Natural Language Generation: An Introduction

Lecture 1

January 17, 2012

http://www.inf.ed.ac.uk/teaching/courses/nlg

Natural Language Generation

- Instructors: Johanna Moore and Jon Oberlander
- With help from Amy Isard
- Class meetings
  - Tues, Fri 16:10--17:00
  - Chrystal Macmillan Building Seminar Room 4
- Prerequisites: (Inf 2A), FNLP or ANLP
- Lectures; no tutorials
  - but some lab sessions devoted to helping with use of software tools
- Assessment
  - 30% coursework (2 assessed assignments)
  - 70% final exam

Books & Course Readings

- **Recommended Text**

  Ehud Reiter and Robert Dale, *Building Natural Language Generation Systems,* Cambridge University Press, 2000.

- **Readings**
  - available on web site

What's it all about?

- How computer programs can be made to produce high-quality natural language text or speech
  - from computer-internal representations of information
  - other texts

Goal, Semantic Input →

→ Text, Speech, Graphics …

Data stream, Log Files, Reasoner output, Logical forms, News stories …

Reports, Explanations, Summaries, Recommendations, …

Topics include

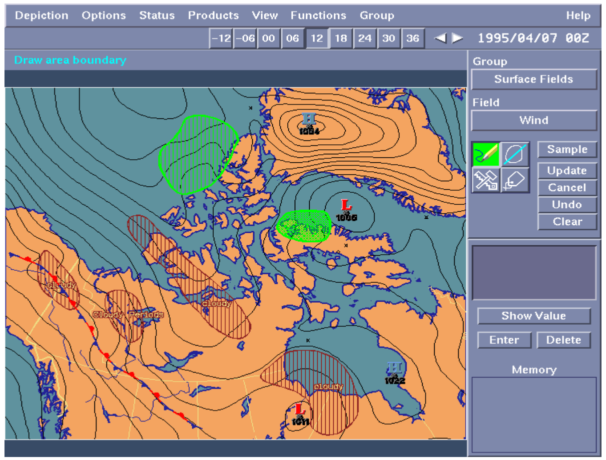
- Basic NLG tasks
- Generating coherent discourse
- Evaluation methods
- Human language production
- Multimodal generation
- Knowledge-based and statistical approaches
- Using example applications of NLG
  - Recommendation and Comparison
  - Report Generation
  - Summarization
  - Paraphrase
  - Prompt and response generation in dialogue systems

Example System #1: FoG

- Function:
  - Produces textual weather reports in English and French
- Input:
  - Numerical weather simulation data annotated by human forecaster
- User:
  - Environment Canada (Canadian Weather Service)
- Developer:
  - CoGenTex
- Status:
  - Fielded, in operational use since 1993

E. Goldberg, R. Kittredge, and N. Driedger. 1994. FoG: A New Approach to the Synthesis of Weather Forecast Text. In IEEE Expert, April 1994.

FoG: Input



Graphical depiction of predicted weather system over Northern Canada

FoG: Output

Marine forecast describing predicted weather over various points in Northern Canada

Example #2: MATCH Multimodal Dialogue System

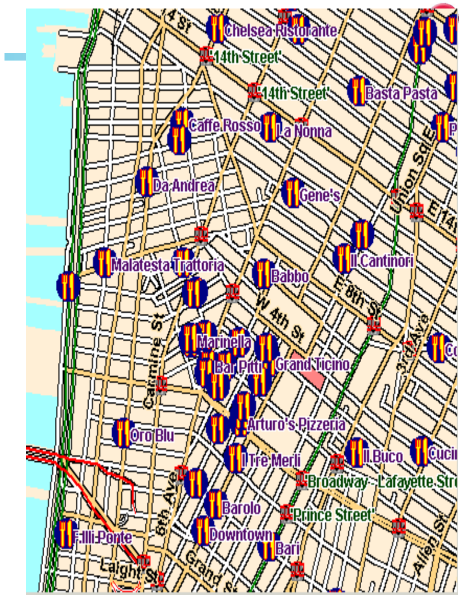
- Function: Provides information about restaurants in New York City
- Input:
  - User query: Typed and spoken language, gesture
  - User model
  - Restaurant database
- Output: Spoken, written and graphical output
- Developer: AT&T Research Labs
- Status: Research Prototype

Johnston, M., et al., "MATCH: An Architecture for Multimodal Dialogue Systems", ACL 2002

"Show me Italian restaurants in the West Village".

User can then click on and find information about each restaurant in turn

Time-consuming, potentially confusing and hit-and-miss



Solution: User-Tailored Generation

- More compact, directed information presentations could improve the user experience and aid in task completion
- User models can help:
  - Highlight options the user is likely to like
  - Highlight reasons the user is likely to like them
- Evaluation of MATCH and several other systems employing user models indicates user tailored generation leads to improved
  - User satisfaction
  - Task efficiency
  - Task effectiveness

Comparisons for two users: CK and OR

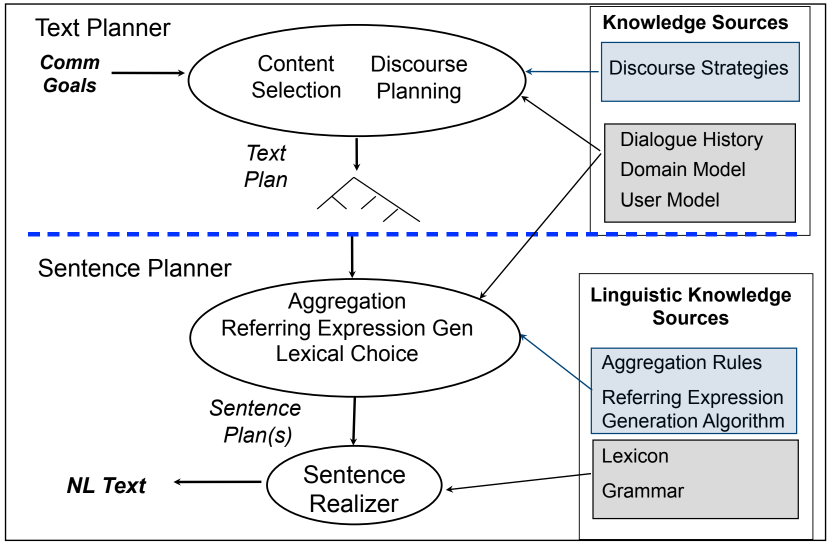
- CK: *Among the selected restaurants, the following offer exceptional overall value. Babbo's price is 60 dollars. It has superb food quality, excellent service and excellent decor. Il Mulino's price is 65 dollars. It has superb food quality, excellent service and very good decor. Uguale's price is 33 dollars. It has excellent food quality, very good service and good decor.*

- OR: *Among the selected restaurants, the following offer exceptional overall value. Uguale's price is 33 dollars. It has good decor and very good service. It's a French, Italian restaurant. Da Andrea's price is 28 dollars. It has good decor and very good service. It's an Italian restaurant. John's Pizzeria's price is 20 dollars. It has mediocre decor and decent service. It's an Italian, Pizza restaurant.*

NLG is all about making choices

- Content to be included/omitted
- Organization of content into coherent structure
- Style (formality, opinion, genre, personality…)
- Packaging into sentences
- Syntactic constructions
- How to refer to entities (referring expression generation)
- What words to use (lexical choice)

NLG Tasks and Pipeline Architecture



Example: Monthly Weather Summary Generator

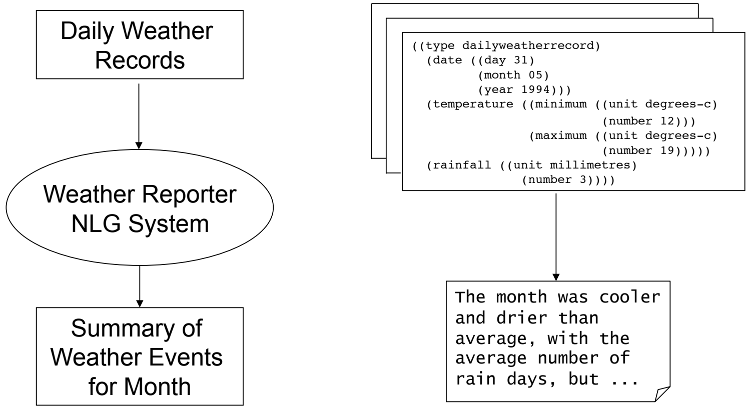
```
MARSFIELD (Macquarie University No 1)
On Campus, Square F9

TEMPERATURES (C)

Mean Max for Mth:        18.1 Warmer than average
Mean Max for June (20 yrs):          17.2
Highest Max (Warmest Day):           23.9 on 01
Lowest Max (Coldest Day):            13. On 12
Mean Min for Mth:        08.2 Much warmer than ave
Mean Min for June (20 yrs):          06.4
Lowest Min (Coldest Night):          02.6 on 09
Highest Min (Warmest Night):         13.5 on 24

RAINFALL (mm) (24 hrs to 09:00)

Total Rain for Mth:      90.4 on 12 days.
                         Slightly below average.
Wettest Day (24h to 09:00):          26.4 on 11
Average for June (25 yrs):           109.0 on 10
Total for 06 mths so far:            542.0 on 72
days.
                         Very depleted.
Average for 06 mths (25 yrs):        762.0 on 71
days
Annual Average Rainfall (25 yrs):1142.8 on 131
days

WIND RUN (at 2m height) (km) (24 hrs to 09:00)

Total Wind Run for Mth:              1660
Windiest Day (24 hrs to 09:00):      189 on 24,
                        185 on 26, 172 on 27
Calmest Day (24 hrs to 09:00):       09 on 16

SUNRISE & SUNSET

Date        Sunrise     Sunset      Difference
01 Jun      06:52       16:54       10:02
11 Jun      06:57       16:53       09:56
21 Jun      07:00       16:54       09:54
30 Jun      07:01       16:57       09:56

(Sunset times began to get later after about June 11)
(Sunrise times continue to get later until early July)
(Soon we can take advantage of the later sunsets)
```

SUMMARY

The month was warmer than average with average rainfall, but the total rain so far for the year is still very depleted. The month began with mild to warm maximums, and became cooler as the month progressed, with some very cold nights such as June 09 with 02.6. Some other years have had much colder June nights than this, and minimums below zero in June are not very unusual. The month was mostly calm, but strong winds blew on 23, 24 and 26, 27. Fog occurred on 17, 18 after some rain on 17, heavy rain fell on 11 June.

Inputs and Outputs

Communicative Goal: `SummarizeMonth(051994)`



Text/Document Planning

Determine

- **what information** to communicate
- how to **structure information** into a coherent text

Two Common Approaches:

- methods based on observations about common text structures (Schemas)
- methods based on reasoning about the purpose of the text and discourse coherence (Rhetorical Structure Theory, planning)

Content Selection: Schema-based

Based on MESSAGES, predefined data structures:

- correspond to informational units in the text
- collect together underlying data in ways that are convenient for linguistic expression

How to devise MESSAGE types?

- Rhetorical predicates: generalizations made by linguists
- From corpus analysis, identify agglomerations of informational elements that allow required flexibility in linguistic expression
  - Application dependent

Rhetorical predicates

Attributive: *Mary has a pink coat.*

Equivalence: *Wines described as 'great' are fine wines from an especially good village.*

Specification: *[The machine is heavy.] It weighs 2 tons.*

Constituency: *[This is an octopus.] There is his eye, these are his legs, and he has these suction cups.*

Evidence: *[The audience recognized the difference.] They started laughing right from the very first frames of that film.*

…

Alternatives: *We can visit the Empire State Building or the Natural History Museum.*

Adapted from: McKeown, K., "Text Generation", Cambridge University Press, 1985.

Content Selection in WeatherReporter

Corpus based approach

- Routine messages: *always included*
  - MonthlyRainFallMsg, MonthlyTemperatureMsg, RainSoFarMsg, MonthlyRainyDaysMsg
- Significant Event messages: *Only constructed if the data warrants it: e.g., if rain occurs on more than a specified number of days in a row*
  - RainEventMsg, RainSpellMsg, TemperatureEventMsg, TemperatureSpellMsg

Content Selection in WeatherReporter

A RainSpellMsg:

```
((message-id msg096)
 (message-type rainspellmsg)
 (period ((begin ((day 04)
                  (month 02)
                  (year 1995)))
          (end ((day 11)
                (month 02)
                (year 1995)))
          (duration ((unit day)
                     (number 8)))))
 (amount ((unit millimetres)
          (number 120))))
```


Document Planning in WeatherReporter

Define Schemas:

```
WeatherSummary →
    TemperatureInfo RainfallInfo
TemperatureInfo →
    MonthlyTemperatureMsg [ExtremeTempInfo] [TempSpellsInfo]
RainfallInfo →
    MonthlyRainfallMsg [RainyDaysInfo] [RainSpellsInfo]
RainyDaysInfo →
    MonthlyRainyDaysMsg RainSoFarMsg
...
```


Text/Document Planning

- Produces a text/document plan
  - a tree structure populated by messages at its leaf nodes
- For a very simple NLG system, next step is realizing the messages as text

A Simple Realizer

Sets of sentence templates, e.g.,

For the MonthlyTemperatureMsg:

```
TempString = case (TEMP - AVERAGETEMP)
    [2.0 … 2.9]:    'very much warmer than average.'
    [1.0 … 1.9]:    'much warmer than average.'
    [0.1 … 0.9]:    'slightly warmer than average.'
    [-0.1 … -0.9]:  'slightly cooler than average.'
    [-1.0 … -1.9]:  'much cooler than average.'
    [-2.0 … -2.9]:  'very much cooler than average.'
endcase
Sentence = 'The month was' + TempString
```

One Message per Sentence

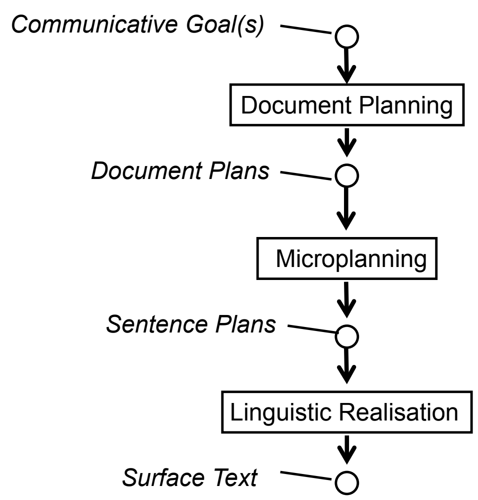
- The Result:

```
The month was cooler than average.
The month was drier than average.
There was the average number of rain days.
The total rain for the year so far is well below average.
There was rain on every day for 8 days from 11th to 18th.
Rainfall amounts were mostly small.
```

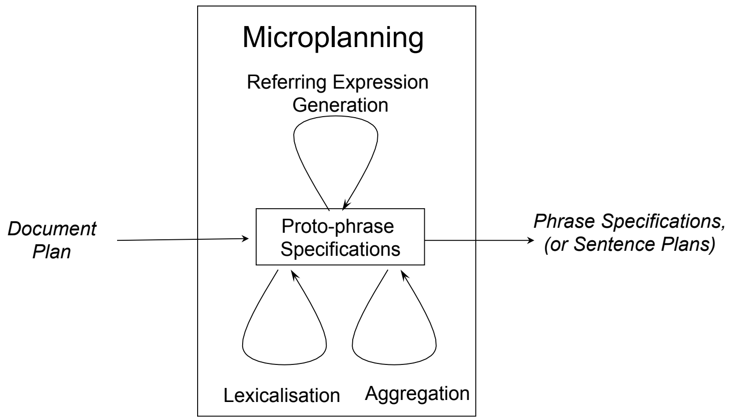
- What we'd really like:

```
The month was cooler and drier than average.  The total
rain for the year so far is well below average, even
though there was an average number of rain days this
month.  There was rain on every day for 8 days from 11th
to 18th, but rainfall amounts were mostly small.
```


The NLG Pipeline



Generation Tasks in Microplanning



Aggregation

Deciding how messages should be composed together to produce specifications for sentences or other linguistic units

On the basis of

- Information content
- Possible forms of realization
- Semantics!

Some possibilities:

- Simple conjunction
- Ellipsis
- Embedding
- Set introduction

Some Weather Reporter Examples

Without aggregation:

- Heavy rain fell on the 27th.
  Heavy rain fell on the 28th.

With aggregation via simple conjunction:

- Heavy rain fell on the 27th and heavy rain fell on the 28th.

With aggregation via ellipsis:

- Heavy rain fell on the 27th and [] on the 28th.

With aggregation via set introduction:

- Heavy rain fell on the 27th and 28th.

Lexicalisation

- Choose words and syntactic structures to express content selected
- If several lexicalisations are possible, consider:
  - user knowledge and preferences
  - consistency with previous usage
  - Pragmatics: emphasis, level of formality, personality, …
  - interaction with other aspects of microplanning
- Example:

S:	rainfall was very poor
NP:	a much worse than average rainfall
ADJP:	much drier than average

Generating Referring Expressions (GRE)

- How do we identify specific domain objects and entities?
- GRE produces description of object or event that allows hearer to distinguish it from distractors
- Two issues:
  - Initial introduction of an object
  - Subsequent references to an already salient object

Referring Expression Generation in WeatherReporter

- Referring to months:
  - June 1999
  - June
  - the month
  - next June
- Referring to temporal intervals
  - 8 days starting from the 11^{th}
  - From the 11^{th} to the 18^{th}
- Relatively simple, so can be hardcoded in document planning

With Sentence Planning

Many different results are possible:

- The month was cooler than average. It was also drier than average, even though there was an average number of rain days this month. Although there was rain every day for 8 days from the 11th to the 18th, rainfall amounts were mostly small. The total rain for the year so far is well below average.
- The month was cooler and drier than average, with the average number of rain days. The total rain for the year so far is well below average. Even though there was rain every day from the 11th to the 18th, rainfall amounts were mostly small.

Realization

Goal:

to convert text specifications into actual text

Purpose:

to hide the peculiarities of English (or whatever the target language is) from the rest of the NLG system

Linguistic Realisation

Map semantic representations to lexico-syntactic representation using grammar and lexicon

Techniques:

- Semantic Head Driven Generation
- Unification
- Chart Generation
- Many ad-hoc approaches

- We'll be using OpenCCG:
  - Combinatory Categorial Grammar formalism
  - Chart Generation

Structure Realisation

- Add document markup
- An example: means of marking paragraphs:
  - HTML <P>
  - LaTeX (blank line)
  - RTF \par
  - SABLE (speech) <BREAK>
- Depends on the document presentation system
- Usually done with simple mapping rules

Next time

- Understanding input language for OpenCCG
- Hybrid logic dependency semantics

- Reading:
  - Michael White. Efficient Realization of Coordinate Structures in Combinatory Categorial Grammar. *Research on Language and Computation,* 4(1):39–75, 2006.