Genome 540 discussion

January 16th, 2025 Joe Min





Review of probability and Bayes' rule

Randomness and sampling in programming

Quick topic brainstorm

Conditional probability and Bayes' rule

What is probability?



S is the "event space"; A and B are events

P(A) is how often an event in S occurs that is an A event

What is conditional probability?



"|A" means "given A" or "conditioned upon A"; that is, we are limiting the total event space to

Bayes' rule

Bayes' theorem may be derived from the definition of conditional probability:

$$P(A|B)=rac{P(A\cap B)}{P(B)}, ext{ if } P(B)
eq 0,$$

where $P(A \cap B)$ is the probability of both A and B being true. Similarly,

$$P(B|A)=rac{P(A\cap B)}{P(A)}, ext{ if } P(A)
eq 0.$$

Solving for $P(A \cap B)$ and substituting into the above expression for P(A|B) yields Bayes' theorem:

$$P(A|B)=rac{P(B|A)P(A)}{P(B)}, ext{ if } P(B)
eq 0.$$

Conditioning changes probabilities

ESM inherently assigns probabilities for amino acids given the neighboring amino acids



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Randomness and sampling from probability distributions

What is randomness?

Randomness is a true lack of pattern or predictability

Cannot be modeled using deterministic processes (computers are deterministic, as are most things in life)

Sources of randomness

The environment

(E.g., particle collisions in Brownian motion)



Not *truly* random, but appears random because of the huge number of bodies involved

Sources of randomness

Sensitivity to slight variations in initial conditions (e.g., the three body problem)

Still deterministic and can be modeled but it's difficult to do so precisely

Is there anything truly random??

We *think* certain quantum properties are random

- E.g., a light particle traveling as a wave
- Upon detection, the wave function collapses and appears randomly on the reporter (as determined by the probability of the wave function)

Simulating randomness

Our computers are not quantum-ready (yet)

They instead use some state inherent to the system as input to some function

• E.g., the computer's clock value modulo 2 to simulate flipping a coin

Randomly sampling in code

Modern libraries handle randomness for you

```
examples > python >  roll_dice.py
       import random
  1
  2
  3
  4
       results_histogram = {i: 0 for i in range(1, 7)}
       for i in range(1000):
  5
           rand_num = random.choices(range(1, 7), weights=(0.2, 0.1, 0.15, 0.15, 0.25, 0.15))[0]
  6
           results histogram[rand num] += 1
  7
  8
  9
       print(results histogram)
 10
```

86dca6b58045:/source# python roll_dice.py {1: 207, 2: 102, 3: 164, 4: 133, 5: 246, 6: 148} 86dca6b58045:/source#

Quick topic brainstorm

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General programming

- Git/version control
- Object-oriented code

Specialty topics

- Encryption/cryptography
- Parallel programming
- Machine learning

- Data structures
- Search/sort algorithms

- Data transfer protocols
- Dynamic programming
- Recursion



Reminder:

Homework 1 is due this Sunday (Jan 19) at 11:59pm!

Feel free to hang out and work on the homework, ask questions, or leave!