Communication

July 14, 2005

CS 486/686

University of Waterloo

Outline

- Communication
- Symbolic Natural Language Processing

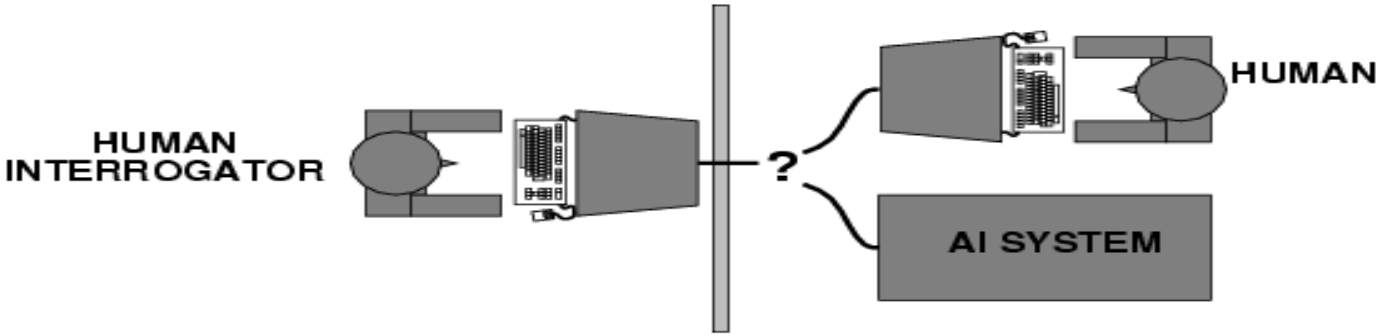
- Reading: R&N Sect. 22.1-22.6

Communication

- Communication: intentional exchange of information brought about by the production and perception of signs drawn from shared system of convention.
- Language:
  - Enables us to communicate
  - Intimately tied to thinking

Turing Test

- Can a computer fool a human to think that it is communicating with another human?



Speech

- Speech: communication act
  - Talking
  - Writing
  - Facial expression
  - Gesture

} utterances

Components of Communication

- Intention
  - Speaker S decides that there is some proposition P worth saying to hearer H.
- Generation
  - Speaker plans how to turn proposition P into an utterance (i.e. a sequence of words W)
- Synthesis
  - Speaker produces the physical realization W' of the words W (i.e., vibration in air, ink on paper)

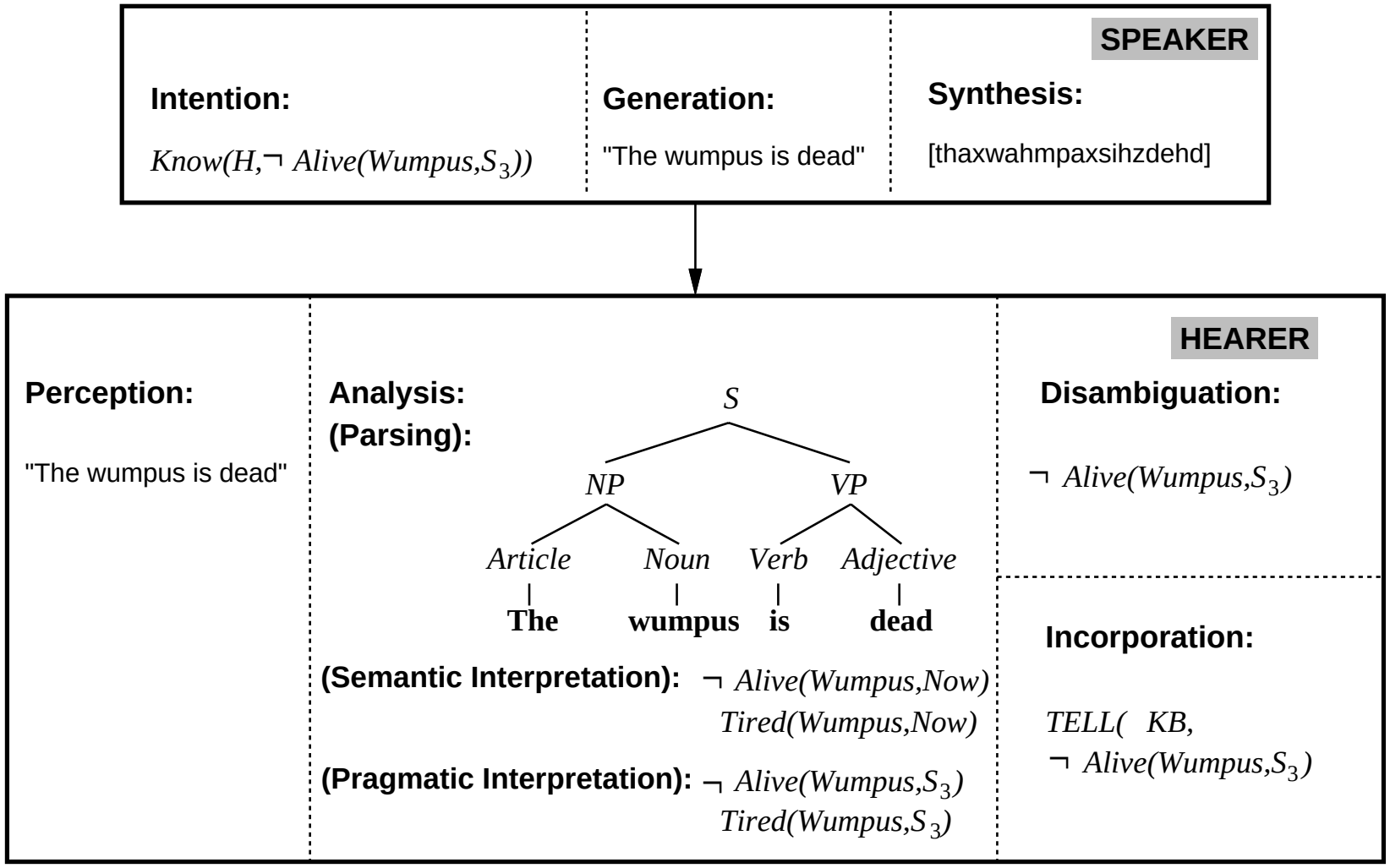
Components of Communication

- Perception
  - Hearer perceives physical realization W' as W_2 and decodes it as the words W_2 (i.e., speech recognition, optical character recognition)
- Analysis
  - Hearer infers W_2 has possible meanings P_1, P_2, …, P_n
  - Three parts:
    - Syntactic interpretation
    - Semantic interpretation
    - Pragmatic interpretation

Components of Communication

- Disambiguation
  - Hearer infers that speaker intended to convey P_i (where ideally $P_i = P$).
- Incorporation
  - Hearer decides to believe P_i (or not).

Components of Communication



Difficulties

- How could communication go wrong?
  - Insincerity
  - Speech recognition errors
  - Ambiguous utterance
  - Different contexts

Language

- Formal language
  - Set of strings of terminal symbols (words)
  - Strict rules
  - E.g., first order logic, Java
- Natural language
  - No strict definition
  - Chinese, Danish, English, etc.

Grammar

- Grammar specifies the compositional structure of complex messages
- Each string in a language can be analyzed/generated by the grammar
- A grammar is a set of rewrite rules
  - S → NP VP
  - Article → the | a | an | …

Grammar Types

- Regular grammar:
  - nonterminal → terminal [nonterminal]
  - S → a S
  - S → b
- Context free grammar (CFG):
  - nonterminal → anything
  - S → aSb

Grammar Types

- Context sensitive grammar:
  - More terminals on right-hand side
  - ASB → AAaBB
- Recursively enumerable grammar:
  - No constraints

Lexicon example

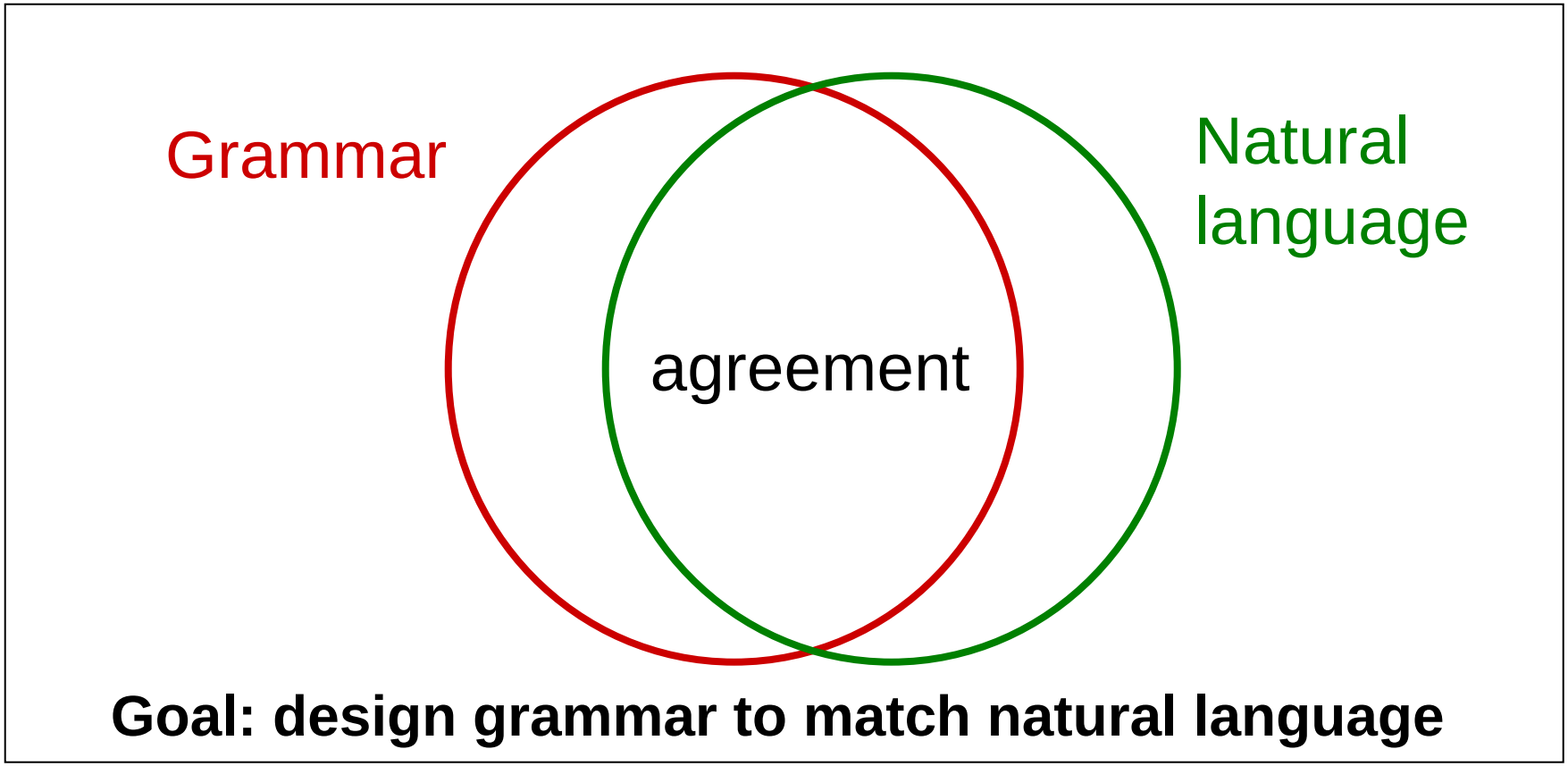
- Noun → **breeze | glitter | agent**
- Verb → **is | see | smell | shoot**
- Adjective → **right | left | east | dead**
- Adverb → **there | nearby | ahead**
- Pronoun → **me | you | I | it**
- Name → **John | Mary | Boston**
- Article → **the | a | an**

Grammar example

- S → **NP VP | S Conjunction S**
- NP → **Pronoun | Name | Noun | Article Noun | NP PP | NP RelClause**
- VP → **Verb | VP NP | VP Adjective | VP PP | VP Adverb**
- PP → **Preposition PP**
- RelClause → **that VP**

Grammaticality Judgements

Set of strings



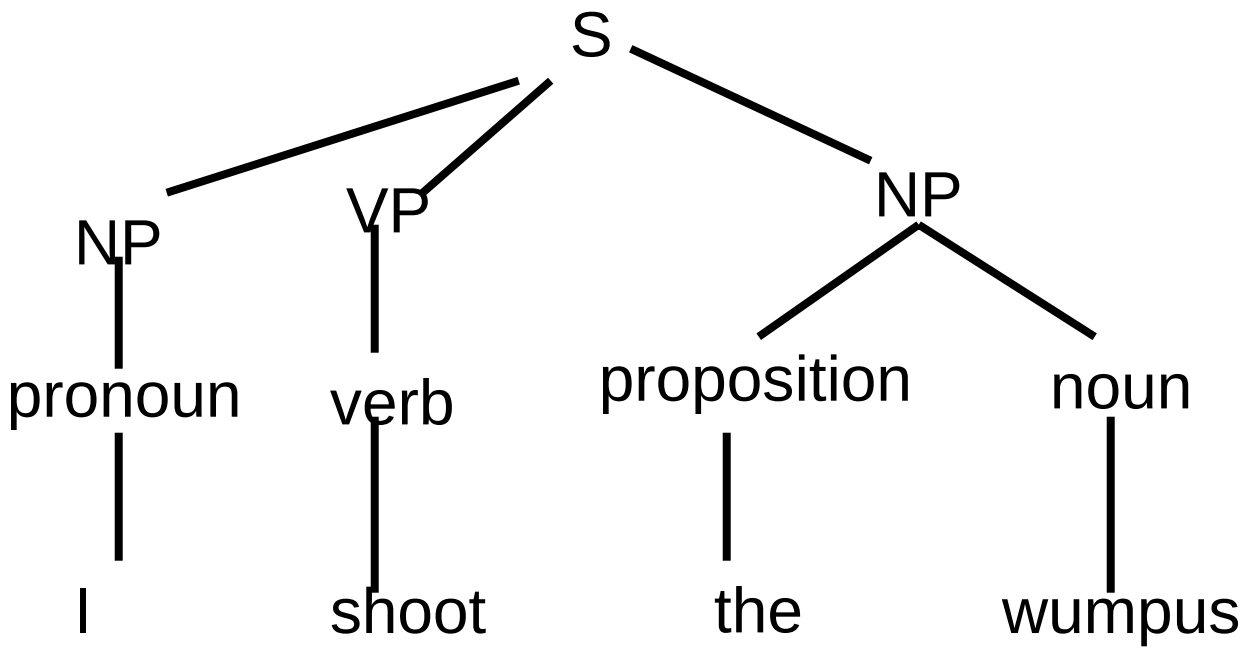
Goal: design grammar to match natural language

Grammaticality Judgements

- Overgeneration examples:
  - Me go Boston.
  - I smell pit gold wumpus nothing east.
- Undergeneration example:
  - I think the wumpus is smelly

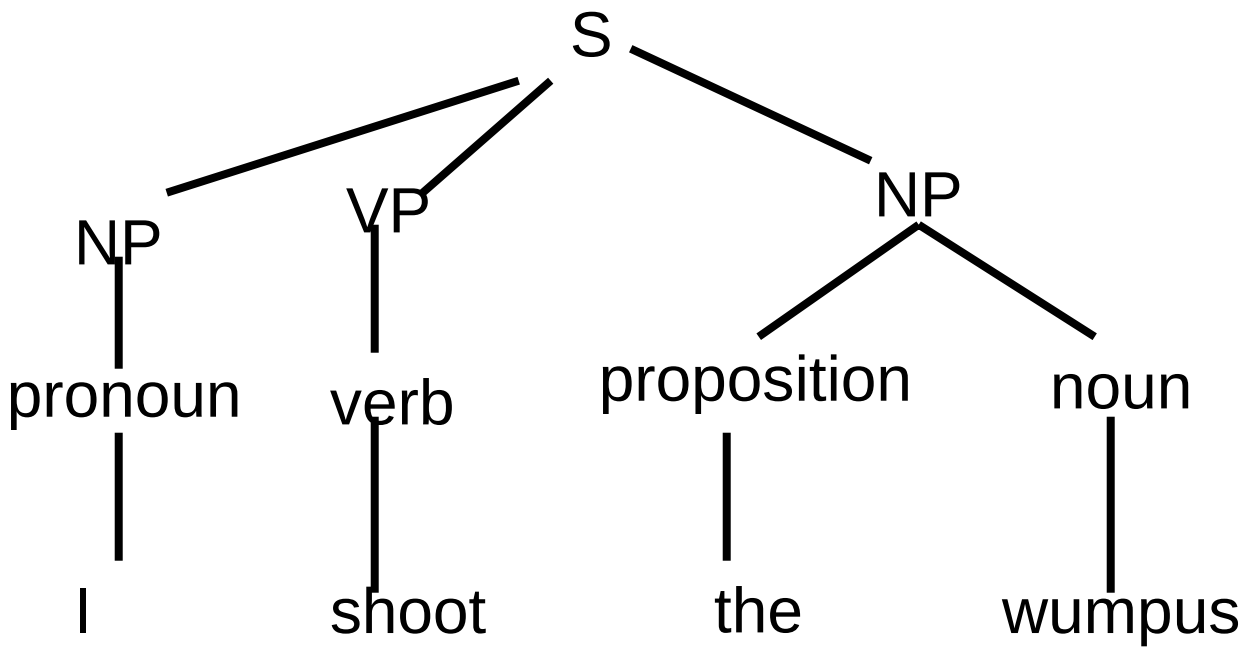
Syntactic Analysis

- Parsing: process of finding a parse tree for a given input string



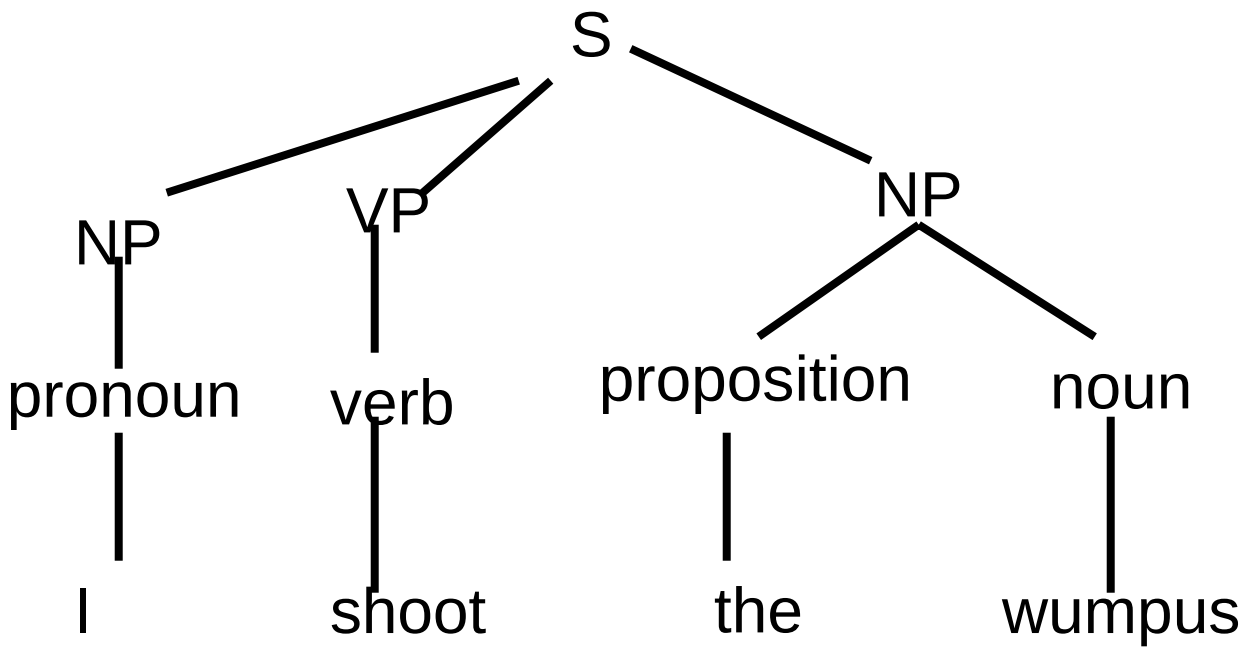
Top-down parsing

- Start with S and search for a tree that has string at leaves



Bottom up parsing

- Start with string and search for a tree that has S as root



Parsing efficiency

- Top-down and bottom up parsing inefficient…
  - Exponential running time
- Alternative: chart parsing
  - Dynamic programming
  - Cubic running time

Augmented Grammars

- Grammars tend to overgenerate
  - Ex: “me eat apple”
- Augment grammar to require
  - Agreement between subject and verb
    - Ex: “I smells” vs “I smell”
  - Agreement between verb subcategory and complement
    - Ex: “give the gold to me”
    - Ex: “give me the gold”

Parse ambiguity

- Some sentences have many grammatical parses

- Example:
  - "Fall leaves fall and spring leaves spring"

Semantic Interpretation

- Extract meaning from utterances
- Traditional approach
  - Express meaning with logic

- Problem
  - Ambiguous semantics
  - Ex: “Helicopter powered by human flies”

Ambiguity

- Possible causes:
  - Metonymy: figure of speech in which one object is used to stand for another
  - Metaphor: figure of speech in which a phrase with one literal meaning is used to suggest a different meaning by analogy
  - Vagueness
  - Unknown context

Context/Experience

- Meaning often grounded in experience

- But humans and machines have different experiences because of different sensors…
- Is that a problem for natural language understanding?

Next Class

- Next Class:
  - Probabilistic Language Processing
  - Russell and Norvig Ch. 23