16 Interpreting natural language

What is natural language?

- Aural communication system in a particular species of social primates
- sounds $\longrightarrow$ interpreted meanings, intentions, etc.

16.1 A lot of species specific characteristics

- Babies discriminate speech from non-speech sounds at birth
- 7 months old: All children discriminate same speech sounds
- 10 months old: Children begin to discriminate only speech sounds specific to their environmental language

Language development

- 3 months: coo
- 7 months: babble (in language-specific intonation and sound patterns)
- 1-1.5 years: words
  (mommy, daddy, juice, bow-wow, spash!, uh oh, shoot ball)

  2 word sentences
  3 word sentences
- 4-5: morphological rules, verb tenses, noun plurals
- Grammar, speech acts
- Figures of speech
- Rules of discourse, social conventions

16.2 Spoken versus written language

Spoken
- Utterances (sequences of phonemes grouped into words)
- Pauses occur between *sentence* breaks, not word breaks

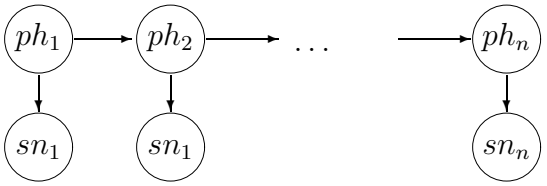
Written
- Character strings
- Western languages: white-space separated words
- Eastern languages: word boundaries are not explicit

16.3 Speech recognition

sound $\longrightarrow$ phoneme sequence $\longrightarrow$ word sequence

- Difficult
- State of the art: probability models ("hidden Markov models")

Hidden Markov model



Given sound sequence, infer most likely hidden sequence of phonemes

16.4 Some elements of written language (English)

String of word symbols

Syntax
- Not all word strings are legal
- Characterizing legal versus illegal word strings
- Surprisingly tricky

Semantics
- Hidden meaning of word strings

Basic functional form

Objects: dog, Bill, water (noun phrases)

Predicates: gave, heard, finished (verbs)

Statements: john gave mary the book
(completed relations: verb + arguments)

Linearization rules for functional forms

- Permuting verb and arguments
- Cannot break apart objects by verb and other arguments
- Rules for composing objects

Sentence types

Declarative (statement)

Imperative (command)

Interrogative (question)

Exclamatory (yikes!)

Modification and elaboration

Words modify components

- adjectives modify nouns
- adverbs modify verbs
- sentential modifiers modify statements

Phrases modify components

- Prepositional phrases modify: NPs, verbs, statements
- Relative clauses modify: NPs, verbs, statements

Word types

Function words ("closed class" words)

- conjunctions
- determiners
- prepositions
- to, which, that

"Open class" words

- Nouns
- Verbs
- Adjectives
- Adverbs

Rules of type, composition, and ordering

- Complex rules of type and composition
- Complex rules of ordering

E.g. Noun phrases (denote objects)
obey a complex type/composition system:

dog	Bill	water
dog falls ×	Bill falls	water falls
the dog falls	the Bill falls ×	the water falls

red dog	Bill's dog
red the dog ×	Bill's the dog ×
the red dog	the Bill's dog ×

16.5 Parsing and disambiguation

Given word sequence, identify: relations, arguments, modifiers

- Critical preprocessing step to determining meaning
- Most robust approach: Use probability models!

Readings

Russell and Norvig: Chapter 22
Dean, Allen, Aloimonos: Sections 10.1, 10.6-10.9