Noisy Channel Model for Spelling Correction

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Week 2: Lecture 3

Noisy Channel

We see an observation x of the misspelled word

Find the correct word w

$$\hat{w} = \arg\max_{w \in V} P(w|x)$$

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Non-word spelling error: acress

Words with similar spelling

Small edit distance to error

Words with similar pronuncitation

Small edit distance of pronunciation to error

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Damerau-Levenshtein edit distance

Minimum edit distance, where edits are:

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Damerau-Levenshtein edit distance

Minimum edit distance, where edits are:
Insertion, Deletion, Substitution,
Transposition of two adjacent letters

Words within edit distance 1 of acress

Error	Candidate Correction	Correct Letter	Error Letter	Type
acress	actress	t	–	deletion
acress	cress	–	a	insertion
acress	caress	ca	ac	transposition
acress	access	c	r	substitution
acress	across	o	e	substitution
acress	acres	–	s	insertion
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Candidate generation

- 80% of errors are within edit distance 1
- Almost all errors within edit distance 2

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Allow deletion of space or hyphen

- thisidea $\rightarrow$ this idea
- inlaw $\rightarrow$ in-law

Computing error probability: confusion matrix

- del[x,y]: count (xy typed as x)
- ins[x,y]: count (x typed as xy)
- sub[x,y]: count (x typed as y)
- trans[x,y]: count(xy typed as yx)

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Insertion and deletion are conditioned on previous character

Channel model

$$P(x|w) = \begin{cases} \frac{\text{del}[w_{i-1}, w_i]}{\text{count}[w_{i-1} w_i]}, & \text{if deletion} \\ \frac{\text{ins}[w_{i-1}, x_i]}{\text{count}[w_{i-1}]}, & \text{if insertion} \\ \frac{\text{sub}[x_i, w_i]}{\text{count}[w_i]}, & \text{if substitution} \\ \frac{\text{trans}[w_i, w_{i+1}]}{\text{count}[w_i w_{i+1}]}, & \text{if transposition} \end{cases}$$

Channel model for acress

Candidate Correction	Correct Letter	Error Letter	x|w	P(x|word)
actress	t	-	c|ct	.000117
cress	-	a	a|#	.00000144
caress	ca	ac	ac|ca	.00000164
access	c	r	r|c	.000000209
across	o	e	e|o	.0000093
acres	-	s	es|e	.0000321
acres	-	s	ss|s	.0000342

Noisy channel probability for acress

Candidate Correction	Correct Letter	Error Letter	x|w	P(x|word)	P(word)	10^9 * P(x|w)P(w)
actress	t	–	c|ct	.000117	.0000231	2.7
cress	–	a	a|#	.00000144	.000000544	.00078
caress	ca	ac	ac|ca	.00000164	.00000170	.0028
access	c	r	r|c	.000000209	.0000916	.019
across	o	e	e|o	.0000093	.000299	2.8
acres	–	s	es|e	.0000321	.0000318	1.0
acres	–	s	ss|s	.0000342	.0000318	1.0

Using a bigram language model

- “ ... versatile acress whose ...”

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- P("versatile actress whose") = 0.000021 * 0.0010 = 210 x 10^{-10}
- P("versatile across whose") = 0.000021 * 0.000006 = 1 x10^{-10}

Real-word spelling errors

- The study was conducted mainly **be** John Black
- The design **an** construction of the system ...

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- The study was conducted mainly **be** John Black
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25-40% of spelling errors are real words

Noisy channel for real-word spell correction

Given a sentence $X = w_1, w_2, w_3 \ldots, w_n$

- Candidate (w_1) = $\{w_1, w'_1, w''_1, w'''_1, \ldots\}$
- Candidate (w_2) = $\{w_2, w'_2, w''_2, w'''_2, \ldots\}$
- Candidate (w_3) = $\{w_3, w'_3, w''_3, w'''_3, \ldots\}$

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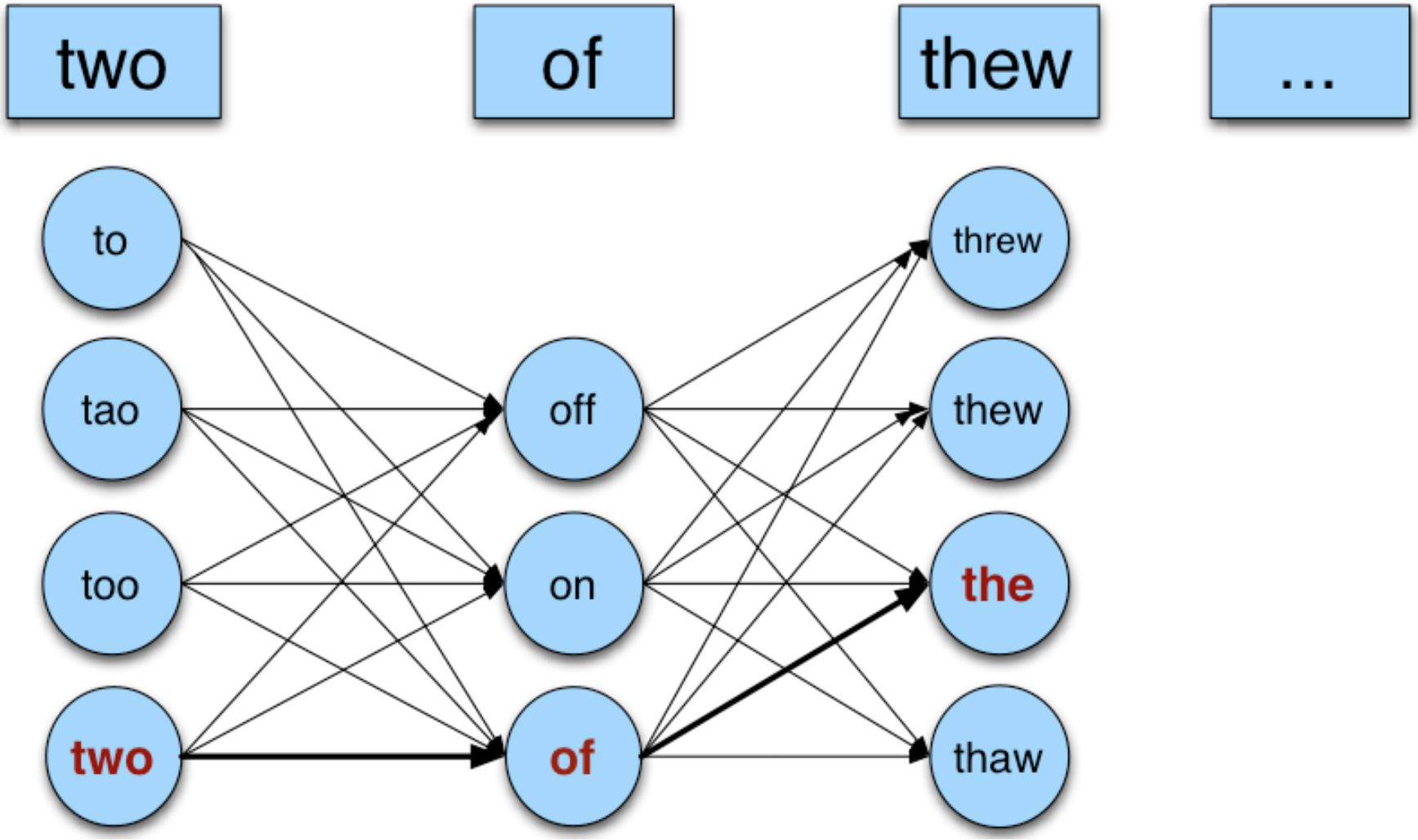
Choose the sequence W that maximizes $P(W|X)$

Noisy channel for real-world spell correction



Simplification: One error per sentence

Choose among all possible sentences with one word replaced

two of thew

- w_1, w''_2, w_3 two **off** thew
- w_1, w_2, w'_3 two of **the**
- w'''_1, w_2, w_3 **too** of thew

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Choose the sequence W that maximizes $P(W|X)$

Getting the probability values

Noisy Channel

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where X is the observed sentence and S is the set of all the possible sequences from the candidate set

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P(X|W)

- Same as for non-word spelling correction
- Also require proabability for no error $P(w|w)$

Probability of no error

What is the probability for a correctly typed word? P(“the”|“the”)

Probability of no error

What is the probability for a correctly typed word? P("the"|"the")

It may depend on the source text under consideration

- 1 error in 10 words $\rightarrow$ 0.9
- 1 error in 100 words $\rightarrow$ 0.99

Computing $P(W)$

Use Language Model

- Unigram
- Bigram
- ...