Topic : Introduction to Multi-Layer Perceptron

Objective for this template:

1. To understand the basic steps needed to define a Multi-layer Perceptron in scikit-learn
2. To demonstrate how the basic MLP prediction model works
3. To practice building a basic deployment interface for the MLP prediction model

Designed By: Rodolfo C. Raga Jr. Copyright @2021

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Step 1.

Declare and import all needed libraries

```python
# Kick off by importing libraries, and outlining the Iris dataset
import pandas as pd
import numpy as np
import sklearn
from sklearn import preprocessing
from sklearn.model_selection import train_test_split
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import classification_report, confusion_matrix
```

Step 2.

Declare class categories for use in categorically classifying the prediction output

```python
# Let's start by naming the class categories
species_names = ['Bream', 'Roach', 'Perch', 'Whitefish', 'Parkki',
'Smelt', 'Pike']
```

Step 3.

Read the dataset and inspect its characteristics

```python
# Reading the dataset through a Pandas function
df = pd.read_csv('E:/My Documents/Files (1st Sem
2021-2022)/Research/Training - DataScience and DL
workshop/datasets/Fish_Species.csv')
print(df.describe())
print(df.head)
```

| | Weight | Length1 | Length2 | Length3 | Height |
Width
count	159.000000	159.000000	159.000000	159.000000	159.000000

```
            159.000000
mean      398.326415    26.247170    28.415723    31.227044    8.970994
4.417486
std       357.978317     9.996441    10.716328    11.610246    4.286208
1.685804
min         0.000000     7.500000     8.400000     8.800000    1.728400
1.047600
25%       120.000000    19.050000    21.000000    23.150000    5.944800
3.385650
50%       273.000000    25.200000    27.300000    29.400000    7.786000
4.248500
75%       650.000000    32.700000    35.500000    39.650000   12.365900
5.584500
max      1650.000000    59.000000    63.400000    68.000000   18.957000
8.142000
<bound method NDFrame.head of     Species  Weight  Length1  Length2
Length3   Height   Width
0       Bream    242.0     23.2     25.4     30.0   11.5200   4.0200
1       Bream    290.0     24.0     26.3     31.2   12.4800   4.3056
2       Bream    340.0     23.9     26.5     31.1   12.3778   4.6961
3       Bream    363.0     26.3     29.0     33.5   12.7300   4.4555
4       Bream    430.0     26.5     29.0     34.0   12.4440   5.1340
..        ...      ...      ...      ...      ...       ...      ...
154     Smelt     12.2     11.5     12.2     13.4    2.0904   1.3936
155     Smelt     13.4     11.7     12.4     13.5    2.4300   1.2690
156     Smelt     12.2     12.1     13.0     13.8    2.2770   1.2558
157     Smelt     19.7     13.2     14.3     15.2    2.8728   2.0672
158     Smelt     19.9     13.8     15.0     16.2    2.9322   1.8792

[159 rows x 7 columns]>
```

Step 4.

Extract Feature matrix and target array. The fish dataset has seven columns. The task is to predict the class (which are the species in the first column) that a fish belongs to.

```
# Extract feature matrix and assign to variable "X"
X = df.iloc[:, 1:7]
# Extract target and assign them to variable "Y". Object dtype refers
to strings.
y = df.select_dtypes(include=[object])
```

Step 5.1.

Apply first preprocessing for testing later. In this case, Normalization using the MinMax Scale.

```
from sklearn.preprocessing import MinMaxScaler
X.head()
```

```python
#Convert the list to a NumPy array
X_np = np.array(X)
print("Raw data form:\n",X_np.reshape(1,-1))

#Normalize the vector
X_norm = MinMaxScaler().fit_transform(X_np)
print("\nNormalized data form:\n",X_norm.reshape(1,-1))
```

```
Raw data form:
 [[2.42000e+02 2.32000e+01 2.54000e+01 3.00000e+01 1.15200e+01
4.02000e+00
  2.90000e+02 2.40000e+01 2.63000e+01 3.12000e+01 1.24800e+01
4.30560e+00
  3.40000e+02 2.39000e+01 2.65000e+01 3.11000e+01 1.23778e+01
4.69610e+00
  3.63000e+02 2.63000e+01 2.90000e+01 3.35000e+01 1.27300e+01
4.45550e+00
  4.30000e+02 2.65000e+01 2.90000e+01 3.40000e+01 1.24440e+01
5.13400e+00
  4.50000e+02 2.68000e+01 2.97000e+01 3.47000e+01 1.36024e+01
4.92740e+00
  5.00000e+02 2.68000e+01 2.97000e+01 3.45000e+01 1.41795e+01
5.27850e+00
  3.90000e+02 2.76000e+01 3.00000e+01 3.50000e+01 1.26700e+01
4.69000e+00
  4.50000e+02 2.76000e+01 3.00000e+01 3.51000e+01 1.40049e+01
4.84380e+00
  5.00000e+02 2.85000e+01 3.07000e+01 3.62000e+01 1.42266e+01
4.95940e+00
  4.75000e+02 2.84000e+01 3.10000e+01 3.62000e+01 1.42628e+01
5.10420e+00
  5.00000e+02 2.87000e+01 3.10000e+01 3.62000e+01 1.43714e+01
4.81460e+00
  5.00000e+02 2.91000e+01 3.15000e+01 3.64000e+01 1.37592e+01
4.36800e+00
  3.40000e+02 2.95000e+01 3.20000e+01 3.73000e+01 1.39129e+01
5.07280e+00
  6.00000e+02 2.94000e+01 3.20000e+01 3.72000e+01 1.49544e+01
5.17080e+00
  6.00000e+02 2.94000e+01 3.20000e+01 3.72000e+01 1.54380e+01
5.58000e+00
  7.00000e+02 3.04000e+01 3.30000e+01 3.83000e+01 1.48604e+01
5.28540e+00
  7.00000e+02 3.04000e+01 3.30000e+01 3.85000e+01 1.49380e+01
5.19750e+00
  6.10000e+02 3.09000e+01 3.35000e+01 3.86000e+01 1.56330e+01
5.13380e+00
  6.50000e+02 3.10000e+01 3.35000e+01 3.87000e+01 1.44738e+01
5.72760e+00
  5.75000e+02 3.13000e+01 3.40000e+01 3.95000e+01 1.51285e+01
```

```
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    6.85000e+02 3.14000e+01 3.40000e+01 3.92000e+01 1.59936e+01
5.37040e+00
    6.20000e+02 3.15000e+01 3.45000e+01 3.97000e+01 1.55227e+01
5.28010e+00
    6.80000e+02 3.18000e+01 3.50000e+01 4.06000e+01 1.54686e+01
6.13060e+00
    7.00000e+02 3.19000e+01 3.50000e+01 4.05000e+01 1.62405e+01
5.58900e+00
    7.25000e+02 3.18000e+01 3.50000e+01 4.09000e+01 1.63600e+01
6.05320e+00
    7.20000e+02 3.20000e+01 3.50000e+01 4.06000e+01 1.63618e+01
6.09000e+00
    7.14000e+02 3.27000e+01 3.60000e+01 4.15000e+01 1.65170e+01
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    1.00000e+03 3.35000e+01 3.70000e+01 4.26000e+01 1.89570e+01
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    9.20000e+02 3.50000e+01 3.85000e+01 4.41000e+01 1.80369e+01
6.30630e+00
    9.55000e+02 3.50000e+01 3.85000e+01 4.40000e+01 1.80840e+01
6.29200e+00
    9.25000e+02 3.62000e+01 3.95000e+01 4.53000e+01 1.87542e+01
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6.37050e+00
    4.00000e+01 1.29000e+01 1.41000e+01 1.62000e+01 4.14720e+00
2.26800e+00
    6.90000e+01 1.65000e+01 1.82000e+01 2.03000e+01 5.29830e+00
2.82170e+00
    7.80000e+01 1.75000e+01 1.88000e+01 2.12000e+01 5.57560e+00
2.90440e+00
    8.70000e+01 1.82000e+01 1.98000e+01 2.22000e+01 5.61660e+00
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3.75440e+00
    1.45000e+02 2.05000e+01 2.20000e+01 2.43000e+01 6.63390e+00
3.54780e+00
    1.60000e+02 2.05000e+01 2.25000e+01 2.53000e+01 7.03340e+00
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3.80000e+00
   1.69000e+02 2.20000e+01 2.40000e+01 2.72000e+01 7.53440e+00
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   1.61000e+02 2.20000e+01 2.34000e+01 2.67000e+01 6.91530e+00
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4.49680e+00
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5.35500e+00
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4.24760e+00
   2.70000e+02 2.41000e+01 2.65000e+01 2.93000e+01 8.14540e+00
4.24850e+00
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3.29280e+00
   1.40000e+02 1.90000e+01 2.07000e+01 2.32000e+01 8.53760e+00
3.29440e+00
   1.70000e+02 1.90000e+01 2.07000e+01 2.32000e+01 9.39600e+00
3.41040e+00
   1.45000e+02 1.98000e+01 2.15000e+01 2.41000e+01 9.73640e+00
3.15710e+00
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 4.23400e+00
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 1.99920e+00
    4.00000e+01 1.38000e+01 1.50000e+01 1.60000e+01 3.82400e+00
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 3.32160e+00
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    8.00000e+01 1.72000e+01 1.90000e+01 2.02000e+01 5.63580e+00
 3.05020e+00
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 3.03680e+00
    8.50000e+01 1.82000e+01 2.00000e+01 2.10000e+01 5.08200e+00
 2.77200e+00
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 3.55500e+00
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 3.30750e+00
    1.25000e+02 1.90000e+01 2.10000e+01 2.25000e+01 5.69250e+00
 3.66750e+00
    1.30000e+02 1.93000e+01 2.13000e+01 2.28000e+01 6.38400e+00
 3.53400e+00
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 3.40750e+00
    1.20000e+02 2.00000e+01 2.20000e+01 2.35000e+01 5.64000e+00
 3.52500e+00
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 3.52500e+00
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 3.52500e+00
    1.10000e+02 2.00000e+01 2.20000e+01 2.35000e+01 5.52250e+00
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    1.30000e+02 2.05000e+01 2.25000e+01 2.40000e+01 5.85600e+00
 3.62400e+00
    1.50000e+02 2.05000e+01 2.25000e+01 2.40000e+01 6.79200e+00
 3.62400e+00
    1.45000e+02 2.07000e+01 2.27000e+01 2.42000e+01 5.95320e+00
 3.63000e+00
    1.50000e+02 2.10000e+01 2.30000e+01 2.45000e+01 5.21850e+00
 3.62600e+00
    1.70000e+02 2.15000e+01 2.35000e+01 2.50000e+01 6.27500e+00
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3.72300e+00
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3.82500e+00
   1.88000e+02 2.26000e+01 2.46000e+01 2.62000e+01 6.73340e+00
4.16580e+00
   1.80000e+02 2.30000e+01 2.50000e+01 2.65000e+01 6.43950e+00
3.68350e+00
   1.97000e+02 2.35000e+01 2.56000e+01 2.70000e+01 6.56100e+00
4.23900e+00
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4.14400e+00
   3.00000e+02 2.52000e+01 2.73000e+01 2.87000e+01 8.32300e+00
5.13730e+00
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4.33500e+00
   2.65000e+02 2.54000e+01 2.75000e+01 2.89000e+01 7.05160e+00
4.33500e+00
   2.50000e+02 2.54000e+01 2.75000e+01 2.89000e+01 7.28280e+00
4.56620e+00
   2.50000e+02 2.59000e+01 2.80000e+01 2.94000e+01 7.82040e+00
4.20420e+00
   3.00000e+02 2.69000e+01 2.87000e+01 3.01000e+01 7.58520e+00
4.63540e+00
   3.20000e+02 2.78000e+01 3.00000e+01 3.16000e+01 7.61560e+00
4.77160e+00
   5.14000e+02 3.05000e+01 3.28000e+01 3.40000e+01 1.00300e+01
6.01800e+00
   5.56000e+02 3.20000e+01 3.45000e+01 3.65000e+01 1.02565e+01
6.38750e+00
   8.40000e+02 3.25000e+01 3.50000e+01 3.73000e+01 1.14884e+01
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6.74080e+00
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6.36660e+00
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7.49340e+00
   6.50000e+02 3.65000e+01 3.90000e+01 4.14000e+01 1.11366e+01
6.00300e+00
   8.20000e+02 3.66000e+01 3.90000e+01 4.13000e+01 1.24313e+01
7.35140e+00
   8.50000e+02 3.69000e+01 4.00000e+01 4.23000e+01 1.19286e+01
7.10640e+00
   9.00000e+02 3.70000e+01 4.00000e+01 4.25000e+01 1.17300e+01
```

```
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  7.46240e+00
  8.20000e+02 3.71000e+01 4.00000e+01 4.25000e+01 1.11350e+01
  6.63000e+00
  1.10000e+03 3.90000e+01 4.20000e+01 4.46000e+01 1.28002e+01
  6.86840e+00
  1.00000e+03 3.98000e+01 4.30000e+01 4.52000e+01 1.19328e+01
  7.27720e+00
  1.10000e+03 4.01000e+01 4.30000e+01 4.55000e+01 1.25125e+01
  7.41650e+00
  1.00000e+03 4.02000e+01 4.35000e+01 4.60000e+01 1.26040e+01
  8.14200e+00
  1.00000e+03 4.11000e+01 4.40000e+01 4.66000e+01 1.24888e+01
  7.59580e+00
  2.00000e+02 3.00000e+01 3.23000e+01 3.48000e+01 5.56800e+00
  3.37560e+00
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  4.38440e+00
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  4.01980e+00
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  4.57650e+00
  3.45000e+02 3.60000e+01 3.85000e+01 4.10000e+01 6.39600e+00
  3.97700e+00
  4.56000e+02 4.00000e+01 4.25000e+01 4.55000e+01 7.28000e+00
  4.32250e+00
  5.10000e+02 4.00000e+01 4.25000e+01 4.55000e+01 6.82500e+00
  4.45900e+00
  5.40000e+02 4.01000e+01 4.30000e+01 4.58000e+01 7.78600e+00
  5.12960e+00
  5.00000e+02 4.20000e+01 4.50000e+01 4.80000e+01 6.96000e+00
  4.89600e+00
  5.67000e+02 4.32000e+01 4.60000e+01 4.87000e+01 7.79200e+00
  4.87000e+00
  7.70000e+02 4.48000e+01 4.80000e+01 5.12000e+01 7.68000e+00
  5.37600e+00
  9.50000e+02 4.83000e+01 5.17000e+01 5.51000e+01 8.92620e+00
  6.17120e+00
  1.25000e+03 5.20000e+01 5.60000e+01 5.97000e+01 1.06863e+01
  6.98490e+00
  1.60000e+03 5.60000e+01 6.00000e+01 6.40000e+01 9.60000e+00
  6.14400e+00
  1.55000e+03 5.60000e+01 6.00000e+01 6.40000e+01 9.60000e+00
  6.14400e+00
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3.27272727e-01  6.33009709e-01  6.29090909e-01  6.25000000e-01
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6.65454545e-01  6.62162162e-01  3.03657871e-01  5.42456022e-01
3.43636364e-01  6.93203883e-01  6.83636364e-01  6.73986486e-01
3.51949665e-01  5.38791159e-01  4.66666667e-01  7.24271845e-01
7.20000000e-01  7.16216216e-01  3.45448847e-01  6.10115020e-01
5.75757576e-01  7.92233010e-01  7.87272727e-01  7.82094595e-01
4.17782060e-01  7.22203428e-01  7.57575758e-01  8.64077670e-01
8.65454545e-01  8.59797297e-01  5.19943582e-01  8.36899526e-01
9.69696970e-01  9.41747573e-01  9.38181818e-01  9.32432432e-01
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2.54545455e-02  3.37837838e-02  6.03647423e-04  0.00000000e+00
4.54545455e-03  4.85436893e-02  3.81818182e-02  4.72972973e-02
1.41392800e-02  1.58434822e-02  4.24242424e-03  5.04854369e-02
```

```
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  5.87878788e-03 5.63106796e-02 4.72727273e-02 5.40540541e-02
  2.71409168e-02 4.68538566e-02 5.93939394e-03 6.21359223e-02
  5.09090909e-02 6.08108108e-02 2.05936640e-02 3.23635544e-02
  5.27272727e-03 6.40776699e-02 5.27272727e-02 6.41891892e-02
  1.44991468e-02 3.34912043e-02 6.06060606e-03 7.37864078e-02
  6.18181818e-02 7.26351351e-02 2.81798869e-02 3.32938656e-02
  6.00000000e-03 7.37864078e-02 6.18181818e-02 7.26351351e-02
  2.81798869e-02 1.66751240e-02 5.93939394e-03 7.57281553e-02
  6.54545455e-02 7.43243243e-02 2.76284782e-02 1.42083897e-02
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  2.10115738e-02 4.87708615e-02 8.12121212e-03 8.15533981e-02
  7.27272727e-02 7.93918919e-02 4.07229839e-02 3.12077131e-02
  7.39393939e-03 8.93203883e-02 8.36363636e-02 8.44594595e-02
  3.18424016e-02 2.93470907e-02 1.19393939e-02 1.10679612e-01
  1.07272727e-01 1.08108108e-01 6.64244338e-02 1.43718990e-01
  1.20606061e-02 1.22330097e-01 1.20000000e-01 1.25000000e-01
  6.98721893e-02 1.17219215e-01]]
```

Step 5.2.

Apply 2nd preprocessing for testing later. In this case, Standarization using the
StandardScaler.

```python
from sklearn.preprocessing import StandardScaler
# Feature scaling
#scaler = StandardScaler()
#scaler.fit(X_train)
#X_train = scaler.transform(X_train)
#X_test = scaler.transform(X_test)

X.head()

#Convert the list to a NumPy array
X_np = np.array(X)
print("Raw data form:\n",X_np.reshape(1,-1))

#Standardize the matrix
scaler = StandardScaler()
X_std = scaler.fit_transform(X_np)
print("\nStandardized data form:\n",X_std.reshape(1,-1))
```

```
Raw data form:
 [[2.42000e+02 2.32000e+01 2.54000e+01 3.00000e+01 1.15200e+01
4.02000e+00
  2.90000e+02 2.40000e+01 2.63000e+01 3.12000e+01 1.24800e+01
4.30560e+00
  3.40000e+02 2.39000e+01 2.65000e+01 3.11000e+01 1.23778e+01
4.69610e+00
  3.63000e+02 2.63000e+01 2.90000e+01 3.35000e+01 1.27300e+01
```

```
4.45550e+00
  4.30000e+02 2.65000e+01 2.90000e+01 3.40000e+01 1.24440e+01
5.13400e+00
  4.50000e+02 2.68000e+01 2.97000e+01 3.47000e+01 1.36024e+01
4.92740e+00
  5.00000e+02 2.68000e+01 2.97000e+01 3.45000e+01 1.41795e+01
5.27850e+00
  3.90000e+02 2.76000e+01 3.00000e+01 3.50000e+01 1.26700e+01
4.69000e+00
  4.50000e+02 2.76000e+01 3.00000e+01 3.51000e+01 1.40049e+01
4.84380e+00
  5.00000e+02 2.85000e+01 3.07000e+01 3.62000e+01 1.42266e+01
4.95940e+00
  4.75000e+02 2.84000e+01 3.10000e+01 3.62000e+01 1.42628e+01
5.10420e+00
  5.00000e+02 2.87000e+01 3.10000e+01 3.62000e+01 1.43714e+01
4.81460e+00
  5.00000e+02 2.91000e+01 3.15000e+01 3.64000e+01 1.37592e+01
4.36800e+00
  3.40000e+02 2.95000e+01 3.20000e+01 3.73000e+01 1.39129e+01
5.07280e+00
  6.00000e+02 2.94000e+01 3.20000e+01 3.72000e+01 1.49544e+01
5.17080e+00
  6.00000e+02 2.94000e+01 3.20000e+01 3.72000e+01 1.54380e+01
5.58000e+00
  7.00000e+02 3.04000e+01 3.30000e+01 3.83000e+01 1.48604e+01
5.28540e+00
  7.00000e+02 3.04000e+01 3.30000e+01 3.85000e+01 1.49380e+01
5.19750e+00
  6.10000e+02 3.09000e+01 3.35000e+01 3.86000e+01 1.56330e+01
5.13380e+00
  6.50000e+02 3.10000e+01 3.35000e+01 3.87000e+01 1.44738e+01
5.72760e+00
  5.75000e+02 3.13000e+01 3.40000e+01 3.95000e+01 1.51285e+01
5.56950e+00
  6.85000e+02 3.14000e+01 3.40000e+01 3.92000e+01 1.59936e+01
5.37040e+00
  6.20000e+02 3.15000e+01 3.45000e+01 3.97000e+01 1.55227e+01
5.28010e+00
  6.80000e+02 3.18000e+01 3.50000e+01 4.06000e+01 1.54686e+01
6.13060e+00
  7.00000e+02 3.19000e+01 3.50000e+01 4.05000e+01 1.62405e+01
5.58900e+00
  7.25000e+02 3.18000e+01 3.50000e+01 4.09000e+01 1.63600e+01
6.05320e+00
  7.20000e+02 3.20000e+01 3.50000e+01 4.06000e+01 1.63618e+01
6.09000e+00
  7.14000e+02 3.27000e+01 3.60000e+01 4.15000e+01 1.65170e+01
5.85150e+00
  8.50000e+02 3.28000e+01 3.60000e+01 4.16000e+01 1.68896e+01
```

```
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6.30630e+00
  9.55000e+02 3.50000e+01 3.85000e+01 4.40000e+01 1.80840e+01
6.29200e+00
  9.25000e+02 3.62000e+01 3.95000e+01 4.53000e+01 1.87542e+01
6.74970e+00
  9.75000e+02 3.74000e+01 4.10000e+01 4.59000e+01 1.86354e+01
6.74730e+00
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6.37050e+00
  4.00000e+01 1.29000e+01 1.41000e+01 1.62000e+01 4.14720e+00
2.26800e+00
  6.90000e+01 1.65000e+01 1.82000e+01 2.03000e+01 5.29830e+00
2.82170e+00
  7.80000e+01 1.75000e+01 1.88000e+01 2.12000e+01 5.57560e+00
2.90440e+00
  8.70000e+01 1.82000e+01 1.98000e+01 2.22000e+01 5.61660e+00
3.17460e+00
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  0.00000e+00 1.90000e+01 2.05000e+01 2.28000e+01 6.47520e+00
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3.39570e+00
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3.29430e+00
  1.50000e+02 2.04000e+01 2.20000e+01 2.47000e+01 5.80450e+00
3.75440e+00
  1.45000e+02 2.05000e+01 2.20000e+01 2.43000e+01 6.63390e+00
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  1.60000e+02 2.11000e+01 2.25000e+01 2.50000e+01 6.40000e+00
3.80000e+00
  1.69000e+02 2.20000e+01 2.40000e+01 2.72000e+01 7.53440e+00
3.83520e+00
  1.61000e+02 2.20000e+01 2.34000e+01 2.67000e+01 6.91530e+00
3.63120e+00
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4.12720e+00
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3.90600e+00
  2.90000e+02 2.40000e+01 2.60000e+01 2.92000e+01 8.87680e+00
4.49680e+00
  2.72000e+02 2.50000e+01 2.70000e+01 3.06000e+01 8.56800e+00
```

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5.35500e+00
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    2.70000e+02 2.41000e+01 2.65000e+01 2.93000e+01 8.14540e+00
4.24850e+00
    3.06000e+02 2.56000e+01 2.80000e+01 3.08000e+01 8.77800e+00
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6.52500e+00
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```

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3.62400e+00
   1.50000e+02 2.05000e+01 2.25000e+01 2.40000e+01 6.79200e+00
3.62400e+00
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3.63000e+00
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3.62600e+00
   1.70000e+02 2.15000e+01 2.35000e+01 2.50000e+01 6.27500e+00
3.72500e+00
   2.25000e+02 2.20000e+01 2.40000e+01 2.55000e+01 7.29300e+00
3.72300e+00
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3.68350e+00
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4.14400e+00
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5.13730e+00
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```

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4.33500e+00
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4.56620e+00
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4.63540e+00
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6.01800e+00
  5.56000e+02 3.20000e+01 3.45000e+01 3.65000e+01 1.02565e+01
6.38750e+00
  8.40000e+02 3.25000e+01 3.50000e+01 3.73000e+01 1.14884e+01
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  6.85000e+02 3.40000e+01 3.65000e+01 3.90000e+01 1.08810e+01
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  7.00000e+02 3.45000e+01 3.70000e+01 3.94000e+01 1.08350e+01
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6.00300e+00
  8.20000e+02 3.66000e+01 3.90000e+01 4.13000e+01 1.24313e+01
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  8.50000e+02 3.69000e+01 4.00000e+01 4.23000e+01 1.19286e+01
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7.46240e+00
  8.20000e+02 3.71000e+01 4.00000e+01 4.25000e+01 1.11350e+01
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  1.00000e+03 3.98000e+01 4.30000e+01 4.52000e+01 1.19328e+01
7.27720e+00
  1.10000e+03 4.01000e+01 4.30000e+01 4.55000e+01 1.25125e+01
7.41650e+00
  1.00000e+03 4.02000e+01 4.35000e+01 4.60000e+01 1.26040e+01
8.14200e+00
  1.00000e+03 4.11000e+01 4.40000e+01 4.66000e+01 1.24888e+01
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  2.00000e+02 3.00000e+01 3.23000e+01 3.48000e+01 5.56800e+00
```

```
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  4.15800e+00
  3.00000e+02 3.27000e+01 3.50000e+01 3.88000e+01 5.93640e+00
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  4.57650e+00
  3.45000e+02 3.60000e+01 3.85000e+01 4.10000e+01 6.39600e+00
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  4.56000e+02 4.00000e+01 4.25000e+01 4.55000e+01 7.28000e+00
  4.32250e+00
  5.10000e+02 4.00000e+01 4.25000e+01 4.55000e+01 6.82500e+00
  4.45900e+00
  5.40000e+02 4.01000e+01 4.30000e+01 4.58000e+01 7.78600e+00
  5.12960e+00
  5.00000e+02 4.20000e+01 4.50000e+01 4.80000e+01 6.96000e+00
  4.89600e+00
  5.67000e+02 4.32000e+01 4.60000e+01 4.87000e+01 7.79200e+00
  4.87000e+00
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1.40583558e+00	1.02888863e+00	9.90798186e-01	8.78973472e-01
5.06846345e-01	1.83036299e+00	7.05262728e-01	1.02888863e+00
9.90798186e-01	8.78973472e-01	5.06846345e-01	9.43481048e-01
1.18165227e+00	1.03892379e+00	9.90798186e-01	8.70333177e-01
8.09862625e-01	1.74586404e+00	1.26572101e+00	1.06902930e+00
1.08440857e+00	9.56736133e-01	6.92208895e-01	1.60007360e+00
1.40583558e+00	1.07906446e+00	1.08440857e+00	9.74016725e-01
6.45727831e-01	1.67064808e+00	1.72809910e+00	1.07906446e+00
1.08440857e+00	9.65376429e-01	7.98043422e-01	1.81191604e+00
1.18165227e+00	1.08909963e+00	1.08440857e+00	9.74016725e-01
5.06471875e-01	1.31658557e+00	1.96629387e+00	1.27976780e+00
1.27162933e+00	1.15546293e+00	8.96201318e-01	1.45844860e+00
1.68606473e+00	1.36004914e+00	1.36523971e+00	1.20730471e+00

```
 6.93191878e-01   1.70171037e+00   1.96629387e+00   1.39015464e+00
 1.36523971e+00   1.23322559e+00   8.28866967e-01   1.78460265e+00
 1.68606473e+00   1.40018981e+00   1.41204490e+00   1.27642707e+00
 8.50281959e-01   2.21632088e+00   1.68606473e+00   1.49050631e+00
 1.45885010e+00   1.32826885e+00   8.23320133e-01   1.89129745e+00
-5.55768412e-01   3.76602775e-01   3.63608628e-01   3.08713960e-01
-7.96448981e-01  -6.19987567e-01  -2.75539270e-01   5.47200613e-01
 5.22746277e-01   5.67922829e-01  -7.63729683e-01  -1.54410249e-01
-2.75539270e-01   6.47552283e-01   6.16356659e-01   6.54325786e-01
-7.10227310e-01  -1.96879786e-02  -2.75539270e-01   8.58290789e-01
 8.31660537e-01   7.40728742e-01  -6.27843954e-01  -2.36647961e-01
 8.87586153e-02   9.28536958e-01   8.97187805e-01   8.01210812e-01
-3.93425860e-01   9.46236302e-02  -1.49436156e-01   9.78712793e-01
 9.43992995e-01   8.44412290e-01  -6.02660860e-01  -2.62116659e-01
 1.61618192e-01   1.38011947e+00   1.31843452e+00   1.23322559e+00
-3.95766297e-01  -5.65223804e-02   3.12941929e-01   1.38011947e+00
 1.31843452e+00   1.23322559e+00  -5.02256146e-01   2.47037237e-02
 3.97010672e-01   1.39015464e+00   1.36523971e+00   1.25914648e+00
-2.77340223e-01   4.23752994e-01   2.84919015e-01   1.58082281e+00
 1.55246048e+00   1.44923299e+00  -4.70660256e-01   2.84746270e-01
 4.72672540e-01   1.70124481e+00   1.64607086e+00   1.50971505e+00
-2.75935961e-01   2.69274631e-01   1.04153770e+00   1.86180749e+00
 1.83329162e+00   1.72572245e+00  -3.02148847e-01   5.70376526e-01
 1.54595015e+00   2.21303833e+00   2.17965004e+00   2.06269398e+00
-1.04836824e-02   1.04357065e+00   2.38663758e+00   2.58433951e+00
 2.58217468e+00   2.46014758e+00   4.01456501e-01   1.52777344e+00
 3.36743958e+00   2.98574618e+00   2.95661621e+00   2.83168029e+00
 1.47214912e-01   1.02738494e+00   3.22732501e+00   2.98574618e+00
 2.95661621e+00   2.83168029e+00   1.47214912e-01   1.02738494e+00
 3.50755415e+00   3.28680119e+00   3.27489150e+00   3.17729212e+00
 4.30875784e-01   1.82238915e+00  -1.09745134e+00  -1.70067679e+00
-1.74262496e+00  -1.76495700e+00  -1.69264883e+00  -2.00529431e+00
-1.09520951e+00  -1.63043062e+00  -1.67709770e+00  -1.69583463e+00
-1.63806985e+00  -1.93840923e+00  -1.09661066e+00  -1.62039545e+00
-1.66773666e+00  -1.69583463e+00  -1.69508288e+00  -1.94531196e+00
-1.08904447e+00  -1.59028995e+00  -1.63029251e+00  -1.66127345e+00
-1.58564408e+00  -1.80749536e+00  -1.08876424e+00  -1.56018445e+00
-1.61157043e+00  -1.62671227e+00  -1.61204420e+00  -1.86866784e+00
-1.09184676e+00  -1.55014928e+00  -1.60220939e+00  -1.60943167e+00
-1.63661878e+00  -1.86390733e+00  -1.08820378e+00  -1.49997345e+00
-1.55540420e+00  -1.56623020e+00  -1.58145470e+00  -1.86474042e+00
-1.08848401e+00  -1.49997345e+00  -1.55540420e+00  -1.56623020e+00
-1.58145470e+00  -1.93489835e+00  -1.08876424e+00  -1.48993828e+00
-1.53668212e+00  -1.55758990e+00  -1.58367812e+00  -1.94531196e+00
-1.08203874e+00  -1.47990311e+00  -1.51796005e+00  -1.54030931e+00
-1.61035909e+00  -1.79940250e+00  -1.07867599e+00  -1.45983278e+00
-1.49923797e+00  -1.53166901e+00  -1.53087787e+00  -1.87354735e+00
-1.08203874e+00  -1.41969211e+00  -1.44307174e+00  -1.50574813e+00
-1.56668655e+00  -1.88140219e+00  -1.06102155e+00  -1.30930527e+00
-1.32137825e+00  -1.38478399e+00  -1.42724336e+00  -1.39856804e+00
```

```
      -1.06046110e+00 -1.24909427e+00 -1.25585098e+00 -1.29838103e+00
      -1.41334117e+00 -1.51043989e+00]]
```

Step 6.

Inspect target array and convert to numeriic encoded form

```python
# Now transforming categorial into numerical values
le = preprocessing.LabelEncoder()
#y_enc = y.apply(le.fit_transform)

# Fit the labels
y_encoded = le.fit(y)
y_enc=y_encoded.transform(y)


print("Target Array")
print("Raw Categorical Form:",y.values.reshape(1,-1))
print("\nEncoded Numeric Form:",y_enc)


Target Array
Raw Categorical Form: [['Bream' 'Bream' 'Bream' 'Bream' 'Bream'
'Bream' 'Bream' 'Bream' 'Bream'
  'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream'
'Bream'
  'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream'
'Bream'
  'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream' 'Bream'
'Roach'
  'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach'
'Roach'
  'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach' 'Roach'
'Roach'
  'Roach' 'Whitefish' 'Whitefish' 'Whitefish' 'Whitefish' 'Whitefish'
  'Whitefish' 'Parkki' 'Parkki' 'Parkki' 'Parkki' 'Parkki' 'Parkki'
  'Parkki' 'Parkki' 'Parkki' 'Parkki' 'Parkki' 'Perch' 'Perch' 'Perch'
  'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch'
'Perch'
  'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch'
'Perch'
  'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch'
'Perch'
  'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch'
'Perch'
  'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch' 'Perch'
'Pike'
  'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Pike'
```

```
'Pike'
  'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Pike' 'Smelt' 'Smelt' 'Smelt'
  'Smelt' 'Smelt' 'Smelt' 'Smelt' 'Smelt' 'Smelt' 'Smelt' 'Smelt'
'Smelt'
  'Smelt' 'Smelt']]
```

```
Encoded Numeric Form: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 4 4
 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 6 6 6 6 6 6 1 1 1 1 1 1 1 1 1 1 1
2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2
 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 5
5 5
 5 5 5 5 5 5 5 5 5 5 5]
```

```
c:\Users\Jundy\anaconda3\lib\site-packages\sklearn\utils\
validation.py:63: DataConversionWarning: A column-vector y was passed
when a 1d array was expected. Please change the shape of y to
(n_samples, ), for example using ravel().
  return f(*args, **kwargs)
```

Step 7.

Generate training and validation datasets

```python
# Now for train and test split (80% of  dataset into  training set and
other 20% into test data)
X_train, X_test, y_train, y_test = train_test_split(X_norm, y_enc,
test_size = 0.20)

print("Total Testing data",y_test.shape[0],"records")
print(y_test)

Total Testing data 32 records
[2 2 3 0 0 4 2 1 4 1 2 2 0 5 0 1 6 0 3 5 3 2 5 2 0 2 0 5 3 5 2 2]
```

Step 8.

Instantiate prediction model and with fit with training data.

```python
# Finally for the MLP- Multilayer Perceptron
mlp = MLPClassifier(hidden_layer_sizes=(10, 10, 10), max_iter=1000)
mlp.fit(X_train, y_train.ravel())
```

```
c:\Users\Jundy\anaconda3\lib\site-packages\sklearn\neural_network\
_multilayer_perceptron.py:614: ConvergenceWarning: Stochastic
Optimizer: Maximum iterations (1000) reached and the optimization
hasn't converged yet.
  warnings.warn(

MLPClassifier(hidden_layer_sizes=(10, 10, 10), max_iter=1000)
```

Step 9.

Validate prediction model performance using testing data.

```
y_pred = mlp.predict(X_test)

print("Actual Species:",y_test)
print("Predicted Species:",y_pred)

# Last thing: evaluation of MLP algorithm performance in classifying
fish species
print("\nConfusion Matrix\n",confusion_matrix(y_test,y_pred))
print("\nSummary Performance Report\
n",classification_report(y_test,y_pred))
```

```
Actual Species: [2 2 3 0 0 4 2 1 4 1 2 2 0 5 0 1 6 0 3 5 3 2 5 2 0 2 0
5 3 5 2 2]
Predicted Species: [4 2 3 0 0 4 5 1 4 1 2 2 0 5 0 1 2 0 3 5 3 2 5 2 0
5 0 5 3 5 2 2]

Confusion Matrix
 [[7 0 0 0 0 0 0]
 [0 3 0 0 0 0 0]
 [0 0 7 0 1 2 0]
 [0 0 0 4 0 0 0]
 [0 0 0 0 2 0 0]
 [0 0 0 0 0 5 0]
 [0 0 1 0 0 0 0]]

Summary Performance Report
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         7
           1       1.00      1.00      1.00         3
           2       0.88      0.70      0.78        10
           3       1.00      1.00      1.00         4
           4       0.67      1.00      0.80         2
           5       0.71      1.00      0.83         5
           6       0.00      0.00      0.00         1

    accuracy                           0.88        32
   macro avg       0.75      0.81      0.77        32
weighted avg       0.86      0.88      0.86        32
```

c:\Users\Jundy\anaconda3\lib\site-packages\sklearn\metrics\
_classification.py:1245: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))

```
c:\Users\Jundy\anaconda3\lib\site-packages\sklearn\metrics\
_classification.py:1245: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
c:\Users\Jundy\anaconda3\lib\site-packages\sklearn\metrics\
_classification.py:1245: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Step 10.

Model Deployment. Your task is to design and implement a basic deployment interface for this prediction model.

```
prediction =  mlp.predict(np.array([[242.0, 23.2, 25.4, 30.0, 11.5200,
4.0200]]))
print(species_names[prediction[0]])
```

```
Bream
```