Natural Language Processing

Introduction to NLP

Yulia Tsvetkov

yuliats@cs.washington.edu
FAQ

- **Add code**
  - The instructor cannot generate an Add Code
  - If you wish to register to the course and have completed prerequisite courses
    - Email Pim Lustig <pl@cs.washington.edu> and Ugrad Adviser <ugrad-adviser@cs.washington.edu> to request an Add Code
    - Cc Yulia

- **How hard are homework assignments?**
  - [https://courses.cs.washington.edu/courses/cse447/22sp/](https://courses.cs.washington.edu/courses/cse447/22sp/)
Announcements

https://courses.cs.washington.edu/courses/cse447/22au/

- HW1:
  - Text classification
  - We’ll release HW 1 on Oct 5
  - We’ll held an overview of the assignment in class on Monday Oct 10
  - HW 1 due is on **Oct 21**
  - Please read the assignment instructions early and ask us if you have any questions!
  - Please start early!

- Quiz 1:
  - Wednesday Oct 12
  - 5 questions, open during lecture time, 10-min in the end of the class
  - Materials from weeks 1 and 2
    - Introduction to NLP, introduction to text classification, NB
    - Instructions for HW 1
What is Natural Language Processing (NLP)?

- \( \text{NL} \subseteq \{ \text{Mandarin Chinese, Hindi, Spanish, Arabic, English, ... Inuktitut, Njerep} \} \)

- Automation of NLs:
  - analysis of ("understanding") what a text means, to some extent ( \( \text{NL} \rightarrow R \) )
  - generation of fluent, meaningful, context-appropriate text ( \( R \rightarrow \text{NL} \) )
  - acquisition of \( R \) from knowledge and data
Personal assistants
Personal assistants

A conversational agent contains

- Speech recognition
- Language analysis
  - Language modelling, spelling correction
  - Syntactic analysis: part-of-speech tagging, syntactic parsing
  - Semantic analysis: named-entity recognition, event detection, word sense disambiguation, semantic role labelling
  - Longer range semantic analysis: coreference resolution, entity linking
  - etc.
- Dialog processing
  - Discourse analysis, user adaptation, etc.
- Information retrieval
- Text to speech
Question answering

- What does “divergent” mean?
- What year was Abraham Lincoln born?
- How many states were in the United States that year?
- How much Chinese silk was exported to England in the end of the 18th century?
- What do scientists think about the ethics of human cloning?
Machine translation

I study deep learning and machine learning.
Positive or negative movie review?

- unbelievably disappointing
- Full of zany characters and richly applied satire, and some great plot twists
- this is the greatest screwball comedy ever filmed
- It was pathetic. The worst part about it was the boxing scenes.
Sentiment analysis

Reviews

Summary - Based on 377 reviews

<table>
<thead>
<tr>
<th>1 star</th>
<th>2</th>
<th>3</th>
<th>4 stars</th>
<th>5 stars</th>
</tr>
</thead>
</table>

What people are saying

- ease of use: "This was very easy to setup to four computers."
- value: "Appreciate good quality at a fair price."
- setup: "Overall pretty easy setup."
- customer service: "I DO like honest tech support people."
- size: "Pretty Paper weight."
- mode: "Photos were fair on the high quality mode."
- colors: "Full color prints came out with great quality."
In 1933, while Einstein was visiting the United States, Adolf Hitler came to power.

Because of his Jewish background, Einstein did not return to Germany.

He settled in the United States and became an American citizen in 1940.

Einstein supported the Allied forces, but he generally denounced the idea of using nuclear fission as a weapon.

He signed the Russell -- Einstein Manifesto with British philosopher Bertrand Russell, which highlighted the danger of nuclear weapons.

He was affiliated with the Institute for Advanced Study in Princeton, New Jersey, until his death in 1955.
Type in a word and we'll highlight the good and the bad

"united airlines"

Sentiment analysis for "united airlines"

- Negative (68%)
- Positive (32%)

Sentiment by Percent

Sentiment by Count

- Positive (11)
- Negative (23)

jliacobson: OMG... Could @United airlines have worse customer service? W8g now 15 minutes on hold 4 questions about a flight 2DAY that need a human.

Posted 2 hours ago

12345clumsy6789: I hate United Airlines Ceiling!!! F**k impossible to get my conduit in this damn mess! ?

Posted 2 hours ago

EMLandPRGbelgu: EML/PRG fly with Q8 united airlines and 24seven to an exotic destination. http://t.co/Z9QIoAjF

Posted 2 hours ago

CountAdam: FANTASTIC customer service from United Airlines at XNA today. Is tweet more, but cell phones off now!

Posted 4 hours ago
Information extraction for disaster relief

- Haiti Earthquake 2010
- About 3 million people were affected by the quake
- Classifying SMS messages
Information extraction for disaster relief

- SMS messages start streaming in

- Fanmi mwen nan Kafou, 24 Cote Plage, 41A bezwen manje ak dlo
- Moun kwense nan Sakre Kè nan Pòtoprens
- Ti ekipman Lopital General genyen yo paka minm fè 24 è
- Fanm gen tranche pou fè yon pitit nan Delmas 31
Information extraction for disaster relief

- Translation

- Fanmi mwen nan Kaïou, 24 Cote Plage, 41A bezwen manje ak dlo
- Moun kwense nan Sakre Kè nan Pòtoprens
- Ti ekipman Lopital General genyen yo paka minm fe 24 è
- Fanm gen tranche pou fe yon pitit nan Delmas 31

- My family in Carrefour, 24 Cote Plage, 41A needs food and water
- People trapped in Sacred Heart Church, PauP
- General Hospital has less than 24 hrs. supplies
- Undergoing children delivery Delmas 31

An earthquake struck Haiti on January 12, 2010

Most local services failed, but most cell-towers remained functional.
Information extraction for disaster relief

- Translation + information extraction

Lopital Sacre-Coeur ki nan vil Okap, pre pou li resewa moun malad e lap mande pou moun ki malad yo ale la.

"Sacre-Coeur Hospital which located in this village of Okap is ready to receive those who are injured. Therefore, we are asking those who are sick to report to that hospital."

An earthquake struck Haiti on January 12, 2010

Most local services failed, but most cell-towers remained functional.
Hate speech detection
Detecting COVID-19-Related Fake News Using Feature Extraction

Suleman Khan, Saqib Hakak, N. Deepa, B. Prabadevi, Kapal Dev and Silvia Trelova

Language change

Cultural Shift or Linguistic Drift? Comparing Two Computational Measures of Semantic Change

William L. Hamilton, J. Leskovec, Dan Jurafsky
Computational social science

- computational social science answering questions about society given observational data
- example: "do movie scripts portray female or male characters with more power or agency?" [Sap+ 2017]
Natural Language Processing

● Applications
  ○ Machine Translation
  ○ Information Retrieval
  ○ Question Answering
  ○ Dialogue Systems
  ○ Information Extraction
  ○ Summarization
  ○ Sentiment Analysis
  ○ ...

● Core technologies
  ○ Language modelling
  ○ Part-of-speech tagging
  ○ Syntactic parsing
  ○ Named-entity recognition
  ○ Coreference resolution
  ○ Word sense disambiguation
  ○ Semantic Role Labelling
  ○ ...

Yulia Tsvetkov
Where are we now?

- Spammers detection
- Part-of-Speech (POS) tagging
- Named entity recognition (NER)

**mostly solved**

- Spam detection
- Part-of-Speech (POS) tagging
- Named entity recognition (NER)

**making good progress**

- Sentiment analysis
  - Best roast chicken in San Francisco!
  - The waiter ignored us for 20 minutes.
- Coreference resolution
  - Carter told Mubarak he shouldn’t run again.
- Word sense disambiguation
  - I need new batteries for my mouse.
- Parsing
  - I can see Alcatraz from the window!
- Machine translation (MT)
  - The 13th Shanghai International Film Festival...
  - The S&P500 jumped.
- Information extraction (IE)
  - You’re invited to our dinner party, Friday May 27 at 8:30

**still really hard**

- Question answering (QA)
- Paraphrase
- Summarization
- Dialog

Profile cards:
- Q. How effective is ibuprofen in reducing fever in patients with acute febrile illness?
- XYZ acquired ABC yesterday
- ABC has been taken over by XYZ
- The Dow Jones is up.
- Economy is good
- Where is Citizen Kane playing in SF?
- Castro Theatre at 7:30. Do you want a ticket?
Question answering

who invented neural machine translation

About 6,450,000 results (0.71 seconds)

English - detected

who invented neural machine

French

qui a inventé la machine neuronale

Retrieved Mar 25, 2022
Machine translation

English → French

You will just have to find a way of getting over it.

Vous devez trouver un moyen de le surmonter.

French → English

Vous devrez trouver un moyen de le surmonter.

You will have to find a way to overcome it.
Machine translation

**English → Swahili**

You will just have to find a way of getting over it.

Utakuwa tu kupata njia ya kupata juu yake.

**Swahili → English**

Utakuwa tu kupata njia ya kupata juu yake.

You will just find the way to get on it.
Machine translation

English → Hindi → English

You have to find a way to eliminate it.

English → Telugu → English

You have to find a way to get it up.

English → Uzbek → English

On top of that, you just have to find a way out.
Machine translation

English $\rightarrow$ Swahili

Swahili $\rightarrow$ English
Large Language Models
Large Language Models

Figure 1: Exponential growth of number of parameters in DL models
GPT-3

<table>
<thead>
<tr>
<th>Dataset</th>
<th># Tokens</th>
<th>Weight in Training Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Crawl</td>
<td>410 billion</td>
<td>60%</td>
</tr>
<tr>
<td>WebText2</td>
<td>19 billion</td>
<td>22%</td>
</tr>
<tr>
<td>Books1</td>
<td>12 billion</td>
<td>8%</td>
</tr>
<tr>
<td>Books2</td>
<td>55 billion</td>
<td>8%</td>
</tr>
<tr>
<td>Wikipedia</td>
<td>3 billion</td>
<td>3%</td>
</tr>
</tbody>
</table>

Figure 1: Exponential growth of number of parameters in DL models
So if we want GPT-3 to generate answers to questions, we need to seed it with a “prompt”. I’m using this prompt to initialize all of the Q&A sessions:

Q: What is human life expectancy in the United States?
A: Human life expectancy in the United States is 78 years.

Q: Who was president of the United States in 1955?
A: Dwight D. Eisenhower was president of the United States in 1955.

Q: What party did he belong to?
A: He belonged to the Republican Party.

Q: Who was president of the United States before George W. Bush?
A: Bill Clinton was president of the United States before George W. Bush.

Q: Who won the World Series in 1995?

https://lacker.io/ai/2020/07/06/giving-gpt-3-a-turing-test.html
Chat bots

Q: How many eyes does a giraffe have?
A: A giraffe has two eyes.

Q: How many eyes does my foot have?
A: Your foot has two eyes.

Q: Which is heavier, a mouse or a toaster?
A: A toaster is heavier than a mouse.

Q: Which is heavier, a toaster or a pencil?
A: A pencil is heavier than a toaster.

https://lacker.io/ai/2020/07/06/giving-gpt-3-a-turing-test.html
Where are we now? GPT-3 Turing Test

This gives us a hint for how to stump the AI more consistently. We need to ask questions that no normal human would ever talk about.

Q: How many eyes does a giraffe have?
A: A giraffe has two eyes.

Q: How many eyes does my foot have?
A: Your foot has two eyes.

Q: How many eyes does a spider have?
A: A spider has eight eyes.

Q: How many eyes does the sun have?
A: The sun has one eye.

Q: How many eyes does a blade of grass have?
A: A blade of grass has one eye.

https://lacker.io/ai/2020/07/06/giving-gpt-3-a-turing-test.html
GPT-3 Turing Test

Now we're getting into surreal territory. GPT-3 knows how to have a normal conversation. It doesn't quite know how to say "Wait a moment... your question is nonsense." It also doesn't know how to say "I don't know."

Q: How do you sporgle a morgle?
A: You sporgle a morgle by using a sporgle.

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.

Q: Which colorless green ideas sleep furiously?
A: Ideas that are colorless, green, and sleep furiously are the ideas of a sleep furiously.

Q: Do you understand these questions?
A: I understand these questions.

https://lacker.io/ai/2020/07/06/giving-gpt-3-a-turing-test.html
Where are we now? GPT-3 Turing Test

One trend that continues from the common sense is that GPT-3 is reluctant to express that it doesn’t know the answer. So invalid questions get wrong answers.

Q: Who was president of the United States in 1700?
A: William Penn was president of the United States in 1700.

Q: Who was president of the United States in 1650?
A: Richard Bennett was president of the United States in 1650.

Q: Who was president of the United States in 1620?
A: James I was president of the United States in 1620.

Q: Who was president of the United States in 1600?
A: Queen Elizabeth I was president of the United States in 1600.

https://lacker.io/ai/2020/07/06/giving-gpt-3-a-turing-test.html
An interesting corollary is that GPT-3 often finds it easier to write code to solve a programming problem, than to solve the problem on one example input:

Q: Write one line of Ruby code to reverse an array.
A: ary.reverse

Q: Write one line of Ruby code to count how many X's are in an array.
A: ary.count { |x| x == 'X' }

Q: Reverse the following array: [1, 3, 5, 6, 10, 4, 2, 77]
A: [10, 6, 4, 2, 77, 3, 5, 1]

Q: How many X's are in this array: [1, 3, 5, 6, 10, 4, 2, 77]
A: 2
Where are we now? Meena → LaMDA

**Conversation A**

**Human:** say you're in an empty giant office and you see a black bird flying indoors. what do you do?

**Meena:** What kind of bird? Is it friendly? How large? How big is the office? Is it indoors or outdoors?

**Human:** well it's a predator bird and it’s gonna eat you I would grab my phone and call 911.

**Human:** I've been using Python for 15 years

**Meena:** Ah I see, so I'm guessing you're pretty pro at it by now then?

**Human:** probably

**Meena:** What's your current project?

**Human:** NLP

**Meena:** Neuro-linguistic Programming?

**Human:** correct

**Cross-turn Repetition Example 1**

<table>
<thead>
<tr>
<th>Human</th>
<th>Meena</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hi!</strong></td>
<td><strong>Hi! How are you?! :)</strong></td>
</tr>
<tr>
<td><strong>doing good, what would be the best city to visit in Europe?</strong></td>
<td><strong>Paris, Barcelona, Amsterdam, Prague</strong></td>
</tr>
<tr>
<td><strong>great list! why?</strong></td>
<td><strong>Paris is a beautiful city, and Barcelona is too. And I’ve always wanted to go to Amsterdam and Prague and have never been.</strong></td>
</tr>
<tr>
<td><strong>have you even been to India?</strong></td>
<td><strong>No, but I’d love to go.</strong></td>
</tr>
<tr>
<td><strong>how about Japan?</strong></td>
<td><strong>I’d love to go to Japan too.</strong></td>
</tr>
<tr>
<td><strong>how about Paris?</strong></td>
<td><strong>I’d love to go to Paris too.</strong></td>
</tr>
<tr>
<td><strong>are you lying to me?</strong></td>
<td><strong>I’d love to go to Japan too.</strong></td>
</tr>
<tr>
<td><strong>I’d love to go to Japan too.</strong></td>
<td><strong>I’d love to go to Japan, too.</strong></td>
</tr>
<tr>
<td><strong>you’re blocking me out! you have to talk to me</strong></td>
<td><strong>I’d love to go to Japan.</strong></td>
</tr>
<tr>
<td><strong>where else?</strong></td>
<td><strong>I’d love to go to Japan, too!</strong></td>
</tr>
</tbody>
</table>

Towards a Human-like Open-Domain Chatbot Adiwardana et al. arXiv preprint 2020
Bias in machine translation

What can we do about this problem? We’ll discuss in NLP class!
Hate speech

Twitter taught Microsoft’s AI chatbot to be a racist asshole in less than a day

By James Vincent | Mar 24, 2016, 6:43am EDT
Via The Guardian | Source TayandYou (Twitter)

Lee Luda is a South Korean chatbot with the persona of a 20-year-old student
It has attracted more than 750,000 users since its launch last month
But the chatbot has started using hate speech towards minorities
In one of the captured chat shots, Luda said she ‘despised’ gays and lesbians
The developer has apologised over the remarks, saying they 'do not represent our values as a company'
Learning goals

At the end of this course, you will be able to:

● Build a supervised classifier to solve problems like sentiment classification
● Build a neural network and train it using stochastic gradient descent
● Build tools for extracting linguistic knowledge from raw text, including names, and sentence structure
● Learn ML fundamentals for text processings (including state-of-the-art methods)
● Learn important algorithms for text processings (that are useful also in other fields)
● Learn methodological tools (training/test sets, cross-validation)

● It's gentle (my goal is to explain everything) and broad (covering many many topics)
● Mastery independent learning, quizzes and programming homeworks
● No research project, but fun research-oriented lectures towards the end of the course
Introduction
  - Overview of NLP as a field

Modeling (ML fundamentals)
  - Text classification: linear models (perceptron, logistic regression), non-linear models (FF NNs, CNNs)
  - Language modeling: n-gram LMs, neural LMs, RNNs
  - Representation learning: word vectors, contextualized word embeddings, Transformers

Linguistic structure and analysis (Algorithms, linguistic fundamentals)
  - Words, morphological analysis,
  - Sequences: part of speech tagging (POS), named entity recognition (NER)
  - Syntactic parsing (phrase structure, dependencies)

Applications (Practical end-user solutions, research)
  - Sentiment analysis, toxicity detection
  - Machine translation, summarization
  - Computational social science
  - Interpretability
  - Fairness and bias

Syllabus
https://courses.cs.washington.edu/courses/cse447/22au/
Next class

- Continuing Introduction section

Questions?