Birla Institute of Applied Sciences
बिरला इंस्टिट्यूट ऑफ़ अप्लाइड साइंसेस
Bhimtal, Distt: Nainital, Uttarakhand- 263136

Pattern Recognition

- S. S. Samant

Decision Tree Classifier

These are *multistage* decision systems in which classes are sequentially rejected until we reach a finally accepted class. To this end, the feature space is split into unique regions, corresponding to the classes, *in a sequential manner*.

- A *splitting criterion* must be adopted according to which the best split from the set of candidate ones is chosen.
- A stop-splitting rule is required that controls the growth of the tree, and a node is declared as a terminal one (*leaf*).
- A rule is required that assigns each leaf to a specific class.

Information gain (entropy)

RID	*age*	*income*	*student*	*credit_rating*	*Class: buys_computer*
1	youth	high	no	fair	no
2	youth	high	no	excellent	no
3	middle_aged	high	no	fair	yes
4	senior	medium	no	fair	yes
5	senior	low	yes	fair	yes
6	senior	low	yes	excellent	no
7	middle_aged	low	yes	excellent	yes
8	youth	medium	no	fair	no
9	youth	low	yes	fair	yes
10	senior	medium	yes	fair	yes
11	youth	medium	yes	excellent	yes
12	middle_aged	medium	no	excellent	yes
13	middle_aged	high	yes	fair	yes
14	senior	medium	no	excellent	no

$$Info(D) = -\frac{9}{14}\log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right) = 0.940 \text{ bits.}$$

What if we split on age?

age?

youth

income	*student*	*credit_rating*	*class*
high	no	fair	no
high	no	excellent	no
medium	no	fair	no
low	yes	fair	yes
medium	yes	excellent	yes

middle_aged

income	*student*	*credit_rating*	*class*
high	no	fair	yes
low	yes	excellent	yes
medium	no	excellent	yes
high	yes	fair	yes

senior

income	*student*	*credit_rating*	*class*
medium	no	fair	yes
low	yes	fair	yes
low	yes	excellent	no
medium	yes	fair	yes
medium	no	excellent	no

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$$\begin{aligned} Info_{age}(D) = {} & \frac{5}{14} \times \left(-\frac{2}{5}\log_2\frac{2}{5} - \frac{3}{5}\log_2\frac{3}{5}\right) \\ & + \frac{4}{14} \times \left(-\frac{4}{4}\log_2\frac{4}{4} - \frac{0}{4}\log_2\frac{0}{4}\right) \\ & + \frac{5}{14} \times \left(-\frac{3}{5}\log_2\frac{3}{5} - \frac{2}{5}\log_2\frac{2}{5}\right) \\ = {} & 0.694 \text{ bits.} \end{aligned}$$

$$Info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times Info(D_j)$$

Information gain (entropy)

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13	middle_aged	high	yes	fair	yes
14	senior	medium	no	excellent	no

$$Gain(age) = Info(D) - Info_{age}(D) = 0.940 - 0.694 = 0.246 \text{ bits}$$

$$Gain(income) = 0.029 \text{ bits}$$

$$Gain(student) = 0.151 \text{ bits}$$

$$Gain(credit\_rating) = 0.048 \text{ bits}$$

$$Info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times Info(D_j)$$

Representing nominal variables

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Python only accepts numeric values for attributes, how to represent **categorical** variables such as age and income?

So, if age takes 3 values ***youth***, ***middle-aged***, **and** ***senior***
We can use 3 – 1 (=2) **dummy variables** for each age-value the variable takes

Dummy variable : a numeric variable that represents **categorical** data, such as gender, race, etc.

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Dummy variable : a numeric variable that represents **categorical** data, such as gender, race, etc.

For ex. age can take three values, so we can use 2 dummy variables as:

middle-aged	**senior**	**youth**
1	0	
0	1	
0	0	

Representing nominal variables

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Dummy variable : a numeric variable that represents **categorical** data, such as gender, race, etc.

For ex. age can take three values, so we can use 2 dummy variables as:

middle-aged	senior	youth
1	0	
0	1	
0	0	

Can infer this value from the other two

Attribute Selection Measures

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
0	0	1	1	0	0	0	n
1	0	1	0	0	0	0	n
2	0	0	1	0	0	0	y
3	1	0	1	0	1	0	y
4	1	0	1	1	0	1	y
5	1	0	0	1	0	1	n
6	0	0	0	1	0	1	y
7	0	1	1	0	1	0	n
8	0	1	1	1	0	1	y
9	1	0	1	0	1	1	y
10	0	1	0	0	1	1	y
11	0	0	0	0	1	0	y
12	0	0	1	0	0	1	y
13	1	0	0	0	1	0	n

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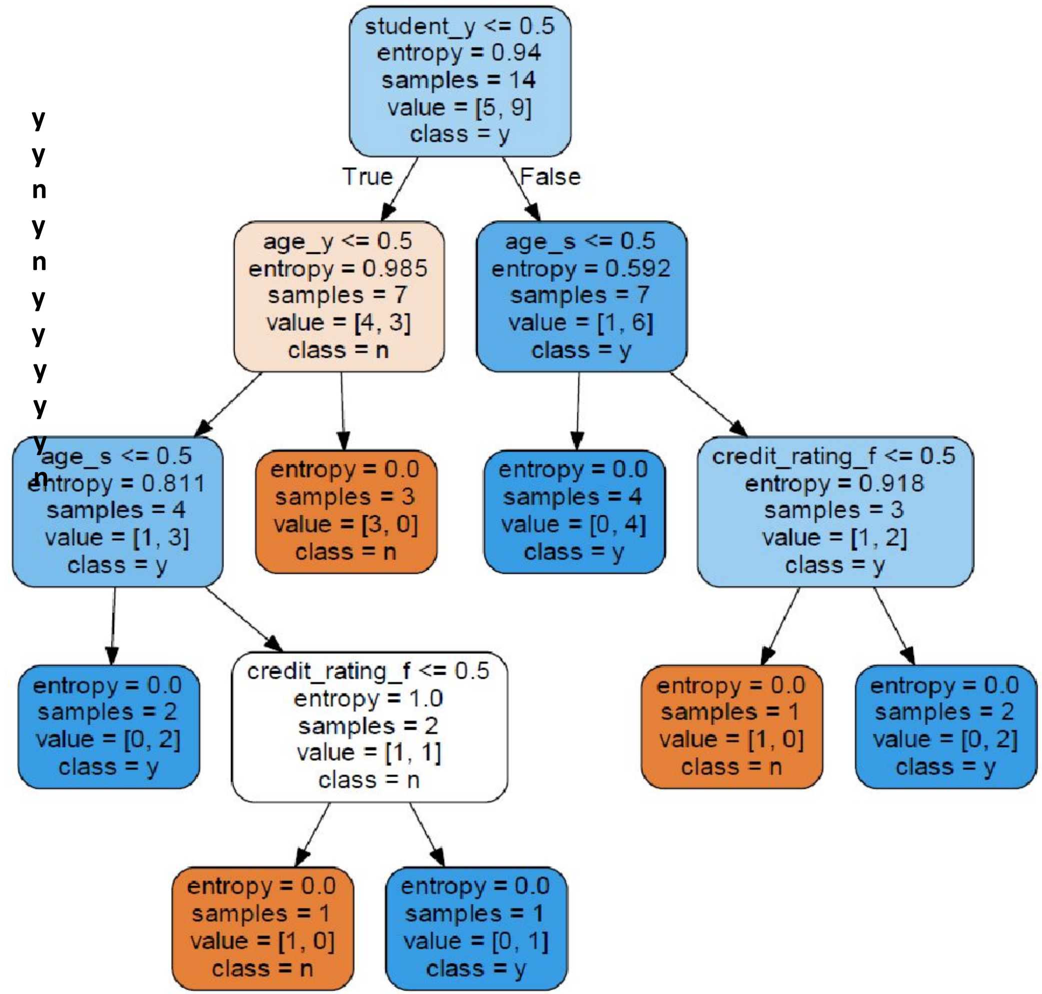
6	senior	low	yes	excellent	no
7	middle_aged	low	yes	excellent	yes
8	youth	medium	no	fair	no
9	youth	low	yes	fair	yes
10	senior	medium	yes	fair	yes
11	youth	medium	yes	excellent	yes
12	middle_aged	medium	no	excellent	yes
13	middle_aged	high	yes	fair	yes
14	senior	medium	no	excellent	no



Dataset

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
0	0	1	1	0	0	0	n
1	0	1	0	0	0	0	n
2	0	0	1	0	0	0	y
3	1	0	1	0	1	0	y
4	1	0	1	1	0	1	y
5	1	0	0	1	0	1	n
6	0	0	0	1	0	1	y
7	0	1	1	0	1	0	n
8	0	1	1	1	0	1	y
9	1	0	1	0	1	1	y
10	0	1	0	0	1	1	y
11	0	0	0	0	1	0	y
12	0	0	1	0	0	1	y
13	1	0	0	0	1	0	n

Initial entropy = 0.9402, entropy on splits (ages_s=?, age_y=?, credit_rating_f=?, income_l=?, income_m=?, student_y=?)

Dataset

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
0	0	1	1	0	0	0	n
1	0	1	0	0	0	0	n
2	0	0	1	0	0	0	y
3	1	0	1	0	1	0	y
4	1	0	1	1	0	1	y
5	1	0	0	1	0	1	n
6	0	0	0	1	0	1	y
7	0	1	1	0	1	0	n
8	0	1	1	1	0	1	y
9	1	0	1	0	1	1	y
10	0	1	0	0	1	1	y
11	0	0	0	0	1	0	y
12	0	0	1	0	0	1	y
13	1	0	0	0	1	0	n

Initial entropy = 0.9402, entropy on splits (ages_s=0.9371, age_y=0.838, credit_rating_f=0.8921, income_l=0.9253, income_m=0.9389, student_y=0.7884)

Dataset

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
0	0	1	1	0	0	0	n
1	0	1	0	0	0	0	n
2	0	0	1	0	0	0	y
3	1	0	1	0	1	0	y
7	0	1	1	0	1	0	n
11	0	0	0	0	1	0	y
13	1	0	0	0	1	0	n

Initial entropy = 0.9852, entropy on splits (ages_s=0.9792, age_y=0.4635, credit_rating_f=0.9649, income_l=0.9852, income_m=0.9649)

Dataset

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
2	0	0	1	0	0	0	y
3	1	0	1	0	1	0	y
11	0	0	0	0	1	0	y
13	1	0	0	0	1	0	n

Initial entropy = 0.8112, entropy on splits (ages_s=0.5, credit_rating_f=0.5, income_l=0.8112, income_m=0.6887)

Dataset

	age_s	age_y	credit_rating_f	income_l	income_m	student_y	Class
2	0	0	1	0	0	0	y
11	0	0	0	0	1	0	y

Initial entropy = 0, so Class='y'

DT implementation

```
#   install graphviz from anaconda prompt by running
#       conda install python-graphviz
#       conda install graphviz
import pandas as pd
from sklearn.tree import DecisionTreeClassifier
from sklearn.tree import export_graphviz
import graphviz

data = pd.DataFrame()
data['age']     = ['y','y','m','s','s','s','m','y','y','s','y','m','m','s']
data['income']  = ['h','h','h','m','l','l','l','m','l','m','m','m','h','m']
data['student']= ['n','n','n','n','y','y','y','n','y','y','y','n','y','n']
data['credit_rating']= ['f','e','f','f','f','e','e','f','f','f','e','e','f','e’]
#print (data)
df = pd.DataFrame([['s','m','y','f'], ['s','m','y','e']],
columns=['age','income','student','credit_rating'])
df2 = data.append(df,ignore_index=True )
fea = pd.get_dummies(df2,drop_first=True)
y =['n','n','y','y','y','n','y','n','y','y','y','y','y','n']
df_train, df_test = fea[:14], fea[14:]
dt = DecisionTreeClassifier(criterion='entropy', random_state=1)
dt.fit(df_train, y)
dot_data = export_graphviz(dt, out_file=None,
     feature_names =list(fea.columns.values), class_names = ['n', 'y'], filled=True,
rounded=True)
graph = graphviz.Source(dot_data)
graph.render('buys_computer')  # saves Dtree in a file buys_computer.pdf
```

Thank You!