CSCI 5582
Artificial Intelligence

Lecture 12

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Today 10/12

- Review
- Basic probability
- Break
- Belief Networks

Review

- Where we are…
  - Agents can use search to find useful actions based on looking into the future
  - Agents can use logic to complement search to represent and reason about
    - Unseen parts of the current environment
    - Past environments
    - Future environments
  - And they can play a mean game of chess

Where we aren't

- Agents can't
  - Deal well with uncertain situations (not clear people are all that great at this)
  - Learn
  - See, speak, hear, move, or feel

Exercise

- You go to the doctor and for insurance reasons they perform a test for a horrible disease
- You test positive
- The doctor says the test is 99% accurate
- Do you worry?

An Exercise

- It depends; let's say…
  - The disease occurs 1 in 10000 folks
  - And that the 99% means that 99 times out a 100 when you give the test to someone without the disease it will return negative
  - And that when you have the disease it always says you are positive
  - Do you worry?

An Exercise

- The test's false positive rate is 1/100
- Only 1/10000 people have the disease
- If you gave the test to 10000 random people you would have
  - 100 false positives
  - 1 true positive
- Do you worry?

An Exercise

- Do you worry?
  - Yes, I always worry
  - Yes, my chances of having the disease are 100x they were before I went to the doctor
    - Went from 1/10000 to 1/100 (approx)
  - No, I live with a lot of other 1/100 bad things without worrying

Another Example

- You hear on the news…
  - People who attend grad school to get a masters degree have a 10x increased chance of contracting schistosomiasis
- Do you worry?
  - Depends on where you go to grad school

Back to Basics

- Prior (or unconditional) probability
  - Written as P(A)
  - For now think of A as a proposition that can turn out to be True or False
  - P(A) is your belief that A is true given that you know nothing else relevant to A

Also

- Just as with logic we can create complex sentences with a partially compositional semantics (sort of)...

$$P(A \wedge B), P(A \vee B), P(\neg A \vee B)...$$

Basics

- Conditional (or posterior) probabilities
- Written as P(A|B)
- Pronounced as the probability of A given B
- Think of it as your belief in A given that you know absolutely that B is true.

And

- P(A|B)… your belief in A given that you know B is true
- AND B is all you know that is relevant to A

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Conditionals Defined

- Conditionals $$P(A \mid B) = \frac{P(A \wedge B)}{P(B)}$$
- Rearranging $$P(A \wedge B) = P(A \mid B)P(B)$$
- And also $$P(A \wedge B) = P(B \mid A)P(A)$$

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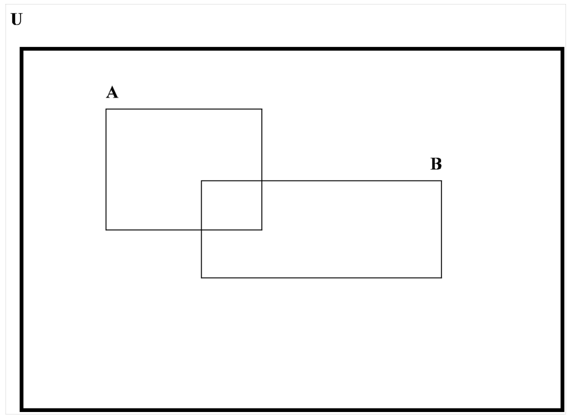
Conditionals Defined



Inference

- Inference means updating your beliefs as evidence comes in
  - P(A)… belief in A given that you know nothing else of relevance
  - P(A|B)… belief in A once you know B and nothing else relevant
  - P(A|B^C) belief in A once you know B and C and nothing else relevant

Also

- What you'd expect… we can have P(A|B^C) or P(A^D|E) or P(A^B|C^D) etc…

Joint Semantics

- Joint probability distribution… the equivalent of truth tables in logic
- Given a complete truth table you can answer any question you want
- Given the joint probability distribution over N variables you can answer any question you might want to that involve those variables

Joint Semantics

- With logic you don't always need the whole truth table; you can use inference methods and compositional semantics
  - I.e if I know the truth values for A and B, I can retrieve the value of A^B
- With probability, you need the joint to do inference unless you're willing to make some assumptions

Joint

	Toothache=True	Toothache=False
Cavity = True	0.04	0.06
Cavity = False	0.01	0.89

- What's the probability of having a cavity and a toothache?
- What's the probability of having a toothache?
- What's the probability of not having a cavity?
- What's the probability of having a toothache or a cavity?

Note

- Adding up across a row is really a form of reasoning by cases…
- Consider calculating P(Cavity)…
  - We know that in this world you either have a toothache or you don't. I.e toothaches partition the world.
  - So…

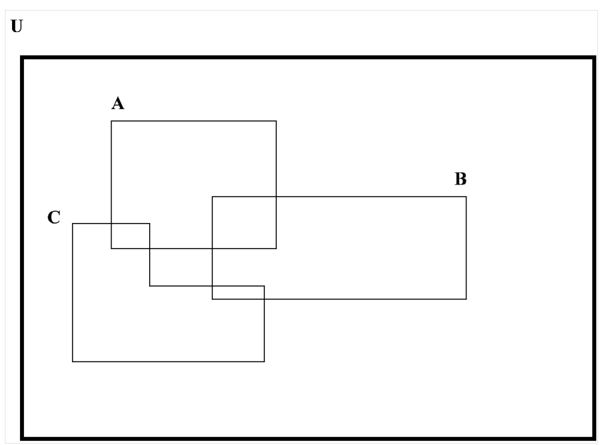
Partitioning

$$P(Cavity) = P(Cavity \wedge Toothache) + P(Cavity \wedge \neg Toothache)$$

Combining Evidence

- Suppose you know the values for
  - P(A|B)=0.2
  - P(A|C)=0.05
  - Then you learn B is true
    - What's your belief in A?
  - Then you learn C is true
    - What's your belief in A?

Combining Evidence



Details…

- Where do all the numbers come from?
  - Mostly counting
  - Sometimes theory
  - Sometimes guessing
  - Sometimes all of the above

Numbers

- P(A) $$\frac{Count(All\ As)}{Count(All\ Events)}$$
- P(A^B) $$\frac{Count(All\ A\ and\ B\ together)}{Count(AllEvents)}$$
- P(A|B) $$\frac{Count(All\ A\ and\ B\ Together)}{Count(All\ Bs)}$$

Break

- HW Questions?

Bayes

- We know…

$$P(A \wedge B) = P(A \mid B)P(B)$$

and

$$P(A \wedge B) = P(B \mid A)P(A)$$

- So rearranging things

$$P(A \mid B)P(B) = P(B \mid A)P(A)$$

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

Bayes

- Memorize this

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

Bayesian Diagnosis

- Given a set of symptoms choose the best disease (the disease most likely to give rise to those symptoms)
  - I.e. Choose the disease the gives the highest P(Disease|Symptoms) for all possible diseases
- But you probably can't assess that…
- So maximize this…

$$P(Disease \mid Symptoms) = \frac{P(Symptoms \mid Disease)P(Disease)}{P(Symptoms)}$$

Meningitis

$$P(S \mid M) = 0.5$$
$$P(M) = 0.00002$$
$$P(S) = 0.05$$
$$so....$$
$$P(M \mid S) = \frac{P(S \mid M)P(M)}{P(S)}$$
$$= \frac{0.5 * 0.00002}{0.05}$$
$$= 0.0002$$

Differential Diagnosis

- Why on earth would anyone know P(S)?
- And do you need to know it?
  - Asking for the most probable disease given some symptoms doesn't entail knowing the probability of the diseases.

    Argmax $_D$ P(D|S) = P(S|D) P(D)/P(S) is the same as

    Argmax $_D$ P(D|S) = P(S|D) P(D)

Well

- What if you needed the exact probability

$$P(S) = P(S \wedge M) + P(S \wedge \neg M)$$
$$= P(S \mid M)P(M) + P(S \mid \neg M)P(\neg M)$$

Next Time

- Graphical models or Belief Nets
  - Chapter 14
- Quiz is postponed 1 Week
  - Now on 10/26
  - Covers 7, 8, 9, 13 and 14