Illustrative Example for ID3 Induction

An Illustrative Example

The dependent variable „Tennis“ determines if the weather is good for tennis („Yes“) or not („No“).

Element	*Outlook*	*Temperature*	*Humidity*	*Wind*	*Tennis*
1	Sunny	Hot	High	Weak	No
2	Sunny	Hot	High	Strong	No
3	Overcast	Hot	High	Weak	Yes
4	Rain	Mild	High	Weak	Yes
5	Rain	Cold	Normal	Weak	Yes
6	Rain	Cold	Normal	Strong	No
7	Overcast	Cold	Normal	Strong	Yes
8	Sunny	Mild	High	Weak	No
9	Sunny	Cold	Normal	Weak	Yes
10	Rain	Mild	Normal	Weak	Yes
11	Sunny	Mild	Normal	Strong	Yes
12	Overcast	Mild	High	Strong	Yes
13	Overcast	Hot	Normal	Weak	Yes
14	Rain	Mild	High	Strong	No

Entropy of the Decision Tree

$$\text{Entropy}(S) = -\frac{9}{14} * \log_2\left(\frac{9}{14}\right) - \frac{5}{14} * \log_2\left(\frac{5}{14}\right)$$
$$= 0{,}94$$

Element	*Outlook*	*Temperature*	*Humidity*	*Wind*	*Tennis*
1	Sunny	Hot	High	Weak	No
2	Sunny	Hot	High	Strong	No
3	Overcast	Hot	High	Weak	Yes
4	Rain	Mild	High	Weak	Yes
5	Rain	Cold	Normal	Weak	Yes
6	Rain	Cold	Normal	Strong	No
7	Overcast	Cold	Normal	Strong	Yes
8	Sunny	Mild	High	Weak	No
9	Sunny	Cold	Normal	Weak	Yes
10	Rain	Mild	Normal	Weak	Yes
11	Sunny	Mild	Normal	Strong	Yes
12	Overcast	Mild	High	Strong	Yes
13	Overcast	Hot	Normal	Weak	Yes
14	Rain	Mild	High	Strong	No

positive frequency (Yes)
negative frequency (No)

Selection of the topmost Node

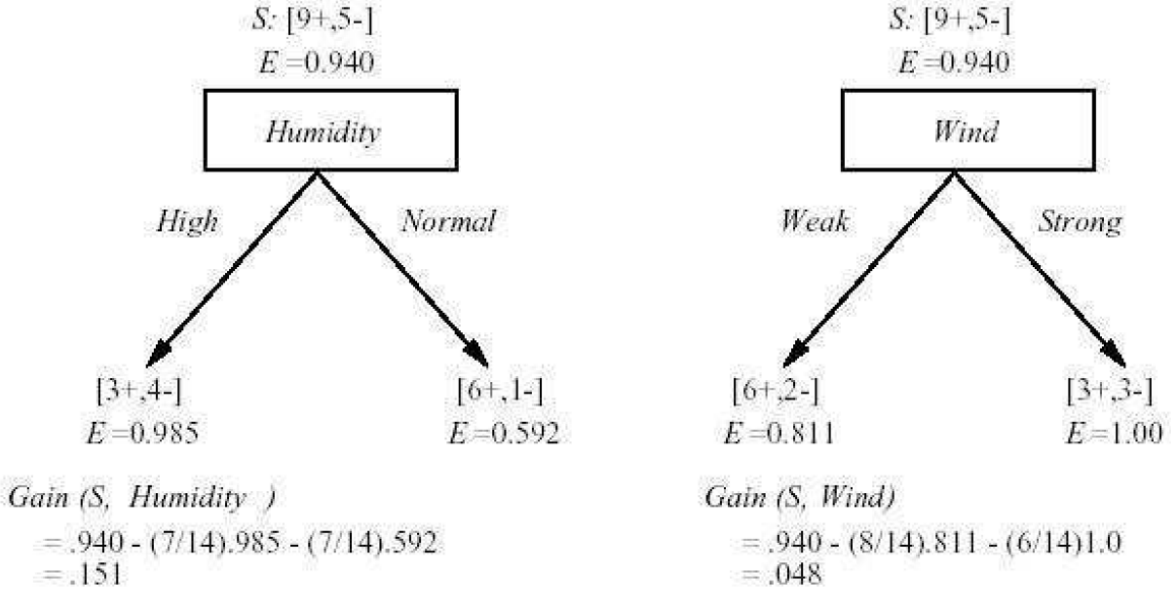
- In order to determine the attribute that should be tested first in the tree, the information gain for attributes (*Outlook* , *Temperature* ,*Humidity* and *Wind*) are determined.
  - Gain(S,Outlook) = 0.246
  - Gain(S,Humidity) = 0.151
  - Gain(S,Wind) = 0.048
  - Gain(S,Temperature) = 0.029
- Since *Outlook* attribute provides the best prediction, it is selected as the decision attribute for the root node.

Example: Computation of Information Gain

- The computation of Information Gain for Outlook:

$$GAIN(S,Outlook) = Entropy(S) - EV(Outlook)$$
$$= 0.94 - 0.694 = \mathbf{0.246}$$

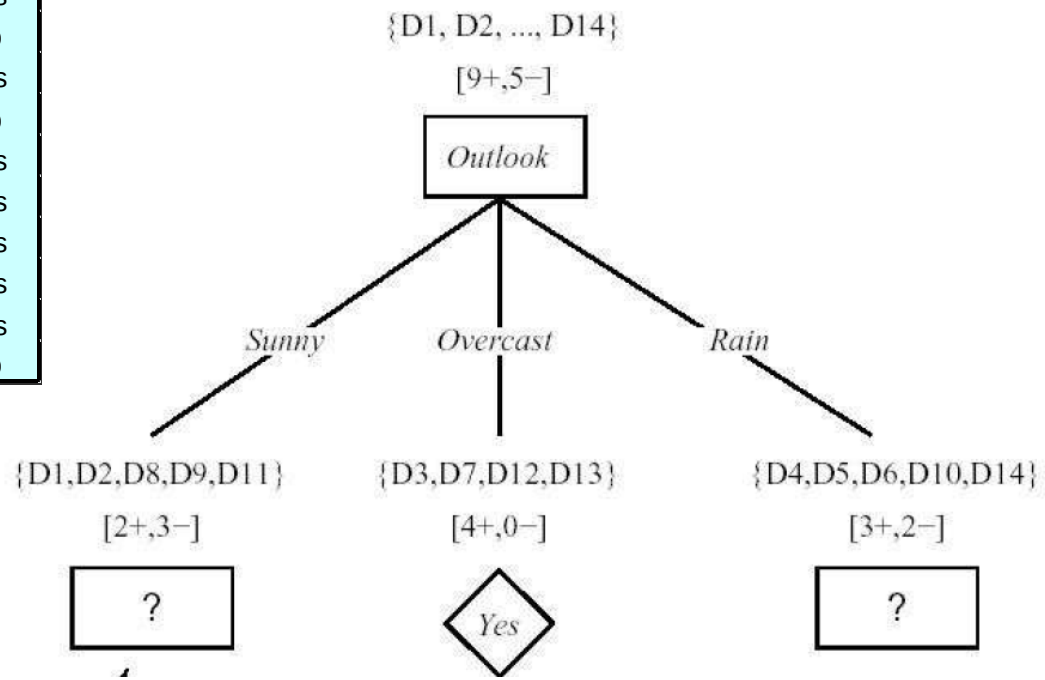
- The computation of information gain for *Humidity* and *Wind:*



Partially Resulting Subtree

Element	Outlook	Temperature	Humidity	Wind	Tennis
1	Sunny	Hot	High	Weak	No
2	Sunny	Hot	High	Strong	No
3	Overcast	Hot	High	Weak	Yes
4	Rain	Mild	High	Weak	Yes
5	Rain	Cold	Normal	Weak	Yes
6	Rain	Cold	Normal	Strong	No
7	Overcast	Cold	Normal	Strong	Yes
8	Sunny	Mild	High	Weak	No
9	Sunny	Cold	Normal	Weak	Yes
10	Rain	Mild	Normal	Weak	Yes
11	Sunny	Mild	Normal	Strong	Yes
12	Overcast	Mild	High	Strong	Yes
13	Overcast	Hot	Normal	Weak	Yes
14	Rain	Mild	High	Strong	No

- The partially learned decision tree resulting from the first step of ID3:



Entropie of a Subtree

The subtree with root Sunny:

Entropy(Sunny) = $- 2/5 \log_2 (2/5) - 3/5 \log_2 (3/5)$

= 0,970

Element	Outlook	Temperature	Humidity	Wind	Tennis
1	Sunny	Hot	High	Weak	No
2	Sunny	Hot	High	Strong	No
3	Overcast	Hot	High	Weak	Yes
4	Rain	Mild	High	Weak	Yes
5	Rain	Cold	Normal	Weak	Yes
6	Rain	Cold	Normal	Strong	No
7	Overcast	Cold	Normal	Strong	Yes
8	Sunny	Mild	High	Weak	No
9	Sunny	Cold	Normal	Weak	Yes
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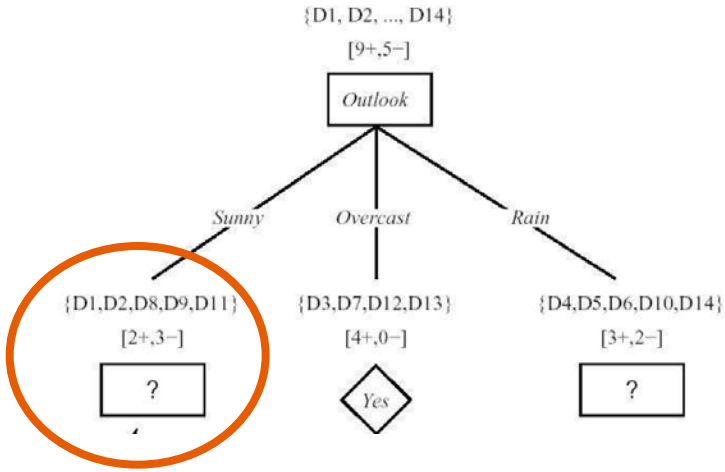
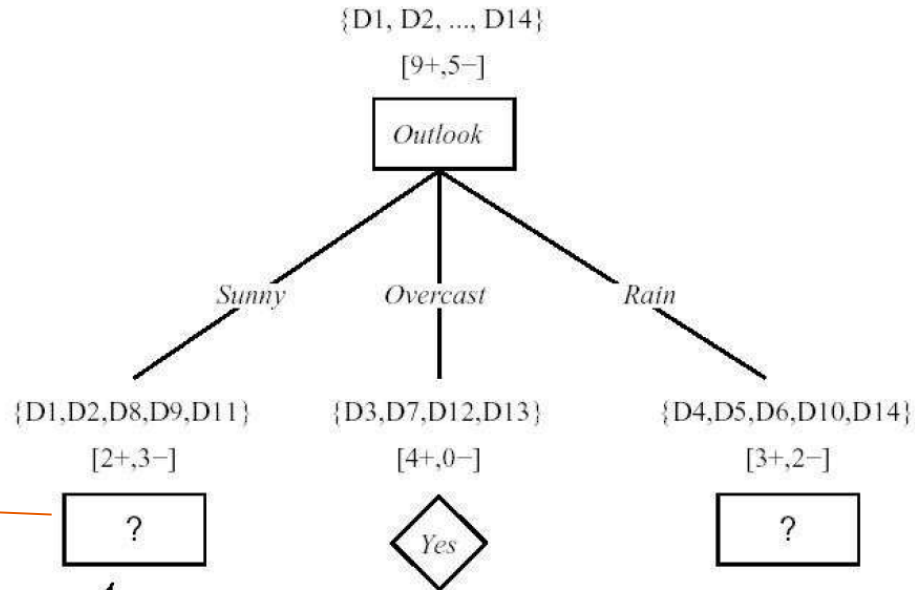


The more **up** in the decision tree, the smaller the entropy of the subtree

Which attribute should be tested here?



$S_{sunny} = \{D1, D2, D8, D9, D11\}$

$Gain\ (S_{sunny}, Humidity) = .970 - (3/5)\ 0.0 - (2/5)\ 0.0 = .970$

$Gain\ (S_{sunny}, Temperature) = .970 - (2/5)\ 0.0 - (2/5)\ 1.0 - (1/5)\ 0.0 = .570$

$Gain\ (S_{sunny}, Wind) = .970 - (2/5)\ 1.0 - (3/5)\ .918 = .019$

The Resulting Decision Tree

The dependent variable „Tennis“ determines if the weather is good for tennis („Yes“) or not („No“).

Element	Outlook	Temperature	Humidity	Wind	Tennis
1	Sunny	Hot	High	Weak	No
2	Sunny	Hot	High	Strong	No
3	Overcast	Hot	High	Weak	Yes
4	Rain	Mild	High	Weak	Yes
5	Rain	Cold	Normal	Weak	Yes
6	Rain	Cold	Normal	Strong	No
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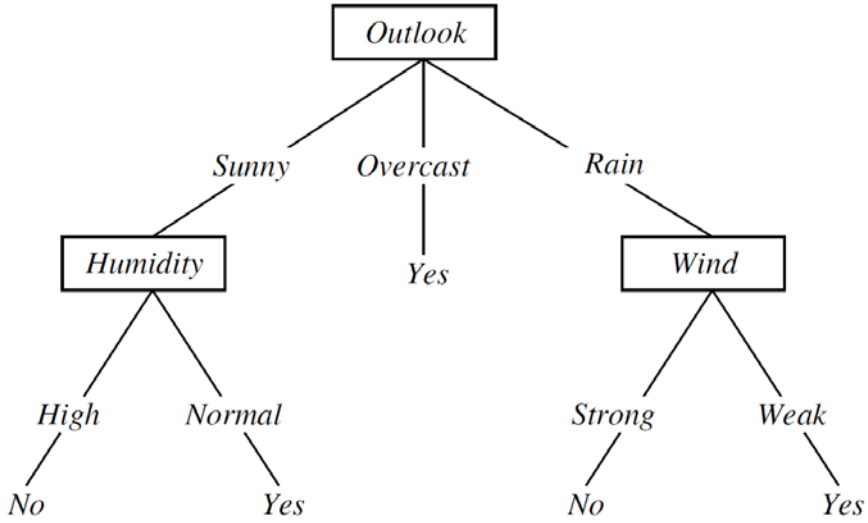

The result of the induction algorithms classifies the data with only three of the four attributes into the classes „Yes“ and „No“.