Crosslinguistic Resources for the Rapid Development of Precision Computational Grammars

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Overview

- *Why build precision grammars?*
- *Hurdles to robust processing with precision grammars*
- *The Grammar Matrix*
  - *Crosslinguistic core*
  - *Modeling variation with 'modules'*
- *Future work: software support for endangered language documentation*

Background:
Why build precision grammars?

Natural language syntax & semantics

- *Constituent structure*
- *Mapping of linear string to predicate-argument structure (word order, case, agreement)*
- *Long distance dependencies*
  - What did Kim think Pat said Chris saw?
- *Idioms, collocations*

Formal/‘Generative’ Grammars

- *Characterize a set of strings (phrases and sentences)*
- *These strings should correspond to those that native speakers find acceptable*
- *Assign one or more syntactic structures to each string*
- *Assign one or more semantic structures to each string*

Formal/‘Generative Grammars

- *No complete generative grammar has ever been written for any language*

Precision Computational Grammars

- *Knowledge engineering of formal grammars, for:*
- *Parsing: assigning syntactic structure and semantic representation to strings*
- *Generation: assigning surface strings to semantic representations*

Why build precision grammars?

- *Linguistic hypothesis testing*
  - *Test interacting analyses for consistency*
  - *Test grammar against test suites and naturally occuring text*
  - *More precise language documentation*

Why build precision grammars?

- *'Deep' NLP/NLU*
  - *Automated customer service response*
  - *Machine translation (symbolic, hybrid)*
  - *Speech prostheses*
  - *Hybrid Q&A systems*

Why build precision grammars?

- *'Deep' NLP/NLU*
  - *Human-computer dialog/collaboration*
  - *Machine mediated human-human interaction*
  - *Better treebanks*

Background:
Hurdles to robust processing with precision grammars

Hurdles

- *Efficient processing* *(Oepen et al 2002)*
- *Ambiguity resolution* *(Baldridge & Osborn 2003, Toutanova et al 2005, Riezler et al 2002)*
- *Domain portability* *(Baldwin et al 2005)*
- *Lexical acquisition* *(Baldwin & Bond 2003, Baldwin 2005)*
- *Extragrammatical/ungrammatical input* *(Baldwin et al 2005)*
- *Scaling to many languages*

The LinGO Grammar Matrix

The Grammar Matrix: Overview

- *Motivation*
- *HPSG*
- *Semantic representations*
- *Cross-linguistic core*
- *Modules*

Matrix: Motivation

- *English Resource Grammar:*
  - *140,000 lines of code (25,000 exclusive of lexicon)*
  - *~3000 types*
  - *16+ person-years of effort*
- *Much of that is useful in other languages*
- *Reduces the cost of developing new grammars*

Matrix: Motivation

- *Hypothesis testing (monolingual and cross-linguistic)*
  - *Interdependencies between analyses*
  - *Adequacy of analyses for naturally occurring text*

Matrix: Motivation

- *Promote consistent semantic representations*
  - *Reuse downstream technology in NLU applications while changing languages*
  - *Transfer-based (symbolic or stochastic MT)*

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HPSG

- *Head-Driven Phrase Structure Grammar (Pollard & Sag 1994)*
- *Mildly-context sensitive (Joshi et al 1991)*
- *Typed feature-structures*
- *Declarative, order-independent, constraint-based formalism*

An HPSG consists of

- *A collection of feature-structure descriptions for phrase structure rules and lexical entries*
- *Organized into a type hierarchy, with supertypes encoding appropriate features and constraints inherited by subtypes*
- *All rules and entries contain both syntactic and semantic information*

An HPSG is used

- *By a parser to assign structures and semantic representations to strings*
- *By a generator to assign structures and strings to semantic representations*
- *Rules, entries, and structures are DAGs, with type name labeling the nodes*
- *Constraints on rules and entries are combined via unification*

Example rule type

$$\textit{head-subj-phrase}: \begin{bmatrix} \textit{binary-headed-phrase}\ \& \\ \textit{head-compositional} \\ \text{SUBJ} & \langle\ \rangle \\ \text{COMPS} & \boxed{1} \\ \text{HEAD-DTR} & \begin{bmatrix} \text{SUBJ} & \langle \boxed{2} \rangle \\ \text{COMPS} & \boxed{1} \end{bmatrix} \\ \text{NON-HEAD-DTR} & \boxed{2} \end{bmatrix}$$

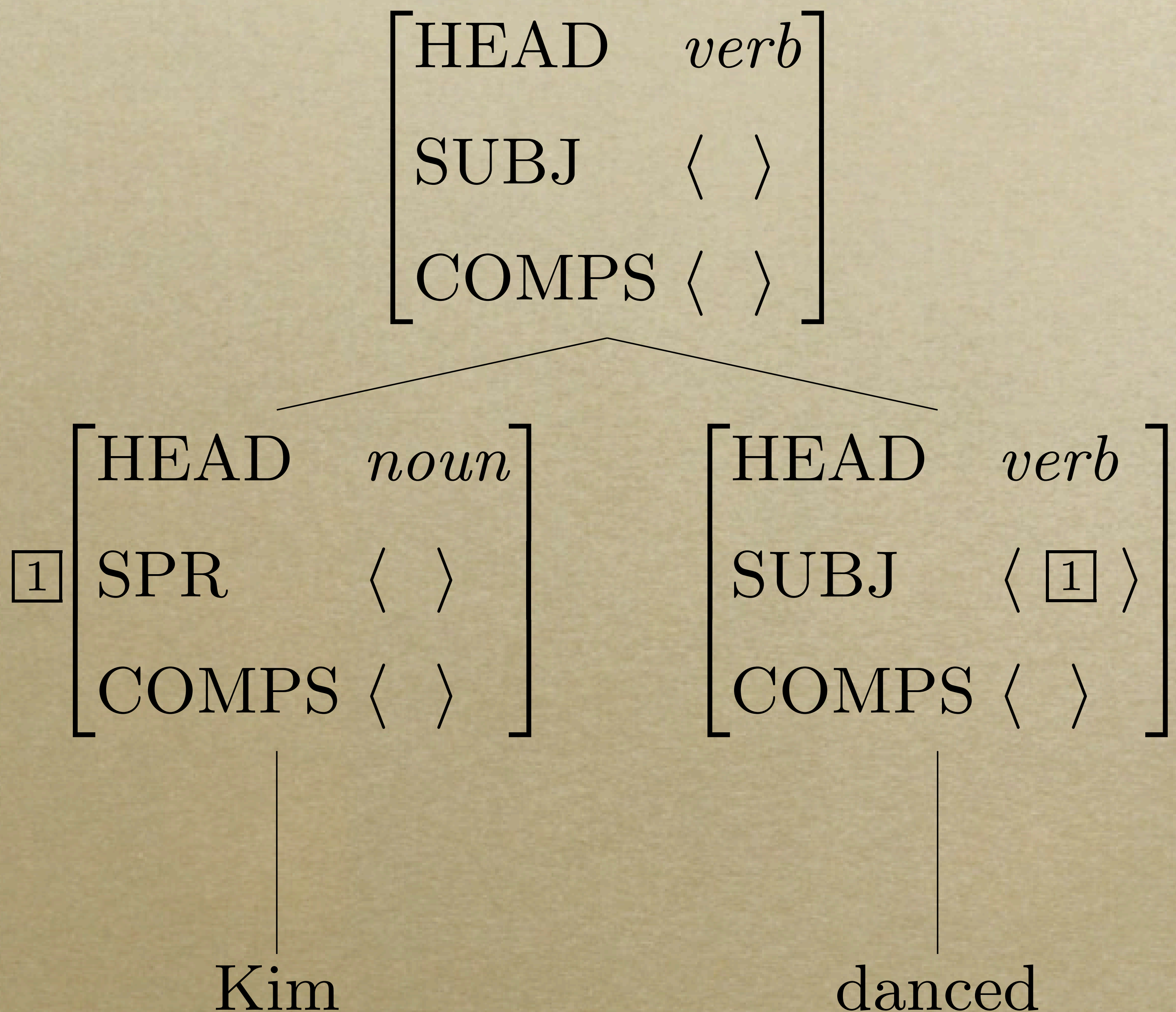
Example rule type

head-final:

$$\begin{bmatrix} \textit{binary-headed-phrase}\ \& & \\ \text{HEAD-DTR} & \boxed{1} \\ \text{NON-HEAD-DTR} & \boxed{2} \\ \text{ARGS} & \langle\ \boxed{2}, \boxed{1}\ \rangle \end{bmatrix}$$

subj-head: *head-subj-phrase* & *head-final*

Example parse



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Semantic Representations

- *Not going for an interlingua*
- *Not representing connection to world knowledge*
- *Not representing lexical semantics (the meaning of life is life')*
- *Making explicit the relationships among parts of a sentence*

Semantic Representations

- *Kim gave a book to Sandy*
- *give(e,x,y,z), name(x,'Kim'), book(y), name(z,'Sandy'), past(e)*

Semantic Representations

- *Sandy was given a book by Kim*
- *Kim continues to give books to Sandy*
- *This is the book that Kim gave Sandy*
- *Which book did Kim give Sandy?*
- *Which book do people often seem to forget that Pat knew Kim gave to Sandy?*
- *This book was difficult for Kim to give to Sandy.*

Semantic representations

- *Minimal Recursion Semantics* *(Copestake et al, forthcoming)*
  - *Expressive adequacy*
  - *Computational tractability*
  - *Grammatical compatibility*
  - *Underspecifiability*

Semantic representations

- *MRS specifies well-formedness*
- *Matrix specifies representations*
    - *Nominal v. verbal predicates*
    - *Quantifiers*
    - *Illocutionary force*
    - *Coordination*

Semantic representations

- *Languages may still differ:*
  - *Lexical predicates*
    - *Japanese: kore, sore, are*
  - *Grammaticized tense/aspect, discourse status*
  - *Ways of saying*
    - *make a wish, center divider*

Design criteria

- *Strip all syntactic information*
- *Stay lexically close to the surface (for hybrid deep/shallow systems)*
- *Encode all distinctions marked in the surface from*
- *Leave underspecified all else that can be computed*

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Matrix: Cross-linguistic core

- *Types defining feature geometry*
- *Types encoding compositional semantics*
- *General classes of phrase structure rules*
- *General classes of lexical items*
- *Configuration and parameter files for LKB (Copestake 2002) and PET (Callmeier 2000)*

Matrix: Hypothesized universals

- *Words and phrases combine to make larger phrases.*
- *The semantics of a phrase is determined by the meaning of its parts and how they're put together.*

Matrix: Hypothesized universals

- *Some rules for phrases add semantics, some don't.*
- *No rule can remove semantic information.*
- *Most phrases have an identifiable head daughter.*

Matrix: Hypothesized universals

- *Heads determine the type of arguments they require, and how they combine semantically with those arguments.*
- *Modifiers determine the type of heads they modify, and how they combine semnatically with the head.*

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Modules: Motivation

- *Many patterns are not universal, yet recurring*
  - *Systems represented in every language:*
    - *word order, negation, questions*
  - *Systems/patterns represented in some languages:*
    - *noun incorporation, numeral classifiers, verb particle construction*

Modules: Motivation

- *Promote reuse of code*
- *Promote consistency of analyses*
- *Sometimes the same technical solution is useful in different constructions across different languages.*

Modules: Motivation

- *Both Basque and Latin have free word order*
- *Except:*
    - *Basque embedded clauses are verb-final*
    - *Latin yes-no questions are verb-initial*

Modules: Open issues

- *How independent can modules be?*
- *How do we design a UI allowing the linguist to find the relevant modules?*

Modules: Proof of concept

- *Implemented modules for word order, negation, yes-no questions*
- *Tested against a convenience sample of 7 languages*
- *Developed abstract test suites for each language*

Modules: Proof of concept

Language	Word order	Negation	Yes-no Q
Hindi	SOV	pre-V adv	sentence-initial particle
Japanese	V-final	verbal suffix	sentence-final particle
Mandarin	SVO	pre-V adv	sentence-final particle, A-not-A
Polish	free	pre-V adv	sentence-initial particle
Slave	SOV	post-V adv	sentence-initial particle
English	SVO	post-aux adv	aux inversion
Spanish	SVO	pre-V adv	main verb inversion

Modules: Proof of concept

Language	Pos.	Coverage	Neg.	Over-generation
Hindi	5	100%	10	10%
Japanese	6	100%	8	0%
Mandarin	4	75%	9	0%
Polish	14	100%	8	0%
Slave	3	100%	6	0%
English	5	80%	11	45%
Spanish	5	80%	8	25%

Further planned modules

- *Coordination*
- *Content questions*
- *Relative clauses*
- *Case, agreement*
- *Tense, aspect, mood*
- *Marking of discourse status*

Outlook:
Assisting endangered language documentation

Current state of the art

- *Existing crosslinguistic core and modules sufficient for rapid prototyping*
- *Results suitable as basis for sustained development*

This year’s Ling 567

- *Basic word order*
- *Case, agreement*
- *Adjectival and adverbial modifiers*
- *Matrix/embedded statements/questions*
- *Coordination*
- *Sentential negation*

The Montage vision

- *A field linguist working on an endangered language*
- *Builds a precision grammar by selecting modules as she learns the facts of the language*
- *Uses the precision grammar to test hypotheses against collected texts, find relevant examples*

The Montage vision

- *Works with a grammar engineer to further fine-tune the precision grammar*
- *Produces language resources (annotated corpora, prose grammar, precision grammar) which are ontologically indexed for smart searching*

The Montage vision

- *Word-wide database of linguistic data and analyses*
- *Machine-readable language resources for minority languages*

Work to be done

- *More modules*
- *Module UI*
- *Data-exchange infrastructure*
- *Ontological indexing of complex objects*
- *Robust processing with partial grammars*

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- *http://www.delph-in.net/matrix/*
- *A version of these slides with full bibliography will be available online: http://faculty.washington.edu/ebender/*

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