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Language modeling with tree-adjoining grammars

Parsing TAG

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Outline

Last sessions

Mon: Motivation and the basic TAG

Tue: Linguistic applications and using LTAG: syntax

Wed: Linguistic applications and using LTAG: semantics

The following sessions

Wed: Introduction to grammar engineering and XMG

Thu: Grammar implementation with XMG

Fri: Parsing TAG

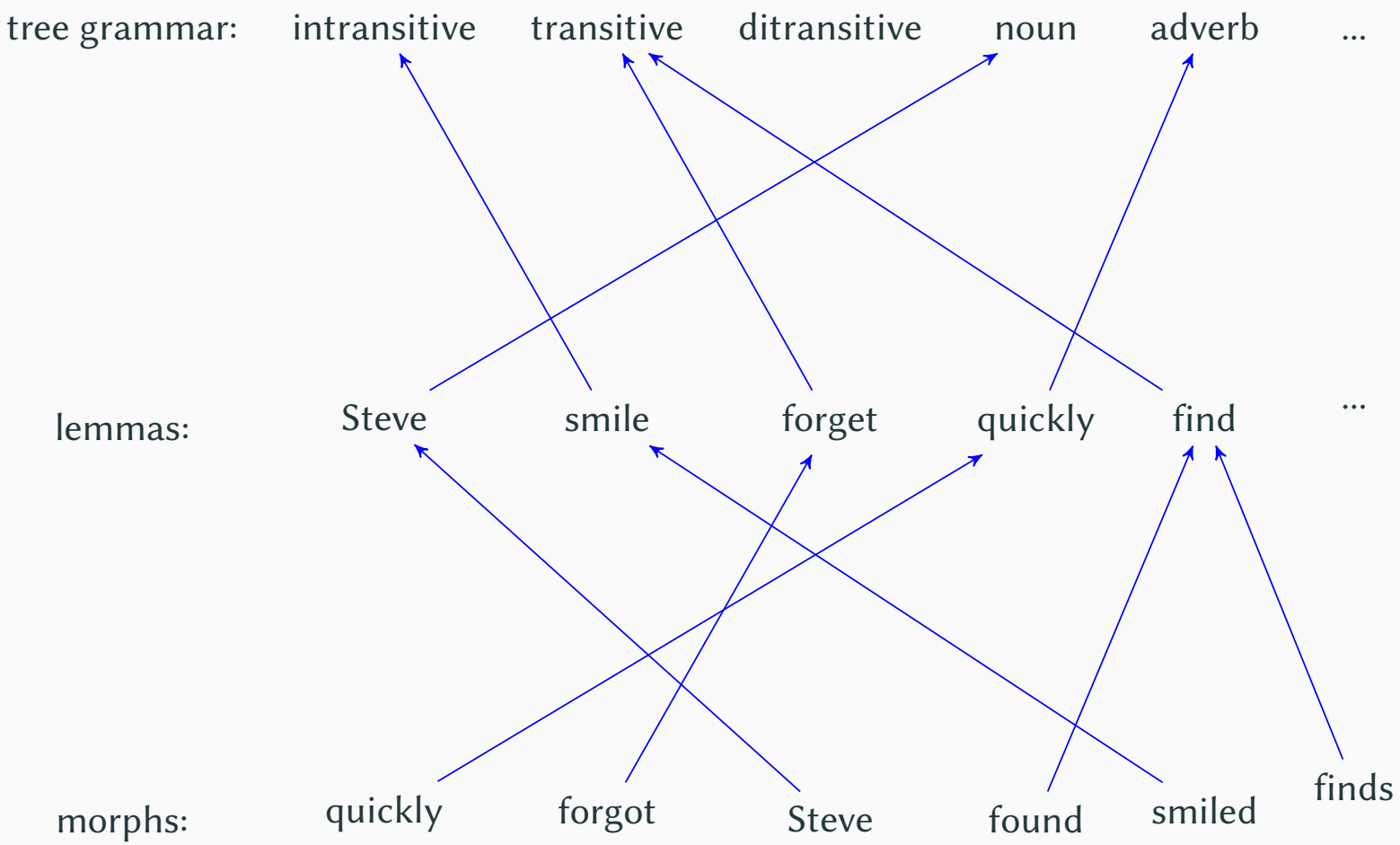
Parsing with TuLiPA

- TuLiPA Arps & Petitjean [1] and Parmentier et al. [2]: parser for Tree Adjoining Grammars and Tree Wrapping Grammars
- Syntax + (frame-based) semantics
- Input: grammar and sentence to parse
- Output: all derivations that can be derived by combining the elementary trees
- Standard CYK algorithm
- Bottom-up, left-to-right traversion of the derived tree
- Available on Github (`https://github.com/spetitjean/TuLiPA-frames`)
- ...or online (`http://xmg.phil.hhu.de/index.php/upload/tulipa`)

Lexicalization

- Lexicalized grammar: all rules contain one lexical item
- Computational interest: parsing with limited number of trees
- Lexical anchoring: separate lexical items from the tree templates
- Trees contain a lexical anchor leaf marked with $\diamond$

- Architecture: inspired by the XTAG grammar XTAG Research Group [3]
- Tree family: all syntactic environments where an anchor can appear
- 2-level lexicon:
  - Lemmas, mapped to a tree family
  - Inflected forms, mapped to a lemma


tree grammar:
intransitive
transitive
ditransitive
noun
adverb
...
lemmas:
Steve
smile
forget
quickly
find
...
morphs:
quickly
forgot
Steve
found
smiled
finds

Structure of the lexicon

- Parsing with XMG → TuLiPA
- 3 levels to describe the syntax-lexicon interface
  - Grammar: set of tree templates organized in families
  - Lexicon of lemmas, mapped to tree families
  - Lexicon of inflected forms, mapped to lemmas
- First step of parsing: lexical anchoring → select all the trees of the grammar which could be used for parsing the current input
- For each word of the sentence, find the corresponding lemma(s). Add the tree families bound to these lemmas to the set of trees to consider.

XMG-2: several compilers

- Build a set of syntactic trees (using the <syn> dimension), possibly paired with semantic frames (<frame> dimension) → `synframe` compiler
- Describe the mapping from lemmas to tree families (using the <lemma> dimension) → `lex` compiler
- Describe the mapping from inflected forms to lemmas (using the <morpho> dimension) → `mph` compiler
- Once the 3 files are written, compile them to produce the lexicalized grammar
- Input of TuLiPA: grammar (3 XML files), axiom (root of the expected derived tree(s)), input sentence
- Also available online: `http://xmg.phil.hhu.de/index.php/upload/tulipa`

The <lemma> dimension

Every entry is a feature structure with specific features:

- entry: the lemma (as a string)
- fam: the tree family it is mapped to
- (sem: the semantic frame corresponding to the lemma)

And possibly standard morphosyntactic features (cat, etc.)

```
1 class LemmaBig
2   {
3   <lemma>{
4     entry <- "big";
5     sem <- FrameBig;
6     cat <- a;
7     fam <- Adj
8   }
9 }
```

The <lemma> dimension: example with abstractions

```
1  class Determiner
2  {
3    <lemma>{
4      cat   <- d;
5      fam   <- Det
6    }
7  }
8
9  class LemmaThe
10 import Determiner[]
11 {
12   <lemma> {entry <- "the"}
13 }
14
15 class LemmaA
16 import Determiner[]
17 {
18   <lemma> {entry <- "a"}
19 }
```

The <morpho> dimension

Specific features:

- morph: the inflected form (string)
- lemma: the lemma this form is mapped to (string)

Other features can be defined:

- cat
- wh, rel (bool)
- agr → thirdsg (bool), num (sg, pl)
- mode (base, ind)
- tnsval (past, etc.)

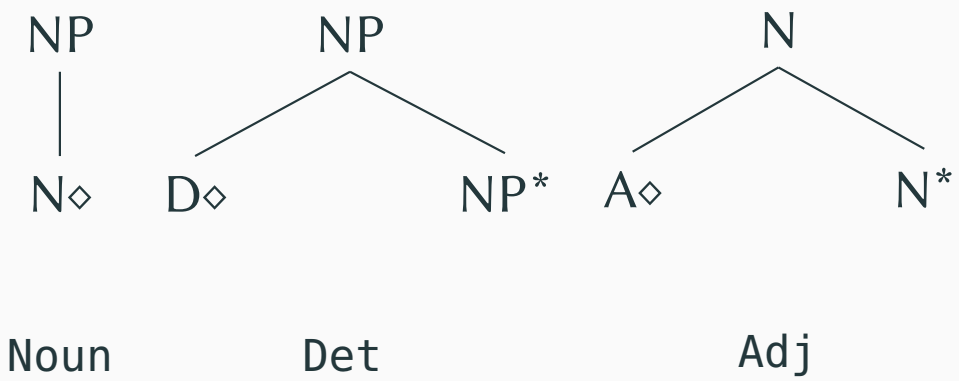
The <morpho> dimension: example

```
class Noun
{
  <morpho>{
    cat   <- N
  }
}

class SingularNoun
import Noun[]
{
  <morpho>{
    agr <- [num = sg,
            thirdsg = +]
  }
}
```

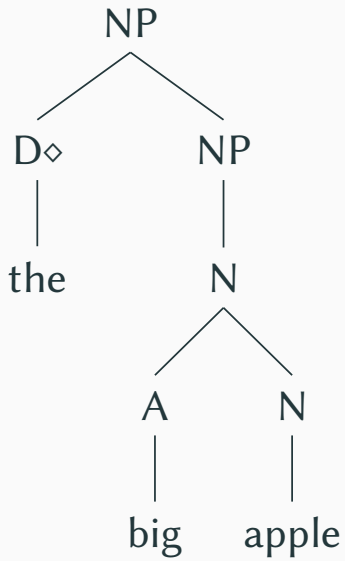
```
class Form[?Morph, ?Lemma]
{
  <morpho>{
    lemma <- ?Lemma;
    morph <- ?Morph
  }
}

class MorphApples
import PluralNoun[]
{
  Form["apples","apple"];
}
```

Example: nouns and determiners

- Minimal grammar: tree for nouns, tree for determiners, tree for adjectives
- Lexicon: 5 nouns (apple, apples, John, who what), 3 determiners (a, an, the), 1 adjective (big)



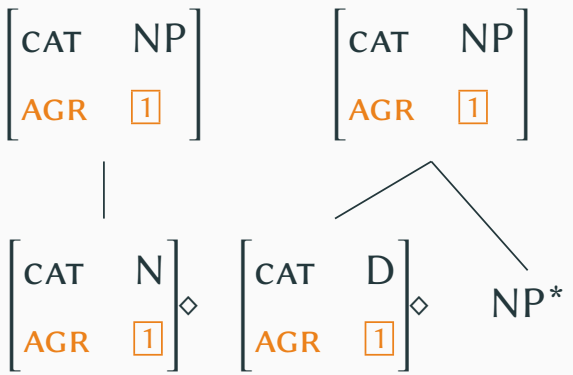
Example: nouns and determiners



Agreement constraints

- Try parsing “a big apples”
- Solution: `agr` feature
- Example: $\begin{bmatrix} \textsc{agr} & \begin{bmatrix} \textsc{num} & \textsc{sg} \\ \textsc{thirdsg} & + \end{bmatrix} \end{bmatrix}$

Agreement constraints



apple

$$\begin{bmatrix} \text{CAT} & \text{N} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{sg} \\ \text{THIRDSG} & + \end{bmatrix} \end{bmatrix}$$

apples

$$\begin{bmatrix} \text{CAT} & \text{N} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{pl} \\ \text{THIRDSG} & - \end{bmatrix} \end{bmatrix}$$

a

$$\begin{bmatrix} \text{CAT} & \text{D} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{sg} \\ \text{THIRDSG} & + \end{bmatrix} \end{bmatrix}$$

an

$$\begin{bmatrix} \text{CAT} & \text{D} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{sg} \\ \text{THIRDSG} & + \end{bmatrix} \end{bmatrix}$$

the

$$\begin{bmatrix} \text{CAT} & \text{D} \end{bmatrix}$$

Obligatory adjunction constraint

- Try parsing “apple”
- Solution: `det` feature

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apples

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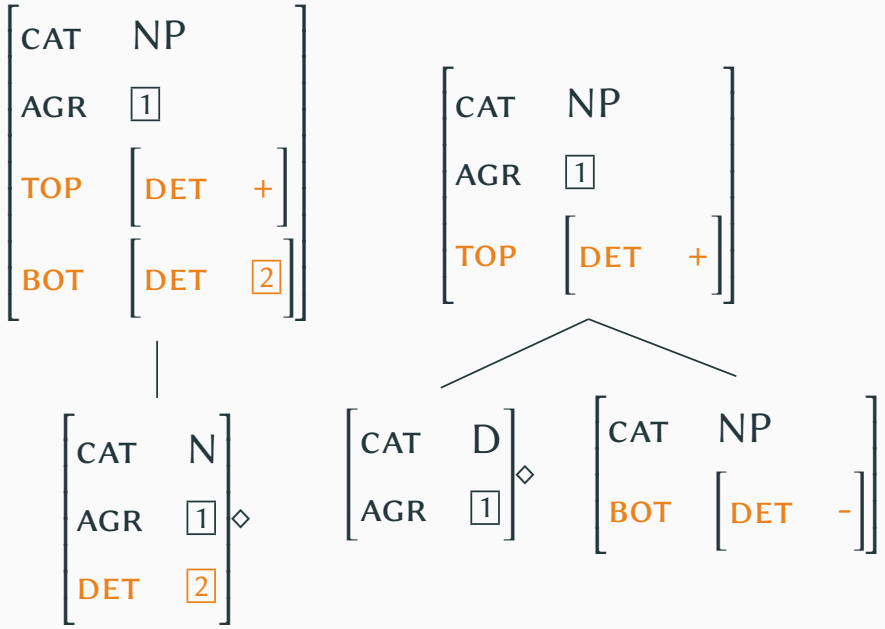

[1] Arps, David & Simon Petitjean. 2018. A Parser for LTAG and Frame Semantics. In Nicoletta Calzolari (Conference chair), Khalid Choukri, Christopher Cieri, Thierry Declerck, Sara Goggi, Koiti Hasida, Hitoshi Isahara, Bente Maegaard, Joseph Mariani, Hélène Mazo, Asuncion Moreno, Jan Odijk, Stelios Piperidis & Takenobu Tokunaga (eds.), *Proceedings of the eleventh international conference on language resources and evaluation (lrec 2018)*. Miyazaki, Japan: European Language Resources Association (ELRA).

[2] Parmentier, Yannick, Laura Kallmeyer, Wolfgang Maier, Timm Lichte & Johannes Dellert. 2008. TuLiPA: A syntax-semantics parsing environment for mildly context-sensitive formalisms. In *Proceedings of the ninth international workshop on Tree Adjoining Grammars and related formalisms (TAG+9)*, 121–128. Tübingen, Germany.

[3] XTAG Research Group. 2001. *A Lexicalized Tree Adjoining Grammar for English*. Tech. rep. Philadelphia, PA: Institute for Research in Cognitive Science, University of Pennsylvania.