A Note on Sequential Rule-Based POS Tagging

S. Schmitz

LSV, ENS Cachan & CNRS

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Outline

Brill Tagger

a rule-based POS tagger

this talk

a simple constructive proof of sequentiality based on (Simon, 1994)

contents

Brill Tagger

(Brill, 1992)

1. *lexical tagger*: most probable tag for each word
2. *unknown word tagger*
3. *contextual tagger*: correct tag assignments

Contextual Tagger

Example

*Chapman/NNP killed/VBN John/NNP Lennon/NNP

*John/NNP Lennon/NNP was/VBD shot/VBD by/IN Chapman/NNP

He/PRP witnessed/VBD Lennon/NNP killed/VBN by/IN Chapman/NNP

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Contextual Tagger

Formally

- sequence of rewrite rules $\mathcal{C} = r_1 r_2 \cdots r_n$
- rules $r_i = u_i \to v_i$ in $\Sigma^* \times \Sigma^*$
- leftmost applications
- $[\![r_i]\!]$ is a total function $\Sigma^* \to \Sigma^*$ (identity over $\Sigma^* \setminus \Sigma^* u_i \Sigma^*$)
- $[\![\mathcal{C}]\!] = [\![r_1]\!] \,;\, [\![r_2]\!] \,;\, \cdots \,;\, [\![r_n]\!]$

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Contextual Tagger

Algorithmically

- naive algorithm: try to match each rule at each position of input w:

$$O\left(|w| \cdot \sum_i |u_i|\right)$$

- Roche and Schabes (1995): construct a sequential transducer $\mathcal{T}$ and run over w:

$$O\left(|w| + |\mathcal{T}|\right)$$

Contextual Tagger

Algorithmically

- but in (Roche and Schabes, 1995)

$$|\mathcal{T}| \sim O(2^{\prod_{i=1}^{n} 2^{|u_i|}})$$

- here:

$$|\mathcal{T}| = O(\prod_{i=1}^{n} |u_i|)$$

Sequential Transducers

(Schützenberger, 1977)

- $\mathcal{T} = \langle Q, \Sigma, \Delta, q_0, \delta, \eta, \iota, \rho \rangle$:
  - $\delta : Q \times \Sigma \to Q$ partial transition function
  - $\eta : Q \times \Sigma \to \Delta^*$ partial transition output function with $\mathrm{dom}(\delta) = \mathrm{dom}(\eta)$
  - $\iota \in \Delta^*$ initial output string
  - $\rho : Q \to \Delta^*$ partial final output function
- defines a *sequential function* $[\![\mathcal{T}]\!] : \Sigma^* \to \Delta^*$
- existence of a canonical minimal sequential transducer

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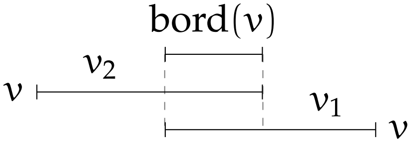
Borders

- u is a *border* of a v iff $\exists v_1, v_2, v = uv_1 = v_2u$
- if $v \neq \varepsilon$, $\mathrm{bord}(v)$ is the longest border of v different from v



Example

$$\mathrm{bord}(b) = \varepsilon \qquad \mathrm{bord}(aa) = a$$
$$\mathrm{bord}(abb) = \varepsilon \qquad \mathrm{bord}(abaa) = a$$
$$\mathrm{bord}(ababa) = aba$$

Sequential Transducer of $\mathtt{ababb} \rightarrow \mathtt{abbbb}$

$$\mathcal{T}_r = \langle \mathrm{Pref}(u), \Sigma, \Sigma, \varepsilon, \delta, \eta, \varepsilon, \rho \rangle$$

$$\varepsilon \rightarrow \varepsilon \xrightarrow{a} a \xrightarrow{b} ab \xrightarrow{a} aba \xrightarrow{b} abab \xrightarrow{b} ababb$$

$$\delta(w, a) = \begin{cases} wa & \text{if } wa \leqslant_{\text{pref}} u \\ w & \text{if } w = u \\ \mathrm{bord}(wa) & \text{otherwise} \end{cases}$$

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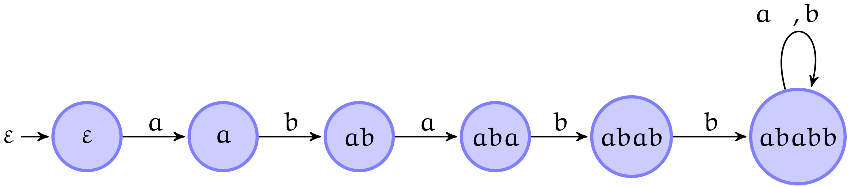

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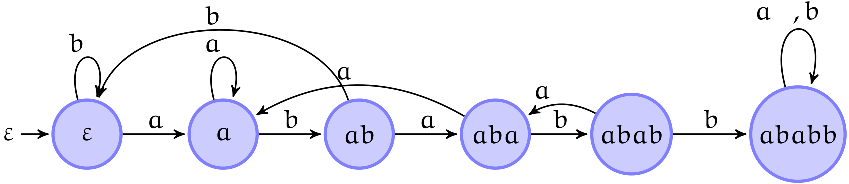

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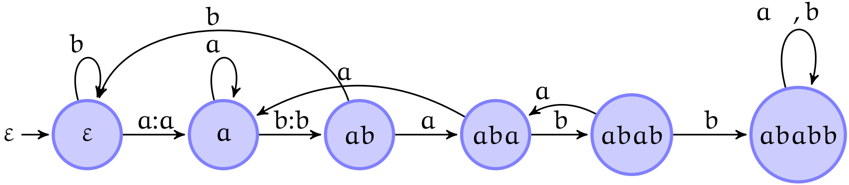

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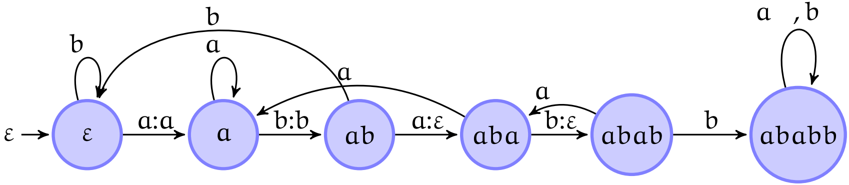

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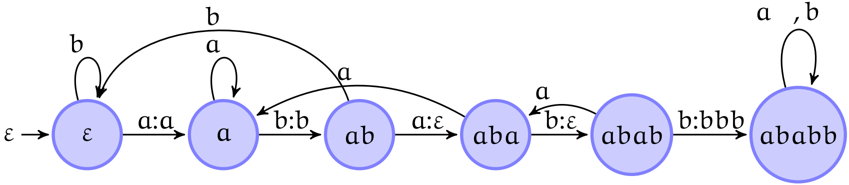

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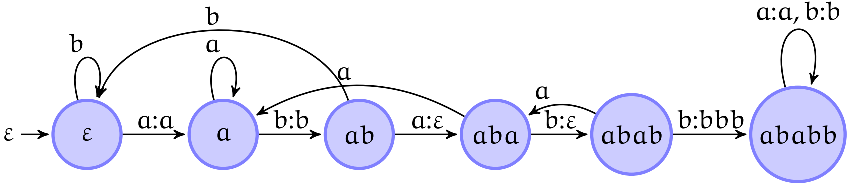

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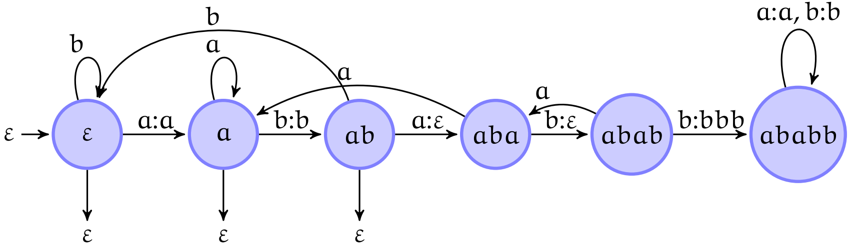

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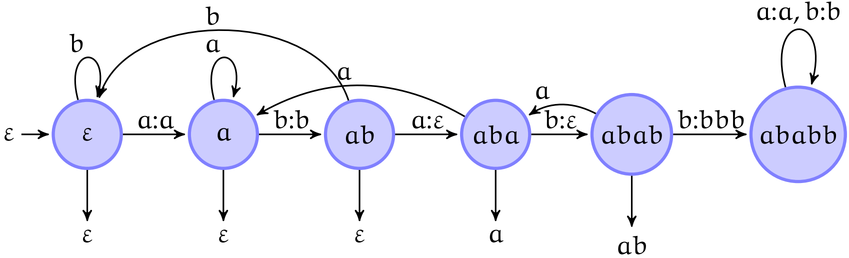

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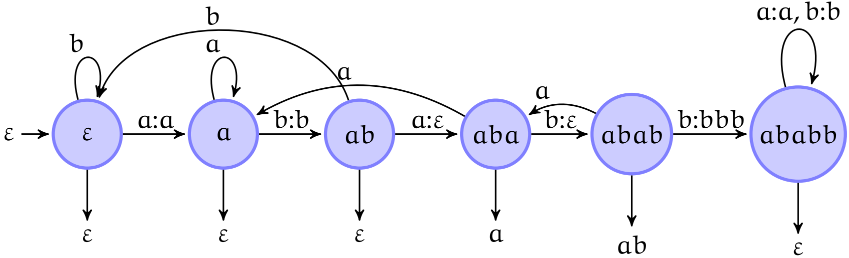

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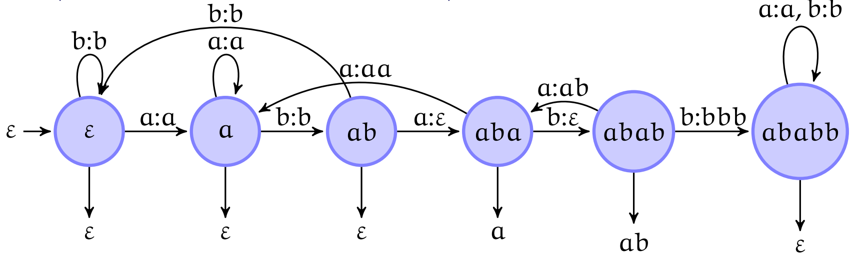

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Result

See paper

- correctness: $[\![\mathcal{T}_r]\!] = [\![r]\!]$
- $\mathcal{T}_r$ is normalized
- $\mathcal{T}_r$ is minimal
- $|\mathcal{T}_r| = |u| + 1$ (state complexity)

Remaining Issues: Composition

Is there a smart way of composing the $\mathcal{T}_{r_i}$ to obtain $\mathcal{T}_{\mathcal{C}}$?

PTime-completeness of word problem for a sequence of length-preserving rewrite rules might indicate: NO

Remaining Issues: Semantics of Rules

- in the paper: single leftmost application
- in (Roche and Schabes, 1995): iterated left-to-right leftmost application according to construction
- in (Brill, 1992): iterated left-to-right leftmost application with possible overlap according to source code...

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