

# Parsing Beyond Context-Free Grammars: FTAG: Feature based TAG

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# Case and agreement

- case assignment:

Joe expected her to come.

\*Joe expected she to come.

Joe saw her. / \*Joe saw she.

- person agreement:

You sing. / \*You sings.

She sings. / \*She sing.

- number agreement:

This woman sings. / \*This woman sing.

These women sing. / \*These women sings.

# Feature structures

- solution: *feature structures*
- a list of features (e.g. case) and values (e.g. nom)
- feature structures can be represented as *attribute value matrices*

women:

$$\begin{bmatrix} \text{cat} & \text{N} \\ \text{num} & \text{plur} \\ \text{pers} & 3 \\ \text{case} & \text{nom} \end{bmatrix}$$

sing:

$$\begin{bmatrix} \text{cat} & \text{V} \\ \text{num} & \text{plur} \\ \text{pers} & 3 \\ \text{vform} & \text{finite} \end{bmatrix}$$

- combining constituents via *unification* of feature structures

# Attribute value matrices

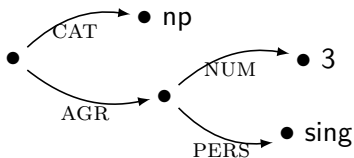
- atomic feature values

$$\begin{bmatrix} \text{NUM} & \text{sing} \\ \text{PERS} & 3 \end{bmatrix}$$

- feature values can be feature structures

$$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{sing} \\ \text{PERS} & 3 \end{bmatrix} \end{bmatrix}$$

- AVMs can be represented as directed graphs



# Reentrancy

- the paths that both lead to the same node → to the same value  
→ hence, they share that value
- this property is called *reentrancy*
- in AVMs, reentrancy is expressed by coindexing the shared values

$$\left[ \begin{array}{l} \text{CAT} \quad \text{vp} \\ \text{AGR} \quad \boxed{1} \left[ \begin{array}{l} \text{NUM} \quad \text{pl} \\ \text{PERS} \quad 3 \end{array} \right] \\ \text{HEAD} \quad \left[ \text{AGR} \quad \boxed{1} \right] \end{array} \right]$$

# Unification

- unification is a partial operation on feature structures
  - operation of combining two feature structures such that the new feature structure contains all the information of the original two and nothing more
- e.g.  $F_1 \sqcup F_2 = F_3$

$$F_1 : \begin{bmatrix} \text{CAT} & \text{vp} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{pl} \end{bmatrix} \end{bmatrix} \sqcup \begin{bmatrix} \text{CAT} & \text{vp} \\ \text{AGR} & \begin{bmatrix} \text{PERS} & 3 \end{bmatrix} \end{bmatrix} = \begin{bmatrix} \text{CAT} & \text{vp} \\ \text{AGR} & \begin{bmatrix} \text{NUM} & \text{pl} \\ \text{PERS} & 3 \end{bmatrix} \end{bmatrix}$$

# Unification

- partial operation  $\rightarrow$  unification does not always return a result  $\rightarrow$  unification can fail
- the AVMs have to match

$F_1$ :

$F_2$ :

$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{NUM} & \text{sg} \end{bmatrix}$

$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{NUM} & \text{pl} \end{bmatrix}$

- features can be underspecified

$F_3$ :

$F_4$ :

$F_3 \sqcup F_4$ :

$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{NUM} & \text{nom/acc} \end{bmatrix}$

$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{NUM} & \text{acc} \end{bmatrix}$

$\begin{bmatrix} \text{CAT} & \text{np} \\ \text{NUM} & \text{acc} \end{bmatrix}$

# Unification examples

- F: 
$$\left[ \begin{array}{l} \text{AGR} \left[ \text{NUM} \quad \text{sg} \right] \\ \text{SUBJ} \left[ \text{AGR} \left[ \text{NUM} \quad \text{sg} \right] \right] \end{array} \right]$$

- G: 
$$\left[ \begin{array}{l} \text{SUBJ} \left[ \text{AGR} \left[ \text{PERS} \quad 3 \right] \right] \end{array} \right]$$

- F  $\sqcup$  G: 
$$\left[ \begin{array}{l} \text{AGR} \left[ \text{NUM} \quad \text{sg} \right] \\ \text{SUBJ} \left[ \text{AGR} \left[ \begin{array}{l} \text{NUM} \quad \text{sg} \\ \text{PERS} \quad 3 \end{array} \right] \right] \end{array} \right]$$



# Unification examples

- $F: \left[ \begin{array}{l} \text{AGR} \quad \boxed{1} \left[ \text{NUM} \quad \text{sg} \right] \\ \text{SUBJ} \quad \left[ \text{AGR} \quad \boxed{1} \right] \end{array} \right]$
- $G: \left[ \begin{array}{l} \text{SUBJ} \quad \left[ \text{AGR} \quad \left[ \text{PERS} \quad 3 \right] \right] \end{array} \right]$
- $F \sqcup G: \left[ \begin{array}{l} \text{AGR} \quad \boxed{1} \left[ \begin{array}{l} \text{NUM} \quad \text{sg} \\ \text{PERS} \quad 3 \end{array} \right] \\ \text{SUBJ} \quad \left[ \text{AGR} \quad \boxed{1} \right] \end{array} \right]$

# TAG without feature structures

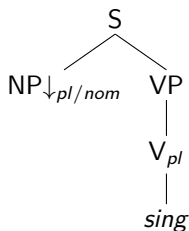
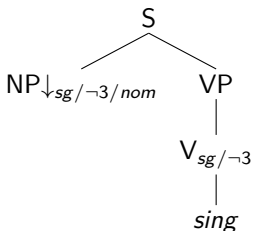
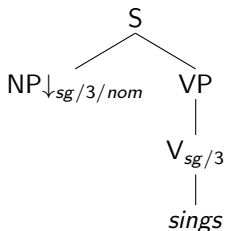
- agreement without feature structures:
  - generalization of agreement is not captured
  - every morphological alternative gives rise to a new elementary tree

NP<sub>sg/3/nom</sub>  
|  
*she*

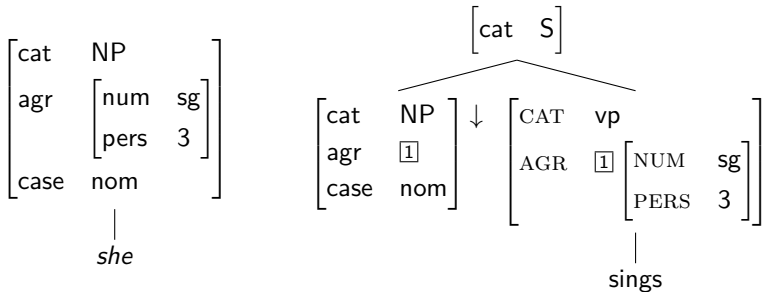
NP<sub>sg/3/acc</sub>  
|  
*her*

NP<sub>pl/1/nom</sub>  
|  
*we*

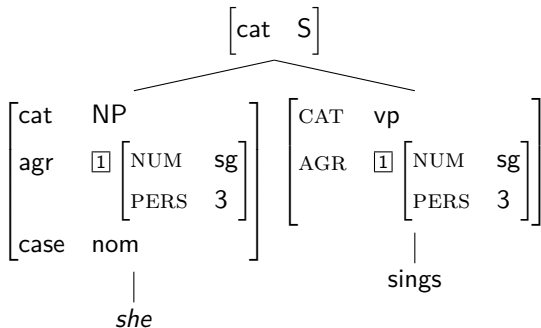
NP<sub>sg/1/acc</sub>  
|  
*us*



# Feature structures as tree nodes



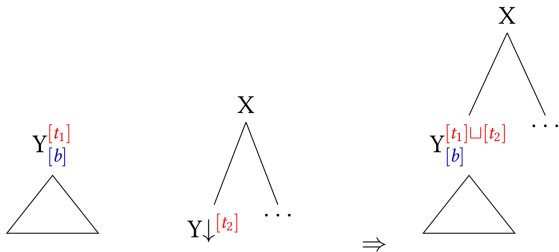
# Feature structures as tree nodes



- TAG + feature structures = FTAG [VSJ88]
- Idea: feature structures used as non-terminal nodes
- Advantage: smaller grammars that are easier to maintain
- Capture agreement
  - She sings. \*She sing.  
→ the finite verb and its subject agree in number and person
- Capture case marking
  - Pim likes her. \*Pim likes she.  
→ the object of a transitive verb must be in accusative case

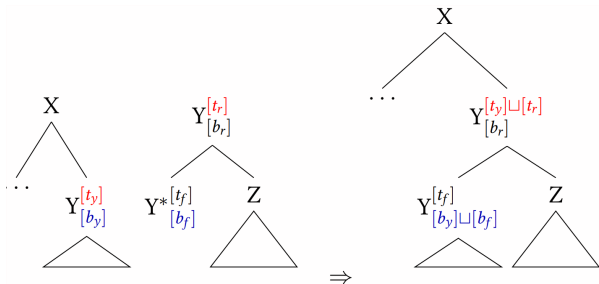
# FTAG: substitution

- The top features of the root of the tree to substitute unify with the top features of the substitution node



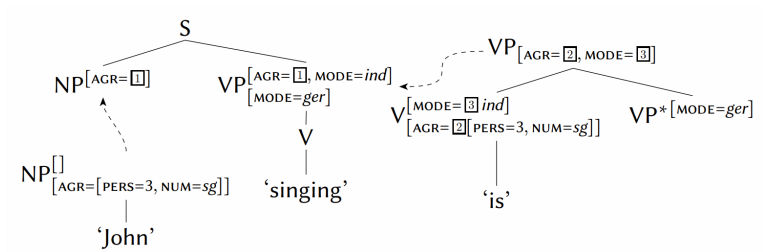
# FTAG: adjunction

- The top features of the root of the auxiliary tree unify with the top features of the adjunction node, and the bottom features of the footnode of the auxiliary tree unify with the bottom features of the adjunction node.



# FTAG: example

① John is singing.





# References I

- [VSJ88] K. Vijay-Shanker and Aravind K. Joshi.  
Feature structures based tree adjoining grammar.  
In *Proceedings of COLING*, pages 714–719, Budapest, 1988.