Homework 1

April 17, 2019

1 Homework 1

1.1 Initial Set-Up:

```
In [1]: # Read in data manipulation packages
        import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt

        # Use for data-preprocessing
        wine_dat = pd.read_csv('./wine_modified.csv')
        print('Wine modified dimensions:', wine_dat.shape)
        wine_dat.head()

        # Use for remaining sections
        X_train = pd.read_csv('./wine_train_data.csv')
        y_train = pd.read_csv('./wine_train_labels.csv')
        X_valid = pd.read_csv('./wine_val_data.csv')
        y_valid = pd.read_csv('./wine_val_labels.csv')
        X_test = pd.read_csv('./wine_test_data.csv')
        y_test = pd.read_csv('./wine_test_labels.csv')
        print('Traning data dimensions:',X_train.shape)
        print('Number of rows of training:', X_train.shape[0])
        print('Number of rows of validation:', X_valid.shape[0])
        print('Number of rows of testing:', X_test.shape[0])
```

```
Wine modified dimensions: (178, 14)
Traning data dimensions: (100, 13)
Number of rows of training: 100
Number of rows of validation: 39
Number of rows of testing: 39
```

1.2 Data Preprocessing:

Problem 1:

```
In [4]: # Where are the missing values?
        wine_dat.isnull().sum()
```

```
Out[4]: class                   10
        Alcohol                  0
        Malic acid              12
        Ash                    112
        Alcalinity of ash       12
        Magnesium               22
        Total phenols            0
        Flavanoids              48
        Nonflavanoid phenols    14
        Proanthocyanins         12
        Color intensity         12
        Hue                     14
        OD280/OD315             11
        Proline                 14
        dtype: int64
```

```
In [25]: # Remove NaN in Class
         wine_clean = wine_dat.dropna(subset=['class'])
         # Remove Rows with > 7 missing
         wine_clean = wine_clean.dropna(thresh=wine_clean.shape[1]-7)
         # Report new number of rows
         print('New number of rows:',wine_clean.shape[0])
```

```
New number of rows: 154
```

Problem 2:

```
In [26]: # Detect breakdown of missing values
         wine_clean.isnull().sum()/wine_clean.shape[0]
```

```
Out[26]: class                   0.000000
         Alcohol                 0.000000
         Malic acid              0.000000
         Ash                     0.616883
         Alcalinity of ash       0.000000
         Magnesium               0.058442
         Total phenols           0.000000
         Flavanoids              0.227273
         Nonflavanoid phenols    0.000000
         Proanthocyanins         0.000000
         Color intensity         0.000000
         Hue                     0.000000
         OD280/OD315             0.000000
         Proline                 0.000000
         dtype: float64
```

```
In [27]: # Remove ash
         wine_clean.drop('Ash', axis=1, inplace=True)
```

```
# Print new shape
print('New data dimensions:',wine_clean.shape)
print('Removed Ash feature')
```

```
New data dimensions: (154, 13)
Removed Ash feature
```

```
In [28]: # Fill in missing data with mean
         features_detect = wine_clean.columns[pd.isnull(wine_clean).sum() > 0].tolist()
         print(features_detect,'are features with missing values')
         wine_clean = wine_clean.fillna(wine_clean.mean())
         print('New standard deviations are:')
         wine_clean[features_detect].std()
```

```
['Magnesium', 'Flavanoids'] are features with missing values
New standard deviations are:
```

```
Out[28]: Magnesium     14.440377
         Flavanoids     0.873573
         dtype: float64
```

Problem 3:

```
In [31]: # Remove rows that are within 3 standard deviations (~99.7%) of the data.
         wine_clean = wine_clean[np.abs(wine_clean.Alcohol - wine_clean.Alcohol.mean()) <= (3*wi
         wine_clean = wine_clean[np.abs(wine_clean.Proline - wine_clean.Proline.mean()) <= (3*wi
         print('Final dimensions are:',wine_clean.shape)
```

```
Final dimensions are: (148, 13)
```

While there are many different ways to classify an individual data point as an outlier, the most straightforward and indisputable approach is to remove rows where the value is above or below 3 standard deviations of the data. This value would need to be more extreme than 99.7% of the rest of the data. Hence, the data point is pretty safe to be classified as an outlier and removed.

1.3 Decision Trees:

Problem 4:

```
In [4]: from sklearn.tree import DecisionTreeClassifier, export_graphviz
        import pydotplus
        from sklearn.neighbors import KNeighborsClassifier
        from sklearn import preprocessing

        # For final predictions:
        X_train_fin = pd.concat([X_train,X_valid],ignore_index=True)
```

```
y_train_fin = pd.concat([y_train,y_valid],ignore_index=True)

best_acc = 0
computations = ['gini', 'entropy']

for i in computations:
    clf = DecisionTreeClassifier(i)
    clf.fit(X_train, y_train)
    accuracy = np.sum(clf.predict(X_valid)==y_valid['class'].values)*1/len(y_valid['clas
    print('For criterion =', i, 'the validation accuracy = ' + str(accuracy))
    if (accuracy > best_acc):
        best_acc = accuracy
        best_computation = i
print("")
print('The best criterion is', best_computation, 'with a validation accuracy of', best_a

clf = DecisionTreeClassifier(criterion=best_computation)
clf.fit(X_train_fin, y_train_fin)
predictions = clf.predict(X_test)
fin_accuracy = np.sum(predictions==y_test['class'].values)*1/len(y_test['class'].values)
print('\n')
print('Final accuracy on total training data = ' + str(fin_accuracy))
```

```
For criterion = gini the validation accuracy = 0.948717948718
For criterion = entropy the validation accuracy = 0.974358974359

The best criterion is entropy with a validation accuracy of 0.974358974359


Final accuracy on total training data = 0.820512820513
```

Problem 5:

In [13]:
```
best_acc = 0
min_sample = [2,5,10,20]

for i in min_sample:
    clf = DecisionTreeClassifier(best_computation,min_samples_split=i)
    clf.fit(X_train, y_train)
    accuracy = np.sum(clf.predict(X_valid)==y_valid['class'].values)*1/len(y_valid['cla
    print('For min sample =', i, 'the validation accuracy = ' + str(accuracy))
    if (accuracy > best_acc):
        best_acc = accuracy
        best_sample = i
print("")
print('The best sample is', best_sample, 'with a validation accuracy of', best_acc)
```

```
clf = DecisionTreeClassifier(criterion=best_computation,min_samples_split = best_sample
clf.fit(X_train_fin, y_train_fin)
predictions = clf.predict(X_test)
fin_accuracy = np.sum(predictions==y_test['class'].values)*1/len(y_test['class'].values
print('\n')
print('Final accuracy = ' + str(fin_accuracy))
```

```
For min sample = 2 the validation accuracy = 0.948717948718
For min sample = 5 the validation accuracy = 0.948717948718
For min sample = 10 the validation accuracy = 0.923076923077
For min sample = 20 the validation accuracy = 0.948717948718

The best sample is 2 with a validation accuracy of 0.948717948718


Final accuracy = 0.820512820513
```

Problem 6:

```
In [15]: sample_size = [20,40,60,80,100]
         acc_list = []

         for i in sample_size:
             clf = DecisionTreeClassifier(best_computation,min_samples_split=best_sample)
             clf.fit(X_train[:i], y_train[:i])
             accuracy = np.sum(clf.predict(X_valid)==y_valid['class'].values)*1/len(y_valid['cla
             print('For training data sample size =', i, 'the validation accuracy = ' + str(accu
             acc_list.append(accuracy)
```

```
For training data sample size = 20 the validation accuracy = 0.641025641026
For training data sample size = 40 the validation accuracy = 0.846153846154
For training data sample size = 60 the validation accuracy = 0.871794871795
For training data sample size = 80 the validation accuracy = 0.871794871795
For training data sample size = 100 the validation accuracy = 0.948717948718
```

```
In [21]: # Generate Line Plot
         plt.plot(sample_size,acc_list)

         # Label the axes
         plt.xlabel('Sample Size')
         plt.ylabel('Accuracy')

         #Figure Title
         plt.title('More Training Data Achieves Greater Accuracy')

         plt.show()
```

1.4 KNN

Problem 7:

```
In [22]: # Use Standard Scaler from Sklearn to normalize data in full training data:
         normalize = preprocessing.StandardScaler().fit(X_train_fin)
         X_train_fin_norm = normalize.transform(X_train_fin)

         # Apply normalizing of aggregate training set to other data-sets:
         X_train_norm = normalize.transform(X_train)
         X_valid_norm = normalize.transform(X_valid)
         X_test_norm = normalize.transform(X_test)
```

```
In [28]: # Build KNN classifier
         clf = KNeighborsClassifier(n_neighbors=3,metric = 'euclidean')
         clf.fit(X_train_fin_norm, y_train_fin.values.ravel())
         predictions = clf.predict(X_test_norm)
         accuracy = np.sum(predictions == y_test['class'].values)*1.0/len(y_test['class'].values
         print('Test accuracy with k = 3 is', accuracy)
```

```
Test accuracy with k = 3 is 0.871794871795
```

Problem 8:

```
In [31]: best_acc = 0
         dist_metric = ['euclidean','manhattan','chebyshev']

         for i in dist_metric:
             clf = KNeighborsClassifier(n_neighbors=3,metric = i)
             clf.fit(X_train_norm, y_train)
             accuracy = np.sum(clf.predict(X_valid_norm)==y_valid['class'].values)*1/len(y_valid
             print('For distance metric =', i, 'the validation accuracy = ' + str(accuracy))
             if (accuracy > best_acc):
                 best_acc = accuracy
                 best_dist = i
         print("")
         print('The best distance metric is', best_dist, 'with a validation accuracy of', best_a

         clf = KNeighborsClassifier(n_neighbors=3,metric = best_dist)
         clf.fit(X_train_fin_norm, y_train_fin.values.ravel())
         predictions = clf.predict(X_test_norm)
         fin_accuracy = np.sum(predictions==y_test['class'].values)*1/len(y_test['class'].values
         print('\n')
         print('Final accuracy = ' + str(fin_accuracy))
```

```
For distance metric = euclidean the validation accuracy = 0.923076923077
For distance metric = manhattan the validation accuracy = 0.948717948718
For distance metric = chebyshev the validation accuracy = 0.923076923077

The best distance metric is manhattan with a validation accuracy of 0.948717948718


Final accuracy = 0.974358974359


/Users/kkannapp/anaconda/lib/python3.6/site-packages/ipykernel_launcher.py:6: DataConversionWarn
```

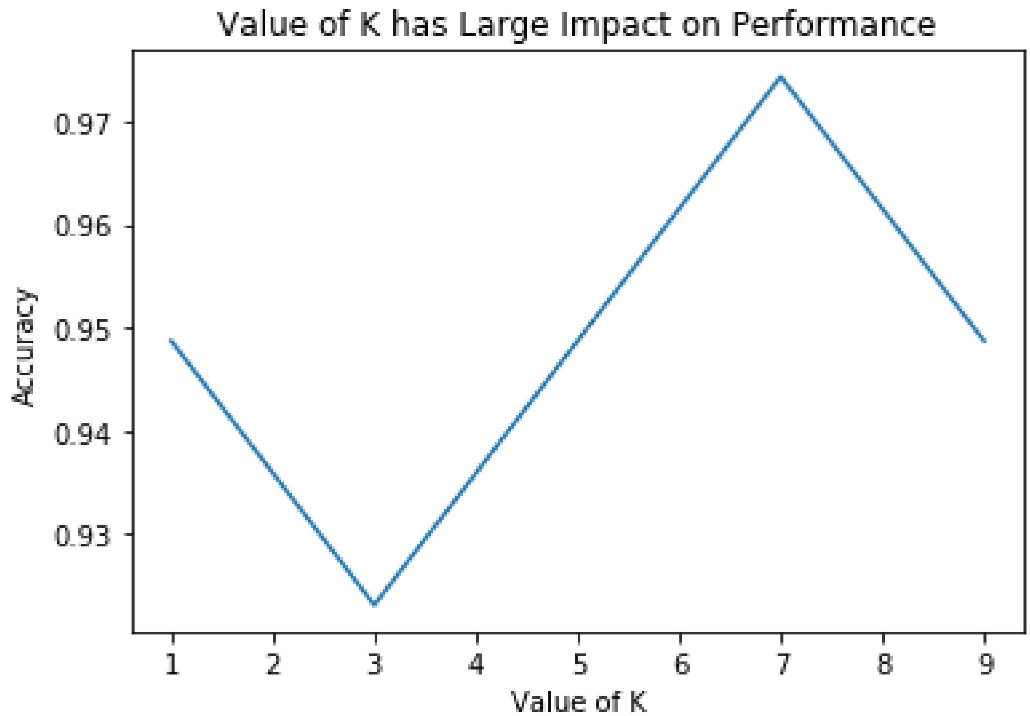
Problem 9:

```
In [32]: k_list = [1,3,5,7,9]
         acc_list = []
         best_acc = 0

         for i in k_list:
             clf = KNeighborsClassifier(n_neighbors=i,metric = 'euclidean')
             clf.fit(X_train_norm, y_train)
             accuracy = np.sum(clf.predict(X_valid_norm)==y_valid['class'].values)*1/len(y_valid
             print('For k =', i, 'the validation accuracy = ' + str(accuracy))
             acc_list.append(accuracy)
             if (accuracy > best_acc):
                 best_acc = accuracy
```

```
            best_k = i
    print("")
    print('The best k-value is', best_k, 'with a validation accuracy of', best_acc)

    clf = KNeighborsClassifier(n_neighbors=best_k,metric = 'euclidean')
    clf.fit(X_train_fin_norm, y_train_fin.values.ravel())
    predictions = clf.predict(X_test_norm)
    fin_accuracy = np.sum(predictions==y_test['class'].values)*1/len(y_test['class'].values
    print('\n')
    print('Final accuracy = ' + str(fin_accuracy))
```

```
For k = 1 the validation accuracy = 0.948717948718
For k = 3 the validation accuracy = 0.923076923077
For k = 5 the validation accuracy = 0.948717948718
For k = 7 the validation accuracy = 0.974358974359
For k = 9 the validation accuracy = 0.948717948718

The best k-value is 7 with a validation accuracy of 0.974358974359


Final accuracy = 0.923076923077


/Users/kkannapp/anaconda/lib/python3.6/site-packages/ipykernel_launcher.py:7: DataConversionWarn
  import sys
```

In [34]:
```
# Generate Line Plot
plt.plot(k_list,acc_list)

# Label the axes
plt.xlabel('Value of K')
plt.ylabel('Accuracy')

#Figure Title
plt.title('Value of K has Large Impact on Performance')

plt.show()
```



Problem 10:

```
In [36]: sample_size = [20,40,60,80,100]
         acc_list = []

         for i in sample_size:
             clf = KNeighborsClassifier(n_neighbors=3,metric = 'euclidean')
             clf.fit(X_train_norm[:i], y_train[:i])
             accuracy = np.sum(clf.predict(X_valid_norm)==y_valid['class'].values)*1/len(y_valid
             print('For sample size =', i, 'the validation accuracy = ' + str(accuracy))
             acc_list.append(accuracy)
```

```
For sample size = 20 the validation accuracy = 0.948717948718
For sample size = 40 the validation accuracy = 1.0
For sample size = 60 the validation accuracy = 1.0
For sample size = 80 the validation accuracy = 1.0
For sample size = 100 the validation accuracy = 0.923076923077
```

```
/Users/kkannapp/anaconda/lib/python3.6/site-packages/ipykernel_launcher.py:6: DataConversionWarn
```

```
In [37]: # Generate Line Plot
         plt.plot(sample_size,acc_list)
```

```
# Label the axes
plt.xlabel('Sample Size')
plt.ylabel('Accuracy')

#Figure Title
plt.title('Shuffling Data Important, Predictions could be Unrealistic')

plt.show()
```