Creating LRs with FSTs Part IV

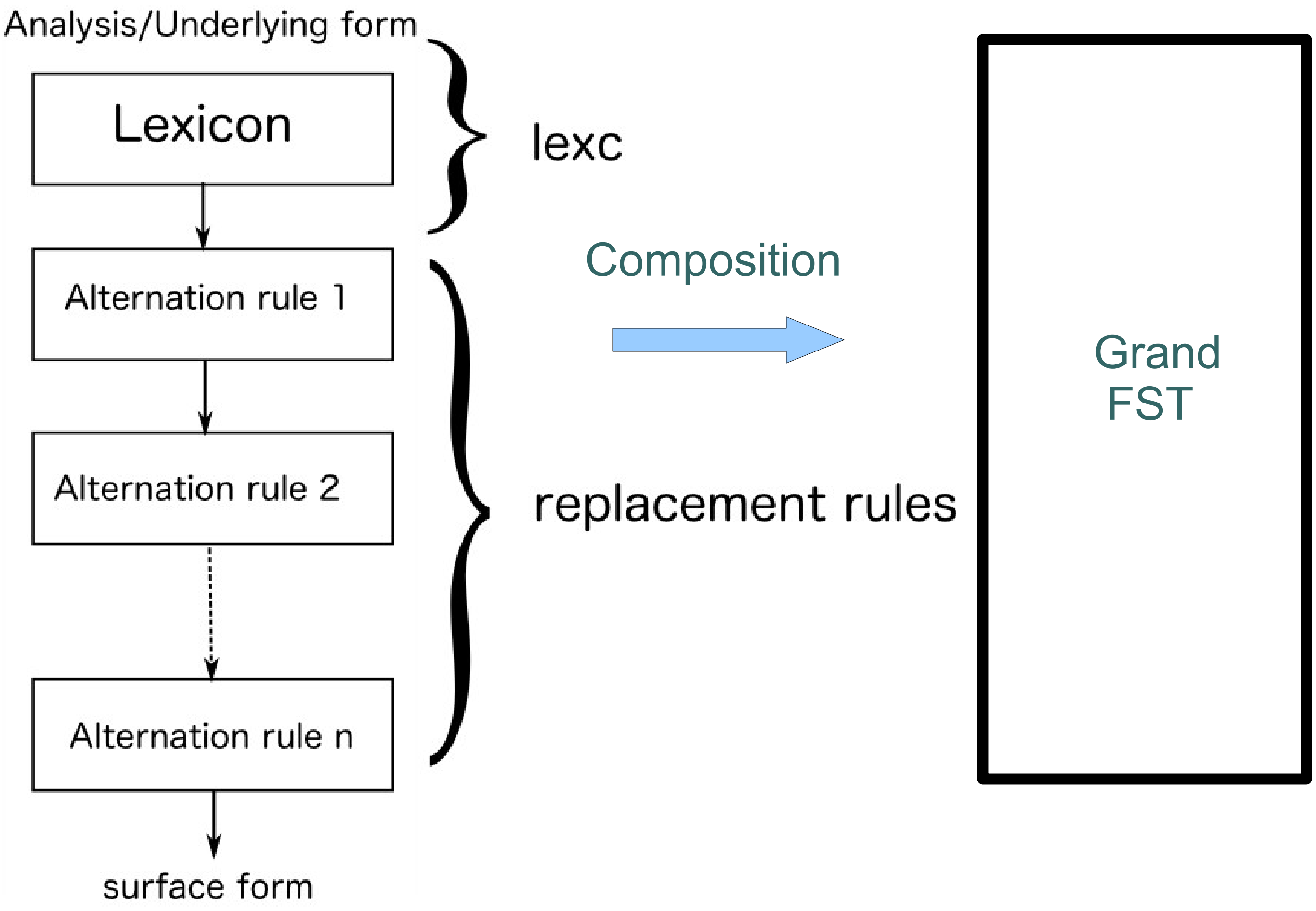
Rules & putting it all together

Mans Hulden
(University of Helsinki)
Iñaki Alegria
(University of The Basque Country)

Overview

- Designing a rewrite-grammar
- Composing the lexicon with the rules
- Compiling & testing a complete grammar
- A few examples

The Big Picture (again)



Running English example

- We created a lexc-grammar that takes us from analyses to intermediate forms:

```
c i t y +N +Pl
c i t y ^   s
```

- The task now is to create the replacement rule transducers to be composed with the lexc-transducer, yielding correct surface forms:

```
c i t y   +N  +Pl  (lexc upper)
c i t y   ^     s  (lexc lower)
c i t i e ^     s  (after y -> i e rule)
...
c i t i e s        (after nth rule)
```

The facts to be modeled II

(1) E-deletion: silent e dropped before -ing and -ed (make/making)

```
m a k e +V +PresPart     (lexc upper)
m a k e ^ i n g          (lexc lower)
...
m a k 0 ^ i n g          (after E-deletion)
...
```

The rule can be defined as:

```
define EDeletion e -> 0 || _ "^" [ i n g | e d ] ;
```

Let's test the rule *separately [in foma]*:

The facts to be modeled II

(2) K-insertion: verbs ending with vowel-c add -k at end of stem when succeeded by -ed/-ing

```
p a n i c   +V +PresPart    (lexc upper)
p a n i c   ^ i n g         (lexc lower)
...
p a n i c k ^ i n g         (after K-insertion)
...
```

The rule can be defined as:

```
define V [a | e | i | o | u ];
define KInsertion [..] -> k ||  V c _ "^" [e d|i n g];
```

The facts to be modeled II

(3) E-insertion:

```
f o x   +N +Pl      (lexc upper)
f o x   ^  s        (lexc lower)
...
f o x e ^ s         (after E-insertion)
...
```

The rule can be defined as:*

```
define EInsertion [..] -> e || [s|z|x|c h|s h] _ "^" s ;
```

*This is not foolproof: consider arch → arches vs. monarch → monarchs

The facts to be modeled II

(4) Consonant doubling: 1-letter consonant doubled before -ing/-ed

```
b e g   +V  +PresPart (lexc upper)
b e g   ^   i n g     (lexc lower)
...
b e g g ^   i n g     (after C-doubling)
...
```

The rule can be defined (for g) as:

```
define V [a | e | i | o | u ];
define ConsonantDoubling g -> g g || V _ "^" i n g ;
```

The facts to be modeled II

(5) Y-replacement: y changes to ie before -s, and i before -ed

```
t r y        +N   +Pl          (lexc upper)
t r y        ^     s           (lexc lower)
...
t r i e      ^     s           (after Y-replacement)
...
```

The rule can be defined as:

```
define YReplacement y -> i e || _ "^" s    ,,
                    y -> i   || _ "^" e d ;
```

The facts to be modeled II

(6) After we're done with the alternations, we remove the boundary markers:

```
t r y      +N  +Pl      (lexc upper)
t r y      ^    s       (lexc lower)
...
t r i e         s       (after Cleanup)
...
```

The rule can be defined as:

```
define Cleanup "^" -> 0;
```

Putting the grammar together

```
...

read lexc english.lexc
define Lexicon;

regex Lexicon .o. ConsonantDoubling .o. EDeletion .o.
   EInsertion .o. YReplacement .o. KInsertion .o.
   Cleanup;
```

Compiling

```
foma[0]: source english.foma
Opening file 'english.foma'.
defined V: 317 bytes. 2 states, 5 arcs, 5 paths.
Root...2, Noun...6, Verb...6, Ninf...2, Vinf...5
Building lexicon...Determinizing...Minimizing...Done!
1.3 kB. 32 states, 46 arcs, 42 paths.
defined Lexicon: 1.3 kB. 32 states, 46 arcs, 42 paths.
defined ConsonantDoubling: 1.0 kB. 11 states, 47 arcs, Cyclic.
defined EDeletion: 1.1 kB. 11 states, 52 arcs, Cyclic.
defined EInsertion: 1000 bytes. 7 states, 43 arcs, Cyclic.
defined YReplacement: 874 bytes. 9 states, 36 arcs, Cyclic.
defined KInsertion: 1.2 kB. 11 states, 59 arcs, Cyclic.
defined Cleanup: 260 bytes. 1 states, 2 arcs, Cyclic.
1.8 kB. 47 states, 70 arcs, 42 paths.
foma[1]:
```

Let's test the grammar!

Testing...debugging...

```
foma[1]: lower-words
cat
cats
city
cities
panic
panics
panic
panics
panicking
panicked
panicked
...
make
makes
making
maked
beg
```

Is an exception and we will postpone its treatment for a minute...

Review of lexc+rules

General strategy:

- Create lexc-grammar, load in foma, define:

```
read lexc english.lexc
define Lexicon;
```

- Replacement rules in foma:

```
define Rule1 x -> y ...
```

- Combine with composition:

```
define Grammar Lexicon .o. Rule1 .o. ... .o. RuleN;
regex Grammar;
```

Real-life example 2 (simplified)

Many more rules:

rules_eu

```
...
define RULES T0 .o. TD .o. BAIT .o. TDA .o. H0 .o. EI .o. R2
   .o. RR .o. Q0 .o. QR .o. A0 .o. ABI0 .o. AA .o. AA2 .o.
   KG .o. KG2 .o. BAT0 .o.  EE .o. E0 .o. N0 .o. NN .o. PLUS ;

read lexc lex_eu
define LEX

define MORPHO LEX .o. RULES ;
```

[demo]

Points...

Rule order

Simple Spanish (pluralization) rules

```
# examples: papel+s:papeles; pez+s:peces
# sequential (ordered)
(1)    z -> c || _ "+" s .#. ;
(2) [..] -> e || Cons "+" _ s .#. ;
```

Compare:

```
pez+s (1) → pec+s  (2) → pec+es
pez+s (2) → pez+es (1) → *pez+es
```

Points...

Simple Basque Rules

```
# phonology with r
define MM "+" ;
## hard r (R)
define R2 R -> r r || _ MM (Q) Vowel ;
       # zakuR+a:zakurra
       # itziaR+Qen:itziarr+Qen:itziarren
define RR R -> r ;
       # ekaR+tzen:ekartzen

## epenthetical r (Q)
define Q0 Q -> 0 || Cons MM _ ;
       #ur+Qen:uren
define QR Q -> r ;
       # amA+Qen:amA+ren:amaren

define RandQ R2 .o. RR .o. Q0 .o. QR;
```