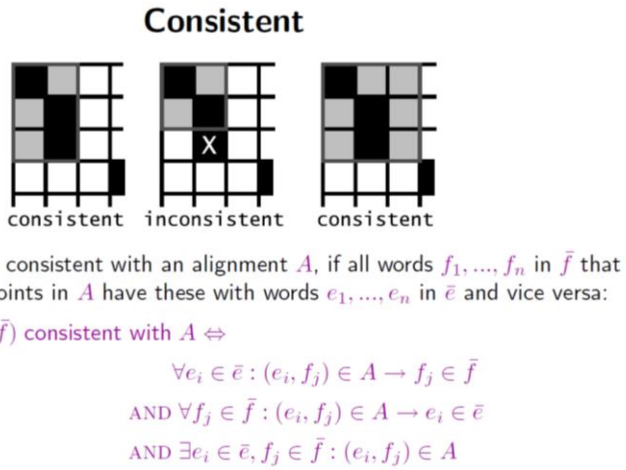
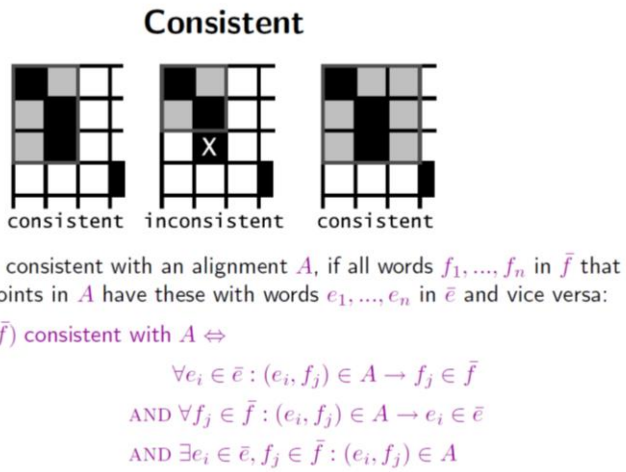
MT Summer Term 2021 Ex4: PB-SMT

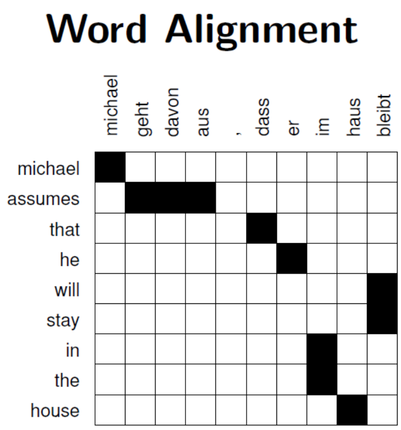
1. Phrase Extraction: in your own words, explain the formal definition of phrase pair $(\bar{e}, \bar{f})$ being consistent with an alignment A below:



2. Phrase Extraction: given the following definitions of a phrase pair $(\bar{e}, \bar{f})$ being consistent with an alignment A:



and the word alignments below:



which of the following phrase pairs are consistent with the alignment, which are not?

1. (michael assumes , michael geht davon aus)
2. (michael assumes , michael get davon aus)
3. (michael assumes , michael geht davon aus , dass)
4. (he will stay , er im Haus bleibt)
5. (he will stay in the house , er im Haus bleibt)
6. (stay in the house , im Haus bleibt)

3. Scoring phrases: given a phrase pair $(\bar{e}, \bar{f})$, how can you estimate $P(\bar{e}, \bar{f})$ from data using MLE and counts?

4. PB-SMT: draw a map of basic PB-SMT: which is the translation, the reordering and the language model in the formula below:

$$e_{\text{best}} = \text{argmax}_e \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)\ d(start_i - end_{i-1} - 1) \prod_{i=1}^{|\mathbf{e}|} p_{LM}(e_i|e_1 \ldots e_{i-1})$$

5. PB-SMT: in your own words, what are the main differences between IBM Model 3 and basic PB-SMT?

$$P(a, f|e) = \binom{m - \varphi_0}{\varphi_0} \times p_0^{(m-2\varphi_0)} \times p_1^{\varphi_0}$$
$$\times \prod_{i=1}^{l} n(\varphi_i|e_i) \times \prod_{j=1}^{m} t\left(f_j \middle| e_{a_j}\right)$$
$$\times \prod_{j:a_j \neq 0}^{m} d\left(j \middle| a_j, l, m\right) \times \prod_{i=0}^{l} \varphi_i! \times \frac{1}{\varphi_0!}$$

$$e_{\text{best}} = \text{argmax}_e \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)\ d(start_i - end_{i-1} - 1) \prod_{i=1}^{|\mathbf{e}|} p_{LM}(e_i|e_1 \ldots e_{i-1})$$

Think about: words, phrases, NULL, fertility, what are the independence assumptions in each?

6. Logarithms: in your own words, explain $\log_a(b)$. What happens to probabilities in log-space? What are $\log(1)$ and $\log(0)$? If you want to maximise a probability, what do you have to do with the corresponding log, what would you have to do with the corresponding negative of the log? Can you express the log of a product as a sum? What is $\log(x^y)$ and why? Given $\log_e(x)$ what is its inverse function?

7. PB-SMT: in your own words, how are the following related:

$$e_{\text{best}} = \text{argmax}_e \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)\ d(start_i - end_{i-1} - 1) \prod_{i=1}^{|\mathbf{e}|} p_{LM}(e_i|e_1 \ldots e_{i-1})$$

$$e_{\text{best}} = \text{argmax}_e \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)^{\lambda_\phi}\ d(start_i - end_{i-1} - 1)^{\lambda_d} \prod_{i=1}^{|\mathbf{e}|} p_{LM}(e_i|e_1 \ldots e_{i-1})^{\lambda_{LM}}$$

$$p(x) = \exp \sum_{i=1}^{n} \lambda_i h_i(x)$$

$$\begin{aligned} p(e, a|f) = \text{exp}(\lambda_\phi & \sum_{i=1}^{I} \text{log } \phi(\bar{f}_i|\bar{e}_i) + \\ \lambda_d & \sum_{i=1}^{I} \text{log } d(a_i - b_{i-1} - 1) + \\ \lambda_{LM} & \sum_{i=1}^{|\mathbf{e}|} \text{log } p_{LM}(e_i|e_1 \ldots e_{i-1})) \end{aligned}$$

8. Distance-based reordering: given the following simple definition of PB-SMT:

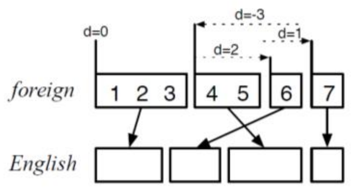
$$e_{\text{best}} = \text{argmax}_e \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)\ d(start_i - end_{i-1} - 1) \prod_{i=1}^{|\mathbf{e}|} p_{LM}(e_i|e_1 \ldots e_{i-1})$$

with simple distance based reordering:

$$d(start_i - end_{i-1} - 1)$$

in your own words please describe:

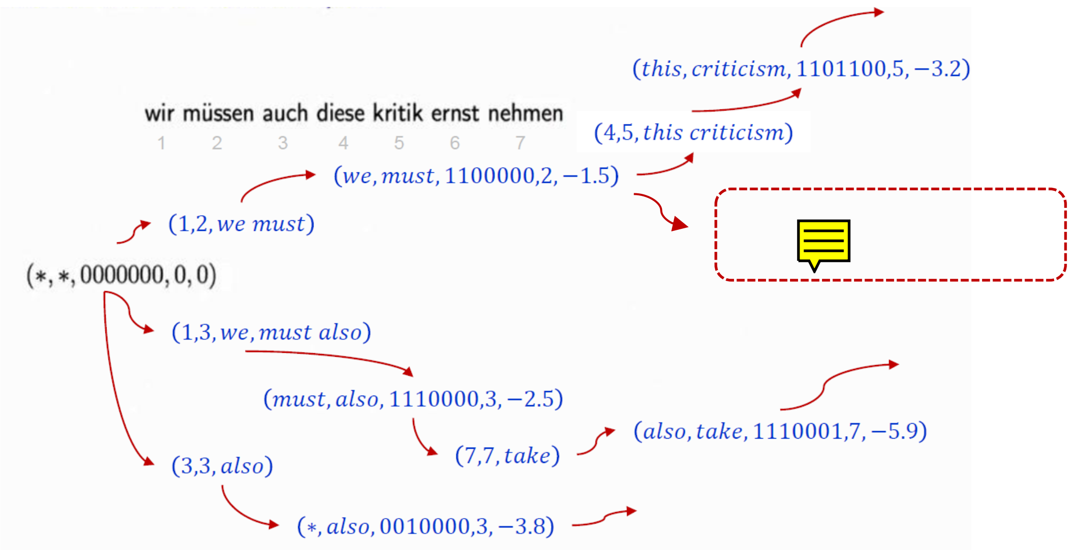
Distance-Based Reordering



phrase	translates	movement	distance
1	1–3	start at beginning	0
2	6	skip over 4–5	+2
3	4–5	move back over 4–6	-3
4	7	skip over 6	+1

Scoring function: $d(x) = \alpha^{|x|}$ — exponential with distance

9. PB-SMT decoder: please extend the following partial decoder graph at the position indicated in the red dashed rectangle below

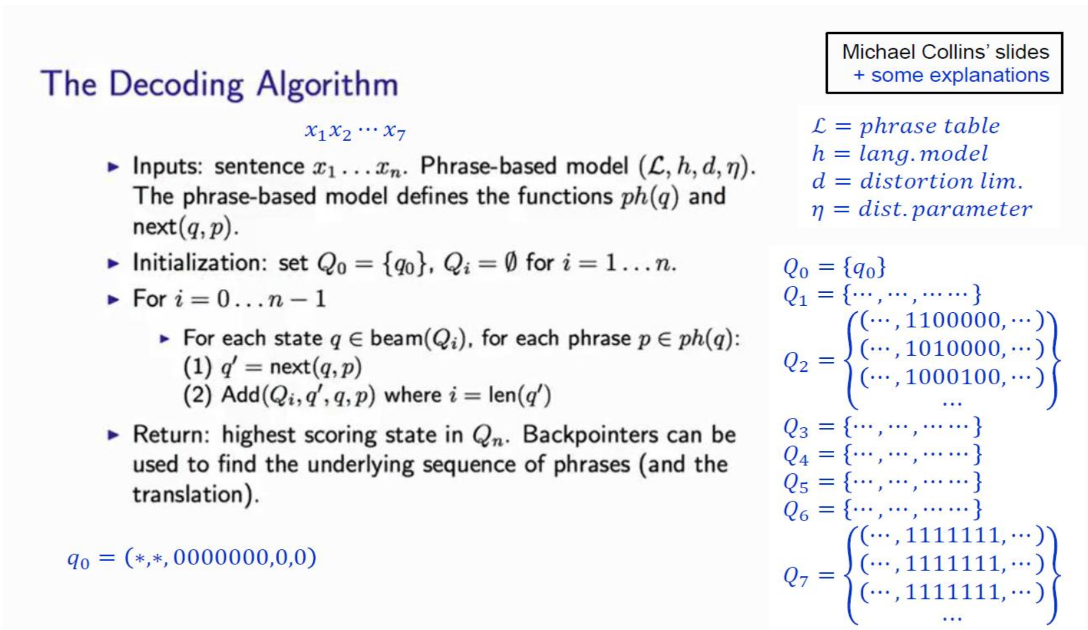


with $(3,3, also)$ and compute the next state $(\_, \_, \_, \_, \_)$. (You can make up the cost score!)

In your own words, what information do the slots in state quintuples $(\_, \_, \_, \_, \_)$ capture?

What would state representation tuples look like if instead of a 3-gram LM we had used a 5-gram LM?

10. PB-SMT Decoder: in your own words, please describe how the sets Q_i (in blue on the right) evolve during decoding, given the decoder pseudo code on the left:



In particular, what does index i in Q_i capture?

11. PB-SMT Decoder: please explain why we use beam search in the decoder? Can you describe two forms of beam search?