BAYESIAN NETWORKS

CSE 511A: Introduction to Artificial Intelligence

Medical Diagnosis:
What is the disease based on the observed symptoms?

MEDICAL DIAGNOSIS

- Disease: *COVID-19*
- Symptoms: *Fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhea*

- Disease: *Flu*
- Symptoms: *Fever or feeling feverish/chills, cough, sore throat, runny or stuffy nose, muscle or body aches, headaches, fatigue, some people may have vomiting and diarrhea, though this is more common in children than adults.*

- Assume that you have a very bad fever and that you are coughing and tired all the time. Which is the more likely prognosis?

JOINT PROBABILITY TABLE

S1	S2	S3	S4	S5	S6	D1	D2	D3	
T	T	T	T	T	T	T	T	T	0.05
T	T	T	T	T	T	T	T	F	0.03
T	T	T	T	T	T	T	F	T	0.06
...	...	...	...	...	...	...	...	...	...

Say you have S1, S2 and S4, but not S3, S5 and S6
$P(D1 \mid S1, S2, S4, \neg S3, \neg S5, \neg S6) = ?$
$P(D2 \mid S1, S2, S4, \neg S3, \neg S5, \neg S6) = ?$
$P(D3 \mid S1, S2, S4, \neg S3, \neg S5, \neg S6) = ?$

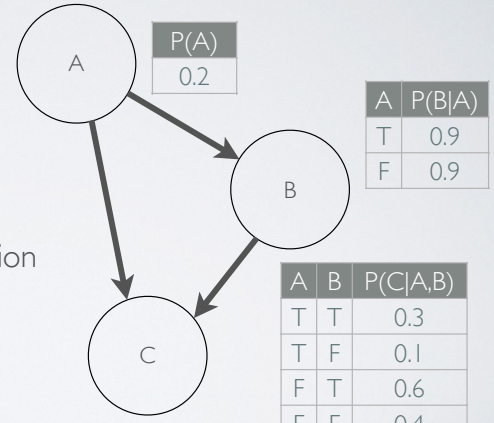
JOINT PROBABILITY TABLE

S1	S2	S3	S4	S5	S6	D1	D2	D3	
T	T	T	T	T	T	T	T	T	0.05
T	T	T	T	T	T	T	T	F	0.03
T	T	T	T	T	T	T	F	T	0.06
...	...	...	...	...	...	...	...	...	...

Hard to acquire probabilities
Takes up a lot of space

BAYES NET

- Bayesian networks
  - aka Bayes net, belief nets
  - DAG with CPTs
  - Exploits independence inherent in the problem
  - More compact representation
  - More intuitive probabilities
- Nodes = random variables
- Edges = direct influences



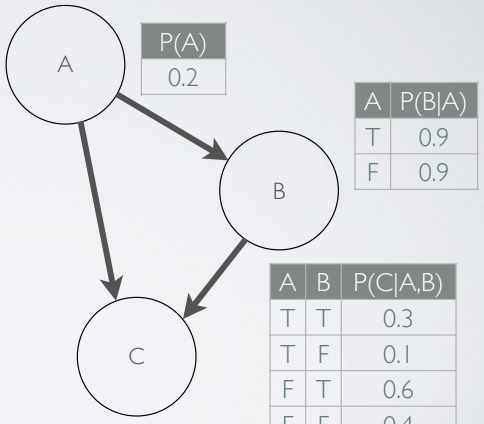
P(A)
0.2

A	P(B|A)
T	0.9
F	0.9

A	B	P(C|A,B)
T	T	0.3
T	F	0.1
F	T	0.6
F	F	0.4

BAYES NET

A	B	C	Prob
T	T	T	0.054
T	T	F	0.126
T	F	T	0.002
T	F	F	0.018
F	T	T	0.432
F	T	F	0.288
F	F	T	0.032
F	F	F	0.048



P(A)
0.2

A	P(B|A)
T	0.9
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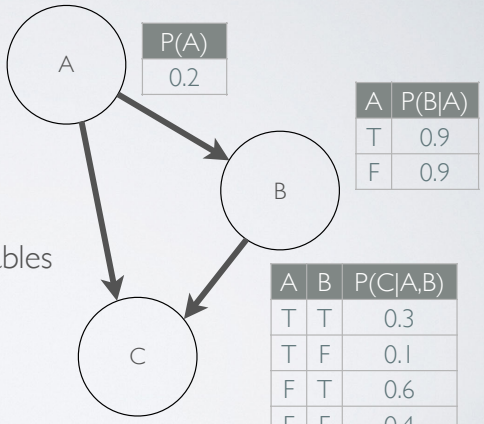
A	B	P(C|A,B)
T	T	0.3
T	F	0.1
F	T	0.6
F	F	0.4

BAYES NET

- How to construct a Bayes net?
  - Pick a variable
  - Condition it upon the smallest possible set of variables previously picked
  - Repeat until all variables are picked



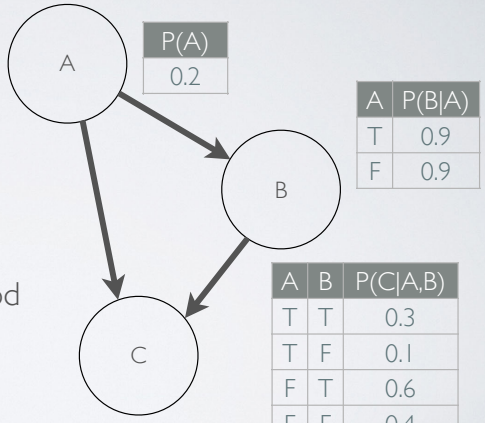
P(A)
0.2

A	P(B|A)
T	0.9
F	0.9

A	B	P(C|A,B)
T	T	0.3
T	F	0.1
F	T	0.6
F	F	0.4

BAYES NET

- Important:
  - Bayes net ONLY represent joint probability distribution
  - It DOES NOT imply causality
- Any variable ordering is good



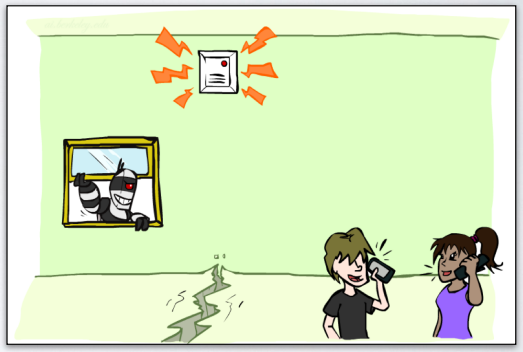
P(A)
0.2

A	P(B|A)
T	0.9
F	0.9

A	B	P(C|A,B)
T	T	0.3
T	F	0.1
F	T	0.6
F	F	0.4

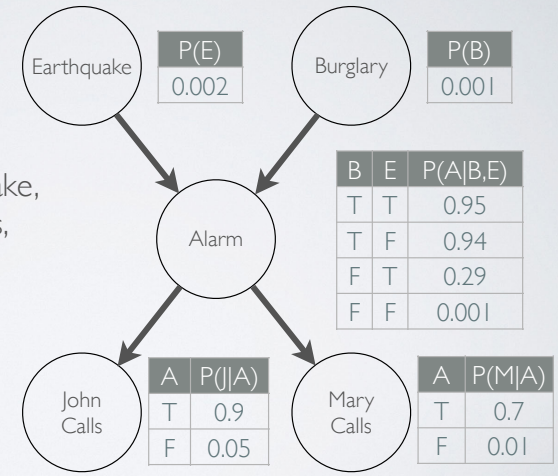
BAYES NET

- Exercise: Build a Bayes net with the following variables:
  - Burglary
  - Alarm goes off
  - Mary calls
  - John calls
  - Earthquake



BAYES NET

- Is variable ordering important?
- Say you picked earthquake, burglary, alarm, John calls, Mary calls
- Size of CPT: 10 rows



P(E)
0.002

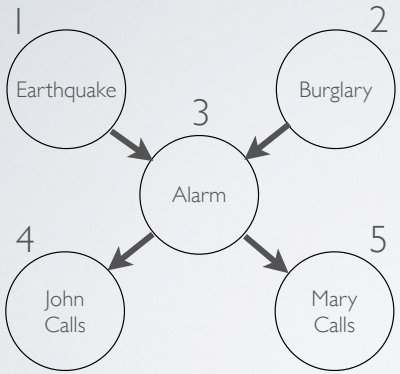
P(B)
0.001

B	E	P(A|B,E)
T	T	0.95
T	F	0.94
F	T	0.29
F	F	0.001

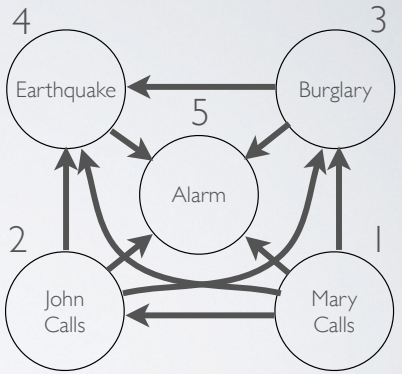
A	P(J|A)
T	0.9
F	0.05

A	P(M|A)
T	0.7
F	0.01

BAYES NET



Size of CPT: *10 rows*



Size of CPT: *31 rows*

Rule of thumb: *Choose causes before effects*