Building Applied Natural Language Generation Systems

Robert Dale and Ehud Reiter
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NLG System Architecture

- The Component Tasks in NLG
- A Standard Architecture
- Alternatives Architectures
Component Tasks in NLG

1. Content determination
2. Discourse planning
3. Sentence aggregation
4. Lexicalisation
5. Referring expression generation
6. Syntactic and morphological realization
7. Orthographic realization
1 Content Determination

- The process of deciding what to say
- Can be viewed as the construction of a set of MESSAGES from the underlying data source
- Messages are aggregations of data that are appropriate for linguistic expression: each may correspond to the meaning of a word or a phrase
- Messages are based on domain entities, concepts, and relations
Some Messages

IDENTITY(NEXTTRAIN, CALEDONIANEXPRESS) ; The next train is the Caledonian Express
DEPARTURETIME(CALEDONIANEXPRESS, 1000). ; The Caledonian Express leaves at 10am
COUNT((TRAIN, SOURCE(ABERDEEN), DESTINATION(GLASGOW)), 20, PERDAY) ; There are 20 trains daily from Aberdeen to Glasgow
2 Discourse Planning

- A text is not just a random collection of sentences
- Texts have an underlying structure in which the parts are related together
- Two related issues:
  - conceptual grouping
  - rhetorical relationships
There are 20 trains daily from Aberdeen to Glasgow. The next train is the Caledonian Express. It leaves Aberdeen at 10am.
A Text Plan

Sequence

NextTrainInformation

COUNT(…)

IDENTITY(…)

Elaboration

DEPARTURETIME(…)

9
3 Sentence Aggregation

- A one-to-one mapping from messages to sentences results in disfluent text
- Messages need to be combined to produce larger and more complex sentences
- The result is a sentence specification or SENTENCE PLAN
An Example of Sentence Aggregation

- Without aggregation:
  - The next train is the Caledonian Express.
  - It leaves Aberdeen at 10am

- With aggregation:
  - The next train, which leaves at 10am, is the Caledonian Express.
4 Lexicalisation

• So far we have determined text content and the structuring of the information into paragraphs and sentences
• Lexicalisation determines the particular words to be used to express domain concepts and relations
Lexicalisation

• In our example, should the DEPARTURETIME relation be expressed using the verb leave or depart?
• How do we express different nuances of meaning?
• What words should be used in different languages?
Referring Expression Generation

- Referring expression generation is concerned with how we describe domain entities in such a way that the hearer will know what we are talking about.
- Major issue is avoiding ambiguity.
- Fluency pulls in the opposite direction.
Kinds of Referring Expressions

- Proper names
  - Aberdeen, Scotland
  - Aberdeen

- Definite Descriptions
  - the train that leaves at 10am
  - the next train

- Pronouns
  - it
6 Syntactic and Morphological Realization

- Every natural language has grammatical rules that govern how words and sentences are constructed
- Morphology: rules of word formation
- Syntax: rules of sentence formation
Morphological Realization

Rules like:

- to form the past tense of a verb add *ed*
  - walk + ed = walked

- to form the plural of a noun add *s*
  - train + s = trains

- if a root ends in *e* and the suffix starts with a vowel, delete the final *e* in the root
  - like + ed = liked
Syntactic Realization

Rules like:

- the subject goes before the verb
- the subject and verb should agree in number
7 Orthographic Realization

• Orthographic realization is concerned with matters like casing and punctuation
• This also extends into typographic issues: font size, column width ...
Orthographic Rules

Rules like:

- sentences begin with upper case letters
- sentences end in full stops
- if the last word in a sentence is an abbreviation that ends in a full stop, then this is merged with the full stop at the end of the sentence
# Tasks and Architecture in NLG

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A Pipelined Architecture

- Text Planning
- Sentence Planning
- Linguistic Realization
Intermediate Representations

- Text Planning
  - Text Plan
    - Sentence Planning
      - Sentence Plans
        - Linguistic Realization
A Text Plan

((type textplan)
 (relations ((sequence satellite-01 satellite-02)))
 (satellite-01 ((nucleus ((message-id msg091)
                         (process exists)
                         (args ((object train)
                                  (source aberdeen)
                                  (destination glasgow)
                                  (frequency ((number 20) (period day)))))))
 (satellite-02 ((relations ((elaboration nucleus satellite-01)))
                 (nucleus ((message-id msg092)
                           (process identity)
                           (args ((arg1 next-train)
                                  (arg2 cal-express))))))
 (satellite-01 ((nucleus ((message-id msg093)
                           (process departure)
                           (args ((object cal-express)
                                  (time 1000))))))))
There are 20 trains daily from Aberdeen to Glasgow.
Other Architectures

Variants on the ‘standard’ architecture:

• shift tasks around
  – for example, include lexicalisation in the realizer

• allow feedback between stages
Integrated Architectures

Integrate everything into one reasoner:
• represent all tasks in the same way: eg as constraints, axioms, plan operators ...
• feed specifications into a constraint-solver, theorem-prover ...

Pros and Cons
• For: theoretically very elegant
• For: good support for interdependencies between tasks
• Against: absence of modularisation makes it very expensive in engineering terms
Research Questions

• How do the different tasks interact?
• Is there an architecture which combines the theoretical elegance of integrated approaches with the engineering simplicity of the pipeline?
• How should text and sentence plans be represented?
• How should multimodal documents be represented?
Overview

1. An Introduction to NLG
2. Requirements Analysis for NLG
3. NLG Architecture and System Design
4. A Case Study
5. A Closer Look at the Component Tasks
6. Conclusions and Pointers
A Case Study in Applied NLG

- Each month an institutional newsletter publishes a summary of the month’s weather.
- The summaries are based on automatically collected meteorological data.
- The person who writes these summaries will no longer be able to.
- The institution wants to continue publishing the reports and so is interested in using NLG techniques to do so.
A Weather Summary

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 M n for Mth: 08.2 Much warmer than ave
Mean M n for June (20 yrs): 06.4
Lowest M n (Coldest Night): 02.6 on 09
Highest M n (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 Wnd Run for Mth: 1660
Wndiest Day (24 hrs to 09:00): 185 on 26, 172 on 27
Caldest Day (24 hrs to 09:00): 09 on 16

SUNRISE & SUNSET

<table>
<thead>
<tr>
<th>Date</th>
<th>Sunrise</th>
<th>Sunset</th>
<th>Difference</th>
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<tr>
<td>01 Jun</td>
<td>06:52</td>
<td>16:54</td>
<td>10:02</td>
</tr>
<tr>
<td>11 Jun</td>
<td>06:57</td>
<td>16:53</td>
<td>09:56</td>
</tr>
<tr>
<td>21 Jun</td>
<td>07:00</td>
<td>16:54</td>
<td>09:54</td>
</tr>
<tr>
<td>30 Jun</td>
<td>07:01</td>
<td>16:57</td>
<td>09:56</td>
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(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 maxima, 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 minima 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.
A Weather 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.
The Input Data

- A set of 16 data elements collected automatically every 15 minutes: air pressure, temperature, wind speed, rainfall ...

- Preprocessed to construct DailyWeatherRecords:

```lisp
((type dailyweatherrecord)
 (date ((day ...)
          (month ...)
          (year ...)))
 (temperature ((minimum ((unit degrees-centigrade)
                             (number ...)))
               (maximum ((unit degrees-centigrade)
                            (number ...))))
 (rainfall ((unit millimetres)
            (number ...))))
)```
Other Available Data

- **Historical Data**: Average temperature and rainfall figures for each month in the Period of Record (1971 to present)
- **Historical Averages**: Average values for temperature and rainfall for the twelve months of the year over the period of record
Building the Target Texts

For each text:

- Omit information that is not available in a computationally tractable form
- Assume we don’t have wind, sunshine, thunderstorm and mist or fog information
- Then, edit the results for fluency
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. There was rain on every day for 8 days from 11th to 18th, with mist and fog patches on 16th and 17th. Rainfall amounts were mostly small, with light winds.
Text #1: Simplifications

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. There was rain on every day for 8 days from 11th to 18th, with mist and fog patches on 16th and 17th. Rainfall amounts were mostly small, with light winds.
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. There was rain on every day for 8 days from 11th to 18th. Rainfall amounts were mostly small.
The month was cooler and drier than average, with the average number of rain days, but the total rain for the year so far is well below average. Although there was rain on every day for 8 days from 11th to 18th, rainfall amounts were mostly small.
The month was rather dry with only three days of rain in the middle of the month. The total for the year so far is very depleted again, after almost catching up during March. Mars Creek dried up again on 30th April at the waterfall, but resumed on 1st May 1 light rain. This is the fourth time it dried up this year.
The month was rather dry with only three days of rain in the middle of the month. The total for the year so far is very depleted again, after almost catching up during March. Mars Creek dried up again on 30th April at the waterfall, but resumed on 1st May 1 light rain. This is the fourth time it dried up this year.
The month was rather dry with only three days of rain in the middle of the month. The total for the year so far is very depleted again.
The month was our driest and warmest August in our 24 year record, and our first 'rainless' month. The 26th August was our warmest August day in our record with 30.1, and our first 'hot' August day (30). The month forms part of our longest dry spell 47 days from 18 July to 02 September 1995. Rainfall so far is the same as at the end of July but now is very deficient.
The month was our driest and warmest August in our 24 year record, and our first rainless month. The 26th August was our warmest August day in our record with 30.1, and our first hot August day. Rainfall is now very deficient.
The Case Study So Far

We’ll assume that:

- We have located the source data
- We have preprocessed the data to build the DailyWeatherRecords
- We have constructed an initial corpus of texts
- We have modified the initial corpus to produce a set of target texts
Is it Worth Using NLG?

• For one summary a month probably not, especially given the simplifications required to the texts to make them easy to generate

• However, the client is interested in a pilot study:
  – in the future there may be a shift to weekly summaries
  – there are many automatic weather data collection sites each of which could use the technology