Tree Adjoining Grammars: XMG

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Introduction

- Large scale Tree Adjoining Grammars are composed of thousands of trees
- Manual description by an expert: time consuming
- Automatic methods: need a corpus
- Precise resources, with easier development and maintenance: semi automatic methods

Our task

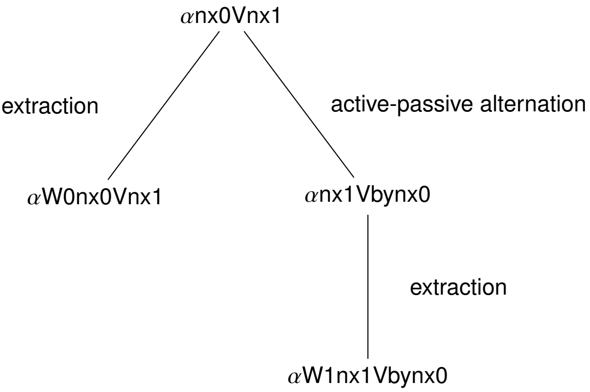
- Implement a TAG and use it to parse sentences
- Structure of the grammar: similar to XTAG (3 levels)
- Generate the trees: XMG
- Morphological/syntactic lexicons: lexConverter
- Parser: TuLiPA

Semi automatic methods: Metarules

- XTAG: Metarules to generate tree families from “standard” tree
- A metarule modifies a tree (adds/removes nodes) to create a new one
- Process: apply all possible metarules until a fixpoint is reached

Metarules for LTAG: Example

Tnx0nx1:



Semi automatic methods: Metagrammars

- MetaGrammatical Approach ([Candito, 1996]): linguistic description of the grammar
- Instead of writing rules, define parts of rules
- The rule fragments come in a 3-dimension hierarchy (subcategorization, syntactic functions redistribution, final functions realizations)
- All the fragments from dimension 1 are combined with the ones from dimension 2
- The resulting fragments are combined with the ones in dimension 3

Object of the description

- Languages can be described at several levels: syntax, morphology, semantic, prosody, discourse, ...
- Different formalisms have been proposed: Head-driven phrase structure grammar, Lexical Functional Grammar, Tree Adjoining Grammar, Categorial Grammar, Paradigm Function Morphology, Network Morphology, ...
- eXtensible MetaGrammar (XMG): MetaGrammar compiler initially used to create large scale Tree Adjoining Grammars ([Joshi et al., 1975]) and Interaction Grammars ([Perrier, 2000])

Description tools

- Need to use a description language, adapted to the task
- Chosing a tool (LKB, XLE, . . .): definitive, no way to adapt the description language
- Fit language to linguistic intuition

Slogan (XMG-2)

The user should not have to adapt to the tool
The tool should adapt to the user

XMG ([Crabbé et al., 2013])

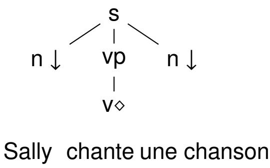
Ambition

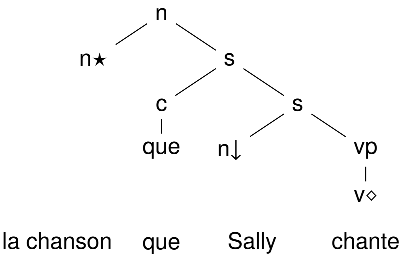
- Arbitrarily many levels of linguistic description (syntax, semantics, . . .): dimensions
- Affect a Domain Specific Language (DSL) to each one of these levels

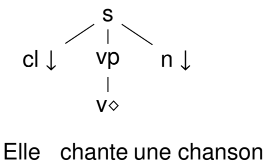
Methodology

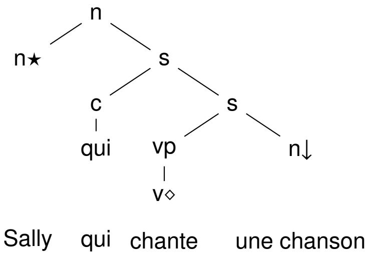
- Declarative definition of rule fragments (classes)
- Combination of rule fragments with logical operators

Transitive verbs (in French)

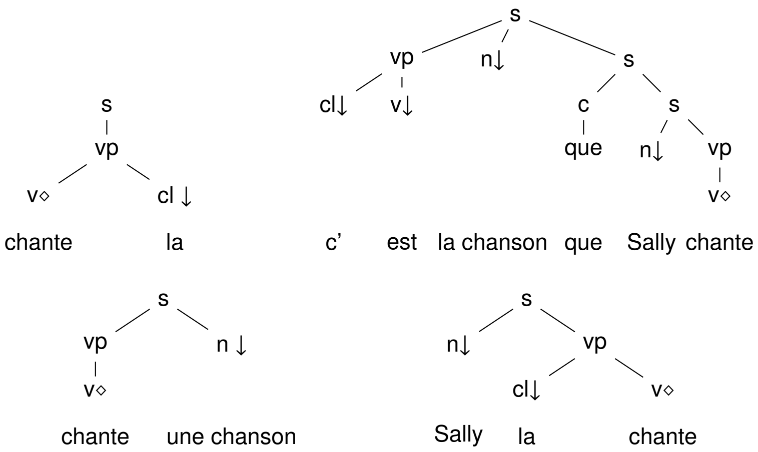




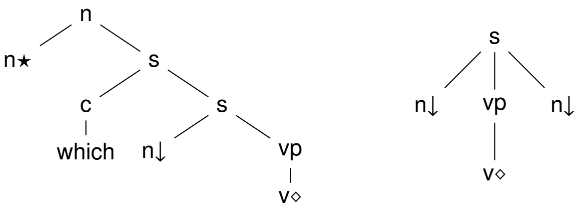




Transitive verbs (in French)

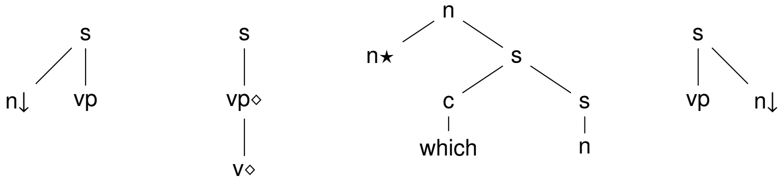


XMG: example

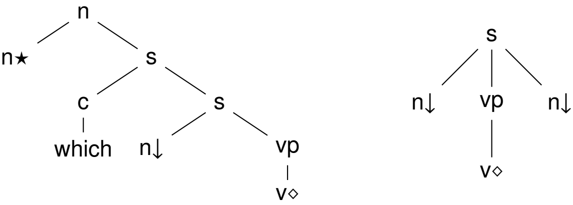


XMG: example

CanSubj Active RelObj CanObj



CanSubj ∧ Active ∧ (RelObj ∨ CanObj)



XMG: a MetaGrammar “compiler”

XMG is usually called a MetaGrammar compiler

- Compiler: Source code → Executable code
- XMG: Metagrammar (Grammar description) → Grammar

To make it short:

- A grammar is a description of a language
- A metagrammar is a description of a grammar

Generation steps

XMG processing steps are as follow:

- The metagrammar is compiled: metagrammatical language is translated into executable code
- The generated code is executed: accumulation of descriptions into the dimensions
- Descriptions are solved: every dimension comes with a dedicated solver
- Models are converted into the output language (XML)

Tools

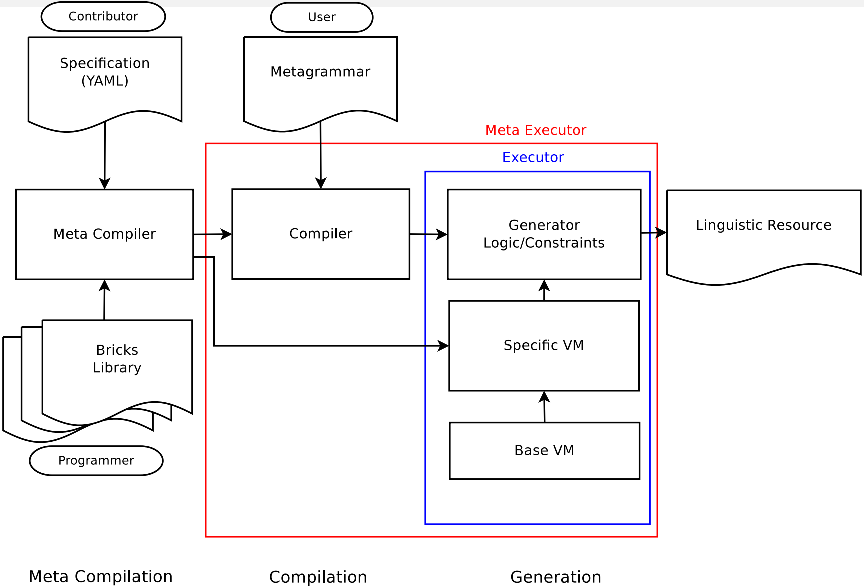
XMG-1

- eXtensible (?) Metagrammar
- Only 3 dimensions

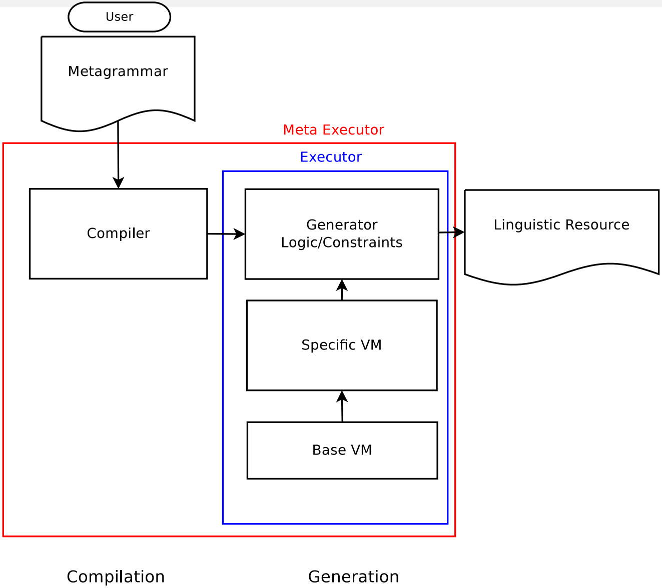
XMG-2

- Arbitrarily many dimensions, with DSLs
- Modular assembly of DSL, using bricks
- Methodology to generate a whole processing chain

XMG-2: Architecture



XMG-2: Architecture (relevant part for this class)



Plan

Installing XMG

Two options, provided by the documentation: `dokufarm.phil.hhu.de/xmg`

- Follow the steps (Ubuntu), or
- Install VirtualBox and get the XMG image

Installing contributions

- XMG bricks are distributed as contributions
- Making a contribution available is done with the `install` command

```
xmg@xmg:~/xmg-ng$ cd contributions
xmg@xmg:~/xmg-ng/contributions$ xmg install core
xmg@xmg:~/xmg-ng/contributions$ xmg install treemg
xmg@xmg:~/xmg-ng/contributions$ xmg install compat
xmg@xmg:~/xmg-ng/contributions$ xmg install synsemCompiler
```

Installing compilers

- A set of already assembled compilers is available
- Building one of them can be done with the `build` command

```
xmg@xmg:~/xmg-ng$ cd contributions/synsemCompiler/
xmg@xmg:~/xmg-ng/.../synsemCompiler$ cd compilers/synsem/
xmg@xmg:~/xmg-ng/.../synsem$ xmg build
```

- To avoid these steps: scripts (`reinstall.sh`)

Compiling a first metagrammar

The `compile` command takes two arguments

- The compiler which will be used
- The metagrammar

```
xmg@xmg:~/xmg-ng$ xmg compile synsem MetaGrammars/synsem
/TagExample.mg
```

The control language

XMG descriptions:

- Associate a content to an identifier (abstraction)
- Describe structures inside dimensions, with dedicated languages
- Use other abstractions (classes)
- Combine contents in a disjunctive or a conjunctive way

$$\begin{aligned} \textit{Class} &:= \textit{Name} \rightarrow \textit{Content} \\ \textit{Content} &:= \langle \textit{Dimension} \rangle \{ \textit{Description} \} \mid \textit{Name} \mid \\ &\quad\; \textit{Content} \vee \textit{Content} \mid \textit{Content} \wedge \textit{Content} \end{aligned}$$

Describing trees

The <syn> dimension

- Declaring nodes: keyword **node**, optional node variable, optional features and properties
  `node ?S [cat=s]`
- Expressing constraints between nodes: dominance operators (`->`, `->+`, `->*`) and precedence operators (`>>`, `>>+`, `>>*`)
- Combining these statements: with logical operators (`;` and `|`)

Example:

```
node ?S [cat=s];
node ?VP [cat=vp];
node ?V (mark=anchor) [cat=v];
node ?NP (mark=subst) [cat=n];
?S -> ?VP;
?VP -> ?V;
?S -> ?NP;
?NP >> ?VP
```

Alternative syntax: bracket notation

The <syn> dimension

- Declaring nodes: same as for the standard notation
- Expressing dominance and precedence constraints thanks to bracketing, and special operators for non immediate relations (`...` , `...+` , `,,,` , `,,,+`)

```
node ?S [cat=s]{
  node ?NP (mark=subst) [cat=np]
  node ?VP [cat=vp]{
    node ?V (mark=anchor) [cat=v]
  }
}
```

Using dimensions

Contributing descriptions

- Descriptions (constraints) are accumulated into dimensions
- Every dimension is associated to a solver (sometimes identity)
- **<syn>**: a tree solver generates all minimal models

```
<syn>{
    node ?S [cat=s];
    node ?VP [cat=vp];
    node ?V (mark=anchor) [cat=v];
    node ?NP (mark=subst) [cat=n];
    ?S -> ?VP;
    ?VP -> ?V;
    ?S -> ?NP;
    ?NP >> ?VP
}
```

Syntactic nodes

Two nodes can be unified if:

- their feature structures can be unified
- their properties can be unified

Unification of nodes happens at two different stages:

- During the execution of the code ("explicit" unification: unification instruction = or reuse of variable)
- After solving: some nodes may be merged to obtain a minimal model

Minimal models

A minimal model is a model of the description where:

- no constraint is violated
- no additional node is created

What are the minimal models for the following sets of constraints?

```
?S ->+ ?A ; ?S -> ?B
```

```
?S -> ?A ; ?S -> ?B ; ?S -> ?C ; ?A >>* ?C
```

Which set of constraints leads to the following minimal models?

Defining abstractions

Classes allow to:

- Control the scope of variables
- Make (parametrized) abstractions

Examples (just headers):

```
class kicked_the_bucket
import nx0Vnx1[]
declare ?X0 ?X1
```

```
class nx0Vnx1
export ?S ?NP_Subj ?VP ?V ?NP_Obj
declare ?S ?NP_Subj ?VP ?V ?NP_Obj ?X0 ?X1
```

Defining abstractions

```
class Intransitive
declare ?S ?NP ?VP ?V
{
  <syn>{
        node ?S [cat=s];
        node ?VP [cat=vp];
        node ?V (mark=anchor) [cat=v];
        node ?NP (mark=subst) [cat=n];
        ?S -> ?VP; ?VP -> ?V;
        ?S -> ?NP; ?NP >> ?VP
  }
}
```

Valuation

To specify for which class models have to be computed (the axioms), the instruction **value** has to be used after the class definitions.

```
value Intransitive
value Transitive
```

Using abstractions

Classes can be used by other classes by two means:

- Importing the class in the header: all the (exported) variables are added to the scope, all the constraints from the class are added to the current set of constraints
- Calling the class in the body: variables are not added to the scope

Calling classes has two advantages:

- alternatives are possible (disjunction)
- it allows to use parameters

Examples:

```
CanObj[] | RelObj[]
```

```
?C=Class[?X]
```

Classes: examples (1)

```
class a
export ?A
declare ?A ?S
{
  <syn>{
    ?S -> ?A
  }
}

class b
import a[]
declare ?B
{
  <syn>{
    ?B -> ?A
  }
}
```

Classes: examples (2)

```
class a
export ?S
declare ?A ?S
{
  <syn>{
    ?S -> ?A
  }
}

class b
import a[]
declare ?A
{
  <syn>{
    ?S -> ?A
  }
}
```

Definition of types and constants

Everything inside the metagrammar has a type: values, feature structures, nodes, dimensions. . .

Four ways to define new types:

- Enumerated type: type T={a,b,c,d}
- Structured type: type T=[a_1:t_1,. . . ,a_n:t_n]
- Interval type: type T=[1..3]
- Unspecified type: type T!

Definition of types and constants

We can now specify the types of features and properties:

```
type CAT=  {np,vp,s,n,v,det}
type MARK= {lex,anchor,subst}
type LABEL !
type PERS= [1..3]
type GEN = {m,f}
type NUM = {sg,pl}
type AGR = [gen:GEN, num:NUM]


feature cat:  CAT
feature e:    LABEL
feature pers: PERS
feature agr:  AGR

property mark: MARK
```

Conclusion

XMG-NG

- Different levels of linguistic description (syntax, semantics, . . .): dimensions
- A Domain Specific Language (DSL) for each one of these levels
- A specific solver for the descriptions in each dimension
- The **<syn>** dimension: tree descriptions and tree solver (minimal models)

Methodology

- Write a metagrammar: create abstractions on rules and combine these abstractions with logical operators
- Compile the metagrammar to generate the grammar

For any question

- `dokufarm.phil.hhu.de/xmg`

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