Comparing nondeterministic and quasideterministic finite-state transducers built from morphological dictionaries*

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Transformations usually specified in terms of (morphological, bilingual) dictionaries.

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Sequential processing possible because inputs sharing a prefix correspond to outputs sharing a nontrivial prefix.

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Dictionary alignments ignored: "deterministic alignment"

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Disadvantages of quasideterministic transducers:

- Any linguistic knowledge encoded in dictionary alignments is thrown away.
- For large dictionaries, irregularities may lead to very short longest common output prefixes and very long output suffixes.
- Adding a new dictionary entry may force a complete reconstruction (longest common output prefixes may change)

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- more than one state may be reached for each state and input symbol;
- output is associated to state-to-state transitions so that a set of output prefix candidates is built incrementally by maintaining a set of alive state-output pairs during processing;
- output suffixes are no longer necessary.

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- When expressed as finite-state letter transducers (with transitions reading or writing at most one symbol), they may be determinized and minimized similarly to finite automata.
- New entries may be added and removed without realignment and maintaining minimality (Garrido et al., TMI-2002).

[Details]

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Building quasideterministic transducers from unaligned dictionaries [Details]

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5. Minimize the resulting transducer

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- Determinize and minimize the resulting letter transducers
- Compare (unfair without conversion: LTs are more “rudimentary”)

Comparing quasi- and non-deterministic transducers/2

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Comparing quasi- and non-deterministic transducers/2

Results:

- Without conversion, both kinds of transducers have roughly the same number of states (comparison unfair to LT)
- After conversion, nondeterministic transducers are consistently 2.5 times more compact than quasideterministic transducers
- Observed nondeterminism (average number of ASOPs) is of the order of corpus-computed ambiguity in dictionaries: quasidet., 1.3; nondet., 1.5–1.9 (slightly worse)

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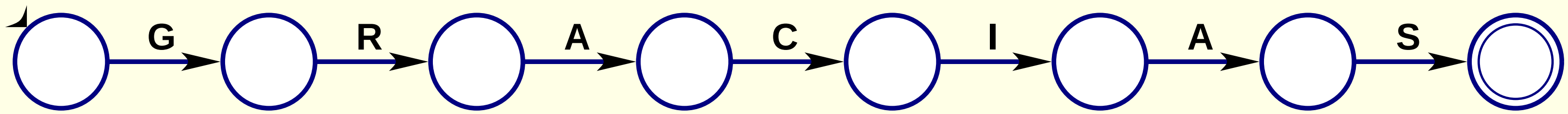
Nondeterministic letter transducers are in use in `www.interNOSTRUM.com` (a Spanish–Catalan MT system)


G
R
A
C
I
A
S

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- $\delta : Q \times L \to 2^Q$: transition function

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- $q_I \in Q$: initial state
- $F \subseteq Q$: acceptance states

[back]

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- Output γ can be an output symbol from Γ or nothing (θ)

Clearly, (θ, θ) arrows do nothing may be avoided.

[back]

Finite-state letter transducers/3

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$t = |w|$ (at the end of w): $\tau(w) = \{z : (q,z) \in \mathcal{V}^{[|w|]} \wedge q \in F\}$.

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Longest common output prefix

The longest common output prefix for input w is

$$\mathsf{LCOP}(w) = \mathsf{LCP}(\tau(ww^{-1}E))$$

where

- $E \subset \Sigma^*$ is the vocabulary of inputs,
- $\tau : E \to 2^{\Gamma^*}$ is the transformation function, and
- $ww^{-1}E = \{x \in E \ : \ w \in \mathsf{Pr}(x)\}$.

[back]

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- With a trie structure: $Q = \mathsf{Pr}(E) \cup \{\perp\}$ ($\perp$ is the absorption state), $q_I = \epsilon$, and

$$\delta(x, \sigma) = \begin{cases} x\sigma & \text{if } x, x\sigma \in \mathsf{Pr}(E) \\ \perp & \text{otherwise} \end{cases}$$

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- With output suffix sets $\psi(w) = (\mathrm{LCOP}(w))^{-1}\tau(w)$.

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Building quasideterministic transducers: details/1

Build a p-subsequential transducer $T = (Q, \Sigma, \Gamma, \delta, \lambda, q_I, \psi)$:

- With a trie structure: $Q = \mathsf{Pr}(E) \cup \{\perp\}$ ($\perp$ is the absorption state), $q_I = \epsilon$, and

$$\delta(x, \sigma) = \begin{cases} x\sigma & \text{if } x, x\sigma \in \mathsf{Pr}(E) \\ \perp & \text{otherwise} \end{cases}$$

- With transition outputs $\lambda(x, \sigma) = (\mathsf{LCOP}(x))^{-1}\mathsf{LCOP}(x\sigma)$ for $x, x\sigma \in \mathsf{Pr}(E)$, and undefined otherwise.
- With output suffix sets $\psi(w) = (\mathsf{LCOP}(w))^{-1}\tau(w)$.

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Building quasideterministic transducers: details/2

The resulting transducer is minimized using the equivalence class algorithm (which iteratively refines a partition of Q).

Two different states q and r are not equivalent if

- $\psi(q) \neq \psi(r)$
- for some σ, $\delta(q, \sigma)$ not in the same class as $\delta(r, \sigma)$
- for some σ, $\lambda(q, \sigma) \neq \lambda(r, \sigma)$.

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Building nondeterministic transducers: details/1

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... may be aligned as $(\texttt{h}, \texttt{h})(\texttt{a}, \texttt{a})(\texttt{c}, \texttt{z})(\theta, \texttt{<n>})(\theta, \texttt{<m>})(\texttt{e}, \theta)(\texttt{s}, \texttt{<pl>})$.

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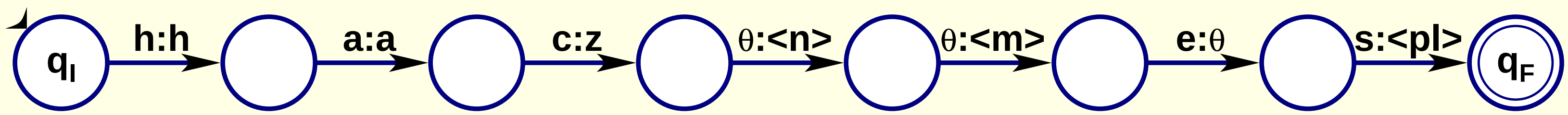
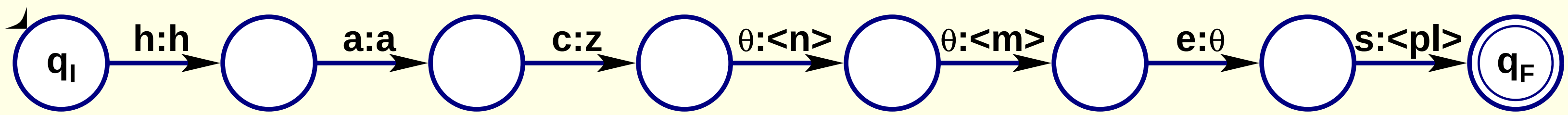
Building nondeterministic transducers: details/2



Building nondeterministic transducers: details/2



The resulting transducer is determinized and minimized.

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Converting into letter transducers: details

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