Decision Tree Classifier

Name Sidhantha Poddar ¶

Roll no 17bce2044

https://archive.ics.uci.edu/ml/datasets/banknote+authentication
(https://archive.ics.uci.edu/ml/datasets/banknote+authentication)

```
Data Set Information:
Data were extracted from images that were taken from genuine and forged banknote-like
specimens. For
digitization, an industrial camera usually used for print inspection was used. The final
images have 400x
400 pixels. Due to the object lens and distance to the investigated object gray-scale
pictures with a
resolution of about 660 dpi were gained. Wavelet Transform tool were used to extract
features from
images.
Attribute Information:
1. variance of Wavelet Transformed image (continuous)
2. skewness of Wavelet Transformed image (continuous)
3. curtosis of Wavelet Transformed image (continuous)
4. entropy of image (continuous)
5. class (integer)
```

In [1]:

```
import itertools
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report, confusion_matrix
%matplotlib inline
```

In [6]:

```
#Importing The Dataset
dataset=pd.read_csv('bill_authentication.csv')
#Getting a basic idea of the dataset
dataset.head()
```

Out[6]:

	Variance	Skewness	Curtosis	Entropy	Class
0	3.62160	8.6661	-2.8073	-0.44699	0
1	4.54590	8.1674	-2.4586	-1.46210	0
2	3.86600	-2.6383	1.9242	0.10645	0
3	3.45660	9.5228	-4.0112	-3.59440	0
4	0.32924	-4.4552	4.5718	-0.98880	0

In [7]:

```
#Gaining information about the size of our dataset
dataset.shape
```

Out[7]:

```
(1372, 5)
```

In [8]:

```
#Dividing Dataset into inputs and outcomes
X = dataset.drop('Class', axis=1)
y = dataset['Class']
```

In [10]:

```
#Splitting our data into training and test set, with test set including 20% of the data
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20)
```

In [11]:

```
#Building our model
classifier = DecisionTreeClassifier()
#Fitting our model into the dataset and training it
classifier.fit(X_train, y_train)
```

Out[11]:

```
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best')
```

In [12]:

```
#Predict the outcomes of test set on the basis of our model
y_pred = classifier.predict(X_test)
```

In [13]:

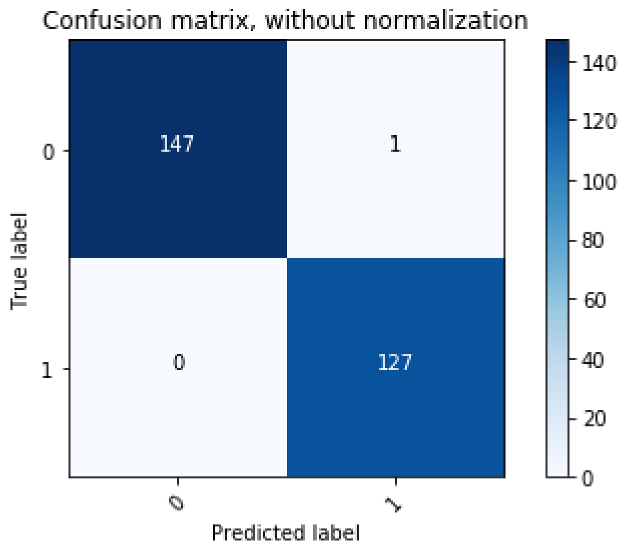
```
#Building a confusion matrix
mat=confusion_matrix(y_test, y_pred)
print(mat)
```

```
[[147   1]
 [  0 127]]
```

In [19]:

```
#Visualising the result after using Decision Tree Classifier
def plot_confusion_matrix(cm, classes,normalize=False,title='Confusion matrix',cmap=plt.cm.
    """
    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')
    print(cm)
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)
    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
            horizontalalignment="center",
            color="white" if cm[i, j] > thresh else "black")
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.tight_layout()
    # Plot non-normalized confusion matrix
plt.figure()
plot_confusion_matrix(mat, classes=[0,1],
    title='Confusion matrix, without normalization')
```

```
Confusion matrix, without normalization
[[147   1]
 [  0 127]]
```



In [20]:

```
#Splitting our confusion matrix into their corresponding semantics
tp=mat[0][0]
tn=mat[1][1]
fp=mat[1][0]
fn=mat[0][1]
```

In [21]:

```
#Calaculating the necessary statistical metrics of our model
acc=(tp+tn)/(tp+tn+fp+fn)*100
error=(100-acc)
prec=(tp/(tp+fp))*100
sens=(tp/(tp+fn))*100
spec=(tn/(tn+fp))*100
print("accuracy: ",round(acc,4))
print("error rate: ",round(error,4))
print("precision: ",round(prec,4))
print("sensitivity: ",round(sens,4))
print("specificity: ",round(spec,4))
```

```
accuracy:  99.6364
error rate:  0.3636
precision:  100.0
sensitivity:  99.3243
specificity:  100.0
```

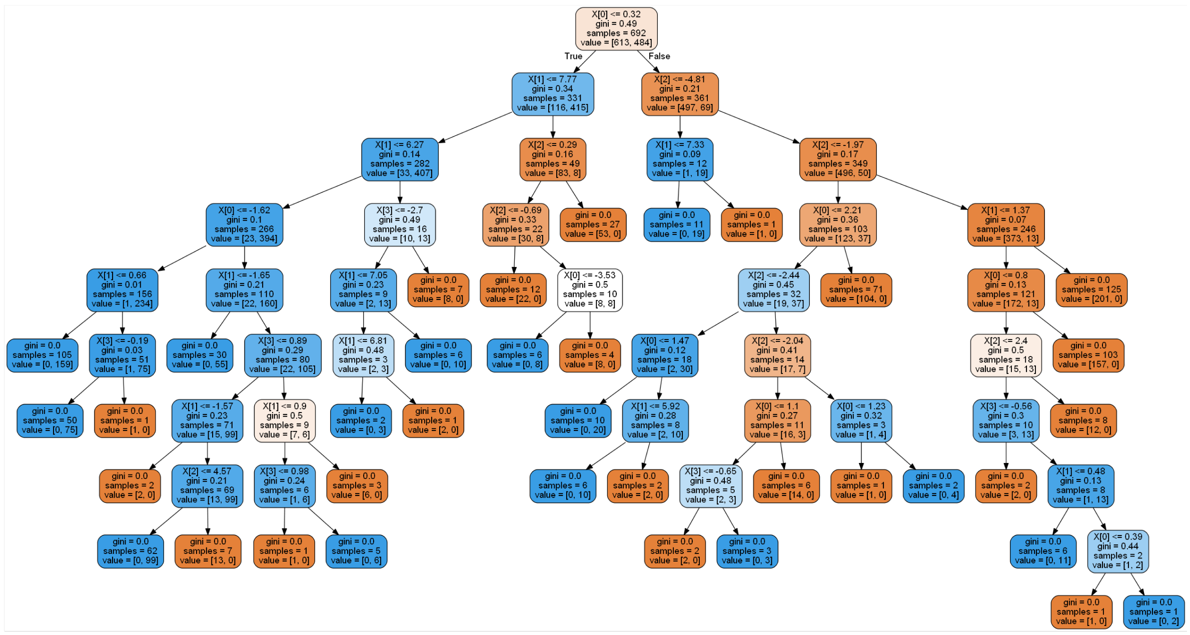
In [39]:

```
from sklearn.ensemble import RandomForestClassifier

iris=dataset
model = RandomForestClassifier(max_depth = None, n_estimators=10)
model.fit(X_train, y_train)
estimator_nonlimited = model.estimators_[5]

from sklearn.tree import export_graphviz
export_graphviz(estimator_limited, out_file='tree_limited.dot',rounded = True, proportion =
export_graphviz(estimator_nonlimited, out_file='tree_nonlimited.dot', rounded = True, propo
```

the graph is created using graphviz file format dot and then the dot file is coverted to png format using GVedit

In [61]:

```
# Display in python
import matplotlib.pyplot as plt
plt.figure(figsize = (280, 360))
plt.imshow(plt.imread('tree.png'))
plt.axis('off');
plt.show();
```



X[0] <= 0.32 gini = 0.49 samples = 692 value = [613, 484]
True
False
X[1] <= 7.77 gini = 0.34 samples = 331 value = [116, 415]
X[2] <= -4.81 gini = 0.21 samples = 361 value = [497, 69]
X[1] <= 6.27 gini = 0.14 samples = 282 value = [33, 407]
X[2] <= 0.29 gini = 0.16 samples = 49 value = [83, 8]
X[1] <= 7.33 gini = 0.09 samples = 12 value = [1, 19]
X[2] <= -1.97 gini = 0.17 samples = 349 value = [496, 50]
X[0] <= -1.62 gini = 0.1 samples = 266 value = [23, 394]
X[3] <= -2.7 gini = 0.49 samples = 16 value = [10, 13]
X[2] <= -0.69 gini = 0.33 samples = 22 value = [30, 8]
gini = 0.0 samples = 27 value = [53, 0]
gini = 0.0 samples = 11 value = [0, 19]
gini = 0.0 samples = 1 value = [1, 0]
X[0] <= 2.21 gini = 0.36 samples = 103 value = [123, 37]
X[1] <= 1.37 gini = 0.07 samples = 246 value = [373, 13]
X[1] <= 0.66 gini = 0.01 samples = 156 value = [1, 234]
X[1] <= -1.65 gini = 0.21 samples = 110 value = [22, 160]
X[1] <= 7.05 gini = 0.23 samples = 9 value = [2, 13]
gini = 0.0 samples = 7 value = [8, 0]
gini = 0.0 samples = 12 value = [22, 0]
X[0] <= -3.53 gini = 0.5 samples = 10 value = [8, 8]
X[2] <= -2.44 gini = 0.45 samples = 32 value = [19, 37]
gini = 0.0 samples = 71 value = [104, 0]
X[0] <= 0.8 gini = 0.13 samples = 121 value = [172, 13]
gini = 0.0 samples = 125 value = [201, 0]
gini = 0.0 samples = 105 value = [0, 159]
X[3] <= -0.19 gini = 0.03 samples = 51 value = [1, 75]
gini = 0.0 samples = 30 value = [0, 55]
X[3] <= 0.89 gini = 0.29 samples = 80 value = [22, 105]
X[1] <= 6.81 gini = 0.48 samples = 3 value = [2, 3]
gini = 0.0 samples = 6 value = [0, 10]
gini = 0.0 samples = 6 value = [0, 8]
gini = 0.0 samples = 4 value = [8, 0]
X[0] <= 1.47 gini = 0.12 samples = 18 value = [2, 30]
X[2] <= -2.04 gini = 0.41 samples = 14 value = [17, 7]
X[2] <= 2.4 gini = 0.5 samples = 18 value = [15, 13]
gini = 0.0 samples = 103 value = [157, 0]
gini = 0.0 samples = 50 value = [0, 75]
gini = 0.0 samples = 1 value = [1, 0]
X[1] <= -1.57 gini = 0.23 samples = 71 value = [15, 99]
X[1] <= 0.9 gini = 0.5 samples = 9 value = [7, 6]
gini = 0.0 samples = 2 value = [0, 3]
gini = 0.0 samples = 1 value = [2, 0]
gini = 0.0 samples = 10 value = [0, 20]
X[1] <= 5.92 gini = 0.28 samples = 8 value = [2, 10]
X[0] <= 1.1 gini = 0.27 samples = 11 value = [16, 3]
X[0] <= 1.23 gini = 0.32 samples = 3 value = [1, 4]
X[3] <= -0.56 gini = 0.3 samples = 10 value = [3, 13]
gini = 0.0 samples = 8 value = [12, 0]
gini = 0.0 samples = 2 value = [2, 0]
X[2] <= 4.57 gini = 0.21 samples = 69 value = [13, 99]
X[3] <= 0.98 gini = 0.24 samples = 6 value = [1, 6]
gini = 0.0 samples = 3 value = [6, 0]
gini = 0.0 samples = 6 value = [0, 10]
gini = 0.0 samples = 2 value = [2, 0]
X[3] <= -0.65 gini = 0.48 samples = 5 value = [2, 3]
gini = 0.0 samples = 6 value = [14, 0]
gini = 0.0 samples = 1 value = [1, 0]
gini = 0.0 samples = 2 value = [0, 4]
gini = 0.0 samples = 2 value = [2, 0]
X[1] <= 0.48 gini = 0.13 samples = 8 value = [1, 13]
gini = 0.0 samples = 62 value = [0, 99]
gini = 0.0 samples = 7 value = [13, 0]
gini = 0.0 samples = 1 value = [1, 0]
gini = 0.0 samples = 5 value = [0, 6]
gini = 0.0 samples = 2 value = [2, 0]
gini = 0.0 samples = 3 value = [0, 3]
gini = 0.0 samples = 6 value = [0, 11]
X[0] <= 0.39 gini = 0.44 samples = 2 value = [1, 2]
gini = 0.0 samples = 1 value = [1, 0]
gini = 0.0 samples = 1 value = [0, 2]

In [57]:

```
"""
from sklearn.externals.six import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
dot_data = StringIO()
export_graphviz(classifier, out_file=dot_data,  filled=True, rounded=True,special_character
graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
from subprocess import call
import subprocess

z="call(['dot', '-Tpng', dot_data, '-o', 'tree.png', '-Gdpi=600'])"
process = subprocess.Popen(z, shell=True)
call(['dot', '-Tpng', dot_data, '-o', 'tree.png', '-Gdpi=600'])
#Image(graph.create_png())"""
```

```
'dot' is not recognized as an internal or external command,
operable program or batch file.
```

In [62]:

```
"""# Convert to png
import subprocess
#call(['dot', '-Tpng', 'tree_nonlimited.dot', '-o', 'tree.png', '-Gdpi=600'])
z="call(['dot', '-Tpng', 'tree_nonlimited.dot', '-o', 'tree.png', '-Gdpi=600'])"
process = subprocess.Popen(z, shell=True)"""
```

Out[62]:

```
'# Convert to png\nimport subprocess \n#call([\'dot\', \'-Tpng\', \'tree_non
limited.dot\', \'-o\', \'tree.png\', \'-Gdpi=600\'])\nz="call([\'dot\', \'-T
png\', \'tree_nonlimited.dot\', \'-o\', \'tree.png\', \'-Gdpi=600\'])"\nproc
ess = subprocess.Popen(z, shell=True)'
```

In [ ]:

```
```