6222
Epoch 47/200
60/60 [==============================] - 0s 167us/step - loss: 1.0162 - accuracy: 0.6500
- val_loss: 0.9884 - val_accuracy: 0.6222
Epoch 48/200
60/60 [==============================] - 0s 133us/step - loss: 1.0145 - accuracy: 0.6500
- val_loss: 0.9868 - val_accuracy: 0.6222
Epoch 49/200
60/60 [==============================] - 0s 133us/step - loss: 1.0129 - accuracy: 0.6667
- val_loss: 0.9852 - val_accuracy: 0.6222
Epoch 50/200
60/60 [==============================] - 0s 176us/step - loss: 1.0111 - accuracy: 0.6667
- val_loss: 0.9828 - val_accuracy: 0.6222
Epoch 51/200
60/60 [==============================] - 0s 117us/step - loss: 1.0092 - accuracy: 0.6500
- val_loss: 0.9811 - val_accuracy: 0.6222
Epoch 52/200
60/60 [==============================] - 0s 150us/step - loss: 1.0074 - accuracy: 0.6500
- val_loss: 0.9790 - val_accuracy: 0.6222
Epoch 53/200
60/60 [==============================] - 0s 176us/step - loss: 1.0055 - accuracy: 0.6500
- val_loss: 0.9772 - val_accuracy: 0.6222
Epoch 54/200
60/60 [==============================] - 0s 117us/step - loss: 1.0043 - accuracy: 0.6500
- val_loss: 0.9756 - val_accuracy: 0.6222
Epoch 55/200
60/60 [==============================] - 0s 133us/step - loss: 1.0023 - accuracy: 0.6500
- val_loss: 0.9738 - val_accuracy: 0.6222
Epoch 56/200
60/60 [==============================] - 0s 167us/step - loss: 1.0000 - accuracy: 0.6500
- val_loss: 0.9715 - val_accuracy: 0.6222
Epoch 57/200
60/60 [==============================] - 0s 133us/step - loss: 0.9983 - accuracy: 0.6500
- val_loss: 0.9693 - val_accuracy: 0.6222
Epoch 58/200
60/60 [==============================] - 0s 183us/step - loss: 0.9964 - accuracy: 0.6500
- val_loss: 0.9671 - val_accuracy: 0.6222
Epoch 59/200
60/60 [==============================] - 0s 150us/step - loss: 0.9948 - accuracy: 0.6333
- val_loss: 0.9646 - val_accuracy: 0.6222
Epoch 60/200
60/60 [==============================] - 0s 150us/step - loss: 0.9928 - accuracy: 0.6167
- val_loss: 0.9625 - val_accuracy: 0.6222
Epoch 61/200
60/60 [==============================] - 0s 167us/step - loss: 0.9912 - accuracy: 0.6167
- val_loss: 0.9608 - val_accuracy: 0.6222
Epoch 62/200
60/60 [==============================] - 0s 133us/step - loss: 0.9892 - accuracy: 0.6167
- val_loss: 0.9592 - val_accuracy: 0.6222
Epoch 63/200
60/60 [==============================] - 0s 117us/step - loss: 0.9872 - accuracy: 0.6167
- val_loss: 0.9573 - val_accuracy: 0.6222
Epoch 64/200
60/60 [==============================] - 0s 167us/step - loss: 0.9853 - accuracy: 0.6167
- val_loss: 0.9555 - val_accuracy: 0.6222
Epoch 65/200
60/60 [==============================] - 0s 167us/step - loss: 0.9835 - accuracy: 0.6167
- val_loss: 0.9537 - val_accuracy: 0.6222
Epoch 66/200
60/60 [==============================] - 0s 117us/step - loss: 0.9822 - accuracy: 0.6500
- val_loss: 0.9515 - val_accuracy: 0.6222
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Epoch 67/200
60/60 [==============================] - 0s 167us/step - loss: 0.9796 - accuracy: 0.6167
- val_loss: 0.9497 - val_accuracy: 0.6222
Epoch 68/200
60/60 [==============================] - 0s 117us/step - loss: 0.9781 - accuracy: 0.6000
- val_loss: 0.9477 - val_accuracy: 0.6222
Epoch 69/200
60/60 [==============================] - 0s 150us/step - loss: 0.9759 - accuracy: 0.6500
- val_loss: 0.9463 - val_accuracy: 0.6222
Epoch 70/200
60/60 [==============================] - 0s 183us/step - loss: 0.9738 - accuracy: 0.6500
- val_loss: 0.9450 - val_accuracy: 0.6222
Epoch 71/200
60/60 [==============================] - 0s 117us/step - loss: 0.9719 - accuracy: 0.6500
- val_loss: 0.9434 - val_accuracy: 0.6222
Epoch 72/200
60/60 [==============================] - 0s 150us/step - loss: 0.9705 - accuracy: 0.6500
- val_loss: 0.9424 - val_accuracy: 0.6222
Epoch 73/200
60/60 [==============================] - 0s 183us/step - loss: 0.9686 - accuracy: 0.6667
- val_loss: 0.9408 - val_accuracy: 0.6333
Epoch 74/200
60/60 [==============================] - 0s 117us/step - loss: 0.9664 - accuracy: 0.6500
- val_loss: 0.9384 - val_accuracy: 0.6222
Epoch 75/200
60/60 [==============================] - 0s 200us/step - loss: 0.9647 - accuracy: 0.6500
- val_loss: 0.9368 - val_accuracy: 0.6222
Epoch 76/200
60/60 [==============================] - 0s 167us/step - loss: 0.9622 - accuracy: 0.6500
- val_loss: 0.9345 - val_accuracy: 0.6222
Epoch 77/200
60/60 [==============================] - 0s 150us/step - loss: 0.9603 - accuracy: 0.6500
- val_loss: 0.9317 - val_accuracy: 0.6222
Epoch 78/200
60/60 [==============================] - 0s 167us/step - loss: 0.9586 - accuracy: 0.6500
- val_loss: 0.9288 - val_accuracy: 0.6222
Epoch 79/200
60/60 [==============================] - 0s 133us/step - loss: 0.9562 - accuracy: 0.6333
- val_loss: 0.9265 - val_accuracy: 0.6222
Epoch 80/200
60/60 [==============================] - 0s 133us/step - loss: 0.9549 - accuracy: 0.6333
- val_loss: 0.9247 - val_accuracy: 0.6222
Epoch 81/200
60/60 [==============================] - 0s 183us/step - loss: 0.9522 - accuracy: 0.6500
- val_loss: 0.9224 - val_accuracy: 0.6222
Epoch 82/200
60/60 [==============================] - 0s 100us/step - loss: 0.9502 - accuracy: 0.6333
- val_loss: 0.9200 - val_accuracy: 0.6222
Epoch 83/200
60/60 [==============================] - 0s 133us/step - loss: 0.9486 - accuracy: 0.6000
- val_loss: 0.9174 - val_accuracy: 0.6111
Epoch 84/200
60/60 [==============================] - 0s 183us/step - loss: 0.9466 - accuracy: 0.6000
- val_loss: 0.9156 - val_accuracy: 0.6222
Epoch 85/200
60/60 [==============================] - 0s 116us/step - loss: 0.9442 - accuracy: 0.6000
- val_loss: 0.9133 - val_accuracy: 0.6111
Epoch 86/200
60/60 [==============================] - 0s 183us/step - loss: 0.9423 - accuracy: 0.6000
- val_loss: 0.9115 - val_accuracy: 0.6222
Epoch 87/200
60/60 [==============================] - 0s 183us/step - loss: 0.9402 - accuracy: 0.6000
- val_loss: 0.9092 - val_accuracy: 0.6111
Epoch 88/200
60/60 [==============================] - 0s 150us/step - loss: 0.9386 - accuracy: 0.6000
```

```
- val_loss: 0.9067 - val_accuracy: 0.6000
Epoch 89/200
60/60 [==============================] - 0s 133us/step - loss: 0.9362 - accuracy: 0.6000
- val_loss: 0.9052 - val_accuracy: 0.6111
Epoch 90/200
60/60 [==============================] - 0s 200us/step - loss: 0.9338 - accuracy: 0.6000
- val_loss: 0.9033 - val_accuracy: 0.6222
Epoch 91/200
60/60 [==============================] - 0s 183us/step - loss: 0.9324 - accuracy: 0.6000
- val_loss: 0.9009 - val_accuracy: 0.6111
Epoch 92/200
60/60 [==============================] - 0s 100us/step - loss: 0.9297 - accuracy: 0.6000
- val_loss: 0.8993 - val_accuracy: 0.6222
Epoch 93/200
60/60 [==============================] - 0s 167us/step - loss: 0.9279 - accuracy: 0.6167
- val_loss: 0.8977 - val_accuracy: 0.6222
Epoch 94/200
60/60 [==============================] - 0s 117us/step - loss: 0.9254 - accuracy: 0.6500
- val_loss: 0.8956 - val_accuracy: 0.6222
Epoch 95/200
60/60 [==============================] - 0s 150us/step - loss: 0.9234 - accuracy: 0.6500
- val_loss: 0.8935 - val_accuracy: 0.6222
Epoch 96/200
60/60 [==============================] - 0s 167us/step - loss: 0.9212 - accuracy: 0.6500
- val_loss: 0.8912 - val_accuracy: 0.6222
Epoch 97/200
60/60 [==============================] - 0s 133us/step - loss: 0.9193 - accuracy: 0.6333
- val_loss: 0.8885 - val_accuracy: 0.6222
Epoch 98/200
60/60 [==============================] - 0s 116us/step - loss: 0.9176 - accuracy: 0.6000
- val_loss: 0.8857 - val_accuracy: 0.6222
Epoch 99/200
60/60 [==============================] - 0s 167us/step - loss: 0.9153 - accuracy: 0.6167
- val_loss: 0.8842 - val_accuracy: 0.6222
Epoch 100/200
60/60 [==============================] - 0s 133us/step - loss: 0.9127 - accuracy: 0.6333
- val_loss: 0.8818 - val_accuracy: 0.6222
Epoch 101/200
60/60 [==============================] - 0s 200us/step - loss: 0.9105 - accuracy: 0.6333
- val_loss: 0.8795 - val_accuracy: 0.6222
Epoch 102/200
60/60 [==============================] - 0s 150us/step - loss: 0.9087 - accuracy: 0.6333
- val_loss: 0.8775 - val_accuracy: 0.6222
Epoch 103/200
60/60 [==============================] - 0s 150us/step - loss: 0.9062 - accuracy: 0.6500
- val_loss: 0.8748 - val_accuracy: 0.6222
Epoch 104/200
60/60 [==============================] - 0s 183us/step - loss: 0.9041 - accuracy: 0.6333
- val_loss: 0.8726 - val_accuracy: 0.6222
Epoch 105/200
60/60 [==============================] - 0s 183us/step - loss: 0.9021 - accuracy: 0.6333
- val_loss: 0.8697 - val_accuracy: 0.6111
Epoch 106/200
60/60 [==============================] - 0s 117us/step - loss: 0.8997 - accuracy: 0.6000
- val_loss: 0.8675 - val_accuracy: 0.6111
Epoch 107/200
60/60 [==============================] - 0s 133us/step - loss: 0.8974 - accuracy: 0.6000
- val_loss: 0.8652 - val_accuracy: 0.6111
Epoch 108/200
60/60 [==============================] - 0s 200us/step - loss: 0.8952 - accuracy: 0.6000
- val_loss: 0.8625 - val_accuracy: 0.6000
Epoch 109/200
60/60 [==============================] - 0s 100us/step - loss: 0.8934 - accuracy: 0.5833
- val_loss: 0.8597 - val_accuracy: 0.5778
Epoch 110/200
```

```
60/60 [==============================] - 0s 200us/step - loss: 0.8909 - accuracy: 0.5833
- val_loss: 0.8577 - val_accuracy: 0.5778
Epoch 111/200
60/60 [==============================] - 0s 183us/step - loss: 0.8885 - accuracy: 0.5833
- val_loss: 0.8555 - val_accuracy: 0.5889
Epoch 112/200
60/60 [==============================] - 0s 167us/step - loss: 0.8863 - accuracy: 0.5833
- val_loss: 0.8535 - val_accuracy: 0.6000
Epoch 113/200
60/60 [==============================] - 0s 117us/step - loss: 0.8840 - accuracy: 0.6000
- val_loss: 0.8510 - val_accuracy: 0.5889
Epoch 114/200
60/60 [==============================] - 0s 183us/step - loss: 0.8817 - accuracy: 0.5833
- val_loss: 0.8488 - val_accuracy: 0.5889
Epoch 115/200
60/60 [==============================] - 0s 167us/step - loss: 0.8796 - accuracy: 0.5833
- val_loss: 0.8463 - val_accuracy: 0.5778
Epoch 116/200
60/60 [==============================] - 0s 133us/step - loss: 0.8773 - accuracy: 0.5833
- val_loss: 0.8439 - val_accuracy: 0.5778
Epoch 117/200
60/60 [==============================] - 0s 150us/step - loss: 0.8750 - accuracy: 0.5833
- val_loss: 0.8420 - val_accuracy: 0.6000
Epoch 118/200
60/60 [==============================] - 0s 200us/step - loss: 0.8729 - accuracy: 0.5833
- val_loss: 0.8395 - val_accuracy: 0.6000
Epoch 119/200
60/60 [==============================] - 0s 150us/step - loss: 0.8708 - accuracy: 0.6000
- val_loss: 0.8378 - val_accuracy: 0.6222
Epoch 120/200
60/60 [==============================] - 0s 166us/step - loss: 0.8680 - accuracy: 0.6167
- val_loss: 0.8353 - val_accuracy: 0.6222
Epoch 121/200
60/60 [==============================] - 0s 167us/step - loss: 0.8659 - accuracy: 0.6167
- val_loss: 0.8333 - val_accuracy: 0.6222
Epoch 122/200
60/60 [==============================] - 0s 117us/step - loss: 0.8636 - accuracy: 0.6167
- val_loss: 0.8305 - val_accuracy: 0.6111
Epoch 123/200
60/60 [==============================] - 0s 117us/step - loss: 0.8612 - accuracy: 0.6000
- val_loss: 0.8277 - val_accuracy: 0.6000
Epoch 124/200
60/60 [==============================] - 0s 150us/step - loss: 0.8588 - accuracy: 0.5833
- val_loss: 0.8254 - val_accuracy: 0.6000
Epoch 125/200
60/60 [==============================] - 0s 117us/step - loss: 0.8565 - accuracy: 0.6000
- val_loss: 0.8231 - val_accuracy: 0.6000
Epoch 126/200
60/60 [==============================] - 0s 167us/step - loss: 0.8542 - accuracy: 0.6000
- val_loss: 0.8207 - val_accuracy: 0.6000
Epoch 127/200
60/60 [==============================] - 0s 167us/step - loss: 0.8528 - accuracy: 0.5667
- val_loss: 0.8176 - val_accuracy: 0.5889
Epoch 128/200
60/60 [==============================] - 0s 150us/step - loss: 0.8496 - accuracy: 0.5833
- val_loss: 0.8151 - val_accuracy: 0.5889
Epoch 129/200
60/60 [==============================] - 0s 167us/step - loss: 0.8472 - accuracy: 0.5833
- val_loss: 0.8130 - val_accuracy: 0.5889
Epoch 130/200
60/60 [==============================] - 0s 117us/step - loss: 0.8449 - accuracy: 0.5833
- val_loss: 0.8107 - val_accuracy: 0.6000
Epoch 131/200
60/60 [==============================] - 0s 133us/step - loss: 0.8425 - accuracy: 0.5833
- val_loss: 0.8082 - val_accuracy: 0.5889
```

```
Epoch 132/200
60/60 [==============================] - 0s 183us/step - loss: 0.8402 - accuracy: 0.6000
- val_loss: 0.8060 - val_accuracy: 0.6000
Epoch 133/200
60/60 [==============================] - 0s 167us/step - loss: 0.8378 - accuracy: 0.5833
- val_loss: 0.8035 - val_accuracy: 0.6000
Epoch 134/200
60/60 [==============================] - 0s 117us/step - loss: 0.8354 - accuracy: 0.5833
- val_loss: 0.8011 - val_accuracy: 0.5889
Epoch 135/200
60/60 [==============================] - 0s 167us/step - loss: 0.8336 - accuracy: 0.5833
- val_loss: 0.7981 - val_accuracy: 0.5889
Epoch 136/200
60/60 [==============================] - 0s 100us/step - loss: 0.8310 - accuracy: 0.5333
- val_loss: 0.7954 - val_accuracy: 0.5778
Epoch 137/200
60/60 [==============================] - 0s 133us/step - loss: 0.8284 - accuracy: 0.5500
- val_loss: 0.7932 - val_accuracy: 0.5889
Epoch 138/200
60/60 [==============================] - 0s 167us/step - loss: 0.8260 - accuracy: 0.5500
- val_loss: 0.7909 - val_accuracy: 0.5889
Epoch 139/200
60/60 [==============================] - 0s 150us/step - loss: 0.8237 - accuracy: 0.5500
- val_loss: 0.7886 - val_accuracy: 0.5889
Epoch 140/200
60/60 [==============================] - 0s 133us/step - loss: 0.8213 - accuracy: 0.5500
- val_loss: 0.7863 - val_accuracy: 0.5889
Epoch 141/200
60/60 [==============================] - 0s 217us/step - loss: 0.8190 - accuracy: 0.5667
- val_loss: 0.7837 - val_accuracy: 0.5778
Epoch 142/200
60/60 [==============================] - 0s 167us/step - loss: 0.8168 - accuracy: 0.5500
- val_loss: 0.7817 - val_accuracy: 0.5889
Epoch 143/200
60/60 [==============================] - 0s 117us/step - loss: 0.8143 - accuracy: 0.5833
- val_loss: 0.7791 - val_accuracy: 0.5889
Epoch 144/200
60/60 [==============================] - 0s 150us/step - loss: 0.8119 - accuracy: 0.5500
- val_loss: 0.7767 - val_accuracy: 0.5778
Epoch 145/200
60/60 [==============================] - 0s 183us/step - loss: 0.8095 - accuracy: 0.5500
- val_loss: 0.7743 - val_accuracy: 0.5778
Epoch 146/200
60/60 [==============================] - 0s 133us/step - loss: 0.8072 - accuracy: 0.5667
- val_loss: 0.7720 - val_accuracy: 0.5778
Epoch 147/200
60/60 [==============================] - 0s 183us/step - loss: 0.8051 - accuracy: 0.5667
- val_loss: 0.7691 - val_accuracy: 0.5667
Epoch 148/200
60/60 [==============================] - 0s 134us/step - loss: 0.8024 - accuracy: 0.5333
- val_loss: 0.7667 - val_accuracy: 0.5778
Epoch 149/200
60/60 [==============================] - 0s 117us/step - loss: 0.8001 - accuracy: 0.5500
- val_loss: 0.7643 - val_accuracy: 0.5778
Epoch 150/200
60/60 [==============================] - 0s 167us/step - loss: 0.7982 - accuracy: 0.5333
- val_loss: 0.7613 - val_accuracy: 0.5667
Epoch 151/200
60/60 [==============================] - 0s 117us/step - loss: 0.7954 - accuracy: 0.5000
- val_loss: 0.7591 - val_accuracy: 0.5667
Epoch 152/200
60/60 [==============================] - 0s 183us/step - loss: 0.7930 - accuracy: 0.5333
- val_loss: 0.7566 - val_accuracy: 0.5778
Epoch 153/200
60/60 [==============================] - 0s 167us/step - loss: 0.7906 - accuracy: 0.5333
```

```
- val_loss: 0.7541 - val_accuracy: 0.5778
Epoch 154/200
60/60 [==============================] - 0s 183us/step - loss: 0.7883 - accuracy: 0.5167
- val_loss: 0.7514 - val_accuracy: 0.5667
Epoch 155/200
60/60 [==============================] - 0s 133us/step - loss: 0.7861 - accuracy: 0.4833
- val_loss: 0.7486 - val_accuracy: 0.5556
Epoch 156/200
60/60 [==============================] - 0s 183us/step - loss: 0.7839 - accuracy: 0.4833
- val_loss: 0.7459 - val_accuracy: 0.5444
Epoch 157/200
60/60 [==============================] - 0s 167us/step - loss: 0.7816 - accuracy: 0.5000
- val_loss: 0.7441 - val_accuracy: 0.5667
Epoch 158/200
60/60 [==============================] - 0s 133us/step - loss: 0.7788 - accuracy: 0.5333
- val_loss: 0.7418 - val_accuracy: 0.5667
Epoch 159/200
60/60 [==============================] - 0s 167us/step - loss: 0.7765 - accuracy: 0.5167
- val_loss: 0.7395 - val_accuracy: 0.5667
Epoch 160/200
60/60 [==============================] - 0s 183us/step - loss: 0.7741 - accuracy: 0.5333
- val_loss: 0.7371 - val_accuracy: 0.5556
Epoch 161/200
60/60 [==============================] - 0s 133us/step - loss: 0.7717 - accuracy: 0.5167
- val_loss: 0.7346 - val_accuracy: 0.5444
Epoch 162/200
60/60 [==============================] - 0s 183us/step - loss: 0.7694 - accuracy: 0.5167
- val_loss: 0.7322 - val_accuracy: 0.5444
Epoch 163/200
60/60 [==============================] - 0s 183us/step - loss: 0.7670 - accuracy: 0.5000
- val_loss: 0.7296 - val_accuracy: 0.5444
Epoch 164/200
60/60 [==============================] - 0s 117us/step - loss: 0.7647 - accuracy: 0.5000
- val_loss: 0.7273 - val_accuracy: 0.5444
Epoch 165/200
60/60 [==============================] - 0s 150us/step - loss: 0.7626 - accuracy: 0.5000
- val_loss: 0.7251 - val_accuracy: 0.5556
Epoch 166/200
60/60 [==============================] - 0s 167us/step - loss: 0.7600 - accuracy: 0.5167
- val_loss: 0.7227 - val_accuracy: 0.5556
Epoch 167/200
60/60 [==============================] - 0s 117us/step - loss: 0.7577 - accuracy: 0.5000
- val_loss: 0.7201 - val_accuracy: 0.5333
Epoch 168/200
60/60 [==============================] - 0s 167us/step - loss: 0.7556 - accuracy: 0.4500
- val_loss: 0.7175 - val_accuracy: 0.5000
Epoch 169/200
60/60 [==============================] - 0s 167us/step - loss: 0.7531 - accuracy: 0.4500
- val_loss: 0.7152 - val_accuracy: 0.5000
Epoch 170/200
60/60 [==============================] - 0s 150us/step - loss: 0.7510 - accuracy: 0.4667
- val_loss: 0.7133 - val_accuracy: 0.5222
Epoch 171/200
60/60 [==============================] - 0s 133us/step - loss: 0.7490 - accuracy: 0.4667
- val_loss: 0.7107 - val_accuracy: 0.5000
Epoch 172/200
60/60 [==============================] - 0s 183us/step - loss: 0.7464 - accuracy: 0.4500
- val_loss: 0.7085 - val_accuracy: 0.5000
Epoch 173/200
60/60 [==============================] - 0s 133us/step - loss: 0.7442 - accuracy: 0.4667
- val_loss: 0.7064 - val_accuracy: 0.5111
Epoch 174/200
60/60 [==============================] - 0s 133us/step - loss: 0.7419 - accuracy: 0.4833
- val_loss: 0.7047 - val_accuracy: 0.5444
Epoch 175/200
```

```
60/60 [==============================] - 0s 167us/step - loss: 0.7395 - accuracy: 0.5333
- val_loss: 0.7027 - val_accuracy: 0.5778
Epoch 176/200
60/60 [==============================] - 0s 117us/step - loss: 0.7374 - accuracy: 0.5500
- val_loss: 0.7005 - val_accuracy: 0.5667
Epoch 177/200
60/60 [==============================] - 0s 167us/step - loss: 0.7350 - accuracy: 0.5833
- val_loss: 0.6984 - val_accuracy: 0.5889
Epoch 178/200
60/60 [==============================] - 0s 167us/step - loss: 0.7332 - accuracy: 0.6333
- val_loss: 0.6967 - val_accuracy: 0.6111
Epoch 179/200
60/60 [==============================] - 0s 100us/step - loss: 0.7307 - accuracy: 0.6333
- val_loss: 0.6942 - val_accuracy: 0.6000
Epoch 180/200
60/60 [==============================] - 0s 183us/step - loss: 0.7287 - accuracy: 0.5833
- val_loss: 0.6916 - val_accuracy: 0.5778
Epoch 181/200
60/60 [==============================] - 0s 150us/step - loss: 0.7262 - accuracy: 0.6167
- val_loss: 0.6896 - val_accuracy: 0.5889
Epoch 182/200
60/60 [==============================] - 0s 150us/step - loss: 0.7240 - accuracy: 0.6167
- val_loss: 0.6871 - val_accuracy: 0.5778
Epoch 183/200
60/60 [==============================] - 0s 183us/step - loss: 0.7220 - accuracy: 0.5833
- val_loss: 0.6846 - val_accuracy: 0.5778
Epoch 184/200
60/60 [==============================] - 0s 150us/step - loss: 0.7196 - accuracy: 0.5833
- val_loss: 0.6826 - val_accuracy: 0.5778
Epoch 185/200
60/60 [==============================] - 0s 133us/step - loss: 0.7174 - accuracy: 0.5833
- val_loss: 0.6803 - val_accuracy: 0.5667
Epoch 186/200
60/60 [==============================] - 0s 167us/step - loss: 0.7157 - accuracy: 0.5500
- val_loss: 0.6778 - val_accuracy: 0.5556
Epoch 187/200
60/60 [==============================] - 0s 150us/step - loss: 0.7132 - accuracy: 0.5667
- val_loss: 0.6759 - val_accuracy: 0.5778
Epoch 188/200
60/60 [==============================] - 0s 250us/step - loss: 0.7110 - accuracy: 0.6000
- val_loss: 0.6736 - val_accuracy: 0.5778
Epoch 189/200
60/60 [==============================] - 0s 217us/step - loss: 0.7087 - accuracy: 0.6000
- val_loss: 0.6716 - val_accuracy: 0.5889
Epoch 190/200
60/60 [==============================] - 0s 150us/step - loss: 0.7069 - accuracy: 0.6167
- val_loss: 0.6697 - val_accuracy: 0.6000
Epoch 191/200
60/60 [==============================] - 0s 133us/step - loss: 0.7045 - accuracy: 0.6000
- val_loss: 0.6672 - val_accuracy: 0.5778
Epoch 192/200
60/60 [==============================] - 0s 183us/step - loss: 0.7027 - accuracy: 0.6167
- val_loss: 0.6652 - val_accuracy: 0.5889
Epoch 193/200
60/60 [==============================] - 0s 167us/step - loss: 0.7003 - accuracy: 0.6000
- val_loss: 0.6627 - val_accuracy: 0.5889
Epoch 194/200
60/60 [==============================] - 0s 117us/step - loss: 0.6981 - accuracy: 0.6000
- val_loss: 0.6602 - val_accuracy: 0.5667
Epoch 195/200
60/60 [==============================] - 0s 167us/step - loss: 0.6960 - accuracy: 0.6000
- val_loss: 0.6580 - val_accuracy: 0.5667
Epoch 196/200
60/60 [==============================] - 0s 183us/step - loss: 0.6939 - accuracy: 0.6000
- val_loss: 0.6556 - val_accuracy: 0.5778
```

```
Epoch 197/200
60/60 [==============================] - 0s 117us/step - loss: 0.6918 - accuracy: 0.5833
- val_loss: 0.6533 - val_accuracy: 0.5778
Epoch 198/200
60/60 [==============================] - 0s 150us/step - loss: 0.6899 - accuracy: 0.5667
- val_loss: 0.6512 - val_accuracy: 0.5889
Epoch 199/200
60/60 [==============================] - 0s 183us/step - loss: 0.6881 - accuracy: 0.5667
- val_loss: 0.6486 - val_accuracy: 0.5556
Epoch 200/200
60/60 [==============================] - 0s 183us/step - loss: 0.6860 - accuracy: 0.5500
- val_loss: 0.6463 - val_accuracy: 0.5667
```

Out[12]:
```
<keras.callbacks.callbacks.History at 0x1d2f589e2e8>
```

In [13]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [14]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 b) Test 2: Split the X and Y into training and test sets and let us use a training dataset of 0.7 or 30% with the same number of epochs

In [15]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.7)
```

In [16]:
```
print(X_train.shape, X_test.shape)
```

```
(45, 4) (105, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)¶

In [17]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [18]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 200 epochs and see

how it performs on training and test data sets

In [19]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=200)
```

```
Train on 45 samples, validate on 105 samples
Epoch 1/200
45/45 [==============================] - 0s 3ms/step - loss: 1.1982 - accuracy: 0.3111 -
val_loss: 1.1171 - val_accuracy: 0.3810
Epoch 2/200
45/45 [==============================] - 0s 245us/step - loss: 1.1865 - accuracy: 0.3111
- val_loss: 1.1052 - val_accuracy: 0.3810
Epoch 3/200
45/45 [==============================] - 0s 200us/step - loss: 1.1735 - accuracy: 0.3556
- val_loss: 1.0930 - val_accuracy: 0.4095
Epoch 4/200
45/45 [==============================] - 0s 200us/step - loss: 1.1612 - accuracy: 0.4000
- val_loss: 1.0809 - val_accuracy: 0.4286
Epoch 5/200
45/45 [==============================] - 0s 244us/step - loss: 1.1485 - accuracy: 0.4222
- val_loss: 1.0688 - val_accuracy: 0.4381
Epoch 6/200
45/45 [==============================] - 0s 289us/step - loss: 1.1361 - accuracy: 0.4222
- val_loss: 1.0569 - val_accuracy: 0.4667
Epoch 7/200
45/45 [==============================] - 0s 267us/step - loss: 1.1236 - accuracy: 0.4222
- val_loss: 1.0450 - val_accuracy: 0.4762
Epoch 8/200
45/45 [==============================] - 0s 155us/step - loss: 1.1118 - accuracy: 0.4222
- val_loss: 1.0333 - val_accuracy: 0.4762
Epoch 9/200
45/45 [==============================] - 0s 267us/step - loss: 1.1003 - accuracy: 0.4667
- val_loss: 1.0216 - val_accuracy: 0.4952
Epoch 10/200
45/45 [==============================] - 0s 222us/step - loss: 1.0882 - accuracy: 0.4889
- val_loss: 1.0102 - val_accuracy: 0.5238
Epoch 11/200
45/45 [==============================] - 0s 267us/step - loss: 1.0761 - accuracy: 0.5111
- val_loss: 0.9989 - val_accuracy: 0.5524
Epoch 12/200
45/45 [==============================] - 0s 156us/step - loss: 1.0646 - accuracy: 0.5333
- val_loss: 0.9879 - val_accuracy: 0.5524
Epoch 13/200
45/45 [==============================] - 0s 289us/step - loss: 1.0533 - accuracy: 0.5333
- val_loss: 0.9769 - val_accuracy: 0.5714
Epoch 14/200
45/45 [==============================] - 0s 289us/step - loss: 1.0422 - accuracy: 0.5333
- val_loss: 0.9662 - val_accuracy: 0.5905
Epoch 15/200
45/45 [==============================] - 0s 222us/step - loss: 1.0308 - accuracy: 0.5778
- val_loss: 0.9555 - val_accuracy: 0.6000
Epoch 16/200
45/45 [==============================] - 0s 178us/step - loss: 1.0195 - accuracy: 0.5778
- val_loss: 0.9450 - val_accuracy: 0.6286
Epoch 17/200
45/45 [==============================] - 0s 289us/step - loss: 1.0085 - accuracy: 0.5778
- val_loss: 0.9346 - val_accuracy: 0.6381
Epoch 18/200
45/45 [==============================] - 0s 222us/step - loss: 0.9986 - accuracy: 0.6000
- val_loss: 0.9244 - val_accuracy: 0.6381
Epoch 19/200
45/45 [==============================] - 0s 155us/step - loss: 0.9875 - accuracy: 0.6222
- val_loss: 0.9144 - val_accuracy: 0.6571
Epoch 20/200
```

```
45/45 [==============================] - 0s 222us/step - loss: 0.9772 - accuracy: 0.6222
- val_loss: 0.9046 - val_accuracy: 0.6571
Epoch 21/200
45/45 [==============================] - 0s 267us/step - loss: 0.9668 - accuracy: 0.6222
- val_loss: 0.8949 - val_accuracy: 0.6571
Epoch 22/200
45/45 [==============================] - 0s 289us/step - loss: 0.9573 - accuracy: 0.6222
- val_loss: 0.8854 - val_accuracy: 0.6667
Epoch 23/200
45/45 [==============================] - 0s 178us/step - loss: 0.9468 - accuracy: 0.6222
- val_loss: 0.8761 - val_accuracy: 0.6667
Epoch 24/200
45/45 [==============================] - 0s 178us/step - loss: 0.9370 - accuracy: 0.6222
- val_loss: 0.8669 - val_accuracy: 0.6667
Epoch 25/200
45/45 [==============================] - 0s 267us/step - loss: 0.9273 - accuracy: 0.6222
- val_loss: 0.8579 - val_accuracy: 0.6667
Epoch 26/200
45/45 [==============================] - 0s 244us/step - loss: 0.9176 - accuracy: 0.6222
- val_loss: 0.8491 - val_accuracy: 0.6667
Epoch 27/200
45/45 [==============================] - 0s 289us/step - loss: 0.9078 - accuracy: 0.6222
- val_loss: 0.8402 - val_accuracy: 0.6667
Epoch 28/200
45/45 [==============================] - 0s 178us/step - loss: 0.8984 - accuracy: 0.6222
- val_loss: 0.8314 - val_accuracy: 0.6667
Epoch 29/200
45/45 [==============================] - 0s 267us/step - loss: 0.8890 - accuracy: 0.6222
- val_loss: 0.8226 - val_accuracy: 0.6667
Epoch 30/200
45/45 [==============================] - 0s 222us/step - loss: 0.8798 - accuracy: 0.6222
- val_loss: 0.8140 - val_accuracy: 0.6667
Epoch 31/200
45/45 [==============================] - 0s 245us/step - loss: 0.8708 - accuracy: 0.6222
- val_loss: 0.8055 - val_accuracy: 0.6667
Epoch 32/200
45/45 [==============================] - 0s 289us/step - loss: 0.8616 - accuracy: 0.6222
- val_loss: 0.7972 - val_accuracy: 0.6667
Epoch 33/200
45/45 [==============================] - 0s 200us/step - loss: 0.8528 - accuracy: 0.6444
- val_loss: 0.7890 - val_accuracy: 0.6667
Epoch 34/200
45/45 [==============================] - 0s 244us/step - loss: 0.8438 - accuracy: 0.6444
- val_loss: 0.7809 - val_accuracy: 0.6667
Epoch 35/200
45/45 [==============================] - 0s 244us/step - loss: 0.8354 - accuracy: 0.6444
- val_loss: 0.7729 - val_accuracy: 0.6667
Epoch 36/200
45/45 [==============================] - 0s 155us/step - loss: 0.8269 - accuracy: 0.6444
- val_loss: 0.7651 - val_accuracy: 0.6667
Epoch 37/200
45/45 [==============================] - 0s 222us/step - loss: 0.8183 - accuracy: 0.6444
- val_loss: 0.7575 - val_accuracy: 0.6667
Epoch 38/200
45/45 [==============================] - 0s 244us/step - loss: 0.8107 - accuracy: 0.6444
- val_loss: 0.7499 - val_accuracy: 0.6667
Epoch 39/200
45/45 [==============================] - 0s 156us/step - loss: 0.8025 - accuracy: 0.6444
- val_loss: 0.7426 - val_accuracy: 0.6667
Epoch 40/200
45/45 [==============================] - 0s 222us/step - loss: 0.7947 - accuracy: 0.6444
- val_loss: 0.7354 - val_accuracy: 0.6667
Epoch 41/200
45/45 [==============================] - 0s 267us/step - loss: 0.7869 - accuracy: 0.6444
- val_loss: 0.7282 - val_accuracy: 0.6667
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Epoch 42/200
45/45 [==============================] - 0s 200us/step - loss: 0.7797 - accuracy: 0.6444
- val_loss: 0.7212 - val_accuracy: 0.6667
Epoch 43/200
45/45 [==============================] - 0s 200us/step - loss: 0.7717 - accuracy: 0.6444
- val_loss: 0.7143 - val_accuracy: 0.6667
Epoch 44/200
45/45 [==============================] - 0s 244us/step - loss: 0.7645 - accuracy: 0.6444
- val_loss: 0.7076 - val_accuracy: 0.6667
Epoch 45/200
45/45 [==============================] - 0s 222us/step - loss: 0.7571 - accuracy: 0.6444
- val_loss: 0.7008 - val_accuracy: 0.6667
Epoch 46/200
45/45 [==============================] - 0s 200us/step - loss: 0.7503 - accuracy: 0.6444
- val_loss: 0.6941 - val_accuracy: 0.6667
Epoch 47/200
45/45 [==============================] - 0s 200us/step - loss: 0.7429 - accuracy: 0.6444
- val_loss: 0.6876 - val_accuracy: 0.6667
Epoch 48/200
45/45 [==============================] - 0s 289us/step - loss: 0.7364 - accuracy: 0.6444
- val_loss: 0.6813 - val_accuracy: 0.6667
Epoch 49/200
45/45 [==============================] - 0s 289us/step - loss: 0.7294 - accuracy: 0.6444
- val_loss: 0.6751 - val_accuracy: 0.6667
Epoch 50/200
45/45 [==============================] - 0s 222us/step - loss: 0.7227 - accuracy: 0.6444
- val_loss: 0.6691 - val_accuracy: 0.6667
Epoch 51/200
45/45 [==============================] - 0s 222us/step - loss: 0.7162 - accuracy: 0.6444
- val_loss: 0.6632 - val_accuracy: 0.6667
Epoch 52/200
45/45 [==============================] - 0s 222us/step - loss: 0.7099 - accuracy: 0.6444
- val_loss: 0.6574 - val_accuracy: 0.6667
Epoch 53/200
45/45 [==============================] - 0s 222us/step - loss: 0.7037 - accuracy: 0.6444
- val_loss: 0.6516 - val_accuracy: 0.6667
Epoch 54/200
45/45 [==============================] - 0s 133us/step - loss: 0.6975 - accuracy: 0.6444
- val_loss: 0.6460 - val_accuracy: 0.6667
Epoch 55/200
45/45 [==============================] - 0s 177us/step - loss: 0.6912 - accuracy: 0.6444
- val_loss: 0.6405 - val_accuracy: 0.6667
Epoch 56/200
45/45 [==============================] - 0s 267us/step - loss: 0.6853 - accuracy: 0.6444
- val_loss: 0.6350 - val_accuracy: 0.6762
Epoch 57/200
45/45 [==============================] - 0s 223us/step - loss: 0.6794 - accuracy: 0.6444
- val_loss: 0.6296 - val_accuracy: 0.6762
Epoch 58/200
45/45 [==============================] - 0s 200us/step - loss: 0.6736 - accuracy: 0.6444
- val_loss: 0.6243 - val_accuracy: 0.6762
Epoch 59/200
45/45 [==============================] - 0s 244us/step - loss: 0.6678 - accuracy: 0.6444
- val_loss: 0.6191 - val_accuracy: 0.6762
Epoch 60/200
45/45 [==============================] - 0s 244us/step - loss: 0.6623 - accuracy: 0.6444
- val_loss: 0.6140 - val_accuracy: 0.6857
Epoch 61/200
45/45 [==============================] - 0s 156us/step - loss: 0.6565 - accuracy: 0.6444
- val_loss: 0.6090 - val_accuracy: 0.6952
Epoch 62/200
45/45 [==============================] - 0s 244us/step - loss: 0.6511 - accuracy: 0.6444
- val_loss: 0.6040 - val_accuracy: 0.6952
Epoch 63/200
45/45 [==============================] - 0s 222us/step - loss: 0.6459 - accuracy: 0.6444
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- val_loss: 0.5992 - val_accuracy: 0.6952
Epoch 64/200
45/45 [==============================] - 0s 156us/step - loss: 0.6407 - accuracy: 0.6667
- val_loss: 0.5945 - val_accuracy: 0.6952
Epoch 65/200
45/45 [==============================] - 0s 222us/step - loss: 0.6354 - accuracy: 0.6667
- val_loss: 0.5899 - val_accuracy: 0.6952
Epoch 66/200
45/45 [==============================] - 0s 244us/step - loss: 0.6304 - accuracy: 0.6667
- val_loss: 0.5854 - val_accuracy: 0.6952
Epoch 67/200
45/45 [==============================] - 0s 155us/step - loss: 0.6256 - accuracy: 0.6667
- val_loss: 0.5810 - val_accuracy: 0.6952
Epoch 68/200
45/45 [==============================] - 0s 178us/step - loss: 0.6207 - accuracy: 0.6667
- val_loss: 0.5767 - val_accuracy: 0.6952
Epoch 69/200
45/45 [==============================] - 0s 245us/step - loss: 0.6160 - accuracy: 0.6667
- val_loss: 0.5724 - val_accuracy: 0.6952
Epoch 70/200
45/45 [==============================] - 0s 200us/step - loss: 0.6114 - accuracy: 0.6667
- val_loss: 0.5682 - val_accuracy: 0.7048
Epoch 71/200
45/45 [==============================] - 0s 200us/step - loss: 0.6068 - accuracy: 0.6667
- val_loss: 0.5642 - val_accuracy: 0.7143
Epoch 72/200
45/45 [==============================] - 0s 222us/step - loss: 0.6024 - accuracy: 0.6667
- val_loss: 0.5602 - val_accuracy: 0.7143
Epoch 73/200
45/45 [==============================] - 0s 222us/step - loss: 0.5980 - accuracy: 0.6667
- val_loss: 0.5563 - val_accuracy: 0.7143
Epoch 74/200
45/45 [==============================] - 0s 222us/step - loss: 0.5937 - accuracy: 0.6889
- val_loss: 0.5525 - val_accuracy: 0.7143
Epoch 75/200
45/45 [==============================] - 0s 222us/step - loss: 0.5895 - accuracy: 0.6889
- val_loss: 0.5488 - val_accuracy: 0.7143
Epoch 76/200
45/45 [==============================] - 0s 244us/step - loss: 0.5853 - accuracy: 0.6889
- val_loss: 0.5451 - val_accuracy: 0.7238
Epoch 77/200
45/45 [==============================] - 0s 155us/step - loss: 0.5812 - accuracy: 0.6889
- val_loss: 0.5414 - val_accuracy: 0.7238
Epoch 78/200
45/45 [==============================] - 0s 178us/step - loss: 0.5772 - accuracy: 0.7111
- val_loss: 0.5379 - val_accuracy: 0.7238
Epoch 79/200
45/45 [==============================] - 0s 267us/step - loss: 0.5731 - accuracy: 0.7111
- val_loss: 0.5343 - val_accuracy: 0.7238
Epoch 80/200
45/45 [==============================] - 0s 244us/step - loss: 0.5692 - accuracy: 0.7111
- val_loss: 0.5309 - val_accuracy: 0.7238
Epoch 81/200
45/45 [==============================] - 0s 178us/step - loss: 0.5651 - accuracy: 0.7111
- val_loss: 0.5275 - val_accuracy: 0.7238
Epoch 82/200
45/45 [==============================] - 0s 244us/step - loss: 0.5614 - accuracy: 0.7111
- val_loss: 0.5241 - val_accuracy: 0.7238
Epoch 83/200
45/45 [==============================] - 0s 244us/step - loss: 0.5577 - accuracy: 0.7111
- val_loss: 0.5209 - val_accuracy: 0.7333
Epoch 84/200
45/45 [==============================] - 0s 222us/step - loss: 0.5536 - accuracy: 0.7111
- val_loss: 0.5177 - val_accuracy: 0.7333
Epoch 85/200
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45/45 [==============================] - 0s 200us/step - loss: 0.5499 - accuracy: 0.7111
- val_loss: 0.5145 - val_accuracy: 0.7429
Epoch 86/200
45/45 [==============================] - 0s 267us/step - loss: 0.5463 - accuracy: 0.7111
- val_loss: 0.5113 - val_accuracy: 0.7429
Epoch 87/200
45/45 [==============================] - 0s 267us/step - loss: 0.5425 - accuracy: 0.7111
- val_loss: 0.5081 - val_accuracy: 0.7429
Epoch 88/200
45/45 [==============================] - 0s 178us/step - loss: 0.5390 - accuracy: 0.7111
- val_loss: 0.5050 - val_accuracy: 0.7429
Epoch 89/200
45/45 [==============================] - 0s 200us/step - loss: 0.5352 - accuracy: 0.7111
- val_loss: 0.5020 - val_accuracy: 0.7524
Epoch 90/200
45/45 [==============================] - 0s 244us/step - loss: 0.5318 - accuracy: 0.7111
- val_loss: 0.4990 - val_accuracy: 0.7714
Epoch 91/200
45/45 [==============================] - 0s 156us/step - loss: 0.5282 - accuracy: 0.7111
- val_loss: 0.4961 - val_accuracy: 0.7714
Epoch 92/200
45/45 [==============================] - 0s 156us/step - loss: 0.5247 - accuracy: 0.7333
- val_loss: 0.4931 - val_accuracy: 0.7714
Epoch 93/200
45/45 [==============================] - 0s 245us/step - loss: 0.5211 - accuracy: 0.7333
- val_loss: 0.4902 - val_accuracy: 0.7810
Epoch 94/200
45/45 [==============================] - 0s 222us/step - loss: 0.5180 - accuracy: 0.7333
- val_loss: 0.4873 - val_accuracy: 0.7810
Epoch 95/200
45/45 [==============================] - 0s 200us/step - loss: 0.5144 - accuracy: 0.7556
- val_loss: 0.4845 - val_accuracy: 0.7810
Epoch 96/200
45/45 [==============================] - 0s 244us/step - loss: 0.5111 - accuracy: 0.7778
- val_loss: 0.4817 - val_accuracy: 0.7810
Epoch 97/200
45/45 [==============================] - 0s 267us/step - loss: 0.5079 - accuracy: 0.7778
- val_loss: 0.4789 - val_accuracy: 0.7905
Epoch 98/200
45/45 [==============================] - 0s 267us/step - loss: 0.5050 - accuracy: 0.7778
- val_loss: 0.4762 - val_accuracy: 0.7905
Epoch 99/200
45/45 [==============================] - 0s 200us/step - loss: 0.5015 - accuracy: 0.7778
- val_loss: 0.4736 - val_accuracy: 0.7905
Epoch 100/200
45/45 [==============================] - 0s 200us/step - loss: 0.4985 - accuracy: 0.7778
- val_loss: 0.4711 - val_accuracy: 0.7905
Epoch 101/200
45/45 [==============================] - 0s 289us/step - loss: 0.4954 - accuracy: 0.7778
- val_loss: 0.4685 - val_accuracy: 0.7905
Epoch 102/200
45/45 [==============================] - 0s 222us/step - loss: 0.4926 - accuracy: 0.7778
- val_loss: 0.4659 - val_accuracy: 0.7905
Epoch 103/200
45/45 [==============================] - 0s 178us/step - loss: 0.4897 - accuracy: 0.7778
- val_loss: 0.4634 - val_accuracy: 0.8000
Epoch 104/200
45/45 [==============================] - 0s 244us/step - loss: 0.4868 - accuracy: 0.7778
- val_loss: 0.4610 - val_accuracy: 0.8095
Epoch 105/200
45/45 [==============================] - 0s 289us/step - loss: 0.4840 - accuracy: 0.8000
- val_loss: 0.4586 - val_accuracy: 0.8095
Epoch 106/200
45/45 [==============================] - 0s 200us/step - loss: 0.4812 - accuracy: 0.8222
- val_loss: 0.4563 - val_accuracy: 0.8190
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Epoch 107/200
45/45 [==============================] - 0s 200us/step - loss: 0.4784 - accuracy: 0.8222
- val_loss: 0.4539 - val_accuracy: 0.8190
Epoch 108/200
45/45 [==============================] - 0s 311us/step - loss: 0.4758 - accuracy: 0.8444
- val_loss: 0.4516 - val_accuracy: 0.8190
Epoch 109/200
45/45 [==============================] - 0s 200us/step - loss: 0.4730 - accuracy: 0.8444
- val_loss: 0.4493 - val_accuracy: 0.8190
Epoch 110/200
45/45 [==============================] - 0s 244us/step - loss: 0.4705 - accuracy: 0.8444
- val_loss: 0.4470 - val_accuracy: 0.8190
Epoch 111/200
45/45 [==============================] - 0s 178us/step - loss: 0.4677 - accuracy: 0.8444
- val_loss: 0.4447 - val_accuracy: 0.8190
Epoch 112/200
45/45 [==============================] - 0s 289us/step - loss: 0.4651 - accuracy: 0.8444
- val_loss: 0.4424 - val_accuracy: 0.8190
Epoch 113/200
45/45 [==============================] - 0s 245us/step - loss: 0.4626 - accuracy: 0.8444
- val_loss: 0.4402 - val_accuracy: 0.8190
Epoch 114/200
45/45 [==============================] - 0s 289us/step - loss: 0.4601 - accuracy: 0.8444
- val_loss: 0.4380 - val_accuracy: 0.8095
Epoch 115/200
45/45 [==============================] - 0s 200us/step - loss: 0.4576 - accuracy: 0.8444
- val_loss: 0.4358 - val_accuracy: 0.8095
Epoch 116/200
45/45 [==============================] - 0s 466us/step - loss: 0.4550 - accuracy: 0.8444
- val_loss: 0.4338 - val_accuracy: 0.8190
Epoch 117/200
45/45 [==============================] - 0s 244us/step - loss: 0.4526 - accuracy: 0.8667
- val_loss: 0.4317 - val_accuracy: 0.8190
Epoch 118/200
45/45 [==============================] - 0s 178us/step - loss: 0.4501 - accuracy: 0.8667
- val_loss: 0.4297 - val_accuracy: 0.8190
Epoch 119/200
45/45 [==============================] - 0s 244us/step - loss: 0.4477 - accuracy: 0.8667
- val_loss: 0.4277 - val_accuracy: 0.8190
Epoch 120/200
45/45 [==============================] - 0s 244us/step - loss: 0.4453 - accuracy: 0.8667
- val_loss: 0.4257 - val_accuracy: 0.8190
Epoch 121/200
45/45 [==============================] - 0s 244us/step - loss: 0.4429 - accuracy: 0.8667
- val_loss: 0.4237 - val_accuracy: 0.8190
Epoch 122/200
45/45 [==============================] - 0s 222us/step - loss: 0.4404 - accuracy: 0.8667
- val_loss: 0.4217 - val_accuracy: 0.8190
Epoch 123/200
45/45 [==============================] - 0s 178us/step - loss: 0.4381 - accuracy: 0.8667
- val_loss: 0.4198 - val_accuracy: 0.8190
Epoch 124/200
45/45 [==============================] - 0s 311us/step - loss: 0.4360 - accuracy: 0.8667
- val_loss: 0.4178 - val_accuracy: 0.8286
Epoch 125/200
45/45 [==============================] - 0s 267us/step - loss: 0.4333 - accuracy: 0.8667
- val_loss: 0.4159 - val_accuracy: 0.8286
Epoch 126/200
45/45 [==============================] - 0s 200us/step - loss: 0.4312 - accuracy: 0.8667
- val_loss: 0.4140 - val_accuracy: 0.8381
Epoch 127/200
45/45 [==============================] - 0s 200us/step - loss: 0.4290 - accuracy: 0.8667
- val_loss: 0.4122 - val_accuracy: 0.8381
Epoch 128/200
45/45 [==============================] - 0s 289us/step - loss: 0.4268 - accuracy: 0.8667
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- val_loss: 0.4103 - val_accuracy: 0.8476
Epoch 129/200
45/45 [==============================] - 0s 267us/step - loss: 0.4245 - accuracy: 0.8667
- val_loss: 0.4085 - val_accuracy: 0.8476
Epoch 130/200
45/45 [==============================] - 0s 200us/step - loss: 0.4224 - accuracy: 0.8667
- val_loss: 0.4067 - val_accuracy: 0.8476
Epoch 131/200
45/45 [==============================] - 0s 200us/step - loss: 0.4202 - accuracy: 0.8667
- val_loss: 0.4050 - val_accuracy: 0.8476
Epoch 132/200
45/45 [==============================] - 0s 267us/step - loss: 0.4182 - accuracy: 0.8667
- val_loss: 0.4033 - val_accuracy: 0.8476
Epoch 133/200
45/45 [==============================] - 0s 267us/step - loss: 0.4161 - accuracy: 0.8667
- val_loss: 0.4016 - val_accuracy: 0.8476
Epoch 134/200
45/45 [==============================] - 0s 156us/step - loss: 0.4141 - accuracy: 0.8667
- val_loss: 0.3999 - val_accuracy: 0.8476
Epoch 135/200
45/45 [==============================] - 0s 200us/step - loss: 0.4120 - accuracy: 0.8889
- val_loss: 0.3983 - val_accuracy: 0.8476
Epoch 136/200
45/45 [==============================] - 0s 289us/step - loss: 0.4100 - accuracy: 0.8889
- val_loss: 0.3968 - val_accuracy: 0.8476
Epoch 137/200
45/45 [==============================] - 0s 311us/step - loss: 0.4080 - accuracy: 0.8889
- val_loss: 0.3952 - val_accuracy: 0.8476
Epoch 138/200
45/45 [==============================] - 0s 222us/step - loss: 0.4061 - accuracy: 0.8889
- val_loss: 0.3936 - val_accuracy: 0.8476
Epoch 139/200
45/45 [==============================] - 0s 222us/step - loss: 0.4040 - accuracy: 0.8889
- val_loss: 0.3920 - val_accuracy: 0.8476
Epoch 140/200
45/45 [==============================] - 0s 222us/step - loss: 0.4019 - accuracy: 0.8889
- val_loss: 0.3904 - val_accuracy: 0.8476
Epoch 141/200
45/45 [==============================] - 0s 311us/step - loss: 0.4001 - accuracy: 0.8889
- val_loss: 0.3887 - val_accuracy: 0.8476
Epoch 142/200
45/45 [==============================] - 0s 311us/step - loss: 0.3979 - accuracy: 0.8889
- val_loss: 0.3871 - val_accuracy: 0.8476
Epoch 143/200
45/45 [==============================] - 0s 289us/step - loss: 0.3958 - accuracy: 0.8889
- val_loss: 0.3854 - val_accuracy: 0.8476
Epoch 144/200
45/45 [==============================] - 0s 244us/step - loss: 0.3940 - accuracy: 0.8889
- val_loss: 0.3838 - val_accuracy: 0.8571
Epoch 145/200
45/45 [==============================] - 0s 222us/step - loss: 0.3919 - accuracy: 0.8889
- val_loss: 0.3822 - val_accuracy: 0.8476
Epoch 146/200
45/45 [==============================] - 0s 200us/step - loss: 0.3901 - accuracy: 0.8889
- val_loss: 0.3806 - val_accuracy: 0.8476
Epoch 147/200
45/45 [==============================] - 0s 244us/step - loss: 0.3879 - accuracy: 0.8889
- val_loss: 0.3791 - val_accuracy: 0.8476
Epoch 148/200
45/45 [==============================] - 0s 289us/step - loss: 0.3860 - accuracy: 0.8889
- val_loss: 0.3775 - val_accuracy: 0.8476
Epoch 149/200
45/45 [==============================] - 0s 245us/step - loss: 0.3842 - accuracy: 0.8889
- val_loss: 0.3761 - val_accuracy: 0.8476
Epoch 150/200
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45/45 [==============================] - 0s 311us/step - loss: 0.3821 - accuracy: 0.8889
- val_loss: 0.3746 - val_accuracy: 0.8476
Epoch 151/200
45/45 [==============================] - 0s 200us/step - loss: 0.3804 - accuracy: 0.8889
- val_loss: 0.3732 - val_accuracy: 0.8476
Epoch 152/200
45/45 [==============================] - 0s 178us/step - loss: 0.3785 - accuracy: 0.8889
- val_loss: 0.3718 - val_accuracy: 0.8476
Epoch 153/200
45/45 [==============================] - 0s 222us/step - loss: 0.3766 - accuracy: 0.8889
- val_loss: 0.3705 - val_accuracy: 0.8476
Epoch 154/200
45/45 [==============================] - 0s 156us/step - loss: 0.3749 - accuracy: 0.8889
- val_loss: 0.3691 - val_accuracy: 0.8476
Epoch 155/200
45/45 [==============================] - 0s 178us/step - loss: 0.3731 - accuracy: 0.8889
- val_loss: 0.3678 - val_accuracy: 0.8476
Epoch 156/200
45/45 [==============================] - 0s 222us/step - loss: 0.3714 - accuracy: 0.8889
- val_loss: 0.3664 - val_accuracy: 0.8476
Epoch 157/200
45/45 [==============================] - 0s 200us/step - loss: 0.3696 - accuracy: 0.8889
- val_loss: 0.3651 - val_accuracy: 0.8476
Epoch 158/200
45/45 [==============================] - 0s 178us/step - loss: 0.3679 - accuracy: 0.8889
- val_loss: 0.3638 - val_accuracy: 0.8476
Epoch 159/200
45/45 [==============================] - 0s 222us/step - loss: 0.3662 - accuracy: 0.8889
- val_loss: 0.3625 - val_accuracy: 0.8476
Epoch 160/200
45/45 [==============================] - 0s 200us/step - loss: 0.3646 - accuracy: 0.8889
- val_loss: 0.3612 - val_accuracy: 0.8476
Epoch 161/200
45/45 [==============================] - 0s 200us/step - loss: 0.3628 - accuracy: 0.8889
- val_loss: 0.3598 - val_accuracy: 0.8476
Epoch 162/200
45/45 [==============================] - 0s 289us/step - loss: 0.3611 - accuracy: 0.8889
- val_loss: 0.3585 - val_accuracy: 0.8476
Epoch 163/200
45/45 [==============================] - 0s 244us/step - loss: 0.3594 - accuracy: 0.8889
- val_loss: 0.3572 - val_accuracy: 0.8476
Epoch 164/200
45/45 [==============================] - 0s 222us/step - loss: 0.3577 - accuracy: 0.8889
- val_loss: 0.3558 - val_accuracy: 0.8476
Epoch 165/200
45/45 [==============================] - 0s 200us/step - loss: 0.3561 - accuracy: 0.8889
- val_loss: 0.3545 - val_accuracy: 0.8476
Epoch 166/200
45/45 [==============================] - 0s 245us/step - loss: 0.3543 - accuracy: 0.8889
- val_loss: 0.3531 - val_accuracy: 0.8476
Epoch 167/200
45/45 [==============================] - 0s 244us/step - loss: 0.3529 - accuracy: 0.8889
- val_loss: 0.3518 - val_accuracy: 0.8476
Epoch 168/200
45/45 [==============================] - 0s 178us/step - loss: 0.3511 - accuracy: 0.8889
- val_loss: 0.3504 - val_accuracy: 0.8476
Epoch 169/200
45/45 [==============================] - 0s 266us/step - loss: 0.3496 - accuracy: 0.8889
- val_loss: 0.3491 - val_accuracy: 0.8476
Epoch 170/200
45/45 [==============================] - 0s 289us/step - loss: 0.3481 - accuracy: 0.9111
- val_loss: 0.3479 - val_accuracy: 0.8571
Epoch 171/200
45/45 [==============================] - 0s 289us/step - loss: 0.3466 - accuracy: 0.9111
- val_loss: 0.3466 - val_accuracy: 0.8571
```

```
Epoch 172/200
45/45 [==============================] - 0s 267us/step - loss: 0.3451 - accuracy: 0.9111
- val_loss: 0.3454 - val_accuracy: 0.8571
Epoch 173/200
45/45 [==============================] - 0s 156us/step - loss: 0.3435 - accuracy: 0.9111
- val_loss: 0.3442 - val_accuracy: 0.8667
Epoch 174/200
45/45 [==============================] - 0s 200us/step - loss: 0.3422 - accuracy: 0.9111
- val_loss: 0.3431 - val_accuracy: 0.8667
Epoch 175/200
45/45 [==============================] - 0s 222us/step - loss: 0.3407 - accuracy: 0.9111
- val_loss: 0.3420 - val_accuracy: 0.8667
Epoch 176/200
45/45 [==============================] - 0s 267us/step - loss: 0.3393 - accuracy: 0.9111
- val_loss: 0.3410 - val_accuracy: 0.8667
Epoch 177/200
45/45 [==============================] - 0s 200us/step - loss: 0.3378 - accuracy: 0.9111
- val_loss: 0.3399 - val_accuracy: 0.8667
Epoch 178/200
45/45 [==============================] - 0s 222us/step - loss: 0.3364 - accuracy: 0.9111
- val_loss: 0.3388 - val_accuracy: 0.8667
Epoch 179/200
45/45 [==============================] - 0s 222us/step - loss: 0.3350 - accuracy: 0.9111
- val_loss: 0.3377 - val_accuracy: 0.8667
Epoch 180/200
45/45 [==============================] - 0s 156us/step - loss: 0.3334 - accuracy: 0.9111
- val_loss: 0.3367 - val_accuracy: 0.8571
Epoch 181/200
45/45 [==============================] - 0s 222us/step - loss: 0.3322 - accuracy: 0.9111
- val_loss: 0.3357 - val_accuracy: 0.8571
Epoch 182/200
45/45 [==============================] - 0s 267us/step - loss: 0.3307 - accuracy: 0.9111
- val_loss: 0.3348 - val_accuracy: 0.8571
Epoch 183/200
45/45 [==============================] - 0s 289us/step - loss: 0.3294 - accuracy: 0.9111
- val_loss: 0.3338 - val_accuracy: 0.8571
Epoch 184/200
45/45 [==============================] - 0s 223us/step - loss: 0.3281 - accuracy: 0.9111
- val_loss: 0.3329 - val_accuracy: 0.8571
Epoch 185/200
45/45 [==============================] - 0s 244us/step - loss: 0.3267 - accuracy: 0.9111
- val_loss: 0.3319 - val_accuracy: 0.8476
Epoch 186/200
45/45 [==============================] - 0s 178us/step - loss: 0.3254 - accuracy: 0.9111
- val_loss: 0.3309 - val_accuracy: 0.8476
Epoch 187/200
45/45 [==============================] - 0s 267us/step - loss: 0.3241 - accuracy: 0.9111
- val_loss: 0.3300 - val_accuracy: 0.8476
Epoch 188/200
45/45 [==============================] - 0s 267us/step - loss: 0.3228 - accuracy: 0.9111
- val_loss: 0.3291 - val_accuracy: 0.8476
Epoch 189/200
45/45 [==============================] - 0s 245us/step - loss: 0.3216 - accuracy: 0.9111
- val_loss: 0.3281 - val_accuracy: 0.8476
Epoch 190/200
45/45 [==============================] - 0s 178us/step - loss: 0.3204 - accuracy: 0.9111
- val_loss: 0.3271 - val_accuracy: 0.8476
Epoch 191/200
45/45 [==============================] - 0s 267us/step - loss: 0.3189 - accuracy: 0.9111
- val_loss: 0.3260 - val_accuracy: 0.8476
Epoch 192/200
45/45 [==============================] - 0s 289us/step - loss: 0.3177 - accuracy: 0.9111
- val_loss: 0.3249 - val_accuracy: 0.8571
Epoch 193/200
45/45 [==============================] - 0s 245us/step - loss: 0.3163 - accuracy: 0.9111
```

```
- val_loss: 0.3238 - val_accuracy: 0.8571
Epoch 194/200
45/45 [==============================] - 0s 178us/step - loss: 0.3152 - accuracy: 0.9111
- val_loss: 0.3227 - val_accuracy: 0.8667
Epoch 195/200
45/45 [==============================] - 0s 222us/step - loss: 0.3138 - accuracy: 0.9111
- val_loss: 0.3216 - val_accuracy: 0.8667
Epoch 196/200
45/45 [==============================] - 0s 244us/step - loss: 0.3126 - accuracy: 0.9111
- val_loss: 0.3206 - val_accuracy: 0.8667
Epoch 197/200
45/45 [==============================] - ETA: 0s - loss: 0.2847 - accuracy: 0.93 - 0s 20
0us/step - loss: 0.3113 - accuracy: 0.9111 - val_loss: 0.3196 - val_accuracy: 0.8667
Epoch 198/200
45/45 [==============================] - 0s 178us/step - loss: 0.3100 - accuracy: 0.9111
- val_loss: 0.3186 - val_accuracy: 0.8762
Epoch 199/200
45/45 [==============================] - 0s 222us/step - loss: 0.3088 - accuracy: 0.9111
- val_loss: 0.3176 - val_accuracy: 0.8762
Epoch 200/200
45/45 [==============================] - 0s 244us/step - loss: 0.3075 - accuracy: 0.9111
- val_loss: 0.3166 - val_accuracy: 0.8762
```

Out[19]:
```
<keras.callbacks.callbacks.History at 0x1d2f5981630>
```

In [20]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [21]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 c) Test 3: Split the X and Y into training and test sets and let us use a training dataset of 0.8 or 20% with the same number of epochs

In [22]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.8)
```

In [23]:
```
print(X_train.shape, X_test.shape)
```

```
(30, 4) (120, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [24]:
```
model = Sequential()
```

```
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [25]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 200 epochs and see how it performs on training and test data sets

In [26]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=200)
```

```
Train on 30 samples, validate on 120 samples
Epoch 1/200
30/30 [==============================] - 0s 4ms/step - loss: 1.1843 - accuracy: 0.4667 -
val_loss: 1.1537 - val_accuracy: 0.3750
Epoch 2/200
30/30 [==============================] - 0s 167us/step - loss: 1.1780 - accuracy: 0.4667
- val_loss: 1.1493 - val_accuracy: 0.3833
Epoch 3/200
30/30 [==============================] - 0s 267us/step - loss: 1.1718 - accuracy: 0.4667
- val_loss: 1.1448 - val_accuracy: 0.4167
Epoch 4/200
30/30 [==============================] - 0s 167us/step - loss: 1.1656 - accuracy: 0.4667
- val_loss: 1.1403 - val_accuracy: 0.4250
Epoch 5/200
30/30 [==============================] - 0s 333us/step - loss: 1.1594 - accuracy: 0.4667
- val_loss: 1.1359 - val_accuracy: 0.4250
Epoch 6/200
30/30 [==============================] - 0s 200us/step - loss: 1.1533 - accuracy: 0.4667
- val_loss: 1.1316 - val_accuracy: 0.4333
Epoch 7/200
30/30 [==============================] - 0s 233us/step - loss: 1.1474 - accuracy: 0.4667
- val_loss: 1.1272 - val_accuracy: 0.4333
Epoch 8/200
30/30 [==============================] - 0s 267us/step - loss: 1.1414 - accuracy: 0.4667
- val_loss: 1.1228 - val_accuracy: 0.4333
Epoch 9/200
30/30 [==============================] - 0s 200us/step - loss: 1.1353 - accuracy: 0.4667
- val_loss: 1.1185 - val_accuracy: 0.4333
Epoch 10/200
30/30 [==============================] - 0s 300us/step - loss: 1.1293 - accuracy: 0.4667
- val_loss: 1.1142 - val_accuracy: 0.4333
Epoch 11/200
30/30 [==============================] - 0s 167us/step - loss: 1.1233 - accuracy: 0.4667
- val_loss: 1.1099 - val_accuracy: 0.4333
Epoch 12/200
30/30 [==============================] - 0s 300us/step - loss: 1.1173 - accuracy: 0.4667
- val_loss: 1.1057 - val_accuracy: 0.4417
Epoch 13/200
30/30 [==============================] - 0s 333us/step - loss: 1.1114 - accuracy: 0.4667
- val_loss: 1.1014 - val_accuracy: 0.4500
Epoch 14/200
30/30 [==============================] - 0s 233us/step - loss: 1.1054 - accuracy: 0.4667
- val_loss: 1.0972 - val_accuracy: 0.4583
Epoch 15/200
30/30 [==============================] - 0s 333us/step - loss: 1.0995 - accuracy: 0.4667
- val_loss: 1.0930 - val_accuracy: 0.4667
Epoch 16/200
30/30 [==============================] - 0s 200us/step - loss: 1.0937 - accuracy: 0.5000
```

```
- val_loss: 1.0888 - val_accuracy: 0.4667
Epoch 17/200
30/30 [==============================] - 0s 233us/step - loss: 1.0878 - accuracy: 0.5000
- val_loss: 1.0846 - val_accuracy: 0.4917
Epoch 18/200
30/30 [==============================] - 0s 167us/step - loss: 1.0820 - accuracy: 0.5000
- val_loss: 1.0805 - val_accuracy: 0.5000
Epoch 19/200
30/30 [==============================] - 0s 267us/step - loss: 1.0762 - accuracy: 0.5000
- val_loss: 1.0764 - val_accuracy: 0.5000
Epoch 20/200
30/30 [==============================] - 0s 267us/step - loss: 1.0705 - accuracy: 0.5000
- val_loss: 1.0723 - val_accuracy: 0.5083
Epoch 21/200
30/30 [==============================] - 0s 233us/step - loss: 1.0647 - accuracy: 0.5333
- val_loss: 1.0682 - val_accuracy: 0.5250
Epoch 22/200
30/30 [==============================] - 0s 367us/step - loss: 1.0590 - accuracy: 0.6000
- val_loss: 1.0642 - val_accuracy: 0.5250
Epoch 23/200
30/30 [==============================] - 0s 167us/step - loss: 1.0533 - accuracy: 0.6000
- val_loss: 1.0602 - val_accuracy: 0.5250
Epoch 24/200
30/30 [==============================] - 0s 267us/step - loss: 1.0477 - accuracy: 0.6000
- val_loss: 1.0561 - val_accuracy: 0.5333
Epoch 25/200
30/30 [==============================] - 0s 300us/step - loss: 1.0421 - accuracy: 0.6000
- val_loss: 1.0521 - val_accuracy: 0.5417
Epoch 26/200
30/30 [==============================] - 0s 200us/step - loss: 1.0365 - accuracy: 0.6000
- val_loss: 1.0481 - val_accuracy: 0.5417
Epoch 27/200
30/30 [==============================] - 0s 300us/step - loss: 1.0310 - accuracy: 0.6000
- val_loss: 1.0442 - val_accuracy: 0.5417
Epoch 28/200
30/30 [==============================] - 0s 200us/step - loss: 1.0255 - accuracy: 0.6000
- val_loss: 1.0403 - val_accuracy: 0.5417
Epoch 29/200
30/30 [==============================] - 0s 200us/step - loss: 1.0201 - accuracy: 0.6000
- val_loss: 1.0363 - val_accuracy: 0.5417
Epoch 30/200
30/30 [==============================] - 0s 300us/step - loss: 1.0147 - accuracy: 0.6000
- val_loss: 1.0325 - val_accuracy: 0.5500
Epoch 31/200
30/30 [==============================] - 0s 267us/step - loss: 1.0092 - accuracy: 0.6000
- val_loss: 1.0286 - val_accuracy: 0.5500
Epoch 32/200
30/30 [==============================] - 0s 300us/step - loss: 1.0039 - accuracy: 0.6000
- val_loss: 1.0247 - val_accuracy: 0.5500
Epoch 33/200
30/30 [==============================] - 0s 167us/step - loss: 0.9985 - accuracy: 0.6000
- val_loss: 1.0209 - val_accuracy: 0.5500
Epoch 34/200
30/30 [==============================] - 0s 433us/step - loss: 0.9932 - accuracy: 0.6000
- val_loss: 1.0170 - val_accuracy: 0.5417
Epoch 35/200
30/30 [==============================] - 0s 267us/step - loss: 0.9878 - accuracy: 0.6000
- val_loss: 1.0132 - val_accuracy: 0.5500
Epoch 36/200
30/30 [==============================] - 0s 233us/step - loss: 0.9825 - accuracy: 0.6000
- val_loss: 1.0094 - val_accuracy: 0.5500
Epoch 37/200
30/30 [==============================] - 0s 267us/step - loss: 0.9772 - accuracy: 0.6000
- val_loss: 1.0056 - val_accuracy: 0.5417
Epoch 38/200
```

```
30/30 [==============================] - 0s 233us/step - loss: 0.9720 - accuracy: 0.6000
- val_loss: 1.0018 - val_accuracy: 0.5417
Epoch 39/200
30/30 [==============================] - 0s 333us/step - loss: 0.9668 - accuracy: 0.6000
- val_loss: 0.9981 - val_accuracy: 0.5417
Epoch 40/200
30/30 [==============================] - 0s 267us/step - loss: 0.9616 - accuracy: 0.6000
- val_loss: 0.9944 - val_accuracy: 0.5500
Epoch 41/200
30/30 [==============================] - 0s 266us/step - loss: 0.9565 - accuracy: 0.6000
- val_loss: 0.9908 - val_accuracy: 0.5583
Epoch 42/200
30/30 [==============================] - 0s 300us/step - loss: 0.9513 - accuracy: 0.6000
- val_loss: 0.9871 - val_accuracy: 0.5583
Epoch 43/200
30/30 [==============================] - 0s 300us/step - loss: 0.9462 - accuracy: 0.5667
- val_loss: 0.9835 - val_accuracy: 0.5667
Epoch 44/200
30/30 [==============================] - 0s 300us/step - loss: 0.9411 - accuracy: 0.5667
- val_loss: 0.9799 - val_accuracy: 0.5750
Epoch 45/200
30/30 [==============================] - 0s 300us/step - loss: 0.9361 - accuracy: 0.6000
- val_loss: 0.9763 - val_accuracy: 0.5917
Epoch 46/200
30/30 [==============================] - 0s 167us/step - loss: 0.9310 - accuracy: 0.6000
- val_loss: 0.9728 - val_accuracy: 0.5917
Epoch 47/200
30/30 [==============================] - 0s 267us/step - loss: 0.9260 - accuracy: 0.6000
- val_loss: 0.9693 - val_accuracy: 0.5833
Epoch 48/200
30/30 [==============================] - 0s 167us/step - loss: 0.9210 - accuracy: 0.6000
- val_loss: 0.9658 - val_accuracy: 0.5917
Epoch 49/200
30/30 [==============================] - 0s 334us/step - loss: 0.9160 - accuracy: 0.6000
- val_loss: 0.9622 - val_accuracy: 0.6000
Epoch 50/200
30/30 [==============================] - 0s 167us/step - loss: 0.9110 - accuracy: 0.6000
- val_loss: 0.9588 - val_accuracy: 0.6000
Epoch 51/200
30/30 [==============================] - 0s 300us/step - loss: 0.9061 - accuracy: 0.6333
- val_loss: 0.9553 - val_accuracy: 0.6000
Epoch 52/200
30/30 [==============================] - 0s 333us/step - loss: 0.9012 - accuracy: 0.6333
- val_loss: 0.9519 - val_accuracy: 0.6000
Epoch 53/200
30/30 [==============================] - 0s 200us/step - loss: 0.8964 - accuracy: 0.6333
- val_loss: 0.9484 - val_accuracy: 0.6167
Epoch 54/200
30/30 [==============================] - 0s 333us/step - loss: 0.8916 - accuracy: 0.6333
- val_loss: 0.9450 - val_accuracy: 0.6167
Epoch 55/200
30/30 [==============================] - 0s 200us/step - loss: 0.8868 - accuracy: 0.6333
- val_loss: 0.9417 - val_accuracy: 0.6167
Epoch 56/200
30/30 [==============================] - 0s 233us/step - loss: 0.8820 - accuracy: 0.6333
- val_loss: 0.9383 - val_accuracy: 0.6167
Epoch 57/200
30/30 [==============================] - 0s 267us/step - loss: 0.8773 - accuracy: 0.6333
- val_loss: 0.9350 - val_accuracy: 0.6167
Epoch 58/200
30/30 [==============================] - 0s 200us/step - loss: 0.8725 - accuracy: 0.6333
- val_loss: 0.9317 - val_accuracy: 0.6167
Epoch 59/200
30/30 [==============================] - 0s 333us/step - loss: 0.8678 - accuracy: 0.6333
- val_loss: 0.9284 - val_accuracy: 0.6250
```

```
Epoch 60/200
30/30 [==============================] - 0s 167us/step - loss: 0.8632 - accuracy: 0.6333
- val_loss: 0.9251 - val_accuracy: 0.6333
Epoch 61/200
30/30 [==============================] - 0s 300us/step - loss: 0.8585 - accuracy: 0.6333
- val_loss: 0.9218 - val_accuracy: 0.6333
Epoch 62/200
30/30 [==============================] - 0s 200us/step - loss: 0.8539 - accuracy: 0.6333
- val_loss: 0.9186 - val_accuracy: 0.6333
Epoch 63/200
30/30 [==============================] - 0s 367us/step - loss: 0.8493 - accuracy: 0.6333
- val_loss: 0.9154 - val_accuracy: 0.6333
Epoch 64/200
30/30 [==============================] - 0s 234us/step - loss: 0.8446 - accuracy: 0.6667
- val_loss: 0.9122 - val_accuracy: 0.6333
Epoch 65/200
30/30 [==============================] - 0s 233us/step - loss: 0.8401 - accuracy: 0.6667
- val_loss: 0.9090 - val_accuracy: 0.6500
Epoch 66/200
30/30 [==============================] - 0s 333us/step - loss: 0.8355 - accuracy: 0.6667
- val_loss: 0.9058 - val_accuracy: 0.6500
Epoch 67/200
30/30 [==============================] - 0s 200us/step - loss: 0.8310 - accuracy: 0.6333
- val_loss: 0.9026 - val_accuracy: 0.6500
Epoch 68/200
30/30 [==============================] - 0s 333us/step - loss: 0.8266 - accuracy: 0.6333
- val_loss: 0.8995 - val_accuracy: 0.6583
Epoch 69/200
30/30 [==============================] - 0s 167us/step - loss: 0.8221 - accuracy: 0.6333
- val_loss: 0.8964 - val_accuracy: 0.6583
Epoch 70/200
30/30 [==============================] - 0s 233us/step - loss: 0.8177 - accuracy: 0.6333
- val_loss: 0.8933 - val_accuracy: 0.6667
Epoch 71/200
30/30 [==============================] - 0s 233us/step - loss: 0.8132 - accuracy: 0.6333
- val_loss: 0.8902 - val_accuracy: 0.6833
Epoch 72/200
30/30 [==============================] - 0s 233us/step - loss: 0.8089 - accuracy: 0.6333
- val_loss: 0.8871 - val_accuracy: 0.6917
Epoch 73/200
30/30 [==============================] - 0s 267us/step - loss: 0.8045 - accuracy: 0.6333
- val_loss: 0.8841 - val_accuracy: 0.7000
Epoch 74/200
30/30 [==============================] - 0s 200us/step - loss: 0.8001 - accuracy: 0.6333
- val_loss: 0.8810 - val_accuracy: 0.7000
Epoch 75/200
30/30 [==============================] - 0s 267us/step - loss: 0.7958 - accuracy: 0.6333
- val_loss: 0.8780 - val_accuracy: 0.7083
Epoch 76/200
30/30 [==============================] - 0s 233us/step - loss: 0.7915 - accuracy: 0.6333
- val_loss: 0.8751 - val_accuracy: 0.7083
Epoch 77/200
30/30 [==============================] - 0s 267us/step - loss: 0.7873 - accuracy: 0.6333
- val_loss: 0.8721 - val_accuracy: 0.7083
Epoch 78/200
30/30 [==============================] - 0s 200us/step - loss: 0.7830 - accuracy: 0.6333
- val_loss: 0.8691 - val_accuracy: 0.7083
Epoch 79/200
30/30 [==============================] - 0s 300us/step - loss: 0.7788 - accuracy: 0.6667
- val_loss: 0.8662 - val_accuracy: 0.7083
Epoch 80/200
30/30 [==============================] - 0s 200us/step - loss: 0.7746 - accuracy: 0.7000
- val_loss: 0.8633 - val_accuracy: 0.7083
Epoch 81/200
30/30 [==============================] - 0s 266us/step - loss: 0.7705 - accuracy: 0.7000
```

```
- val_loss: 0.8604 - val_accuracy: 0.7083
Epoch 82/200
30/30 [==============================] - 0s 300us/step - loss: 0.7663 - accuracy: 0.7000
- val_loss: 0.8575 - val_accuracy: 0.7083
Epoch 83/200
30/30 [==============================] - 0s 200us/step - loss: 0.7622 - accuracy: 0.7000
- val_loss: 0.8546 - val_accuracy: 0.7250
Epoch 84/200
30/30 [==============================] - 0s 300us/step - loss: 0.7581 - accuracy: 0.7000
- val_loss: 0.8518 - val_accuracy: 0.7250
Epoch 85/200
30/30 [==============================] - 0s 200us/step - loss: 0.7541 - accuracy: 0.7000
- val_loss: 0.8490 - val_accuracy: 0.7250
Epoch 86/200
30/30 [==============================] - 0s 266us/step - loss: 0.7500 - accuracy: 0.7333
- val_loss: 0.8461 - val_accuracy: 0.7250
Epoch 87/200
30/30 [==============================] - 0s 167us/step - loss: 0.7460 - accuracy: 0.7333
- val_loss: 0.8433 - val_accuracy: 0.7250
Epoch 88/200
30/30 [==============================] - 0s 233us/step - loss: 0.7420 - accuracy: 0.7333
- val_loss: 0.8406 - val_accuracy: 0.7250
Epoch 89/200
30/30 [==============================] - 0s 200us/step - loss: 0.7381 - accuracy: 0.7333
- val_loss: 0.8378 - val_accuracy: 0.7250
Epoch 90/200
30/30 [==============================] - 0s 266us/step - loss: 0.7341 - accuracy: 0.7333
- val_loss: 0.8350 - val_accuracy: 0.7250
Epoch 91/200
30/30 [==============================] - 0s 267us/step - loss: 0.7302 - accuracy: 0.7333
- val_loss: 0.8323 - val_accuracy: 0.7167
Epoch 92/200
30/30 [==============================] - 0s 200us/step - loss: 0.7263 - accuracy: 0.7333
- val_loss: 0.8296 - val_accuracy: 0.7250
Epoch 93/200
30/30 [==============================] - 0s 300us/step - loss: 0.7224 - accuracy: 0.7333
- val_loss: 0.8269 - val_accuracy: 0.7250
Epoch 94/200
30/30 [==============================] - 0s 200us/step - loss: 0.7185 - accuracy: 0.7333
- val_loss: 0.8242 - val_accuracy: 0.7333
Epoch 95/200
30/30 [==============================] - 0s 300us/step - loss: 0.7147 - accuracy: 0.7333
- val_loss: 0.8215 - val_accuracy: 0.7333
Epoch 96/200
30/30 [==============================] - 0s 200us/step - loss: 0.7109 - accuracy: 0.7667
- val_loss: 0.8189 - val_accuracy: 0.7333
Epoch 97/200
30/30 [==============================] - 0s 233us/step - loss: 0.7072 - accuracy: 0.7667
- val_loss: 0.8163 - val_accuracy: 0.7417
Epoch 98/200
30/30 [==============================] - 0s 200us/step - loss: 0.7034 - accuracy: 0.8000
- val_loss: 0.8137 - val_accuracy: 0.7417
Epoch 99/200
30/30 [==============================] - 0s 233us/step - loss: 0.6997 - accuracy: 0.8000
- val_loss: 0.8112 - val_accuracy: 0.7333
Epoch 100/200
30/30 [==============================] - 0s 333us/step - loss: 0.6960 - accuracy: 0.8000
- val_loss: 0.8086 - val_accuracy: 0.7333
Epoch 101/200
30/30 [==============================] - 0s 167us/step - loss: 0.6923 - accuracy: 0.8000
- val_loss: 0.8060 - val_accuracy: 0.7333
Epoch 102/200
30/30 [==============================] - 0s 300us/step - loss: 0.6886 - accuracy: 0.8000
- val_loss: 0.8035 - val_accuracy: 0.7417
Epoch 103/200
```

```
30/30 [==============================] - 0s 200us/step - loss: 0.6849 - accuracy: 0.8000
- val_loss: 0.8010 - val_accuracy: 0.7417
Epoch 104/200
30/30 [==============================] - 0s 300us/step - loss: 0.6813 - accuracy: 0.8000
- val_loss: 0.7985 - val_accuracy: 0.7417
Epoch 105/200
30/30 [==============================] - 0s 167us/step - loss: 0.6777 - accuracy: 0.8000
- val_loss: 0.7960 - val_accuracy: 0.7417
Epoch 106/200
30/30 [==============================] - 0s 200us/step - loss: 0.6741 - accuracy: 0.8000
- val_loss: 0.7935 - val_accuracy: 0.7417
Epoch 107/200
30/30 [==============================] - 0s 167us/step - loss: 0.6705 - accuracy: 0.8000
- val_loss: 0.7910 - val_accuracy: 0.7417
Epoch 108/200
30/30 [==============================] - 0s 267us/step - loss: 0.6670 - accuracy: 0.8000
- val_loss: 0.7886 - val_accuracy: 0.7417
Epoch 109/200
30/30 [==============================] - 0s 433us/step - loss: 0.6634 - accuracy: 0.8000
- val_loss: 0.7862 - val_accuracy: 0.7417
Epoch 110/200
30/30 [==============================] - 0s 333us/step - loss: 0.6599 - accuracy: 0.8333
- val_loss: 0.7838 - val_accuracy: 0.7417
Epoch 111/200
30/30 [==============================] - 0s 233us/step - loss: 0.6564 - accuracy: 0.8333
- val_loss: 0.7814 - val_accuracy: 0.7417
Epoch 112/200
30/30 [==============================] - 0s 266us/step - loss: 0.6529 - accuracy: 0.8667
- val_loss: 0.7790 - val_accuracy: 0.7500
Epoch 113/200
30/30 [==============================] - 0s 367us/step - loss: 0.6494 - accuracy: 0.8667
- val_loss: 0.7766 - val_accuracy: 0.7583
Epoch 114/200
30/30 [==============================] - 0s 200us/step - loss: 0.6460 - accuracy: 0.8667
- val_loss: 0.7743 - val_accuracy: 0.7583
Epoch 115/200
30/30 [==============================] - 0s 300us/step - loss: 0.6425 - accuracy: 0.8667
- val_loss: 0.7719 - val_accuracy: 0.7583
Epoch 116/200
30/30 [==============================] - 0s 367us/step - loss: 0.6392 - accuracy: 0.8667
- val_loss: 0.7696 - val_accuracy: 0.7583
Epoch 117/200
30/30 [==============================] - 0s 400us/step - loss: 0.6358 - accuracy: 0.8667
- val_loss: 0.7672 - val_accuracy: 0.7583
Epoch 118/200
30/30 [==============================] - 0s 300us/step - loss: 0.6325 - accuracy: 0.8667
- val_loss: 0.7649 - val_accuracy: 0.7583
Epoch 119/200
30/30 [==============================] - 0s 467us/step - loss: 0.6292 - accuracy: 0.8667
- val_loss: 0.7627 - val_accuracy: 0.7583
Epoch 120/200
30/30 [==============================] - 0s 367us/step - loss: 0.6260 - accuracy: 0.8667
- val_loss: 0.7604 - val_accuracy: 0.7583
Epoch 121/200
30/30 [==============================] - 0s 500us/step - loss: 0.6227 - accuracy: 0.8667
- val_loss: 0.7581 - val_accuracy: 0.7583
Epoch 122/200
30/30 [==============================] - 0s 400us/step - loss: 0.6195 - accuracy: 0.8667
- val_loss: 0.7559 - val_accuracy: 0.7667
Epoch 123/200
30/30 [==============================] - 0s 367us/step - loss: 0.6163 - accuracy: 0.8667
- val_loss: 0.7536 - val_accuracy: 0.7667
Epoch 124/200
30/30 [==============================] - 0s 267us/step - loss: 0.6131 - accuracy: 0.8667
- val_loss: 0.7514 - val_accuracy: 0.7667
```

```
Epoch 125/200
30/30 [==============================] - 0s 333us/step - loss: 0.6100 - accuracy: 0.8667
- val_loss: 0.7492 - val_accuracy: 0.7667
Epoch 126/200
30/30 [==============================] - 0s 367us/step - loss: 0.6069 - accuracy: 0.8667
- val_loss: 0.7470 - val_accuracy: 0.7583
Epoch 127/200
30/30 [==============================] - 0s 267us/step - loss: 0.6038 - accuracy: 0.8667
- val_loss: 0.7448 - val_accuracy: 0.7583
Epoch 128/200
30/30 [==============================] - 0s 400us/step - loss: 0.6007 - accuracy: 0.8667
- val_loss: 0.7427 - val_accuracy: 0.7583
Epoch 129/200
30/30 [==============================] - 0s 400us/step - loss: 0.5977 - accuracy: 0.8667
- val_loss: 0.7405 - val_accuracy: 0.7500
Epoch 130/200
30/30 [==============================] - 0s 467us/step - loss: 0.5947 - accuracy: 0.8667
- val_loss: 0.7384 - val_accuracy: 0.7500
Epoch 131/200
30/30 [==============================] - 0s 500us/step - loss: 0.5916 - accuracy: 0.8667
- val_loss: 0.7363 - val_accuracy: 0.7500
Epoch 132/200
30/30 [==============================] - 0s 533us/step - loss: 0.5886 - accuracy: 0.8667
- val_loss: 0.7341 - val_accuracy: 0.7500
Epoch 133/200
30/30 [==============================] - 0s 534us/step - loss: 0.5857 - accuracy: 0.8667
- val_loss: 0.7320 - val_accuracy: 0.7500
Epoch 134/200
30/30 [==============================] - 0s 467us/step - loss: 0.5827 - accuracy: 0.8667
- val_loss: 0.7299 - val_accuracy: 0.7500
Epoch 135/200
30/30 [==============================] - 0s 467us/step - loss: 0.5798 - accuracy: 0.8667
- val_loss: 0.7278 - val_accuracy: 0.7500
Epoch 136/200
30/30 [==============================] - 0s 400us/step - loss: 0.5769 - accuracy: 0.8667
- val_loss: 0.7258 - val_accuracy: 0.7500
Epoch 137/200
30/30 [==============================] - 0s 467us/step - loss: 0.5740 - accuracy: 0.8667
- val_loss: 0.7237 - val_accuracy: 0.7500
Epoch 138/200
30/30 [==============================] - 0s 400us/step - loss: 0.5711 - accuracy: 0.8667
- val_loss: 0.7217 - val_accuracy: 0.7500
Epoch 139/200
30/30 [==============================] - 0s 500us/step - loss: 0.5683 - accuracy: 0.8667
- val_loss: 0.7196 - val_accuracy: 0.7500
Epoch 140/200
30/30 [==============================] - 0s 467us/step - loss: 0.5654 - accuracy: 0.8667
- val_loss: 0.7176 - val_accuracy: 0.7500
Epoch 141/200
30/30 [==============================] - 0s 566us/step - loss: 0.5626 - accuracy: 0.8667
- val_loss: 0.7156 - val_accuracy: 0.7500
Epoch 142/200
30/30 [==============================] - 0s 767us/step - loss: 0.5598 - accuracy: 0.8667
- val_loss: 0.7136 - val_accuracy: 0.7500
Epoch 143/200
30/30 [==============================] - 0s 469us/step - loss: 0.5571 - accuracy: 0.8667
- val_loss: 0.7116 - val_accuracy: 0.7500
Epoch 144/200
30/30 [==============================] - 0s 517us/step - loss: 0.5543 - accuracy: 0.8667
- val_loss: 0.7096 - val_accuracy: 0.7500
Epoch 145/200
30/30 [==============================] - 0s 467us/step - loss: 0.5516 - accuracy: 0.8667
- val_loss: 0.7077 - val_accuracy: 0.7500
Epoch 146/200
30/30 [==============================] - 0s 366us/step - loss: 0.5489 - accuracy: 0.8667
```

```
- val_loss: 0.7057 - val_accuracy: 0.7500
Epoch 147/200
30/30 [==============================] - 0s 400us/step - loss: 0.5463 - accuracy: 0.8667
- val_loss: 0.7037 - val_accuracy: 0.7500
Epoch 148/200
30/30 [==============================] - 0s 433us/step - loss: 0.5436 - accuracy: 0.8667
- val_loss: 0.7018 - val_accuracy: 0.7500
Epoch 149/200
30/30 [==============================] - 0s 367us/step - loss: 0.5410 - accuracy: 0.8667
- val_loss: 0.6998 - val_accuracy: 0.7500
Epoch 150/200
30/30 [==============================] - 0s 367us/step - loss: 0.5384 - accuracy: 0.8667
- val_loss: 0.6979 - val_accuracy: 0.7500
Epoch 151/200
30/30 [==============================] - 0s 233us/step - loss: 0.5358 - accuracy: 0.8667
- val_loss: 0.6959 - val_accuracy: 0.7500
Epoch 152/200
30/30 [==============================] - 0s 366us/step - loss: 0.5332 - accuracy: 0.8667
- val_loss: 0.6940 - val_accuracy: 0.7500
Epoch 153/200
30/30 [==============================] - 0s 433us/step - loss: 0.5307 - accuracy: 0.8667
- val_loss: 0.6921 - val_accuracy: 0.7500
Epoch 154/200
30/30 [==============================] - 0s 400us/step - loss: 0.5281 - accuracy: 0.8667
- val_loss: 0.6902 - val_accuracy: 0.7500
Epoch 155/200
30/30 [==============================] - 0s 300us/step - loss: 0.5256 - accuracy: 0.8667
- val_loss: 0.6883 - val_accuracy: 0.7500
Epoch 156/200
30/30 [==============================] - 0s 300us/step - loss: 0.5231 - accuracy: 0.8667
- val_loss: 0.6864 - val_accuracy: 0.7500
Epoch 157/200
30/30 [==============================] - 0s 266us/step - loss: 0.5206 - accuracy: 0.8667
- val_loss: 0.6845 - val_accuracy: 0.7500
Epoch 158/200
30/30 [==============================] - 0s 367us/step - loss: 0.5182 - accuracy: 0.8667
- val_loss: 0.6826 - val_accuracy: 0.7417
Epoch 159/200
30/30 [==============================] - 0s 500us/step - loss: 0.5157 - accuracy: 0.8667
- val_loss: 0.6808 - val_accuracy: 0.7417
Epoch 160/200
30/30 [==============================] - 0s 467us/step - loss: 0.5133 - accuracy: 0.8667
- val_loss: 0.6789 - val_accuracy: 0.7417
Epoch 161/200
30/30 [==============================] - 0s 267us/step - loss: 0.5109 - accuracy: 0.8667
- val_loss: 0.6771 - val_accuracy: 0.7417
Epoch 162/200
30/30 [==============================] - 0s 333us/step - loss: 0.5086 - accuracy: 0.8667
- val_loss: 0.6753 - val_accuracy: 0.7417
Epoch 163/200
30/30 [==============================] - 0s 266us/step - loss: 0.5062 - accuracy: 0.8667
- val_loss: 0.6735 - val_accuracy: 0.7417
Epoch 164/200
30/30 [==============================] - 0s 400us/step - loss: 0.5039 - accuracy: 0.8667
- val_loss: 0.6717 - val_accuracy: 0.7417
Epoch 165/200
30/30 [==============================] - 0s 333us/step - loss: 0.5015 - accuracy: 0.8667
- val_loss: 0.6699 - val_accuracy: 0.7417
Epoch 166/200
30/30 [==============================] - 0s 267us/step - loss: 0.4992 - accuracy: 0.8667
- val_loss: 0.6681 - val_accuracy: 0.7417
Epoch 167/200
30/30 [==============================] - 0s 233us/step - loss: 0.4969 - accuracy: 0.8667
- val_loss: 0.6663 - val_accuracy: 0.7417
Epoch 168/200
```

```
30/30 [==============================] - 0s 367us/step - loss: 0.4947 - accuracy: 0.8667
- val_loss: 0.6645 - val_accuracy: 0.7417
Epoch 169/200
30/30 [==============================] - 0s 300us/step - loss: 0.4924 - accuracy: 0.8667
- val_loss: 0.6628 - val_accuracy: 0.7417
Epoch 170/200
30/30 [==============================] - 0s 200us/step - loss: 0.4901 - accuracy: 0.8667
- val_loss: 0.6610 - val_accuracy: 0.7417
Epoch 171/200
30/30 [==============================] - 0s 300us/step - loss: 0.4879 - accuracy: 0.8667
- val_loss: 0.6593 - val_accuracy: 0.7417
Epoch 172/200
30/30 [==============================] - 0s 233us/step - loss: 0.4857 - accuracy: 0.8667
- val_loss: 0.6575 - val_accuracy: 0.7500
Epoch 173/200
30/30 [==============================] - 0s 333us/step - loss: 0.4835 - accuracy: 0.8667
- val_loss: 0.6558 - val_accuracy: 0.7500
Epoch 174/200
30/30 [==============================] - 0s 300us/step - loss: 0.4813 - accuracy: 0.8667
- val_loss: 0.6541 - val_accuracy: 0.7500
Epoch 175/200
30/30 [==============================] - 0s 200us/step - loss: 0.4791 - accuracy: 0.8667
- val_loss: 0.6524 - val_accuracy: 0.7417
Epoch 176/200
30/30 [==============================] - 0s 300us/step - loss: 0.4770 - accuracy: 0.8667
- val_loss: 0.6507 - val_accuracy: 0.7417
Epoch 177/200
30/30 [==============================] - 0s 267us/step - loss: 0.4748 - accuracy: 0.8667
- val_loss: 0.6490 - val_accuracy: 0.7417
Epoch 178/200
30/30 [==============================] - 0s 300us/step - loss: 0.4727 - accuracy: 0.8667
- val_loss: 0.6473 - val_accuracy: 0.7417
Epoch 179/200
30/30 [==============================] - 0s 400us/step - loss: 0.4706 - accuracy: 0.8667
- val_loss: 0.6456 - val_accuracy: 0.7417
Epoch 180/200
30/30 [==============================] - 0s 367us/step - loss: 0.4685 - accuracy: 0.8667
- val_loss: 0.6439 - val_accuracy: 0.7417
Epoch 181/200
30/30 [==============================] - 0s 200us/step - loss: 0.4664 - accuracy: 0.8667
- val_loss: 0.6423 - val_accuracy: 0.7417
Epoch 182/200
30/30 [==============================] - 0s 300us/step - loss: 0.4643 - accuracy: 0.8667
- val_loss: 0.6406 - val_accuracy: 0.7417
Epoch 183/200
30/30 [==============================] - 0s 333us/step - loss: 0.4622 - accuracy: 0.8667
- val_loss: 0.6390 - val_accuracy: 0.7417
Epoch 184/200
30/30 [==============================] - 0s 300us/step - loss: 0.4602 - accuracy: 0.8667
- val_loss: 0.6374 - val_accuracy: 0.7417
Epoch 185/200
30/30 [==============================] - 0s 400us/step - loss: 0.4582 - accuracy: 0.8667
- val_loss: 0.6357 - val_accuracy: 0.7500
Epoch 186/200
30/30 [==============================] - 0s 333us/step - loss: 0.4561 - accuracy: 0.8667
- val_loss: 0.6341 - val_accuracy: 0.7500
Epoch 187/200
30/30 [==============================] - 0s 400us/step - loss: 0.4541 - accuracy: 0.8667
- val_loss: 0.6325 - val_accuracy: 0.7500
Epoch 188/200
30/30 [==============================] - 0s 400us/step - loss: 0.4522 - accuracy: 0.8667
- val_loss: 0.6309 - val_accuracy: 0.7500
Epoch 189/200
30/30 [==============================] - 0s 367us/step - loss: 0.4502 - accuracy: 0.8667
- val_loss: 0.6293 - val_accuracy: 0.7500
```

```
Epoch 190/200
30/30 [==============================] - 0s 367us/step - loss: 0.4482 - accuracy: 0.8667
- val_loss: 0.6277 - val_accuracy: 0.7500
Epoch 191/200
30/30 [==============================] - 0s 367us/step - loss: 0.4463 - accuracy: 0.8667
- val_loss: 0.6262 - val_accuracy: 0.7417
Epoch 192/200
30/30 [==============================] - 0s 200us/step - loss: 0.4444 - accuracy: 0.8667
- val_loss: 0.6246 - val_accuracy: 0.7417
Epoch 193/200
30/30 [==============================] - 0s 266us/step - loss: 0.4425 - accuracy: 0.9000
- val_loss: 0.6231 - val_accuracy: 0.7417
Epoch 194/200
30/30 [==============================] - 0s 367us/step - loss: 0.4406 - accuracy: 0.9000
- val_loss: 0.6215 - val_accuracy: 0.7417
Epoch 195/200
30/30 [==============================] - 0s 300us/step - loss: 0.4387 - accuracy: 0.9000
- val_loss: 0.6200 - val_accuracy: 0.7417
Epoch 196/200
30/30 [==============================] - 0s 233us/step - loss: 0.4368 - accuracy: 0.9000
- val_loss: 0.6184 - val_accuracy: 0.7417
Epoch 197/200
30/30 [==============================] - 0s 366us/step - loss: 0.4350 - accuracy: 0.9000
- val_loss: 0.6169 - val_accuracy: 0.7417
Epoch 198/200
30/30 [==============================] - 0s 400us/step - loss: 0.4331 - accuracy: 0.9000
- val_loss: 0.6154 - val_accuracy: 0.7417
Epoch 199/200
30/30 [==============================] - 0s 367us/step - loss: 0.4313 - accuracy: 0.9000
- val_loss: 0.6139 - val_accuracy: 0.7417
Epoch 200/200
30/30 [==============================] - 0s 367us/step - loss: 0.4295 - accuracy: 0.9000
- val_loss: 0.6124 - val_accuracy: 0.7417
```

Out[26]: `<keras.callbacks.callbacks.History at 0x1d2f6f72fd0>`

In [27]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [28]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 d) Test 4: Split the X and Y into training and test sets and let us use a training dataset of 0.6 or 40% with a different number of epochs

In [29]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.6)
```

In [30]:
```
print(X_train.shape, X_test.shape)
```

```
(60, 4) (90, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [31]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [32]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 150 epochs and see how it performs on training and test data sets

In [33]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=150)
```

```
Train on 60 samples, validate on 90 samples
Epoch 1/150
60/60 [==============================] - 0s 2ms/step - loss: 1.1784 - accuracy: 0.3667 -
val_loss: 1.2735 - val_accuracy: 0.2667
Epoch 2/150
60/60 [==============================] - 0s 217us/step - loss: 1.1645 - accuracy: 0.3833
- val_loss: 1.2567 - val_accuracy: 0.2778
Epoch 3/150
60/60 [==============================] - 0s 183us/step - loss: 1.1510 - accuracy: 0.3833
- val_loss: 1.2393 - val_accuracy: 0.2778
Epoch 4/150
60/60 [==============================] - 0s 200us/step - loss: 1.1377 - accuracy: 0.3833
- val_loss: 1.2221 - val_accuracy: 0.3111
Epoch 5/150
60/60 [==============================] - 0s 167us/step - loss: 1.1239 - accuracy: 0.3833
- val_loss: 1.2051 - val_accuracy: 0.3111
Epoch 6/150
60/60 [==============================] - 0s 166us/step - loss: 1.1108 - accuracy: 0.4167
- val_loss: 1.1881 - val_accuracy: 0.3111
Epoch 7/150
60/60 [==============================] - 0s 167us/step - loss: 1.0975 - accuracy: 0.4167
- val_loss: 1.1714 - val_accuracy: 0.3111
Epoch 8/150
60/60 [==============================] - 0s 183us/step - loss: 1.0840 - accuracy: 0.4333
- val_loss: 1.1549 - val_accuracy: 0.3222
Epoch 9/150
60/60 [==============================] - 0s 167us/step - loss: 1.0713 - accuracy: 0.4333
- val_loss: 1.1386 - val_accuracy: 0.3222
Epoch 10/150
60/60 [==============================] - 0s 133us/step - loss: 1.0585 - accuracy: 0.4333
- val_loss: 1.1225 - val_accuracy: 0.3333
Epoch 11/150
60/60 [==============================] - 0s 183us/step - loss: 1.0452 - accuracy: 0.4333
- val_loss: 1.1067 - val_accuracy: 0.3333
Epoch 12/150
60/60 [==============================] - 0s 133us/step - loss: 1.0329 - accuracy: 0.4333
- val_loss: 1.0911 - val_accuracy: 0.3444
Epoch 13/150
```

```
60/60 [==============================] - 0s 150us/step - loss: 1.0214 - accuracy: 0.4333
- val_loss: 1.0757 - val_accuracy: 0.3444
Epoch 14/150
60/60 [==============================] - 0s 150us/step - loss: 1.0091 - accuracy: 0.4333
- val_loss: 1.0604 - val_accuracy: 0.3556
Epoch 15/150
60/60 [==============================] - 0s 100us/step - loss: 0.9978 - accuracy: 0.4333
- val_loss: 1.0452 - val_accuracy: 0.3556
Epoch 16/150
60/60 [==============================] - 0s 159us/step - loss: 0.9855 - accuracy: 0.4500
- val_loss: 1.0304 - val_accuracy: 0.3556
Epoch 17/150
60/60 [==============================] - 0s 183us/step - loss: 0.9746 - accuracy: 0.4500
- val_loss: 1.0156 - val_accuracy: 0.3667
Epoch 18/150
60/60 [==============================] - 0s 133us/step - loss: 0.9627 - accuracy: 0.4500
- val_loss: 1.0011 - val_accuracy: 0.3667
Epoch 19/150
60/60 [==============================] - 0s 167us/step - loss: 0.9509 - accuracy: 0.4500
- val_loss: 0.9868 - val_accuracy: 0.3667
Epoch 20/150
60/60 [==============================] - 0s 150us/step - loss: 0.9403 - accuracy: 0.4500
- val_loss: 0.9727 - val_accuracy: 0.3667
Epoch 21/150
60/60 [==============================] - 0s 217us/step - loss: 0.9291 - accuracy: 0.4667
- val_loss: 0.9587 - val_accuracy: 0.3667
Epoch 22/150
60/60 [==============================] - 0s 133us/step - loss: 0.9185 - accuracy: 0.4667
- val_loss: 0.9447 - val_accuracy: 0.3667
Epoch 23/150
60/60 [==============================] - 0s 167us/step - loss: 0.9074 - accuracy: 0.4667
- val_loss: 0.9311 - val_accuracy: 0.3667
Epoch 24/150
60/60 [==============================] - 0s 150us/step - loss: 0.8970 - accuracy: 0.4667
- val_loss: 0.9176 - val_accuracy: 0.3778
Epoch 25/150
60/60 [==============================] - 0s 150us/step - loss: 0.8864 - accuracy: 0.4833
- val_loss: 0.9043 - val_accuracy: 0.3778
Epoch 26/150
60/60 [==============================] - 0s 283us/step - loss: 0.8762 - accuracy: 0.4833
- val_loss: 0.8912 - val_accuracy: 0.4222
Epoch 27/150
60/60 [==============================] - 0s 167us/step - loss: 0.8657 - accuracy: 0.5167
- val_loss: 0.8784 - val_accuracy: 0.4444
Epoch 28/150
60/60 [==============================] - 0s 233us/step - loss: 0.8557 - accuracy: 0.5333
- val_loss: 0.8657 - val_accuracy: 0.4889
Epoch 29/150
60/60 [==============================] - 0s 167us/step - loss: 0.8461 - accuracy: 0.5333
- val_loss: 0.8531 - val_accuracy: 0.5444
Epoch 30/150
60/60 [==============================] - 0s 167us/step - loss: 0.8356 - accuracy: 0.5500
- val_loss: 0.8408 - val_accuracy: 0.5556
Epoch 31/150
60/60 [==============================] - 0s 183us/step - loss: 0.8262 - accuracy: 0.5667
- val_loss: 0.8286 - val_accuracy: 0.5889
Epoch 32/150
60/60 [==============================] - 0s 183us/step - loss: 0.8169 - accuracy: 0.6000
- val_loss: 0.8164 - val_accuracy: 0.6222
Epoch 33/150
60/60 [==============================] - 0s 183us/step - loss: 0.8066 - accuracy: 0.6167
- val_loss: 0.8047 - val_accuracy: 0.6667
Epoch 34/150
60/60 [==============================] - 0s 233us/step - loss: 0.7980 - accuracy: 0.6167
- val_loss: 0.7930 - val_accuracy: 0.6778
```

```
Epoch 35/150
60/60 [==============================] - 0s 183us/step - loss: 0.7890 - accuracy: 0.6333
- val_loss: 0.7814 - val_accuracy: 0.6889
Epoch 36/150
60/60 [==============================] - 0s 250us/step - loss: 0.7798 - accuracy: 0.6333
- val_loss: 0.7702 - val_accuracy: 0.7111
Epoch 37/150
60/60 [==============================] - 0s 267us/step - loss: 0.7708 - accuracy: 0.6667
- val_loss: 0.7591 - val_accuracy: 0.7556
Epoch 38/150
60/60 [==============================] - 0s 168us/step - loss: 0.7618 - accuracy: 0.7167
- val_loss: 0.7482 - val_accuracy: 0.7778
Epoch 39/150
60/60 [==============================] - 0s 167us/step - loss: 0.7533 - accuracy: 0.7333
- val_loss: 0.7374 - val_accuracy: 0.7889
Epoch 40/150
60/60 [==============================] - 0s 217us/step - loss: 0.7447 - accuracy: 0.7500
- val_loss: 0.7269 - val_accuracy: 0.7889
Epoch 41/150
60/60 [==============================] - 0s 167us/step - loss: 0.7364 - accuracy: 0.7500
- val_loss: 0.7165 - val_accuracy: 0.7889
Epoch 42/150
60/60 [==============================] - 0s 176us/step - loss: 0.7282 - accuracy: 0.7500
- val_loss: 0.7062 - val_accuracy: 0.7889
Epoch 43/150
60/60 [==============================] - 0s 259us/step - loss: 0.7205 - accuracy: 0.7500
- val_loss: 0.6961 - val_accuracy: 0.8000
Epoch 44/150
60/60 [==============================] - 0s 250us/step - loss: 0.7123 - accuracy: 0.7500
- val_loss: 0.6862 - val_accuracy: 0.8000
Epoch 45/150
60/60 [==============================] - 0s 267us/step - loss: 0.7045 - accuracy: 0.7500
- val_loss: 0.6766 - val_accuracy: 0.8000
Epoch 46/150
60/60 [==============================] - 0s 167us/step - loss: 0.6970 - accuracy: 0.7500
- val_loss: 0.6672 - val_accuracy: 0.8000
Epoch 47/150
60/60 [==============================] - 0s 217us/step - loss: 0.6896 - accuracy: 0.7500
- val_loss: 0.6579 - val_accuracy: 0.8000
Epoch 48/150
60/60 [==============================] - 0s 233us/step - loss: 0.6821 - accuracy: 0.7667
- val_loss: 0.6489 - val_accuracy: 0.8111
Epoch 49/150
60/60 [==============================] - 0s 250us/step - loss: 0.6752 - accuracy: 0.7667
- val_loss: 0.6400 - val_accuracy: 0.8222
Epoch 50/150
60/60 [==============================] - 0s 225us/step - loss: 0.6680 - accuracy: 0.7667
- val_loss: 0.6313 - val_accuracy: 0.8222
Epoch 51/150
60/60 [==============================] - 0s 217us/step - loss: 0.6606 - accuracy: 0.7667
- val_loss: 0.6229 - val_accuracy: 0.8222
Epoch 52/150
60/60 [==============================] - 0s 217us/step - loss: 0.6541 - accuracy: 0.7833
- val_loss: 0.6147 - val_accuracy: 0.8222
Epoch 53/150
60/60 [==============================] - 0s 150us/step - loss: 0.6475 - accuracy: 0.7833
- val_loss: 0.6067 - val_accuracy: 0.8333
Epoch 54/150
60/60 [==============================] - 0s 200us/step - loss: 0.6409 - accuracy: 0.7833
- val_loss: 0.5988 - val_accuracy: 0.8667
Epoch 55/150
60/60 [==============================] - 0s 193us/step - loss: 0.6346 - accuracy: 0.7833
- val_loss: 0.5912 - val_accuracy: 0.8667
Epoch 56/150
60/60 [==============================] - 0s 167us/step - loss: 0.6283 - accuracy: 0.7833
```

```
- val_loss: 0.5837 - val_accuracy: 0.8667
Epoch 57/150
60/60 [==============================] - 0s 167us/step - loss: 0.6222 - accuracy: 0.7833
- val_loss: 0.5764 - val_accuracy: 0.8778
Epoch 58/150
60/60 [==============================] - 0s 200us/step - loss: 0.6163 - accuracy: 0.7833
- val_loss: 0.5692 - val_accuracy: 0.8778
Epoch 59/150
60/60 [==============================] - 0s 217us/step - loss: 0.6101 - accuracy: 0.7833
- val_loss: 0.5623 - val_accuracy: 0.8778
Epoch 60/150
60/60 [==============================] - 0s 192us/step - loss: 0.6046 - accuracy: 0.7833
- val_loss: 0.5555 - val_accuracy: 0.8778
Epoch 61/150
60/60 [==============================] - 0s 250us/step - loss: 0.5991 - accuracy: 0.7833
- val_loss: 0.5489 - val_accuracy: 0.8778
Epoch 62/150
60/60 [==============================] - 0s 183us/step - loss: 0.5936 - accuracy: 0.7833
- val_loss: 0.5424 - val_accuracy: 0.8778
Epoch 63/150
60/60 [==============================] - 0s 200us/step - loss: 0.5882 - accuracy: 0.7833
- val_loss: 0.5361 - val_accuracy: 0.8778
Epoch 64/150
60/60 [==============================] - 0s 167us/step - loss: 0.5830 - accuracy: 0.8000
- val_loss: 0.5300 - val_accuracy: 0.8778
Epoch 65/150
60/60 [==============================] - 0s 233us/step - loss: 0.5779 - accuracy: 0.8000
- val_loss: 0.5240 - val_accuracy: 0.8778
Epoch 66/150
60/60 [==============================] - 0s 233us/step - loss: 0.5727 - accuracy: 0.8000
- val_loss: 0.5182 - val_accuracy: 0.8778
Epoch 67/150
60/60 [==============================] - 0s 217us/step - loss: 0.5680 - accuracy: 0.8000
- val_loss: 0.5124 - val_accuracy: 0.8778
Epoch 68/150
60/60 [==============================] - 0s 200us/step - loss: 0.5634 - accuracy: 0.8000
- val_loss: 0.5068 - val_accuracy: 0.8778
Epoch 69/150
60/60 [==============================] - 0s 217us/step - loss: 0.5586 - accuracy: 0.8000
- val_loss: 0.5013 - val_accuracy: 0.8778
Epoch 70/150
60/60 [==============================] - 0s 167us/step - loss: 0.5542 - accuracy: 0.8000
- val_loss: 0.4960 - val_accuracy: 0.8889
Epoch 71/150
60/60 [==============================] - 0s 183us/step - loss: 0.5495 - accuracy: 0.8000
- val_loss: 0.4908 - val_accuracy: 0.8889
Epoch 72/150
60/60 [==============================] - 0s 150us/step - loss: 0.5452 - accuracy: 0.8000
- val_loss: 0.4858 - val_accuracy: 0.8889
Epoch 73/150
60/60 [==============================] - 0s 183us/step - loss: 0.5409 - accuracy: 0.8000
- val_loss: 0.4808 - val_accuracy: 0.8889
Epoch 74/150
60/60 [==============================] - 0s 167us/step - loss: 0.5368 - accuracy: 0.8000
- val_loss: 0.4760 - val_accuracy: 0.8889
Epoch 75/150
60/60 [==============================] - 0s 133us/step - loss: 0.5327 - accuracy: 0.8167
- val_loss: 0.4713 - val_accuracy: 0.9000
Epoch 76/150
60/60 [==============================] - 0s 183us/step - loss: 0.5287 - accuracy: 0.8167
- val_loss: 0.4667 - val_accuracy: 0.9000
Epoch 77/150
60/60 [==============================] - 0s 183us/step - loss: 0.5248 - accuracy: 0.8167
- val_loss: 0.4622 - val_accuracy: 0.9000
Epoch 78/150
```

```
60/60 [==============================] - 0s 183us/step - loss: 0.5210 - accuracy: 0.8167
- val_loss: 0.4578 - val_accuracy: 0.9000
Epoch 79/150
60/60 [==============================] - 0s 167us/step - loss: 0.5171 - accuracy: 0.8167
- val_loss: 0.4536 - val_accuracy: 0.9000
Epoch 80/150
60/60 [==============================] - 0s 167us/step - loss: 0.5133 - accuracy: 0.8167
- val_loss: 0.4495 - val_accuracy: 0.9000
Epoch 81/150
60/60 [==============================] - 0s 200us/step - loss: 0.5099 - accuracy: 0.8167
- val_loss: 0.4454 - val_accuracy: 0.9000
Epoch 82/150
60/60 [==============================] - 0s 200us/step - loss: 0.5061 - accuracy: 0.8167
- val_loss: 0.4415 - val_accuracy: 0.9000
Epoch 83/150
60/60 [==============================] - 0s 183us/step - loss: 0.5029 - accuracy: 0.8167
- val_loss: 0.4376 - val_accuracy: 0.9000
Epoch 84/150
60/60 [==============================] - 0s 133us/step - loss: 0.4994 - accuracy: 0.8167
- val_loss: 0.4338 - val_accuracy: 0.9000
Epoch 85/150
60/60 [==============================] - 0s 167us/step - loss: 0.4961 - accuracy: 0.8333
- val_loss: 0.4302 - val_accuracy: 0.9000
Epoch 86/150
60/60 [==============================] - 0s 167us/step - loss: 0.4928 - accuracy: 0.8333
- val_loss: 0.4266 - val_accuracy: 0.9000
Epoch 87/150
60/60 [==============================] - 0s 150us/step - loss: 0.4896 - accuracy: 0.8333
- val_loss: 0.4230 - val_accuracy: 0.9000
Epoch 88/150
60/60 [==============================] - 0s 150us/step - loss: 0.4863 - accuracy: 0.8333
- val_loss: 0.4196 - val_accuracy: 0.9000
Epoch 89/150
60/60 [==============================] - 0s 217us/step - loss: 0.4832 - accuracy: 0.8333
- val_loss: 0.4162 - val_accuracy: 0.9000
Epoch 90/150
60/60 [==============================] - 0s 167us/step - loss: 0.4803 - accuracy: 0.8333
- val_loss: 0.4129 - val_accuracy: 0.9000
Epoch 91/150
60/60 [==============================] - 0s 133us/step - loss: 0.4772 - accuracy: 0.8333
- val_loss: 0.4096 - val_accuracy: 0.9111
Epoch 92/150
60/60 [==============================] - 0s 150us/step - loss: 0.4742 - accuracy: 0.8333
- val_loss: 0.4064 - val_accuracy: 0.9111
Epoch 93/150
60/60 [==============================] - 0s 167us/step - loss: 0.4713 - accuracy: 0.8333
- val_loss: 0.4033 - val_accuracy: 0.9111
Epoch 94/150
60/60 [==============================] - 0s 133us/step - loss: 0.4685 - accuracy: 0.8333
- val_loss: 0.4003 - val_accuracy: 0.9222
Epoch 95/150
60/60 [==============================] - 0s 133us/step - loss: 0.4656 - accuracy: 0.8333
- val_loss: 0.3973 - val_accuracy: 0.9222
Epoch 96/150
60/60 [==============================] - 0s 167us/step - loss: 0.4628 - accuracy: 0.8333
- val_loss: 0.3943 - val_accuracy: 0.9333
Epoch 97/150
60/60 [==============================] - 0s 167us/step - loss: 0.4602 - accuracy: 0.8333
- val_loss: 0.3914 - val_accuracy: 0.9333
Epoch 98/150
60/60 [==============================] - 0s 150us/step - loss: 0.4576 - accuracy: 0.8333
- val_loss: 0.3886 - val_accuracy: 0.9333
Epoch 99/150
60/60 [==============================] - 0s 200us/step - loss: 0.4549 - accuracy: 0.8333
- val_loss: 0.3859 - val_accuracy: 0.9222
```

```
Epoch 100/150
60/60 [==============================] - 0s 217us/step - loss: 0.4523 - accuracy: 0.8333
- val_loss: 0.3832 - val_accuracy: 0.9222
Epoch 101/150
60/60 [==============================] - 0s 176us/step - loss: 0.4497 - accuracy: 0.8333
- val_loss: 0.3805 - val_accuracy: 0.9222
Epoch 102/150
60/60 [==============================] - 0s 117us/step - loss: 0.4473 - accuracy: 0.8333
- val_loss: 0.3779 - val_accuracy: 0.9222
Epoch 103/150
60/60 [==============================] - 0s 165us/step - loss: 0.4448 - accuracy: 0.8333
- val_loss: 0.3754 - val_accuracy: 0.9222
Epoch 104/150
60/60 [==============================] - 0s 183us/step - loss: 0.4424 - accuracy: 0.8333
- val_loss: 0.3729 - val_accuracy: 0.9222
Epoch 105/150
60/60 [==============================] - 0s 167us/step - loss: 0.4401 - accuracy: 0.8333
- val_loss: 0.3704 - val_accuracy: 0.9222
Epoch 106/150
60/60 [==============================] - 0s 117us/step - loss: 0.4376 - accuracy: 0.8333
- val_loss: 0.3680 - val_accuracy: 0.9222
Epoch 107/150
60/60 [==============================] - 0s 167us/step - loss: 0.4353 - accuracy: 0.8333
- val_loss: 0.3656 - val_accuracy: 0.9222
Epoch 108/150
60/60 [==============================] - 0s 117us/step - loss: 0.4330 - accuracy: 0.8333
- val_loss: 0.3632 - val_accuracy: 0.9222
Epoch 109/150
60/60 [==============================] - 0s 150us/step - loss: 0.4306 - accuracy: 0.8333
- val_loss: 0.3609 - val_accuracy: 0.9222
Epoch 110/150
60/60 [==============================] - 0s 200us/step - loss: 0.4284 - accuracy: 0.8333
- val_loss: 0.3586 - val_accuracy: 0.9222
Epoch 111/150
60/60 [==============================] - 0s 176us/step - loss: 0.4261 - accuracy: 0.8333
- val_loss: 0.3564 - val_accuracy: 0.9222
Epoch 112/150
60/60 [==============================] - 0s 117us/step - loss: 0.4240 - accuracy: 0.8333
- val_loss: 0.3542 - val_accuracy: 0.9222
Epoch 113/150
60/60 [==============================] - 0s 150us/step - loss: 0.4217 - accuracy: 0.8333
- val_loss: 0.3520 - val_accuracy: 0.9222
Epoch 114/150
60/60 [==============================] - 0s 217us/step - loss: 0.4195 - accuracy: 0.8333
- val_loss: 0.3499 - val_accuracy: 0.9222
Epoch 115/150
60/60 [==============================] - 0s 150us/step - loss: 0.4174 - accuracy: 0.8333
- val_loss: 0.3477 - val_accuracy: 0.9222
Epoch 116/150
60/60 [==============================] - 0s 133us/step - loss: 0.4152 - accuracy: 0.8333
- val_loss: 0.3457 - val_accuracy: 0.9222
Epoch 117/150
60/60 [==============================] - 0s 200us/step - loss: 0.4130 - accuracy: 0.8333
- val_loss: 0.3436 - val_accuracy: 0.9222
Epoch 118/150
60/60 [==============================] - 0s 150us/step - loss: 0.4109 - accuracy: 0.8333
- val_loss: 0.3416 - val_accuracy: 0.9222
Epoch 119/150
60/60 [==============================] - 0s 133us/step - loss: 0.4088 - accuracy: 0.8333
- val_loss: 0.3396 - val_accuracy: 0.9222
Epoch 120/150
60/60 [==============================] - 0s 167us/step - loss: 0.4069 - accuracy: 0.8333
- val_loss: 0.3376 - val_accuracy: 0.9222
Epoch 121/150
60/60 [==============================] - 0s 167us/step - loss: 0.4048 - accuracy: 0.8333
```

```
- val_loss: 0.3357 - val_accuracy: 0.9222
Epoch 122/150
60/60 [==============================] - 0s 133us/step - loss: 0.4027 - accuracy: 0.8333
- val_loss: 0.3337 - val_accuracy: 0.9333
Epoch 123/150
60/60 [==============================] - 0s 183us/step - loss: 0.4007 - accuracy: 0.8333
- val_loss: 0.3318 - val_accuracy: 0.9333
Epoch 124/150
60/60 [==============================] - 0s 183us/step - loss: 0.3988 - accuracy: 0.8333
- val_loss: 0.3300 - val_accuracy: 0.9333
Epoch 125/150
60/60 [==============================] - 0s 150us/step - loss: 0.3968 - accuracy: 0.8333
- val_loss: 0.3281 - val_accuracy: 0.9333
Epoch 126/150
60/60 [==============================] - 0s 117us/step - loss: 0.3948 - accuracy: 0.8667
- val_loss: 0.3263 - val_accuracy: 0.9333
Epoch 127/150
60/60 [==============================] - 0s 183us/step - loss: 0.3929 - accuracy: 0.8667
- val_loss: 0.3245 - val_accuracy: 0.9333
Epoch 128/150
60/60 [==============================] - 0s 233us/step - loss: 0.3910 - accuracy: 0.8667
- val_loss: 0.3227 - val_accuracy: 0.9333
Epoch 129/150
60/60 [==============================] - 0s 200us/step - loss: 0.3892 - accuracy: 0.8833
- val_loss: 0.3209 - val_accuracy: 0.9333
Epoch 130/150
60/60 [==============================] - 0s 200us/step - loss: 0.3873 - accuracy: 0.8833
- val_loss: 0.3192 - val_accuracy: 0.9333
Epoch 131/150
60/60 [==============================] - 0s 183us/step - loss: 0.3854 - accuracy: 0.8833
- val_loss: 0.3175 - val_accuracy: 0.9333
Epoch 132/150
60/60 [==============================] - 0s 217us/step - loss: 0.3836 - accuracy: 0.8833
- val_loss: 0.3158 - val_accuracy: 0.9333
Epoch 133/150
60/60 [==============================] - 0s 200us/step - loss: 0.3818 - accuracy: 0.8833
- val_loss: 0.3141 - val_accuracy: 0.9333
Epoch 134/150
60/60 [==============================] - 0s 233us/step - loss: 0.3800 - accuracy: 0.8833
- val_loss: 0.3124 - val_accuracy: 0.9333
Epoch 135/150
60/60 [==============================] - 0s 200us/step - loss: 0.3783 - accuracy: 0.8833
- val_loss: 0.3108 - val_accuracy: 0.9333
Epoch 136/150
60/60 [==============================] - 0s 167us/step - loss: 0.3764 - accuracy: 0.8833
- val_loss: 0.3092 - val_accuracy: 0.9333
Epoch 137/150
60/60 [==============================] - 0s 167us/step - loss: 0.3747 - accuracy: 0.8833
- val_loss: 0.3076 - val_accuracy: 0.9333
Epoch 138/150
60/60 [==============================] - 0s 150us/step - loss: 0.3730 - accuracy: 0.8833
- val_loss: 0.3060 - val_accuracy: 0.9333
Epoch 139/150
60/60 [==============================] - 0s 250us/step - loss: 0.3713 - accuracy: 0.8833
- val_loss: 0.3044 - val_accuracy: 0.9333
Epoch 140/150
60/60 [==============================] - 0s 233us/step - loss: 0.3696 - accuracy: 0.8833
- val_loss: 0.3029 - val_accuracy: 0.9444
Epoch 141/150
60/60 [==============================] - 0s 233us/step - loss: 0.3679 - accuracy: 0.8833
- val_loss: 0.3013 - val_accuracy: 0.9444
Epoch 142/150
60/60 [==============================] - 0s 233us/step - loss: 0.3662 - accuracy: 0.8833
- val_loss: 0.2998 - val_accuracy: 0.9444
Epoch 143/150
```

```
60/60 [==============================] - 0s 217us/step - loss: 0.3646 - accuracy: 0.8833
- val_loss: 0.2983 - val_accuracy: 0.9444
Epoch 144/150
60/60 [==============================] - 0s 200us/step - loss: 0.3630 - accuracy: 0.8833
- val_loss: 0.2968 - val_accuracy: 0.9444
Epoch 145/150
60/60 [==============================] - 0s 183us/step - loss: 0.3614 - accuracy: 0.9000
- val_loss: 0.2954 - val_accuracy: 0.9444
Epoch 146/150
60/60 [==============================] - 0s 183us/step - loss: 0.3597 - accuracy: 0.9000
- val_loss: 0.2939 - val_accuracy: 0.9444
Epoch 147/150
60/60 [==============================] - 0s 167us/step - loss: 0.3581 - accuracy: 0.9167
- val_loss: 0.2925 - val_accuracy: 0.9444
Epoch 148/150
60/60 [==============================] - 0s 167us/step - loss: 0.3565 - accuracy: 0.9167
- val_loss: 0.2910 - val_accuracy: 0.9444
Epoch 149/150
60/60 [==============================] - 0s 233us/step - loss: 0.3550 - accuracy: 0.9167
- val_loss: 0.2896 - val_accuracy: 0.9444
Epoch 150/150
60/60 [==============================] - 0s 217us/step - loss: 0.3534 - accuracy: 0.9167
- val_loss: 0.2882 - val_accuracy: 0.9444
```

Out[33]:
```
<keras.callbacks.callbacks.History at 0x1d2f705a2b0>
```

In [34]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [35]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 e) Test 5: Split the X and Y into training and test sets and let us use a training dataset of 0.7 or 30% with a same number of epochs

In [36]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.7)
```

In [37]:
```
print(X_train.shape, X_test.shape)
```

```
(45, 4) (105, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [38]:
```

```

```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [39]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 150 epochs and see how it performs on training and test data sets

In [40]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=150)
```

```
Train on 45 samples, validate on 105 samples
Epoch 1/150
45/45 [==============================] - 0s 3ms/step - loss: 0.9482 - accuracy: 0.6889 -
val_loss: 0.9328 - val_accuracy: 0.5810
Epoch 2/150
45/45 [==============================] - 0s 289us/step - loss: 0.9320 - accuracy: 0.6889
- val_loss: 0.9206 - val_accuracy: 0.5905
Epoch 3/150
45/45 [==============================] - 0s 267us/step - loss: 0.9165 - accuracy: 0.6889
- val_loss: 0.9086 - val_accuracy: 0.5905
Epoch 4/150
45/45 [==============================] - 0s 311us/step - loss: 0.9000 - accuracy: 0.7111
- val_loss: 0.8970 - val_accuracy: 0.6000
Epoch 5/150
45/45 [==============================] - 0s 267us/step - loss: 0.8857 - accuracy: 0.7111
- val_loss: 0.8855 - val_accuracy: 0.6095
Epoch 6/150
45/45 [==============================] - 0s 244us/step - loss: 0.8700 - accuracy: 0.7111
- val_loss: 0.8743 - val_accuracy: 0.6286
Epoch 7/150
45/45 [==============================] - 0s 156us/step - loss: 0.8558 - accuracy: 0.7111
- val_loss: 0.8634 - val_accuracy: 0.6286
Epoch 8/150
45/45 [==============================] - 0s 222us/step - loss: 0.8420 - accuracy: 0.7111
- val_loss: 0.8528 - val_accuracy: 0.6286
Epoch 9/150
45/45 [==============================] - 0s 289us/step - loss: 0.8285 - accuracy: 0.7111
- val_loss: 0.8425 - val_accuracy: 0.6286
Epoch 10/150
45/45 [==============================] - 0s 267us/step - loss: 0.8150 - accuracy: 0.7111
- val_loss: 0.8325 - val_accuracy: 0.6286
Epoch 11/150
45/45 [==============================] - 0s 222us/step - loss: 0.8020 - accuracy: 0.7333
- val_loss: 0.8228 - val_accuracy: 0.6286
Epoch 12/150
45/45 [==============================] - 0s 267us/step - loss: 0.7891 - accuracy: 0.7333
- val_loss: 0.8134 - val_accuracy: 0.6286
Epoch 13/150
45/45 [==============================] - 0s 222us/step - loss: 0.7768 - accuracy: 0.7333
- val_loss: 0.8041 - val_accuracy: 0.6286
Epoch 14/150
45/45 [==============================] - 0s 311us/step - loss: 0.7647 - accuracy: 0.7333
- val_loss: 0.7952 - val_accuracy: 0.6286
Epoch 15/150
45/45 [==============================] - 0s 245us/step - loss: 0.7530 - accuracy: 0.7333
- val_loss: 0.7864 - val_accuracy: 0.6286
Epoch 16/150
```

```
45/45 [==============================] - 0s 267us/step - loss: 0.7418 - accuracy: 0.7333
- val_loss: 0.7779 - val_accuracy: 0.6286
Epoch 17/150
45/45 [==============================] - 0s 178us/step - loss: 0.7309 - accuracy: 0.7333
- val_loss: 0.7696 - val_accuracy: 0.6286
Epoch 18/150
45/45 [==============================] - 0s 267us/step - loss: 0.7203 - accuracy: 0.7333
- val_loss: 0.7615 - val_accuracy: 0.6286
Epoch 19/150
45/45 [==============================] - 0s 244us/step - loss: 0.7098 - accuracy: 0.7333
- val_loss: 0.7537 - val_accuracy: 0.6286
Epoch 20/150
45/45 [==============================] - 0s 311us/step - loss: 0.6998 - accuracy: 0.7333
- val_loss: 0.7461 - val_accuracy: 0.6286
Epoch 21/150
45/45 [==============================] - 0s 289us/step - loss: 0.6896 - accuracy: 0.7333
- val_loss: 0.7387 - val_accuracy: 0.6286
Epoch 22/150
45/45 [==============================] - 0s 289us/step - loss: 0.6811 - accuracy: 0.7333
- val_loss: 0.7315 - val_accuracy: 0.6286
Epoch 23/150
45/45 [==============================] - 0s 289us/step - loss: 0.6717 - accuracy: 0.7333
- val_loss: 0.7246 - val_accuracy: 0.6286
Epoch 24/150
45/45 [==============================] - 0s 156us/step - loss: 0.6625 - accuracy: 0.7333
- val_loss: 0.7178 - val_accuracy: 0.6286
Epoch 25/150
45/45 [==============================] - 0s 244us/step - loss: 0.6544 - accuracy: 0.7333
- val_loss: 0.7112 - val_accuracy: 0.6286
Epoch 26/150
45/45 [==============================] - 0s 267us/step - loss: 0.6456 - accuracy: 0.7333
- val_loss: 0.7048 - val_accuracy: 0.6286
Epoch 27/150
45/45 [==============================] - 0s 311us/step - loss: 0.6375 - accuracy: 0.7333
- val_loss: 0.6986 - val_accuracy: 0.6286
Epoch 28/150
45/45 [==============================] - 0s 289us/step - loss: 0.6294 - accuracy: 0.7333
- val_loss: 0.6924 - val_accuracy: 0.6286
Epoch 29/150
45/45 [==============================] - 0s 289us/step - loss: 0.6218 - accuracy: 0.7333
- val_loss: 0.6864 - val_accuracy: 0.6286
Epoch 30/150
45/45 [==============================] - 0s 200us/step - loss: 0.6141 - accuracy: 0.7333
- val_loss: 0.6806 - val_accuracy: 0.6286
Epoch 31/150
45/45 [==============================] - 0s 245us/step - loss: 0.6067 - accuracy: 0.7333
- val_loss: 0.6749 - val_accuracy: 0.6286
Epoch 32/150
45/45 [==============================] - 0s 289us/step - loss: 0.5996 - accuracy: 0.7333
- val_loss: 0.6694 - val_accuracy: 0.6286
Epoch 33/150
45/45 [==============================] - 0s 223us/step - loss: 0.5924 - accuracy: 0.7333
- val_loss: 0.6641 - val_accuracy: 0.6286
Epoch 34/150
45/45 [==============================] - 0s 245us/step - loss: 0.5860 - accuracy: 0.7333
- val_loss: 0.6589 - val_accuracy: 0.6286
Epoch 35/150
45/45 [==============================] - 0s 222us/step - loss: 0.5792 - accuracy: 0.7333
- val_loss: 0.6538 - val_accuracy: 0.6286
Epoch 36/150
45/45 [==============================] - 0s 289us/step - loss: 0.5729 - accuracy: 0.7333
- val_loss: 0.6489 - val_accuracy: 0.6286
Epoch 37/150
45/45 [==============================] - 0s 244us/step - loss: 0.5667 - accuracy: 0.7333
- val_loss: 0.6442 - val_accuracy: 0.6286
```

```
Epoch 38/150
45/45 [==============================] - 0s 267us/step - loss: 0.5608 - accuracy: 0.7556
- val_loss: 0.6396 - val_accuracy: 0.6286
Epoch 39/150
45/45 [==============================] - 0s 267us/step - loss: 0.5550 - accuracy: 0.7556
- val_loss: 0.6351 - val_accuracy: 0.6286
Epoch 40/150
45/45 [==============================] - 0s 222us/step - loss: 0.5491 - accuracy: 0.7556
- val_loss: 0.6307 - val_accuracy: 0.6286
Epoch 41/150
45/45 [==============================] - 0s 222us/step - loss: 0.5437 - accuracy: 0.7556
- val_loss: 0.6265 - val_accuracy: 0.6286
Epoch 42/150
45/45 [==============================] - 0s 311us/step - loss: 0.5382 - accuracy: 0.7556
- val_loss: 0.6223 - val_accuracy: 0.6286
Epoch 43/150
45/45 [==============================] - 0s 333us/step - loss: 0.5331 - accuracy: 0.7556
- val_loss: 0.6182 - val_accuracy: 0.6286
Epoch 44/150
45/45 [==============================] - 0s 267us/step - loss: 0.5280 - accuracy: 0.7556
- val_loss: 0.6142 - val_accuracy: 0.6286
Epoch 45/150
45/45 [==============================] - 0s 267us/step - loss: 0.5229 - accuracy: 0.7778
- val_loss: 0.6103 - val_accuracy: 0.6286
Epoch 46/150
45/45 [==============================] - 0s 156us/step - loss: 0.5182 - accuracy: 0.7778
- val_loss: 0.6065 - val_accuracy: 0.6286
Epoch 47/150
45/45 [==============================] - 0s 245us/step - loss: 0.5132 - accuracy: 0.7778
- val_loss: 0.6027 - val_accuracy: 0.6286
Epoch 48/150
45/45 [==============================] - 0s 222us/step - loss: 0.5087 - accuracy: 0.7778
- val_loss: 0.5991 - val_accuracy: 0.6286
Epoch 49/150
45/45 [==============================] - 0s 156us/step - loss: 0.5042 - accuracy: 0.7778
- val_loss: 0.5955 - val_accuracy: 0.6286
Epoch 50/150
45/45 [==============================] - 0s 267us/step - loss: 0.4999 - accuracy: 0.7778
- val_loss: 0.5921 - val_accuracy: 0.6286
Epoch 51/150
45/45 [==============================] - 0s 222us/step - loss: 0.4954 - accuracy: 0.7778
- val_loss: 0.5887 - val_accuracy: 0.6286
Epoch 52/150
45/45 [==============================] - 0s 200us/step - loss: 0.4914 - accuracy: 0.7778
- val_loss: 0.5853 - val_accuracy: 0.6286
Epoch 53/150
45/45 [==============================] - 0s 244us/step - loss: 0.4872 - accuracy: 0.7778
- val_loss: 0.5821 - val_accuracy: 0.6286
Epoch 54/150
45/45 [==============================] - 0s 244us/step - loss: 0.4832 - accuracy: 0.7778
- val_loss: 0.5790 - val_accuracy: 0.6286
Epoch 55/150
45/45 [==============================] - 0s 200us/step - loss: 0.4792 - accuracy: 0.7778
- val_loss: 0.5759 - val_accuracy: 0.6286
Epoch 56/150
45/45 [==============================] - 0s 156us/step - loss: 0.4754 - accuracy: 0.7778
- val_loss: 0.5729 - val_accuracy: 0.6286
Epoch 57/150
45/45 [==============================] - 0s 222us/step - loss: 0.4716 - accuracy: 0.7778
- val_loss: 0.5699 - val_accuracy: 0.6381
Epoch 58/150
45/45 [==============================] - 0s 200us/step - loss: 0.4678 - accuracy: 0.8000
- val_loss: 0.5670 - val_accuracy: 0.6476
Epoch 59/150
45/45 [==============================] - 0s 222us/step - loss: 0.4642 - accuracy: 0.8000
```

```
- val_loss: 0.5641 - val_accuracy: 0.6476
Epoch 60/150
45/45 [==============================] - 0s 245us/step - loss: 0.4607 - accuracy: 0.8000
- val_loss: 0.5613 - val_accuracy: 0.6476
Epoch 61/150
45/45 [==============================] - 0s 178us/step - loss: 0.4573 - accuracy: 0.8222
- val_loss: 0.5585 - val_accuracy: 0.6667
Epoch 62/150
45/45 [==============================] - 0s 222us/step - loss: 0.4538 - accuracy: 0.8222
- val_loss: 0.5558 - val_accuracy: 0.6667
Epoch 63/150
45/45 [==============================] - 0s 200us/step - loss: 0.4505 - accuracy: 0.8222
- val_loss: 0.5531 - val_accuracy: 0.6762
Epoch 64/150
45/45 [==============================] - 0s 155us/step - loss: 0.4473 - accuracy: 0.8222
- val_loss: 0.5504 - val_accuracy: 0.6857
Epoch 65/150
45/45 [==============================] - 0s 222us/step - loss: 0.4442 - accuracy: 0.8222
- val_loss: 0.5478 - val_accuracy: 0.6857
Epoch 66/150
45/45 [==============================] - 0s 222us/step - loss: 0.4410 - accuracy: 0.8222
- val_loss: 0.5453 - val_accuracy: 0.6952
Epoch 67/150
45/45 [==============================] - 0s 267us/step - loss: 0.4380 - accuracy: 0.8222
- val_loss: 0.5428 - val_accuracy: 0.7048
Epoch 68/150
45/45 [==============================] - 0s 200us/step - loss: 0.4350 - accuracy: 0.8222
- val_loss: 0.5404 - val_accuracy: 0.7143
Epoch 69/150
45/45 [==============================] - 0s 244us/step - loss: 0.4322 - accuracy: 0.8222
- val_loss: 0.5380 - val_accuracy: 0.7143
Epoch 70/150
45/45 [==============================] - 0s 200us/step - loss: 0.4293 - accuracy: 0.8444
- val_loss: 0.5356 - val_accuracy: 0.7238
Epoch 71/150
45/45 [==============================] - 0s 200us/step - loss: 0.4264 - accuracy: 0.8444
- val_loss: 0.5333 - val_accuracy: 0.7238
Epoch 72/150
45/45 [==============================] - 0s 200us/step - loss: 0.4238 - accuracy: 0.8444
- val_loss: 0.5310 - val_accuracy: 0.7238
Epoch 73/150
45/45 [==============================] - 0s 222us/step - loss: 0.4210 - accuracy: 0.8444
- val_loss: 0.5287 - val_accuracy: 0.7333
Epoch 74/150
45/45 [==============================] - 0s 244us/step - loss: 0.4183 - accuracy: 0.8444
- val_loss: 0.5264 - val_accuracy: 0.7524
Epoch 75/150
45/45 [==============================] - 0s 200us/step - loss: 0.4157 - accuracy: 0.8444
- val_loss: 0.5241 - val_accuracy: 0.7524
Epoch 76/150
45/45 [==============================] - 0s 267us/step - loss: 0.4133 - accuracy: 0.8444
- val_loss: 0.5219 - val_accuracy: 0.7524
Epoch 77/150
45/45 [==============================] - 0s 400us/step - loss: 0.4106 - accuracy: 0.8444
- val_loss: 0.5197 - val_accuracy: 0.7524
Epoch 78/150
45/45 [==============================] - 0s 333us/step - loss: 0.4083 - accuracy: 0.8444
- val_loss: 0.5176 - val_accuracy: 0.7619
Epoch 79/150
45/45 [==============================] - 0s 244us/step - loss: 0.4058 - accuracy: 0.8667
- val_loss: 0.5155 - val_accuracy: 0.7619
Epoch 80/150
45/45 [==============================] - 0s 356us/step - loss: 0.4034 - accuracy: 0.8667
- val_loss: 0.5135 - val_accuracy: 0.7714
Epoch 81/150
```

```
45/45 [==============================] - 0s 244us/step - loss: 0.4011 - accuracy: 0.8667
- val_loss: 0.5114 - val_accuracy: 0.7714
Epoch 82/150
45/45 [==============================] - 0s 311us/step - loss: 0.3988 - accuracy: 0.8667
- val_loss: 0.5094 - val_accuracy: 0.7714
Epoch 83/150
45/45 [==============================] - 0s 311us/step - loss: 0.3966 - accuracy: 0.8667
- val_loss: 0.5074 - val_accuracy: 0.7714
Epoch 84/150
45/45 [==============================] - 0s 333us/step - loss: 0.3945 - accuracy: 0.8667
- val_loss: 0.5053 - val_accuracy: 0.7714
Epoch 85/150
45/45 [==============================] - 0s 333us/step - loss: 0.3924 - accuracy: 0.8667
- val_loss: 0.5033 - val_accuracy: 0.7714
Epoch 86/150
45/45 [==============================] - 0s 311us/step - loss: 0.3903 - accuracy: 0.8667
- val_loss: 0.5013 - val_accuracy: 0.7810
Epoch 87/150
45/45 [==============================] - 0s 333us/step - loss: 0.3881 - accuracy: 0.8667
- val_loss: 0.4993 - val_accuracy: 0.7810
Epoch 88/150
45/45 [==============================] - 0s 311us/step - loss: 0.3862 - accuracy: 0.8667
- val_loss: 0.4974 - val_accuracy: 0.7810
Epoch 89/150
45/45 [==============================] - 0s 289us/step - loss: 0.3841 - accuracy: 0.8667
- val_loss: 0.4955 - val_accuracy: 0.7810
Epoch 90/150
45/45 [==============================] - 0s 244us/step - loss: 0.3823 - accuracy: 0.8889
- val_loss: 0.4936 - val_accuracy: 0.7810
Epoch 91/150
45/45 [==============================] - 0s 333us/step - loss: 0.3803 - accuracy: 0.8889
- val_loss: 0.4918 - val_accuracy: 0.7810
Epoch 92/150
45/45 [==============================] - 0s 244us/step - loss: 0.3783 - accuracy: 0.8889
- val_loss: 0.4901 - val_accuracy: 0.7810
Epoch 93/150
45/45 [==============================] - 0s 200us/step - loss: 0.3766 - accuracy: 0.8889
- val_loss: 0.4883 - val_accuracy: 0.7810
Epoch 94/150
45/45 [==============================] - 0s 222us/step - loss: 0.3746 - accuracy: 0.8889
- val_loss: 0.4865 - val_accuracy: 0.7905
Epoch 95/150
45/45 [==============================] - 0s 311us/step - loss: 0.3729 - accuracy: 0.8889
- val_loss: 0.4847 - val_accuracy: 0.7905
Epoch 96/150
45/45 [==============================] - 0s 356us/step - loss: 0.3710 - accuracy: 0.8889
- val_loss: 0.4830 - val_accuracy: 0.7905
Epoch 97/150
45/45 [==============================] - 0s 289us/step - loss: 0.3693 - accuracy: 0.8889
- val_loss: 0.4814 - val_accuracy: 0.7905
Epoch 98/150
45/45 [==============================] - 0s 289us/step - loss: 0.3675 - accuracy: 0.8889
- val_loss: 0.4799 - val_accuracy: 0.7905
Epoch 99/150
45/45 [==============================] - 0s 267us/step - loss: 0.3658 - accuracy: 0.8889
- val_loss: 0.4784 - val_accuracy: 0.7905
Epoch 100/150
45/45 [==============================] - 0s 267us/step - loss: 0.3641 - accuracy: 0.8889
- val_loss: 0.4769 - val_accuracy: 0.7905
Epoch 101/150
45/45 [==============================] - 0s 178us/step - loss: 0.3624 - accuracy: 0.8889
- val_loss: 0.4754 - val_accuracy: 0.7905
Epoch 102/150
45/45 [==============================] - 0s 267us/step - loss: 0.3608 - accuracy: 0.8889
- val_loss: 0.4739 - val_accuracy: 0.7905
```

```
Epoch 103/150
45/45 [==============================] - 0s 222us/step - loss: 0.3591 - accuracy: 0.8889
- val_loss: 0.4724 - val_accuracy: 0.7905
Epoch 104/150
45/45 [==============================] - 0s 311us/step - loss: 0.3575 - accuracy: 0.8889
- val_loss: 0.4708 - val_accuracy: 0.7905
Epoch 105/150
45/45 [==============================] - 0s 333us/step - loss: 0.3560 - accuracy: 0.8889
- val_loss: 0.4692 - val_accuracy: 0.7810
Epoch 106/150
45/45 [==============================] - 0s 333us/step - loss: 0.3542 - accuracy: 0.8889
- val_loss: 0.4676 - val_accuracy: 0.7905
Epoch 107/150
45/45 [==============================] - 0s 267us/step - loss: 0.3528 - accuracy: 0.8889
- val_loss: 0.4660 - val_accuracy: 0.7905
Epoch 108/150
45/45 [==============================] - 0s 244us/step - loss: 0.3513 - accuracy: 0.8889
- val_loss: 0.4644 - val_accuracy: 0.8000
Epoch 109/150
45/45 [==============================] - 0s 222us/step - loss: 0.3496 - accuracy: 0.8889
- val_loss: 0.4629 - val_accuracy: 0.8095
Epoch 110/150
45/45 [==============================] - 0s 178us/step - loss: 0.3482 - accuracy: 0.8889
- val_loss: 0.4613 - val_accuracy: 0.8095
Epoch 111/150
45/45 [==============================] - 0s 267us/step - loss: 0.3466 - accuracy: 0.8889
- val_loss: 0.4598 - val_accuracy: 0.8190
Epoch 112/150
45/45 [==============================] - 0s 244us/step - loss: 0.3452 - accuracy: 0.8889
- val_loss: 0.4583 - val_accuracy: 0.8190
Epoch 113/150
45/45 [==============================] - 0s 222us/step - loss: 0.3439 - accuracy: 0.8889
- val_loss: 0.4567 - val_accuracy: 0.8190
Epoch 114/150
45/45 [==============================] - 0s 200us/step - loss: 0.3424 - accuracy: 0.8889
- val_loss: 0.4552 - val_accuracy: 0.8190
Epoch 115/150
45/45 [==============================] - 0s 244us/step - loss: 0.3409 - accuracy: 0.8889
- val_loss: 0.4538 - val_accuracy: 0.8190
Epoch 116/150
45/45 [==============================] - 0s 244us/step - loss: 0.3396 - accuracy: 0.8889
- val_loss: 0.4523 - val_accuracy: 0.8190
Epoch 117/150
45/45 [==============================] - 0s 156us/step - loss: 0.3382 - accuracy: 0.8889
- val_loss: 0.4509 - val_accuracy: 0.8190
Epoch 118/150
45/45 [==============================] - 0s 200us/step - loss: 0.3368 - accuracy: 0.8889
- val_loss: 0.4495 - val_accuracy: 0.8190
Epoch 119/150
45/45 [==============================] - 0s 267us/step - loss: 0.3355 - accuracy: 0.8889
- val_loss: 0.4482 - val_accuracy: 0.8190
Epoch 120/150
45/45 [==============================] - 0s 200us/step - loss: 0.3341 - accuracy: 0.8889
- val_loss: 0.4468 - val_accuracy: 0.8190
Epoch 121/150
45/45 [==============================] - 0s 244us/step - loss: 0.3329 - accuracy: 0.8889
- val_loss: 0.4455 - val_accuracy: 0.8190
Epoch 122/150
45/45 [==============================] - 0s 289us/step - loss: 0.3315 - accuracy: 0.8889
- val_loss: 0.4442 - val_accuracy: 0.8190
Epoch 123/150
45/45 [==============================] - 0s 200us/step - loss: 0.3302 - accuracy: 0.8889
- val_loss: 0.4430 - val_accuracy: 0.8190
Epoch 124/150
45/45 [==============================] - 0s 178us/step - loss: 0.3289 - accuracy: 0.8889
```

```
- val_loss: 0.4417 - val_accuracy: 0.8190
Epoch 125/150
45/45 [==============================] - 0s 222us/step - loss: 0.3277 - accuracy: 0.8889
- val_loss: 0.4404 - val_accuracy: 0.8190
Epoch 126/150
45/45 [==============================] - 0s 244us/step - loss: 0.3264 - accuracy: 0.8889
- val_loss: 0.4391 - val_accuracy: 0.8190
Epoch 127/150
45/45 [==============================] - 0s 244us/step - loss: 0.3252 - accuracy: 0.8889
- val_loss: 0.4377 - val_accuracy: 0.8190
Epoch 128/150
45/45 [==============================] - 0s 178us/step - loss: 0.3239 - accuracy: 0.8889
- val_loss: 0.4365 - val_accuracy: 0.8190
Epoch 129/150
45/45 [==============================] - 0s 222us/step - loss: 0.3227 - accuracy: 0.8889
- val_loss: 0.4353 - val_accuracy: 0.8190
Epoch 130/150
45/45 [==============================] - 0s 222us/step - loss: 0.3215 - accuracy: 0.8889
- val_loss: 0.4340 - val_accuracy: 0.8190
Epoch 131/150
45/45 [==============================] - 0s 178us/step - loss: 0.3203 - accuracy: 0.8889
- val_loss: 0.4328 - val_accuracy: 0.8286
Epoch 132/150
45/45 [==============================] - 0s 267us/step - loss: 0.3192 - accuracy: 0.8889
- val_loss: 0.4315 - val_accuracy: 0.8286
Epoch 133/150
45/45 [==============================] - 0s 244us/step - loss: 0.3179 - accuracy: 0.8889
- val_loss: 0.4304 - val_accuracy: 0.8286
Epoch 134/150
45/45 [==============================] - 0s 178us/step - loss: 0.3168 - accuracy: 0.8889
- val_loss: 0.4292 - val_accuracy: 0.8286
Epoch 135/150
45/45 [==============================] - 0s 200us/step - loss: 0.3155 - accuracy: 0.8889
- val_loss: 0.4279 - val_accuracy: 0.8286
Epoch 136/150
45/45 [==============================] - 0s 267us/step - loss: 0.3144 - accuracy: 0.8889
- val_loss: 0.4267 - val_accuracy: 0.8286
Epoch 137/150
45/45 [==============================] - 0s 245us/step - loss: 0.3133 - accuracy: 0.8889
- val_loss: 0.4255 - val_accuracy: 0.8286
Epoch 138/150
45/45 [==============================] - 0s 267us/step - loss: 0.3122 - accuracy: 0.8889
- val_loss: 0.4243 - val_accuracy: 0.8286
Epoch 139/150
45/45 [==============================] - 0s 156us/step - loss: 0.3110 - accuracy: 0.8889
- val_loss: 0.4231 - val_accuracy: 0.8190
Epoch 140/150
45/45 [==============================] - 0s 244us/step - loss: 0.3100 - accuracy: 0.8889
- val_loss: 0.4220 - val_accuracy: 0.8190
Epoch 141/150
45/45 [==============================] - 0s 244us/step - loss: 0.3089 - accuracy: 0.8889
- val_loss: 0.4208 - val_accuracy: 0.8190
Epoch 142/150
45/45 [==============================] - 0s 222us/step - loss: 0.3078 - accuracy: 0.8889
- val_loss: 0.4197 - val_accuracy: 0.8190
Epoch 143/150
45/45 [==============================] - 0s 244us/step - loss: 0.3066 - accuracy: 0.8889
- val_loss: 0.4185 - val_accuracy: 0.8190
Epoch 144/150
45/45 [==============================] - 0s 267us/step - loss: 0.3056 - accuracy: 0.8889
- val_loss: 0.4172 - val_accuracy: 0.8190
Epoch 145/150
45/45 [==============================] - 0s 267us/step - loss: 0.3046 - accuracy: 0.8889
- val_loss: 0.4160 - val_accuracy: 0.8190
Epoch 146/150
```

```
45/45 [==============================] - 0s 222us/step - loss: 0.3035 - accuracy: 0.8889
- val_loss: 0.4148 - val_accuracy: 0.8190
Epoch 147/150
45/45 [==============================] - 0s 200us/step - loss: 0.3024 - accuracy: 0.8889
- val_loss: 0.4136 - val_accuracy: 0.8190
Epoch 148/150
45/45 [==============================] - 0s 244us/step - loss: 0.3014 - accuracy: 0.9111
- val_loss: 0.4125 - val_accuracy: 0.8190
Epoch 149/150
45/45 [==============================] - 0s 289us/step - loss: 0.3004 - accuracy: 0.9111
- val_loss: 0.4113 - val_accuracy: 0.8286
Epoch 150/150
45/45 [==============================] - 0s 267us/step - loss: 0.2993 - accuracy: 0.9111
- val_loss: 0.4102 - val_accuracy: 0.8286
```

Out[40]:
```
<keras.callbacks.callbacks.History at 0x1d2f8397fd0>
```

In [41]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [42]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 f) Test 6: Split the X and Y into training and test sets and let us use a training dataset of 0.8 or 20% with a same number of epochs

In [43]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.8)
```

In [44]:
```
print(X_train.shape, X_test.shape)
```

```
(30, 4) (120, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [45]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [46]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 150 epochs and see how it performs on training and test data sets

In [47]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=150)
```

```
Train on 30 samples, validate on 120 samples
Epoch 1/150
30/30 [==============================] - 0s 4ms/step - loss: 1.0353 - accuracy: 0.5000 -
val_loss: 1.0665 - val_accuracy: 0.3750
Epoch 2/150
30/30 [==============================] - 0s 267us/step - loss: 1.0304 - accuracy: 0.5000
- val_loss: 1.0609 - val_accuracy: 0.3750
Epoch 3/150
30/30 [==============================] - 0s 201us/step - loss: 1.0240 - accuracy: 0.5000
- val_loss: 1.0558 - val_accuracy: 0.3750
Epoch 4/150
30/30 [==============================] - 0s 267us/step - loss: 1.0181 - accuracy: 0.4667
- val_loss: 1.0502 - val_accuracy: 0.3750
Epoch 5/150
30/30 [==============================] - 0s 201us/step - loss: 1.0117 - accuracy: 0.4667
- val_loss: 1.0448 - val_accuracy: 0.3833
Epoch 6/150
30/30 [==============================] - 0s 333us/step - loss: 1.0057 - accuracy: 0.4667
- val_loss: 1.0393 - val_accuracy: 0.3833
Epoch 7/150
30/30 [==============================] - 0s 233us/step - loss: 0.9994 - accuracy: 0.4667
- val_loss: 1.0338 - val_accuracy: 0.4000
Epoch 8/150
30/30 [==============================] - 0s 300us/step - loss: 0.9932 - accuracy: 0.4667
- val_loss: 1.0284 - val_accuracy: 0.4000
Epoch 9/150
30/30 [==============================] - 0s 300us/step - loss: 0.9872 - accuracy: 0.4667
- val_loss: 1.0230 - val_accuracy: 0.4083
Epoch 10/150
30/30 [==============================] - 0s 267us/step - loss: 0.9811 - accuracy: 0.5000
- val_loss: 1.0177 - val_accuracy: 0.4083
Epoch 11/150
30/30 [==============================] - 0s 300us/step - loss: 0.9750 - accuracy: 0.5000
- val_loss: 1.0123 - val_accuracy: 0.4083
Epoch 12/150
30/30 [==============================] - 0s 267us/step - loss: 0.9691 - accuracy: 0.5000
- val_loss: 1.0070 - val_accuracy: 0.4167
Epoch 13/150
30/30 [==============================] - 0s 233us/step - loss: 0.9631 - accuracy: 0.5000
- val_loss: 1.0017 - val_accuracy: 0.4250
Epoch 14/150
30/30 [==============================] - 0s 300us/step - loss: 0.9571 - accuracy: 0.5000
- val_loss: 0.9965 - val_accuracy: 0.4417
Epoch 15/150
30/30 [==============================] - 0s 267us/step - loss: 0.9512 - accuracy: 0.5000
- val_loss: 0.9913 - val_accuracy: 0.4667
Epoch 16/150
30/30 [==============================] - 0s 267us/step - loss: 0.9454 - accuracy: 0.5000
- val_loss: 0.9861 - val_accuracy: 0.4750
Epoch 17/150
30/30 [==============================] - 0s 268us/step - loss: 0.9396 - accuracy: 0.5333
- val_loss: 0.9809 - val_accuracy: 0.5000
Epoch 18/150
30/30 [==============================] - 0s 200us/step - loss: 0.9338 - accuracy: 0.5333
- val_loss: 0.9758 - val_accuracy: 0.5083
Epoch 19/150
30/30 [==============================] - 0s 300us/step - loss: 0.9281 - accuracy: 0.5333
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- val_loss: 0.9708 - val_accuracy: 0.5000
Epoch 20/150
30/30 [==============================] - 0s 233us/step - loss: 0.9225 - accuracy: 0.5667
- val_loss: 0.9658 - val_accuracy: 0.4917
Epoch 21/150
30/30 [==============================] - 0s 333us/step - loss: 0.9169 - accuracy: 0.5667
- val_loss: 0.9609 - val_accuracy: 0.4750
Epoch 22/150
30/30 [==============================] - 0s 367us/step - loss: 0.9114 - accuracy: 0.5333
- val_loss: 0.9560 - val_accuracy: 0.4750
Epoch 23/150
30/30 [==============================] - 0s 200us/step - loss: 0.9059 - accuracy: 0.5333
- val_loss: 0.9511 - val_accuracy: 0.4667
Epoch 24/150
30/30 [==============================] - 0s 267us/step - loss: 0.9004 - accuracy: 0.5333
- val_loss: 0.9463 - val_accuracy: 0.4667
Epoch 25/150
30/30 [==============================] - 0s 300us/step - loss: 0.8950 - accuracy: 0.5667
- val_loss: 0.9416 - val_accuracy: 0.4750
Epoch 26/150
30/30 [==============================] - 0s 200us/step - loss: 0.8898 - accuracy: 0.5667
- val_loss: 0.9368 - val_accuracy: 0.4750
Epoch 27/150
30/30 [==============================] - 0s 367us/step - loss: 0.8845 - accuracy: 0.5667
- val_loss: 0.9321 - val_accuracy: 0.4750
Epoch 28/150
30/30 [==============================] - 0s 300us/step - loss: 0.8793 - accuracy: 0.5667
- val_loss: 0.9274 - val_accuracy: 0.4750
Epoch 29/150
30/30 [==============================] - 0s 200us/step - loss: 0.8742 - accuracy: 0.6000
- val_loss: 0.9228 - val_accuracy: 0.4833
Epoch 30/150
30/30 [==============================] - 0s 333us/step - loss: 0.8692 - accuracy: 0.6000
- val_loss: 0.9183 - val_accuracy: 0.4667
Epoch 31/150
30/30 [==============================] - 0s 400us/step - loss: 0.8641 - accuracy: 0.6000
- val_loss: 0.9138 - val_accuracy: 0.4583
Epoch 32/150
30/30 [==============================] - 0s 167us/step - loss: 0.8591 - accuracy: 0.6000
- val_loss: 0.9093 - val_accuracy: 0.4750
Epoch 33/150
30/30 [==============================] - 0s 367us/step - loss: 0.8541 - accuracy: 0.6333
- val_loss: 0.9049 - val_accuracy: 0.4917
Epoch 34/150
30/30 [==============================] - 0s 267us/step - loss: 0.8492 - accuracy: 0.6333
- val_loss: 0.9005 - val_accuracy: 0.4833
Epoch 35/150
30/30 [==============================] - 0s 266us/step - loss: 0.8443 - accuracy: 0.6333
- val_loss: 0.8961 - val_accuracy: 0.4833
Epoch 36/150
30/30 [==============================] - 0s 367us/step - loss: 0.8395 - accuracy: 0.5667
- val_loss: 0.8917 - val_accuracy: 0.5000
Epoch 37/150
30/30 [==============================] - 0s 267us/step - loss: 0.8347 - accuracy: 0.5667
- val_loss: 0.8874 - val_accuracy: 0.5083
Epoch 38/150
30/30 [==============================] - 0s 367us/step - loss: 0.8299 - accuracy: 0.5667
- val_loss: 0.8831 - val_accuracy: 0.5250
Epoch 39/150
30/30 [==============================] - 0s 267us/step - loss: 0.8252 - accuracy: 0.5667
- val_loss: 0.8789 - val_accuracy: 0.5417
Epoch 40/150
30/30 [==============================] - 0s 333us/step - loss: 0.8205 - accuracy: 0.5667
- val_loss: 0.8747 - val_accuracy: 0.5417
Epoch 41/150
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30/30 [==============================] - 0s 300us/step - loss: 0.8159 - accuracy: 0.5667
- val_loss: 0.8705 - val_accuracy: 0.5417
Epoch 42/150
30/30 [==============================] - 0s 300us/step - loss: 0.8114 - accuracy: 0.5667
- val_loss: 0.8664 - val_accuracy: 0.5583
Epoch 43/150
30/30 [==============================] - 0s 267us/step - loss: 0.8068 - accuracy: 0.5667
- val_loss: 0.8623 - val_accuracy: 0.5667
Epoch 44/150
30/30 [==============================] - 0s 233us/step - loss: 0.8024 - accuracy: 0.5333
- val_loss: 0.8583 - val_accuracy: 0.5667
Epoch 45/150
30/30 [==============================] - 0s 267us/step - loss: 0.7980 - accuracy: 0.5333
- val_loss: 0.8542 - val_accuracy: 0.5750
Epoch 46/150
30/30 [==============================] - 0s 167us/step - loss: 0.7936 - accuracy: 0.5667
- val_loss: 0.8503 - val_accuracy: 0.5917
Epoch 47/150
30/30 [==============================] - 0s 300us/step - loss: 0.7893 - accuracy: 0.6000
- val_loss: 0.8464 - val_accuracy: 0.5917
Epoch 48/150
30/30 [==============================] - 0s 267us/step - loss: 0.7850 - accuracy: 0.6000
- val_loss: 0.8425 - val_accuracy: 0.6167
Epoch 49/150
30/30 [==============================] - 0s 267us/step - loss: 0.7808 - accuracy: 0.6000
- val_loss: 0.8386 - val_accuracy: 0.6333
Epoch 50/150
30/30 [==============================] - 0s 300us/step - loss: 0.7766 - accuracy: 0.6000
- val_loss: 0.8348 - val_accuracy: 0.6333
Epoch 51/150
30/30 [==============================] - 0s 233us/step - loss: 0.7724 - accuracy: 0.6000
- val_loss: 0.8310 - val_accuracy: 0.6500
Epoch 52/150
30/30 [==============================] - 0s 300us/step - loss: 0.7683 - accuracy: 0.6333
- val_loss: 0.8273 - val_accuracy: 0.6583
Epoch 53/150
30/30 [==============================] - 0s 200us/step - loss: 0.7642 - accuracy: 0.6333
- val_loss: 0.8236 - val_accuracy: 0.6583
Epoch 54/150
30/30 [==============================] - 0s 300us/step - loss: 0.7601 - accuracy: 0.7000
- val_loss: 0.8199 - val_accuracy: 0.6583
Epoch 55/150
30/30 [==============================] - 0s 200us/step - loss: 0.7561 - accuracy: 0.7000
- val_loss: 0.8163 - val_accuracy: 0.6667
Epoch 56/150
30/30 [==============================] - 0s 200us/step - loss: 0.7522 - accuracy: 0.7000
- val_loss: 0.8127 - val_accuracy: 0.6833
Epoch 57/150
30/30 [==============================] - 0s 167us/step - loss: 0.7483 - accuracy: 0.7000
- val_loss: 0.8091 - val_accuracy: 0.6833
Epoch 58/150
30/30 [==============================] - 0s 200us/step - loss: 0.7444 - accuracy: 0.7000
- val_loss: 0.8056 - val_accuracy: 0.6833
Epoch 59/150
30/30 [==============================] - 0s 200us/step - loss: 0.7406 - accuracy: 0.7000
- val_loss: 0.8021 - val_accuracy: 0.6917
Epoch 60/150
30/30 [==============================] - 0s 200us/step - loss: 0.7367 - accuracy: 0.7333
- val_loss: 0.7987 - val_accuracy: 0.6917
Epoch 61/150
30/30 [==============================] - 0s 200us/step - loss: 0.7330 - accuracy: 0.7667
- val_loss: 0.7953 - val_accuracy: 0.7000
Epoch 62/150
30/30 [==============================] - 0s 200us/step - loss: 0.7292 - accuracy: 0.7667
- val_loss: 0.7919 - val_accuracy: 0.7083
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Epoch 63/150
30/30 [==============================] - 0s 133us/step - loss: 0.7254 - accuracy: 0.7667
- val_loss: 0.7885 - val_accuracy: 0.7083
Epoch 64/150
30/30 [==============================] - 0s 267us/step - loss: 0.7217 - accuracy: 0.7667
- val_loss: 0.7852 - val_accuracy: 0.7167
Epoch 65/150
30/30 [==============================] - 0s 200us/step - loss: 0.7180 - accuracy: 0.7667
- val_loss: 0.7818 - val_accuracy: 0.7167
Epoch 66/150
30/30 [==============================] - 0s 300us/step - loss: 0.7143 - accuracy: 0.7667
- val_loss: 0.7785 - val_accuracy: 0.7167
Epoch 67/150
30/30 [==============================] - 0s 167us/step - loss: 0.7106 - accuracy: 0.7667
- val_loss: 0.7753 - val_accuracy: 0.7167
Epoch 68/150
30/30 [==============================] - 0s 233us/step - loss: 0.7069 - accuracy: 0.7667
- val_loss: 0.7720 - val_accuracy: 0.7083
Epoch 69/150
30/30 [==============================] - 0s 167us/step - loss: 0.7033 - accuracy: 0.8000
- val_loss: 0.7688 - val_accuracy: 0.7083
Epoch 70/150
30/30 [==============================] - 0s 200us/step - loss: 0.6997 - accuracy: 0.8000
- val_loss: 0.7655 - val_accuracy: 0.7083
Epoch 71/150
30/30 [==============================] - 0s 167us/step - loss: 0.6962 - accuracy: 0.8000
- val_loss: 0.7623 - val_accuracy: 0.7083
Epoch 72/150
30/30 [==============================] - 0s 333us/step - loss: 0.6926 - accuracy: 0.8000
- val_loss: 0.7592 - val_accuracy: 0.7083
Epoch 73/150
30/30 [==============================] - 0s 300us/step - loss: 0.6891 - accuracy: 0.8000
- val_loss: 0.7560 - val_accuracy: 0.7083
Epoch 74/150
30/30 [==============================] - 0s 200us/step - loss: 0.6856 - accuracy: 0.8000
- val_loss: 0.7529 - val_accuracy: 0.7083
Epoch 75/150
30/30 [==============================] - 0s 200us/step - loss: 0.6822 - accuracy: 0.8000
- val_loss: 0.7499 - val_accuracy: 0.7083
Epoch 76/150
30/30 [==============================] - 0s 233us/step - loss: 0.6788 - accuracy: 0.8000
- val_loss: 0.7468 - val_accuracy: 0.7167
Epoch 77/150
30/30 [==============================] - 0s 300us/step - loss: 0.6754 - accuracy: 0.8000
- val_loss: 0.7438 - val_accuracy: 0.7167
Epoch 78/150
30/30 [==============================] - 0s 167us/step - loss: 0.6720 - accuracy: 0.8000
- val_loss: 0.7408 - val_accuracy: 0.7167
Epoch 79/150
30/30 [==============================] - 0s 267us/step - loss: 0.6686 - accuracy: 0.8000
- val_loss: 0.7378 - val_accuracy: 0.7250
Epoch 80/150
30/30 [==============================] - 0s 167us/step - loss: 0.6653 - accuracy: 0.8000
- val_loss: 0.7348 - val_accuracy: 0.7333
Epoch 81/150
30/30 [==============================] - 0s 300us/step - loss: 0.6620 - accuracy: 0.8000
- val_loss: 0.7319 - val_accuracy: 0.7500
Epoch 82/150
30/30 [==============================] - 0s 166us/step - loss: 0.6587 - accuracy: 0.8000
- val_loss: 0.7290 - val_accuracy: 0.7500
Epoch 83/150
30/30 [==============================] - 0s 267us/step - loss: 0.6555 - accuracy: 0.8000
- val_loss: 0.7261 - val_accuracy: 0.7500
Epoch 84/150
30/30 [==============================] - 0s 200us/step - loss: 0.6523 - accuracy: 0.8000
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- val_loss: 0.7232 - val_accuracy: 0.7500
Epoch 85/150
30/30 [==============================] - 0s 267us/step - loss: 0.6491 - accuracy: 0.8000
- val_loss: 0.7204 - val_accuracy: 0.7500
Epoch 86/150
30/30 [==============================] - 0s 200us/step - loss: 0.6459 - accuracy: 0.8000
- val_loss: 0.7175 - val_accuracy: 0.7500
Epoch 87/150
30/30 [==============================] - 0s 300us/step - loss: 0.6427 - accuracy: 0.8000
- val_loss: 0.7147 - val_accuracy: 0.7500
Epoch 88/150
30/30 [==============================] - 0s 167us/step - loss: 0.6396 - accuracy: 0.8000
- val_loss: 0.7119 - val_accuracy: 0.7583
Epoch 89/150
30/30 [==============================] - 0s 300us/step - loss: 0.6365 - accuracy: 0.8000
- val_loss: 0.7092 - val_accuracy: 0.7667
Epoch 90/150
30/30 [==============================] - 0s 167us/step - loss: 0.6334 - accuracy: 0.8000
- val_loss: 0.7064 - val_accuracy: 0.7667
Epoch 91/150
30/30 [==============================] - 0s 300us/step - loss: 0.6303 - accuracy: 0.8000
- val_loss: 0.7037 - val_accuracy: 0.7667
Epoch 92/150
30/30 [==============================] - 0s 233us/step - loss: 0.6273 - accuracy: 0.8000
- val_loss: 0.7010 - val_accuracy: 0.7667
Epoch 93/150
30/30 [==============================] - 0s 300us/step - loss: 0.6243 - accuracy: 0.8000
- val_loss: 0.6983 - val_accuracy: 0.7667
Epoch 94/150
30/30 [==============================] - 0s 300us/step - loss: 0.6213 - accuracy: 0.8000
- val_loss: 0.6956 - val_accuracy: 0.7750
Epoch 95/150
30/30 [==============================] - 0s 367us/step - loss: 0.6183 - accuracy: 0.8000
- val_loss: 0.6929 - val_accuracy: 0.7750
Epoch 96/150
30/30 [==============================] - 0s 300us/step - loss: 0.6154 - accuracy: 0.8000
- val_loss: 0.6903 - val_accuracy: 0.7750
Epoch 97/150
30/30 [==============================] - 0s 233us/step - loss: 0.6125 - accuracy: 0.8000
- val_loss: 0.6877 - val_accuracy: 0.7750
Epoch 98/150
30/30 [==============================] - 0s 233us/step - loss: 0.6096 - accuracy: 0.8333
- val_loss: 0.6851 - val_accuracy: 0.7750
Epoch 99/150
30/30 [==============================] - 0s 200us/step - loss: 0.6067 - accuracy: 0.8333
- val_loss: 0.6825 - val_accuracy: 0.7750
Epoch 100/150
30/30 [==============================] - 0s 352us/step - loss: 0.6039 - accuracy: 0.8333
- val_loss: 0.6800 - val_accuracy: 0.7750
Epoch 101/150
30/30 [==============================] - 0s 384us/step - loss: 0.6011 - accuracy: 0.8667
- val_loss: 0.6774 - val_accuracy: 0.7833
Epoch 102/150
30/30 [==============================] - 0s 369us/step - loss: 0.5983 - accuracy: 0.8667
- val_loss: 0.6749 - val_accuracy: 0.7833
Epoch 103/150
30/30 [==============================] - 0s 251us/step - loss: 0.5955 - accuracy: 0.8667
- val_loss: 0.6724 - val_accuracy: 0.7833
Epoch 104/150
30/30 [==============================] - 0s 318us/step - loss: 0.5927 - accuracy: 0.8667
- val_loss: 0.6700 - val_accuracy: 0.7833
Epoch 105/150
30/30 [==============================] - 0s 333us/step - loss: 0.5900 - accuracy: 0.8667
- val_loss: 0.6675 - val_accuracy: 0.7833
Epoch 106/150
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30/30 [==============================] - 0s 467us/step - loss: 0.5872 - accuracy: 0.8667
- val_loss: 0.6650 - val_accuracy: 0.7833
Epoch 107/150
30/30 [==============================] - 0s 400us/step - loss: 0.5844 - accuracy: 0.8667
- val_loss: 0.6626 - val_accuracy: 0.7833
Epoch 108/150
30/30 [==============================] - 0s 233us/step - loss: 0.5817 - accuracy: 0.8667
- val_loss: 0.6602 - val_accuracy: 0.7833
Epoch 109/150
30/30 [==============================] - 0s 367us/step - loss: 0.5789 - accuracy: 0.8667
- val_loss: 0.6578 - val_accuracy: 0.7833
Epoch 110/150
30/30 [==============================] - 0s 300us/step - loss: 0.5762 - accuracy: 0.8667
- val_loss: 0.6554 - val_accuracy: 0.7833
Epoch 111/150
30/30 [==============================] - 0s 400us/step - loss: 0.5735 - accuracy: 0.8667
- val_loss: 0.6530 - val_accuracy: 0.7833
Epoch 112/150
30/30 [==============================] - 0s 333us/step - loss: 0.5708 - accuracy: 0.8667
- val_loss: 0.6507 - val_accuracy: 0.7833
Epoch 113/150
30/30 [==============================] - 0s 233us/step - loss: 0.5682 - accuracy: 0.8667
- val_loss: 0.6483 - val_accuracy: 0.7917
Epoch 114/150
30/30 [==============================] - 0s 300us/step - loss: 0.5655 - accuracy: 0.8667
- val_loss: 0.6460 - val_accuracy: 0.7917
Epoch 115/150
30/30 [==============================] - 0s 300us/step - loss: 0.5629 - accuracy: 0.8667
- val_loss: 0.6437 - val_accuracy: 0.7917
Epoch 116/150
30/30 [==============================] - 0s 267us/step - loss: 0.5603 - accuracy: 0.8667
- val_loss: 0.6414 - val_accuracy: 0.7917
Epoch 117/150
30/30 [==============================] - 0s 367us/step - loss: 0.5577 - accuracy: 0.8667
- val_loss: 0.6391 - val_accuracy: 0.7917
Epoch 118/150
30/30 [==============================] - 0s 267us/step - loss: 0.5551 - accuracy: 0.8667
- val_loss: 0.6368 - val_accuracy: 0.7917
Epoch 119/150
30/30 [==============================] - 0s 267us/step - loss: 0.5525 - accuracy: 0.8667
- val_loss: 0.6346 - val_accuracy: 0.7917
Epoch 120/150
30/30 [==============================] - 0s 367us/step - loss: 0.5500 - accuracy: 0.8667
- val_loss: 0.6324 - val_accuracy: 0.7917
Epoch 121/150
30/30 [==============================] - 0s 300us/step - loss: 0.5474 - accuracy: 0.8667
- val_loss: 0.6302 - val_accuracy: 0.7917
Epoch 122/150
30/30 [==============================] - 0s 267us/step - loss: 0.5449 - accuracy: 0.8667
- val_loss: 0.6280 - val_accuracy: 0.7917
Epoch 123/150
30/30 [==============================] - 0s 334us/step - loss: 0.5424 - accuracy: 0.8667
- val_loss: 0.6258 - val_accuracy: 0.7917
Epoch 124/150
30/30 [==============================] - 0s 267us/step - loss: 0.5400 - accuracy: 0.8667
- val_loss: 0.6236 - val_accuracy: 0.7917
Epoch 125/150
30/30 [==============================] - 0s 267us/step - loss: 0.5375 - accuracy: 0.8667
- val_loss: 0.6215 - val_accuracy: 0.7917
Epoch 126/150
30/30 [==============================] - 0s 300us/step - loss: 0.5351 - accuracy: 0.8667
- val_loss: 0.6194 - val_accuracy: 0.7917
Epoch 127/150
30/30 [==============================] - 0s 333us/step - loss: 0.5327 - accuracy: 0.8667
- val_loss: 0.6173 - val_accuracy: 0.7917
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Epoch 128/150
30/30 [==============================] - 0s 300us/step - loss: 0.5303 - accuracy: 0.8667
- val_loss: 0.6152 - val_accuracy: 0.7917
Epoch 129/150
30/30 [==============================] - 0s 333us/step - loss: 0.5280 - accuracy: 0.8667
- val_loss: 0.6131 - val_accuracy: 0.7917
Epoch 130/150
30/30 [==============================] - 0s 300us/step - loss: 0.5256 - accuracy: 0.8667
- val_loss: 0.6111 - val_accuracy: 0.7917
Epoch 131/150
30/30 [==============================] - 0s 333us/step - loss: 0.5233 - accuracy: 0.8667
- val_loss: 0.6091 - val_accuracy: 0.7917
Epoch 132/150
30/30 [==============================] - 0s 267us/step - loss: 0.5210 - accuracy: 0.8667
- val_loss: 0.6071 - val_accuracy: 0.7917
Epoch 133/150
30/30 [==============================] - 0s 300us/step - loss: 0.5187 - accuracy: 0.8667
- val_loss: 0.6051 - val_accuracy: 0.7917
Epoch 134/150
30/30 [==============================] - 0s 300us/step - loss: 0.5164 - accuracy: 0.8667
- val_loss: 0.6031 - val_accuracy: 0.8000
Epoch 135/150
30/30 [==============================] - 0s 267us/step - loss: 0.5142 - accuracy: 0.8667
- val_loss: 0.6011 - val_accuracy: 0.8000
Epoch 136/150
30/30 [==============================] - 0s 266us/step - loss: 0.5119 - accuracy: 0.8667
- val_loss: 0.5992 - val_accuracy: 0.8167
Epoch 137/150
30/30 [==============================] - 0s 267us/step - loss: 0.5097 - accuracy: 0.8667
- val_loss: 0.5972 - val_accuracy: 0.8167
Epoch 138/150
30/30 [==============================] - 0s 367us/step - loss: 0.5075 - accuracy: 0.8667
- val_loss: 0.5953 - val_accuracy: 0.8167
Epoch 139/150
30/30 [==============================] - 0s 300us/step - loss: 0.5054 - accuracy: 0.8667
- val_loss: 0.5934 - val_accuracy: 0.8167
Epoch 140/150
30/30 [==============================] - 0s 300us/step - loss: 0.5032 - accuracy: 0.8667
- val_loss: 0.5915 - val_accuracy: 0.8167
Epoch 141/150
30/30 [==============================] - 0s 267us/step - loss: 0.5011 - accuracy: 0.8667
- val_loss: 0.5896 - val_accuracy: 0.8167
Epoch 142/150
30/30 [==============================] - 0s 367us/step - loss: 0.4989 - accuracy: 0.8667
- val_loss: 0.5878 - val_accuracy: 0.8167
Epoch 143/150
30/30 [==============================] - 0s 233us/step - loss: 0.4968 - accuracy: 0.8667
- val_loss: 0.5859 - val_accuracy: 0.8167
Epoch 144/150
30/30 [==============================] - 0s 267us/step - loss: 0.4947 - accuracy: 0.8667
- val_loss: 0.5841 - val_accuracy: 0.8083
Epoch 145/150
30/30 [==============================] - 0s 267us/step - loss: 0.4926 - accuracy: 0.8667
- val_loss: 0.5822 - val_accuracy: 0.8083
Epoch 146/150
30/30 [==============================] - 0s 300us/step - loss: 0.4906 - accuracy: 0.8667
- val_loss: 0.5804 - val_accuracy: 0.8083
Epoch 147/150
30/30 [==============================] - 0s 300us/step - loss: 0.4885 - accuracy: 0.8667
- val_loss: 0.5786 - val_accuracy: 0.8083
Epoch 148/150
30/30 [==============================] - 0s 266us/step - loss: 0.4865 - accuracy: 0.8667
- val_loss: 0.5769 - val_accuracy: 0.8083
Epoch 149/150
30/30 [==============================] - 0s 267us/step - loss: 0.4844 - accuracy: 0.8667
```

```
- val_loss: 0.5751 - val_accuracy: 0.8083
Epoch 150/150
30/30 [==============================] - 0s 300us/step - loss: 0.4824 - accuracy: 0.8667
- val_loss: 0.5733 - val_accuracy: 0.8083
```

Out[47]:
```
<keras.callbacks.callbacks.History at 0x1d2f8701e10>
```

In [48]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [49]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 g) Test 7: Split the X and Y into training and test sets and let us use a training dataset of 0.6 or 40% with a different number of epochs

In [50]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.6)
```

In [51]:
```
print(X_train.shape, X_test.shape)
```

```
(60, 4) (90, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [52]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [53]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 100 epochs and see how it performs on training and test data sets

In [54]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=100)
```

```
Train on 60 samples, validate on 90 samples
Epoch 1/100
```

```
60/60 [==============================] - 0s 2ms/step - loss: 0.9173 - accuracy: 0.6167 -
val_loss: 0.8581 - val_accuracy: 0.7222
Epoch 2/100
60/60 [==============================] - 0s 167us/step - loss: 0.9084 - accuracy: 0.6167
- val_loss: 0.8483 - val_accuracy: 0.7333
Epoch 3/100
60/60 [==============================] - 0s 183us/step - loss: 0.8992 - accuracy: 0.6333
- val_loss: 0.8385 - val_accuracy: 0.7333
Epoch 4/100
60/60 [==============================] - 0s 200us/step - loss: 0.8904 - accuracy: 0.6500
- val_loss: 0.8287 - val_accuracy: 0.7333
Epoch 5/100
60/60 [==============================] - 0s 200us/step - loss: 0.8814 - accuracy: 0.6833
- val_loss: 0.8187 - val_accuracy: 0.7333
Epoch 6/100
60/60 [==============================] - 0s 183us/step - loss: 0.8724 - accuracy: 0.7000
- val_loss: 0.8088 - val_accuracy: 0.7333
Epoch 7/100
60/60 [==============================] - 0s 200us/step - loss: 0.8636 - accuracy: 0.7000
- val_loss: 0.7988 - val_accuracy: 0.7333
Epoch 8/100
60/60 [==============================] - 0s 133us/step - loss: 0.8545 - accuracy: 0.7000
- val_loss: 0.7892 - val_accuracy: 0.7333
Epoch 9/100
60/60 [==============================] - 0s 200us/step - loss: 0.8455 - accuracy: 0.7000
- val_loss: 0.7797 - val_accuracy: 0.7444
Epoch 10/100
60/60 [==============================] - 0s 200us/step - loss: 0.8371 - accuracy: 0.7000
- val_loss: 0.7702 - val_accuracy: 0.7444
Epoch 11/100
60/60 [==============================] - 0s 183us/step - loss: 0.8287 - accuracy: 0.6833
- val_loss: 0.7608 - val_accuracy: 0.7556
Epoch 12/100
60/60 [==============================] - 0s 167us/step - loss: 0.8202 - accuracy: 0.6500
- val_loss: 0.7517 - val_accuracy: 0.7556
Epoch 13/100
60/60 [==============================] - 0s 183us/step - loss: 0.8124 - accuracy: 0.6500
- val_loss: 0.7426 - val_accuracy: 0.7556
Epoch 14/100
60/60 [==============================] - 0s 183us/step - loss: 0.8041 - accuracy: 0.6667
- val_loss: 0.7338 - val_accuracy: 0.7556
Epoch 15/100
60/60 [==============================] - 0s 183us/step - loss: 0.7963 - accuracy: 0.6667
- val_loss: 0.7251 - val_accuracy: 0.7556
Epoch 16/100
60/60 [==============================] - 0s 183us/step - loss: 0.7885 - accuracy: 0.6667
- val_loss: 0.7165 - val_accuracy: 0.7667
Epoch 17/100
60/60 [==============================] - 0s 133us/step - loss: 0.7806 - accuracy: 0.6667
- val_loss: 0.7081 - val_accuracy: 0.7667
Epoch 18/100
60/60 [==============================] - 0s 183us/step - loss: 0.7729 - accuracy: 0.6667
- val_loss: 0.6999 - val_accuracy: 0.7667
Epoch 19/100
60/60 [==============================] - 0s 183us/step - loss: 0.7654 - accuracy: 0.6667
- val_loss: 0.6918 - val_accuracy: 0.7778
Epoch 20/100
60/60 [==============================] - 0s 133us/step - loss: 0.7579 - accuracy: 0.6667
- val_loss: 0.6840 - val_accuracy: 0.7778
Epoch 21/100
60/60 [==============================] - 0s 150us/step - loss: 0.7505 - accuracy: 0.6833
- val_loss: 0.6762 - val_accuracy: 0.7889
Epoch 22/100
60/60 [==============================] - 0s 183us/step - loss: 0.7431 - accuracy: 0.6833
- val_loss: 0.6686 - val_accuracy: 0.7889
```

```
Epoch 23/100
60/60 [==============================] - 0s 200us/step - loss: 0.7362 - accuracy: 0.6833
- val_loss: 0.6611 - val_accuracy: 0.8000
Epoch 24/100
60/60 [==============================] - 0s 133us/step - loss: 0.7293 - accuracy: 0.6833
- val_loss: 0.6538 - val_accuracy: 0.8000
Epoch 25/100
60/60 [==============================] - 0s 117us/step - loss: 0.7226 - accuracy: 0.7000
- val_loss: 0.6467 - val_accuracy: 0.8111
Epoch 26/100
60/60 [==============================] - 0s 183us/step - loss: 0.7157 - accuracy: 0.7000
- val_loss: 0.6398 - val_accuracy: 0.8111
Epoch 27/100
60/60 [==============================] - 0s 200us/step - loss: 0.7094 - accuracy: 0.7000
- val_loss: 0.6329 - val_accuracy: 0.8111
Epoch 28/100
60/60 [==============================] - 0s 150us/step - loss: 0.7028 - accuracy: 0.7000
- val_loss: 0.6262 - val_accuracy: 0.8333
Epoch 29/100
60/60 [==============================] - 0s 167us/step - loss: 0.6966 - accuracy: 0.7000
- val_loss: 0.6195 - val_accuracy: 0.8333
Epoch 30/100
60/60 [==============================] - 0s 200us/step - loss: 0.6903 - accuracy: 0.7000
- val_loss: 0.6130 - val_accuracy: 0.8333
Epoch 31/100
60/60 [==============================] - 0s 150us/step - loss: 0.6842 - accuracy: 0.7000
- val_loss: 0.6067 - val_accuracy: 0.8444
Epoch 32/100
60/60 [==============================] - 0s 150us/step - loss: 0.6783 - accuracy: 0.7167
- val_loss: 0.6004 - val_accuracy: 0.8556
Epoch 33/100
60/60 [==============================] - 0s 150us/step - loss: 0.6726 - accuracy: 0.7167
- val_loss: 0.5942 - val_accuracy: 0.8556
Epoch 34/100
60/60 [==============================] - 0s 133us/step - loss: 0.6667 - accuracy: 0.7167
- val_loss: 0.5882 - val_accuracy: 0.8444
Epoch 35/100
60/60 [==============================] - 0s 117us/step - loss: 0.6610 - accuracy: 0.7167
- val_loss: 0.5823 - val_accuracy: 0.8556
Epoch 36/100
60/60 [==============================] - 0s 167us/step - loss: 0.6555 - accuracy: 0.7167
- val_loss: 0.5766 - val_accuracy: 0.8556
Epoch 37/100
60/60 [==============================] - 0s 133us/step - loss: 0.6500 - accuracy: 0.7167
- val_loss: 0.5711 - val_accuracy: 0.8667
Epoch 38/100
60/60 [==============================] - 0s 117us/step - loss: 0.6448 - accuracy: 0.7167
- val_loss: 0.5656 - val_accuracy: 0.8667
Epoch 39/100
60/60 [==============================] - 0s 183us/step - loss: 0.6394 - accuracy: 0.7167
- val_loss: 0.5601 - val_accuracy: 0.8778
Epoch 40/100
60/60 [==============================] - 0s 133us/step - loss: 0.6343 - accuracy: 0.7167
- val_loss: 0.5549 - val_accuracy: 0.8889
Epoch 41/100
60/60 [==============================] - 0s 150us/step - loss: 0.6291 - accuracy: 0.7167
- val_loss: 0.5497 - val_accuracy: 0.8889
Epoch 42/100
60/60 [==============================] - 0s 150us/step - loss: 0.6242 - accuracy: 0.7333
- val_loss: 0.5447 - val_accuracy: 0.8889
Epoch 43/100
60/60 [==============================] - 0s 383us/step - loss: 0.6192 - accuracy: 0.7333
- val_loss: 0.5397 - val_accuracy: 0.9000
Epoch 44/100
60/60 [==============================] - 0s 200us/step - loss: 0.6143 - accuracy: 0.7333
```

```
- val_loss: 0.5349 - val_accuracy: 0.9000
Epoch 45/100
60/60 [==============================] - 0s 217us/step - loss: 0.6094 - accuracy: 0.7500
- val_loss: 0.5302 - val_accuracy: 0.9111
Epoch 46/100
60/60 [==============================] - 0s 167us/step - loss: 0.6046 - accuracy: 0.7500
- val_loss: 0.5256 - val_accuracy: 0.9111
Epoch 47/100
60/60 [==============================] - 0s 133us/step - loss: 0.6000 - accuracy: 0.7667
- val_loss: 0.5209 - val_accuracy: 0.9111
Epoch 48/100
60/60 [==============================] - 0s 150us/step - loss: 0.5951 - accuracy: 0.7667
- val_loss: 0.5163 - val_accuracy: 0.9111
Epoch 49/100
60/60 [==============================] - 0s 183us/step - loss: 0.5906 - accuracy: 0.7667
- val_loss: 0.5119 - val_accuracy: 0.9111
Epoch 50/100
60/60 [==============================] - 0s 200us/step - loss: 0.5862 - accuracy: 0.7833
- val_loss: 0.5074 - val_accuracy: 0.9111
Epoch 51/100
60/60 [==============================] - 0s 200us/step - loss: 0.5816 - accuracy: 0.7833
- val_loss: 0.5030 - val_accuracy: 0.9222
Epoch 52/100
60/60 [==============================] - 0s 117us/step - loss: 0.5772 - accuracy: 0.7833
- val_loss: 0.4987 - val_accuracy: 0.9222
Epoch 53/100
60/60 [==============================] - 0s 167us/step - loss: 0.5728 - accuracy: 0.7833
- val_loss: 0.4944 - val_accuracy: 0.9222
Epoch 54/100
60/60 [==============================] - 0s 200us/step - loss: 0.5687 - accuracy: 0.7833
- val_loss: 0.4903 - val_accuracy: 0.9222
Epoch 55/100
60/60 [==============================] - 0s 150us/step - loss: 0.5645 - accuracy: 0.8000
- val_loss: 0.4861 - val_accuracy: 0.9222
Epoch 56/100
60/60 [==============================] - 0s 150us/step - loss: 0.5602 - accuracy: 0.8000
- val_loss: 0.4821 - val_accuracy: 0.9222
Epoch 57/100
60/60 [==============================] - 0s 167us/step - loss: 0.5562 - accuracy: 0.8167
- val_loss: 0.4781 - val_accuracy: 0.9222
Epoch 58/100
60/60 [==============================] - 0s 183us/step - loss: 0.5521 - accuracy: 0.8167
- val_loss: 0.4742 - val_accuracy: 0.9222
Epoch 59/100
60/60 [==============================] - 0s 117us/step - loss: 0.5482 - accuracy: 0.8167
- val_loss: 0.4703 - val_accuracy: 0.9111
Epoch 60/100
60/60 [==============================] - 0s 183us/step - loss: 0.5443 - accuracy: 0.8167
- val_loss: 0.4665 - val_accuracy: 0.9111
Epoch 61/100
60/60 [==============================] - 0s 133us/step - loss: 0.5403 - accuracy: 0.8167
- val_loss: 0.4628 - val_accuracy: 0.9111
Epoch 62/100
60/60 [==============================] - 0s 150us/step - loss: 0.5366 - accuracy: 0.8167
- val_loss: 0.4592 - val_accuracy: 0.9111
Epoch 63/100
60/60 [==============================] - 0s 150us/step - loss: 0.5331 - accuracy: 0.8167
- val_loss: 0.4556 - val_accuracy: 0.9111
Epoch 64/100
60/60 [==============================] - 0s 183us/step - loss: 0.5293 - accuracy: 0.8167
- val_loss: 0.4521 - val_accuracy: 0.9111
Epoch 65/100
60/60 [==============================] - 0s 150us/step - loss: 0.5256 - accuracy: 0.8167
- val_loss: 0.4486 - val_accuracy: 0.9222
Epoch 66/100
```

```
60/60 [==============================] - 0s 133us/step - loss: 0.5221 - accuracy: 0.8167
- val_loss: 0.4452 - val_accuracy: 0.9222
Epoch 67/100
60/60 [==============================] - 0s 167us/step - loss: 0.5185 - accuracy: 0.8333
- val_loss: 0.4418 - val_accuracy: 0.9222
Epoch 68/100
60/60 [==============================] - 0s 167us/step - loss: 0.5151 - accuracy: 0.8333
- val_loss: 0.4385 - val_accuracy: 0.9222
Epoch 69/100
60/60 [==============================] - 0s 133us/step - loss: 0.5116 - accuracy: 0.8333
- val_loss: 0.4352 - val_accuracy: 0.9333
Epoch 70/100
60/60 [==============================] - 0s 150us/step - loss: 0.5082 - accuracy: 0.8333
- val_loss: 0.4320 - val_accuracy: 0.9333
Epoch 71/100
60/60 [==============================] - 0s 200us/step - loss: 0.5047 - accuracy: 0.8333
- val_loss: 0.4287 - val_accuracy: 0.9444
Epoch 72/100
60/60 [==============================] - 0s 183us/step - loss: 0.5013 - accuracy: 0.8333
- val_loss: 0.4255 - val_accuracy: 0.9444
Epoch 73/100
60/60 [==============================] - 0s 217us/step - loss: 0.4980 - accuracy: 0.8333
- val_loss: 0.4223 - val_accuracy: 0.9444
Epoch 74/100
60/60 [==============================] - 0s 117us/step - loss: 0.4947 - accuracy: 0.8333
- val_loss: 0.4193 - val_accuracy: 0.9444
Epoch 75/100
60/60 [==============================] - 0s 200us/step - loss: 0.4913 - accuracy: 0.8333
- val_loss: 0.4161 - val_accuracy: 0.9444
Epoch 76/100
60/60 [==============================] - 0s 150us/step - loss: 0.4879 - accuracy: 0.8333
- val_loss: 0.4131 - val_accuracy: 0.9444
Epoch 77/100
60/60 [==============================] - 0s 133us/step - loss: 0.4847 - accuracy: 0.8333
- val_loss: 0.4101 - val_accuracy: 0.9444
Epoch 78/100
60/60 [==============================] - 0s 167us/step - loss: 0.4816 - accuracy: 0.8500
- val_loss: 0.4072 - val_accuracy: 0.9444
Epoch 79/100
60/60 [==============================] - 0s 150us/step - loss: 0.4783 - accuracy: 0.8667
- val_loss: 0.4042 - val_accuracy: 0.9444
Epoch 80/100
60/60 [==============================] - 0s 133us/step - loss: 0.4750 - accuracy: 0.8667
- val_loss: 0.4014 - val_accuracy: 0.9444
Epoch 81/100
60/60 [==============================] - 0s 167us/step - loss: 0.4718 - accuracy: 0.8667
- val_loss: 0.3985 - val_accuracy: 0.9444
Epoch 82/100
60/60 [==============================] - 0s 167us/step - loss: 0.4688 - accuracy: 0.8667
- val_loss: 0.3957 - val_accuracy: 0.9444
Epoch 83/100
60/60 [==============================] - 0s 117us/step - loss: 0.4655 - accuracy: 0.8667
- val_loss: 0.3929 - val_accuracy: 0.9444
Epoch 84/100
60/60 [==============================] - 0s 183us/step - loss: 0.4626 - accuracy: 0.8667
- val_loss: 0.3901 - val_accuracy: 0.9444
Epoch 85/100
60/60 [==============================] - 0s 167us/step - loss: 0.4595 - accuracy: 0.8833
- val_loss: 0.3873 - val_accuracy: 0.9444
Epoch 86/100
60/60 [==============================] - 0s 117us/step - loss: 0.4565 - accuracy: 0.8833
- val_loss: 0.3847 - val_accuracy: 0.9444
Epoch 87/100
60/60 [==============================] - 0s 167us/step - loss: 0.4535 - accuracy: 0.8833
- val_loss: 0.3820 - val_accuracy: 0.9444
```

```
Epoch 88/100
60/60 [==============================] - 0s 183us/step - loss: 0.4504 - accuracy: 0.8833
- val_loss: 0.3794 - val_accuracy: 0.9444
Epoch 89/100
60/60 [==============================] - 0s 133us/step - loss: 0.4476 - accuracy: 0.9000
- val_loss: 0.3768 - val_accuracy: 0.9444
Epoch 90/100
60/60 [==============================] - 0s 167us/step - loss: 0.4447 - accuracy: 0.8833
- val_loss: 0.3743 - val_accuracy: 0.9444
Epoch 91/100
60/60 [==============================] - 0s 233us/step - loss: 0.4419 - accuracy: 0.8833
- val_loss: 0.3718 - val_accuracy: 0.9444
Epoch 92/100
60/60 [==============================] - 0s 167us/step - loss: 0.4390 - accuracy: 0.8833
- val_loss: 0.3693 - val_accuracy: 0.9444
Epoch 93/100
60/60 [==============================] - 0s 100us/step - loss: 0.4364 - accuracy: 0.8833
- val_loss: 0.3670 - val_accuracy: 0.9444
Epoch 94/100
60/60 [==============================] - 0s 167us/step - loss: 0.4334 - accuracy: 0.8833
- val_loss: 0.3646 - val_accuracy: 0.9444
Epoch 95/100
60/60 [==============================] - 0s 200us/step - loss: 0.4306 - accuracy: 0.8833
- val_loss: 0.3622 - val_accuracy: 0.9444
Epoch 96/100
60/60 [==============================] - 0s 167us/step - loss: 0.4279 - accuracy: 0.8833
- val_loss: 0.3598 - val_accuracy: 0.9444
Epoch 97/100
60/60 [==============================] - 0s 150us/step - loss: 0.4252 - accuracy: 0.8833
- val_loss: 0.3575 - val_accuracy: 0.9444
Epoch 98/100
60/60 [==============================] - 0s 217us/step - loss: 0.4226 - accuracy: 0.8833
- val_loss: 0.3552 - val_accuracy: 0.9444
Epoch 99/100
60/60 [==============================] - 0s 167us/step - loss: 0.4199 - accuracy: 0.9000
- val_loss: 0.3529 - val_accuracy: 0.9444
Epoch 100/100
60/60 [==============================] - 0s 117us/step - loss: 0.4172 - accuracy: 0.9000
- val_loss: 0.3507 - val_accuracy: 0.9444
```

Out[54]: `<keras.callbacks.callbacks.History at 0x1d2f9b4af60>`

In [55]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [56]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 h) Test 8: Split the X and Y into training and test sets and let us use a training dataset of 0.7 or 30% with a different number of epochs

In [57]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.7)
```

In [58]:
```
print(X_train.shape, X_test.shape)
```

```
(45, 4) (105, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [59]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [60]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 100 epochs and see how it performs on training and test data sets

In [61]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=100)
```

```
Train on 45 samples, validate on 105 samples
Epoch 1/100
45/45 [==============================] - 0s 3ms/step - loss: 0.8237 - accuracy: 0.7556 -
val_loss: 0.9005 - val_accuracy: 0.6000
Epoch 2/100
45/45 [==============================] - 0s 252us/step - loss: 0.8161 - accuracy: 0.7556
- val_loss: 0.8944 - val_accuracy: 0.6000
Epoch 3/100
45/45 [==============================] - 0s 267us/step - loss: 0.8086 - accuracy: 0.7556
- val_loss: 0.8886 - val_accuracy: 0.6000
Epoch 4/100
45/45 [==============================] - 0s 267us/step - loss: 0.8002 - accuracy: 0.7556
- val_loss: 0.8826 - val_accuracy: 0.6000
Epoch 5/100
45/45 [==============================] - 0s 244us/step - loss: 0.7926 - accuracy: 0.7778
- val_loss: 0.8769 - val_accuracy: 0.6095
Epoch 6/100
45/45 [==============================] - 0s 266us/step - loss: 0.7846 - accuracy: 0.7778
- val_loss: 0.8712 - val_accuracy: 0.6095
Epoch 7/100
45/45 [==============================] - 0s 244us/step - loss: 0.7772 - accuracy: 0.7778
- val_loss: 0.8655 - val_accuracy: 0.6095
Epoch 8/100
45/45 [==============================] - 0s 289us/step - loss: 0.7697 - accuracy: 0.7778
- val_loss: 0.8598 - val_accuracy: 0.6095
Epoch 9/100
45/45 [==============================] - 0s 267us/step - loss: 0.7622 - accuracy: 0.7778
- val_loss: 0.8542 - val_accuracy: 0.6095
Epoch 10/100
45/45 [==============================] - 0s 267us/step - loss: 0.7547 - accuracy: 0.7778
- val_loss: 0.8486 - val_accuracy: 0.6095
Epoch 11/100
```

```
45/45 [==============================] - 0s 244us/step - loss: 0.7475 - accuracy: 0.7778
- val_loss: 0.8430 - val_accuracy: 0.6095
Epoch 12/100
45/45 [==============================] - 0s 244us/step - loss: 0.7402 - accuracy: 0.7778
- val_loss: 0.8375 - val_accuracy: 0.6095
Epoch 13/100
45/45 [==============================] - 0s 244us/step - loss: 0.7334 - accuracy: 0.7778
- val_loss: 0.8320 - val_accuracy: 0.6095
Epoch 14/100
45/45 [==============================] - 0s 311us/step - loss: 0.7260 - accuracy: 0.7778
- val_loss: 0.8266 - val_accuracy: 0.6095
Epoch 15/100
45/45 [==============================] - 0s 222us/step - loss: 0.7194 - accuracy: 0.7778
- val_loss: 0.8212 - val_accuracy: 0.6095
Epoch 16/100
45/45 [==============================] - 0s 222us/step - loss: 0.7122 - accuracy: 0.7778
- val_loss: 0.8157 - val_accuracy: 0.6095
Epoch 17/100
45/45 [==============================] - 0s 311us/step - loss: 0.7056 - accuracy: 0.7778
- val_loss: 0.8104 - val_accuracy: 0.6095
Epoch 18/100
45/45 [==============================] - 0s 244us/step - loss: 0.6992 - accuracy: 0.7778
- val_loss: 0.8051 - val_accuracy: 0.6095
Epoch 19/100
45/45 [==============================] - 0s 289us/step - loss: 0.6925 - accuracy: 0.7778
- val_loss: 0.7998 - val_accuracy: 0.6095
Epoch 20/100
45/45 [==============================] - 0s 267us/step - loss: 0.6861 - accuracy: 0.7778
- val_loss: 0.7947 - val_accuracy: 0.6095
Epoch 21/100
45/45 [==============================] - 0s 289us/step - loss: 0.6796 - accuracy: 0.7778
- val_loss: 0.7896 - val_accuracy: 0.6095
Epoch 22/100
45/45 [==============================] - 0s 311us/step - loss: 0.6730 - accuracy: 0.7778
- val_loss: 0.7845 - val_accuracy: 0.6095
Epoch 23/100
45/45 [==============================] - 0s 356us/step - loss: 0.6669 - accuracy: 0.7778
- val_loss: 0.7796 - val_accuracy: 0.6095
Epoch 24/100
45/45 [==============================] - 0s 267us/step - loss: 0.6602 - accuracy: 0.7778
- val_loss: 0.7747 - val_accuracy: 0.6095
Epoch 25/100
45/45 [==============================] - 0s 178us/step - loss: 0.6541 - accuracy: 0.7778
- val_loss: 0.7698 - val_accuracy: 0.6095
Epoch 26/100
45/45 [==============================] - 0s 244us/step - loss: 0.6480 - accuracy: 0.7778
- val_loss: 0.7649 - val_accuracy: 0.6095
Epoch 27/100
45/45 [==============================] - 0s 244us/step - loss: 0.6418 - accuracy: 0.7778
- val_loss: 0.7601 - val_accuracy: 0.6095
Epoch 28/100
45/45 [==============================] - 0s 378us/step - loss: 0.6357 - accuracy: 0.7778
- val_loss: 0.7555 - val_accuracy: 0.6095
Epoch 29/100
45/45 [==============================] - 0s 244us/step - loss: 0.6298 - accuracy: 0.7778
- val_loss: 0.7508 - val_accuracy: 0.6095
Epoch 30/100
45/45 [==============================] - 0s 222us/step - loss: 0.6240 - accuracy: 0.7778
- val_loss: 0.7463 - val_accuracy: 0.6095
Epoch 31/100
45/45 [==============================] - 0s 267us/step - loss: 0.6184 - accuracy: 0.7778
- val_loss: 0.7419 - val_accuracy: 0.6095
Epoch 32/100
45/45 [==============================] - 0s 267us/step - loss: 0.6121 - accuracy: 0.7778
- val_loss: 0.7376 - val_accuracy: 0.6095
```

```
Epoch 33/100
45/45 [==============================] - 0s 222us/step - loss: 0.6069 - accuracy: 0.7778
- val_loss: 0.7333 - val_accuracy: 0.6095
Epoch 34/100
45/45 [==============================] - 0s 244us/step - loss: 0.6014 - accuracy: 0.7778
- val_loss: 0.7291 - val_accuracy: 0.6095
Epoch 35/100
45/45 [==============================] - 0s 222us/step - loss: 0.5957 - accuracy: 0.7778
- val_loss: 0.7249 - val_accuracy: 0.6095
Epoch 36/100
45/45 [==============================] - 0s 244us/step - loss: 0.5903 - accuracy: 0.7778
- val_loss: 0.7208 - val_accuracy: 0.6095
Epoch 37/100
45/45 [==============================] - 0s 289us/step - loss: 0.5850 - accuracy: 0.7778
- val_loss: 0.7166 - val_accuracy: 0.6095
Epoch 38/100
45/45 [==============================] - 0s 289us/step - loss: 0.5797 - accuracy: 0.7778
- val_loss: 0.7124 - val_accuracy: 0.6095
Epoch 39/100
45/45 [==============================] - 0s 311us/step - loss: 0.5744 - accuracy: 0.7778
- val_loss: 0.7083 - val_accuracy: 0.6095
Epoch 40/100
45/45 [==============================] - 0s 311us/step - loss: 0.5691 - accuracy: 0.7778
- val_loss: 0.7043 - val_accuracy: 0.6095
Epoch 41/100
45/45 [==============================] - 0s 333us/step - loss: 0.5641 - accuracy: 0.7778
- val_loss: 0.7002 - val_accuracy: 0.6095
Epoch 42/100
45/45 [==============================] - 0s 222us/step - loss: 0.5591 - accuracy: 0.7778
- val_loss: 0.6962 - val_accuracy: 0.6095
Epoch 43/100
45/45 [==============================] - 0s 222us/step - loss: 0.5542 - accuracy: 0.7778
- val_loss: 0.6922 - val_accuracy: 0.6095
Epoch 44/100
45/45 [==============================] - 0s 267us/step - loss: 0.5491 - accuracy: 0.7778
- val_loss: 0.6884 - val_accuracy: 0.6095
Epoch 45/100
45/45 [==============================] - 0s 244us/step - loss: 0.5442 - accuracy: 0.7778
- val_loss: 0.6847 - val_accuracy: 0.6095
Epoch 46/100
45/45 [==============================] - 0s 289us/step - loss: 0.5395 - accuracy: 0.7778
- val_loss: 0.6809 - val_accuracy: 0.6095
Epoch 47/100
45/45 [==============================] - 0s 311us/step - loss: 0.5350 - accuracy: 0.7778
- val_loss: 0.6771 - val_accuracy: 0.6095
Epoch 48/100
45/45 [==============================] - 0s 245us/step - loss: 0.5305 - accuracy: 0.7778
- val_loss: 0.6734 - val_accuracy: 0.6095
Epoch 49/100
45/45 [==============================] - 0s 267us/step - loss: 0.5259 - accuracy: 0.7778
- val_loss: 0.6697 - val_accuracy: 0.6095
Epoch 50/100
45/45 [==============================] - 0s 244us/step - loss: 0.5214 - accuracy: 0.7778
- val_loss: 0.6661 - val_accuracy: 0.6095
Epoch 51/100
45/45 [==============================] - 0s 222us/step - loss: 0.5172 - accuracy: 0.7778
- val_loss: 0.6627 - val_accuracy: 0.6095
Epoch 52/100
45/45 [==============================] - 0s 244us/step - loss: 0.5127 - accuracy: 0.7778
- val_loss: 0.6593 - val_accuracy: 0.6095
Epoch 53/100
45/45 [==============================] - 0s 311us/step - loss: 0.5085 - accuracy: 0.7778
- val_loss: 0.6559 - val_accuracy: 0.6095
Epoch 54/100
45/45 [==============================] - 0s 311us/step - loss: 0.5044 - accuracy: 0.7778
```

```
- val_loss: 0.6525 - val_accuracy: 0.6095
Epoch 55/100
45/45 [==============================] - 0s 245us/step - loss: 0.5003 - accuracy: 0.7778
- val_loss: 0.6490 - val_accuracy: 0.6095
Epoch 56/100
45/45 [==============================] - 0s 267us/step - loss: 0.4962 - accuracy: 0.7778
- val_loss: 0.6454 - val_accuracy: 0.6095
Epoch 57/100
45/45 [==============================] - 0s 156us/step - loss: 0.4924 - accuracy: 0.7778
- val_loss: 0.6419 - val_accuracy: 0.6095
Epoch 58/100
45/45 [==============================] - 0s 244us/step - loss: 0.4884 - accuracy: 0.7778
- val_loss: 0.6385 - val_accuracy: 0.6095
Epoch 59/100
45/45 [==============================] - 0s 267us/step - loss: 0.4847 - accuracy: 0.7778
- val_loss: 0.6352 - val_accuracy: 0.6190
Epoch 60/100
45/45 [==============================] - 0s 267us/step - loss: 0.4808 - accuracy: 0.7778
- val_loss: 0.6319 - val_accuracy: 0.6190
Epoch 61/100
45/45 [==============================] - 0s 311us/step - loss: 0.4772 - accuracy: 0.7778
- val_loss: 0.6288 - val_accuracy: 0.6190
Epoch 62/100
45/45 [==============================] - 0s 289us/step - loss: 0.4737 - accuracy: 0.7778
- val_loss: 0.6258 - val_accuracy: 0.6190
Epoch 63/100
45/45 [==============================] - 0s 244us/step - loss: 0.4701 - accuracy: 0.7778
- val_loss: 0.6230 - val_accuracy: 0.6190
Epoch 64/100
45/45 [==============================] - 0s 267us/step - loss: 0.4667 - accuracy: 0.7778
- val_loss: 0.6202 - val_accuracy: 0.6190
Epoch 65/100
45/45 [==============================] - 0s 244us/step - loss: 0.4632 - accuracy: 0.7778
- val_loss: 0.6172 - val_accuracy: 0.6190
Epoch 66/100
45/45 [==============================] - 0s 289us/step - loss: 0.4599 - accuracy: 0.7778
- val_loss: 0.6142 - val_accuracy: 0.6190
Epoch 67/100
45/45 [==============================] - 0s 311us/step - loss: 0.4566 - accuracy: 0.7778
- val_loss: 0.6112 - val_accuracy: 0.6190
Epoch 68/100
45/45 [==============================] - 0s 311us/step - loss: 0.4536 - accuracy: 0.7778
- val_loss: 0.6083 - val_accuracy: 0.6190
Epoch 69/100
45/45 [==============================] - 0s 289us/step - loss: 0.4503 - accuracy: 0.7778
- val_loss: 0.6054 - val_accuracy: 0.6190
Epoch 70/100
45/45 [==============================] - 0s 289us/step - loss: 0.4472 - accuracy: 0.7778
- val_loss: 0.6026 - val_accuracy: 0.6190
Epoch 71/100
45/45 [==============================] - 0s 267us/step - loss: 0.4441 - accuracy: 0.7778
- val_loss: 0.5999 - val_accuracy: 0.6190
Epoch 72/100
45/45 [==============================] - 0s 333us/step - loss: 0.4411 - accuracy: 0.7778
- val_loss: 0.5973 - val_accuracy: 0.6286
Epoch 73/100
45/45 [==============================] - 0s 222us/step - loss: 0.4381 - accuracy: 0.7778
- val_loss: 0.5948 - val_accuracy: 0.6286
Epoch 74/100
45/45 [==============================] - 0s 200us/step - loss: 0.4354 - accuracy: 0.7778
- val_loss: 0.5923 - val_accuracy: 0.6286
Epoch 75/100
45/45 [==============================] - 0s 244us/step - loss: 0.4323 - accuracy: 0.7778
- val_loss: 0.5898 - val_accuracy: 0.6286
Epoch 76/100
```

```
45/45 [==============================] - 0s 267us/step - loss: 0.4297 - accuracy: 0.7778
- val_loss: 0.5872 - val_accuracy: 0.6286
Epoch 77/100
45/45 [==============================] - 0s 289us/step - loss: 0.4270 - accuracy: 0.7778
- val_loss: 0.5847 - val_accuracy: 0.6286
Epoch 78/100
45/45 [==============================] - 0s 267us/step - loss: 0.4243 - accuracy: 0.7778
- val_loss: 0.5823 - val_accuracy: 0.6286
Epoch 79/100
45/45 [==============================] - 0s 267us/step - loss: 0.4217 - accuracy: 0.7778
- val_loss: 0.5799 - val_accuracy: 0.6286
Epoch 80/100
45/45 [==============================] - 0s 333us/step - loss: 0.4191 - accuracy: 0.7778
- val_loss: 0.5775 - val_accuracy: 0.6286
Epoch 81/100
45/45 [==============================] - 0s 378us/step - loss: 0.4166 - accuracy: 0.7778
- val_loss: 0.5752 - val_accuracy: 0.6286
Epoch 82/100
45/45 [==============================] - 0s 267us/step - loss: 0.4141 - accuracy: 0.7778
- val_loss: 0.5728 - val_accuracy: 0.6286
Epoch 83/100
45/45 [==============================] - 0s 200us/step - loss: 0.4116 - accuracy: 0.7778
- val_loss: 0.5705 - val_accuracy: 0.6286
Epoch 84/100
45/45 [==============================] - 0s 200us/step - loss: 0.4093 - accuracy: 0.7778
- val_loss: 0.5680 - val_accuracy: 0.6286
Epoch 85/100
45/45 [==============================] - 0s 289us/step - loss: 0.4069 - accuracy: 0.7778
- val_loss: 0.5656 - val_accuracy: 0.6381
Epoch 86/100
45/45 [==============================] - 0s 222us/step - loss: 0.4046 - accuracy: 0.8000
- val_loss: 0.5631 - val_accuracy: 0.6381
Epoch 87/100
45/45 [==============================] - 0s 178us/step - loss: 0.4025 - accuracy: 0.8000
- val_loss: 0.5607 - val_accuracy: 0.6381
Epoch 88/100
45/45 [==============================] - 0s 200us/step - loss: 0.4003 - accuracy: 0.8000
- val_loss: 0.5585 - val_accuracy: 0.6476
Epoch 89/100
45/45 [==============================] - 0s 267us/step - loss: 0.3980 - accuracy: 0.8000
- val_loss: 0.5565 - val_accuracy: 0.6476
Epoch 90/100
45/45 [==============================] - 0s 244us/step - loss: 0.3960 - accuracy: 0.8000
- val_loss: 0.5545 - val_accuracy: 0.6476
Epoch 91/100
45/45 [==============================] - 0s 222us/step - loss: 0.3939 - accuracy: 0.8000
- val_loss: 0.5525 - val_accuracy: 0.6476
Epoch 92/100
45/45 [==============================] - 0s 178us/step - loss: 0.3918 - accuracy: 0.8000
- val_loss: 0.5505 - val_accuracy: 0.6476
Epoch 93/100
45/45 [==============================] - 0s 289us/step - loss: 0.3899 - accuracy: 0.8000
- val_loss: 0.5486 - val_accuracy: 0.6476
Epoch 94/100
45/45 [==============================] - 0s 267us/step - loss: 0.3879 - accuracy: 0.8000
- val_loss: 0.5466 - val_accuracy: 0.6476
Epoch 95/100
45/45 [==============================] - 0s 222us/step - loss: 0.3860 - accuracy: 0.8000
- val_loss: 0.5446 - val_accuracy: 0.6571
Epoch 96/100
45/45 [==============================] - 0s 178us/step - loss: 0.3841 - accuracy: 0.8000
- val_loss: 0.5426 - val_accuracy: 0.6571
Epoch 97/100
45/45 [==============================] - 0s 314us/step - loss: 0.3822 - accuracy: 0.8000
- val_loss: 0.5406 - val_accuracy: 0.6571
```

```
Epoch 98/100
45/45 [==============================] - 0s 200us/step - loss: 0.3803 - accuracy: 0.8000
- val_loss: 0.5386 - val_accuracy: 0.6571
Epoch 99/100
45/45 [==============================] - 0s 200us/step - loss: 0.3785 - accuracy: 0.8000
- val_loss: 0.5366 - val_accuracy: 0.6571
Epoch 100/100
45/45 [==============================] - 0s 200us/step - loss: 0.3767 - accuracy: 0.8000
- val_loss: 0.5345 - val_accuracy: 0.6571
```

Out[61]: <keras.callbacks.callbacks.History at 0x1d2f9ec1a58>

In [62]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [63]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

3 i) Test 9: Split the X and Y into training and test sets and let us use a training dataset of 0.8 or 20% with a different number of epochs

In [64]:
```
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.8)
```

In [65]:
```
print(X_train.shape, X_test.shape)
```

```
(30, 4) (120, 4)
```

Now create a model as shown neural model 4-10-3 (4-inputs, 10-neurons, 3-output neurons)

In [66]:
```
model = Sequential()
model.add(Dense(10,input_dim=4, activation='relu')) # first-Layer added
model.add(Dense(3,activation='softmax')) #output layer added
```

In [67]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
```

Train the model for about 100 epochs and see how it performs on training and test data sets

In [68]:
```
model.fit(X_train, Y_train, validation_data=(X_test,Y_test), epochs=100)
```

```
Train on 30 samples, validate on 120 samples
Epoch 1/100
30/30 [==============================] - 0s 4ms/step - loss: 1.2183 - accuracy: 0.3667 -
val_loss: 1.1431 - val_accuracy: 0.4417
Epoch 2/100
30/30 [==============================] - 0s 167us/step - loss: 1.2115 - accuracy: 0.3667
- val_loss: 1.1366 - val_accuracy: 0.4500
Epoch 3/100
30/30 [==============================] - 0s 200us/step - loss: 1.2047 - accuracy: 0.3667
- val_loss: 1.1300 - val_accuracy: 0.4500
Epoch 4/100
30/30 [==============================] - 0s 166us/step - loss: 1.1980 - accuracy: 0.3667
- val_loss: 1.1239 - val_accuracy: 0.4500
Epoch 5/100
30/30 [==============================] - 0s 302us/step - loss: 1.1917 - accuracy: 0.3667
- val_loss: 1.1174 - val_accuracy: 0.4500
Epoch 6/100
30/30 [==============================] - 0s 200us/step - loss: 1.1850 - accuracy: 0.3667
- val_loss: 1.1112 - val_accuracy: 0.4667
Epoch 7/100
30/30 [==============================] - 0s 233us/step - loss: 1.1786 - accuracy: 0.3667
- val_loss: 1.1049 - val_accuracy: 0.4667
Epoch 8/100
30/30 [==============================] - 0s 300us/step - loss: 1.1722 - accuracy: 0.4000
- val_loss: 1.0985 - val_accuracy: 0.4750
Epoch 9/100
30/30 [==============================] - 0s 167us/step - loss: 1.1657 - accuracy: 0.4000
- val_loss: 1.0922 - val_accuracy: 0.4750
Epoch 10/100
30/30 [==============================] - 0s 333us/step - loss: 1.1593 - accuracy: 0.4333
- val_loss: 1.0859 - val_accuracy: 0.4917
Epoch 11/100
30/30 [==============================] - 0s 200us/step - loss: 1.1529 - accuracy: 0.4333
- val_loss: 1.0796 - val_accuracy: 0.4917
Epoch 12/100
30/30 [==============================] - 0s 318us/step - loss: 1.1465 - accuracy: 0.4333
- val_loss: 1.0733 - val_accuracy: 0.5000
Epoch 13/100
30/30 [==============================] - 0s 200us/step - loss: 1.1402 - accuracy: 0.5000
- val_loss: 1.0670 - val_accuracy: 0.5000
Epoch 14/100
30/30 [==============================] - 0s 233us/step - loss: 1.1339 - accuracy: 0.5000
- val_loss: 1.0608 - val_accuracy: 0.5083
Epoch 15/100
30/30 [==============================] - 0s 303us/step - loss: 1.1277 - accuracy: 0.5000
- val_loss: 1.0546 - val_accuracy: 0.5167
Epoch 16/100
30/30 [==============================] - 0s 267us/step - loss: 1.1215 - accuracy: 0.5000
- val_loss: 1.0485 - val_accuracy: 0.5167
Epoch 17/100
30/30 [==============================] - 0s 300us/step - loss: 1.1154 - accuracy: 0.5000
- val_loss: 1.0424 - val_accuracy: 0.5250
Epoch 18/100
30/30 [==============================] - 0s 300us/step - loss: 1.1094 - accuracy: 0.5000
- val_loss: 1.0363 - val_accuracy: 0.5250
Epoch 19/100
30/30 [==============================] - 0s 233us/step - loss: 1.1034 - accuracy: 0.5000
- val_loss: 1.0302 - val_accuracy: 0.5250
Epoch 20/100
30/30 [==============================] - 0s 400us/step - loss: 1.0974 - accuracy: 0.5000
- val_loss: 1.0242 - val_accuracy: 0.5250
Epoch 21/100
30/30 [==============================] - 0s 300us/step - loss: 1.0915 - accuracy: 0.5000
```

```
- val_loss: 1.0182 - val_accuracy: 0.5250
Epoch 22/100
30/30 [==============================] - 0s 233us/step - loss: 1.0855 - accuracy: 0.5000
- val_loss: 1.0123 - val_accuracy: 0.5333
Epoch 23/100
30/30 [==============================] - 0s 300us/step - loss: 1.0797 - accuracy: 0.5000
- val_loss: 1.0064 - val_accuracy: 0.5333
Epoch 24/100
30/30 [==============================] - 0s 166us/step - loss: 1.0739 - accuracy: 0.5000
- val_loss: 1.0006 - val_accuracy: 0.5333
Epoch 25/100
30/30 [==============================] - 0s 300us/step - loss: 1.0681 - accuracy: 0.5000
- val_loss: 0.9947 - val_accuracy: 0.5333
Epoch 26/100
30/30 [==============================] - 0s 300us/step - loss: 1.0624 - accuracy: 0.5000
- val_loss: 0.9890 - val_accuracy: 0.5417
Epoch 27/100
30/30 [==============================] - 0s 167us/step - loss: 1.0567 - accuracy: 0.5000
- val_loss: 0.9833 - val_accuracy: 0.5417
Epoch 28/100
30/30 [==============================] - 0s 400us/step - loss: 1.0512 - accuracy: 0.5000
- val_loss: 0.9776 - val_accuracy: 0.5417
Epoch 29/100
30/30 [==============================] - 0s 400us/step - loss: 1.0456 - accuracy: 0.5000
- val_loss: 0.9720 - val_accuracy: 0.5417
Epoch 30/100
30/30 [==============================] - 0s 233us/step - loss: 1.0401 - accuracy: 0.5000
- val_loss: 0.9664 - val_accuracy: 0.5500
Epoch 31/100
30/30 [==============================] - 0s 233us/step - loss: 1.0347 - accuracy: 0.5000
- val_loss: 0.9609 - val_accuracy: 0.5500
Epoch 32/100
30/30 [==============================] - 0s 267us/step - loss: 1.0293 - accuracy: 0.5000
- val_loss: 0.9554 - val_accuracy: 0.5500
Epoch 33/100
30/30 [==============================] - 0s 300us/step - loss: 1.0240 - accuracy: 0.5000
- val_loss: 0.9499 - val_accuracy: 0.5500
Epoch 34/100
30/30 [==============================] - 0s 300us/step - loss: 1.0186 - accuracy: 0.5000
- val_loss: 0.9444 - val_accuracy: 0.5500
Epoch 35/100
30/30 [==============================] - 0s 167us/step - loss: 1.0133 - accuracy: 0.5000
- val_loss: 0.9390 - val_accuracy: 0.5583
Epoch 36/100
30/30 [==============================] - 0s 300us/step - loss: 1.0081 - accuracy: 0.5000
- val_loss: 0.9337 - val_accuracy: 0.5583
Epoch 37/100
30/30 [==============================] - 0s 300us/step - loss: 1.0029 - accuracy: 0.5000
- val_loss: 0.9284 - val_accuracy: 0.5583
Epoch 38/100
30/30 [==============================] - 0s 233us/step - loss: 0.9977 - accuracy: 0.5000
- val_loss: 0.9231 - val_accuracy: 0.5583
Epoch 39/100
30/30 [==============================] - 0s 300us/step - loss: 0.9926 - accuracy: 0.5000
- val_loss: 0.9178 - val_accuracy: 0.5583
Epoch 40/100
30/30 [==============================] - 0s 233us/step - loss: 0.9875 - accuracy: 0.5000
- val_loss: 0.9127 - val_accuracy: 0.5583
Epoch 41/100
30/30 [==============================] - 0s 333us/step - loss: 0.9824 - accuracy: 0.5000
- val_loss: 0.9075 - val_accuracy: 0.5583
Epoch 42/100
30/30 [==============================] - 0s 267us/step - loss: 0.9773 - accuracy: 0.5333
- val_loss: 0.9024 - val_accuracy: 0.5583
Epoch 43/100
```

```
30/30 [==============================] - 0s 167us/step - loss: 0.9723 - accuracy: 0.5667
- val_loss: 0.8974 - val_accuracy: 0.5750
Epoch 44/100
30/30 [==============================] - 0s 267us/step - loss: 0.9673 - accuracy: 0.5667
- val_loss: 0.8924 - val_accuracy: 0.5917
Epoch 45/100
30/30 [==============================] - 0s 167us/step - loss: 0.9623 - accuracy: 0.5667
- val_loss: 0.8874 - val_accuracy: 0.5917
Epoch 46/100
30/30 [==============================] - 0s 300us/step - loss: 0.9574 - accuracy: 0.5667
- val_loss: 0.8824 - val_accuracy: 0.5917
Epoch 47/100
30/30 [==============================] - 0s 300us/step - loss: 0.9525 - accuracy: 0.5667
- val_loss: 0.8775 - val_accuracy: 0.6000
Epoch 48/100
30/30 [==============================] - 0s 200us/step - loss: 0.9477 - accuracy: 0.5667
- val_loss: 0.8727 - val_accuracy: 0.6083
Epoch 49/100
30/30 [==============================] - 0s 300us/step - loss: 0.9430 - accuracy: 0.5667
- val_loss: 0.8679 - val_accuracy: 0.6083
Epoch 50/100
30/30 [==============================] - 0s 233us/step - loss: 0.9383 - accuracy: 0.5667
- val_loss: 0.8632 - val_accuracy: 0.6167
Epoch 51/100
30/30 [==============================] - 0s 300us/step - loss: 0.9336 - accuracy: 0.5667
- val_loss: 0.8585 - val_accuracy: 0.6250
Epoch 52/100
30/30 [==============================] - 0s 300us/step - loss: 0.9289 - accuracy: 0.5667
- val_loss: 0.8538 - val_accuracy: 0.6250
Epoch 53/100
30/30 [==============================] - 0s 200us/step - loss: 0.9244 - accuracy: 0.5667
- val_loss: 0.8492 - val_accuracy: 0.6250
Epoch 54/100
30/30 [==============================] - 0s 300us/step - loss: 0.9198 - accuracy: 0.5667
- val_loss: 0.8446 - val_accuracy: 0.6250
Epoch 55/100
30/30 [==============================] - 0s 200us/step - loss: 0.9153 - accuracy: 0.5667
- val_loss: 0.8400 - val_accuracy: 0.6250
Epoch 56/100
30/30 [==============================] - 0s 267us/step - loss: 0.9108 - accuracy: 0.5667
- val_loss: 0.8355 - val_accuracy: 0.6250
Epoch 57/100
30/30 [==============================] - 0s 333us/step - loss: 0.9063 - accuracy: 0.5667
- val_loss: 0.8310 - val_accuracy: 0.6250
Epoch 58/100
30/30 [==============================] - 0s 200us/step - loss: 0.9019 - accuracy: 0.5667
- val_loss: 0.8266 - val_accuracy: 0.6250
Epoch 59/100
30/30 [==============================] - 0s 267us/step - loss: 0.8975 - accuracy: 0.5667
- val_loss: 0.8222 - val_accuracy: 0.6417
Epoch 60/100
30/30 [==============================] - 0s 167us/step - loss: 0.8932 - accuracy: 0.5667
- val_loss: 0.8178 - val_accuracy: 0.6500
Epoch 61/100
30/30 [==============================] - 0s 366us/step - loss: 0.8888 - accuracy: 0.5667
- val_loss: 0.8135 - val_accuracy: 0.6500
Epoch 62/100
30/30 [==============================] - 0s 233us/step - loss: 0.8845 - accuracy: 0.5667
- val_loss: 0.8092 - val_accuracy: 0.6500
Epoch 63/100
30/30 [==============================] - 0s 200us/step - loss: 0.8802 - accuracy: 0.5667
- val_loss: 0.8049 - val_accuracy: 0.6500
Epoch 64/100
30/30 [==============================] - 0s 300us/step - loss: 0.8759 - accuracy: 0.5667
- val_loss: 0.8007 - val_accuracy: 0.6583
```

```
Epoch 65/100
30/30 [==============================] - 0s 233us/step - loss: 0.8717 - accuracy: 0.5667
- val_loss: 0.7965 - val_accuracy: 0.6667
Epoch 66/100
30/30 [==============================] - 0s 300us/step - loss: 0.8675 - accuracy: 0.5667
- val_loss: 0.7923 - val_accuracy: 0.6750
Epoch 67/100
30/30 [==============================] - 0s 200us/step - loss: 0.8633 - accuracy: 0.5667
- val_loss: 0.7882 - val_accuracy: 0.6833
Epoch 68/100
30/30 [==============================] - 0s 267us/step - loss: 0.8592 - accuracy: 0.5667
- val_loss: 0.7841 - val_accuracy: 0.6917
Epoch 69/100
30/30 [==============================] - 0s 267us/step - loss: 0.8550 - accuracy: 0.5667
- val_loss: 0.7800 - val_accuracy: 0.6917
Epoch 70/100
30/30 [==============================] - 0s 233us/step - loss: 0.8509 - accuracy: 0.5667
- val_loss: 0.7759 - val_accuracy: 0.6917
Epoch 71/100
30/30 [==============================] - 0s 333us/step - loss: 0.8468 - accuracy: 0.5667
- val_loss: 0.7719 - val_accuracy: 0.7000
Epoch 72/100
30/30 [==============================] - 0s 200us/step - loss: 0.8427 - accuracy: 0.5667
- val_loss: 0.7679 - val_accuracy: 0.7000
Epoch 73/100
30/30 [==============================] - 0s 300us/step - loss: 0.8386 - accuracy: 0.5667
- val_loss: 0.7639 - val_accuracy: 0.7000
Epoch 74/100
30/30 [==============================] - 0s 233us/step - loss: 0.8347 - accuracy: 0.6000
- val_loss: 0.7600 - val_accuracy: 0.7000
Epoch 75/100
30/30 [==============================] - 0s 233us/step - loss: 0.8307 - accuracy: 0.6000
- val_loss: 0.7561 - val_accuracy: 0.7000
Epoch 76/100
30/30 [==============================] - 0s 267us/step - loss: 0.8268 - accuracy: 0.6000
- val_loss: 0.7522 - val_accuracy: 0.7083
Epoch 77/100
30/30 [==============================] - 0s 300us/step - loss: 0.8229 - accuracy: 0.6000
- val_loss: 0.7485 - val_accuracy: 0.7083
Epoch 78/100
30/30 [==============================] - 0s 166us/step - loss: 0.8191 - accuracy: 0.6000
- val_loss: 0.7447 - val_accuracy: 0.7083
Epoch 79/100
30/30 [==============================] - 0s 233us/step - loss: 0.8153 - accuracy: 0.6000
- val_loss: 0.7410 - val_accuracy: 0.7167
Epoch 80/100
30/30 [==============================] - 0s 200us/step - loss: 0.8115 - accuracy: 0.6333
- val_loss: 0.7373 - val_accuracy: 0.7167
Epoch 81/100
30/30 [==============================] - 0s 267us/step - loss: 0.8078 - accuracy: 0.6333
- val_loss: 0.7337 - val_accuracy: 0.7167
Epoch 82/100
30/30 [==============================] - 0s 233us/step - loss: 0.8041 - accuracy: 0.6333
- val_loss: 0.7301 - val_accuracy: 0.7167
Epoch 83/100
30/30 [==============================] - 0s 234us/step - loss: 0.8004 - accuracy: 0.6667
- val_loss: 0.7265 - val_accuracy: 0.7167
Epoch 84/100
30/30 [==============================] - 0s 200us/step - loss: 0.7968 - accuracy: 0.6667
- val_loss: 0.7230 - val_accuracy: 0.7250
Epoch 85/100
30/30 [==============================] - 0s 300us/step - loss: 0.7931 - accuracy: 0.6667
- val_loss: 0.7195 - val_accuracy: 0.7250
Epoch 86/100
30/30 [==============================] - 0s 200us/step - loss: 0.7895 - accuracy: 0.6667
```

```
- val_loss: 0.7160 - val_accuracy: 0.7250
Epoch 87/100
30/30 [==============================] - 0s 300us/step - loss: 0.7860 - accuracy: 0.7000
- val_loss: 0.7126 - val_accuracy: 0.7250
Epoch 88/100
30/30 [==============================] - 0s 300us/step - loss: 0.7824 - accuracy: 0.7000
- val_loss: 0.7092 - val_accuracy: 0.7250
Epoch 89/100
30/30 [==============================] - 0s 200us/step - loss: 0.7789 - accuracy: 0.7000
- val_loss: 0.7059 - val_accuracy: 0.7250
Epoch 90/100
30/30 [==============================] - 0s 300us/step - loss: 0.7755 - accuracy: 0.7000
- val_loss: 0.7025 - val_accuracy: 0.7333
Epoch 91/100
30/30 [==============================] - 0s 167us/step - loss: 0.7720 - accuracy: 0.7000
- val_loss: 0.6993 - val_accuracy: 0.7417
Epoch 92/100
30/30 [==============================] - 0s 300us/step - loss: 0.7685 - accuracy: 0.7000
- val_loss: 0.6960 - val_accuracy: 0.7417
Epoch 93/100
30/30 [==============================] - 0s 233us/step - loss: 0.7651 - accuracy: 0.7000
- val_loss: 0.6928 - val_accuracy: 0.7417
Epoch 94/100
30/30 [==============================] - 0s 300us/step - loss: 0.7616 - accuracy: 0.7000
- val_loss: 0.6896 - val_accuracy: 0.7500
Epoch 95/100
30/30 [==============================] - 0s 200us/step - loss: 0.7582 - accuracy: 0.7000
- val_loss: 0.6864 - val_accuracy: 0.7500
Epoch 96/100
30/30 [==============================] - 0s 233us/step - loss: 0.7549 - accuracy: 0.7000
- val_loss: 0.6832 - val_accuracy: 0.7583
Epoch 97/100
30/30 [==============================] - 0s 400us/step - loss: 0.7515 - accuracy: 0.7000
- val_loss: 0.6801 - val_accuracy: 0.7583
Epoch 98/100
30/30 [==============================] - 0s 233us/step - loss: 0.7483 - accuracy: 0.7000
- val_loss: 0.6770 - val_accuracy: 0.7583
Epoch 99/100
30/30 [==============================] - 0s 300us/step - loss: 0.7450 - accuracy: 0.7000
- val_loss: 0.6740 - val_accuracy: 0.7583
Epoch 100/100
30/30 [==============================] - 0s 267us/step - loss: 0.7418 - accuracy: 0.7000
- val_loss: 0.6710 - val_accuracy: 0.7583
```

Out[68]:
```
<keras.callbacks.callbacks.History at 0x1d2fa4bdfd0>
```

In [69]:
```
w = model.get_weights()
```

In order to get better performance, the input data has to be normalized so that all features are weighted equally in classification

In [70]:
```
X = preprocessing.scale(iris['data'])
Y = to_categorical(iris['target'])
```

Save the trained model to the disk to retrieve

later and use it to predict the unlabeled samples (use the network as feed forward network)

In [71]:
```
model.save('iris_model.mdl')
```

In [72]:
```
model1 = keras.models.load_model('iris_model.mdl')
```

In [73]:
```
out_put = model.predict(X_test)
print(out_put.shape)
```

```
(120, 3)
```

In [74]:
```
label = np.zeros(out_put.shape[0], dtype = 'uint8')
for i in range(out_put.shape[0]):
    label[i] = 1+np.argmax(out_put[i,])
```

In [75]:
```
print(label)
```

```
[1 3 2 3 3 3 3 1 3 3 3 1 3 2 1 3 1 3 1 1 2 3 3 3 3 1 2 1 3 3 3 1 3 1 3 3 3
 3 3 3 1 3 1 3 3 1 1 3 3 2 1 3 3 3 1 3 1 1 1 3 3 1 3 3 1 3 1 1 3 1 1 3 3 3
 3 1 1 1 1 3 1 3 3 3 3 3 3 3 1 2 1 2 3 3 3 3 3 3 2 3 3 3 1 1 3 3 1 3 1 3 1
 1 2 1 3 3 1 3 1 1]
```

4) Concluding Remarks

With a 4-10-3 neuron size along with 200 epochs, and a training dataset of 0.6, I noticed that the accuracy was around 0.6667. Using the same number of epochs and increasing the training dataset to 0.7 increased the accuracy to 0.8286 and increasing it further to 0.8 increased the accuracy to 0.8583.

Reducing the epoch size to 150 along with a training dataset of 0.6 increased the accuracy to 0.71111. Using the same number of epochs and increasing the training dataset to 0.7 increased the accuracy to 0.8857, however, increasing it further to 0.8 reduced the accuracy to 0.8083.

Reducing the epoch size to 100 along with a training dataset of 0.6 increased the accuracy to 0.7667. With the same number of epochs, increasing the training dataset to 0.7 increased the accuracy to 0.7717, increasing it further to 0.8 increased the accuracy to 0.8167.