Authorship recognition

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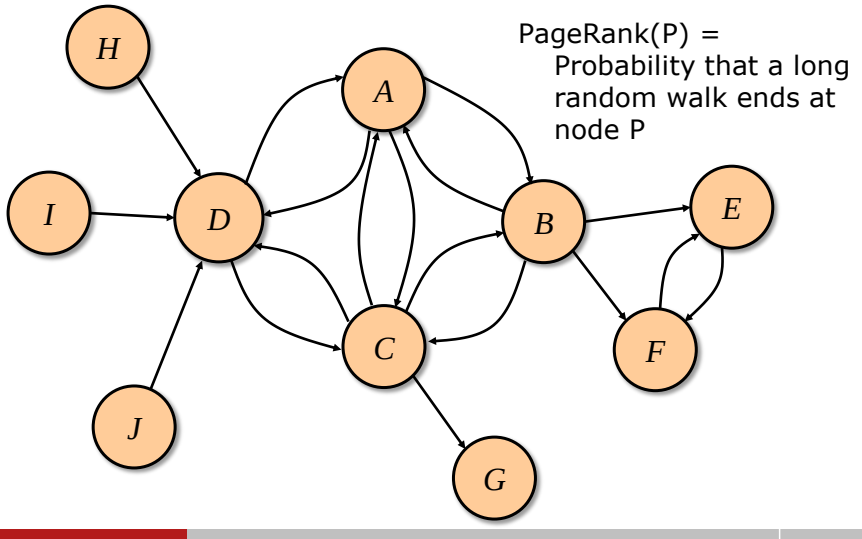
Administrivia

- Assignments:
  - A5P2 due tomorrow
  - Please sign up for a demo slot if you haven't already
  - A6 released tomorrow
- Quiz Tuesday, 4/24
- Final project proposal
  - Should be in; I will give feedback soon

Administrivia

- Final projects
  - Demo session on Tuesday, May 15, 1:30-3:30pm (tentative)

Google's PageRank



PageRank(P) = Probability that a long random walk ends at node P

Back to text

- We can use Markov chains to generate new text
- Can they also help us recognize text?
  - In particular, the author?
  - Who wrote this paragraph?

"Suppose that communal kitchen years to come perhaps. All trotting down with porringers and tommycans to be filled. Devour contents in the street. John Howard Parnell example the provost of Trinity every mother's son don't talk of your provosts and provost of Trinity women and children cabmen priests parsons fieldmarshals archbishops."

Author recognition

- We can use Markov chains to generate new text
- Can they also help us recognize text?
  - How about this one?

„Diess Alles schaute Zarathustra mit grosser Verwunderung; dann prüfte er jeden Einzelnen seiner Gäste mit leutseliger Neugierde, las ihre Seelen ab und wunderte sich von Neuem. Inzwischen hatten sich die Versammelten von ihren Sitzen erhoben und warteten mit Ehrfurcht, dass Zarathustra reden werde."

Author recognition

- Simple problem:

  Given two Markov chains, say *Austen* (*A*) and *Dickens* (*D*), and a string *s* (with *n* words), how do we decide whether *A* or *D* wrote *s*?

- Idea: For both *A* and *D*, compute the probability that a random walk of length *n* generates *s*

Probability of a sequence

- What is the probability of a given *n*-length sequence *s*?

  $s = s_1\ s_2\ s_3\ \ldots\ s_n$

- Probability of generating *s* = the product of transition probabilities:

$$\Pr(S_1 = s_1)\ \Pr(S_2 = s_2|S_1 = s_1)\ \Pr(S_3 = s_3|S_2 = s_2) \ldots \Pr(S_n = s_n|S_{n-1} = s_{n-1})$$

Probability that a sequence starts with s_1

Transition probabilities

Likelihood

- Compute this probability for *A* and *D*

$\Pr(s|A)$

"likelihood" of A

$\Pr(s|D)$

"likelihood" of D

$\Pr(s|A) > \Pr(s|D)$

Jane Austen wrote *s*

$\Pr(s|A) < \Pr(s|D)$

Charles Dickens wrote *s*

$\Pr(s|A) = \Pr(s|D)$

???

Problems with likelihood

1. Most strings of text (of significant length) have probability zero
   - Why?
2. Even if it's not zero, it's probably extremely small
   - What's 0.01 * 0.01 * 0.01 * … (x200) … * 0.01?
   - According to Matlab, zero

- How can we fix these problems?

	a	dog	is	man's	best	friend	it's	eat	world	out	there	.
a		2/3		1/3								
dog			1/3					1/3	1/3			
is	1											
man's					1							
best						1						
friend												1
it's	1											
eat		1										
world										1		
out											1	
there												1
.							1					

Pr("is dog man's best friend") = 0

Bigger example

	it	was	the	best	of	times	worst	…	birthday	…	far	better
it	0.004	0.17	0.005		0.002							0.002
was	0.004		0.06		0.004						0.001	
the				0.003			0.002					0.002
best					0.26							
of	0.017		0.23			0.001						
times	0.04					0.04						
worst					0.47							
…												
birthday					0.5							
…												
far											0.025	0.025
better					0.036							

13253 cols

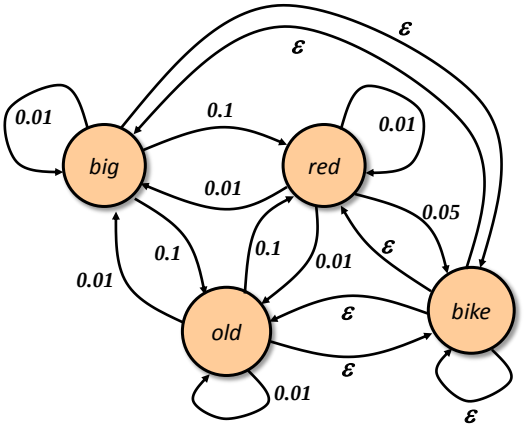
13253 rows

Handling zeroes

- We don't want to give every string with a new word / transition zero probability

- Several possibilities to consider:
  1. Transition from a known word to an new word
  2. Transition from a new word to a new word
  3. Transition from a new word to a known word
  4. Transition from a known word to a known word (unseen transition)

Handling zeroes



Trained Markov chain (in part)

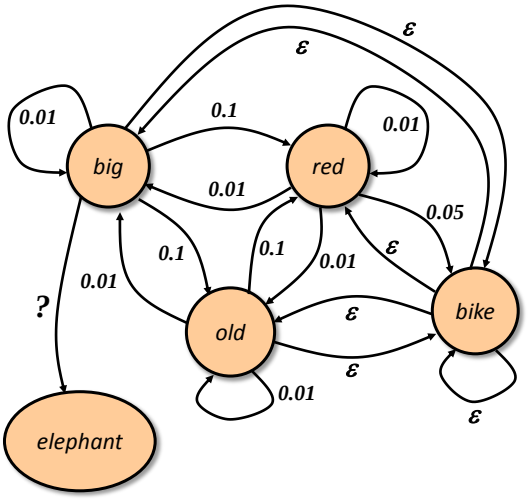
Test text: ***"… big bike …"***

The probability of generating this string with this Markov chain is zero

Idea: we'll add a small probability ε of any unobserved transition

(Reminiscent of PageRank)

Handling zeroes

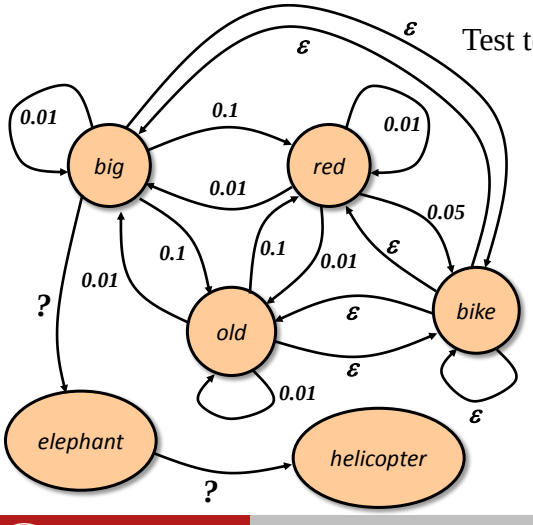


Test text: ***"… big elephant …"***

We didn't see "elephant" in the training text

What should be the probability of a transition from "big" → "elephant"?

Handling zeroes

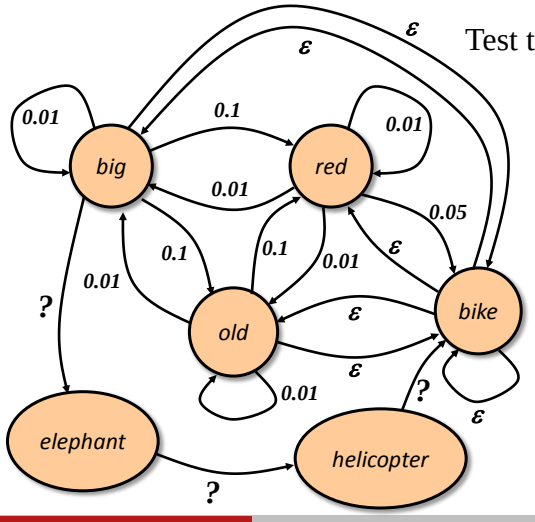


Test text: ***"… elephant helicopter…"***

We didn't see "elephant" or "helicopter" in the training text

What should be the probability of a transition from "elephant" → "helicopter"?

Handling zeroes



Test text: ***"… helicopter bike …"***

We didn't see "helicopter" in the training text

What should be the probability of a transition from "helicopter" → "bike"?

Handling very low probabilities

- There's a smallest (positive) number that Matlab can store (why?)

```
>> realmin
ans =
   2.2251e-308
```

- Pretty small (the size of an electron is 10^{-15} m)
- The probability of generating a given long string can easily be *less* than this (but still > 0)

Handling very low probabilities

0.01 * 0.01 * 0.01 * … (200 times) … * 0.01 = 0

- How can we fix this?
- We'll compute the *log* of the probability instead

log(0.01 * 0.01 * 0.01 * … (200 times) … * 0.01)
= log(0.01) + log(0.01) + … (200 times) … + log(0.01)
= -2 - 2 - … (200 times) - 2
= -400

Handling very low probabilities

log(0.01 * 0.01 * 0.01 * … (x200) … * 0.01)
= log(0.01) + log(0.01) + … (x200) … + log(0.01)
= -2 - 2 - … (x200) - 2
= -400

- I.e., we're compute the *exponent* of the probability (roughly speaking)
- If log(P) > log(Q), then P > Q

Testing authorship

- In A6, you'll train Markov chains for several authors
- Given several new test sequences, you'll guess who wrote which sequence
  - By finding the chain with the highest log-likelihood

- You're free to extend this in any way you can think of (treat periods and other punctuation differently, higher-order Markov models, etc)
- The best performing code (on our tests) will get two points of extra credit

Testing authorship

- This is actually useful in practice
  - There are many texts whose authorship is uncertain
  - Statistical methods are the only hope for figuring out who wrote a given text

Questions?

Quiz

- Suppose we discover a bunch of new novels
- We don't know who wrote each one
- We don't have examples of previous novels by these authors
- We know there are three authors

- How do we tell which of the novels go together?