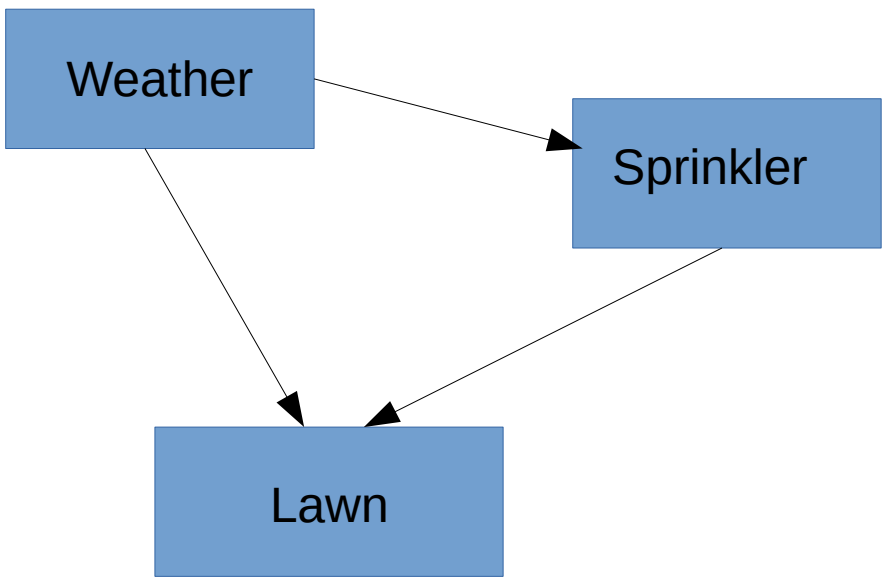
Probabilistic Knowledge Representation and Reasoning

based on Gilad Barkan's slides, slideshare

Belief Networks



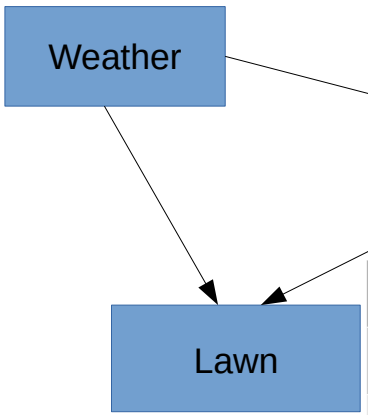
Belief Networks

- Probabilistic Graphical Model (PGM)
- Graphical (Directed Acyclic Graph) Model
- Nodes are variables (features):
  - random variable with a probability distribution
  - set of parameters/values/states. For example:
    - Weather = {sunny, cloudy, rainy}; Sprinkler={off,on}; Lawn={dry,wet}
    - Possible scenario: {Weather=rainy, Sprinkler=off, Lawn = wet}
- Edges (links) represent relations between variables
- Edges **may** indicate causality (for example, “rainy weather” ou “sprinkler” may cause “wet lawn”).

Belief Networks

- Conditional Probability Table: used to store all beliefs related with the possible states of a node (variable)

Belief Networks



Weather	
Sunny	10%
Cloudy	30%
Rainy	60%

Sprinkler		
Weather	On	Off
Sunny	20%	80%
Cloudy	10%	90%
Rainy	0%	100%

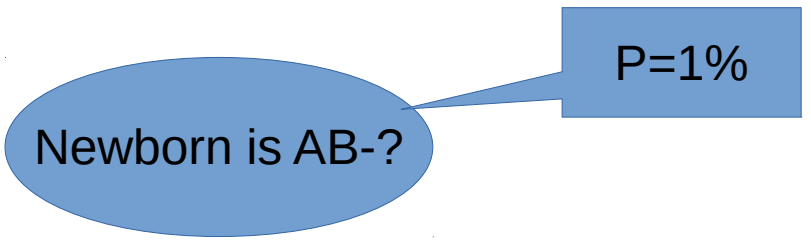
Lawn			
Weather	Sprinkler	Wet	Dry
Sunny	On	20%	80%
Cloudy	On	40%	60%
Rainy	On	100%	0%
Sunny	Off	0%	100%
Cloudy	Off	10%	90%
Rainy	Off	100%	0%

Conditional Probability:
P(L=wet|W=sunny,S=on)

Bayesian Inference

- Once we have a model consisting of a **graph** and **TPCs**, we can answer queries like:
  - Given that it rained, would the lawn be wet? (trivial)
  - Given that the lawn is wet, what could be the reason?
    - "rainy weather"?
    - "sprinkler on"?

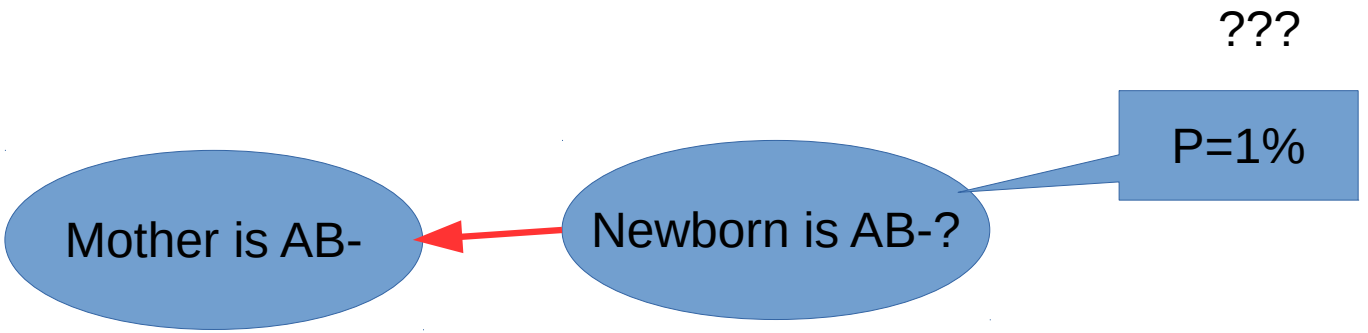
Bayes theorem in action!



Hipótese=
O que queremos saber

Prior belief

Bayes theorem in action!



Evidência!

Hipótese=
O que queremos saber

Prior belief

Sabendo a evidência, P pode deixar de ter valor 0.01
Nova probabilidade para P: a posteriori update belief

Bayesian Inference

- From our example, what can we answer using the Bayes theorem?
- Possible metric (Bayesian decision rule): Maximum a Posteriori Probability (MAP)
  - P(Weather=rainy|Lawn=wet) = 0.93; P(Sprinkler=on|Lawn=wet)=0.016
- In this case, the lawn is wet because it rained!

Bayesian Inference

Is the lawn wet because it rained?

$$P(Weather = rainy \mid Lawn = Wet) =$$

$$= \frac{P(Weather = rainy \wedge Lawn = Wet)}{P(Lawn = Wet)} =$$

$$= \frac{P(Weather = rainy \wedge Lawn = Wet \wedge Sprinkler)}{P(Lawn = Wet \wedge Weather \wedge Sprinkler)}$$