Question 2 Extra

December 15, 2022

Arunaggiri Pandian Karunanidhi

0.0.1 I. EXTRA CREDIT (5 points): Use PyTorch (by switching to a different kernel) to build a simple fully-connected artificial neural network for the beans classification based on the chosen features provided in the data. Generate a confusion matrix for the test data set to demonstrate the accuracy of the model. Based on your model, classify the beans provided in the unlabeled beans-unknown.csv data set. Indicate which classification has been assigned to each of the unlabeled beans. How do the results with the artificial neural network compare to the support vector machine model?

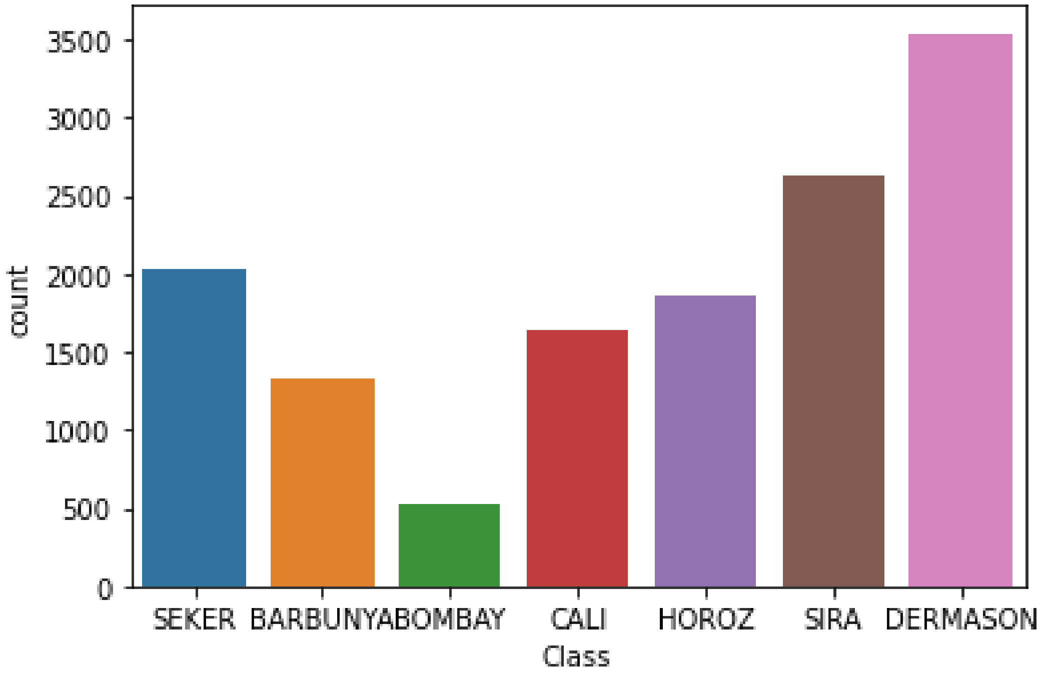
```
In [1]: import pandas as pd
        from sklearn import preprocessing
        import torch
        import torch.nn as nn
        import seaborn as sns
```

```
In [2]: df = pd.read_csv('beans.csv')
        df.head(3)
```

```
Out[2]:     Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
        0  28395    610.291       208.178117       173.888747     1.197191
        1  28734    638.018       200.524796       182.734419     1.097356
        2  29380    624.110       212.826130       175.931143     1.209713

           Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
        0      0.549812       28715     190.141097  0.763923  0.988856   0.958027
        1      0.411785       29172     191.272751  0.783968  0.984986   0.887034
        2      0.562727       29690     193.410904  0.778113  0.989559   0.947849

           Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4  Class
        0     0.913358      0.007332      0.003147      0.834222      0.998724  SEKER
        1     0.953861      0.006979      0.003564      0.909851      0.998430  SEKER
        2     0.908774      0.007244      0.003048      0.825871      0.999066  SEKER
```

```
In [3]: # Visualizing the distribution of the target class

        sns.countplot(x = 'Class', data=df)
```

```
Out[3]: <AxesSubplot:xlabel='Class', ylabel='count'>
```



```
In [4]: df['Class'].unique()

Out[4]: array(['SEKER', 'BARBUNYA', 'BOMBAY', 'CALI', 'HOROZ', 'SIRA', 'DERMASON'],
              dtype=object)

In [5]: le = preprocessing.LabelEncoder()
        le.fit(df['Class'])

Out[5]: LabelEncoder()

In [6]: df['Class'] = le.transform(df['Class'])

In [7]: df['Class'].unique()

Out[7]: array([5, 0, 1, 2, 4, 6, 3])

In [8]: df.head(3)

Out[8]:     Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
        0  28395    610.291       208.178117       173.888747     1.197191
        1  28734    638.018       200.524796       182.734419     1.097356
        2  29380    624.110       212.826130       175.931143     1.209713

           Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
        0      0.549812       28715     190.141097  0.763923  0.988856   0.958027
        1      0.411785       29172     191.272751  0.783968  0.984986   0.887034
```

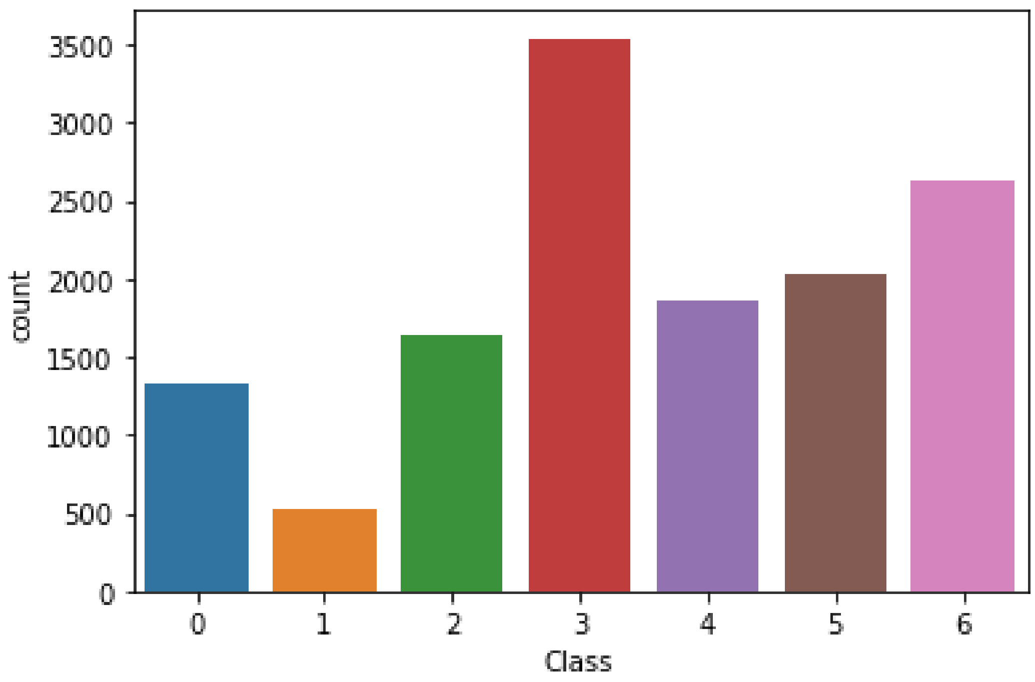
```
2      0.562727       29690     193.410904  0.778113  0.989559   0.947849

   Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4  Class
0     0.913358      0.007332      0.003147      0.834222      0.998724      5
1     0.953861      0.006979      0.003564      0.909851      0.998430      5
2     0.908774      0.007244      0.003048      0.825871      0.999066      5
```

```
In [9]: print(df.isnull().sum())
```

```
Area               0
Perimeter          0
MajorAxisLength    0
MinorAxisLength    0
AspectRatio        0
Eccentricity       0
ConvexArea         0
EquivDiameter      0
Extent             0
Solidity           0
roundness          0
Compactness        0
ShapeFactor1       0
ShapeFactor2       0
ShapeFactor3       1
ShapeFactor4       0
Class              0
dtype: int64
```

```
In [10]: sns.countplot(x = 'Class', data=df)
```

```
Out[10]: <AxesSubplot:xlabel='Class', ylabel='count'>
```



```
In [11]: # replacing null value with median value

         # mode value is
         print(df['ShapeFactor3'].median())

         # add .mode()[0] as mode returns a series
         df['ShapeFactor3'] = df["ShapeFactor3"].fillna(df['ShapeFactor3'].median())

         print(len(df[df['ShapeFactor3'].isna()]['ShapeFactor3']))

0.6424101875
0
```

```
In [12]: # scaling features

         from sklearn.preprocessing import StandardScaler, RobustScaler, MinMaxScaler, PowerTra


         columns_need_to_be_scaled = df.drop(columns=['Class']).columns

         SS = StandardScaler().fit(df[columns_need_to_be_scaled])

         df[columns_need_to_be_scaled] = pd.DataFrame(SS.transform(df[columns_need_to_be_scalec
                                                   columns=columns_need_to_be_scaled)
         df.head(3)

Out[12]:        Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
         0 -0.838853  -1.139688        -1.301921        -0.632217    -1.564982
         1 -0.827322  -1.010590        -1.391089        -0.435922    -1.971943
         2 -0.805349  -1.075346        -1.247768        -0.586894    -1.513942

            Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
         0     -2.182023   -0.839544      -1.060495  0.288035  0.366749   1.420254
         1     -3.684171   -0.824236      -1.041419  0.697652 -0.465418   0.225234
         2     -2.041468   -0.806883      -1.005376  0.578012  0.517851   1.248936

            Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4  Class
         0     1.838075      0.681965      2.397588      1.924193      0.838758      5
         1     2.496844      0.369690      3.096544      2.690565      0.771240      5
         2     1.763526      0.604443      2.230451      1.839561      0.917476      5

In [13]: X = df.iloc[:, 0:-1]

In [14]: y = df.iloc[:, -1]

In [15]: X = X.to_numpy()

In [16]: X

Out[16]: array([[-0.8388525 , -1.13968829, -1.30192147, ...,  2.39758822,
                  1.92419328,  0.83875835],
                [-0.82732195, -1.01058983, -1.39108908, ...,  3.09654363,
                  2.69056462,  0.77123968],
                [-0.80534927, -1.07534626, -1.24776821, ...,  2.23045069,
                  1.83956129,  0.91747579],
                ...,
                [-0.37137187, -0.44579629, -0.44719479, ...,  0.28391186,
                  0.32981927,  0.38873236],
                [-0.37109977, -0.4250396 , -0.42572569, ...,  0.22306101,
                  0.24219074,  0.03341647],
                [-0.37069161, -0.38565868, -0.2887106 , ..., -0.1332084 ,
                 -0.28491007,  0.71357655]])

In [17]: y = y.to_numpy()

In [18]: y

Out[18]: array([5, 5, 5, ..., 3, 3, 3])

In [19]: from sklearn.model_selection import train_test_split
         X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2)
```

```
In [20]: # input layer nodes = 16 --> number of features
         # hidden layer nodes = 3
         # outplut layer nodes = 3 --> number of categories
         iln = 16
         hln = 3
         oln = 7
         eta = 0.01
         num_epoch = 10000
```

```
In [21]: # fc = fully connected
         class Net(nn.Module):
             def __init__(self):
                 super(Net, self).__init__()
                 self.fc1 = nn.Linear(iln, hln)
                 self.out = nn.Linear(hln, oln)
             def forward(self, x):
                 x = self.fc1(x)
                 x = nn.functional.relu(x)
                 x = self.out(x)
                 out = nn.functional.softmax(x, dim = 1)
                 return out
```

```
In [22]: model = Net()
```

```
In [23]: criterion = nn.CrossEntropyLoss()
         optimizer = torch.optim.SGD(model.parameters(), lr = eta)
```

```
In [24]: X = torch.Tensor(X_train).float()
         y = torch.Tensor(y_train).long()
```

```
In [25]: for epoch in range(num_epoch):
             optimizer.zero_grad()
             out = model(X)
             loss = criterion(out, y)
             loss.backward()
             optimizer.step()
             if epoch % 1000 == 0:
                 print('epoch:', epoch, 'loss:', loss.item())
```

```
epoch: 0 loss: 1.9576890468597412
epoch: 1000 loss: 1.9133504629135132
epoch: 2000 loss: 1.8884079456329346
epoch: 3000 loss: 1.8597699403762817
epoch: 4000 loss: 1.7924624681472778
epoch: 5000 loss: 1.7611249685287476
epoch: 6000 loss: 1.730120062828064
epoch: 7000 loss: 1.6823604106903076
epoch: 8000 loss: 1.6413053274154663
epoch: 9000 loss: 1.5863434076309204
```

```
In [44]: X = torch.Tensor(X_test).float()
         y = torch.Tensor(y_test).long()

In [45]: out = model(X)

In [46]: (values, prediction) = torch.max(out.data, dim = 1)

In [47]: prediction

Out[47]: tensor([3, 1, 2,  ..., 3, 3, 3])

In [48]: prediction = pd.Series(prediction)
         list(prediction)
         len(prediction)

Out[48]: 2707

In [49]: y = list(pd.Series(y))
         len(y)

Out[49]: 2707

In [50]: y = set(y)
         len(y)

Out[50]: 7

In [29]: print('Accuracy is:', (100 * torch.sum(y == prediction).double() / len(y)))

Accuracy is: tensor(73.0329, dtype=torch.float64)


In [67]: test = pd.read_csv('beans-unknown.csv')
         test.head(3)

Out[67]:     Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
         0  37500    728.191       275.840463       173.818266     1.586948
         1  37500    715.578       272.171813       175.668301     1.549351
         2  37511    718.350       267.039757       179.141937     1.490660

            Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
         0      0.776481       37944     218.509686  0.703406  0.988299   0.888690
         1      0.763818       37797     218.509686  0.786229  0.992142   0.920295
         2      0.741599       37868     218.541732  0.717365  0.990573   0.913474

            Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4
         0     0.792160      0.007356      0.001787      0.627517      0.995836
         1     0.802837      0.007258      0.001860      0.644548      0.998631
         2     0.818387      0.007119      0.001970      0.669756      0.998379
```

```
In [68]: # scaling features

         from sklearn.preprocessing import StandardScaler, RobustScaler, MinMaxScaler, PowerTra


         columns_need_to_be_scaled = test.columns

         SS = StandardScaler().fit(test[columns_need_to_be_scaled])

         test[columns_need_to_be_scaled] = pd.DataFrame(SS.transform(test[columns_need_to_be_sc
                                                        columns=columns_need_to_be_scaled)

         test.head(3)
```

```
Out[68]:        Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
         0 -1.210167   1.400528         1.669933        -1.592466     1.643560
         1 -1.210167  -1.279132         0.428741        -0.574199     0.490283
         2  0.541390  -0.690215        -1.307557         1.337707    -1.310044

            Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
         0      1.603313    0.655770      -1.210169 -1.393678 -0.808631  -1.409751
         1      0.527208   -1.639425      -1.210169  0.793939  1.585230   1.272624
         2     -1.360985   -0.530861       0.541415 -1.024995  0.607604   0.693712

            Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4
         0    -1.658083      1.668114     -1.647227     -1.652531     -1.863595
         1    -0.446369      0.441809     -0.455052     -0.451837      0.940218
         2     1.318173     -1.299832      1.333936      1.325410      0.688126
```

```
In [69]: X = test.to_numpy()
```

```
In [70]: X = torch.Tensor(X).float()
```

```
In [71]: out = model(X)
```

```
In [72]: (values, prediction) = torch.max(out.data, dim = 1)
```

```
In [73]: prediction
```

```
Out[73]: tensor([4, 3, 5, 5, 5])
```

```
In [77]: import numpy as np
         pre = []
         pre = np.array(pre)
         for i in prediction:
             if i == 0:
                 i = 'BARBUNYA'
             elif i == 1:
                 i = 'BOMBAY'
```

```
            elif i == 2:
                i = 'CALI'
            elif i == 3:
                i = 'DERMASON'
            elif i == 4:
                i = 'HOROZ'
            elif i == 5:
                i = 'SEKER'
            elif i == 6:
                i = 'SIRA'
            pre = np.append(pre, [i])
```

```
In [79]: len(pre)
```

```
Out[79]: 5
```

```
In [82]: prediction = pd.Series(pre)
```

```
In [83]: prediction
```

```
Out[83]: 0       HOROZ
         1    DERMASON
         2       SEKER
         3       SEKER
         4       SEKER
         dtype: object
```

```
In [84]: test['Predicted Class'] = prediction
```

```
In [85]: test.head(10)
```

```
Out[85]:        Area  Perimeter  MajorAxisLength  MinorAxisLength  AspectRatio  \
         0 -1.210167   1.400528         1.669933        -1.592466     1.643560
         1 -1.210167  -1.279132         0.428741        -0.574199     0.490283
         2  0.541390  -0.690215        -1.307557         1.337707    -1.310044
         3  0.859855  -0.333720        -0.444881         0.439992    -0.449276
         4  1.019088   0.902540        -0.346237         0.388967    -0.374523

            Eccentricity  ConvexArea  EquivDiameter    Extent  Solidity  roundness  \
         0      1.603313    0.655770      -1.210169 -1.393678 -0.808631  -1.409751
         1      0.527208   -1.639425      -1.210169  0.793939  1.585230   1.272624
         2     -1.360985   -0.530861       0.541415 -1.024995  0.607604   0.693712
         3     -0.423925    1.233472       0.859851  0.643799 -1.195077   0.336891
         4     -0.345611    0.281044       1.019072  0.980934 -0.189126  -0.893476

            Compactness  ShapeFactor1  ShapeFactor2  ShapeFactor3  ShapeFactor4  \
         0    -1.658083      1.668114     -1.647227     -1.652531     -1.863595
         1    -0.446369      0.441809     -0.455052     -0.451837      0.940218
         2     1.318173     -1.299832      1.333936      1.325410      0.688126
```

```
3     0.442221     -0.452559      0.434216      0.438891      0.383911
4     0.344058     -0.357531      0.334126      0.340067     -0.148661

  Predicted Class
0           HOROZ
1        DERMASON
2           SEKER
3           SEKER
4           SEKER
```

0.1 How do the results with the artificial neural network compare to the support vector machine model?

The Random Forest Classifier had a better accuracy (94.16%) when compared to the ANN model (73.03%)