Natural Language Processing

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Outline

- AI and Language
- Natural Language Processing
- Syntactic Analysis
  - Grammars
  - Parsing
  - Chart Parsing Algorithm

The Turing test

Q: In the first line of your sonnet which reads "Shall I compare thee to a summer's day," would not "a spring day" do as well or better?
A: It wouldn't scan.
Q: How about "a winter's day"? That would scan all right.
A: Yes, but nobody wants to be compared to a winter's day.
Q: Would you say Mr. Pickwick reminded you of Christmas?
A: In a way.
Q: Yet Christmas is a winter's day, and I do not think Mr. Pickwick would mind the comparison.
A: I don't think you are serious. By a winter's day one means a typical winter's day, rather than a special one like Christmas.

Eliza – sample dialog

P: Men are all alike.
E: In what way?
P: They're always bugging us about something or other.
E: Can you think of a specific example?
P: Well, my boyfriend made me come here.
E: Your boyfriend made you come here.
P: He says I'm depressed much of the time.
E: I'm sorry to hear you are depressed.
P: It's true. I am unhappy.
E: Do you think coming here will help you not to be unhappy?
P: I need some help, that much seems certain.
E: What would it mean to you if you got some help?
P: Perhaps I could learn to get along with my mother.

Eliza – sample patterns

Word	Rank	Pattern	Outputs
alike	10	?X	In what way? What resemblance do you see?
are	3 3	?X are you ? Y ?X are ?Y	Would you prefer it if I weren't ?Y? What if they were not ?Y?
always	5	?X	Can you think of a specific example? When? Really, always?
what	2	?X	Why do you ask? Does that interest you?

What understanding isn't

- Merely reacting in a fixed or random manner to certain words in the text, and ignoring the rest of the text and the wider context.
- Programs like Eliza can give illusion of understanding if circumstances are right. Rarely can illusion be sustained.

Schank's scripts

"A man went into a restaurant and ordered a hamburger. When the hamburger arrived it was burned to a crisp, and the man stormed out of the restaurant angrily, without paying for the hamburger or leaving a tip".

Goals of Language Processing

- A scientific theory of communication by language:
  - to understand the structure of language and its use as a complex computational system,
  - to develop the algorithms and data structure that can implement/approximate the system.

Some applications

- Speech recognition
- Text-to-speech synthesizers
- Web-search engines
- Machine translation
- Information extraction
- Automatic summarization
- Question answering

Levels of Analysis

- Phonetics
- Phonology
- Morphology
- Lexicon
- Syntax
- Semantics
- Pragmatics and Discourse

Syntax

- Syntax is the study of the regularities and constraints of word order and phrase structure.
  - Which words are grouped together into a "phrase"
  - How words within a phrase are related to a common "theme"
  - How different phrases are related to each other

Phrase Structures

- Noun phrases
  - A noun phrase consists of a head noun and a set of modifiers.
  - The meaning of the noun phrase is largely determined by the noun.
- Verb phrases
  - A verb phrase consists of a head verb and a set of modifiers
  - the head verb denotes the action/activity/state

Grammar

- Must specify:
  - the primitive elements
  - how they can combine
- Terminology
  - constituents
  - start symbol, productions, terminals, non-terminals, derivation
  - grammatical vs. ungrammatical

Example Grammar

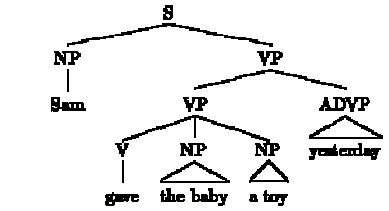
- S -> NP VP
- NP -> Art N
- NP -> Art Adj N
- NP -> NP PP
- VP -> V
- VP -> V NP
- PP -> P NP
- Art -> the, a
- Adj -> old, happy
- N -> cat, car, sofa
- V -> laugh, scratch
- P -> in, to, under

Parsing

- The task of assigning a correct tree to a string given some Context-Free Gramar.
  - "correct" means consistent with the input and the grammar
  - the leaves of the tree cover all and only the input
  - the tree corresponds to a valid derivation according to the grammar

A parse tree

(15)



Parsing as Search

- The search space is the space of trees generated by the grammar.
- The search is guided by the structure of the space and by the input.

Multiplication of parses

- "List the sales of the products produced in 1972 with the products produced in 1972".
- 455 parses
- Extending the coverage of the grammar to obscure constructions increases the number of undesired parses for common sequences.

Parsing: Top-Down vs. Bottom-up

- "goal-driven"
- start from the root node S
- expand constituents recursively
- stop when a tree matches the input
- always compatible with the grammar

- "data-driven"
- start from the input words
- group constituents into larger ones
- stop when a tree rooted in S is built
- always compatible with the input

Main Problems

- ambiguity
  - global ambiguity
  - local ambiguity
- repeated parsing of sub-trees
- left-recursion

A smarter parsing algorithm

- solves the left-recursion problem
- does not do repeated work
- solves an exponential problem in polynomial time
- answer: dynamic programming

Combining the Top-Down and the Bottom-Up Approaches

- Use top-down search control strategy with bottom-up filtering
- Depth-First Search strategy
- Search control issues
  - which node to expand next
  - which of the grammar rules to try
- Top-Down, Depth-First, Left-to-Right

Ambiguity

- Categorial: "I saw that gasoline can explode."
- Lexical: "Joe played baseball/ the piano/ a sonata/ Mozart."
- Structural: "I saw the man with binoculars."
- Reference: "Ross put the wine on the table. Because it wasn't level, it slid off."

Overlapping fields

- Computer science
- Linguistics
- Cognitive psychology
- Philosophy
- Mathematics
- Engineering