Data Reliability

Interpreting Sensor Data

Review of Important Theorems

- Total Probability Theorem:

  $P(A) = P(A|C_1)\ P(C_1) + \ldots + P(A|C_n)\ P(C_n)$

  where $C_1, \ldots, C_n$ cover the space of all possibilities

- Bayes Theorem:

  $P(A|B) = P(B|A).\ P(A)/P(B)$

- Other: $P(A,B) = P(A|B)\ P(B)$

Intrusion Detection, Again

- A motion alarm is used to detect unauthorized access to a warehouse after hours. The motion sensor is mounted near the only entrance to the warehouse. If a burglar enters the building, there is a 99% chance that the burglar triggers the motion alarm.
- At 9pm, on September 16th, 2013, the alarm was set off. What are the odds that a burglar is in the building?

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- Assume the alarm goes off about 3 days a year and burglaries happen about once a year

Intrusion Detection, Again

A Second Sensor

- In the intrusion detection example, assume that there is a vibration sensor on the floor that detects footsteps. If a burglar enters the building, there is a 90% chance that the vibration sensor will fire. If the vibration sensor fires, what are the odds that there is a burglar? Assume that the vibration sensor fires 10 times a year

A Second Sensor

Two Sensor Example

- In the intrusion detection example, what are the odds of burglary if both sensors fire?
- P (Burg|A, Vib) = ?

Remember: If burglar enters, motion alarm fires 99% of the time and vibration alarm fires 90% of the time. Burglaries occur once a year, motion alarm fires 3 times a year, and vibration alarm fires 10 times a year.

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Now what?

Is it OK to say P(A,V|B) = P(A|B)P(V|B)?

Is it OK to say P(A,V) = P(A)P(V)?

Independence versus Conditional Independence

- John and Sally follow Mike on Twitter.
- When Mike tweets something, John re-tweets it with a 50% probability. Sally re-tweets it with a 30% probability.
- Are John's and Sally's tweets independent?

Independence versus Conditional Independence

- John and Sally follow Mike on Twitter.
- When Mike tweets something, John re-tweets it with a 50% probability. Sally re-tweets it with a 30% probability.
- Are John's and Sally's tweets independent?
  - No. However, given that Mike says something, their decisions to re-tweet it are independent (conditional independence)

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OK to say $P(A,V|B) = P(A|B)P(V|B)$

~~$P(A,V) = P(A)P(V)$?~~

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- $P(B|A,V) = P(A,V|B)\,P(B)/P(A,V)$ where

$P(A,V) = P(A,V|B)\,P(B) + P(A,V|\bar{B})\,P(\bar{B})$

and $P(A,V|B) = P(A|B)P(V|B)$

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Two Sensor Example

A Robotic Design Example

- A robot has a camera that detects obstacles with probability 70%, a bump sensor that detects imminent collisions with a probability of 99.9% (when an obstacle is 1 inch away), and a cliff sensor that detects imminent falls off a cliff with a probability of 99.9% (when the cliff is 1 inch away). The robot has breaks that can stop it within 0.1 second. The mission is to deliver supplies from point A to point B, safely.
  - What are safety-critical requirements?
  - What are mission-critical (i.e., performance) requirements?
  - What is a safe state?
  - How to ensure well-formed dependencies?
  - What is a safe speed for the robot?
  - Is the algorithm that computes speed based on preferred arrival time and route safety-critical or mission-critical?

A Robotic Design Example

- Notes: