Decision Tree Implementation

11/11/2019

Decision Tree

Implement Decision Tree algorithm as follows:

DTree(*records*, *attributes*) returns a tree

the best feature to split

If stopping criterion is met, return a leaf node with the assigned class.
Else pick an *attribute* F based on Gini Index and create a node *R* for it
For each possible value *v* of *F*:
Let *Sv* be the subset of records that have value *v* for *F*
call DTree(*Sv*, *attributes* – {*F*}) and attach the resulting tree as the subtree to the current node.
Return the subtree.

Example

- Golf dataset
  - 4 features
  - Label: yes/no
- We use multi-way Split in this assignment

Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Overcast	Hot	High	FALSE	Yes
Sunny	Mild	High	FALSE	Yes
Sunny	Cool	Normal	FALSE	Yes
Sunny	Cool	Normal	TRUE	No
Overcast	Cool	Normal	TRUE	Yes
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Sunny	Mild	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes
Sunny	Mild	High	TRUE	No

Example

- Find best split feature
  - For each feature, calculate the gain of gini indexes

If Feature = Outlook

$$\text{Gini}=1-\left(\frac{5}{14}\right)^2-\left(\frac{9}{14}\right)^2=0.46$$

Outlook = Rainy

$$\text{gini}=1-\left(\frac{3}{5}\right)^2-\left(\frac{2}{5}\right)^2=0.48$$

Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Overcast	Hot	High	FALSE	Yes
Sunny	Mild	High	FALSE	Yes
Sunny	Cool	Normal	FALSE	Yes
Sunny	Cool	Normal	TRUE	No
Overcast	Cool	Normal	TRUE	Yes
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Sunny	Mild	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes
Sunny	Mild	High	TRUE	No

Example

- Find best split feature
  - For each feature, calculate the gain of gini indexes

If Feature = Outlook

$$\text{Gini}=1-\left(\frac{5}{14}\right)^2-\left(\frac{9}{14}\right)^2=0.46$$

Outlook = Rainy

$$\text{gini}=1-\left(\frac{3}{5}\right)^2-\left(\frac{2}{5}\right)^2=0.48$$

Outlook = overcast

$$\text{gini}=1-\left(\frac{4}{4}\right)^2=0$$

Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Overcast	Hot	High	FALSE	Yes
Sunny	Mild	High	FALSE	Yes
Sunny	Cool	Normal	FALSE	Yes
Sunny	Cool	Normal	TRUE	No
Overcast	Cool	Normal	TRUE	Yes
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Sunny	Mild	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes
Sunny	Mild	High	TRUE	No

Example

- Find best split feature
  - For each feature, calculate the gain of gini

If Feature = Outlook

$$\text{Gini}=1-\left(\frac{5}{14}\right)^2-\left(\frac{9}{14}\right)^2=0.46$$

Outlook = Rainy

$$\text{gini}=1-\left(\frac{3}{5}\right)^2-\left(\frac{2}{5}\right)^2=0.48$$

Outlook = overcast

$$\text{gini}=1-\left(\frac{4}{4}\right)^2=0$$

Outlook = sunny

$$\text{gini}=1-\left(\frac{3}{5}\right)^2-\left(\frac{2}{5}\right)^2=0.48$$

$$\text{Gain}=0.46-\left(\frac{5}{14}*0.48+\frac{4}{14}*0+\frac{5}{14}*0.48\right)=0.117$$

Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Overcast	Hot	High	FALSE	Yes
Sunny	Mild	High	FALSE	Yes
Sunny	Cool	Normal	FALSE	Yes
Sunny	Cool	Normal	TRUE	No
Overcast	Cool	Normal	TRUE	Yes
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Sunny	Mild	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes
Sunny	Mild	High	TRUE	No

Example

- Find best split feature
  - For each feature, calculate the gain
    - If Feature = Temperature, follow the same procedure to obtain the gain value
    - After the calculation for each feature on the dataset, we obtain

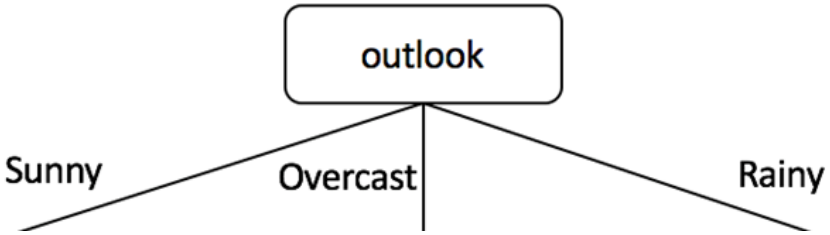
Gain(outlook) = 0.117

Gain(temperature)=0.018

Gain(humidity)=0.092

Gain(windy)=0.031

So Outlook is the best feature to split

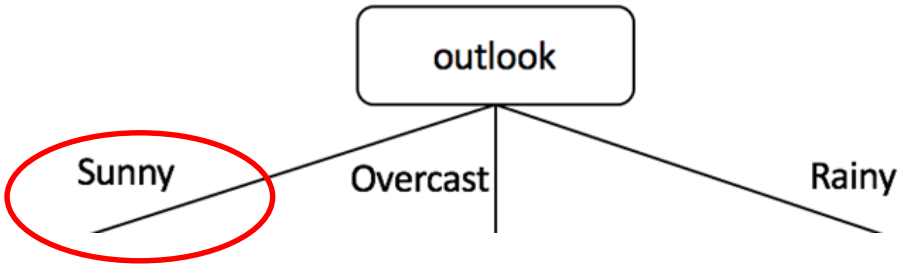


Example

- Split the dataset

splitData function (has been provided)

Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Overcast	Hot	High	FALSE	Yes
Sunny	Mild	High	FALSE	Yes
Sunny	Cool	Normal	FALSE	Yes
Sunny	Cool	Normal	TRUE	No
Overcast	Cool	Normal	TRUE	Yes
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Sunny	Mild	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes
Sunny	Mild	High	TRUE	No



Temperature	Humidity	Windy	Label
Mild	High	FALSE	Yes
Cool	Normal	FALSE	Yes
Cool	Normal	TRUE	No
Mild	Normal	FALSE	Yes
Mild	High	TRUE	No

Example

- Find best split on sub-dataset (outlook=sunny)

  follow the same procedure

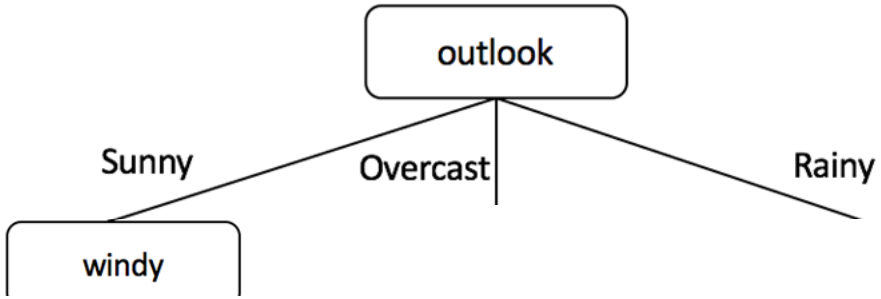
  Gain(temperature)=0.0133

  Gain(Humidity)=0.0133

  Gain(windy)=0.48

  So windy is the best feature to split on the sub-dataset (when outlook='sunny')

Temperature	Humidity	Windy	Label
Mild	High	FALSE	Yes
Cool	Normal	FALSE	Yes
Cool	Normal	TRUE	No
Mild	Normal	FALSE	Yes
Mild	High	TRUE	No

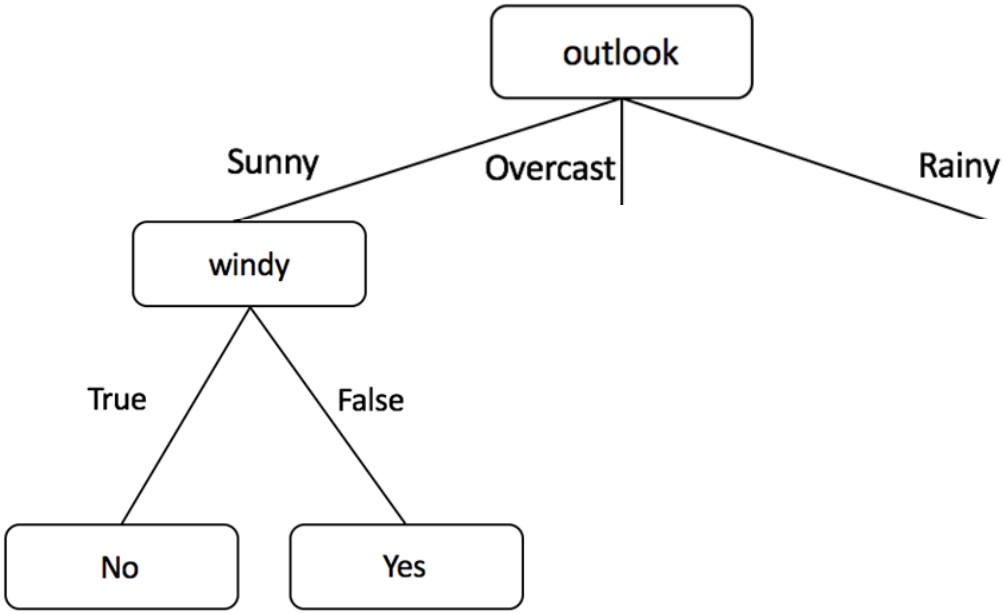


Example

- Iterate until stopping criteria satisfied

Windy = False → Yes

Windy = True → No



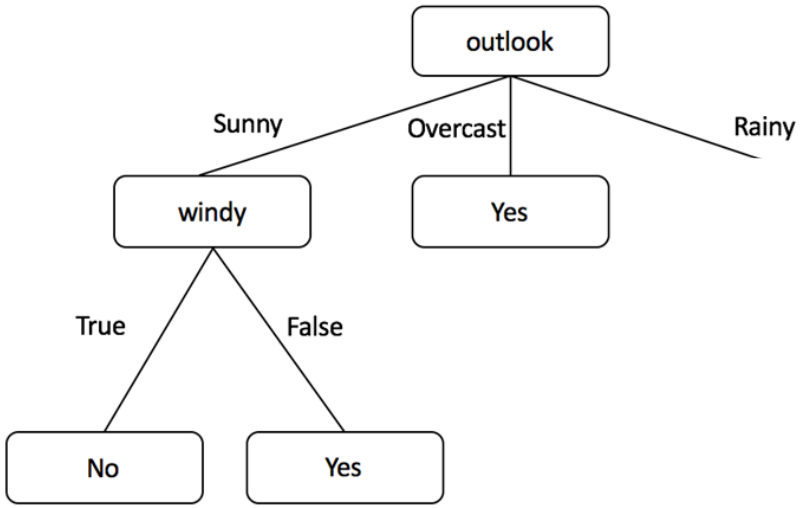
(outlook=sunny)

Temperature	Humidity	Windy	Label
Mild	High	FALSE	Yes
Cool	Normal	FALSE	Yes
Cool	Normal	TRUE	No
Mild	Normal	FALSE	Yes
Mild	High	TRUE	No

Example

- Follow the same procedure for overcast and Rainy
  - Outlook = overcast → label=yes

(outlook=Overcast)

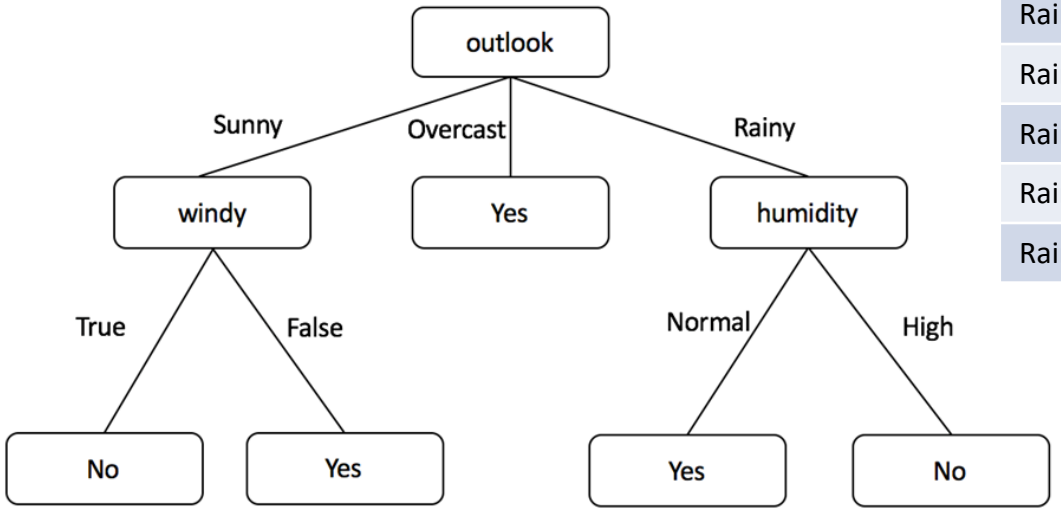


Outlook	Temperature	Humidity	Windy	Label
Overcast	Hot	High	FALSE	Yes
Overcast	Cool	Normal	TRUE	Yes
Overcast	Mild	High	TRUE	Yes
Overcast	Hot	Normal	FALSE	Yes

Example

- Follow the same procedure for overcast and Rainy
  - Outlook = Rainy

(outlook=Rainy)



Outlook	Temperature	Humidity	Windy	Label
Rainy	Hot	High	FALSE	No
Rainy	Hot	High	TRUE	No
Rainy	Mild	High	FALSE	No
Rainy	Cool	Normal	FALSE	Yes
Rainy	Mild	Normal	TRUE	Yes

Gain(temperature)=0.28
Gain(Humidity)=0.48
Gain(windy)=0.013

Humidity = High → No
Humidity = Normal → Yes

Pseudocode

- Find best split feature

chooseBestFeature(dataset)

for each feature i in the dataset

calculate gini index on dataset

for each $value$ of the feature

subset = splitData(dataset, i, $value$)

calculate gini index on the subset

calculate Gain for feature i

Find the bestGain and the corresponding feature id

Pseudocode

- Stopping criteria

```
stopCriteria(dataset)
    assignedLabel = None
    if all class labels are the same
            assignedLabel = label
    else if no more features to split
            assignedLabel = majority(labels)
```