Incremental Semantic Role Labeling with Tree Adjoining Grammar

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Human Language Processing

Human language processing is *incremental:* we update our parse of the input for each new word that comes in.

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Incrementality leads to local ambiguity, which we can observe in *garden path sentences:*

(1) a. The old man the boat.
    b. I convinced her children are noisy.

Human Language Processing

Many garden paths are not due to syntactic ambiguity alone, they also involve *semantic role ambiguity*

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(2) The athlete realised her goals . . .

a. . . . at the competition.

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This indicates that humans *incrementally* assign semantic roles.

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a. ... at the competition.

b. ... were out of reach.

This indicates that humans *incrementally* assign semantic roles.

Let's look at this example in more detail.

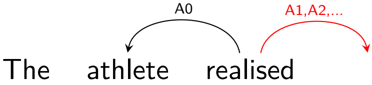
Human Language Processing - Example

A0

The athlete realised

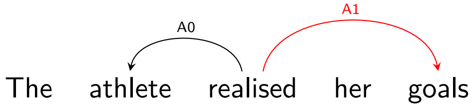
⟨A0,athlete,realised⟩

Human Language Processing - Example



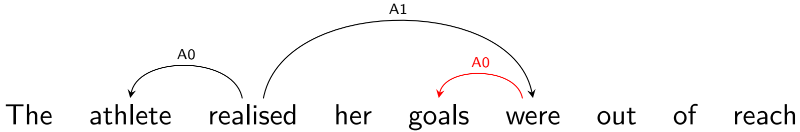
⟨A0,athlete,realised⟩
⟨[A1,A2],nil,realised⟩

Human Language Processing - Example



⟨A0,athlete,realised⟩
⟨A1,goals,realised⟩

Human Language Processing - Example



⟨A0,athlete,realised⟩
⟨A1,were,realised⟩
⟨A0,goals,were⟩

Incremental Semantic Role Labeling

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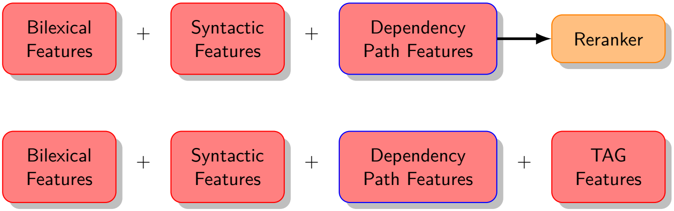
- Given a sentence prefix and its partial syntactic structure:
  1. Identify Arguments and Predicates
  2. Assign correct role labels
- Assign incomplete semantic roles

Non-incremental SRL

Pipeline approach

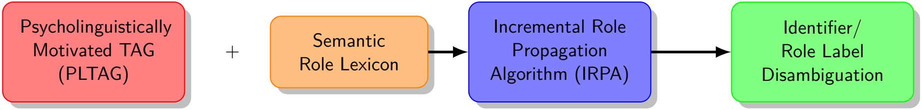
- Liu and Sarkar (2007)
- Màrquez et al. (2008)
- Björkelund et al. (2009) (MATE)



Màrquez et al. (2008), Björkelund et al. (2009)

Liu and Sarkar (2007)

Model


Psycholinguistically Motivated TAG (PLTAG)
+
Semantic Role Lexicon
Incremental Role Propagation Algorithm (IRPA)
Identifier/ Role Label Disambiguation

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- the standard TAG operations are substitution and adjunction;
- it adds verification to verify predictive trees;

PLTAG supports parsing with incremental, fully connected structures.

PLTAG

Lexicon:

- Standard TAG lexicon
- Predictive lexicon (PLTAG)

Operations:

- Substitution
- Adjunction
- Verification (PLTAG)

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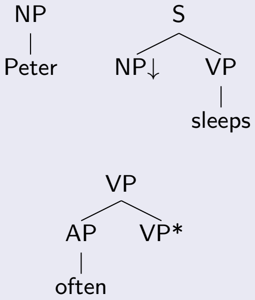
Example

Initial Tree:

Auxiliary Tree:



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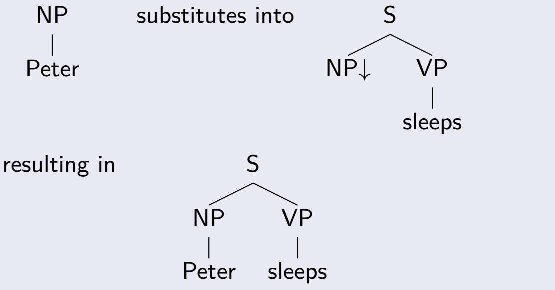

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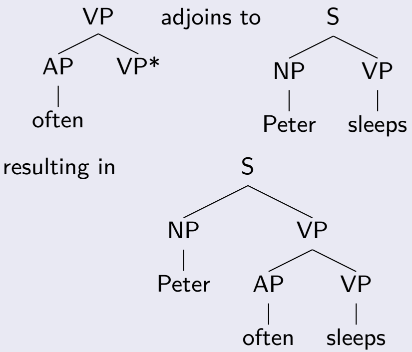

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Example

Prediction Tree:

$$\mathrm{S}_k \to \mathrm{NP}^k\!\downarrow \quad \mathrm{VP}^k_k$$

Index k marks predicted node.

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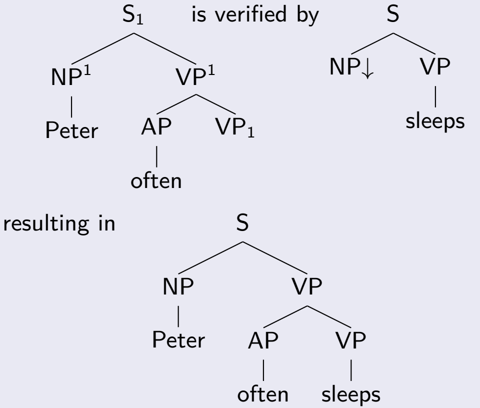
Example

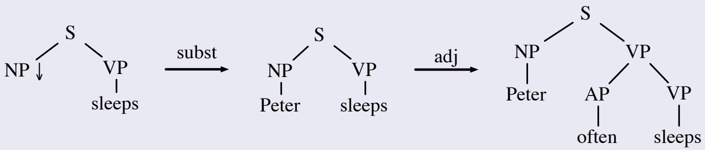


All nodes indexed with k have to be verified.

Comparison with TAG

TAG derivations are not always incremental.

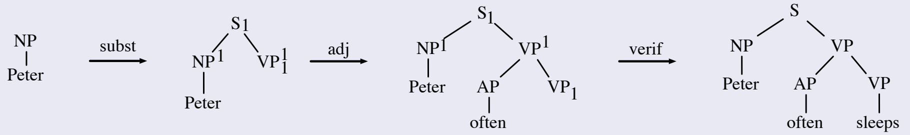
Example



Comparison with TAG

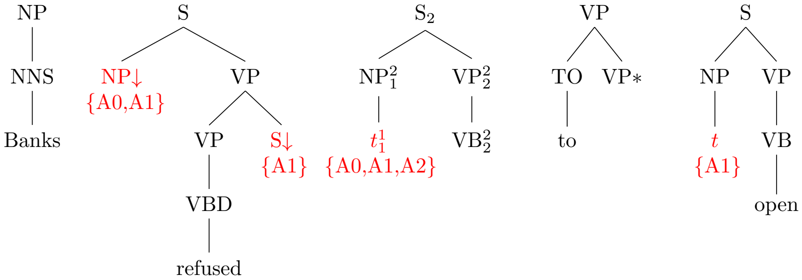
PLTAG derivation are always incremental and fully connected.

Example

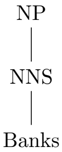


Semantic Roles in Lexicon

Used information for verb predicates *only*, derived from PropBank (Palmer, 2005)



Incremental Role Propagation Algorithm



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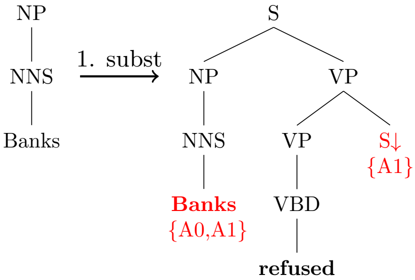

1. NP $\rightarrow$ ⟨{A0,A1},Banks,refused⟩
   S $\rightarrow$ ⟨A1,nil,refused⟩

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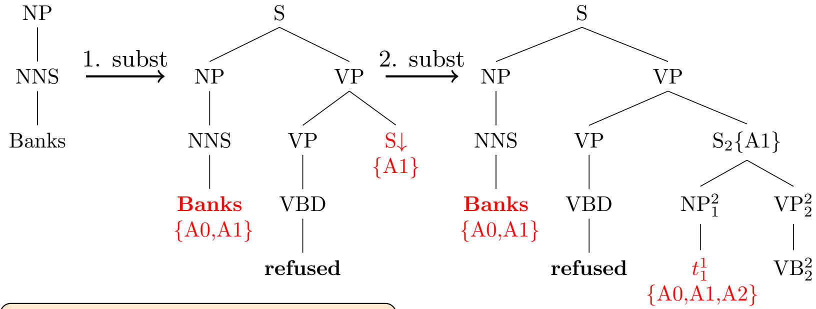

1. $\text{NP} \rightarrow \langle\{\text{A0,A1}\},\text{Banks},\text{refused}\rangle$
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2. $\text{NP} \rightarrow \langle\{\text{A0,A1}\},\text{Banks},\text{refused}\rangle$
   $\text{S} \rightarrow \langle\text{A1},S_2,\text{refused}\rangle$
   $\text{NP} \rightarrow \langle\{\text{A0,A1,A2}\},t,\text{nil}\rangle$

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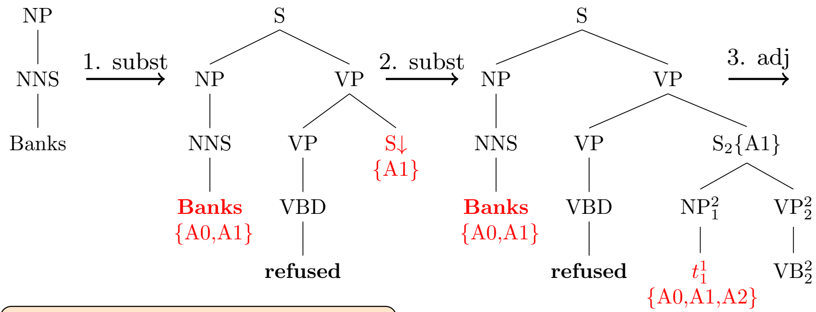

1. NP $\rightarrow \langle$\{A0,A1\},Banks,refused$\rangle$
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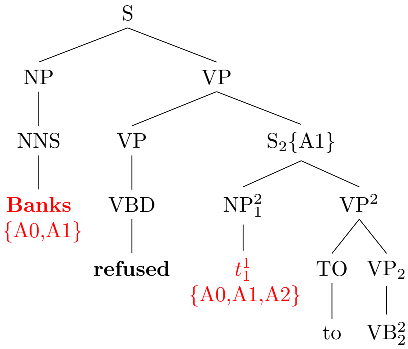
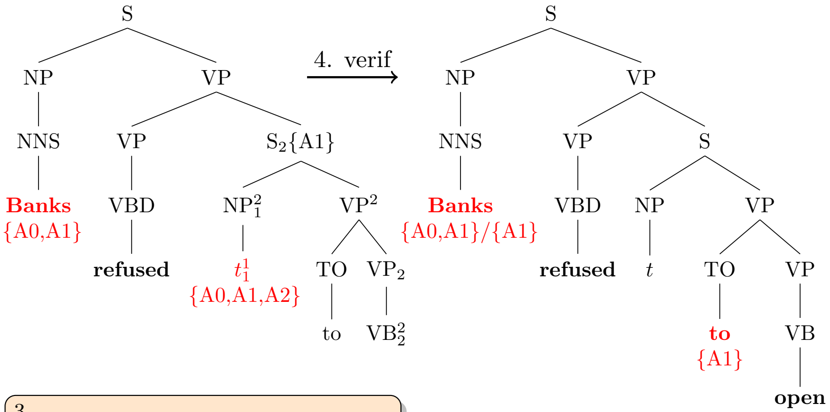


3. —

Incremental Role Propagation Algorithm



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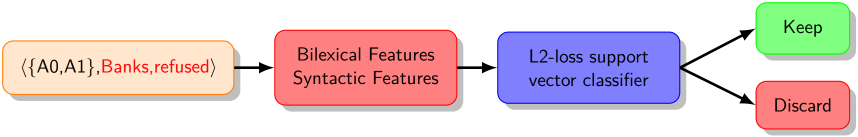
4. NP $\rightarrow$ ⟨{A0,A1},Banks,refused⟩
   S $\rightarrow$ ⟨A1,to,refused⟩
   NP $\rightarrow$ ⟨A1,Banks,open⟩

Argument Identification - Role Label Disambiguation

Argument Identification



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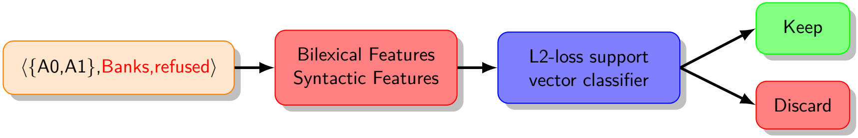
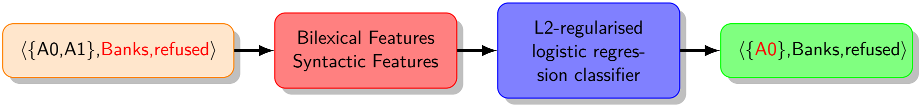


Role Label Disambiguation



Experiments

- Train PLTAG on sections WSJ 02-21 (79.41% F_1)
- Train classifiers on CoNLL 2009 (Ident.: 92.18%, Lab.: 82.37%)
- Gold lexicon entries during parsing - CoNLL-SRL-only task

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Evaluation

- Full sentence Accuracy (F_1)
- Unlabelled Prediction Score (UPS)
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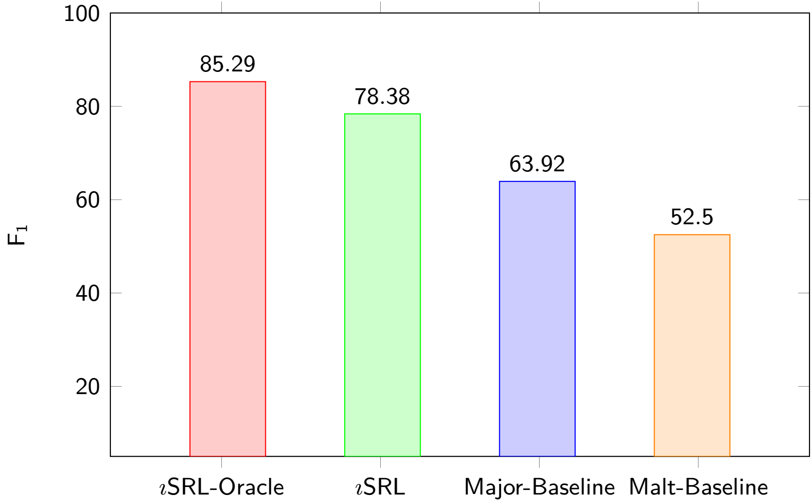
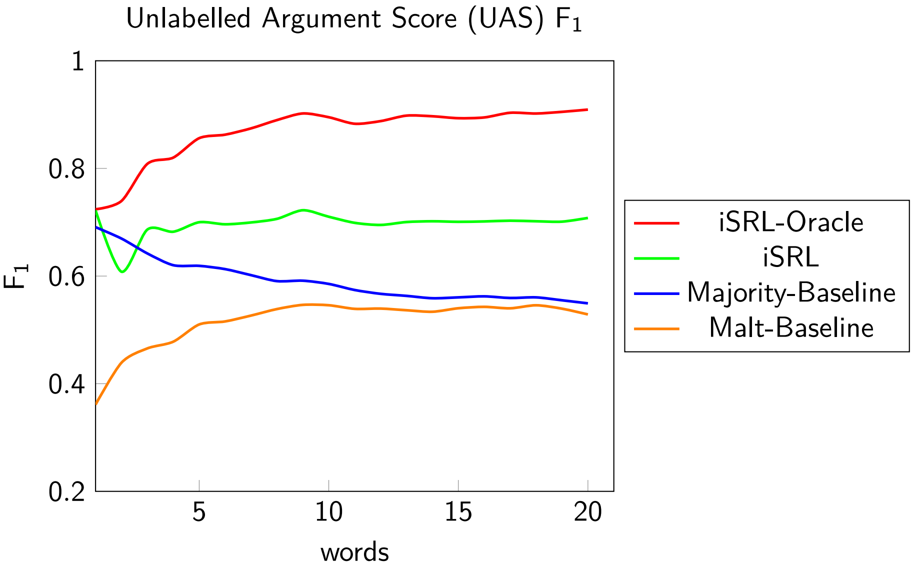
System Comparison

- $\imath$SRL -Oracle
- $\imath$SRL
- Majority-Baseline
- Malt-Baseline

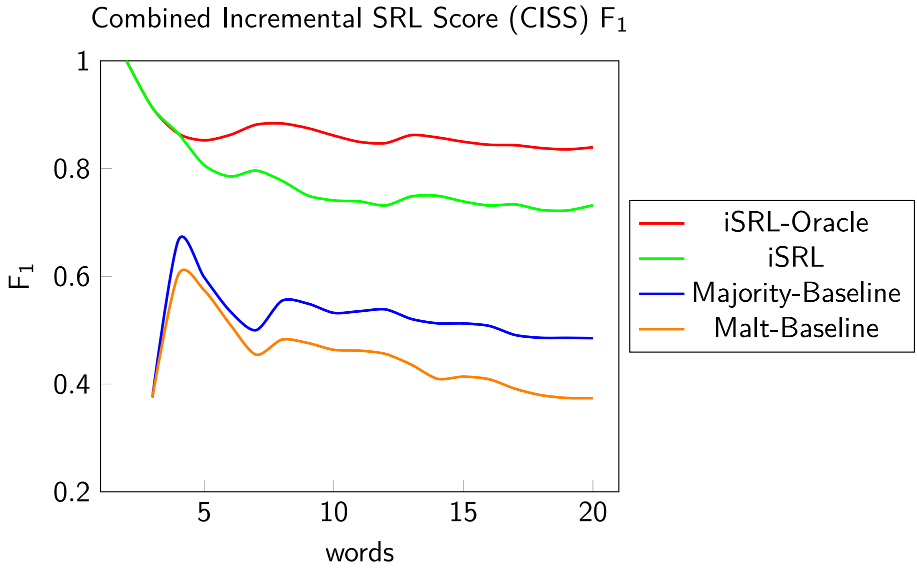
Results - Full sentence



Results - Incremental



Results - Incremental



Conclusions

- New task of Incremental Semantic Role Labeling
- Our system combines:
  - Psycholinguistically Motivated TAG (PLTAG)
  - Semantic Role Lexicon
  - Incremental Role Propagation Algorithm (IRPA)
  - Argument Identification, Role Disambiguation Classifiers
- Outperforms baselines
- Performs well incrementally: predicts (in)-complete triples early in the sentence

Fusing Syntax with Semantics

- Use $\imath$SRL labels as pivotal points and score with model of semantics
- PLTAG Parser Reranker

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Banks

$$y^* \qquad f(d_1^*) \times \alpha$$

$$\hat{y} \qquad \begin{pmatrix} f(d_{11}) \times \alpha & & \\ f(d_{21}) \times \alpha & & \\ f(d_{31}) \times \alpha & & \\ f(d_{41}) \times \alpha & \rightarrow & \hat{y}_1 \\ f(d_{51}) \times \alpha & & \end{pmatrix}$$

$$\alpha \leftarrow \alpha + f(d_1^*) - f(d_{41})$$

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$$
\begin{array}{lcc}
 & \text{Banks} & \text{refused} \\
y^* & f(d_1^*) \times \alpha & f(d_2^*) \times \alpha \\
\hat{y} & \begin{pmatrix} f(d_{11}) \times \alpha & & \\ f(d_{21}) \times \alpha & & \\ f(d_{31}) \times \alpha & & \\ f(d_{41}) \times \alpha & \rightarrow & \hat{y}_1 \\ f(d_{51}) \times \alpha & & \end{pmatrix} & \begin{pmatrix} f(d_{12}) \times \alpha & & \\ f(d_{22}) \times \alpha & \rightarrow & \hat{y}_2 \\ f(d_{32}) \times \alpha & & \\ f(d_{42}) \times \alpha & & \\ f(d_{52}) \times \alpha & & \end{pmatrix} \\
 & \alpha \leftarrow \alpha + f(d_1^*) - f(d_{41}) & \alpha \leftarrow \alpha + f(d_2^*) - f(d_{22})
\end{array}
$$

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$$
\begin{array}{cccc}
 & \text{Banks} & \text{refused} & \text{to} \\
y^* & f(d_1^*)\times\alpha & f(d_2^*)\times\alpha & f(d_3^*)\times\alpha \\
\hat{y} &
\begin{pmatrix} f(d_{11})\times\alpha & \\ f(d_{21})\times\alpha & \\ f(d_{31})\times\alpha & \\ f(d_{41})\times\alpha & \rightarrow\ \hat{y}_1 \\ f(d_{51})\times\alpha & \end{pmatrix} &
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\begin{pmatrix} f(d_{13})\times\alpha & \\ f(d_{23})\times\alpha & \rightarrow \hat{y}_3 \\ f(d_{33})\times\alpha & \\ f(d_{43})\times\alpha & \\ f(d_{53})\times\alpha & \end{pmatrix} &
\begin{pmatrix} f(d_{14})\times\alpha & \\ f(d_{24})\times\alpha & \\ f(d_{34})\times\alpha & \rightarrow \hat{y}_4 \\ f(d_{44})\times\alpha & \\ f(d_{54})\times\alpha & \end{pmatrix} \\
 & \alpha \leftarrow \alpha + f(d_1^*) - f(d_{41}) & \alpha \leftarrow \alpha + f(d_2^*) - f(d_{22}) & \alpha \leftarrow \alpha + f(d_3^*) - f(d_{23}) & \alpha \leftarrow \alpha + f(d_4^*) - f(d_{34})
\end{array}
$$

Features

- Baseline PLTAG probability model score
- Syntactic Features
  - Current lexicon entry
  - Previous lexicon entry
  - Bigram lexicon entries
  - Unlexicalised features
- Current SRL triple(s)
- Semantic Score

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Semantic Score

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- Sayeed and Demberg, ongoing: Baroni and Lenci, 2010 -inspired also trained using SRL instead of dependencies
- Baselines (No syntax)
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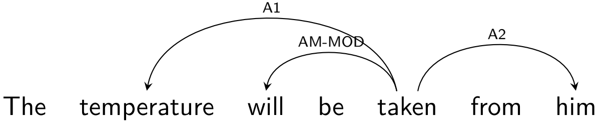
Multiple Triples (vary composition function)



⟨A1,temperature,taken⟩
⟨AM-MOD,will,taken⟩
⟨A2,him,taken⟩

Thank you