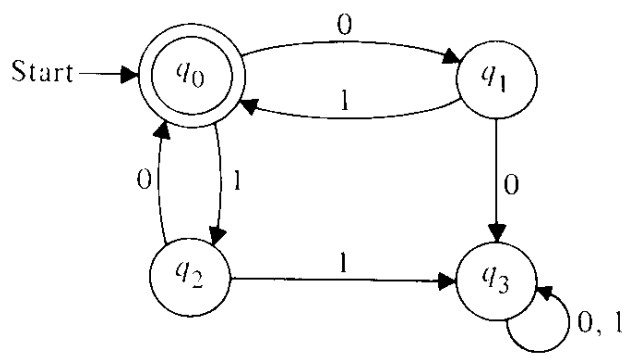
Natural Language Processing

Fall 2022

Unit 1: Sequence Models

Lectures 2-3: Finite-State Acceptors/Transducers



Liang Huang

This Week: Finite-State Machines

- Finite-State Acceptors and Languages
  - DFAs (deterministic)
  - NFAs (non-deterministic)
- Finite-State Transducers
- Applications in Language Processing
  - part-of-speech tagging, morphology, text-to-sound
  - word alignment (machine translation)
- Next Week: putting probabilities into FSMs

Languages and Machines

- Q1: how to formally define a *language*?
- a language is a set of strings
  - could be finite, but often infinite (due to recursion)
  - L = { aa, ab, ac, ..., ba, bb, ..., zz } (finite)
  - English is the set of *grammatical English sentences*
  - variable names in C is set of alphanumeric strings
- Q2: how to *describe* a (possibly infinite) language?
  - use a finite (but recursive) representation
  - finite-state acceptors (FSAs) or regular-expressions

English Adjective Morphology

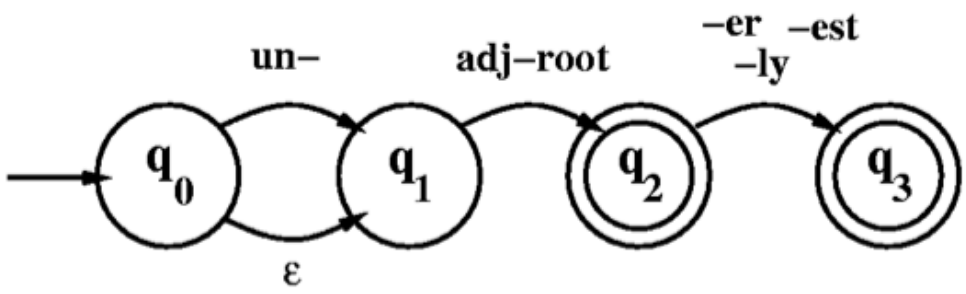


Figure 3.4 An FSA for a fragment of English adjective morphology: Antworth's Proposal #1.

exceptions?

Finite-State Acceptors

- L1 = { aa, ab, ac, ..., ba, bb, ..., zz } (finite)
  - start state, final states

- L2 = { *all letter sequences* } (infinite)
  - recursion (cycle)

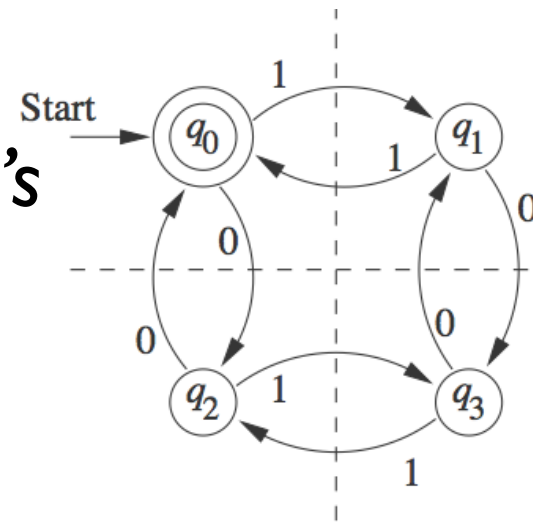
- L3 = { *all alphanumeric strings* }

More Examples

- L4 = { *all letter strings with at least a vowel* }

- L5 = { *all letter strings with vowels in order* }

- L6 = { *all 01 strings with even number of 0's and even number of 1's* }



English Adjective Morphology

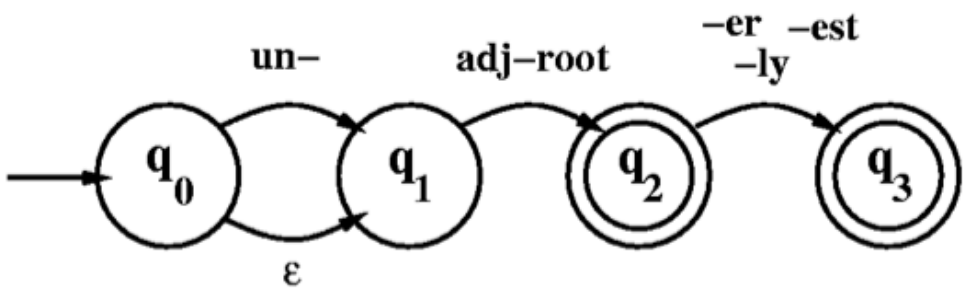


Figure 3.4 An FSA for a fragment of English adjective morphology: Antworth's Proposal #1.

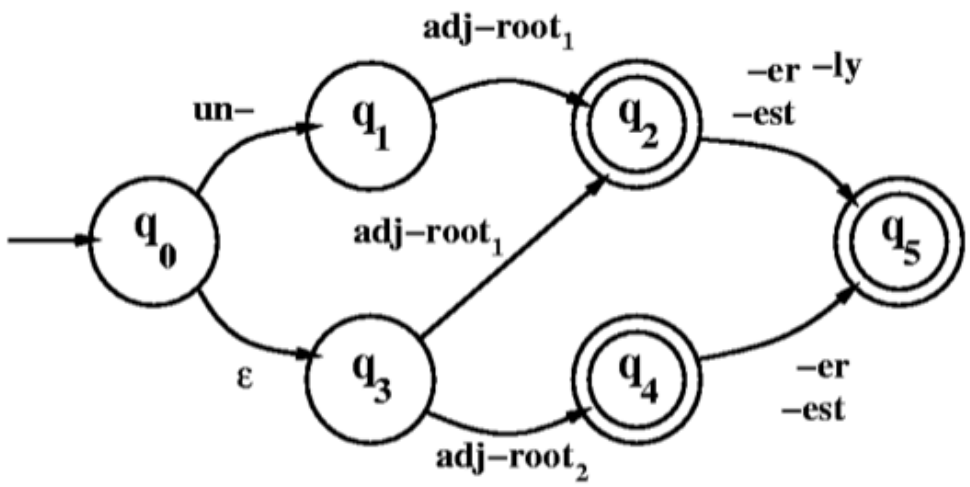


Figure 3.5 An FSA for a fragment of English adjective morphology: Antworth's Proposal #2.

More English Morphology

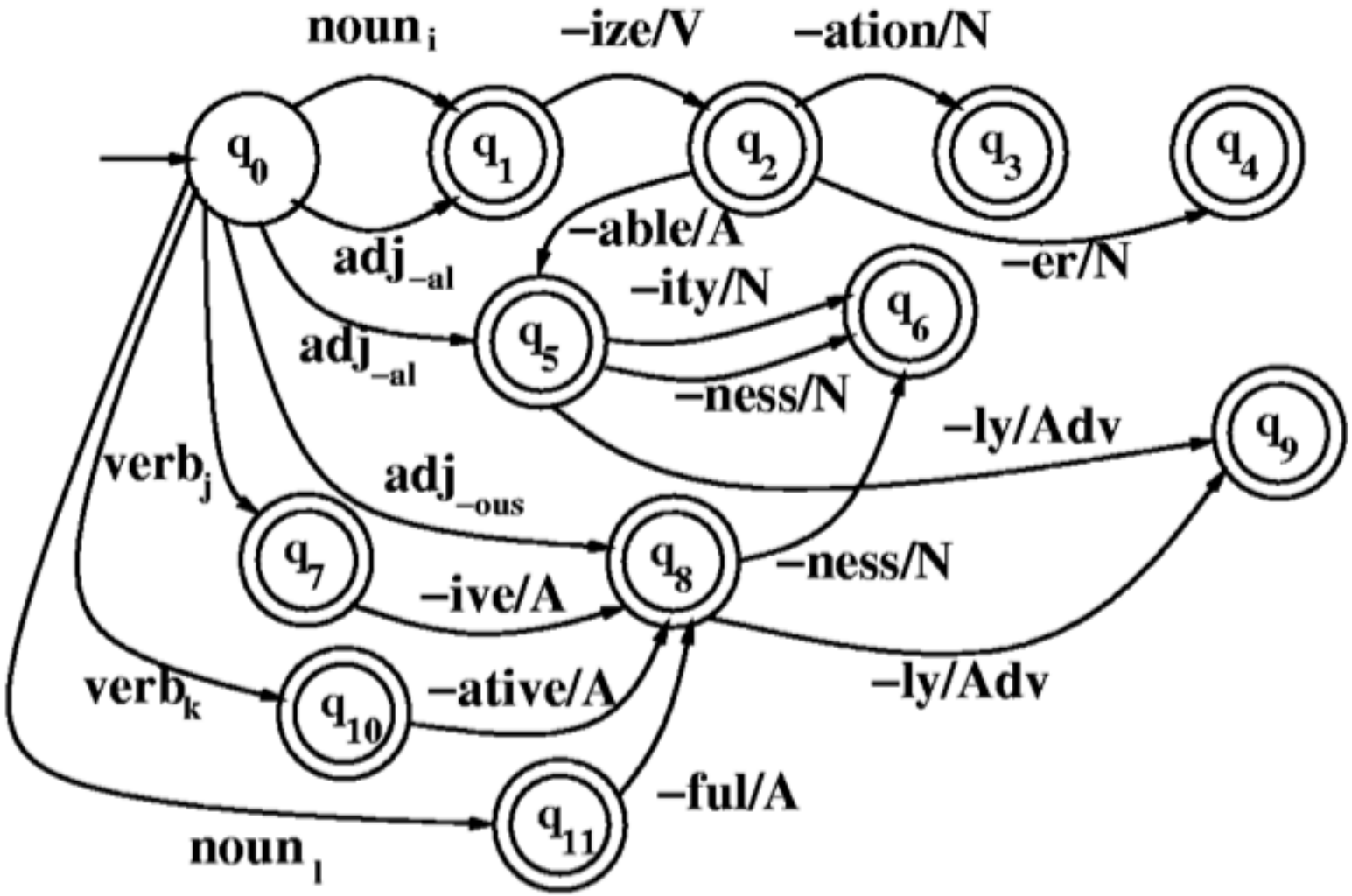
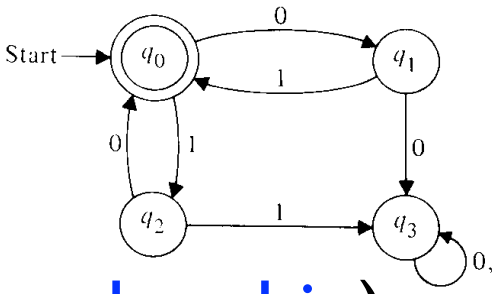


Figure 3.6 An FSA for another fragment of English derivational morphology.

Membership and Complement

- deterministic FSA: iff no state has two exiting transitions with the same label. (DFA)



- the language *L* of a DFA *D*: $L = L(D)$
- how to check if a string *w* is in $L(D)$? (membership)
  - linear-time: follow transitions, check finality at the end
  - no transition for a char means "into a trap state"
- how to construct complement DFA? $L(D') = \neg L(D)$
  - super easy: just reverse the finality of states :)
  - note that "trap states" also become final states

END OF WEEK 1 (half week)