COMP5318/COMP4318 Machine Learning and Data Mining

Week 5 Tutorial exercises
Decision Trees

<u>Exercise 1.</u> Decision trees and information gain (parts a) and b) – done in class; the rest in your own time)

Consider the following set of training examples:

shape	**color**	**class**
circle	blue	+
circle	blue	+
square	blue	-
triangle	blue	-
square	red	+
square	blue	-
square	red	+
circle	red	+

Adapted from M. Kubat, Introduction to Machine Learning, Springer, 2021

a) What is the entropy of this collection of training examples with respect to the class?
b) What is the information gain of the attribute *shape*?
c) Which attribute will be selected as root of the tree based on information gain?
d) Build the whole decision tree. Draw the tree after each selected attribute.

You may use this table to calculate information gain:

x	y	-(x/y)* $\log_2$(x/y)	x	y	-(x/y)* $\log_2$(x/y	x	y	-(x/y)* $\log_2$(x/y	x	y	-(x/y)* $\log_2$(x/y
1	2	0.50	4	5	0.26	6	7	0.19	5	9	0.47
1	3	0.53	1	6	0.43	1	8	0.38	7	9	0.28
2	3	0.39	5	6	0.22	3	8	0.53	8	9	0.15
1	4	0.50	1	7	0.40	5	8	0.42	1	10	0.33
3	4	0.31	2	7	0.52	7	8	0.17	3	10	0.52
1	5	0.46	3	7	0.52	1	9	0.35	7	10	0.36
2	5	0.53	4	7	0.46	2	9	0.48	9	10	0.14
3	5	0.44	5	7	0.35	4	9	0.52			

Solution:

a) H(S)=I(5/8, 3/8) = -5/8 log(5/8)-3/8 log(3/8) = 0.42 + 0.53 = 0.95 bits

b) Split on *shape*:
$H(S_{circle})$=I(3/3, 0/3) = -3/3 log(3/3)-0/3 log(0/3) = 0 + 0 = 0 bits
$H(S_{square})$=I(2/4, 2/4) = -2/4 log(2/4)-2/4 log(2/4) = 0.5 + 0.5 = 1 bit
$H(S_{triangle})$=I(1/1, 0/1) = -1/1 log(1/1)-0/1 log(0/1) = 0 + 0 = 0 bits

H(S|shape)=3/8*0 + 4/8*1 + 1/8*0 = 0.5 bits
gain(shape)=0.95 - 0.5 = 0.45 bits

c) To answer this question we need to calculate the information gain of all attributes. The attribute with the highest information gain will be selected.

There are 2 attributes – *shape* and *colo*r. We already calculate the information gain for shape. Let's do this for *color*.

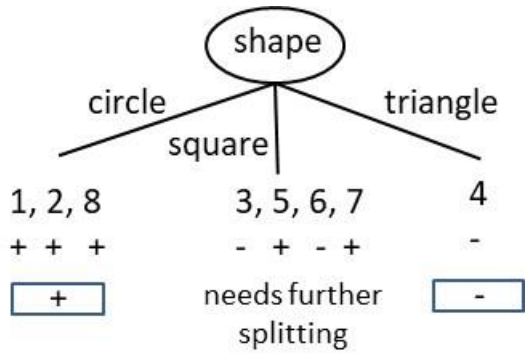
Split on *color*:
$H(S_{blue}) = I(2/5, 3/5) = -2/5 \log(2/5)-3/5 \log(3/5) = 0.53 + 0.44 = 0.97$ bits
$H(S_{red}) = I(3/3, 0/3) = -3/3 \log(3/3)-0/3 \log(0/3)= 0 + 0 = 1$ bit

H(S|color) = 5/8*0.97 + 3/8*0 = 0.61 bits
gain(color)=0.95 - 0.61 = 0.34 bits

gain(shape) > gain(color) = > shape will be selected as the root of the DT (the first attribute to split on)

d) Building the decision tree:

After selecting *shape*:



We need to repeat the procedure for the examples in the middle branch. The final decision tree is: