Tree Adjunction as Minimalist Lowering

Thomas Graf
tgraf@ucla.edu
tgraf.bol.ucla.edu

University of California, Los Angeles

tag+ 2012
September 27, 2012
MGs vs TAG

- **String Languages**

  \[
  \text{CFG} \subset \text{LIG} \equiv \text{TAG} \equiv \text{CCG} \subset \text{LCFRS} \equiv \text{MCTAG} \equiv \text{MG}
  \]

- **Tree Languages**

  \[
  \text{TAG} \not\subseteq \text{MG} \ \& \ \text{MG} \not\subseteq \text{TAG}
  \]

**Question**
Can MGs be extended to subsume TAG on a tree level?
Outline

1 Minimalist Grammars with Reset Lowering
   - Slices and Merge
   - Move & Reset Lowering

2 Translation from MGs to TAG
   - General Idea and Prerequisites
   - Initial Trees & Substitution
   - Tree Adjunction
   - Advanced Topics
Movement-Generalized MGs

- **Standard MGs** (Stabler 1997, 2011)
  - Inspired by Chomsky’s Minimalist Program
  - Two structure building operations:
    - Merge (combines trees) and Move (displaces subtrees)
  - Both operations are controlled by features on the lexical items.

- **Movement-Generalized MGs** (Graf 2012)
  - Extend MGs with a template for defining new variants of Move
    - **without increasing weak generative capacity**
  - Parameters: size of displaced constituent, linear order, direction of Move (upwards/downwards)
  - Defined in terms of their (regular) derivation tree language plus a transduction to derived trees.
We start with a derivation-tree based definition of MGs without movement.

**Slices (≈ elementary trees/phrase projected by a lexical item)**

A slice is a strictly binary branching tree such that

- every interior node is labeled with a positive polarity Merge feature,
- every interior node is a mother of exactly one node labeled □,
- exactly one leaf node is a lexical item (the head) with a negative polarity Merge feature.

A Minimalist derivation is a combination of slices satisfying certain conditions.
Example: Slices and a Combination Thereof

N^+  
\[ \text{the} :: D^- \]  

D^+  
\[ \text{mooe} :: N^- \]  

D^+  
\[ \text{kicked} :: V^- \]  

N^+  
\[ \text{the} :: D^- \]  
\[ \text{mooe} :: N^- \]  

D^+  
\[ \text{kicked} :: V^- \]  

N^+  
\[ \text{the} :: D^- \]  
\[ \text{mooe} :: N^- \]
Conditions on Merge

**Constraint 1: Merge**

Every interior node with a positive polarity Merge feature $F^+$ immediately dominates the root of a slice whose head has the matching feature $F^−$.

**Constraint 2: Final**

The head of the root of the derivation must have a distinguished **final** Merge feature.
Mapping to Derived Trees

Replace interior node labels by arrows pointing in the direction of the head of the slice.

Example

```
          D^+
         /   \
N^+      D^+
        /  \
the :: D^-  moose :: N^-  kicked :: V^-  N^+
          /  \
the :: D^-  moose :: N^-
```
Replace interior node labels by arrows pointing in the direction of the head of the slice.
In derivation trees, Move is only indicated by unary branching — no actual displacement occurs before the mapping to derived trees.
In derivation trees, Move is only indicated by unary branching — **no actual displacement occurs** before the mapping to derived trees.
A slice may contain unary branching nodes.

All unary branching nodes — and only those — are labeled with a positive polarity Move feature with directionality $d \in \{\lambda, \rho\}$.

A head’s negative polarity Merge feature may be followed by a finite number of negative Move features.

Every Move feature furthermore has a non-negative size value indicating the root of the subtree to be displaced.
Example: Slices involving Move

\[
\begin{align*}
N^+ & \quad \text{which :: } D^- \, \text{wh}^-[1] \quad \square \\
T^+ & \quad \text{t}^+\rho[0] \quad \square \\
X^+ & \quad \text{wh}^+_\lambda[5] \\
& \quad \varepsilon :: C^- \\
& \quad \text{top}^+\rho[3] \\
& \quad \text{Y}^+ \\
& \quad \varepsilon :: Z^- \, \text{wh}^- \quad \square
\end{align*}
\]
What are the Relevant Move Nodes?

Finding Occurrences for Reset Lowering

Move node \( m \) with feature \( f^+[i], i \geq 0 \), is an occurrence of head \( h \) iff

- \( h \) has a matching feature \( f^−[i] \), and
- the \( i \)-th node \( n \) of the slice of \( h \) c-commands \( m \) in the derivation tree, and
- there is no head \( h' \) satisfying the previous conditions that is c-commanded by \( n \).
Find the Occurrences!

\[
\begin{align*}
D^+ & :\ D^- \\
Z^+ & :\ F^{-}[1] \\
X^+ & :\ X^- \\
Y^+ & :\ Y^- \\
z & :\ Z^- \\
x & :\ X^- \\
n & :\ f^+[1] \\
z & :\ Z^- \\
\end{align*}
\]
Find the Occurrences!

\[
\begin{align*}
D^+ & \quad Z^+ \\
\text{d} :: D^- & \quad \text{y} :: Y^- \\
X^+ & \quad Z^+ \\
x :: X^- & \quad \text{z} :: Z^- f^-[1] \\
\quad \quad X^+ & \quad f^+[1] \\
x :: X^- & \quad z :: Z^- f^-[1] \\
\quad \quad \quad \quad \quad z :: Z^- \\
\end{align*}
\]
Constraints on Move

**Constraint 1: Move**

For every head $h$ with $n$ negative Move features, $n \geq 1$, there exist $n$ distinct Move nodes that are occurrences of $h$.

**Constraint 2: SMC**

Every Move node is an occurrence of exactly one head.

**Corollary for Reset Lowering**

- No head has two negative Move features with both identical feature names and identical size values.
- The order of a head’s negative Move features is irrelevant.
Constraints on Move

**Constraint 1: Move**
For every head $h$ with $n$ negative Move features, $n \geq 1$, there exist $n$ distinct Move nodes that are occurrences of $h$.

**Constraint 2: SMC**
Every Move node is an occurrence of exactly one head.

**Corollary for Reset Lowering**
- No head has two negative Move features with both identical feature names and identical size values.
- The order of a head’s negative Move features is irrelevant.
General Strategy

- **Given**: derivation tree language of some TAG $G$
- **Step 1**: Put $G$ into a particular normal form.
- **Step 2**: Define a mapping from TAG derivations to Minimalist derivations.
  - Adjunction is Merger of auxiliary tree $T$ at adjunction site $A$ followed by lowering of the material below $A$ to $T$’s foot node.
- **Step 3**: Ensure the output is an MDTL.
Definition (TAG Derivation Tree)

A **TAG derivation tree** is a finite tree with each node’s label consisting of

- the **name** of an elementary tree $e$, and
- the **address** of the node where $e$ is adjoined/substituted (if such a node exists).

### Example

- **A**: $S^\epsilon$
  - $NP^0$
  - $VP^1$
  - $V^{10}$
  - $NP^{11}$
- **B**: $VP^\epsilon$
  - $Aux^0$
  - $VP^1$
- **A** $\rightarrow$ **B, 1**
Definition (TAG Derivation Tree)

A **TAG derivation tree** is a finite tree with each node’s label consisting of

- the **name** of an elementary tree e, and
- the **address** of the node where e is adjoined/substituted (if such a node exists).

Example

```
A: S^ε
  NP^0    VP^1
    V^10   NP^11

B: VP^ε
  Aux^0    VP^1

A → B, 1
```
Preprocessing

All elementary trees must be
- strictly binary branching, and
- projective.

Definition (Projectivity)

Every interior node is a projection of some (possibly empty) leaf that is neither a foot node nor a substitution node.
Initial Trees

Trees containing neither foot nodes nor substitution nodes are straight-forward, thanks to projectivity:

Example

\[
\begin{array}{c}
\text{ZP} \\
y \searrow \\
z
\end{array}
\quad
\begin{array}{c}
\text{Y}^+ \\
y :: Y^- \\
z :: Z^-
\end{array}
\]
Substitution

Substitution is handled by Merge, too:

Example

\[
\begin{align*}
\text{ZP} & \quad \text{ZP} \\
\text{DP} & \quad \text{DP} \\
\text{d} & \quad \text{n}
\end{align*}
\]

\[
\begin{align*}
\text{DP} & \quad \text{ZP} \\
\text{y} & \quad \text{z}
\end{align*}
\]

\[
\begin{align*}
\text{D}^+ & \quad \text{Y}^+ \\
\text{N}^+ & \quad \text{Y}^- \\
\text{D}^- & \quad \text{N}^- \\
n & \quad \text{y} \\
d & \quad \text{z}
\end{align*}
\]
Tree Adjunction

Tree Adjunction $\equiv$ Merge + Reset Lowering

Example
Comparing the Derived Trees

Diagram:

- Left tree:
  - Parent: ZP
  - Left child: DP
    - Left child: d
    - Right child: n
  - Right child: ZP
    - Left child: x
    - Right child: ZP
      - Left child: z
      - Right child: ZP
        - Left child: y
        - Right child: z

- Right tree:
  - Parent: 
    - Left child: <
      - Left child: d
      - Right child: n
    - Right child: >
      - Left child: x
      - Right child: <
        - Left child: z
        - Right child: >
          - Left child: y
          - Right child: z
An Example with Multiple Adjunctions
An elementary tree may have multiple MG correspondents.
An Example with Multiple Adjunctions

An elementary tree may have multiple MG correspondents.
Another Example with Multiple Adjunctions
Another Example with Multiple Adjunctions

D$^+$

N$^+$

d :: D$^-$  n :: N$^-$

X$^+$

x :: X$^-$  y :: Y$^-$  z :: Z$^-$ f$^-[1]$

Z$^+$

x :: X$^-$  f$^+[1]$

z :: Z$^-$ f$^-[1]$

z :: Z$^-$

Observation

A single feature name suffices for all instances of reset lowering.
Another Example with Multiple Adjunctions

Observation
A single feature name suffices for all instances of reset lowering.
But is it a Minimalist Derivation Tree Language?

- The output $L$ of the translation might not be a well-formed MDTL (some combinations of slices might be missing).
- However:
  - TAG derivation tree languages are regular,
  - the translation is a linear tree transduction,
  - regular tree languages are closed under linear tree transduction,
  - MDTLs are (almost) closed under intersection with regular tree languages (Graf 2011; Kobele 2011).
- Take the smallest superset $L'$ of $L$ that is an MDTL ($L'$ is guaranteed to exist) and intersect it with $L$.
- This yields the MDTL of some MG that generates all derived trees of the original TAG, and only those.
Even with only one feature name for reset lowering it is still possible to generate

$$a_1^n \ a_2^n \ \cdots \ a_{k-1}^n \ a_k^n$$

for any $k \geq 1$.

This is so because features are considered identical by the SMC only if they have the same size value.

⇒ size value can emulate additional feature names

If the SMC ignores the size value, only TALs can be generated.
Conclusion

- **Issue**
  - MGs have greater weak generative capacity than TAG.
  - Still the two generate incomparable classes of tree languages.
  - Can this gap be bridged?

- **Solution**
  - Adjunction cuts a tree $t$ into two halves $t_1$ and $t_2$, inserts new material and puts it all back together.
  - MGs generate the auxiliary tree in the intended position and lower $t_2$ to the foot node.

- **Future Research**
  - does not generalize well to higher-order TAG (Rogers 2003)
    — MGs with multiple feature names resemble MCTAG
  - Reset Lowering is not a particularly natural movement type.
  - Sideward Movement should also work, though.
  - More generally: What property must a movement type satisfy in order to subsume (higher-order) Tree Adjunction?
References


