Using Word Dependent Transition Models in HMM Based Word Alignment for Statistical Machine Translation

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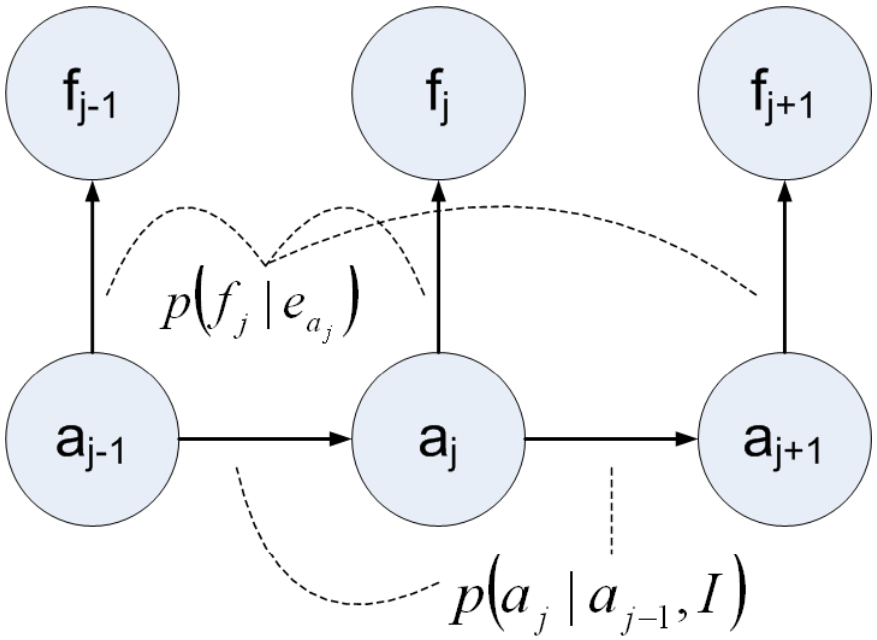
Goal and Approach

- Improve the transition models for HMM alignment
- Introduce word-dependence into the translation models for better modeling
- Use maximum a posteriori (MAP) estimation to address data sparseness

Conventional HMM Alignment

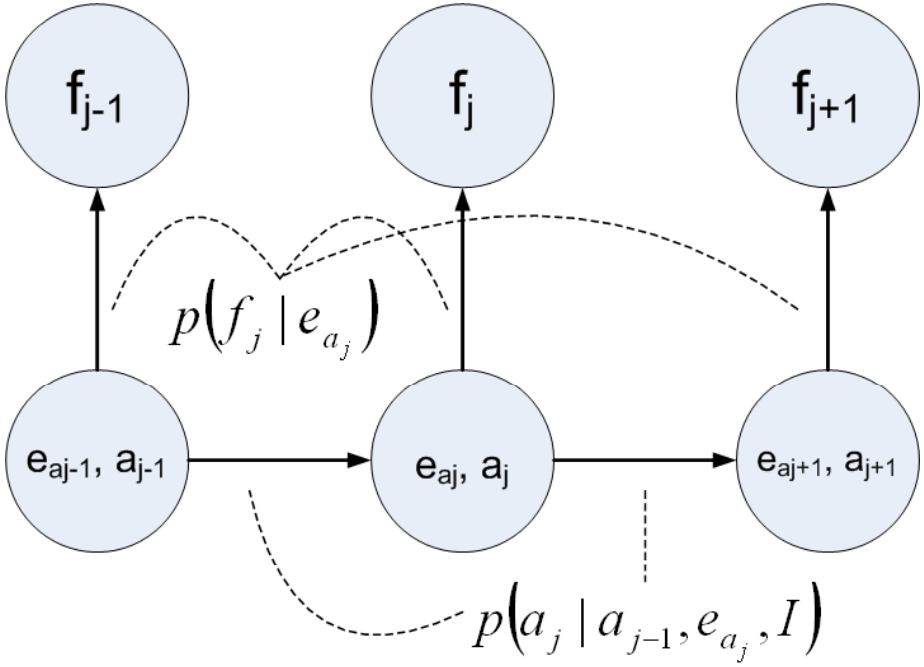


$$p(f_1^J \mid e_1^I) = \sum_{a_1^J} \prod_{j=1}^{J} \left[p(a_j \mid a_{j-1}, I)\, p(f_j \mid e_{a_j}) \right]$$

Transition models are context independent!

Can depend on word classes

Word-dependent HMM Alignment



$$p(f_1^J \mid e_1^I) = \sum_{a_1^J} \prod_{j=1}^{J} \left[p(a_j \mid a_{j-1}, e_{a_j}, I)\, p(f_j \mid e_{a_j}) \right]$$

Maximum Likelihood Estimation

$$p_{ML}\left(i \mid i^{'}, e, I\right) \propto c\left(i - i^{'}; e\right)$$

$$c(d;e) = \sum_{j=1}^{J-1} \sum_{i=1}^{I} \delta\left(e_{a_j}, e\right) p\left(a_j = i, a_{j+1} = i + d \mid f_1^J, e_1^I, \Lambda^{'}\right)$$

- Expected counts: *c(d;e)*
- Over-fitting for infrequent words *e*

MAP Estimation

- See page 83 for the equations (7) – (11)

- A Dirichlet prior over the parameters of transition models
- Hyper-parameters are chosen proportional to the word-independent transition model

- Back-off the word-dependent model to the word-independent model
- "Count" merging

Experiment #1: AER

- English-French Hansards corpus
- Training data: 500K sentence pairs
- Test data: 447 manually aligned sentence pairs
  - *sure* and *possible* alignments
- IBM model 1, HMM model (word-independent or word-independent), and IBM model 4
  - both directions combined

- Figure 1 and Table 1~3 show that WDHMM outperforms the baseline HMM and IBM model 4

Experiment #2: BLEU

- English-to-French track of NAACL 2006 Europarl evaluation workshop
- Training set: 688K sentence pairs
- Devset set: 500 sentence pairs, MERT
- Devtest set: 2000 sentence pairs, the prior parameter
- Test set: 2000 sentences
- NC-test set: 1064 out-of-domain sentences

- Figure 2, 3 and Table 4,5 show that WDHMM gives significant improvement on BLEU over the baseline and IBM model 4

Others

- WDHMM runs as fast as the conventional HMM
- WDHMM need extra memory that is proportional to the vocabulary size of the source language
  - Bucketed distortion

Conclusion

- Pros
  - Relatively simple technique
  - Consistent improvement over the baseline HMM and IBM model 4 alignments
  - …
- Cons
  - An extra prior parameter
  - …
- Questions?