Text Mining for Historical Documents
Introduction to Computational Linguistics

Caroline Sporleder

Computational Linguistics
Universität des Saarlandes

Wintersemester 2010/11

21.02.2011

What is Computational Linguistics?

Computational Linguistics (CL) . . .

". . . is a discipline between linguistics and computer science which is concerned with the computational aspects of the human language faculty. It belongs to the cognitive sciences and overlaps with the field of artificial intelligence (AI), a branch of computer science aiming at computational models of human cognition."
Source:
`http://www.coli.uni-saarland.de/~hansu/what_is_cl.html`
(Hans Uszkoreit)

For our purposes: basically processing human/natural language with a computer ("Natural Language Processing", NLP)

Overview and Terminology

Levels of Linguistic Analysis

An Utterance

Yesterday, the neighbour's dog chased the postman when he was trying to deliver a parcel.

Levels of Linguistic Analysis

An Utterance

Yesterday, the neighbour's dog chased the postman when he was trying to deliver a parcel.

We can analyse:

- the sound of the utterance if it's spoken (**phonetics/phonology**)
- the individual words and their internal structure (**lexicology and morphology**)
- the grammatical structure of the sentence (**syntax**)
- the meaning of words and phrases (**semantics**)

Some Linguistic Terminology

Phonology (Phonetics): the study of speech sounds

- **phoneme (phon):** the smallest meaning-distinguishing unit of language, e.g.
  /cat/ vs. /cut/ $\Rightarrow$ "a" and "u" are phonemes
- cf. **grapheme:** smallest unit in written language, e.g. a letter (Buchstabe)
- **phoneme to grapheme conversion:** mapping phonemes to graphemes, e.g. in **speech recognition**

$\Rightarrow$ important for text-mining of audio archives

Some Linguistic Terminology (2)

Morphology: the study of word structure

- **morpheme:** the smallest meaning-carrying unit of language, e.g.
  reachable $\Rightarrow$ *reach* and *able* are morphemes
- **root:** the important bit of the word, e.g. *reach*
- **affix:** the less important stuff, e.g. *-able*
  affixes are divided into **prefixes** (stuff that comes before the root, like *mis-* in *misrepresent* (or *misunderestimate* ;-))and **suffixes** (stuff that comes after the root, like *-able*)

$\Rightarrow$ important for methods dealing with non-standard orthography

Some Linguistic Terminology (3)

Lexicology: the study of the words of a language

- **lexeme:** elementary unit in lexicology,
  "go", "goes", "gone" are different words but the same lexeme
- **lemma:** the base (dictionary) form of a word
- **lemmatising:** mapping word forms to their lemmas,
  important for further steps of automatic analysis
- **part-of-speech:** (=Wortart), e.g., noun (Nomen, Sustantiv),
  verb (Tu-Wort), adjective (Wie-Wort) etc.
- **part-of-speech tagging (pos tagging):** the process of
  automatically assigning a part-of-speech tag to a word

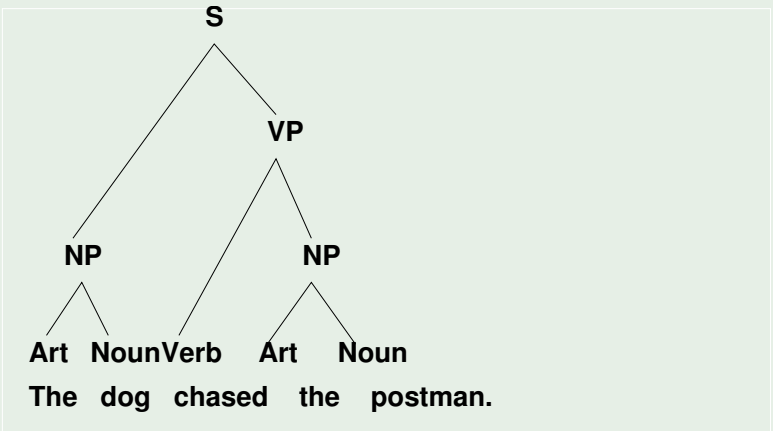
$\Rightarrow$ **POS-tagging**, **lemmatising** (stripping off grammatical affixes), and **stemming** (stripping off all affixes) are important pre-processing steps

Some Linguistic Terminology (4)

Syntax: the study of the internal (grammatical) structure of a sentence

- **syntax tree or parse tree:** an abstract representation of the internal structure of a sentence (as determined by a grammar)
- **parsing:** the process of computing sentence structure automatically
- **parser:** a tool which does parsing

Parse tree



Some Linguistic Terminology (5)

Semantics: the study of meaning

- **word sense:** a word like *bank* has several word senses
- **word sense disambiguation:** the process of determining the word sense of a word
- **hypernym:** *flower* is a hypernym of *rose*, *animal* is a hypernym of *cat*
- **hyponym:** the inverse, i.e. *cat* is a hyponym of *animal*
- **semantic argument structure** (who did what to whom?)

$\Rightarrow$ important for ontology construction, semantic tagging for information retrieval etc.

Automatic Text Processing

The King on a Wellness Holiday

Original Text (Amtspresse Preußens, 1.7.1863)

Die Nachrichten aus Karlsbad über das Befinden unseres Königs lauten sehr erfreulich. Die begonnene Brunnenkur scheint dem hohen Herrn sehr wohl zu thun. Der Präsident des Staatsministeriums, Herr von Bismarck, mit welchem Se. Majestät täglich eine Zeit lang gearbeitet, hat Karlsbad jetzt wieder verlassen.

The King on a Wellness Holiday

Original Text (Amtspresse Preußens, 1.7.1863)

Die Nachrichten aus Karlsbad über das Befinden unseres Königs lauten sehr erfreulich. Die begonnene Brunnenkur scheint dem hohen Herrn sehr wohl zu thun. Der Präsident des Staatsministeriums, Herr von Bismarck, mit welchem Se. Majestät täglich eine Zeit lang gearbeitet, hat Karlsbad jetzt wieder verlassen.

The King on a Wellness Holiday

Original Text (Amtspresse Preußens, 1.7.1863)

Die Nachrichten aus Karlsbad über das Befinden unseres Königs lauten sehr erfreulich. Die begonnene Brunnenkur scheint dem hohen Herrn sehr wohl zu thun. Der Präsident des Staatsministeriums, Herr von Bismarck, mit welchem Se. Majestät täglich eine Zeit lang gearbeitet, hat Karlsbad jetzt wieder verlassen.

Step 1: Tokenisation

- Where are the words in the text? What are the non-word components (punctuation etc.)?
- Where are the sentence boundaries? (sentence splitting)

Tokenisation, isn't that easy?

Simple solution

- words are delimited by spaces
- sentences are delimited by ".", "!", "?"

Tokenisation, isn't that easy?

Simple solution

- words are delimited by spaces
- sentences are delimited by ".", "!", "?"

Yes, but . . .

- . . . where's the sentence boundary in:

  Neil Budde, general manager of Yahoo! News, said: "Our expanded news search dramatically increases the consumer's ability to find events that matter to them."

- . . . how many words does *17.2.2009* consist of? What about *3.5 billion euros*? And what about *United States of America*?

The King on a Wellness Holiday

Tokenised (Amtspresse Preußens, 1.7.1863)

Die Nachrichten aus Karlsbad über das Befinden unseres Königs lauten sehr erfreulich .
Die begonnene Brunnenkur scheint dem hohen Herrn sehr wohl zu thun .
Der Präsident des Staatsministeriums , Herr von Bismarck , mit welchem Se. Majestät täglich eine Zeit lang gearbeitet , hat Karlsbad jetzt wieder verlassen .

The King on a Wellness Holiday

Tokenised (Amtspresse Preußens, 1.7.1863)

Die Nachrichten aus Karlsbad über das Befinden unseres Königs lauten sehr erfreulich .
Die begonnene Brunnenkur scheint dem hohen Herrn sehr wohl zu thun .
Der Präsident des Staatsministeriums , Herr von Bismarck , mit welchem Se. Majestät täglich eine Zeit lang gearbeitet , hat Karlsbad jetzt wieder verlassen .

Step 2: Part-of-Speech Tagging (=Wortarten zuweisen)

- Which parts-of-speech do the words in the text have?

Part-of-Speech Tagging, isn't that easy?

Simple solution (if you have a dictionary)

- look up the words in a dictionary, e.g. "corner"⇒noun, "man"⇒noun, "wins"⇒verb, "spell"⇒verb

Part-of-Speech Tagging, isn't that easy?

Simple solution (if you have a dictionary)

- look up the words in a dictionary, e.g. "corner"⇒noun, "man"⇒noun, "wins"⇒verb, "spell"⇒verb

Yes, but what about . . .

- *Maybe the hunters can corner the tiger.*
- *Steward Crowe waited on the port side until he was told to man the boat.*
- *Tiger Woods makes it seven wins in a row.*
- *Readers are still under the spell of Harry Potter.*

The King on a Wellness Holiday

POS Tagged (Amtspresse Preußens, 1.7.1863)

Die_DET Nachrichten_n aus_prep Karlsbad_n über_prep das_det Befinden_n unseres_pro Königs_n lauten_v sehr_adv erfreulich_adj ._punct

. . .

The King on a Wellness Holiday

POS Tagged (Amtspresse Preußens, 1.7.1863)

Die_DET Nachrichten_n aus_prep Karlsbad_n über_prep das_det Befinden_n unseres_pro Königs_n lauten_v sehr_adv erfreulich_adj ._punct

. . .

Step 3:

- what is the syntactic structure of the sentence?

Parsing, ok this shouldn't be too difficult, should it?

Solution

- apply your grammar rules to the sentence

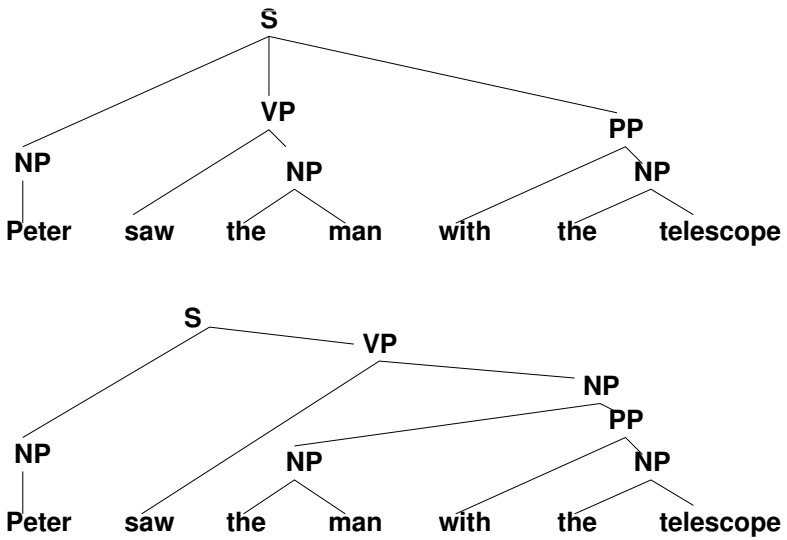
Parsing, ok this shouldn't be too difficult, should it?

Solution

- apply your grammar rules to the sentence

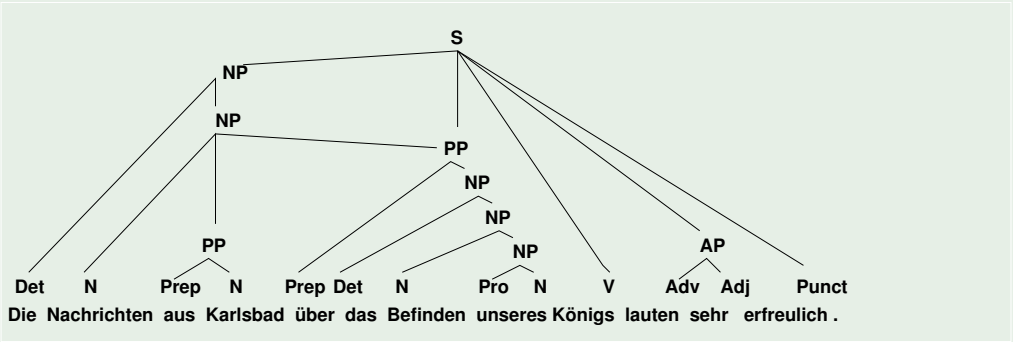
Yes, but what about . . .

Peter saw the man with the telescope.



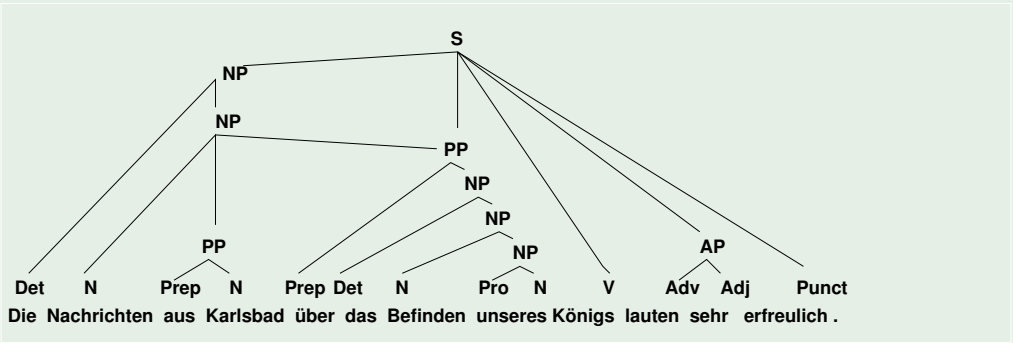
The King on a Wellness Holiday

Parsed (Amtspresse Preußens, 1.7.1863)



The King on a Wellness Holiday

Parsed (Amtspresse Preußens, 1.7.1863)



Step 4: Semantic Analysis

- who did what where and when to whom?

Semantic Analysis, how difficult is it?

Solution

- build on the syntactic structure
- identify the subject, e.g. “Bismarck” in “Bismarck hat Karlsberg verlassen.”
- subject=Agent (the entity doing something)
- object=Patient (the entity to which something is done, e.g. “Karlsbad”)

Semantic Analysis, how difficult is it?

Solution

- build on the syntactic structure
- identify the subject, e.g. “Bismarck” in “Bismarck hat Karlsberg verlassen.”
- subject=Agent (the entity doing something)
- object=Patient (the entity to which something is done, e.g. “Karlsbad”)

Yes, but what about . . .

- *Karlsbad wurde von Bismarck verlassen.* (subject=Karlsbad, agent=Bismarck)
- *Bismarcks abrupte Abreise aus Karlsbad . . .*

Other useful things one can do

Named Entity Tagging

- identify person names, locations, dates, numbers etc.

Pronoun resolution

- Who is "he"?

Co-reference resolution

- Do "Obama" and "the president" refer to the same person?

Ok, so how do you do all this?

Basically two possible approaches

- manually defined rules ("if 'corner' follows an arcticle like 'the' it is a noun")
- use machine learning an let the program figure it out itself

Rule-Based Natural Language Processing

- a lot of work!
- typically high precision (rules are correct) but low coverage (rules don't cover all possible eventualities)

Machine Learning

- also a lot of work: we need manually annotated training data
- typically robust, but not necessarily always correct
- training data can be re-used but only in certain situations (domain and genre should not change), e.g.:
  - can train a system on the Wall Street Journal and apply to the New York Times
  - cannot train a system on *Der Zauberberg* and apply it to the *Amtspresse Preußens*

When dealing with cultural heritage data this is a challenge because annotation of large amounts of data for each text type is infeasible.
$\Rightarrow$ need to think creatively (e.g. domain adaptation methods)

Computational Linguistic Tools

See course web site for a list of useful tools:

`http://www.coli.uni-saarland.de/~csporled/page.php?id=tools`

- web crawlers, language identification
- tokenisation, sentence splitting
- pos tagging
- stemmers, lemmatisers, morphological analysers
- syntactic parsers
- named entity recognisers, temporal expression taggers
- co-reference resolution
- semantic parsing, word sense disambiguation
- general machine learning tools

Further Information

See course web site for a list of links:

`http://www.coli.uni-saarland.de/courses/tm-hist11/links.html`

- Cultural Heritage Portals
- Demos
- Videos
- Projects
  - Digitisation Projects
  - Searching, Accessing, Mining Cultural Heritage Data
  - Standardisation, Semantic Web
  - Personalisation
- Workshops and Conferences