Natural Language Processing

Info 159/259
Lecture 1: Introduction (Jan 19, 2021)

In-class questions: http://bit.ly/nlpqs

David Bamman, UC Berkeley
NLP is interdisciplinary

• Artificial intelligence

• Machine learning (ca. 2000—today); statistical models, neural networks

• Linguistics (representation of language)

• Social sciences/humanities (models of language at use in culture/society)
NLP = processing language with computers
processing as “understanding”
Turing test

Distinguishing human vs. computer only through written language

Turing 1950
Dave Bowman: Open the pod bay doors, HAL
HAL: I’m sorry Dave. I’m afraid I can’t do that

<table>
<thead>
<tr>
<th>Agent</th>
<th>Movie</th>
<th>Complex human emotion mediated through language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hal</td>
<td>2001</td>
<td>Mission execution</td>
</tr>
<tr>
<td>Samantha</td>
<td>Her</td>
<td>Love</td>
</tr>
<tr>
<td>IG-11</td>
<td>The Mandalorian</td>
<td>“to nurse and protect”</td>
</tr>
</tbody>
</table>
Where we are now
Where we are now
Where we are now
Q: What is your favorite animal?
A: My favorite animal is a dog.

Q: Why?
A: Because dogs are loyal and friendly.

Q: What are two reasons that a dog might be in a bad mood?
A: Two reasons that a dog might be in a bad mood are if it is hungry or if it is hot.

Q: How many bonks are in a quoit?
A: There are three bonks in a quoit.

Q: How many rainbows does it take to jump from Hawaii to seventeen?
A: It takes two rainbows to jump from Hawaii to seventeen.
What makes language hard?

- Language is a complex social process
- Tremendous ambiguity at every level of representation
- Modeling it is AI-complete (requires first solving general AI)
What makes language hard?

• Speech acts (“can you pass the salt?”)
  [Austin 1962, Searle 1969]

• Conversational implicature (“The opera singer was amazing; she sang all of the notes”).
  [Grice 1975]

• Shared knowledge (“Warren ran for president”)
Elizabeth Warren
2020

Warren G. Harding
1920
What makes language hard?

- Speech acts (“can you pass the salt?”)
  [Austin 1962, Searle 1969]

- Conversational implicature (“The opera singer was amazing; she sang all of the notes”).
  [Grice 1975]

- Shared knowledge (“Warren ran for president”)

- Variation/Indexicality (“This homework is wicked hard”)
  [Labov 1966, Eckert 2008]
Ambiguity

“One morning I shot an elephant in my pajamas”
Ambiguity

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Ambiguity

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Ambiguity

“One morning I shot an elephant in my pajamas”

Animal Crackers
I made her duck
[SLP2 ch. 1]

• I cooked waterfowl for her
• I cooked waterfowl belonging to her
• I created the (plaster?) duck she owns
• I caused her to quickly lower her head or body
• …
processing as representation

- NLP generally involves representing language for some end, e.g.:
  - dialogue
  - translation
  - speech recognition
  - text analysis
Information theoretic view

"One morning I shot an elephant in my pajamas"

 encode(X) → decode(encode(X))

Shannon 1948
Information theoretic view

When I look at an article in Russian, I say: 'This is really written in English, but it has been coded in some strange symbols. I will now proceed to decode.'

Weaver 1955
Rational speech act view

“One morning I shot an elephant in my pajamas”

Communication involves recursive reasoning: how can X choose words to maximize understanding by Y?

Frank and Goodman 2012
Pragmatic view

“One morning I shot an elephant in my pajamas”

Meaning is co-constructed by the interlocutors and the context of the utterance
Whorfian view

“One morning I shot an elephant in my pajamas”

Weak relativism: structure of language influences thought
Whorfian view

一天早上我穿着睡衣射了一只大象

Weak relativism: structure of language influences thought
Decoding

“One morning I shot an elephant in my pajamas”
• One morning I shot an elephant in my pajamas
• I didn’t shoot an elephant
• Imma let you finish but Beyoncé had one of the best videos of all time
• 一天早上我穿着睡衣射了一只大象
Parts of speech

noun verb noun noun

One morning I shot an elephant in my pajamas
Imma let you finish but Beyonce had one of the best videos of all time
One morning I shot an elephant in my pajamas
Sentiment analysis

"Unfortunately I already had this exact picture tattooed on my chest, but this shirt is very useful in colder weather."

[overlook1977]
Barack Obama taught as a civil rights attorney and professor of constitutional law at the University of Chicago Law School from 1992 to 2004.
Inferring Character Types

Input: text describing plot of a movie or book.

Structure: NER, syntactic parsing + coreference
NLP

• Machine translation
• Question answering
• Information extraction
• Conversational agents
• Summarization
NLP + X
Computational Social Science

• Inferring ideal points of politicians based on voting behavior, speeches

• Detecting the triggers of censorship in blogs/social media

• Inferring power differentials in language use

Link structure in political blogs
Adamic and Glance 2005
Computational Journalism

What do Journalists do with Documents?
Field Notes for Natural Language Processing Researchers

Jonathan Stray
Columbia Journalism School
jms2361@columbia.edu

• Robust import
• Robust analysis
• Search, not exploration
• Quantitative summaries
• Interactive methods
• Clarity and Accuracy
Computational Humanities

Ted Underwood (2018), “Why Literary Time is Measured in Minutes”

Ryan Heuser, Franco Moretti, Erik Steiner (2016), The Emotions of London

Richard Jean So and Hoyt Long (2015), “Literary Pattern Recognition”


Franco Moretti (2005), Graphs, Maps, Trees

Holst Katsma (2014), Loudness in the Novel


Fraction of words about female characters written by women over time.

Ted Underwood, David Bamman, and Sabrina Lee (2018), *The Transformation of Gender in English-Language Fiction,* Cultural Analytics
Text-driven forecasting
Methods

- Finite state automata/transducers (tokenization, morphological analysis)
- Rule-based systems
Methods

- Probabilistic models

- Naive Bayes, Logistic regression, HMM, MEMM, CRF, language models

\[ P(Y = y|X = x) = \frac{P(Y = y)P(X = x|Y = y)}{\sum_y P(Y = y)P(X = x|Y = y)} \]
Methods

- Dynamic programming (combining solutions to subproblems)

Viterbi algorithm, CKY

Viterbi lattice, SLP3 ch. 9
Methods

• Dense representations for features/labels (generally: inputs and outputs)

\[
\begin{align*}
vec(\begin{bmatrix} a_1 & \cdots & a_k \end{bmatrix}) & \rightarrow vec(\begin{bmatrix} \phi(x) \end{bmatrix}) \rightarrow \begin{bmatrix} \mathbb{R}^d \times N \end{bmatrix}
\end{align*}
\]


• Neural networks: multiple, highly parameterized layers of (usually non-linear) interactions mediating the input/output

Vaswani et al. (2017), “Attention is All You Need” (NeurIPS)

Figure 1: The Transformer - model architecture.
Methods

- Latent variable models (specifying probabilistic structure between variables and inferring likely latent values)

Info 159/259

• This is a class about models.
  • You’ll learn and implement algorithms to solve NLP tasks efficiently and understand the fundamentals to innovate new methods.

• This is a class about the linguistic representation of text.
  • You’ll annotate texts for a variety of representations so you’ll understand the phenomena you’ll be modeling
Prerequisites

• Strong programming skills
  • Translate pseudocode into code (Python)
  • Analysis of algorithms (big-O notation)

• Basic probability/statistics
• Calculus
function VITERBI(observations of len \( T \), state-graph of len \( N \)) returns best-path

create a path probability matrix \( viterbi[N+2,T] \)

for each state \( s \) from 1 to \( N \) do

\[
viterbi[s,1] \leftarrow a_{0,s} \ast b_s(o_1) \quad ; \text{initialization step}
\]

\[
backpointer[s,1] \leftarrow 0
\]

for each time step \( t \) from 2 to \( T \) do

for each state \( s \) from 1 to \( N \) do

\[
viterbi[s,t] \leftarrow \max_{s'} viterbi[s',t-1] \ast a_{s',s} \ast b_s(o_t) \quad ; \text{recursion step}
\]

\[
backpointer[s,t] \leftarrow \arg\max_{s'} viterbi[s',t-1] \ast a_{s',s}
\]

\[
viterbi[q_F,T] \leftarrow \max_{s=1}^N viterbi[s,T] \ast a_{s,q_F} \quad ; \text{termination step}
\]

\[
backpointer[q_F,T] \leftarrow \arg\max_{s=1}^N viterbi[s,T] \ast a_{s,q_F} \quad ; \text{termination step}
\]

return the backtrace path by following backpointers to states back in time from backpointer[\( q_F, T \)]
\[
\frac{dx^2}{dx} = 2x
\]
Grading

• Info 159:
  • Homeworks (50%)
  • Weekly quizzes (10%)
  • Midterm (20%)
  • NLP subfield survey (20%)
NLP subfield survey

- 4-page survey for a specific NLP subfield of your choice (e.g., coreference resolution, question answering, interpretability, narrative generation, etc.), synthesizing at least 25 papers published at ACL, EMNLP, NAACL, EACL, AACL, Transactions of the ACL or Computational Linguistics.

- This survey should be able to provide a newcomer (such as yourself at the start of the semester) a sense of the current state of the art in that subfield in 2021, the major historical papers that have defined that area, and the different schools of thought within it.
Grading

• Info 259:
  • Homeworks (40%)
  • Weekly quizzes (10%)
  • Midterm (20%)
  • Project (30%)
259 Project

- Semester-long project (involving 1-3 students) involving natural language processing -- either focusing on core NLP methods or using NLP in support of an empirical research question
  - Project proposal/literature review
  - Midterm report
  - 6-page final report, workshop quality
  - Poster presentation
ACL 2021 workshops

• *SEM 2021: The 10th Joint Conference on Lexical and Computational Semantics
• 2nd International Workshop on Computational Approaches to Historical Language Change (LChange’21)
• Workshop on Natural Language Processing for Programming
• Third Workshop on Gender Bias for Natural Language Processing
• Workshop on Online Abuse and Harms
• 17th Workshop on Multiword Expressions (MWE 2021)
• 6th Workshop on Representation Learning for NLP (RepL4NLP-2021)
• Challenges and Applications of Automated Extraction of Socio-political Events from Text (CASE)
Exams

• We’ll have one exam:
  • Midterm (3/11, tentatively in-class)

• We will not be offering alternative exam dates, so if you anticipate a conflict, don’t take this class!
Late submissions

- All homeworks and quizzes are due on the date/time specified.

- You have 3 late days total over the semester to use when turning in homeworks/quizzes; each day extends the deadline by 24 hours. If all late days have been used up, homeworks/quizzes can be turned in up to 48 hours late for 50% credit; anything submitted after 48 hours late = 0 credit.

- Late days are assessed immediately once homeworks or quizzes are submitted late and can't be retroactively changed (if you submit 2 homeworks and 2 quizzes late, for example, you can't decide after the fact which ones to apply your 3 slip days to -- they apply to whichever homeworks or quizzes use them up first).
Academic integrity

• We’ll follow the UC Berkeley code of conduct http://sa.berkeley.edu/code-of-conduct

• You may discuss homeworks at a high level with your classmates (if you do, include their names on the submission), but each homework deliverable must be completed independently -- all writing and code must be your own; and all quizzes and exams must be completed independently.
Academic integrity

• If you mention the work of others, you must be clear in citing the appropriate source: http://gsi.berkeley.edu/gsi-guide-contents/academic-misconduct-intro/plagiarism/

• This holds for source code as well: if you use others' code (e.g., from StackOverflow), you must cite its source.

• We have zero tolerance policy for cheating and plagiarism; violations will be referred to the Center for Student Conduct and will likely result in failing the class.
Grades in this class will not be curved.
Lectures

- Recordings of lectures will be available on bCourses.
- Attendance is not required for lectures, but strongly recommended.
Waitlisted

• We’ll be adding students from the waitlist for 159 according to their order (respecting priorities for juniors/seniors, data science majors)
Piazza

• We'll use Piazza as a platform for asking and answering questions about the course material, including homeworks.

• Students are encouraged to actively participate on this forum and help others by answering questions that arise (helpful students can see a grade bump across a threshold (e.g., B+ to A-) for this participation.

• When helping with homework questions, keep the discussion to the high-level concepts; don't post answers to homeworks or quiz/exam questions.
TAs

- Katie Stasaski (OH Tues 10-11:30am)
- Jon Gillick (OH Wed 3:30-5pm)
- Chloe Lee (OH Thurs 3:30-5pm)
- Janaki Vivrekar (OH Fri 12-1:30pm)

- Visit TA office hours for help with homeworks/quizzes/exams or just to chat about NLP.
- TA OH will be held through Discord; each OH will have channels organized around topics that you can chat with other students about.
TAs

• Keep academic integrity in mind during TA office hours: you may discuss homework questions at a high level with others present, but don't discuss specific answers or share screens with code solutions. Neither the TA office hours or Piazza should be used for pre-grading (asking if a specific answer to a homework or quiz question is correct before the assignment is due).
DB office hours

• DB office hours Wed 10am-noon (Zoom link on bCourses)

• Come talk to me to discuss concepts from class and NLP more generally — I’m happy to chat!
Next time:

Construction of truth; ethics