CSCI 5832 Natural Language Processing

Lecture 4

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Today 1/24

- English Morphology
- FSAs and Morphology
- Break
- FSTs

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Transition

- Finite-state methods are particularly useful in dealing with a lexicon
- Lots of devices, some with limited memory, need access to big lists of words
- And they need to perform fairly sophisticated tasks with those lists
- So we'll switch to talking about some facts about words and then come back to computational methods

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English Morphology

- Morphology is the study of the ways that words are built up from smaller meaningful units called morphemes
- We can usefully divide morphemes into two classes
  - Stems: The core meaning-bearing units
  - Affixes: Bits and pieces that adhere to stems to change their meanings and grammatical functions

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English Morphology

- We can also divide morphology up into two broad classes
  - Inflectional
  - Derivational

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Word Classes

- By word class, we have in mind familiar notions like noun and verb
- We'll go into the gory details in Chapter 5
- Right now we're concerned with word classes because the way that stems and affixes combine is based to a large degree on the word class of the stem

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Inflectional Morphology

- Inflectional morphology concerns the combination of stems and affixes where the resulting word
  - Has the same word class as the original
  - Serves a grammatical/semantic purpose that is
    - Different from the original
    - But is nevertheless transparently related to the original

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Nouns and Verbs (English)

- Nouns are simple
  - Markers for plural and possessive
- Verbs are only slightly more complex
  - Markers appropriate to the tense of the verb

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Regulars and Irregulars

- Ok, so it gets a little complicated by the fact that some words misbehave (refuse to follow the rules)
  - Mouse/mice, goose/geese, ox/oxen
  - Go/went, fly/flew
- The terms regular and irregular are used to refer to words that follow the rules and those that don't

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Regular and Irregular Verbs

- Regulars…
  - Walk, walks, walking, walked, walked
- Irregulars
  - Eat, eats, eating, ate, eaten
  - Catch, catches, catching, caught, caught
  - Cut, cuts, cutting, cut, cut

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Inflectional Morphology

- So inflectional morphology in English is fairly straightforward
- But is complicated by the fact that are irregularities

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Derivational Morphology

- Derivational morphology is the messy stuff that no one ever taught you.
  - Quasi-systematicity
  - Irregular meaning change
  - Changes of word class

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Derivational Examples

- Converting verbs and adjectives to nouns

-ation	computerize	computerization
-ee	appoint	appointee
-er	kill	killer
-ness	fuzzy	fuzziness

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Derivational Examples

- Nouns and verbs to adjectives

-al	computation	computational
-able	embrace	embraceable
-less	clue	clueless

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Compute

- Many paths are possible…
- Start with compute
  - Computer -> computerize -> computerization
  - Computer -> computerize -> computerizable
- But not all paths/operations are equally good (or even allowable)
  - Clue -> clueable

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Morpholgy and FSAs

- We'd like to use the machinery provided by FSAs to capture facts about morphology
  - Ie. Accept strings that are in the language
  - And reject strings that are not
  - And do it in a way that doesn't require us to in effect list all the words in the language

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Start Simple

- Regular singular nouns are ok
- Regular plural nouns have an -s on the end
- Irregulars are ok as is

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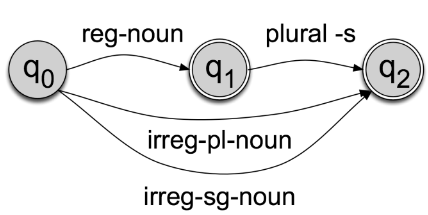
Simple Rules



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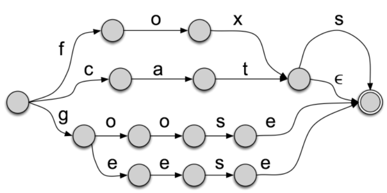
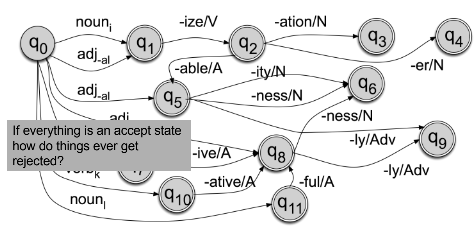
Now Add in the Words



Derivational Rules



Homework

- How big is your vocabulary?

Homework

- Strings are an easy and not very good way to represent texts
- Normally, we want lists of sentences that consist of lists of tokens, that ultimately may point to strings representing words (lexemes)
- Lists are central to Python and will make your life easy if you let them

Parsing/Generation vs. Recognition

- We can now run strings through these machines to recognize strings in the language
  - Accept words that are ok
  - Reject words that are not
- But recognition is usually not quite what we need
  - Often if we find some string in the language we might like to find the structure in it (parsing)
  - Or we have some structure and we want to produce a surface form (production/generation)
- Example
  - From “cats” to “cat +N +PL”

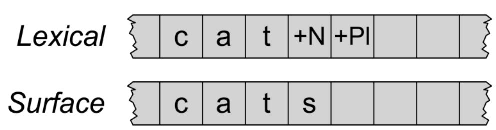
Finite State Transducers

- The simple story
  - Add another tape
  - Add extra symbols to the transitions
  - On one tape we read “cats”, on the other we write “cat +N +PL”

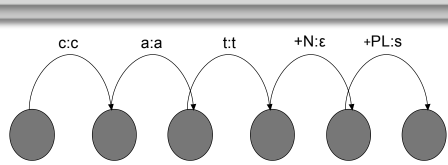
Applications

- The kind of parsing we're talking about is normally called morphological analysis
- It can either be
  - An important stand-alone component of an application (spelling correction, information retrieval)
  - Or simply a link in a chain of processing

FSTs



Transitions



- c:c means read a c on one tape and write a c on the other
- +N:ε means read a +N symbol on one tape and write nothing on the other
- +PL:s means read +PL and write an s

Typical Uses

- Typically, we'll read from one tape using the first symbol on the machine transitions (just as in a simple FSA).
- And we'll write to the second tape using the other symbols on the transitions.

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Ambiguity

- Recall that in non-deterministic recognition multiple paths through a machine may lead to an accept state.
  - Didn't matter which path was actually traversed
- In FSTs the path to an accept state does matter since differ paths represent different parses and different outputs will result

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Ambiguity

- What's the right parse (segmentation) for
  - Unionizable
  - Union-ize-able
  - Un-ion-ize-able
- Each represents a valid path through the derivational morphology machine.

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Ambiguity

- There are a number of ways to deal with this problem
  - Simply take the first output found
  - Find all the possible outputs (all paths) and return them all (without choosing)
  - Bias the search so that only one or a few likely paths are explored

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The Gory Details

- Of course, its not as easy as
  - "cat +N +PL" <-> "cats"
- As we saw earlier there are geese, mice and oxen
- But there are also a whole host of spelling/pronunciation changes that go along with inflectional changes
  - Cats vs Dogs
  - Fox and Foxes

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Multi-Tape Machines

- To deal with this we can simply add more tapes and use the output of one tape machine as the input to the next
- So to handle irregular spelling changes we'll add intermediate tapes with intermediate symbols

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Generativity

- Nothing really privileged about the directions.
- We can write from one and read from the other or vice-versa.
- One way is generation, the other way is analysis

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Multi-Level Tape Machines

Lexical	f	o	x	+N	+Pl			
Intermediate	f	o	x	^	s	#		
Surface	f	o	x	e	s			

- We use one machine to transduce between the lexical and the intermediate level, and another to handle the spelling changes to the surface tape

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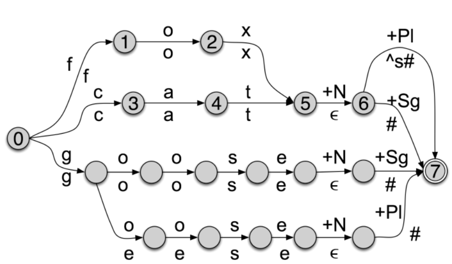
Lexical to Intermediate Level

f



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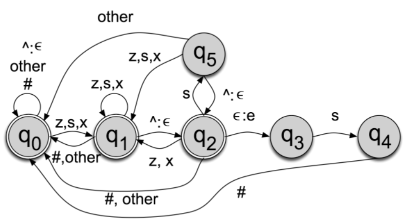
Intermediate to Surface

- The add an "e" rule as in fox^s# <-> foxes#



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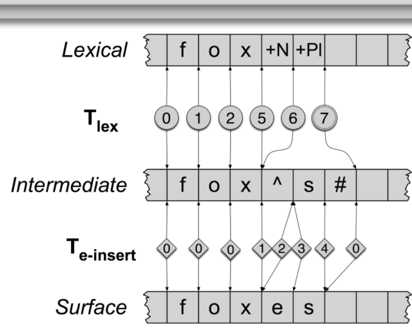
Foxes



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Note

- A key feature of this machine is that it doesn't do anything to inputs to which it doesn't apply.
- Meaning that they are written out unchanged to the output tape.
- Turns out the multiple tapes aren't really needed; they can be compiled away.

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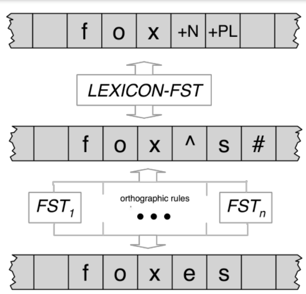
Overall Scheme

- We now have one FST that has explicit information about the lexicon (actual words, their spelling, facts about word classes and regularity).
  - Lexical level to intermediate forms
- We have a larger set of machines that capture orthographic/spelling rules.
  - Intermediate forms to surface forms

Overall Scheme



Cascades

- This is a scheme that we'll see again and again.
  - Overall processing is divided up into distinct rewrite steps
  - The output of one layer serves as the input to the next
  - The intermediate tapes may or may not wind up being useful in their own right

Next Time

- Finish Chapter 3 start on 4

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