CHAPTER 22

COMMUNICATION AND LANGUAGE
Chapter 22

Outline

Communication ◇
Grammar ◇
Syntactic analysis ◇
Problems ◇
Communication

Why?

Searle (1969) Speech Acts
Austin (1962) How to Do Things with Words
Wittgenstein (1953) Philosophical Investigations

Modern view (post-1953):
Language is a form of action

Classical view (pre-1953):
Language consists of sentences that are true/false (cf. logic)
Communicaton

Wittgenstein (1953) Philosophical Investigations

Austin (1962) How to Do Things with Words

Searle (1969) Speech Acts

Why?

"Modern" view (post-1953):

Language is a form of action

"Classical" view (pre-1953):

Language consists of sentences that are true/false (cf. logic)
Why?

Wittgenstein (1953) Philosophical Investigations
Austin (1962) How to Do Things with Words
Searle (1969) Speech Acts

"Modern" view (post-1953): Language is a form of action

"Classical" view (pre-1953): Language consists of sentences that are true/false (cf. logic)
To change the actions of other agents

Why?

Wittgenstein (1953) Philosophical Investigations
Austin (1962) How to Do Things with Words
Searle (1969) Speech Acts

Classical view (pre-1953):

Language consists of sentences that are true/false (cf. logic)

Modern view (post-1953):

Language is a form of action

Chapter 226
Speech acts achieve the speaker's goals:

- Inform
  - "There's a pit in front of you"
- Query
  - "Can you see the gold?"
- Command
  - "Pick it up"
- Promise
  - "I'll share the gold with you"
- Acknowledge
  - "OK"

Speech act planning requires knowledge of:

- Situation
- Semantic and syntactic conventions
- Hearer's goals, knowledge base, and rationality
- Hearer's goals, knowledge base, and rationality
How could this go wrong?

$H$ infers intended meaning $P_i$

$H$ infers possible meanings $P_1, \ldots, P_n$

$H$ perceives $W$ in context $C$

$S$ selects words $W$ to express $P$ in context $C$

$S$ wants to inform $H$ that $P$

Intention

Perception

Analysis

Disambiguation

Synthesis

Incorporation

Stages in communication (informing)
Stages in Communication (Informing)

- Intention
  S wants to inform H that $P$
  H selects words $W$ to express $P$ in context $C$

- Generation
  S selects words $W$ to express $P$ in context $C$
  H perceives $W$ in context $C$

- Synthesis
  S utters $W$
  H infixes possible meanings $P_1, \ldots, P_n$

- Analysis
  H infers possible meanings $P_1, \ldots, P_n$

- Disambiguation
  H infers intended meaning $P_i$

- Incorporation
  H incorporates $P_i$ into KB

- Insincerity ($S$ doesn’t believe $P$)
- Speech wreck (ignition failure)
- Ambiguous utterance
- Differing understanding of current context ($C \neq C'$)

How could this go wrong?

- Insincerity ($S$ doesn’t believe $P$)

Chapter 22
Grammar

Vervet monkeys, antelopes etc. use isolated symbols for sentences restricted set of communicable propositions, no generative capacity (Chomsky (1957): Syntactic Structures)

A formal language is a set of strings of terminal symbols e.g., speech (linear), text (linear), music (two-dimenisonal)

Grammar specifies the compositional structure of complex messages

Here is the sentence symbol, ‘ S ’ and ‘ NP ’ and ‘ VP ’ and ‘ d ’ and ‘ np ’ and ‘ an ’ and ‘ the ’ and ‘ a ’ and ‘ n ’

\[ S \rightarrow \text{Article} \quad \text{Article} \rightarrow \text{the} \quad \text{Article} \rightarrow \text{an} \]

\[ S \rightarrow NP \quad NP \rightarrow VP \quad VP \rightarrow d \quad d \rightarrow np \quad np \rightarrow an \]

The grammar is a set of rewrite rules, e.g.

Each string in the language can be analyzed/generated by the grammar

Chapter 22
Grammar Types

Natural languages probably context-free, parsable in real time.

Related to Post systems and Kleene systems of rewrite rules

Recursively enumerable: no constraints

\[
A \rightarrow VB \quad A \rightarrow AB
\]

Context-sensitive: more nonterminals on right-hand side

\[
q \rightarrow S
\]

Context-free: nonterminal \rightarrow anything

\[
V \rightarrow S
\]

\[
S \rightarrow S
\]

Regular: nonterminal \rightarrow [terminal][nonterminal]
Divided into closed and open classes

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<th>ahead</th>
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<th>Verb</th>
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<th>see</th>
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<th>shoot</th>
<th>feel</th>
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<tr>
<th>Wumpus Lexicon</th>
<th>stench</th>
<th>breeze</th>
<th>glitter</th>
<th>nothing</th>
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Divided into closed and open classes

6 | 8 | 1 | 2 | 4 | 5 | 7 | 9

... | and | or | but

... | to | in | on | near

... | the | a | an

... | Glenn | Mary | Boston | UCB | PAJC

... | right | left | south | back

... | right | there | nearby | ahead

... | is | see | smell | shoot | feel | stinks

... | wumpus | pits | gold | east

... | nothing | glitter | breeze | stench

Wumpus Lexicon
I feel a breeze and I smell a wumpus
34 pits stinks
the wumpus + that is smelly
go + ahead
turn + to the east
is + smelly
feel + a breeze

Wumpus Grammar

Chapter 22
Real grammars I–500 pages, insufficient even for "proper" English

Inter-subjective agreement somewhat reliable, independent of semantics!

Adjusting $L_1$ to agree with $L_2$ is a learning problem!

Formal language $L_1$ may differ from natural language $L_2$

---

Grammarmaticality Judgements

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<tr>
<th>*thegoldgrabthewumpus</th>
<th>*Ismellthewumpusthegold</th>
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<tbody>
<tr>
<td>I givethewumpusthegold</td>
<td>*Idonatethewumpusthegold</td>
</tr>
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False negatives $L_2$ False positives $L_1$

Chapter 22
I shoot the wumpus. 

Exhibit the grammatical structure of a sentence.
Parse trees

Exhibit the grammatical structure of a sentence

I shoot the wumpus
Exhibit the grammatical structure of a sentence.

**I shoot the wumpus**

- **NP**: I
- **VP**: shoot
- **NP**: the wumpus
  - **Article**: the
  - **Noun**: wumpus

**Parse trees**
Exhibit the grammatical structure of a sentence

I shoot the wumpus

**Parse trees**
Exhibit the grammatical structure of a sentence:

I shoot the wumpus.
Most view syntactic structure as an essential step towards meaning:

"Mary hit John", ≠ "John hit Mary"
Most view syntactic structure as an essential step towards meaning.

Mary hit John 

and and and Chips, as well as after Chips'
context-free parsing \equiv \text{Boolean matrix multiplication} \ (\text{Lee, 2002})

Efficient algorithms (e.g., chart parsing, Section 22.3) \(O(n^3)\) for context-free,

RHS of a rule with the rule's LHS.

Bottom-up parsing works by replacing any substring that matches
Logical grammars

BNF notation for grammars too restrictive:

- difficult to add „side conditions“ (number agreement, etc).
- difficult to connect syntax to semantics

Idea: express grammar rules as logic

Here, \((s)X\) means that string \(s\) can be interpreted as an \(X\)

\[
(s)X \leftarrow (s)Z \\
(s)X \leftarrow (s)\lambda \\
\left(\forall\,\rho\in\rho\downarrow\right) X \leftarrow (\exists s)Z \lor (\forall s)\lambda \\
\]

Here, \(X(s)\) means that string \(s\) can be interpreted as an \(X\)

\[
Z \mid \lambda \leftarrow X \\
\rho \downarrow \leftarrow X \\
Z\lambda \leftarrow X
\]
Logical grammars contd.

 Parsing is reduced to logical inference:

 $$\text{ASK}(KB, S(x, \text{AT(Robot, } I), I', 1))$$

 Generation can be done from a given logical sentence:

 If we add arguments to nonterminals to construct sentence semantics, NLP

 $$\text{ASK}(KB, S(x))$$

 Generation simply requires a query with uninstantiated variables:

 (Can add extra arguments to return the parse structure, semantics)

 $$\text{ASK}(KB, S([\text{"snpump", } \text{"am", } \text{"I", } 1]])$$

 Parsing is reduced to logical inference:

 $$(\exists s_1' \forall s_2') S \leftarrow$$

 $$(\forall s_1, n \text{Number}(s_1, n) \lor (\exists s_2) \text{NP} \lor (\exists s_1') \text{VP} \lor (\exists s_1'') \text{Number}(s_1'', n) \lor (\exists s_2') \text{NP}$$

 $$(\exists s_1, s_2) \text{Append}(s_1; s_2)$$

 Now it's easy to augment the rules
Real human languages provide many problems for NLP:

- ambiguity
- anaphora
- indexicality
- vagueness
- discourse structure
- noncompositionality
- metaphor
- metonymy
- metaphor
- noncompositionality
Ambiguity

Squad helps dog bite victim
Ambiguity

Squad helps dog bite victim

Helicopter powered by human flies
Ambiguity

American pushes bottle up Germans
Helicopter powered by human flies
Squad helps dog bite victim
Ambiguity

Helicopter powered by human flies

An American pushes a bottle up

I ate spaghetti with meatballs

Squad helps dog bite victim
Ambiguity

Squad helps dog bite victim

American pushes bottle up Germans

Helicopter powered by human flies

I ate spaghetti with meatballs and salad.
Ambiguity

Chapter 23

Ambiguity

Squad helps dog bite victim

American pushes bottle up Germans

I ate spaghetti with meatballs and salad
Ambiguity

Squad helps dog bite victim

American pushes bottle up Germans

I ate spaghetti with meatballs

did someone abandon a fork

salad
Ambiguity

Squad helps dog bite victim

American pushes bottle up Germans

I ate spaghetti with meatballs

Abandon a fork a friend

Salad
Ambiguity can be lexical (polysemy), syntactic, semantic, referential

a friend
a fork
abandon
salad

I ate spaghetti with meatballs
American pushes bottle up Germans

Helicopter powered by human flies

Squad helps dog bite victim
Anaphora

Using pronouns to refer back to entities already introduced in the text

After Mary proposed to John, they found a preacher and got married.
Anaphora

Using pronouns to refer back to entities already introduced in the text.

After Mary proposed to John, they found a preacher and got married.

For the honeymoon, they went to Hawaii.
Anaphora

Using pronouns to refer back to entities already introduced in the text.

Mary saw a ring through the window and asked John for it.

For the honeymoon, they went to Hawaii.

After Mary proposed to John, they found a preacher and got married.
Anaphora

Using pronouns to refer back to entities already introduced in the text

Mary threw a rock at the window and broke it.

Mary saw a ring through the window and asked John for it.

For the honeymoon, they went to Hawaii.

After Mary proposed to John, they found a preacher and got married.
Indexicality

Indexical sentences refer to utterance situation (place, time, S/H, etc.):

I am over here

Why did you do that?
Metonymy

Using one noun phrase to stand for another

I’ve read Shakespeare

Chrysler announced record profits

The ham sandwich on Table 4 wants another beer
I've tried killing the process but it won't die. Its parent keeps it alive.

“Non-literal” usage of words and phrases, often systematic.
Noncompositionality
Noncompositionality

baby shoes
basketball shoes
Noncompositionality

designer shoes
alligator shoes
baby shoes
basketball shoes
Noncompositionality

break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
red book
break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
red hair
red pen
red book
break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
Noncompositionality
Noncompositionality

red herring
red hair
red pen
red book

break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
Noncompositionality

small moon
red herring
red hair
red pen
red book

break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
Noncompositionality

- Large molecule
- Small moon
- Red herring
- Red hair
- Red pen
- Red book
- Brake shoes
- Designer shoes
- Alligator shoes
- Baby shoes
- Basketball shoes
Chapter 2254

Noncompositionality

mere child
large molecule
small moon
red herring
red hair
red pen
red book
break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes
Noncompositionality

- basketball shoes
- baby shoes
- alligator shoes
- designer shoes
- brakeshoes
- redbook
- redpen
- redhair
- redherring
- smallmoon
- largemolecule
- merechild
- allegedmurderer

Chapter 2255
reall leather
alleged murderer
mere child
large molecule
small moon
red herring
red hair
red pen
red book
break shoes
designer shoes
alligator shoes
baby shoes
basketball shoes

Noncompositionality
Noncompositionality