ASSGN_4_PART_1

February 25, 2022

[1]:
```
# importing modules
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy.io import loadmat
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_validate
from sklearn.metrics import accuracy_score
from sklearn.model_selection import validation_curve
```

[2]:
```
# loading the mat file
XR = loadmat('annualrainfall.mat')
```

[3]:
```
XR = XR["XR"]
```

[4]:
```
XR.shape
```

[4]:
```
(357, 118)
```

[5]:
```
# conversion into dataframe for ease in visualisation
df = pd.DataFrame(XR.T)
```

[6]:
```
df.head()
```

[6]:
```
          0         1         2         3         4         5         6  \
0  0.719022  0.799972  1.116379  0.764488  0.923383  0.961330  0.558784
1  2.572195  2.358573  3.817571  2.544322  1.777028  1.908791  0.716344
2  5.115582  4.459389  5.715812  5.017730  3.644102  3.152490  1.511983
3  0.509786  0.649587  1.357004  0.584740  0.878721  0.927881  0.002060
4  0.600234  1.078375  1.584306  0.753628  1.811034  2.033962  0.332660

          7         8         9  …        347        348        349  \
0  1.043538  2.035055  2.412407  …  13.020404  12.291794  12.565416
1  3.693454  6.151360  4.426207  …  11.486169  10.682952  10.680328
2  5.075399  7.259941  4.552429  …   9.685181   9.213934   9.213934
```

```
3  1.601084  2.431932  2.139452  …  10.281640   9.984426   9.984426
4  1.851805  3.144972  3.733844  …  11.919070  11.156557  11.156557

         350        351        352        353        354        355        356
0  12.688719  12.852414  11.667012  12.174392  12.512038  10.399852  11.287784
1  10.680328  11.080315  10.112830  10.391051  10.737137   9.187904   9.791919
2   9.213934   9.445984   8.772028   8.985728   9.214482   8.054785   8.523733
3   9.977869  10.129921   9.474487   9.726133   9.926839   8.654893   9.182062
4  11.156557  11.543451  10.539118  10.844063  11.189535   9.524974  10.185022

[5 rows x 357 columns]
```

[7]:
```python
# Question 1
year_totals = np.sum(df,axis=1)
print("Total over all locations per year\n")
print(year_totals)
```

```
Total over all locations per year

0      2419.465229
1      2512.018018
2      2667.357994
3      2327.246610
4      2306.637001
          …
113    2320.219852
114    2307.336725
115    2568.183404
116    2575.166233
117    2379.061657
Length: 118, dtype: float64
```

[8]:
```python
# Question 1
mean = np.mean(year_totals)
stdev = np.std(year_totals)
print("Mean :",mean)
print("Standard Deviation: ",stdev)
```

```
Mean : 2731.5638988707724
Standard Deviation:  266.89890593445193
```

[9]:
```python
# Question 2
label = np.where(year_totals>mean+stdev,1,0)
label = np.where(year_totals<mean-stdev,-1,label)
label = label.reshape((-1,1))
```

[10]:
```python
# labels are added to the dataframe
df['label'] = label
```

[11]:
```python
df.head()
```

[11]:
```
          0         1         2         3         4         5         6  \
0  0.719022  0.799972  1.116379  0.764488  0.923383  0.961330  0.558784
1  2.572195  2.358573  3.817571  2.544322  1.777028  1.908791  0.716344
2  5.115582  4.459389  5.715812  5.017730  3.644102  3.152490  1.511983
3  0.509786  0.649587  1.357004  0.584740  0.878721  0.927881  0.002060
4  0.600234  1.078375  1.584306  0.753628  1.811034  2.033962  0.332660

          7         8         9  …        348        349        350  \
0  1.043538  2.035055  2.412407  …  12.291794  12.565416  12.688719
1  3.693454  6.151360  4.426207  …  10.682952  10.680328  10.680328
2  5.075399  7.259941  4.552429  …   9.213934   9.213934   9.213934
3  1.601084  2.431932  2.139452  …   9.984426   9.984426   9.977869
4  1.851805  3.144972  3.733844  …  11.156557  11.156557  11.156557

         351        352        353        354        355        356  label
0  12.852414  11.667012  12.174392  12.512038  10.399852  11.287784     -1
1  11.080315  10.112830  10.391051  10.737137   9.187904   9.791919      0
2   9.445984   8.772028   8.985728   9.214482   8.054785   8.523733      0
3  10.129921   9.474487   9.726133   9.926839   8.654893   9.182062     -1
4  11.543451  10.539118  10.844063  11.189535   9.524974  10.185022     -1

[5 rows x 358 columns]
```

[12]:
```python
X = df.iloc[:,:-1]
Y = df.iloc[:,-1]
```

[13]:
```python
# preparing the train and test sets using 100 years for train only
X_train = X.iloc[0:100,:]
X_test = X.iloc[100:,:]

Y_train = Y.iloc[0:100]
Y_test = Y.iloc[100:]

print("X_train shape: ",X_train.shape)
print("X_test shape: ",X_test.shape)
```

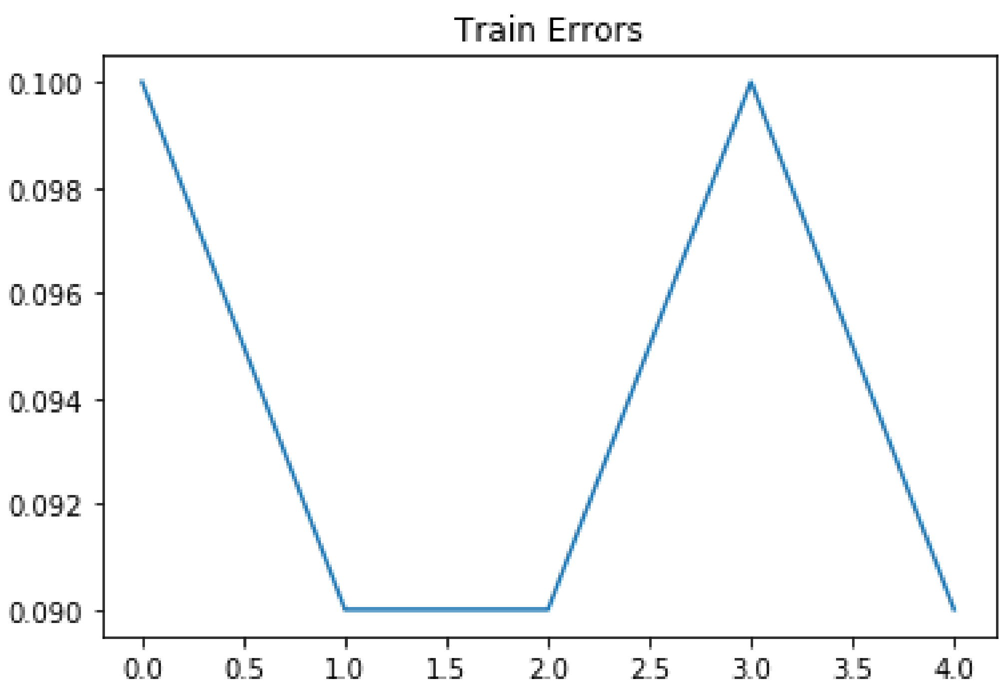
```
X_train shape:  (100, 357)
X_test shape:  (18, 357)
```

[14]:
```python
# Question 3
# Training the decision tree with 5-fold cross validation
clf = DecisionTreeClassifier(max_depth=10,random_state=0)
```

```
scores = cross_validate(estimator = clf, X = X_train,y= Y_train,␣
↪cv=5,return_estimator=True)
clf = clf.fit(X_train, Y_train)
```

[15]:
```
train_error = []
test_error = []
for i in range(5):
    train_outputs = scores["estimator"][i].predict(X_train)
    preds = scores["estimator"][i].predict(X_test)
    train_error.append(1-accuracy_score(y_true = Y_train,y_pred =␣
↪train_outputs))
    test_error.append(1-accuracy_score(y_true = Y_test,y_pred = preds))
```

[16]:
```
plt.plot(train_error)
plt.title("Train Errors")
plt.show()
```

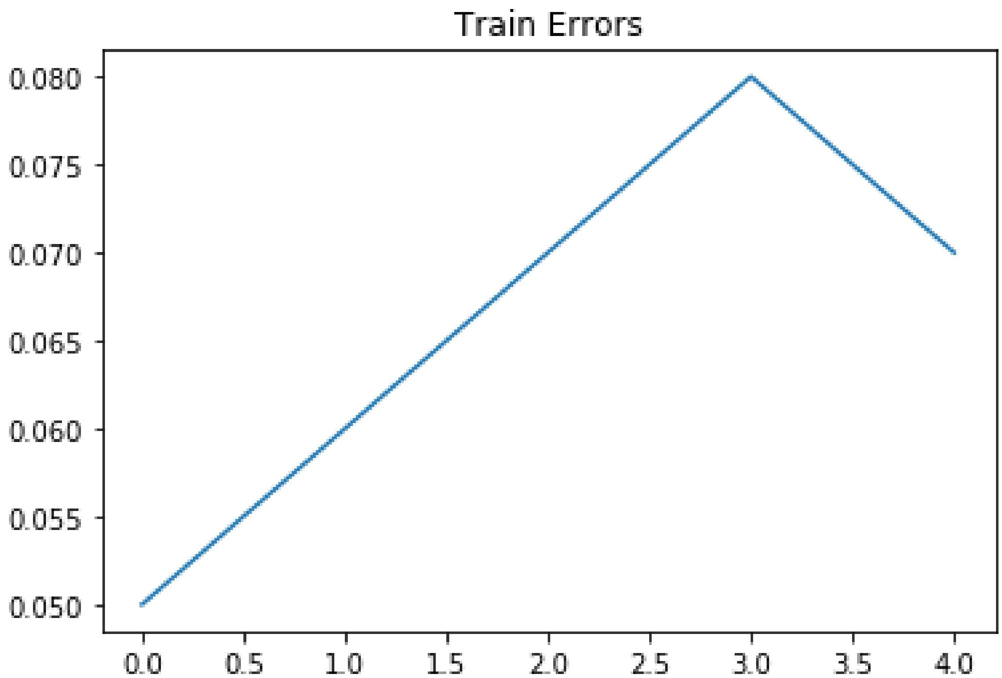


[17]:
```
plt.plot(test_error)
plt.title("Test Errors")
plt.show()
```

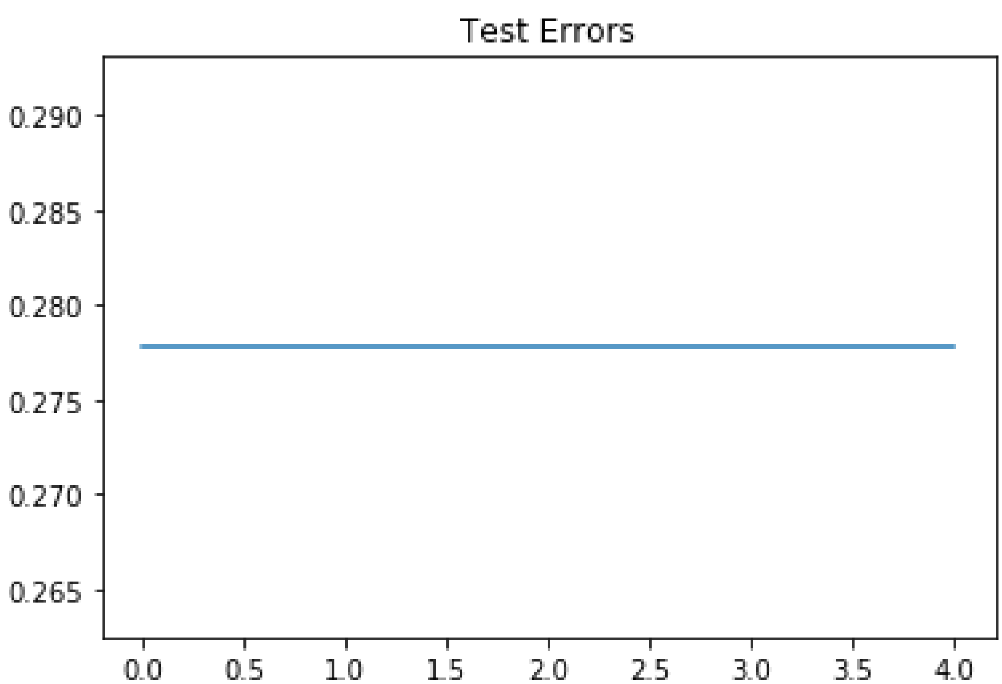
[18]:
```
# Question 4
# Training the random forest with 5-fold cross validation
# Both train and test errors are seen improving
rfclf = RandomForestClassifier(max_depth=10,random_state=0)
scores = cross_validate(rfclf, X_train, Y_train, cv=5,return_estimator=True)
rfclf = rfclf.fit(X_train, Y_train)
```

[19]:
```
train_error = []
test_error = []
for i in range(5):
    train_outputs = scores["estimator"][i].predict(X_train)
    preds = scores["estimator"][i].predict(X_test)
    train_error.append(1-accuracy_score(y_true = Y_train,y_pred =␣
 ↪train_outputs))
    test_error.append(1-accuracy_score(y_true = Y_test,y_pred = preds))
```

[20]:
```
plt.plot(train_error)
plt.title("Train Errors")
plt.show()
```



[21]:
```
plt.plot(test_error)
plt.title("Test Errors")
plt.show()
```



[22]:
```
# Question 5
location_means = np.mean(df.iloc[:,:-1],axis=0)
print("Mean Rainfall for locations\n")
print(location_means)
location_std = np.std(df.iloc[:,:-1],axis=0)
print("\nStd-dev of Rainfall for locations\n")
print(location_std)
```

```
Mean Rainfall for locations

0       2.879478
1       2.798381
2       4.678337
3       3.253128
4       2.866147
          …
352    18.762887
353    19.357414
354    19.317927
355    18.627022
356    19.065612
Length: 357, dtype: float64

Std-dev of Rainfall for locations

0       2.035299
1       2.003111
2       2.328049
3       1.931908
4       1.703730
          …
352     7.968767
353     8.606350
354     9.835775
355     9.662201
356    10.064099
Length: 357, dtype: float64
```

[23]:
```
# Question 5
labels = np.empty((df.shape[0],df.shape[1]-1))
for i in range(labels.shape[0]):
    for j in range(labels.shape[1]):
        if(df.iloc[i,j] > location_means[j]+location_std[j]):
            labels[i,j]=1
        elif(df.iloc[i,j] < location_means[j]-location_std[j]):
            labels[i,j]=-1
```

```
        else:
            labels[i,j]=0
```

[24]:
```
labels.shape
```

[24]: (118, 357)

[25]:
```
# Creating the new dataset
new_X = []
new_Y = []
for i in range(labels.shape[0]):
    for j in range(labels.shape[1]):
        X_row = []
        for k in range(labels.shape[1]):
            if(k!=j):
                X_row.append(df.iloc[i,k])
        new_X.append(X_row)
        new_Y.append(labels[i,j])
```

[26]:
```
new_X = []
new_Y = []
for i in range(labels.shape[0]):
    for j in range(labels.shape[1]):
        X_row = []
        for k in range(labels.shape[1]):
            if(k!=j):
                X_row.append(df.iloc[i,k])
        new_X.append(X_row)
        new_Y.append(labels[i,j])
```

[27]:
```
new_X = np.array(new_X)
new_Y = np.array(new_Y)
```

[28]:
```
new_X.shape
```

[28]: (42126, 356)

[29]:
```
new_Y.shape
```

[29]: (42126,)

[30]:
```
# preparing the train and test splits from new dataset
# train set contains data rows derived from the first 100 years only
new_X_train = new_X[:-6426,:]
new_X_test = new_X[-6426:,:]
new_Y_train = new_Y[:-6426]
```

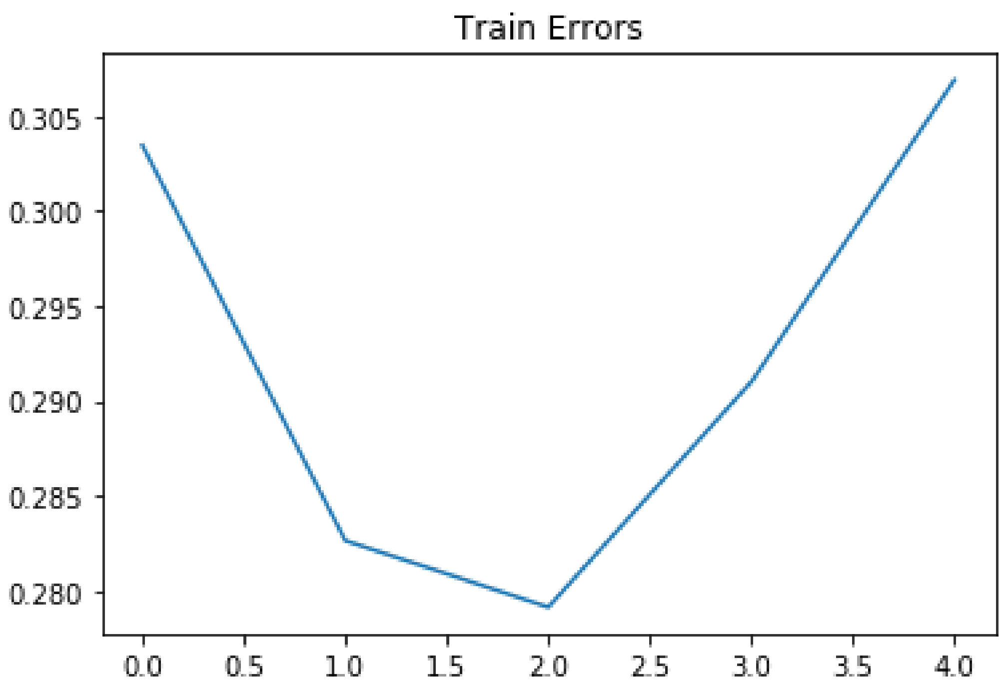
```
new_Y_test = new_Y[-6426:]
```

[31]:
```
# Question 6
# Training the decision tree with 5-fold cross validation
clf = DecisionTreeClassifier(max_depth=10,random_state=0)
scores = cross_validate(estimator = clf, X = new_X_train,y= new_Y_train,␣
↪cv=5,return_estimator=True)
clf = clf.fit(new_X_train, new_Y_train)
```

[32]:
```
feat_importance = clf.tree_.compute_feature_importances()
top_idx = np.argsort(feat_importance)[:-10:-1]
```

[33]:
```
train_error = []
test_error = []
for i in range(5):
    train_outputs = scores["estimator"][i].predict(new_X_train)
    preds = scores["estimator"][i].predict(new_X_test)
    train_error.append(1-accuracy_score(y_true = new_Y_train,y_pred =␣
↪train_outputs))
    test_error.append(1-accuracy_score(y_true = new_Y_test,y_pred = preds))
```

[34]:
```
plt.plot(train_error)
plt.title("Train Errors")
plt.show()
```

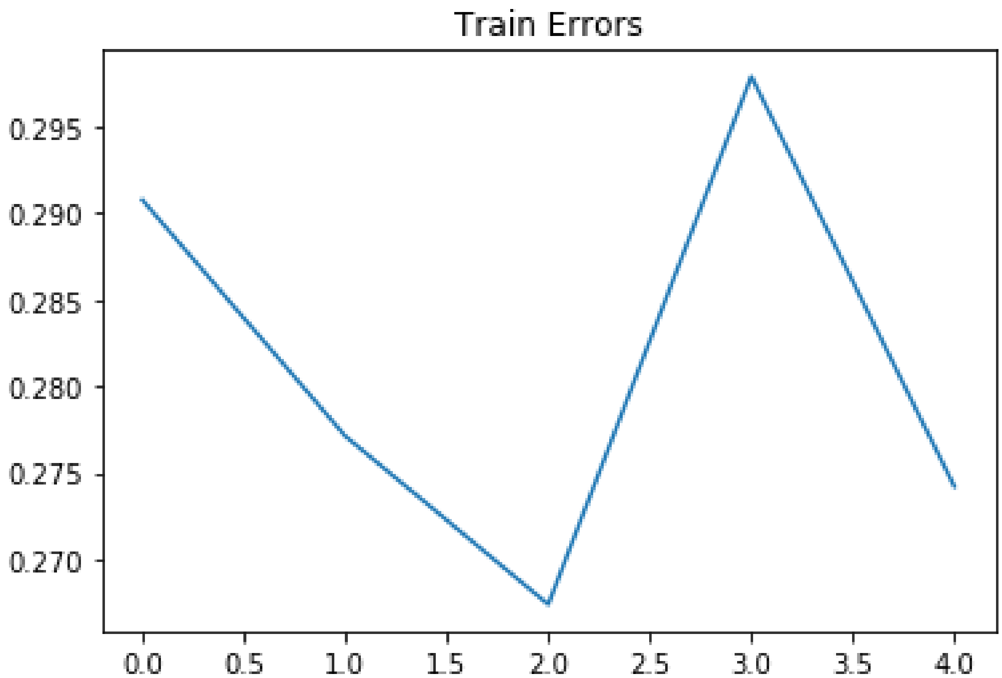


[35]:
```
plt.plot(test_error)
plt.title("Test Errors")
plt.show()
```

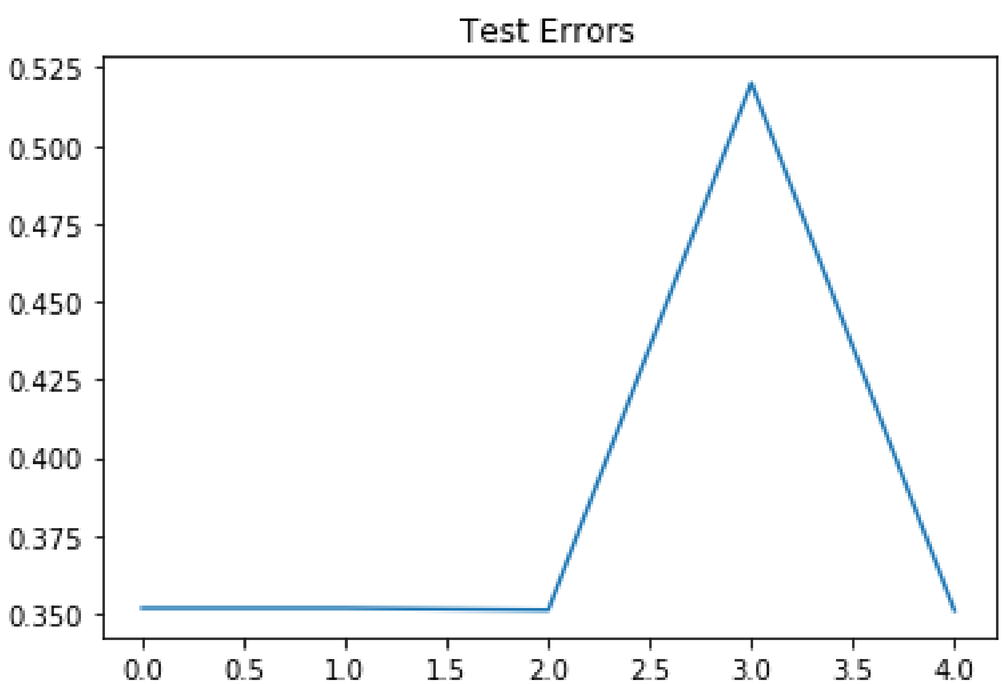
[36]:
```
# Question 7
# Training the random forest with 5-fold cross validation
# Both train and test errors are seen improving
rfclf = RandomForestClassifier(max_depth=10,random_state=0)
scores = cross_validate(rfclf, new_X_train, new_Y_train,␣
↪cv=5,return_estimator=True)
rfclf = rfclf.fit(new_X_train, new_Y_train)
```

[37]:
```
train_error = []
test_error = []
for i in range(5):
    train_outputs = scores["estimator"][i].predict(new_X_train)
    preds = scores["estimator"][i].predict(new_X_test)
    train_error.append(1-accuracy_score(y_true = new_Y_train,y_pred =␣
↪train_outputs))
    test_error.append(1-accuracy_score(y_true = new_Y_test,y_pred = preds))
```

[38]:
```
plt.plot(train_error)
plt.title("Train Errors")
plt.show()
```



[39]:
```
plt.plot(test_error)
plt.title("Test Errors")
plt.show()
```



[ ]:

```

```

[ ]:

```

```

[ ]:

```

```