

Tree Parsing with Synchronous Tree-Adjoining Grammars

Matthias Büchse Mark-Jan Nederhof Heiko Vogler

International Conference on Parsing Technologies

October 2011

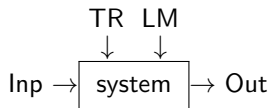
Translation System Example

TR: $\text{Tree} \times \text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ translation probabilities (French, English)

LM: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ probabilities for English parse trees

Inp: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ input weighted tree language

Out: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ output weighted tree language



$$\text{Out}(e) = \sum_{f \in \text{Tree}} \text{Inp}(f) \cdot \text{TR}(f, e) \cdot \text{LM}(e)$$

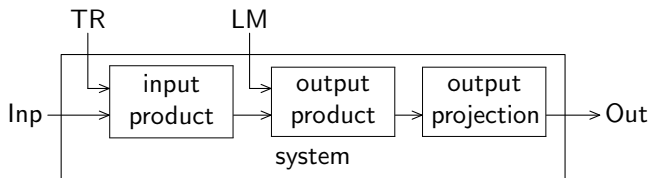
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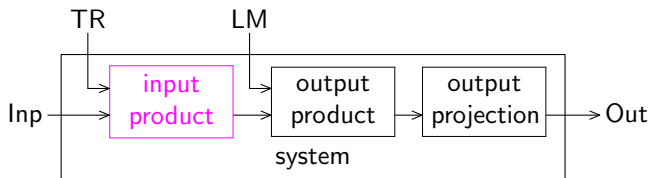
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$$\begin{aligned} \text{Out}(e) &= \sum_{f \in \text{Tree}} \text{Inp}(f) \cdot \text{TR}(f, e) \cdot \text{LM}(e) \\ &= \sum_{f \in \text{Tree}} (\text{Inp} \triangleleft \text{TR})(f, e) \cdot \text{LM}(e) \end{aligned}$$

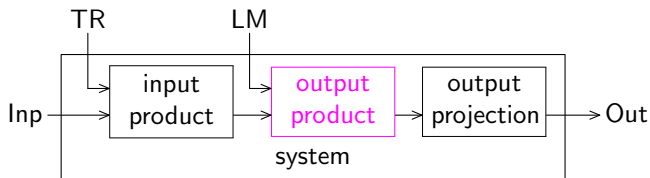
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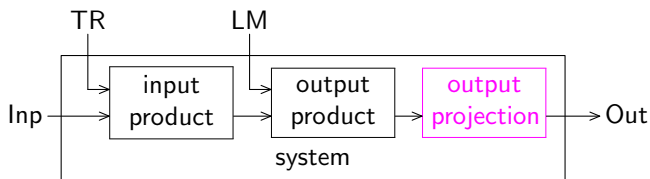
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$$\begin{aligned} \text{Out}(e) &= \sum_{f \in \text{Tree}} \text{Inp}(f) \cdot \text{TR}(f, e) \cdot \text{LM}(e) \\ &= \text{Proj}((\text{Inp} \triangleleft \text{TR}) \triangleright \text{LM})(e) \end{aligned}$$

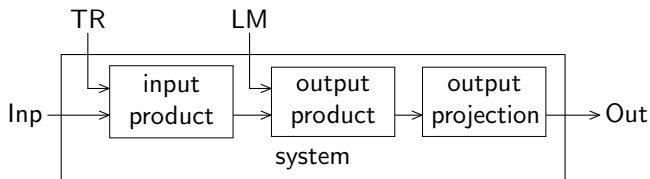
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$$\text{Out} = \text{Proj}((\text{Inp} \triangleleft \text{TR}) \triangleright \text{LM})$$

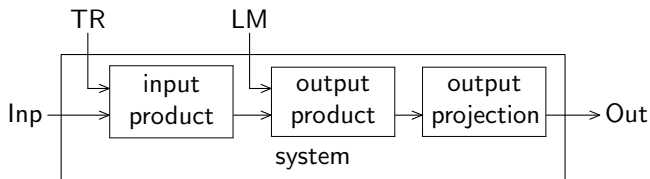
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TR: $\text{Tree} \times \text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ synchronous tree-adjoining grammar

LM: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ regular tree grammar

Imp: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$ regular tree grammar

Out: $\text{Tree} \rightarrow \mathbb{R}_{\infty}^{\geq 0}$???



$$\text{Out} = \text{Proj}((\text{Inp} \triangleleft \text{TR}) \triangleright \text{LM})$$

Finitely representable?

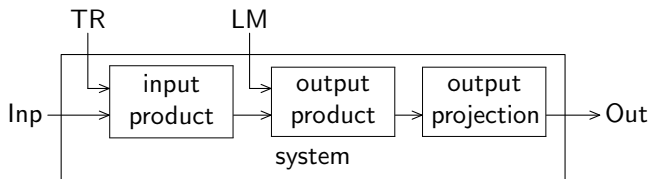
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\rightsquigarrow Tree Parsing

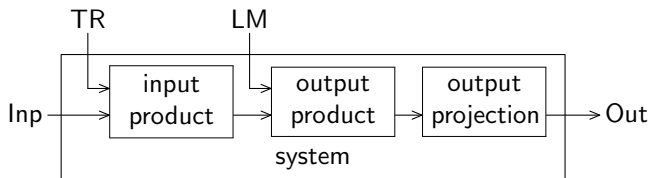
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$$\text{Out} = \text{Proj}((\text{Inp} \triangleleft \text{TR}) \triangleright \text{LM})$$

Finitely representable?

\rightsquigarrow Tree Parsing

Small selection of grammar types?

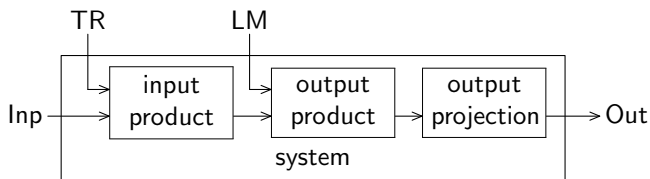
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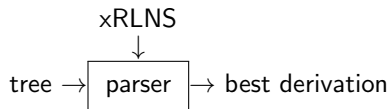
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Finitely representable?
 \rightsquigarrow Tree Parsing

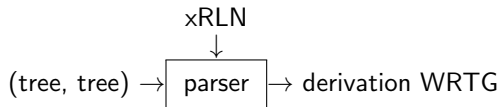
Small selection of grammar types?
 \rightsquigarrow Toolbox

Tree Parsing Results

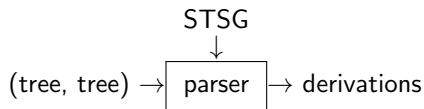
Huang et al. (2006)



Graehl et al. (2008)

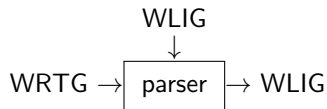


Eisner (2003)

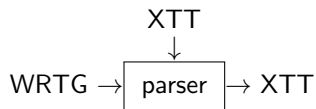


Tree Parsing Results

Nederhof (2009)

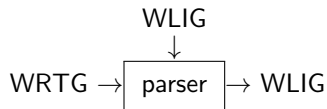


Maletti (2010)

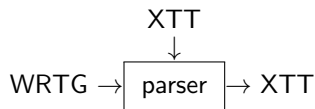


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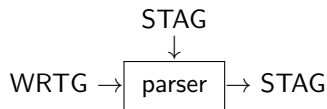
Nederhof (2009)



Maletti (2010)



this talk



Outline

Grammars by Example

Regular Tree Grammar

Synchronous Tree-Adjoining Grammars

Contribution I: Formulation and Construction

Weighted Synchronous Tree-Adjoining Grammars

Input Product Construction

Contribution II: Algorithm

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Weighted Regular Tree Grammar (WRTG)

$$\begin{aligned} \rho_1: r_0 &\rightarrow \begin{array}{c} S \\ / \quad \backslash \\ r_1 \quad r_3 \end{array} \quad \# p(\rho_1) \\ \rho_2: r_1 &\rightarrow \begin{array}{c} Adv \\ | \\ r_2 \end{array} \quad \# p(\rho_2) \\ \rho_3: r_2 &\rightarrow \text{yesterday} \quad \# p(\rho_3) \\ &\quad \vdots \end{aligned}$$

Weighted Regular Tree Grammar (WRTG)

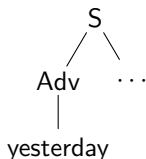
$$\rho_1: r_0 \rightarrow \begin{array}{c} S \\ / \quad \backslash \\ r_1 \quad r_3 \end{array} \quad \# p(\rho_1)$$

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$$\rho_3: r_2 \rightarrow \text{yesterday} \quad \# p(\rho_3)$$

⋮

tree t



Weighted Regular Tree Grammar (WRTG)

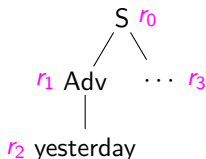
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tree t
run κ



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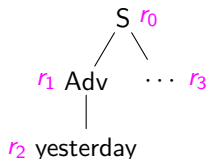
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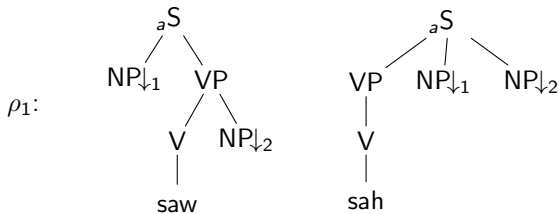


weight of κ
weight of t

$$p(\rho_1) \cdot p(\rho_2) \cdot p(\rho_3) \cdot \dots \\ \sum_{\kappa} p(\kappa)$$

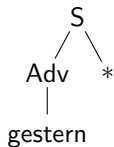
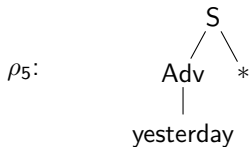
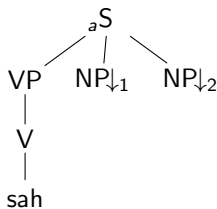
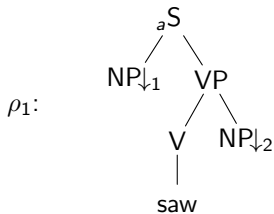
Synchronous Tree-Adjoining Grammar

following DeNeefe and Knight (2009)



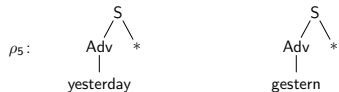
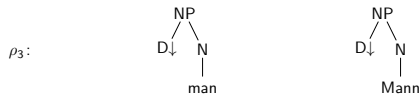
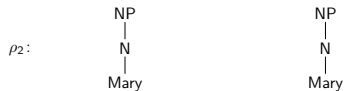
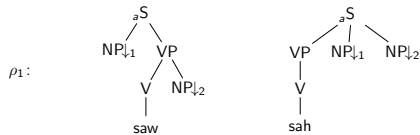
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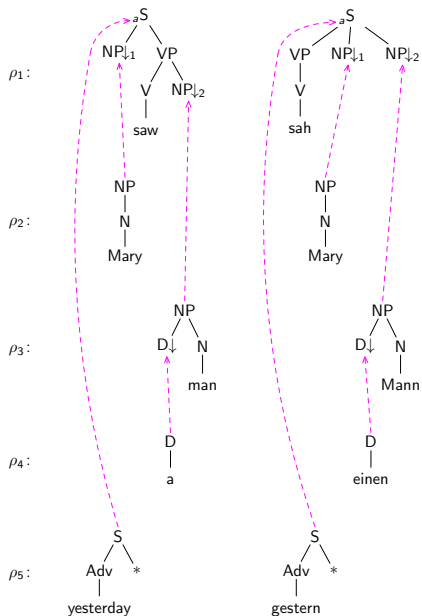
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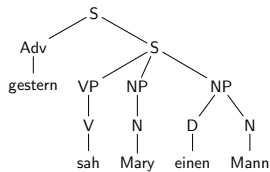
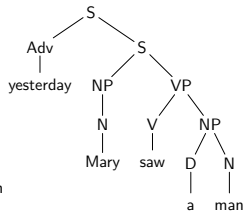
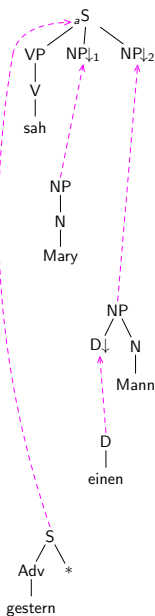
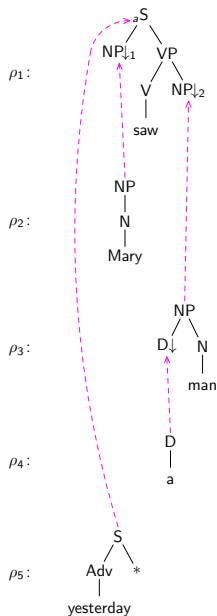
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Synchronous Tree-Adjoining Grammars

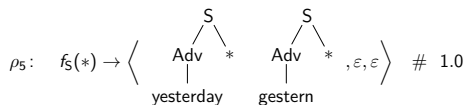
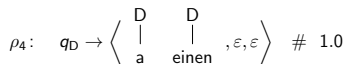
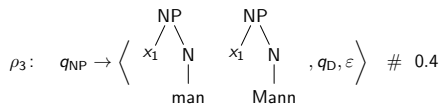
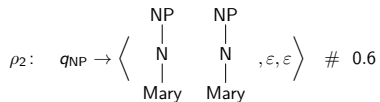
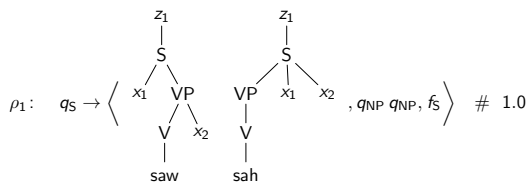
Contribution I: Formulation and Construction

Weighted Synchronous Tree-Adjoining Grammars

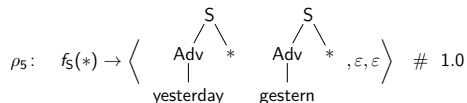
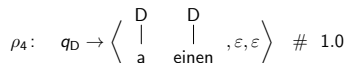
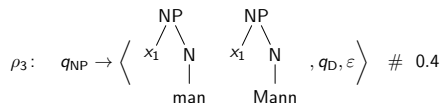
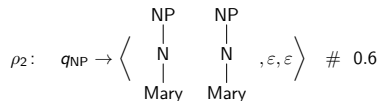
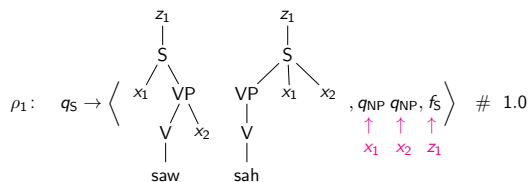
Input Product Construction

Contribution II: Algorithm

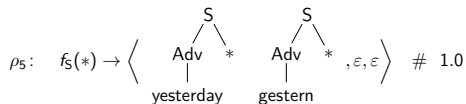
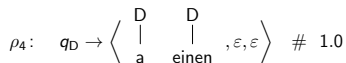
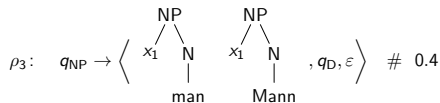
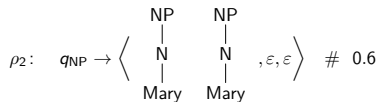
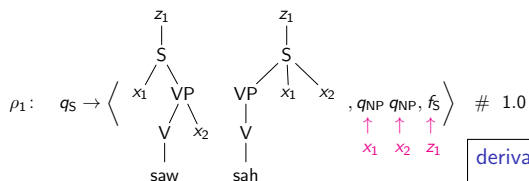
Example Revisited



Example Revisited



Example Revisited



derivation tree WRTG:

$$D(\rho_1): q_S \rightarrow \rho_1(q_{NP}, q_{NP}, f_S) \# 1.0$$

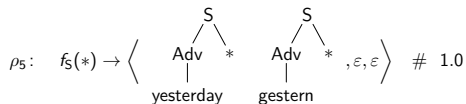
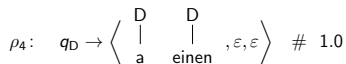
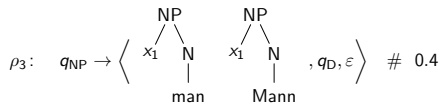
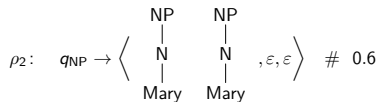
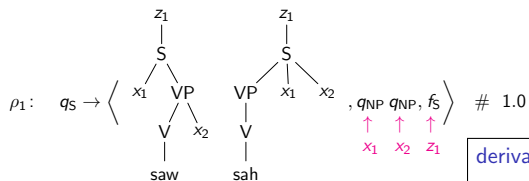
$$D(\rho_2): q_{NP} \rightarrow \rho_2() \# 0.6$$

$$D(\rho_3): q_{NP} \rightarrow \rho_3(q_D) \# 0.4$$

$$D(\rho_4): q_D \rightarrow \rho_4() \# 1.0$$

$$D(\rho_5): f_S \rightarrow \rho_5() \# 1.0$$

Example Revisited



derivation tree WRTG:

$$D(\rho_1): q_S \rightarrow \rho_1(q_{NP}, q_{NP}, f_S) \# 1.0$$

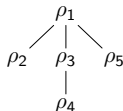
$$D(\rho_2): q_{NP} \rightarrow \rho_2() \# 0.6$$

$$D(\rho_3): q_{NP} \rightarrow \rho_3(q_D) \# 0.4$$

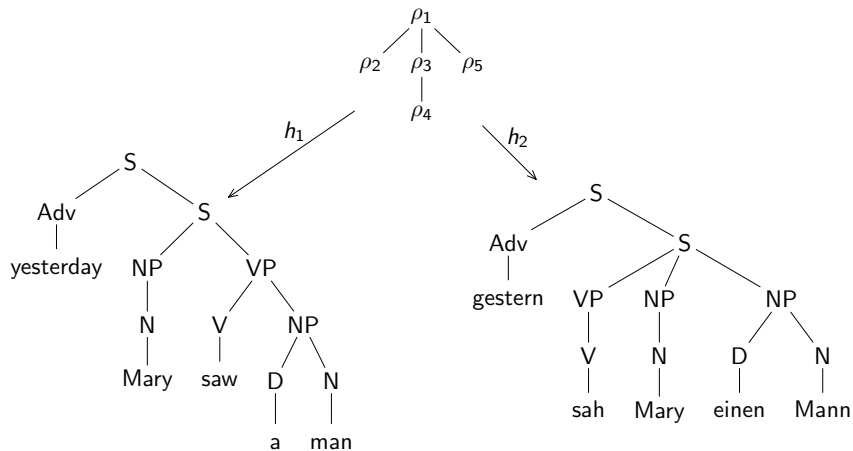
$$D(\rho_4): q_D \rightarrow \rho_4() \# 1.0$$

$$D(\rho_5): f_S \rightarrow \rho_5() \# 1.0$$

derivation tree:



Bimorphism Semantics



Input Product Construction

WSTAG	WRTG	product WSTAG
$q \rightarrow \left\langle \begin{array}{c} A \\ \\ z_1 \\ \\ A \\ \\ x_1 \end{array}, q, f \right\rangle \# 0.2$ $q \rightarrow \langle a, \varepsilon, \varepsilon \rangle \# 0.8$ $f(*) \rightarrow \left\langle \begin{array}{c} B \\ / \quad \backslash \\ b \quad * \end{array}, \varepsilon, \varepsilon \right\rangle \# 0.1$ $f(*) \rightarrow \langle *, \varepsilon, \varepsilon \rangle \# 0.9$		

Input Product Construction

WSTAG	WRTG	product WSTAG
$q \rightarrow \left\langle \begin{array}{c} A \\ \\ z_1 \\ \\ A \\ \\ x_1 \end{array}, q, f \right\rangle \# 0.2$	$r_0 \rightarrow \begin{array}{c} A \\ \\ r_0 \end{array} \# 0.1$	
$q \rightarrow \langle a, \varepsilon, \varepsilon \rangle \# 0.8$	$r_0 \rightarrow \begin{array}{c} B \\ / \quad \backslash \\ r_0 \quad r_1 \end{array} \# 0.5$	
$f(*) \rightarrow \left\langle \begin{array}{c} B \\ / \quad \backslash \\ b \quad * \end{array}, \varepsilon, \varepsilon \right\rangle \# 0.1$	$r_1 \rightarrow \begin{array}{c} A \\ \\ r_1 \end{array} \# 0.5$	
$f(*) \rightarrow \langle *, \varepsilon, \varepsilon \rangle \# 0.9$	$r_1 \rightarrow a \# 0.5$	

Input Product Construction

WSTAG	WRTG	product WSTAG
$q \rightarrow \left\langle \begin{array}{c} A \\ \\ z_1 \\ \\ A \\ \\ x_1 \end{array}, q, f \right\rangle \# 0.2$	$r_0 \rightarrow \begin{array}{c} A \\ \\ r_0 \end{array} \# 0.1$	$qr_0 \rightarrow \left\langle \begin{array}{c} A \\ \\ z_1 \\ \\ A \\ \\ x_1 \end{array}, qr_0, fr_0r_0 \right\rangle \# 0.002$
$q \rightarrow \langle a, \varepsilon, \varepsilon \rangle \# 0.8$	$r_0 \rightarrow \begin{array}{c} B \\ / \quad \backslash \\ r_0 \quad r_1 \end{array} \# 0.5$	$fr_0r_0(*) \rightarrow \langle *, \varepsilon, \varepsilon \rangle \# 0.9$
$f(*) \rightarrow \left\langle \begin{array}{c} B \\ / \quad \backslash \\ b \quad * \end{array}, \varepsilon, \varepsilon \right\rangle \# 0.1$	$r_0 \rightarrow b \# 0.4$	$qr_0 \rightarrow \left\langle \begin{array}{c} A \\ \\ z_1 \\ \\ A \\ \\ x_1 \end{array}, qr_1, fr_0r_1 \right\rangle \# 0.01$
$f(*) \rightarrow \langle *, \varepsilon, \varepsilon \rangle \# 0.9$	$r_1 \rightarrow \begin{array}{c} A \\ \\ r_1 \end{array} \# 0.5$	$fr_0r_1(*) \rightarrow \left\langle \begin{array}{c} B \\ / \quad \backslash \\ b \quad * \end{array}, \varepsilon, \varepsilon \right\rangle \# 0.002$
	$r_1 \rightarrow a \# 0.5$	$qr_1 \rightarrow \langle a, \varepsilon, \varepsilon \rangle \# 0.4$

Outline

Grammars by Example

Regular Tree Grammar

Synchronous Tree-Adjoining Grammars

Contribution I: Formulation and Construction

Weighted Synchronous Tree-Adjoining Grammars

Input Product Construction

Contribution II: Algorithm