Decision Tree Classifier

In [1]:
```
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import matplotlib.pyplot as plt # data visualization
import seaborn as sns # statistical data visualization
%matplotlib inline
```

In [2]:
```
# import dataset

path_to_file = './car_evaluation.csv'
df = pd.read_csv(path_to_file, header=None)
```

In [3]:
```
# view dimensions of dataset

df.shape
```

Out[3]: (1728, 7)

In [4]:
```
# preview the dataset

df.head()
```

Out[4]:

	0	1	2	3	4	5	6
0	vhigh	vhigh	2	2	small	low	unacc
1	vhigh	vhigh	2	2	small	med	unacc
2	vhigh	vhigh	2	2	small	high	unacc
3	vhigh	vhigh	2	2	med	low	unacc
4	vhigh	vhigh	2	2	med	med	unacc

In [5]:
```
# Rename column names

col_names = ['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety', 'class']

df.columns = col_names

col_names
```

Out[5]: ['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety', 'class']

In [6]:
```
# let's again preview the dataset

df.head()
```

Out[6]:

	buying	maint	doors	persons	lug_boot	safety	class
0	vhigh	vhigh	2	2	small	low	unacc
1	vhigh	vhigh	2	2	small	med	unacc
2	vhigh	vhigh	2	2	small	high	unacc
3	vhigh	vhigh	2	2	med	low	unacc
4	vhigh	vhigh	2	2	med	med	unacc

In [7]:
```
# View summary of dataset

df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1728 entries, 0 to 1727
Data columns (total 7 columns):
 #   Column    Non-Null Count  Dtype 
---  ------    --------------  ----- 
 0   buying    1728 non-null   object
 1   maint     1728 non-null   object
 2   doors     1728 non-null   object
 3   persons   1728 non-null   object
 4   lug_boot  1728 non-null   object
 5   safety    1728 non-null   object
 6   class     1728 non-null   object
dtypes: object(7)
memory usage: 94.6+ KB
```

In [8]:
```
# Frequency distribution of values in variables

col_names = ['buying', 'maint', 'doors', 'persons', 'lug_boot', 'safety', 'class']


for col in col_names:

    print(df[col].value_counts())
```

```
vhigh    432
high     432
med      432
low      432
Name: buying, dtype: int64
vhigh    432
high     432
med      432
low      432
Name: maint, dtype: int64
2        432
3        432
4        432
5more    432
Name: doors, dtype: int64
2       576
4       576
more    576
Name: persons, dtype: int64
small    576
med      576
big      576
Name: lug_boot, dtype: int64
low     576
med     576
high    576
Name: safety, dtype: int64
unacc    1210
acc       384
good       69
vgood      65
Name: class, dtype: int64
```

In [9]:
```
# Explore class variable

df['class'].value_counts()
```

Out[9]:
```
unacc    1210
acc       384
good       69
vgood      65
Name: class, dtype: int64
```

In [10]:
```
# check missing values in variables

df.isnull().sum()
```

Out[10]:
```
buying      0
maint       0
doors       0
persons     0
lug_boot    0
safety      0
class       0
dtype: int64
```

In [11]:
```
# Declare feature vector and target variable

X = df.drop(['class'], axis=1)

y = df['class']
```

In [12]:
```
# split X and y into training and testing sets

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.25, random_
```

In [13]:
```
# check the shape of X_train and X_test

X_train.shape, X_test.shape
```

Out[13]:
```
((1296, 6), (432, 6))
```

In [14]:
```
# check data types in X_train

X_train.dtypes
```

Out[14]:
```
buying      object
maint       object
doors       object
persons     object
lug_boot    object
safety      object
dtype: object
```

In [15]:
```
# We can see that all the variables are ordinal categorical data type.

X_train.head()
```

Out[15]:

	buying	maint	doors	persons	lug_boot	safety
1694	low	low	4	more	small	high
1663	low	low	3	4	big	med
1609	low	med	5more	4	big	med
1289	med	low	5more	more	small	high
133	vhigh	high	2	more	big	med

Encoding Data

In [16]:
```
# import category encoders

import category_encoders as ce
```

In [17]:
```
# encode variables with ordinal encoding

encoder = ce.OrdinalEncoder(cols=['buying', 'maint', 'doors', 'persons', 'lug_boot'


X_train = encoder.fit_transform(X_train)

X_test = encoder.transform(X_test)
```

In [18]:
```
X_train.head()
```

Out[18]:

	buying	maint	doors	persons	lug_boot	safety
1694	1	1	1	1	1	1
1663	1	1	2	2	2	2
1609	1	2	3	2	2	2
1289	2	1	3	1	1	1
133	3	3	4	1	2	2

In [19]:
```
X_test.head()
```

Out[19]:

	buying	maint	doors	persons	lug_boot	safety
364	3	1	2	2	3	2
1178	2	2	3	2	2	1
1206	2	1	4	1	1	3
1542	1	2	2	3	3	3
776	4	1	4	1	1	1

Decision Tree Classifier with criterion gini index

In [20]:
```
# import DecisionTreeClassifier

from sklearn.tree import DecisionTreeClassifier
```

In [21]:
```
# instantiate the DecisionTreeClassifier model with criterion gini index

clf_gini = DecisionTreeClassifier(criterion='gini', max_depth=3, random_state=12)


# fit the model
clf_gini.fit(X_train, y_train)
```

Out[21]:
```
DecisionTreeClassifier(max_depth=3, random_state=12)
```

In [22]:
```
# Training set accuarcy
y_pred_train_gini = clf_gini.predict(X_train)

y_pred_train_gini
```

Out[22]:
```
array(['acc', 'acc', 'acc', ..., 'unacc', 'unacc', 'unacc'], dtype=object)
```

In [23]:
```
from sklearn.metrics import accuracy_score

print('Training-set accuracy score: {0:0.4f}'. format(accuracy_score(y_train, y_pre
```

```
Training-set accuracy score: 0.7917
```

In [24]:
```
# Testing test accuracy

y_pred_gini = clf_gini.predict(X_test)

print('Model accuracy score with criterion gini index: {0:0.4f}'. format(accuracy_s
```

```
Model accuracy score with criterion gini index: 0.7917
```

In [25]:
```
# Compare the train-set and test-set accuracy
# print the scores on training and test set

print('Training set score: {:.4f}'.format(clf_gini.score(X_train, y_train)))

print('Test set score: {:.4f}'.format(clf_gini.score(X_test, y_test)))
```

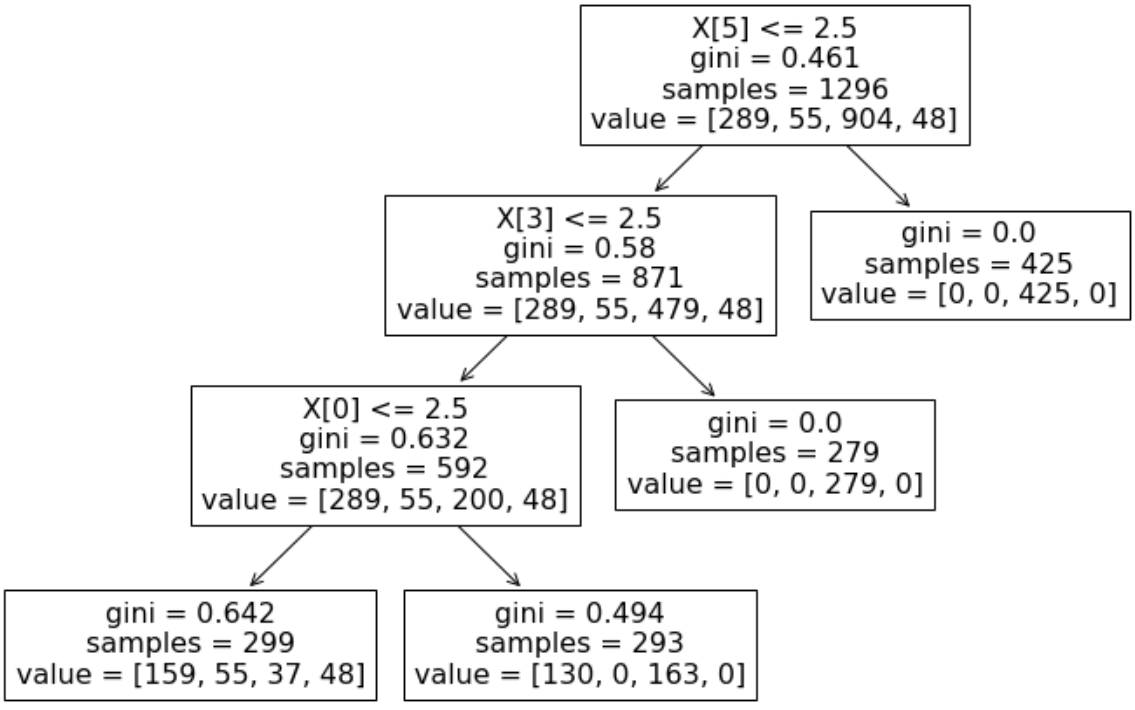
```
Training set score: 0.7917
Test set score: 0.7917
```

Here, the training-set accuracy score is 0.7917 while the test-set accuracy to be 0.7917. These two values are quite comparable. So, there is no sign of overfitting.

Visualize decision-trees

In [26]:
```
from sklearn import tree

plt.figure(figsize=(12,8))
tree.plot_tree(clf_gini.fit(X_train, y_train))
```

Out[26]:
```
[Text(0.6666666666666666, 0.875, 'X[5] <= 2.5\ngini = 0.461\nsamples = 1296\nvalue
= [289, 55, 904, 48]'),
 Text(0.5, 0.625, 'X[3] <= 2.5\ngini = 0.58\nsamples = 871\nvalue = [289, 55, 479,
48]'),
 Text(0.3333333333333333, 0.375, 'X[0] <= 2.5\ngini = 0.632\nsamples = 592\nvalue
= [289, 55, 200, 48]'),
 Text(0.16666666666666666, 0.125, 'gini = 0.642\nsamples = 299\nvalue = [159, 55,
37, 48]'),
 Text(0.5, 0.125, 'gini = 0.494\nsamples = 293\nvalue = [130, 0, 163, 0]'),
 Text(0.6666666666666666, 0.375, 'gini = 0.0\nsamples = 279\nvalue = [0, 0, 279,
0]'),
 Text(0.8333333333333334, 0.625, 'gini = 0.0\nsamples = 425\nvalue = [0, 0, 425,
0]')]
```



In [27]:
```
# Visualize decision-trees with graphviz

import graphviz
dot_data = tree.export_graphviz(clf_gini, out_file=None,
                                feature_names=X_train.columns,
                                class_names=y_train,
                                filled=True, rounded=True,
                                special_characters=True)

graph = graphviz.Source(dot_data)

graph
```

Out[27]:
```
b'
```

\n'

Decision Tree Classifier with criterion entropy

In [28]:
```
# instantiate the DecisionTreeClassifier model with criterion entropy

clf_en = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=0)


# fit the model
clf_en.fit(X_train, y_train)
```

Out[28]:
```
DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=0)
```

In [29]:
```
y_pred_en = clf_en.predict(X_test)
```

```
print('Model accuracy score with criterion entropy: {0:0.4f}'. format(accuracy_scor
```

```
Model accuracy score with criterion entropy: 0.7917
```

In [30]:
```
y_pred_train_en = clf_en.predict(X_train)

y_pred_train_en
```

Out[30]:
```
array(['acc', 'acc', 'acc', ..., 'unacc', 'unacc', 'unacc'], dtype=object)
```

In [31]:
```
print('Training-set accuracy score: {0:0.4f}'. format(accuracy_score(y_train, y_pre
```

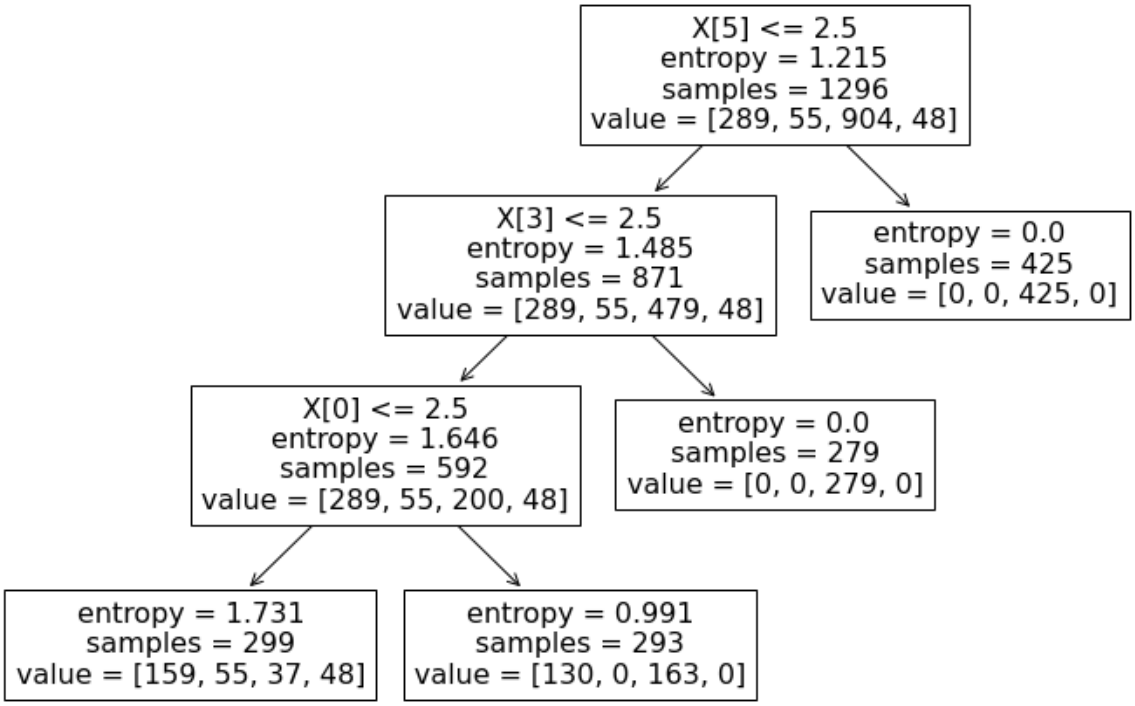
```
Training-set accuracy score: 0.7917
```

In [32]:
```
# print the scores on training and test set

print('Training set score: {:.4f}'.format(clf_en.score(X_train, y_train)))

print('Test set score: {:.4f}'.format(clf_en.score(X_test, y_test)))
```

```
Training set score: 0.7917
Test set score: 0.7917
```

In [33]:
```
plt.figure(figsize=(12,8))

tree.plot_tree(clf_en.fit(X_train, y_train))
```

Out[33]:
```
[Text(0.6666666666666666, 0.875, 'X[5] <= 2.5\nentropy = 1.215\nsamples = 1296\nva
lue = [289, 55, 904, 48]'),
 Text(0.5, 0.625, 'X[3] <= 2.5\nentropy = 1.485\nsamples = 871\nvalue = [289, 55,
479, 48]'),
 Text(0.3333333333333333, 0.375, 'X[0] <= 2.5\nentropy = 1.646\nsamples = 592\nval
ue = [289, 55, 200, 48]'),
 Text(0.16666666666666666, 0.125, 'entropy = 1.731\nsamples = 299\nvalue = [159, 5
5, 37, 48]'),
 Text(0.5, 0.125, 'entropy = 0.991\nsamples = 293\nvalue = [130, 0, 163, 0]'),
 Text(0.6666666666666666, 0.375, 'entropy = 0.0\nsamples = 279\nvalue = [0, 0, 27
9, 0]'),
 Text(0.8333333333333334, 0.625, 'entropy = 0.0\nsamples = 425\nvalue = [0, 0, 42
5, 0]')]
```



In [34]:
```
dot_data = tree.export_graphviz(clf_en, out_file=None,
                                feature_names=X_train.columns,
                                class_names=y_train,
                                filled=True, rounded=True,
                                special_characters=True)

graph = graphviz.Source(dot_data)

graph
```

Out[34]: b'

\n'

'gini', 'entropy', 'log_loss'

In [35]:
```
parameter = ["gini", "entropy"]

for i in range(2):
    model = DecisionTreeClassifier(criterion = parameter[i], max_depth=3, random_st
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print("For " + parameter[i] + " : ")
    print('Accuracy : {0:0.4f}' . format(accuracy_score(y_test, y_pred)))
    print('Train Score : {0:0.4f}' . format(model.score(X_train, y_train)))
    print('Test Score : {0:0.4f}' . format(model.score(X_test, y_test)))
    print("")
```

```
For gini :
Accuracy : 0.7917
Train Score : 0.7917
Test Score : 0.7917

For entropy :
Accuracy : 0.7917
Train Score : 0.7917
Test Score : 0.7917
```

Max depth

In [54]:
```
for i in [1,2,3,4,5,20]:
    model = DecisionTreeClassifier(criterion = 'gini', max_depth=i, random_state=0)
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print("For max_depth = {} : ".format(i))
    print('Accuracy : {0:0.4f}' . format(accuracy_score(y_test, y_pred)))
    print('Train Score : {0:0.4f}' . format(model.score(X_train, y_train)))
    print('Test Score : {0:0.4f}' . format(model.score(X_test, y_test)))
    print("")
```

```
For max_depth = 1 :
Accuracy : 0.7083
Train Score : 0.6975
Test Score : 0.7083

For max_depth = 2 :
Accuracy : 0.8125
Train Score : 0.7662
Test Score : 0.8125

For max_depth = 3 :
Accuracy : 0.7917
Train Score : 0.7917
Test Score : 0.7917

For max_depth = 4 :
Accuracy : 0.8611
Train Score : 0.8472
Test Score : 0.8611

For max_depth = 5 :
Accuracy : 0.8681
Train Score : 0.8789
Test Score : 0.8681

For max_depth = 20 :
Accuracy : 0.9815
Train Score : 1.0000
Test Score : 0.9815
```

Random state

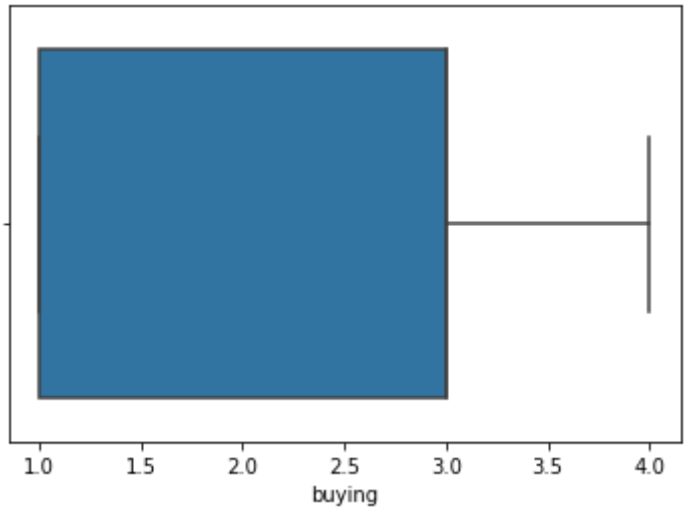
In [55]:
```
for i in [1,2,3,4,5]:
    model = DecisionTreeClassifier(criterion = 'gini', max_depth=20, random_state=i)
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    print("For max_depth = {} : ".format(i))
    print('Accuracy : {0:0.4f}' . format(accuracy_score(y_test, y_pred)))
    print('Train Score : {0:0.4f}' . format(model.score(X_train, y_train)))
    print('Test Score : {0:0.4f}' . format(model.score(X_test, y_test)))
    print("")
```

```
For max_depth = 1 :
Accuracy : 0.9815
Train Score : 1.0000
Test Score : 0.9815

For max_depth = 2 :
Accuracy : 0.9815
Train Score : 1.0000
Test Score : 0.9815

For max_depth = 3 :
Accuracy : 0.9815
Train Score : 1.0000
Test Score : 0.9815

For max_depth = 4 :
Accuracy : 0.9861
Train Score : 1.0000
Test Score : 0.9861

For max_depth = 5 :
Accuracy : 0.9815
Train Score : 1.0000
Test Score : 0.9815
```

In [48]:
```
import seaborn as sns
sns.boxplot((X_train['buying']))
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarnin
g: Pass the following variable as a keyword arg: x. From version 0.12, the only va
lid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

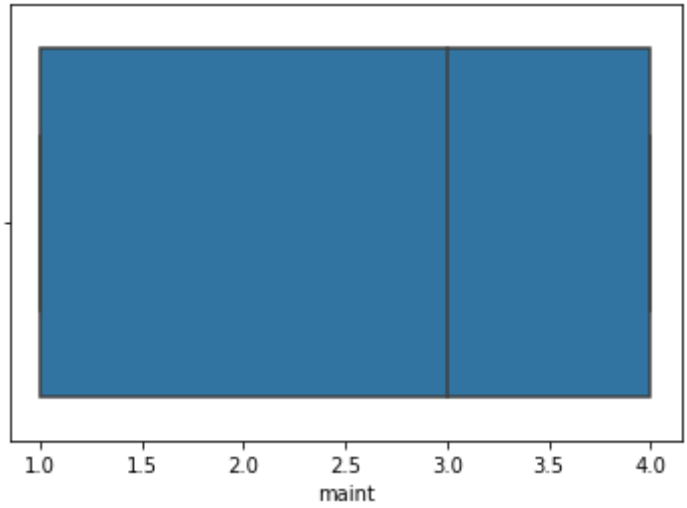
Out[48]: <AxesSubplot:xlabel='buying'>



In [45]:
```
sns.boxplot((X_train['maint']))
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarnin
g: Pass the following variable as a keyword arg: x. From version 0.12, the only va
lid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

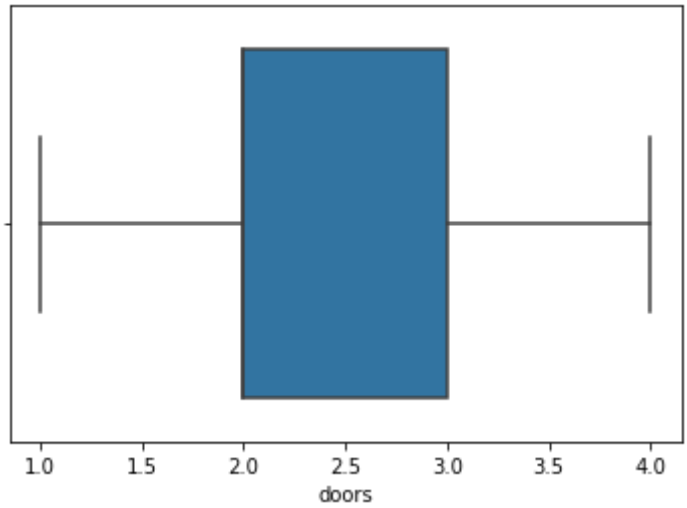
Out[45]: <AxesSubplot:xlabel='maint'>



In [44]:
```
sns.boxplot((X_train['doors']))
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarnin
g: Pass the following variable as a keyword arg: x. From version 0.12, the only va
lid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[44]: <AxesSubplot:xlabel='doors'>



In [ ]: