

# 14. Natural language generation (NLG)

# 14.1 Study of NLG

- How to make computer programs produce high-quality natural language text from its internal representation of information.
- Study and simulation of production of spoken or written discourse.
- Multidisciplinary enterprise: linguists, psychologists, engineers, and computer scientists.
- Ranges from entirely theoretical to entirely practical:
  - Linguistics and psycholinguistics
  - Output production for computer systems

# 14.2 Process of NLG

- Starts with a communicative goal.
- Employs planning to convert the goals into writing or speech.
- **Strategy - tactic** distinction mirrored in
  - *What to say vs. How to say it.*
  - *Text planning* (multi-sentence generation) vs. *realization* (single-sentence generation).
- Tasks of generation vs. process of generation
  - Every generator addresses one or more tasks, and embodies (usually) one process.
  - Tasks: text planning, sentence planning, and surface realization.
  - Generation process can be classified according to its sophistication and expressive power.

# 14.2 NLG techniques

- Canned text systems
  - Single-sentence and multi-sentence generation.
  - Simple, but inflexible.
  - Examples: error messages, warnings.
- Template systems
  - Pre-defined templates or schemata: a few open fields are filled in specified and constrained ways.
  - Multi-sentence production
  - In applications whose texts are relatively regular in structure or the same messages needs to be produced several times with slight modifications.
  - Examples: form letters, business reports.

- Phrase-based systems
  - Generalized templates
  - Sentence level → phrase structure grammar rules:  $C \rightarrow C_1 C_2 \dots C_n$  (e.g.,  $S \rightarrow NP VP$ )
  - Discourse level → text plans
  - The phrasal pattern is first matched at the top level, then parts of the pattern are matched recursively to the subparts of the input. For example:  
(SUBJECT VERB OBJECT) → (DETERMINER  
ADJECTIVE HEAD-NOUN MODIFIERS)
  - Process stops when all the phrasal patterns have been replaced by one or more words.
  - Powerful and robust, but hard to build beyond a certain size.

- Feature-based systems
  - Each sentence is specified by unique set of features:
    - The sentence is either POSITIVE or NEGATIVE,
    - it is a QUESTION or an IMPERATIVE or a STATEMENT,
    - its tense is PRESENT or PAST, and so on.
  - Generation proceeds by incremental collection of features until the whole sentence is fully determined.
  - Single-sentence generation
  - High expressive power and sophistication
  - Simple: any distinction in language can be added as a feature.
  - Interrelationships between features hard to maintain.
- Most current systems are hybrid of the above.

# 14.3 Challenges of NLG

- Easy to build a single-purpose generator for a specific domain.
- Cannot build a general-purpose sentence generator or non-toy text planner. Outstanding problems:
- Lexical selection:
  - One of the most difficult problems in NLG.
  - The most appropriate single word for given input: *John's car vs. John's sports car vs. the red vehicle vs. the red Mazda, ...*
  - Depends on context, preferred style, what has been said so far, ...

- Discourse structure:
  - Reliably plan ahead several paragraphs of text.
  - Required:
    - Theories of natural structure of discourse, coherence and cohesion, and development of theme and focus.
    - Libraries for discourse relations, communicative goals, and text plans.
    - Representational paradigms for characterization of typical texts, such as business reports.
    - Implemented (and tested) text planners that operate in non-toy domains.

- **Sentence planning**

- Structure and contents of the sentence; pronoun specification, ordering or prepositional phrases and adjectives, etc.
- Required:
  - theory of pronoun use
  - theme and focus selection, content aggregation
  - implemented planners
  - testing in realistic domains

- **Domain modeling**

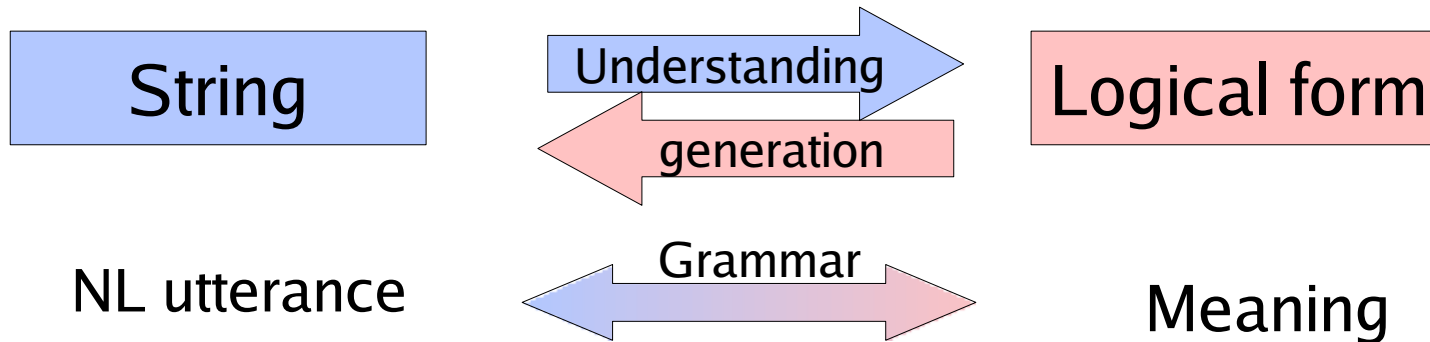
- How to represent the application domain of discourse to the generation system?
- Models traditionally hand-crafted.
- Required: large-scale linguistically appropriate domain models and criteria for their evaluation.

- **Generation choice criteria**
  - Least addressed component in NLG.
  - How to guide the system through choices in the process when there are multiple alternatives.
  - How to choose stylistic variations to express interpersonal and situational meanings: formal/informal, slanted/objective, dry/colorful, etc.?
  - Not only semantic content needs to be specified, but pragmatic.
  - Required:
    - Classification of reader characteristics and goals.
    - Types of author goals.
    - Criteria for evaluating the appropriateness of the generated text.

# 14.4 Infrastructure requirements

- Ultimate challenge to scale up to handle real-world domains.
- Little funding → hardly any infrastructure exists.
- Most needed resources:
  - Large well-structured lexicons in various languages.
  - Larger well-structured knowledge bases to support domain-specific application oriented knowledge bases.
  - Grammars for various languages.
  - Libraries for text plans.

# 14.5 Syntactic generation



- Challenges:
  - Large lexicon and grammars for linguistic competence
  - Reversible grammar: to use one and the same grammar in understanding and generation.
  - Production of non-ambiguous utterances.
  - Integration of template and grammar-based systems for efficiency and flexibility.
- The most elaborated and actively studied field within NLG.

# 14.6 Deep generation

- Lacks clear theoretical foundations.
- Consists of two sub-tasks:
  - Selection the content for the text, and
  - Imposing an appropriate linear order on the content's expression.
- Linguistic decision vs. general inferential capabilities → divide generator to:
  - Surface generator that maps semantics to syntax.
  - Reasoner/pragmatic handler.
- The key problem is appropriately organized knowledge representation!

interdependent

# 14.7 Speech acts

- An action performed by speaking
  - Generation as planning to achieve a communicative goal.
  - Understanding as recognition of speaker's plan.
- Types: request, inform, promise, etc.
- Independent of the linguistic form which realizes it:
  - “Where's the post office?”
  - “Can you tell me where the post office is?”
  - “You wouldn't happen to know where the post office is, would you?”

# 14.8 STRIPS-style planner

## **Request** (sp, hr, act)

### *Preconditions:*

Believe (sp, Cando (hr, act))  
Want (sp, Request (sp, hr, act))  
Channel (sp, hr)

### *Effect:*

Believe (hr, Want (sp, act))

## **Inform** (sp, hr, prop)

### *Preconditions:*

Believe (sp, prop)  
Want (sp, Inform (sp, hr, prop))  
Channel (sp, hr)

### *Effect:*

Believe (hr, Believe (sp, prop))

## **Cause-to-want** (agt1, agt2, act)

### *Preconditions:*

Believe (agt2, Want (agt1, act))  
Believe (agt2, Cando (agt2, act))

### *Effect:*

Want (agt2, act)

## **Convince** (agt1, agt2, prop)

### *Preconditions:*

Believe (agt2, Believe (agt1, prop))

### *Effect:*

Believe (agt2, prop)

# 14.9 Example

Communicative act **Convince by Informing**:

1. Sam says the words *It's raining* with the intention to inform Helen of the fact.
2. Helen hears the sentence *It's raining* and recognizes Sam's intention to inform her of the fact.
3. Because of this, Helen decides that it's Sam's intention to make her believe it is raining.
4. Helen considers the evidence for the fact it is raining, including the Sam's saying it is raining.
5. Helen comes to believe it is raining.