# Q3

April 18, 2021

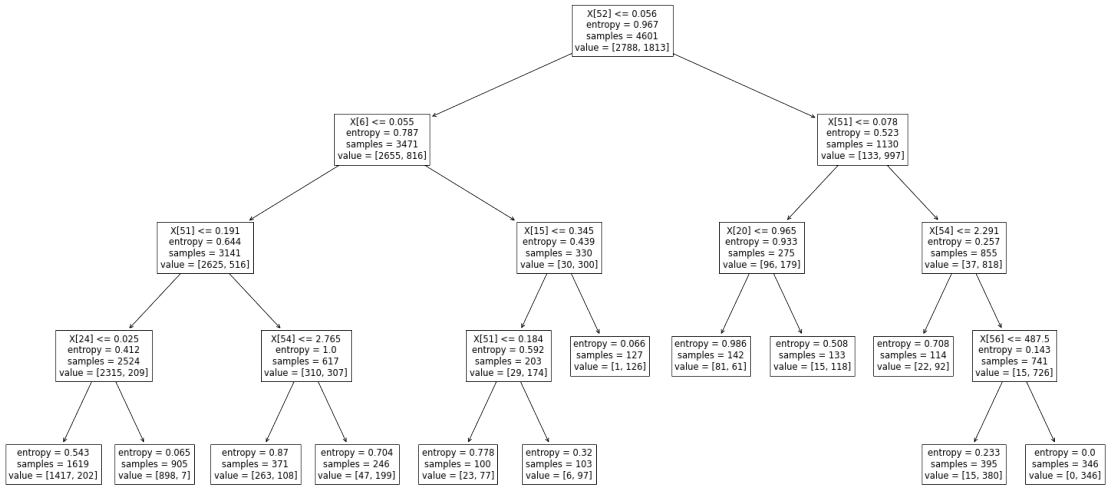
[1]:
```
import pandas as pd
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import plot_tree
from sklearn.metrics import f1_score,classification_report, confusion_matrix
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split,GridSearchCV
from sklearn.ensemble import RandomForestClassifier
import numpy as np
from sklearn import svm
import random
```

[160]:
```
data = pd.read_csv('./data/spambase.data', header=None)
display(data)
output=pd.value_counts(data.iloc[:,-1])
display(output)

X = data.iloc[:,:-1]
y = data.iloc[:,-1]
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)
decisionTree = DecisionTreeClassifier(criterion='entropy',
                              max_depth=4,
                              min_samples_leaf=100)
decisionTree.fit(X, y)
plt.figure(figsize=(26,13))
plot_tree(decisionTree);
```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | … | 48 | \ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.00 | 0.64 | 0.64 | 0.0 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | … | 0.000 | |
| 1 | 0.21 | 0.28 | 0.50 | 0.0 | 0.14 | 0.28 | 0.21 | 0.07 | 0.00 | 0.94 | … | 0.000 | |
| 2 | 0.06 | 0.00 | 0.71 | 0.0 | 1.23 | 0.19 | 0.19 | 0.12 | 0.64 | 0.25 | … | 0.010 | |
| 3 | 0.00 | 0.00 | 0.00 | 0.0 | 0.63 | 0.00 | 0.31 | 0.63 | 0.31 | 0.63 | … | 0.000 | |
| 4 | 0.00 | 0.00 | 0.00 | 0.0 | 0.63 | 0.00 | 0.31 | 0.63 | 0.31 | 0.63 | … | 0.000 | |
| … | … | … | … | … | … | … | … | … | … | … | … | … | |
| 4596 | 0.31 | 0.00 | 0.62 | 0.0 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | … | 0.000 | |
| 4597 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | … | 0.000 | |
| 4598 | 0.30 | 0.00 | 0.30 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | … | 0.102 | |
| 4599 | 0.96 | 0.00 | 0.00 | 0.0 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | … | 0.000 | |

```
4600  0.00  0.00  0.65  0.0  0.00  0.00  0.00  0.00  0.00  0.00  …  0.000

          49   50     51     52     53     54   55     56  57
0      0.000  0.0  0.778  0.000  0.000  3.756   61    278   1
1      0.132  0.0  0.372  0.180  0.048  5.114  101   1028   1
2      0.143  0.0  0.276  0.184  0.010  9.821  485   2259   1
3      0.137  0.0  0.137  0.000  0.000  3.537   40    191   1
4      0.135  0.0  0.135  0.000  0.000  3.537   40    191   1
…      …   …    …      …      …      …   …    ..
4596   0.232  0.0  0.000  0.000  0.000  1.142    3     88   0
4597   0.000  0.0  0.353  0.000  0.000  1.555    4     14   0
4598   0.718  0.0  0.000  0.000  0.000  1.404    6    118   0
4599   0.057  0.0  0.000  0.000  0.000  1.147    5     78   0
4600   0.000  0.0  0.125  0.000  0.000  1.250    5     40   0

[4601 rows x 58 columns]
```

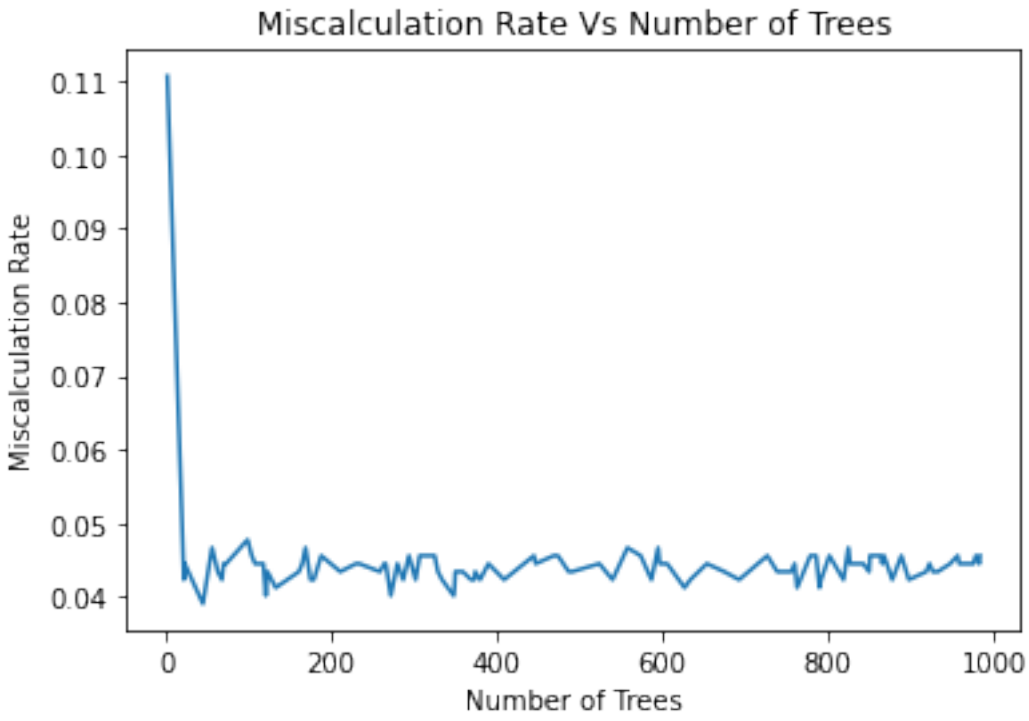
```
0    2788
1    1813
Name: 57, dtype: int64
```



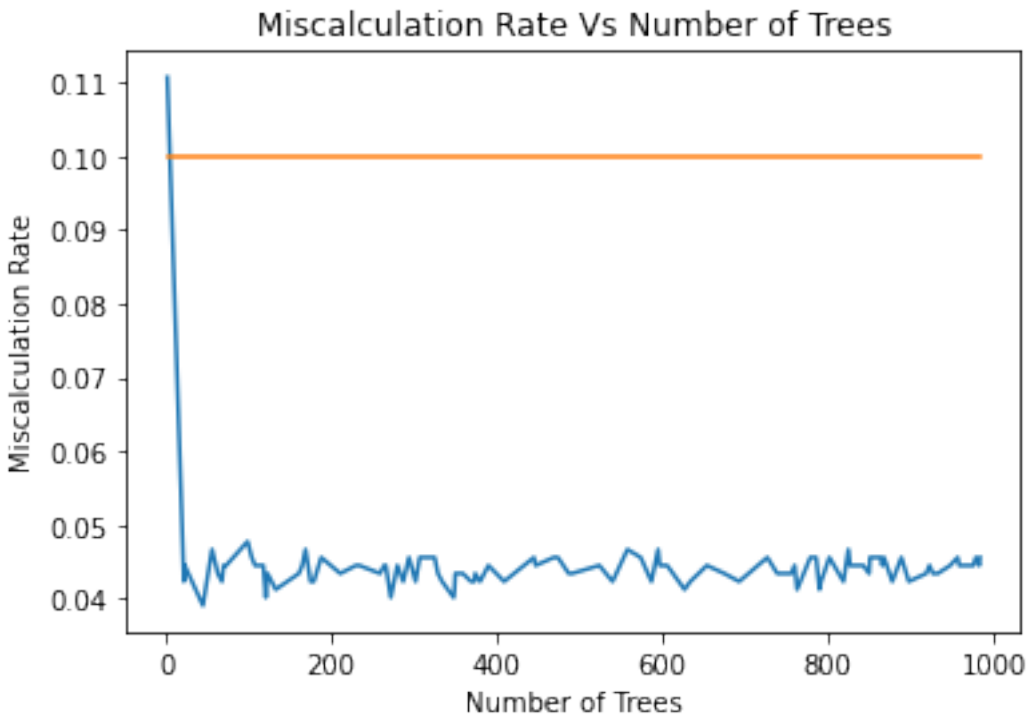

[66]:
```
totalNumberOfDataSets=X_test.shape[0]
print(totalNumberOfDataSets)
miscalcs=[]
nTrees=[]
ran=random.sample(range(0, 1000), 100)
ran.sort()
print(ran)
for nTree in ran:
```

```
    rf=RandomForestClassifier(n_estimators=nTree)
    model=rf.fit(X_train,y_train)
    modelPredict=model.predict(X_test)
    cm=confusion_matrix(y_test, modelPredict)
    fp=cm[0,1]
    fn=cm[1,0]
    miscalc=(fp+fn)/totalNumberOfDataSets
    miscalcs.append(miscalc)
    nTrees.append(nTree)
```

```
921
[2, 22, 23, 45, 56, 63, 68, 70, 73, 99, 104, 108, 118, 121, 123, 133, 161, 165,
169, 175, 179, 188, 211, 230, 234, 259, 264, 266, 272, 280, 287, 294, 302, 307,
325, 329, 334, 348, 349, 350, 359, 369, 373, 374, 380, 390, 409, 445, 447, 469,
474, 487, 491, 524, 540, 558, 574, 587, 595, 597, 606, 627, 634, 654, 675, 693,
727, 739, 752, 756, 760, 763, 779, 786, 790, 792, 802, 819, 825, 827, 843, 850,
851, 864, 866, 868, 878, 889, 898, 919, 923, 927, 933, 948, 957, 959, 976, 979,
983, 984]
```




[164]:

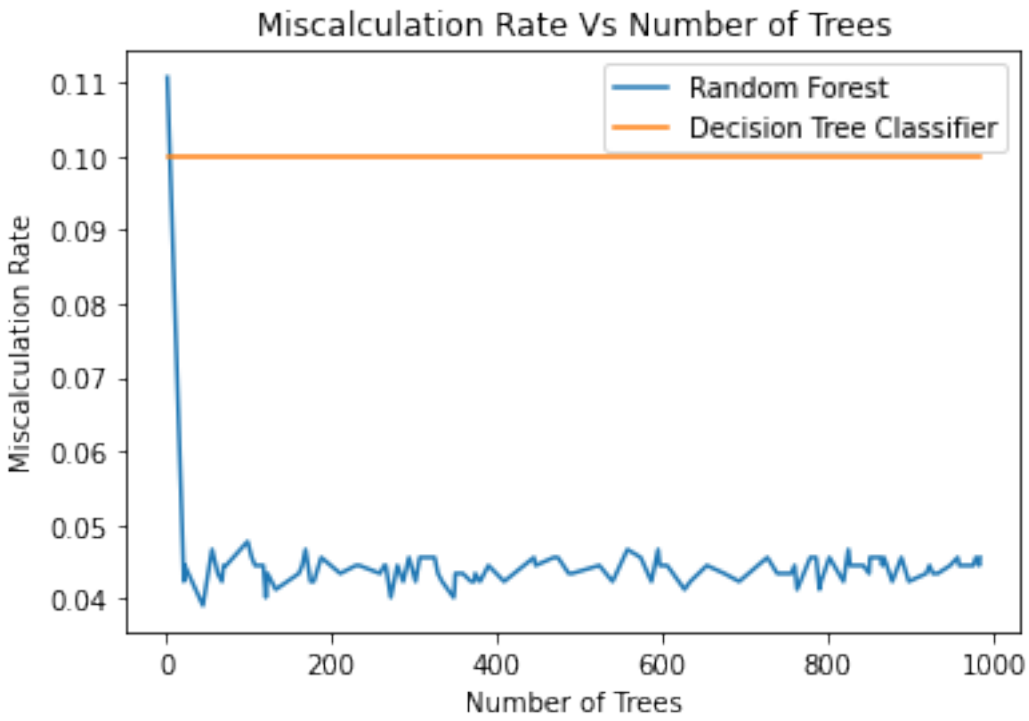



[161]:
```
optimalTrees= nTrees[miscalcs.index(min(miscalcs))]
print(optimalTrees)

rfModel=RandomForestClassifier(n_estimators=optimalTrees)
fit=rfModel.fit(X_train,y_train)
modelPredict=model.predict(X_test)
cm=confusion_matrix(y_test, modelPredict)
fp=cm[0,1]
fn=cm[1,0]
miscalc=(fp+fn)/totalNumberOfDataSets
print("confusion matrix for random forest:")
print(cm)
print("miscalc rate for random forest: ")
print(miscalc)


gs_dt = GridSearchCV(estimator=DecisionTreeClassifier(random_state=20),
                     param_grid={'max_depth': np.arange(1,31)},
                     scoring='roc_auc',
                     cv=5)
gs_dt.fit(X_train, y_train)
dtModel=gs_dt.best_estimator_
print("================")
```

```
predictions=dtModel.predict(X_test)
cm_dt=confusion_matrix(y_test,predictions)
fp_dt=cm_dt[0,1]
fn_dt=cm_dt[1,0]
miscalc_dt=(fp_dt+fn_dt)/totalNumberOfDataSets
print("confusion matrix for decision tree:")
print(cm_dt)
print("miscalc rate for decision tree: ")
print(miscalc_dt)
```

```
45
confusion matrix for random forest:
[[520  11]
 [ 31 359]]
miscalc rate for random forest:
0.04560260586319218
================
confusion matrix for decision tree:
[[513  18]
 [ 74 316]]
miscalc rate for decision tree:
0.0998914223669924
```

[168]:
```
a=np.empty(len(nTrees));
a.fill(miscalc_dt)

plt.plot(nTrees,miscalcs,label='Random Forest')
plt.plot(nTrees,a,label='Decision Tree Classifier')
plt.title('Miscalculation Rate Vs Number of Trees')
plt.xlabel('Number of Trees')
plt.ylabel('Miscalculation Rate')
plt.legend()
plt.show()
```




[176]:
```
# non_spam_emails=X_train[X_train[57]==0]
# clf = svm.OneClassSVM(nu=0.1, kernel="rbf", gamma=0.1)
# clf.fit(X_train)
# display(y_train[y_train[0]==0])
# X = data.iloc[:,:-1]
# y = data.iloc[:,-1]

train,test=train_test_split(data,test_size=0.2, random_state=42)
print(train.shape)
print(test.shape)
print("counts in train data:")
print(train[57].value_counts())
print("counts in test data:")
print(test[57].value_counts())

noofSpam_test=test[57].value_counts()[0]
noofNonSpam_test=test[57].value_counts()[1]
noofData_test = test.shape[0]

X_train=train[train[57]==0]
X_train=X_train.iloc[:,:-1]

# display(train)
```

```
# display(X_train)

clf = svm.OneClassSVM(nu=0.1, kernel="rbf", gamma="auto")
clf.fit(X_train)
y_pred_train = clf.predict(train.iloc[:,:-1])
n_error_train = y_pred_train[y_pred_train == -1].size
print("No of spams detected by model in training set:")
print(n_error_train)

y_pred_test = clf.predict(test.iloc[:,:-1])
y_pred_non_spam = y_pred_test[y_pred_test == -1].size
y_pred_spam = y_pred_test[y_pred_test == 1].size
print("No of spams detected by model in test set:")
print(y_pred_non_spam)
print("No of non-spams detected by model in test set:")
print(y_pred_spam)

tot_miscalc = abs(y_pred_non_spam - noofNonSpam_test) + abs(y_pred_spam -␣
 ↪noofSpam_test)
tot_miscalc_rate = tot_miscalc / noofData_test
print("miscalculation rate:")
print(tot_miscalc_rate)
```

```
(3680, 58)
(921, 58)
counts in train data:
0    2257
1    1423
Name: 57, dtype: int64
counts in test data:
0    531
1    390
Name: 57, dtype: int64
No of spams detected by model in training set:
1581
No of spams detected by model in test set:
527
No of non-spams detected by model in test set:
394
miscalculation rate:
0.2975027144408252
```

[59]:
```
X = np.array([1.5, 1]).T
x=0.5
beta = np.array([1, 0.5]).T
I = np.array([1,1])
np.logspace(2.0, 3.0, num=4)
```

```
# lambdas = [0,0.25,0.5,0.75,1.00,1.25,1.50,1.75,2.00]
lambdas = [0.25]
bias_squared=[]
for l in lambdas:
    b2= (x*((np.dot(X.T,X) + (np.dot(l,I)))**-1)*((np.dot(X.T,X))*beta).T) - np.
 ↪dot(beta,x)
    t1=((np.dot(X.T, X)+np.dot(l,I))**-1)
    t2=((X.T * X)*beta).T
    t3=np.dot(beta,X.T)

    bias_squared.append(b2)
print(bias_squared)
```

```
[array([-0.03571429, -0.01785714])]
```

[ ]: