

Communication

July 14, 2005
CS 486/686
University of Waterloo

Outline

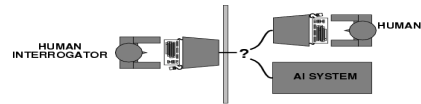
- Communication
- Symbolic Natural Language Processing
- Reading: R&N Sect. 22.1-22.6

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, \dots, P_n
 - Three parts:
 - Syntactic interpretation
 - Semantic interpretation
 - Pragmatic interpretation

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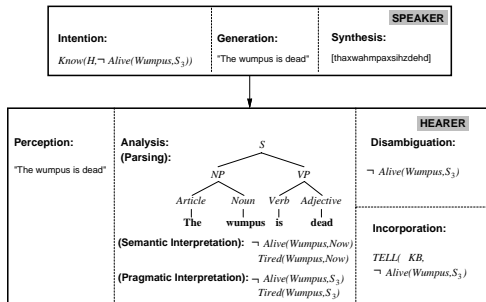
Components of Communication

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

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Components of Communication



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Difficulties

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

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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.

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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**
 - $S \rightarrow NP VP$
 - Article \rightarrow the | a | an | ...

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Grammar Types

- **Regular grammar:**
 - nonterminal \rightarrow terminal [nonterminal]
 - $S \rightarrow a S$
 - $S \rightarrow b$
- **Context free grammar (CFG):**
 - nonterminal \rightarrow anything
 - $S \rightarrow aSb$

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Grammar Types

- **Context sensitive grammar:**
 - More terminals on right-hand side
 - $ASB \rightarrow AAaBB$
- **Recursively enumerable grammar:**
 - No constraints

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Lexicon example

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

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Grammar example

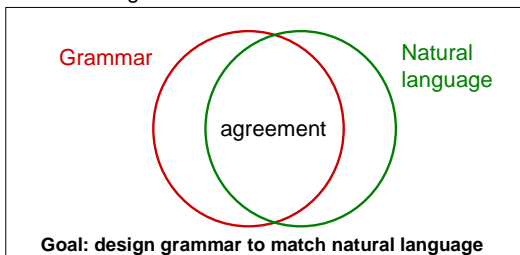
- $S \rightarrow NP VP \mid S Conjunction S$
- $NP \rightarrow Pronoun \mid Name \mid Noun \mid Article Noun \mid NP PP \mid NP RelClause$
- $VP \rightarrow Verb \mid VP NP \mid VP Adjective \mid VP PP \mid VP Adverb$
- $PP \rightarrow Preposition PP$
- $RelClause \rightarrow that VP$

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Grammaticality Judgements

Set of strings



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Grammaticality Judgements

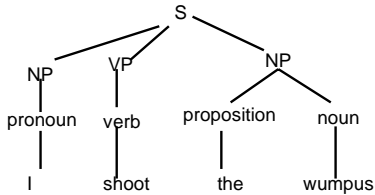
- **Overgeneration** examples:
 - Me go Boston.
 - I smell pit gold wumpus nothing east.
- **Undergeneration** example:
 - I think the wumpus is smelly

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Syntactic Analysis

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

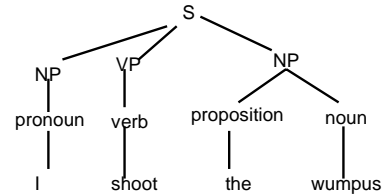


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Top-down parsing

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

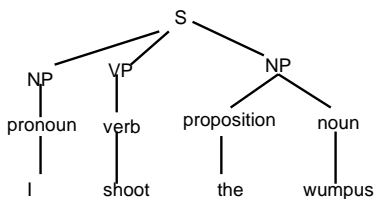


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Bottom up parsing

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



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Parsing efficiency

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

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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"

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Parse ambiguity

- Some sentences have many grammatical parses
- Example:
 - "Fall leaves fall and spring leaves spring"

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Semantic Interpretation

- Extract meaning from utterances
- Traditional approach
 - Express meaning with logic
- Problem
 - Ambiguous semantics
 - Ex: "Helicopter powered by human flies"

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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**

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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?

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Next Class

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

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