ML 2016/17
Exercise 6:
Bayesian Networks

05/12/16

General information

- The assignments are not graded on a scale: it’s simply pass/no pass
    - If one homework is not sufficient you can simply redo it
- All assignments must be delivered one month before **you** take the exam
- Submission through email: send to fabiom.carlucci@dis.uniroma1.it
- Questions can be written to same email address.
- Office hours to meet in person: **Wednesday** at B004 (Via Ariosto, the door in front of library), 10AM-12PM.
- *There is no need to replicate exactly the images I show!*

HW6: BN

For a change, no ***sklearn*** today!

http://www.aispace.org/bayes/version5.1.9/bayes.jar

To launch, double click (on Windows) or type in console:

```
java -jar bayes.jar
```

Once you complete the experience, send the report to fabiom.carlucci@dis.uniroma1.it with subject: **“[ML1617] BN report”**

Bayesian Networks in practice

- We will deal only with Bayesian Networks
- They help with
  - Factorization of the probability distribution
  - Visualization of Conditional independence properties
  - inference algorithms (ex: Markov Chain Montecarlo)

Conditional independence allows us to deal with models which would otherwise be intractable

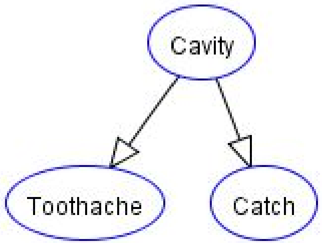
From “AI: A Modern Approach”

A Bayesian network is a directed graph in which each node is annotated with quantitative probability information. The full specification is as follows:

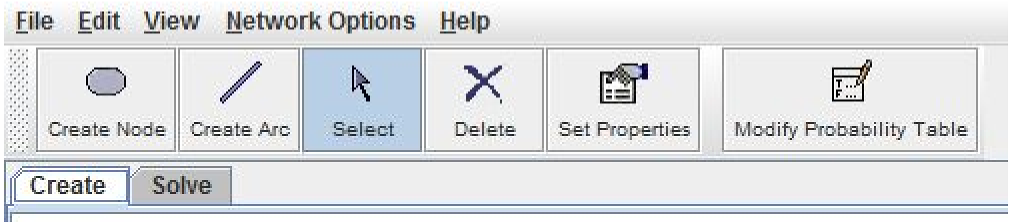
1. Each node corresponds to a random variable, which may be discrete or continuous.
2. A set of directed links or arrows connects pairs of nodes. If there is an arrow from node X to node Y , X is said to be a parent of Y. The graph has no directed cycles (and hence is a directed acyclic graph, or DAG.
3. Each node Xi has a conditional probability distribution P(Xi | Parents(Xi))that quantifies the effect of the parents on the node

BN in practice

- Intuitively causes are parents of effects - X has direct influence on Y
- Catch given Cavity is conditionally independent from Toothache
- $P(toothache, cavity, catch) = P(cavity)P(toothach|cavity)P(catch|cavity)$



The tool - part 1



The tool's website: http://www.aispace.org/bayes/

It allows you to

- Create nodes
- Create arcs
- Set properties
- Set Probability tables
- *(continues...)*

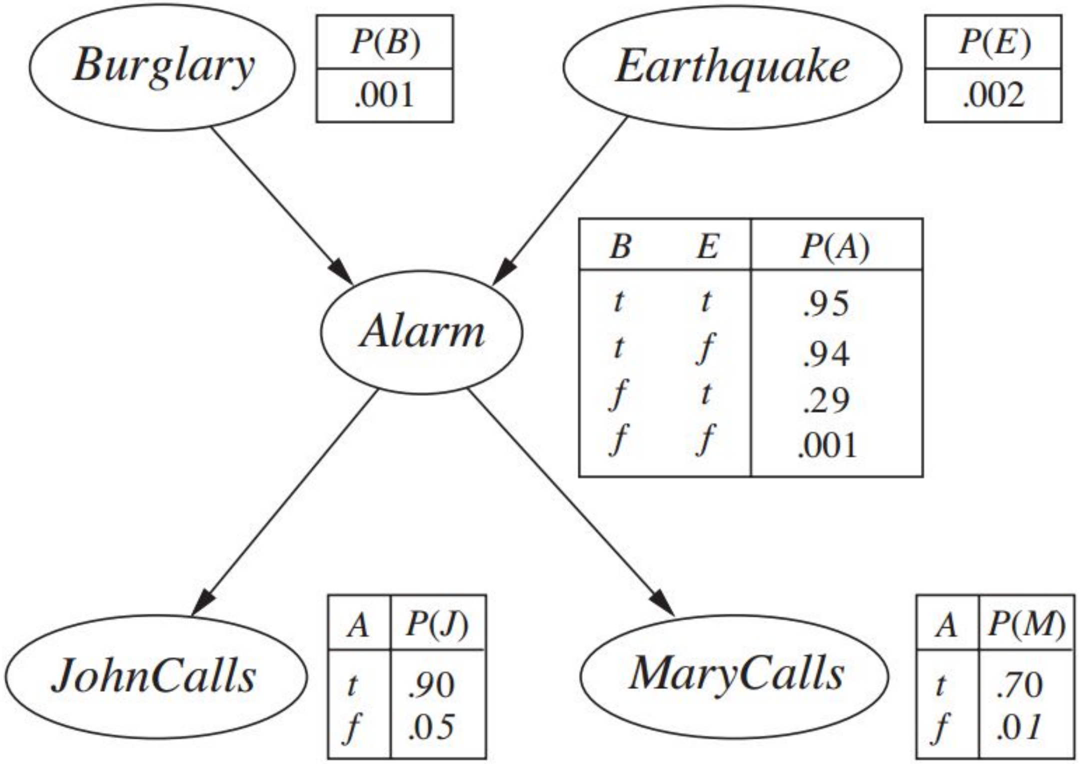
The tool - part 2

- Make observations
- View probabilities
- Quiz yourself
- And other

Burglars and earthquakes example

- There is a probability of 0.001 that there will be a burglary
- There is a probability of 0.002 that there will be an earthquake
- There is an alarm, that will activate with probability
  - 0.95 if there is a burglary *and* an earthquake
  - 0.94 if there is only a burglary
  - 0.29 if there is only an earthquake
  - 0.001 if no earthquake and no burglary
- John will call you with probability 0.9 if the alarm is sounding. There is a 0.05 chance that he will call if even if no alarm has sounded (he imagines things...)
- Mary is a little deaf and will call you with probability 0.7 if the alarms sounds. If the alarms doesn’t sounds there is still a small chance that she will call you by mistake (probability 0.01)

Burglars and earthquakes example



P(B)
.001

P(E)
.002

B	E	P(A)
t	t	.95
t	f	.94
f	t	.29
f	f	.001

A	P(J)
t	.90
f	.05

A	P(M)
t	.70
f	.01

Burglars and earthquakes Joint Probability

By the chain rule:

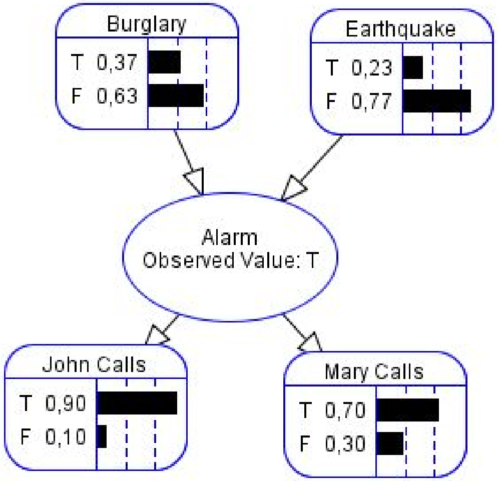
$$P(b, e, a, j, m) = P(m|b, e, a, j)P(b|e, a, j)P(e|a, j)P(a|j)P(j)$$

exploiting the conditional independence defined in the BN:

$$P(b, e, a, j, m) = P(b)P(e)P(a|b, e)P(j|a)P(m|a)$$

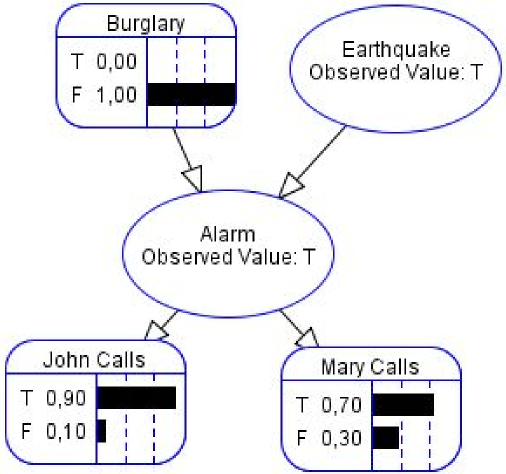
We can make observations

What if we hear the alarm?



What if we also hear an earthquake?

The probability of Burglary changes, but John Calls doesn't, why?



Assignment 1

1. Draw the Bayesian network corresponding to the following:
    a. There is a 0.5 probability that it is cloudy
    b. If it’s cloudy, P(Rain) = 0.8 (The probability that it rains is 0.8)
    c. If it’s not cloudy, then P(Rain) = 0.1
    d. If it’s cloudy, the probability that the sprinklers starts (P(Sprinklers)) is only 0.4
    e. If it’s not cloudy, then P(Sprinklers) = 0.9
    f. If it rains and the sprinklers are activated, then P(WetGrass) = 0.99
    g. If it rains, but the sprinklers are off, then P(WetGrass) = 0.9
    h. If it doens’t rain, but the sprinklers work, then P(WetGrass) = 0.9
    i. If it neither rains, nor the sprinkler works, then P(WetGrass) = 0
2. Write the joint probability function for this graph
3. If WetGrass=True and Cloudy=False, what is the probability it rained? The probability the sprinklers were on?

Assignment 2

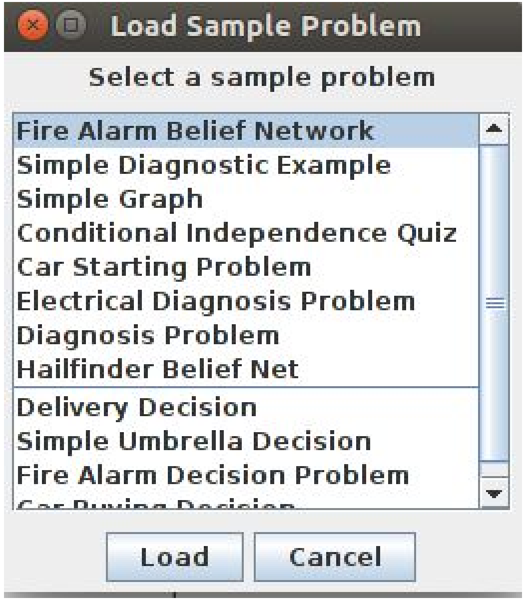
1. Draw the Bayesian network corresponding to the following:

We have a bag of three biased coins a, b, and c with probabilities of coming up heads of 20%, 60%, and 80%, respectively. One coin is drawn randomly from the bag (with equal likelihood of drawing each of the three coins), and then the coin is flipped three times to generate the outcomes X1, X2, and X3.

2. Calculate which coin was most likely to have been drawn from the bag if the observed flips come out heads twice and tails once [note: you should use the tool]

Assignment 3

1. Load the sample problem "Fire Alarm Belief Network"
2. Write down the joint probability
3. Change the network by adding a node representing the probability that someone will call their mother if the alarm goes off



Your turn now! Questions?