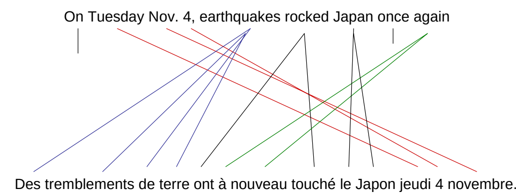
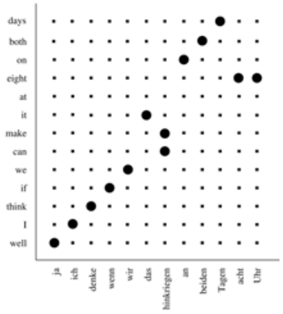
CS 294-5: Statistical Natural Language Processing

Machine Translation II
Lecture 11: 10/12/05

Phrase Movement



Phrase Movement



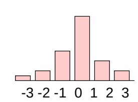
The HMM Model

- Model 2 preferred global monotonicity
- We want local monotonicity:
  - Most jumps are small
- HMM model (Vogel 96)

f	$t(f \mid e)$
nationale	0.469
national	0.418
nationaux	0.054
nationales	0.029

$$P(f,a|e) = \prod_j P(a_j|a_{j-1}) P(f_j|e_i)$$

$P(a_j - a_{j-1})$



  - Re-estimate using the forward-backward algorithm
  - Handling nulls requires some care
- What are we still missing?

IBM Models 3/4/5

Mary did not slap the green witch

Mary not slap slap slap the green witch — n(3|slap)

P(NULL)

Mary not slap slap slap NULL the green witch

t(la|the)

Mary no daba una botefada a la verde bruja

d(j|i)

Mary no daba una botefada a la bruja verde

[Al-Onaizan and Knight, 1998]

Examples: Translation and Fertility

the

f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
le	0.497	1	0.746
la	0.207	0	0.254
les	0.155		
l'	0.086		
ce	0.018		
cette	0.011		

not

f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
ne	0.497	2	0.735
pas	0.442	0	0.154
non	0.029	1	0.107
rien	0.011		

farmers

f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
agriculteurs	0.442	2	0.731
les	0.418	1	0.228
cultivateurs	0.046	0	0.039
producteurs	0.021		

Example: Idioms

nodding

f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
signe	0.164	4	0.342
la	0.123	3	0.293
tête	0.097	2	0.167
oui	0.086	1	0.163
fait	0.073	0	0.023
que	0.073		
hoche	0.054		
hocher	0.048		
faire	0.030		
me	0.024		
approuve	0.019		
qui	0.019		
un	0.012		
faites	0.011		

Example: Morphology

should

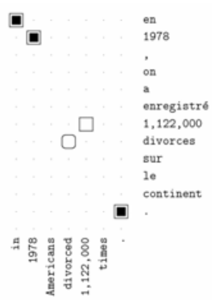
f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
devrait	0.330	1	0.649
devraient	0.123	0	0.336
devrions	0.109	2	0.014
faudrait	0.073		
faut	0.058		
doit	0.058		
aurait	0.041		
doivent	0.024		
devons	0.017		
devrais	0.013		

Alignment Error Rate

- Alignment Error Rate
  - □ = Sure
  - ○ = Possible
  - ■ = Predicted

$$AER(A,S,P) = \left(1 - \frac{|A \cap S| + |A \cap P|}{|A| + |S|}\right)$$

$$= \left(1 - \frac{3+3}{3+4}\right) = \frac{1}{7}$$



Some Results

- [Och and Ney 03]

Model	Training scheme	0.5K	8K	128K	1.47M
Dice		50.9	43.4	39.6	38.9
Dice+C		46.3	37.6	35.0	34.0
Model 1	1^5	40.6	33.6	28.6	25.9
Model 2	$1^5 2^5$	46.7	29.3	22.0	19.5
HMM	$1^5 H^5$	26.3	23.3	15.0	10.8
Model 3	$1^5 2^5 3^3$	43.6	27.5	20.5	18.0
	$1^5 H^5 3^3$	27.5	22.5	16.6	13.2
Model 4	$1^5 2^5 3^3 4^3$	41.7	25.1	17.3	14.1
	$1^5 H^5 3^3 4^3$	26.1	20.2	13.1	9.4
	$1^5 H^5 4^3$	26.3	21.8	13.3	9.3
Model 5	$1^5 H^5 4^3 5^3$	26.5	21.5	13.7	9.6
	$1^5 H^5 3^3 4^3 5^3$	26.5	20.4	13.4	9.4
Model 6	$1^5 H^5 4^3 6^3$	26.0	21.6	12.8	8.8
	$1^5 H^5 3^3 4^3 6^3$	25.9	20.3	12.5	8.7

Decoding

- In these word-to-word models
  - Finding best alignments is easy
  - Finding translations is hard (why?)

```
it is not clear .
|  \  |    \     \
|   \ +     \     \
|    \/ \    \     \
|    /\  \    \     \
CE NE EST PAS CLAIR  .
```

Bag "Generation" (Decoding)

Exact reconstruction (24 of 38)

Please give me your response as soon as possible.
⇒ Please give me your response as soon as possible.

Reconstruction preserving meaning (8 of 38)

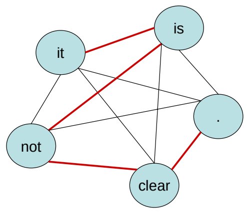
Now let me mention some of the disadvantages.
⇒ Let me mention some of the disadvantages now.

Garbage reconstruction (6 of 38)

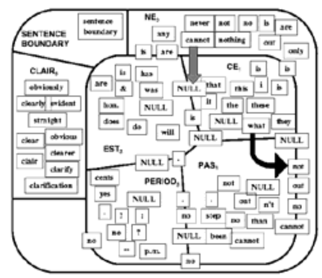
In our organization research has two missions.
⇒ In our missions research organization has two.

Bag Generation as a TSP

- Imagine bag generation with a bigram LM
  - Words are nodes
  - Edge weights are P(w|w')
  - Valid sentences are Hamiltonian paths
- Not the best news for word-based MT!



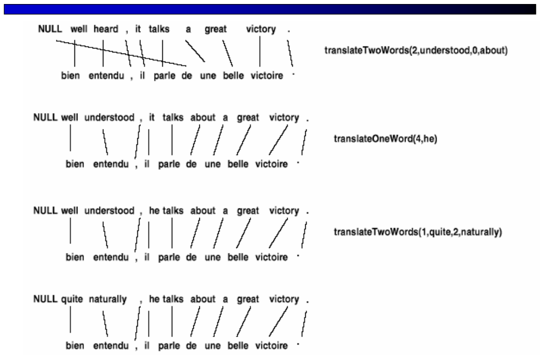
IBM Decoding as a TSP



Decoding, Anyway

- Simplest possible decoder:
  - Enumerate sentences, score each with TM and LM
- Greedy decoding:
  - Assign each French word it's most likely English translation
  - Operators:
    - Change a translation
    - Insert a word into the English (zero-fertile French)
    - Remove a word from the English (null-generated French)
    - Swap two adjacent English words
  - Do hill-climbing (or annealing)

Greedy Decoding



Stack Decoding

- Stack decoding:
  - Beam search
  - Usually A* estimates for completion cost
  - One stack per candidate sentence length
- Other methods:
  - Dynamic programming decoders possible if we make assumptions about the set of allowable permutations

sent length	decoder type	time (sec/sent)	search errors	translation errors (semantic and/or syntactic)	NE	PME	DSE	FSE	HSE	CE
6	IP	47.50	0	57	44	57	0	0	0	0
6	stack	0.79	5	58	43	53	1	0	0	4
6	greedy	0.07	18	60	38	45	5	2	1	10
8	IP	499.00	0	76	27	74	0	0	0	0
8	stack	5.67	20	75	24	57	1	2	2	15
8	greedy	2.66	43	75	20	38	4	5	1	33

WSD?

- Remember when we discussed WSD?
  - Word-based MT systems rarely have a WSD step
  - Why not?

oil

f	$t(f \mid e)$	ϕ	$n(\phi \mid e)$
pétrole	0.558	1	0.760
pétrolières	0.138	0	0.181
pétrolière	0.109	2	0.057
le	0.054		
pétrolier	0.030		
pétroliers	0.024		
huile	0.020		
Oil	0.013		