Natural Language Processing: Part II Overview of Natural Language Processing (L90): ACS

Katia Shutova

Computer Laboratory
University of Cambridge

7 October 2016

Outline of today's lecture

Lecture 1: Introduction
  Overview of the course
  Why NLP is hard
  Scope of NLP
  A sample application: sentiment classification
  More NLP applications
  NLP subtasks

Part II / ACS

- Part II
  - 12 lectures
  - 3 supervisions
  - assessed by exam questions (as in previous years).
- ACS
  - Overview of NLP: other modules go into much greater depth: L90 intended for people with no substantial background in NLP.
  - Same 12 lectures as Part II
  - Practical: apply the material to a real-world task — build a sentiment classification system
  - assessed by a research report
  - practical organised by Simone Teufel, 14 October, 2pm

Also note:

- Lecture notes.
- Slides: on the course web page after each lecture.
- Exercises: pre-lecture and post-lecture.
- Glossary in lecture notes.
- Recommended Book: Jurafsky and Martin (2008).
- Linguistics background: Bender (2013).

What is NLP?

NLP: the computational modelling of human language.

Some popular applications:
- Information retrieval
- Machine translation
- Question answering
- Dialogue systems
- Sentiment analysis
- Recently: social media analysis
- and many many others

NLP and linguistics

1. Morphology — the structure of words: lecture 2.
2. Syntax — the way words are used to form phrases: lectures 3 and 4.
3. Semantics
   - Lexical semantics — the meaning of individual words: lectures 5, 6 and 7.
   - Compositional semantics — the construction of meaning of longer phrases and sentences (based on syntax): lecture 8.
4. Pragmatics — meaning in context: lecture 9.

Why is NLP difficult?

User query:

- ▶ Has my order number 4291 been shipped yet?

Database:

ORDER

Order number	Date ordered	Date shipped
4290	2/2/13	2/2/13
4291	2/2/13	2/2/13
4292	2/2/13	

USER: Has my order number 4291 been shipped yet?
DB QUERY: order(number=4291,date_shipped=?)
RESPONSE: Order number 4291 was shipped on 2/2/13

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?

2. How fast will my TZ arrive?

3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- ▶ Do you sell Sony laptops and disk drives?

- ▶ Do you sell (Sony (laptops and disk drives))?

- ▶ Do you sell (Sony laptops) and (disk drives)?

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?

2. How fast will my TZ arrive?

3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- Do you sell Sony laptops and disk drives?

- Do you sell (Sony (laptops and disk drives))?

- Do you sell (Sony laptops) and (disk drives)?

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?
2. How fast will my TZ arrive?
3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- ▶ Do you sell Sony laptops and disk drives?
- ▶ Do you sell (Sony (laptops and disk drives))?
- ▶ Do you sell (Sony laptops) and (disk drives)?

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?
2. How fast will my TZ arrive?
3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- ▶ Do you sell Sony laptops and disk drives?
- ▶ Do you sell (Sony (laptops and disk drives))?
- ▶ Do you sell (Sony laptops) and (disk drives)?

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?
2. How fast will my TZ arrive?
3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- ► Do you sell Sony laptops and disk drives?
- ► Do you sell (Sony (laptops and disk drives))?
- ► Do you sell (Sony laptops) and (disk drives)?

Why is this difficult?

Similar strings mean different things, different strings mean the same thing:

1. How fast is the TZ?
2. How fast will my TZ arrive?
3. Please tell me when I can expect the TZ I ordered.

Ambiguity:

- ▶ Do you sell Sony laptops and disk drives?
- ▶ Do you sell (Sony (laptops and disk drives))?
- ▶ Do you sell (Sony laptops) and (disk drives)?

Wouldn't it be better if . . . ?

The properties which make natural language difficult to process
are essential to human communication:

- ▶ Flexible
- ▶ Learnable, but expressive and compact
- ▶ Emergent, evolving systems

Synonymy and ambiguity go along with these properties.

Natural language communication can be indefinitely precise:

- ▶ Ambiguity is mostly local (for humans)
- ▶ resolved by immediate context
- ▶ but requires world knowledge

Wouldn't it be better if . . . ?

The properties which make natural language difficult to process
are essential to human communication:

- ▶ Flexible
- ▶ Learnable, but expressive and compact
- ▶ Emergent, evolving systems

Synonymy and ambiguity go along with these properties.

Natural language communication can be indefinitely precise:

- ▶ Ambiguity is mostly local (for humans)
- ▶ resolved by immediate context
- ▶ but requires world knowledge

World knowledge...

"*Knowledge is knowing that a tomato is a fruit*"

BUT

"*Wisdom is knowing not to put it in a fruit salad*"

- ▶ Impossible to hand-code at a large-scale
- ▶ *either* limited domain applications
- ▶ *or* learn approximations from the data

Opinion mining: what do they think about me?

- ▶ Task: scan documents (webpages, tweets etc) for positive and negative opinions on people, products etc.
- ▶ Find all references to entity in some document collection: list as positive, negative (possibly with strength) or neutral.
- ▶ Construct summary report plus examples (text snippets).
- ▶ Fine-grained classification: e.g., for phone, opinions about: overall design, display, camera.

LG G3 review (Guardian 27/8/2014)

*The shiny, brushed effect makes the G3's plastic
design looks deceptively like metal. It feels solid in the
hand and the build quality is great — there's minimal
give or flex in the body. It weighs 149g, which is lighter
than the 160g HTC One M8, but heavier than the 145g
Galaxy S5 and the significantly smaller 112g iPhone
5S.*
*The G3's claim to fame is its 5.5in quad HD display,
which at 2560x1440 resolution has a pixel density of
534 pixels per inch, far exceeding the 432ppi of the
Galaxy S5 and similar rivals. The screen is vibrant and
crisp with wide viewing angles, but the extra pixel
density is not noticeable in general use compared to,
say, a Galaxy S5.*

LG G3 review (Guardian 27/8/2014)

> *The shiny, brushed effect makes the G3's plastic* **design** *looks deceptively like metal. It feels solid in the hand and the build quality is great — there's minimal give or flex in the body. It weighs 149g, which is lighter than the 160g HTC One M8, but heavier than the 145g Galaxy S5 and the significantly smaller 112g iPhone 5S.*
> *The G3's claim to fame is its 5.5in quad HD display, which at 2560x1440 resolution has a pixel density of 534 pixels per inch, far exceeding the 432ppi of the Galaxy S5 and similar rivals. The screen is vibrant and crisp with wide viewing angles, but the extra pixel density is not noticeable in general use compared to, say, a Galaxy S5.*

LG G3 review (Guardian 27/8/2014)

The shiny, brushed effect makes the G3's plastic **design** *looks deceptively like metal. It feels solid in the hand and the* **build quality** *is great — there's minimal give or flex in the body. It weighs 149g, which is lighter than the 160g HTC One M8, but heavier than the 145g Galaxy S5 and the significantly smaller 112g iPhone 5S.*

The G3's claim to fame is its 5.5in quad HD display, which at 2560x1440 resolution has a pixel density of 534 pixels per inch, far exceeding the 432ppi of the Galaxy S5 and similar rivals. The screen is vibrant and crisp with wide viewing angles, but the extra pixel density is not noticeable in general use compared to, say, a Galaxy S5.

LG G3 review (Guardian 27/8/2014)

The shiny, brushed effect makes the G3's plastic **design** *looks deceptively like metal. It feels solid in the hand and the* **build quality** *is* great *— there's minimal give or flex in the body. It* **weighs** *149g, which is* lighter *than the 160g HTC One M8, but* heavier *than the 145g Galaxy S5 and the significantly smaller 112g iPhone 5S.*

The G3's claim to fame is its 5.5in quad HD display, which at 2560x1440 resolution has a pixel density of 534 pixels per inch, far exceeding the 432ppi of the Galaxy S5 and similar rivals. The screen is vibrant and crisp with wide viewing angles, but the extra pixel density is not noticeable in general use compared to, say, a Galaxy S5.

LG G3 review (Guardian 27/8/2014)

The shiny, brushed effect makes the G3's plastic **design** *looks deceptively like metal. It feels solid in the hand and the* **build quality** *is great — there's minimal give or flex in the body. It* **weighs** *149g, which is lighter than the 160g HTC One M8, but heavier than the 145g Galaxy S5 and the significantly smaller 112g iPhone 5S.*

The G3's claim to fame is its 5.5in quad HD **display***, which at 2560x1440 resolution has a pixel density of 534 pixels per inch, far exceeding the 432ppi of the Galaxy S5 and similar rivals. The screen is vibrant and crisp with wide viewing angles, but the extra pixel density is not noticeable in general use compared to, say, a Galaxy S5.*

Sentiment classification: the research task

- ▶ Full task: information retrieval, cleaning up text structure, named entity recognition, identification of relevant parts of text. Evaluation by humans.

- ▶ Research task: preclassified documents, topic known, opinion in text along with some straightforwardly extractable score.

- ▶ Pang et al. 2002: *Thumbs up? Sentiment Classification using Machine Learning Techniques*

- ▶ Movie review corpus: strongly positive or negative reviews from IMDb, 50:50 split, with rating score.

IMDb: An American Werewolf in London (1981)

Rating: 9/10

Ooooo. Scary.
The old adage of the simplest ideas being the best is
once again demonstrated in this, one of the most
entertaining films of the early 80's, and almost
certainly Jon Landis' best work to date. The script is
light and witty, the visuals are great and the
atmosphere is top class. Plus there are some great
freeze-frame moments to enjoy again and again. Not
forgetting, of course, the great transformation scene
which still impresses to this day.
In Summary: Top banana

Bag of words technique

- ▶ Treat the reviews as collections of individual words.
- ▶ Classify reviews according to positive or negative words.
- ▶ Could use word lists prepared by humans, but machine learning based on a portion of the corpus (training set) is preferable.
- ▶ Use human rankings for training and evaluation.
- ▶ Pang et al, 2002: Chance success is 50% (corpus artificially balanced), bag-of-words gives 80%.

Some sources of errors for bag-of-words

- ► Negation:

    Ridley Scott has never directed a bad film.

- ► Overfitting the training data:
  e.g., if training set includes a lot of films from before 2005,
  Ridley may be a strong positive indicator, but then we test
  on reviews for 'Kingdom of Heaven'?

- ► Comparisons and contrasts.

Contrasts in the discourse

This film should be brilliant. It sounds like a great plot, the actors are first grade, and the supporting cast is good as well, and Stallone is attempting to deliver a good performance. However, it can't hold up.

More contrasts

> *AN AMERICAN WEREWOLF IN PARIS is a failed attempt . . . Julie Delpy is far too good for this movie. She imbues Serafine with spirit, spunk, and humanity. This isn't necessarily a good thing, since it prevents us from relaxing and enjoying AN AMERICAN WEREWOLF IN PARIS as a completely mindless, campy entertainment experience. Delpy's injection of class into an otherwise classless production raises the specter of what this film could have been with a better script and a better cast . . . She was radiant, charismatic, and effective . . .*

Doing sentiment classification 'properly'?

- ▶ Morphology, syntax and compositional semantics:
  who is talking about what, what terms are associated with
  what, tense . . .

- ▶ Lexical semantics:
  are words positive or negative in this context? Word
  senses (e.g., *spirit*)?

- ▶ Pragmatics and discourse structure:
  what is the topic of this section of text? Pronouns and
  definite references.

- ▶ Getting all this to work well on arbitrary text is very hard.

- ▶ Ultimately the problem is AI-complete, but can we do well
  enough for NLP to be useful?

IR, IE and QA

- ▶ Information retrieval: return documents in response to a user query (Internet Search is a special case)
- ▶ Information extraction: discover specific information from a set of documents (e.g. company joint ventures)
- ▶ Question answering: answer a specific user question by returning a section of a document:

  What is the capital of France?
  Paris has been the French capital for many centuries.

Machine Translation

- ▶ Earliest attempted NLP application.
- ▶ High quality only if the domain is restricted (or with very close languages: e.g., Swedish-Danish).
- ▶ Utility greatly increased in 1990s with increase in availability of electronic text.
- ▶ Early systems based on transfer rules, now statistical MT is increasingly popular
- ▶ Spoken language translation is viable for limited domains.

Some more NLP applications

- ▶ spelling and grammar checking
- ▶ predictive text
- ▶ optical character recognition (OCR)
- ▶ screen readers
- ▶ augmentative and alternative communication
- ▶ lexicographers' tools

- ▶ document classification
- ▶ document clustering
- ▶ text mining
- ▶ summarization
- ▶ text segmentation
- ▶ exam marking
- ▶ language teaching
- ▶ report generation

NLP subtasks

- ▶ input preprocessing: speech recognizer, text preprocessor or gesture recognizer.
- ▶ morphological analysis (2)
- ▶ part of speech tagging (3)
- ▶ parsing: this includes syntax and compositional semantics (4, 8)
- ▶ semantics: sense disambiguation, inference (5, 6, 7, 8)
- ▶ context processing (9)
- ▶ discourse structuring (10)
- ▶ realization (10)
- ▶ morphological generation (2)
- ▶ output processing: text-to-speech, text formatter, etc.

General comments

- ▶ Even 'simple' applications might need complex knowledge sources.
- ▶ Applications cannot be 100% perfect.
- ▶ Applications that are < 100% perfect can be useful.
- ▶ Aids to humans are easier than replacements for humans.
- ▶ Shallow processing on arbitrary input or deep processing on narrow domains.
- ▶ Limited domain systems require extensive and expensive expertise to port or large amounts of data (also expensive).
- ▶ External influences on NLP are very important.