Synchronous Context-Free Grammars and Machine Translation by Parsing

Presented by:
David Huggins-Daines

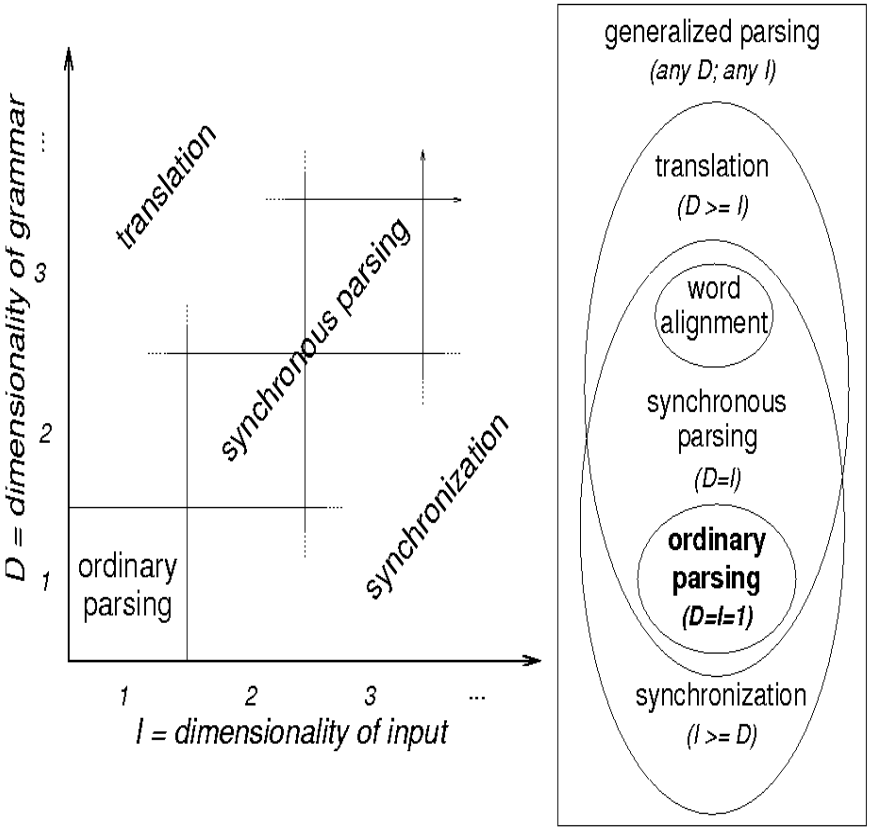
April 13, 2006

Outline

- Synchronous grammars
- Multitext Grammars
- Parsing with MTGs
- Translation by parsing
- Other applications

Synchronous Parsing

- Parsing multiple languages at once
  - Build mapping between them
  - A generalization of translation (transfer), alignment, and parsing
- Idea: implement SMT as a process of generalized parsing
  - 1-dimensional input, N-dimensional output



Synchronous Grammars

- Production rules with N parallel RHS
  - Typically some form of permutation allowed
  - Constrained to reduce complexity
  - But this may limit ability to translate
- Effective ones should account for
  - Reordering of constituents
  - Lexical dependencies
  - Discontinuities

Multitext Grammars

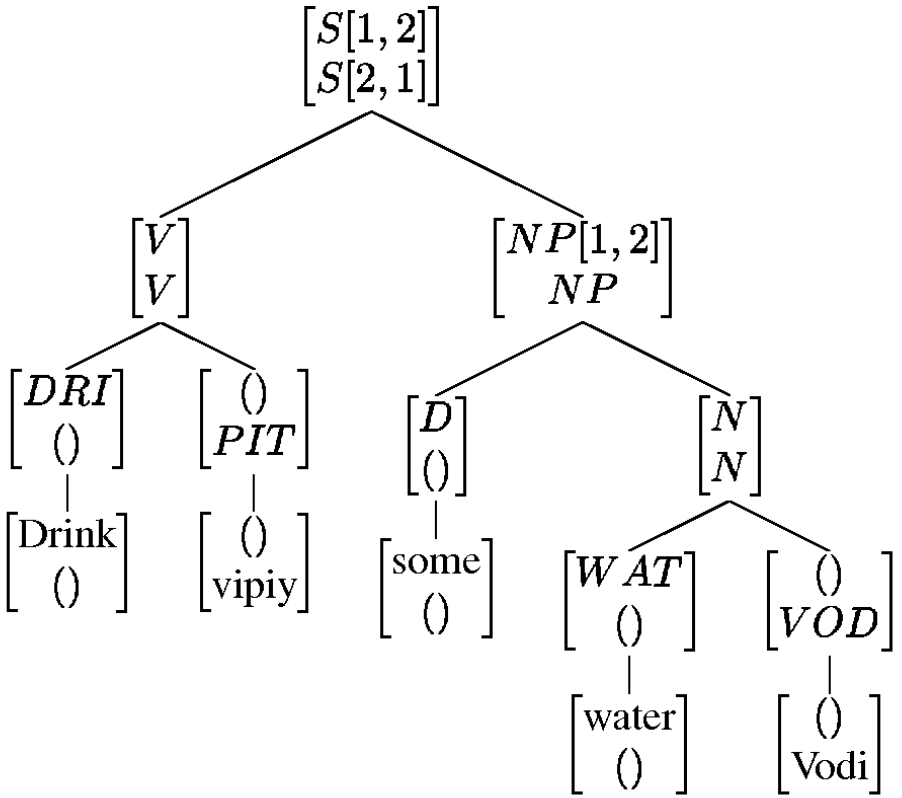
- Generalized form of synchronous grammar
  - Subsumes ITGs (“non-lexicalized 2-MTG(2)”)
  - Generalizes to N dimensions of input and output (2 and 2 for ITGs)
- Rules generate *role templates* and *links*:

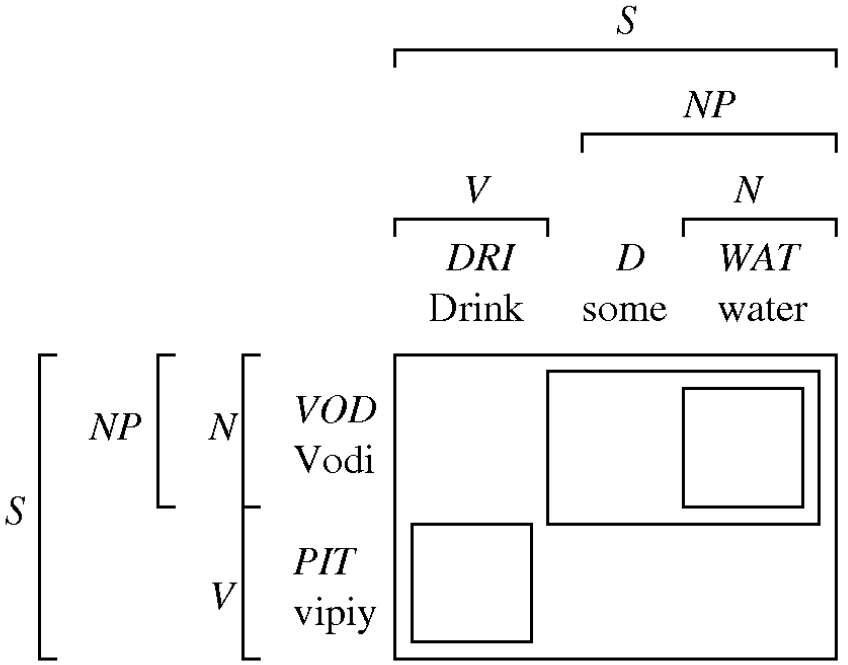
$$\underset{\bowtie}{\begin{matrix}[1,2,3]\\ [1,3,2,4]\\ [3,2,1]\end{matrix}} \begin{pmatrix} \epsilon & \mathrm{a} & \mathrm{b} & \mathrm{c} & \epsilon \\ \mathrm{w} & \mathrm{y} & \mathrm{x} & \epsilon & \mathrm{z} \\ \mathrm{t} & \epsilon & \mathrm{u} & \mathrm{v} & \epsilon \end{pmatrix} = \begin{matrix}\mathrm{abc}\\ \mathrm{wxyz}\\ \mathrm{vut}\end{matrix} \qquad (3)$$

Parsing with MTGs

- Naive parser is a generalized CKY-style chart parser
  - Cells of the chart are multidimensional productions
  - Parser applies inference rules to build on lower cells
- This has a very high complexity
  - Polynomial number of possible rules
  - Can be reduced by binarization
  - Requires special rules to deal with discontinuous constituents (*d*-strings, *d*-spans)

Parsing with MTGs

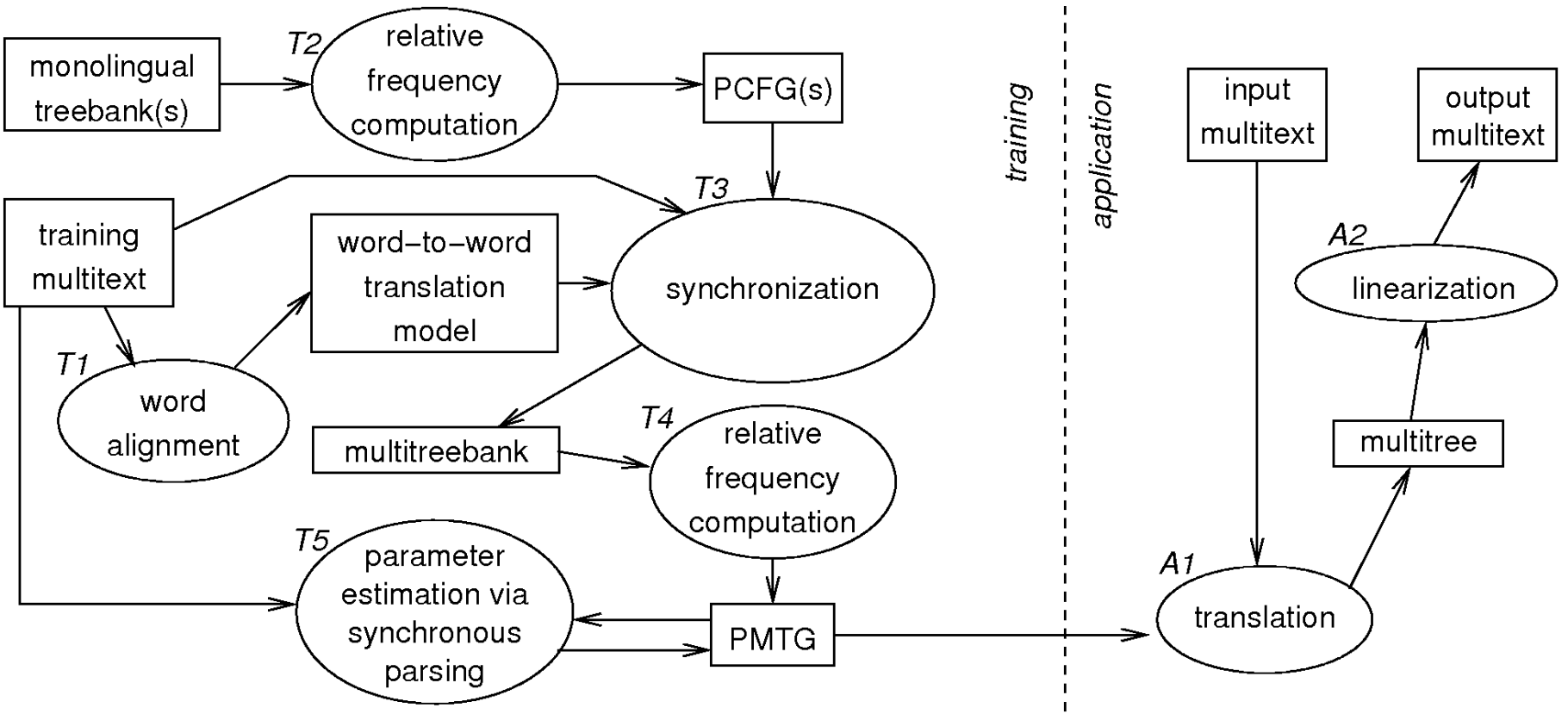




Translation by Parsing

- Translator has three phases
  - **Scan**: Read input and construct entries in the chart (based on tokens of input)
  - **Load**: Construct entries in the chart for possible outputs (based on the grammar)
  - **Compose**: Combine entries in the chart based on rewrite rules of the grammar
    - Satisfying Immediate Dominance and Linear Precedence (i.e. LHS must appear in RHS, and permutations must be consistent

Translation by Parsing



Extensions of MTGs

- Use of N-gram language models
  - A pseudo-noisy channel model
  - Combine MTG parse with a monolingual grammar (or language model)
  - Define an N-gram LM over d-strings
    - essentially skip-N-grams
- MTGs for synchronization (training)
- MTGs for MT evaluation
  - Compare parse of reference to hypothesis

Comparison/Conclusion

- Not much about about implementation
  - 2005 summer workshop implementation
  - Melamed's work defines abstract parsing logics
  - Implementation follows this basic structure
  - Pruning strategies used to reduce complexity
- Questions?