The UPV Translation System for IWSLT 2009

Authors: *Guillem Gascó i Mora*
Joan Andreu Sánchez Peiró

INSTITUTO TECNOLÓGICO DE INFORMÁTICA

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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Motivation and Related Work

- Motivation
  - PBT systems tend to be weak on target language fluency.
  - Long-range dependencies or reorderings cannot be controlled by the n-gram language models.
  - Extending PBT systems with syntactic information is difficult.
  - Syntactic MT systems usually solve such problems but have a low sentence coverage.
  - Solution proposed: Fill the gap between both approaches presenting a hybrid system that uses Stochastic Inversion Transduction Grammars.

- Related Work
  - Maximum entropy models for BTG statistical MT [Xiong06] [Xiong08].
  - Hierarchical MT systems [Chiang 05]
  - Syntax Augmented MT [Venugopal 06]

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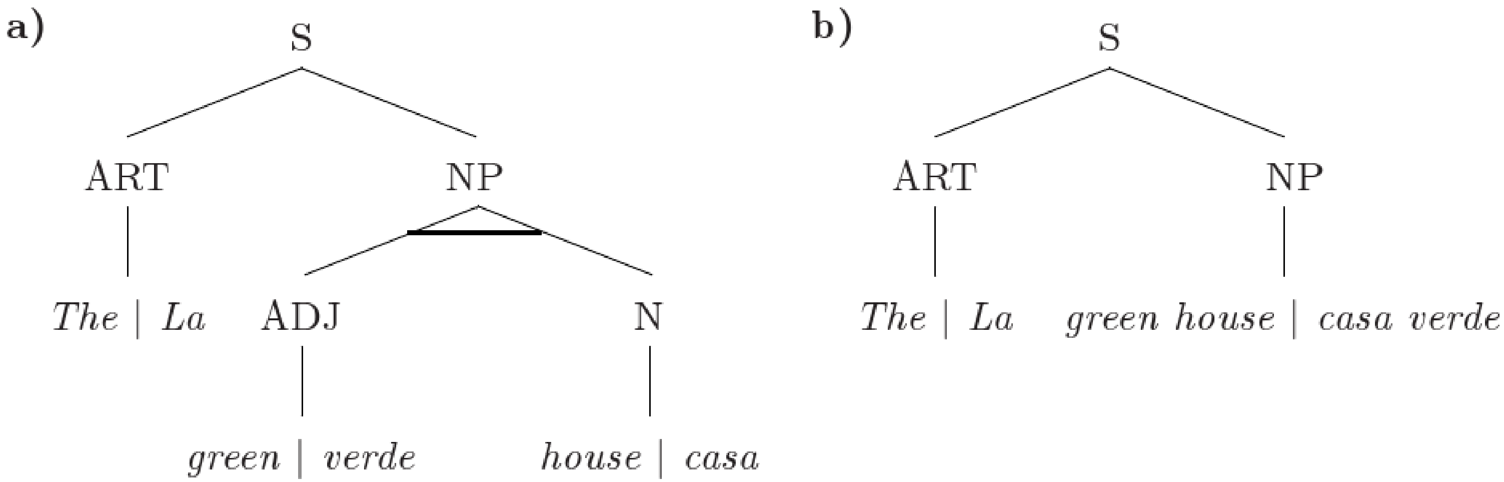
Theoretical Framework: Stochastic Phrasal ITG

- Phrasal Inversion Transduction Grammars $(\mathcal{N}, \Sigma, \Delta, S, \mathcal{R})$:
  - Direct Syntactic rule: $A \rightarrow [BC]$ where A,B,$C \in \mathcal{N}$
  - Inverse Syntactic rule: $A \rightarrow \langle BC \rangle$ where A,B,$C \in \mathcal{N}$
  - Lexical rule: $A \rightarrow x/y$ where $x \in \Sigma^*$ and $y \in \Delta^*$



- SPhITG: Stochastic extension of PhITG.

$$\sum_{B,C \in \mathcal{N}} (\Pr(A \rightarrow [B\ C]) + \Pr(A \rightarrow \langle B\ C \rangle)) + \sum_{\substack{x \in \Sigma^* \\ y \in \Delta^*}} (\Pr(A \rightarrow x/y) = 1$$

Translation Model

- Translation goal:

$$(t^*, D^*) = \operatorname*{argmax}_{t,D} \Pr(S \stackrel{D}{\Longrightarrow} s/t)$$

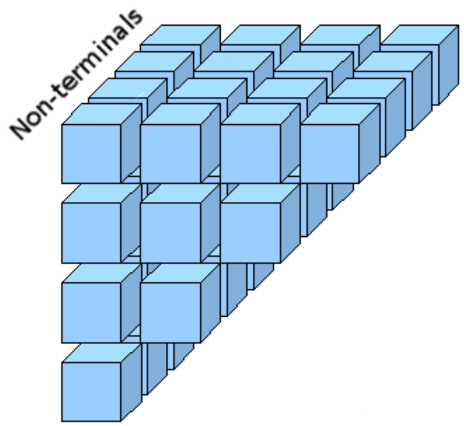
- Log-linear model over the derivations:

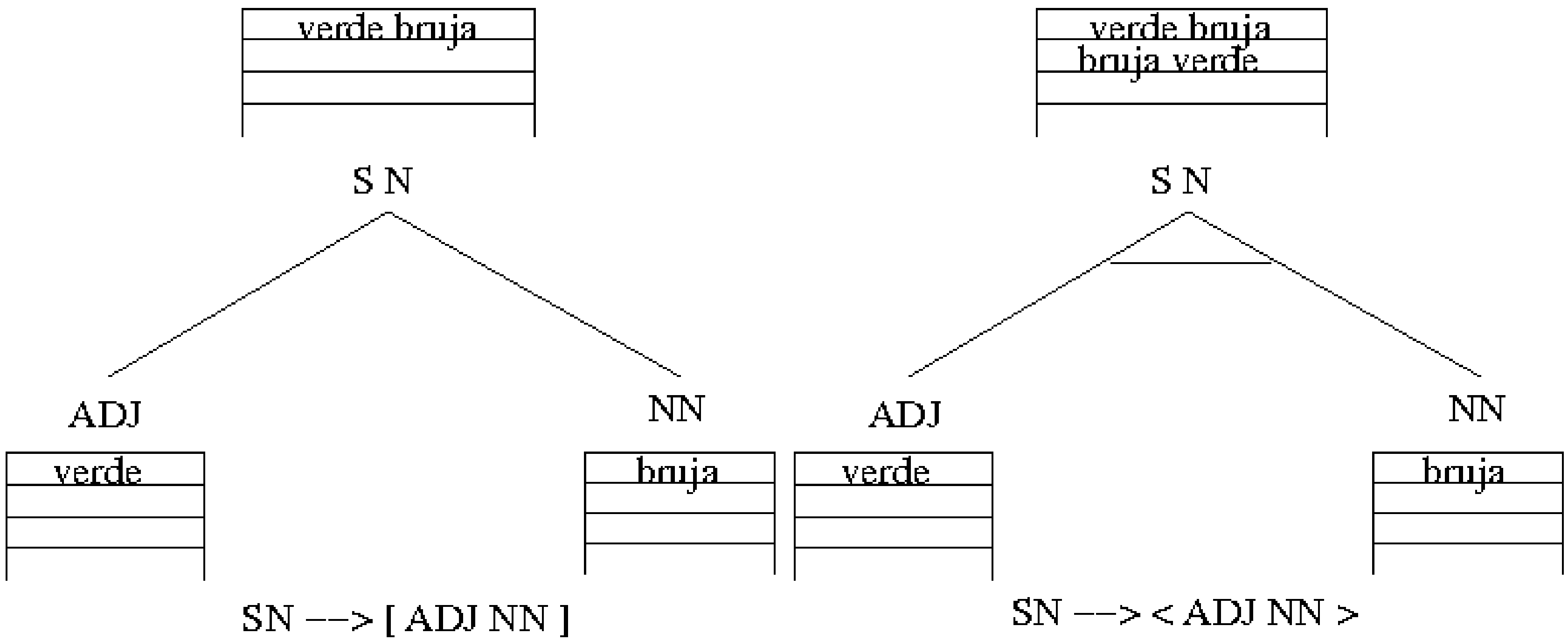
$$\Pr(D) = \prod_i h_i(D)^{\lambda_i}$$

- Models used: Usual models of PBT systems and the syntactic model (probability of the syntactic SITG rules used in D).

Decoding Algorithm

- Without n-gram language model: CKY-like chart decoding.
- Using the n-gram language model: A Hypotheses stack in each cell of the chart.
- Optimization strategies: Recombination of hypotheses, beam pruning and histogram pruning.





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SITG Training

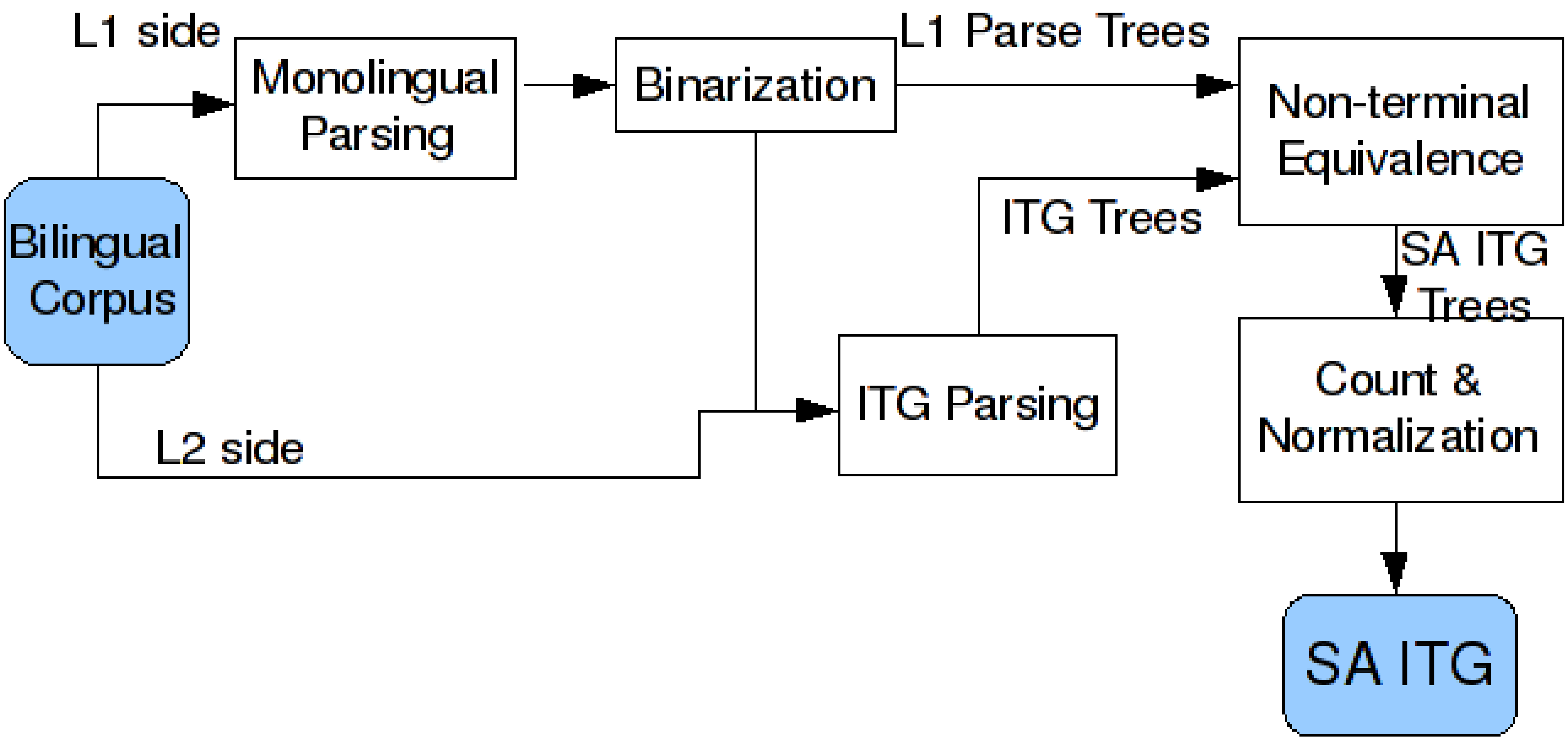
- Initial ITG:
  - Lexical rules from alignments, all with the same non-terminal.
  - All the possible syntactical rules using 4 non-terminals (from NT1 to NT4) with a random probability.

$$NT1 \rightarrow [NT1\ NT1] \ \ ... \ \ NT4 \rightarrow \langle NT4\ NT4 \rangle$$

- Reestimation of the SITG using the Viterbi reestimation algorithm:
  - Get the most likely ITG parse trees.
  - Estimate probabilities by counting productions and normalizing.

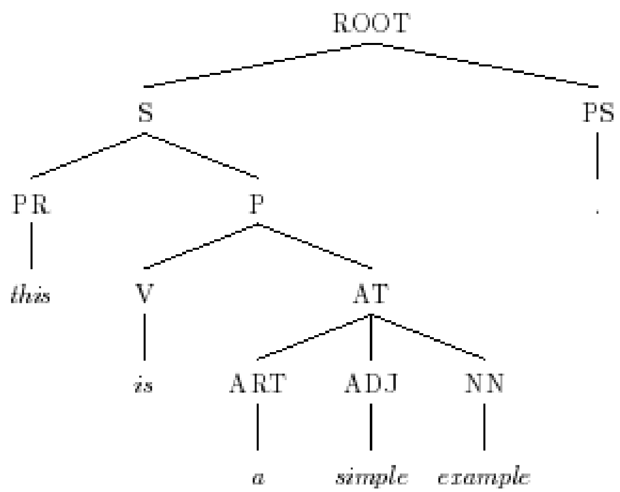
SITG Training

- Association of linguistic meaning (from the input) to the SITG non-terminals.



SITG Training

this is a simple example . # esto es un ejemplo simple .



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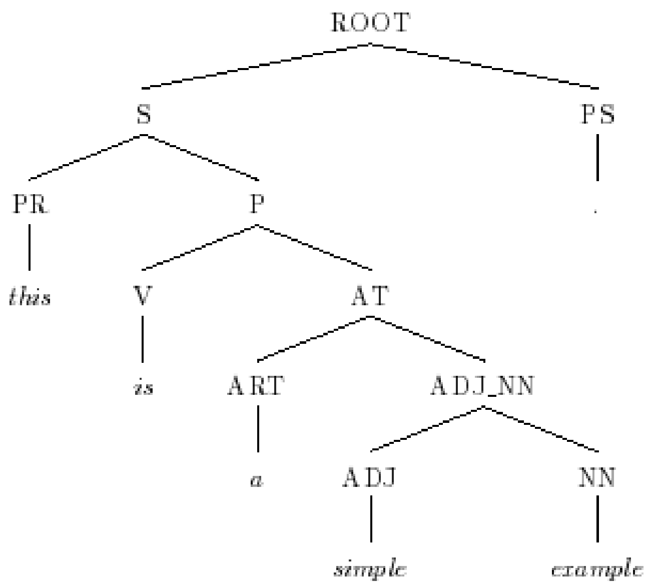

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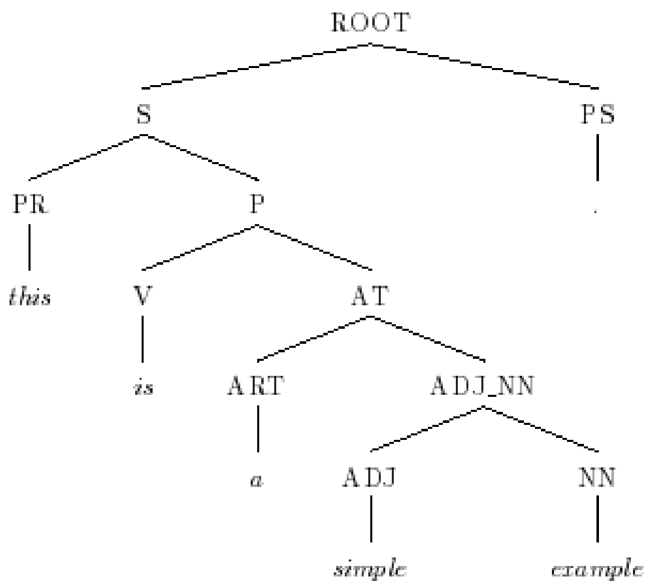

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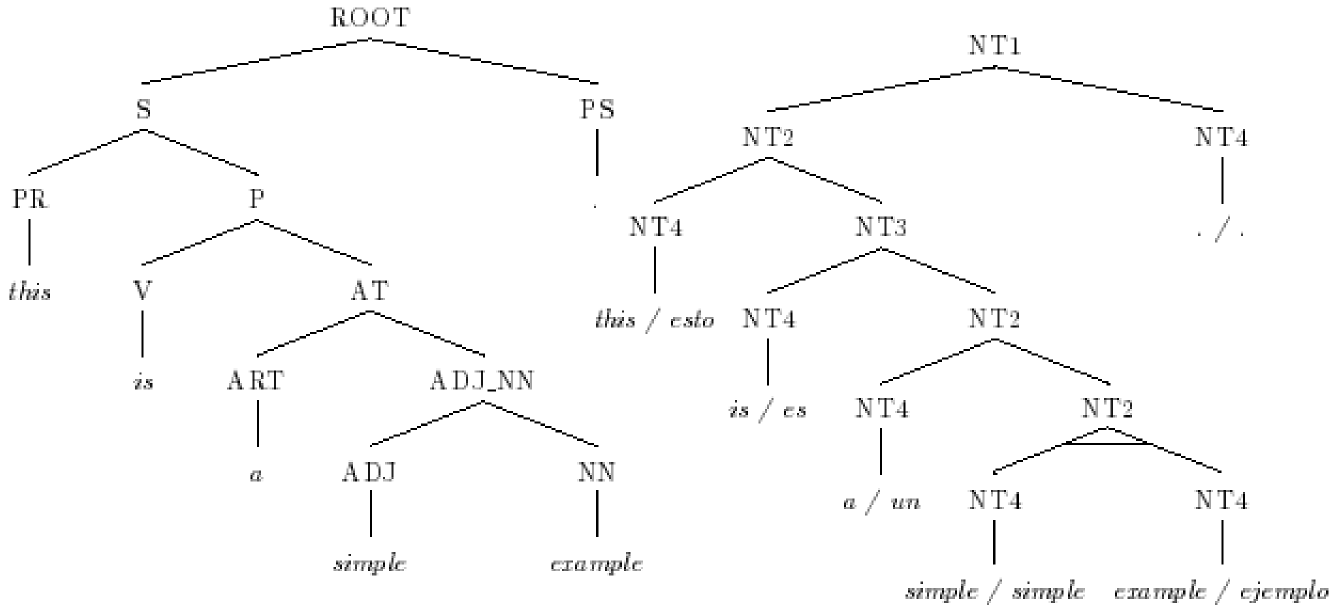

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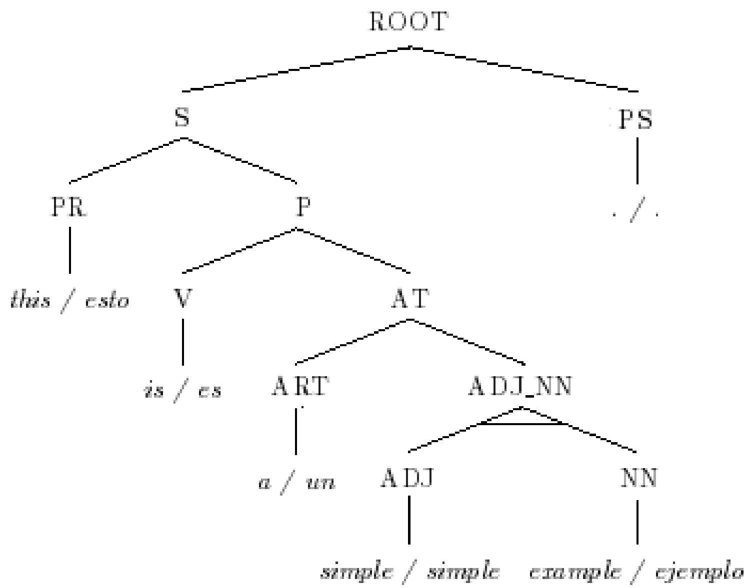

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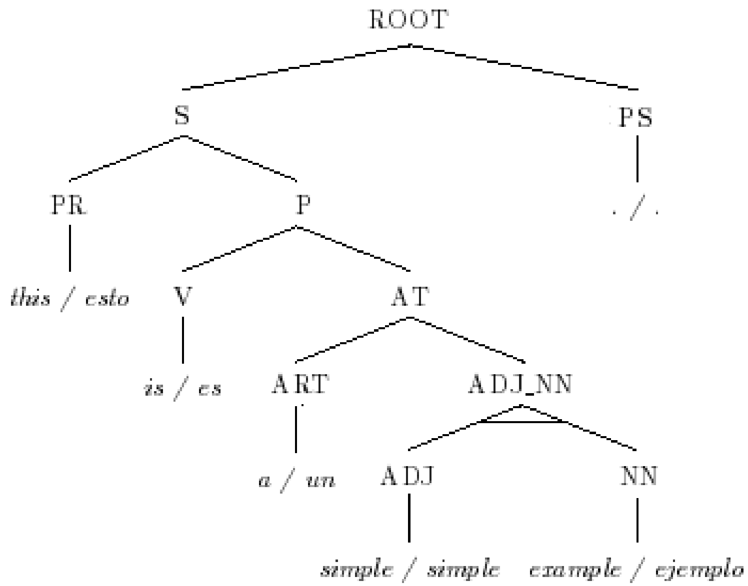
SITG Training

this is a simple example . # esto es un ejemplo simple .

```
ROOT --> [ S PS ]
S      --> [ PR P ]
P      --> [ V AT ]
AT     --> [ ART ADJ_NN ]
ADJ_NN --> < ADJ NN >
PS     --> . / .
PR     --> this / esto
V      --> is / es
ART    --> a / un
ADJ    --> simple / simple
NN     --> example / ejemplo
```



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Experimental Results

- Translation experiments over IWSLT08 Chinese-English corpus:

		Chinese	English
Training	Sentences	19.972	
	Words	171,591	188,960
	Vocabulary Size	8,428	7,182
DevSet	Sentences	489	
	Words	3,169	3,861
	OOV Words	111	115
Test	Sentences	507	
	Words	3,357	-
	OOV Words	97	-

- Baseline System: PBT system with the same phrase table.

Experiment	% BLEU
Baseline	41.1
Initial SITG	41.23
Reestimated SITG	41.79
SAITG	42.85

Experimental Results

PBT	this one and what 's the difference between ?
SAITG	what 's the difference between this with that ?
Ref	how is this one different from that one ?
PBT	call mr. is three four one four five six seven .
SAITG	call mr. is three six four five seven four one .
Ref	the number for s nicholas is three six four five seven four one .
PBT	can i go to the front row ?
SAITG	is it okay to the front row ?
Ref	can i go up to the front ?

- Some rules obtained:

$$\Pr(\text{QP} \rightarrow [\text{CD CD}]) = 0.147$$
$$\Pr(\text{QP} \rightarrow \langle\text{CD CD}\rangle) = 0.046$$
$$\Pr(\text{QP} \rightarrow [\text{CD QP}]) = 0.284$$
$$\Pr(\text{QP} \rightarrow \langle\text{QP CD}\rangle) = 0.061$$

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Conclusions

- SITG based decoder.
- Analyzed heuristics to train the SITG.
- Phrase table from a PBT system.
- When no syntactic information is used, it is almost equivalent to a PBT.
- The use of linguistic information improve the results.

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CKY-like Algorithm

$$\delta_{ij}(A) = \max_t \Pr(A \stackrel{*}{\Rightarrow} s_i^j/t) \qquad \text{For all } A \in N \text{ and } i,j \text{ such that } \begin{cases} 0 \leq i < j \leq |s|, \\ j - i \geq 1, \end{cases}$$

$$\delta_{ij}(A) = \max(\delta_{ij}^{[]}(A), \delta_{ij}^{\langle\rangle}(A), \max_t \Pr(A \rightarrow s_i^j/t)) \tag{1}$$

where

$$\delta_{ij}^{[\,]}(A) = \begin{cases} \max\limits_{\substack{B,C \in N \\ i<I\leq j}} \Pr(A \rightarrow [BC])\delta_{iI}(B)\delta_{Ij}(C) & \text{if } j - i > 1 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

$$\delta_{ij}^{\langle\rangle}(A) = \begin{cases} \max\limits_{\substack{B,C \in N \\ i<I\leq j}} \Pr(A \rightarrow \langle BC\rangle)\delta_{iI}(B)\delta_{Ij}(C) & \text{if } j - i > 1 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

CKY-like Algorithm

$$\tau_{ij}(A) = \underset{t}{\text{argmax}}(\Pr(A \Rightarrow^* s_i^j/t))$$

$$\tau_{ij}(A) = \begin{cases} t & \text{if } \Pr(A \rightarrow s_i^j/t) \quad \text{is the maximum in (1)} \\[2ex] \tau_{iI}(B)\tau_{Ij}(C) & \text{if } \Pr(A \rightarrow [BC])\delta_{iI}(B)\delta_{Ij}(C) \\ & \text{is the maximum in (1)} \\[2ex] \tau_{Ij}(C)\tau_{iI}(B) & \text{if } \Pr(A \rightarrow \langle BC \rangle)\delta_{iI}(B)\delta_{Ij}(C) \\ & \text{is the maximum in (1)} \end{cases} \tag{4}$$

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