Grammar Implementation with Lexicalized Tree Adjoining Grammars and Frame Semantics

Grammar implementation with XMG: Frames

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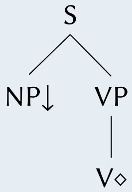
Implementation of syntactic trees



⇓

```
class alphanx0v
import VerbProjection[]
declare ?Subj
{
  ?Subj = Subject[];
  ?Subj.?VP = ?VP
}
```

Today: Frames!

Frame theories come with two components:

- attribute-value descriptions
- attribute-value constraints

How to implement both with XMG?

Attribute-value descriptions (recap.)

Vocabulary / Signature

Attr	attributes (= dyadic functional relation symbols)		
Rel	(proper) relation symbols		
Type	type symbols (= monadic predicates)		
Nname	node names (“nominals”)	} Nlabel	node labels
Nvar	node variables		

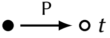
Primitive attribute-value descriptions (pAVDesc)

$$t \;\mid\; p : t \;\mid\; p \doteq q \;\mid\; [p_1, \ldots, p_n] : r \;\mid\; p \triangleq k$$

($t \in$ Type, $r \in$ Rel, $p, q, p_i \in \text{Attr}^*$, $k \in$ Nlabel)

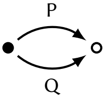
Semantics

$\mathrm{P} : t$



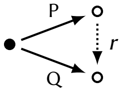
$\begin{bmatrix} \mathrm{P} & [t] \end{bmatrix}$

$\mathrm{P} \doteq \mathrm{Q}$



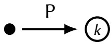
$\begin{bmatrix} \mathrm{P} & \boxed{1} \\ \mathrm{Q} & \boxed{1} \end{bmatrix}$

$[\mathrm{P}, \mathrm{Q}] : r$



$\begin{bmatrix} \mathrm{P} & \boxed{1} \\ \mathrm{Q} & \boxed{2} \end{bmatrix}$
$r(\boxed{1}, \boxed{2})$

$\mathrm{P} \triangleq k$



$\begin{bmatrix} \mathrm{P} & k[\;] \end{bmatrix}$

Attribute-value formulas (recap.)

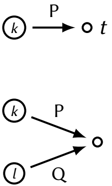
Primitive attribute-value formulas (pAVForm)

$$k \cdot p : t \;\mid\; k \cdot p \triangleq l \cdot q \;\mid\; \langle k_1 \cdot p_1, \ldots, k_n \cdot p_n \rangle : r$$

($t \in$ Type, $r \in$ Rel, $p, q, p_i \in$ Attr*, $k, l, k_i \in$ Nlabel)

Semantics

$k \cdot \mathrm{P} : t$

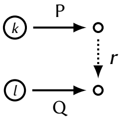


$k \begin{bmatrix} \mathrm{P} & [t] \end{bmatrix}$

$k \cdot \mathrm{P} \triangleq l \cdot \mathrm{Q}$

$k \begin{bmatrix} \mathrm{P} & \boxed{1} \end{bmatrix}$
$l \begin{bmatrix} \mathrm{Q} & \boxed{1} \end{bmatrix}$

$\langle k \cdot \mathrm{P}, l \cdot \mathrm{Q} \rangle : r$

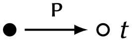
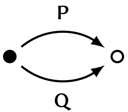
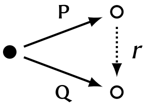
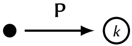


$k \begin{bmatrix} \mathrm{P} & \boxed{1} \end{bmatrix}$
$l \begin{bmatrix} \mathrm{Q} & \boxed{2} \end{bmatrix}$
$r(\boxed{1}, \boxed{2})$

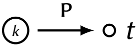
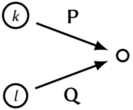
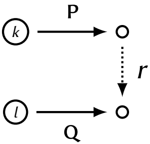
Formal definitions (fairly standard)

Set/universe of "nodes"	V
Interpretation function	$\mathcal{I}$: Attr $\rightarrow [V \rightharpoonup V]$, Type $\rightarrow \wp(V)$,
	Rel $\rightarrow \bigcup_n \wp(V^n)$, Nname $\rightarrow V$

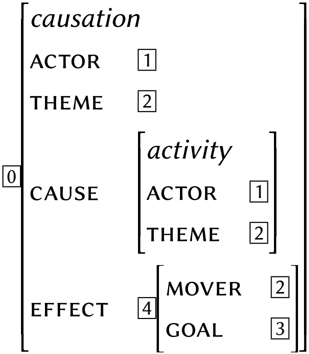
Attribute-value formulas in XMG

$\text{P} : t$		$\begin{bmatrix} \text{P} & [t] \end{bmatrix}$	`[p: t]`
$\text{P} \doteq \text{Q}$		$\begin{bmatrix} \text{P} & \boxed{1} \\ \text{Q} & \boxed{1} \end{bmatrix}$	`[p: ?X1,` `q: ?X1]`
$[\text{P}, \text{Q}] : r$		$\begin{bmatrix} \text{P} & \boxed{1} \\ \text{Q} & \boxed{2} \end{bmatrix}$ $r(\boxed{1}, \boxed{2})$	NOT SUPPORTED YET
$\text{P} \triangleq k$		$\begin{bmatrix} \text{P} & k[\ ] \end{bmatrix}$	`[p: ?K[] ]`

Attribute-value formulas in XMG

$k \cdot \text{P} : t$		$K \begin{bmatrix} \text{P} & \begin{bmatrix} t \end{bmatrix} \end{bmatrix}$	`?K [p: t];`
$k \cdot \text{P} \triangleq l \cdot \text{Q}$		$K \begin{bmatrix} \text{P} & \boxed{1} \end{bmatrix}$ $L \begin{bmatrix} \text{Q} & \boxed{1} \end{bmatrix}$	`?K [p: ?X1];` `?L [q: ?X1]`
$\langle k \cdot \text{P}, l \cdot \text{Q} \rangle : r$		$K \begin{bmatrix} \text{P} & \boxed{1} \end{bmatrix}$ $L \begin{bmatrix} \text{Q} & \boxed{2} \end{bmatrix}$ $r(\boxed{1}, \boxed{2})$	NOT SUPPORTED YET

Attribute-value formulas in XMG: Example




```
<frame>{
?0[causation,
    actor:?1,
    theme:?2,
    cause:[activity,
           actor:?1,
           theme:?2],
    effect:?4[mover:?2,
              goal:?3]
]}
```

Attribute-value constraints (recap.)

Constraints (general format) $\forall\phi,\ \phi \in \text{AVDesc}$

$\langle V, \mathcal{I}, g\rangle \models \forall\phi$ iff $\langle V, \mathcal{I}, g\rangle, v \models \phi$ for every $v \in V$

Notation:

$\phi \ \Rrightarrow\ \psi$ for $\forall(\phi \rightarrow \psi)$

Horn constraints:

$$\phi_1 \wedge \ldots \wedge \phi_n \ \Rrightarrow\ \psi \qquad (\phi_i \in \text{pAVDesc} \cup \{\top\},\ \psi \in \text{pAVDesc} \cup \{\bot\})$$

Examples

$\mathit{activity} \Rrightarrow \mathit{event}$	(every activity is an event)
$\mathit{causation} \wedge \mathit{activity} \Rrightarrow \bot$	(there is nothing which is both a causation and an activity)
$\text{AGENT} : \top \Rrightarrow \text{AGENT} \doteq \text{ACTOR}$	(every agent is also an actor)
$\mathit{activity} \Rrightarrow \text{ACTOR} : \top$	(every activity has an actor)
$\mathit{activity} \wedge \mathit{motion} \Rrightarrow \text{ACTOR} \doteq \text{MOVER}$	...

Attribute-value constraints in XMG

$\mathit{activity} \Rrightarrow \mathit{event}$	`activity -> event`
$\mathit{causation} \wedge \mathit{activity} \Rrightarrow \bot$	`causation activity -> -`
$\textsc{agent} : \top \Rrightarrow \textsc{agent} \doteq \textsc{actor}$	`agent:+ -> agent=actor`
$\mathit{activity} \Rrightarrow \textsc{actor} : \top$	`activity -> actor:+`
$\mathit{activity} \wedge \mathit{motion} \Rrightarrow \textsc{actor} \doteq \textsc{mover}$	`activity motion-> actor=mover`

Attribute-value constraints in XMG: Examples

```
frame-constraints = {
    activity -> event, activity -> [actor:+],
    motion -> event, motion -> [mover:+],
    causation -> event, causation -> [cause:+,effect:+],
    locomotion -> activity motion}
```

What is the graphical represention of this ("type hierarchy")?

```
frame-constraints = {
    activity -> event, activity -> [actor:+],
    motion -> event, motion -> [mover:+],
    causation -> event, causation -> [cause:+,effect:+],
    locomotion -> activity motion}
```

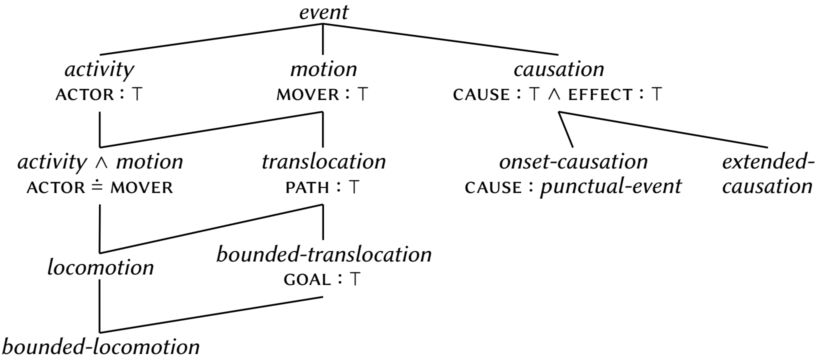
What is the graphical represention of this ("type hierarchy")?

```
frame-type-hierarchy = {
    [event, [activity, actor:+, [locomotion]],
            [motion, mover:+, [locomotion]],
            [causation, cause:+, effect:+]]}
```

NOT YET SUPPORTED

Attribute-value constraints (recap.)

Graphical presentation of constraints



Caveat: Reading convention required !

Implementation exercise with frames

1. implement the large type hierarchy
2. implement two frame descriptions

$$\boxed{e}\begin{bmatrix} \textit{bounded-translocation} & \\ \text{GOAL} & \boxed{x} \end{bmatrix} \qquad \boxed{0}\begin{bmatrix} \textit{causation} & \\ \text{ACTOR} & \boxed{1} \\ \text{THEME} & \boxed{2} \\ \text{CAUSE} & \begin{bmatrix} \textit{activity} & \\ \text{ACTOR} & \boxed{1} \\ \text{THEME} & \boxed{2} \end{bmatrix} \end{bmatrix}$$

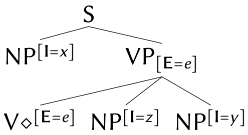
3. implement the unfication of these two frames ($\boxed{e}=\boxed{0}$)

Sketch

[⟶ Kallmeyer/Osswald 2013]

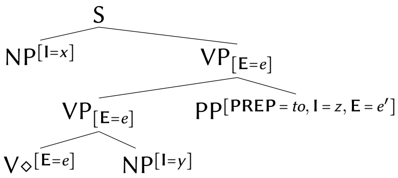
(1) a. John sent Mary the book. (double object construction)
    b. John sent the book to Mary. (prepositional object construction)

a)



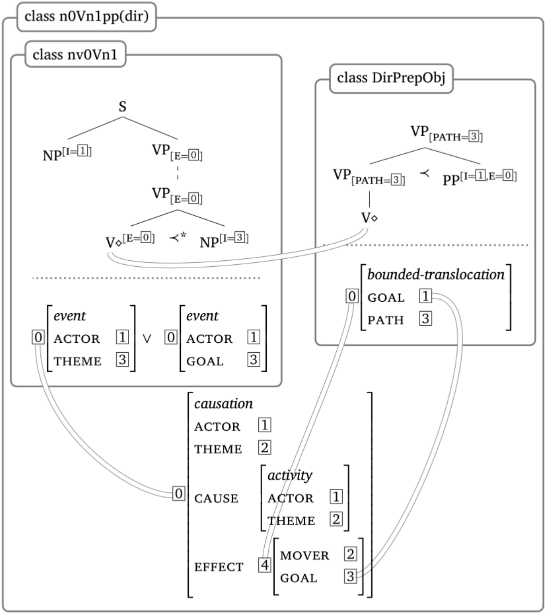
$$e\begin{bmatrix} \textit{causation} & \\ \text{CAUSE} & \begin{bmatrix}\textit{activity} & \\ \text{ACTOR} & x\end{bmatrix} \\ \text{EFFECT} & \begin{bmatrix}\textit{change-of-possession} & \\ \text{THEME} & y \\ \text{RECIPIENT} & z\end{bmatrix}\end{bmatrix}$$

b)

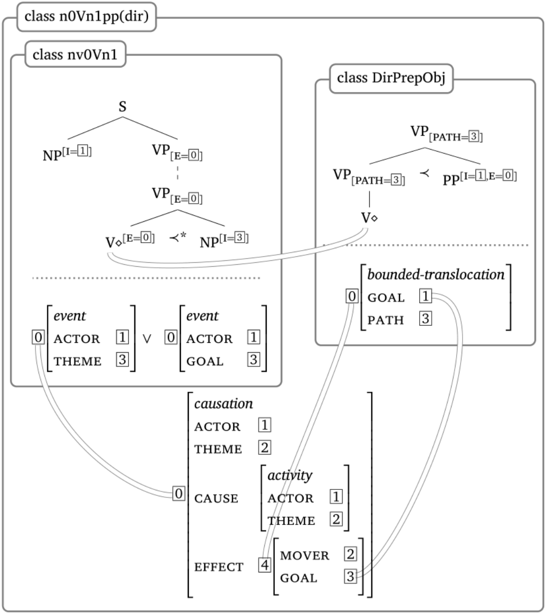


$$e\begin{bmatrix} \textit{causation} & \\ \text{CAUSE} & \begin{bmatrix}\textit{activity} & \\ \text{ACTOR} & x\end{bmatrix} \\ \text{EFFECT} & e'\begin{bmatrix}\textit{bounded-translocation} & \\ \text{MOVER} & y \\ \text{GOAL} & z\end{bmatrix}\end{bmatrix}$$

Implementation exercise with frames



Implementation exercise with frames



The trick:
sharing of variables
across dimensions!

Further applications

Morpho-semantic interface:

- modelling verbal prefixation in Russian (Zinova)
- modelling derivational morphology in English (Andreou & Petitjean)
- modelling root-pattern morphology in Arabic (Petitjean, Samih & Lichte)

Tomorrow

Mon: introduction to grammar engineering and XMG

Tue: implementing syntax with XMG

Wed: implementing semantics with XMG

Thu: parsing implemented grammars with TuLiPA

Fri: conclusion

[1] Petitjean, Simon, Younes Samih & Timm Lichte. 2015. Une métagrammaire de l'interface morpho-sémantique dans les verbes en arabe. In *Actes de la 22e conférence sur le Traitement Automatique des Langues Naturelles*, 473–479. Caen, France. http://www.atala.org/taln_archives/TALN/TALN-2015/taln-2015-court-024.

[2] Zinova, Yulia. 2016. *Russian verbal prefixation: a frame semantic analysis.* Düsseldorf, Germany: Heinrich-Heine-Universität Düsseldorf Dissertation. https://user.phil-fak.uni-duesseldorf.de/~zinova/Thesis.pdf.