Natural Language Processing

Introduction, course logistics

Yulia Tsvetkov

yuliats@cs.washington.edu
Welcome!

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

Mon / Wed / Fri 1:30–2:20pm, KNE 110

CSE 447: Natural Language Processing, Spring 2022
MWF 1:30-2:20pm, KNE 110

Instructor: Yulia Tsvetkov
yulia@cs.washington.edu
OH: Thu 3:30-4:30pm, Zoom (and by appointment)

Teaching Assistant: Xiaochuang Han
xhan77@cs.washington.edu
OH: Mon 11am-12pm, Zoom

Teaching Assistant: Ivy Guo
zhf01@cs.washington.edu
OH: Wed 4:30-5:30pm, Zoom

Teaching Assistant: Kaiser Sun
hukas@cs.washington.edu
OH: Mon 12:20-1:20pm (Zoom ID on Canvas)

Teaching Assistant: Leroy Wang
lry@uw.edu
OH: Fri 11:30am-12:30pm, Zoom

Teaching Assistant: Thai Hoang
qthai912@cs.washington.edu
OH: Tue 2:00-3:00pm (Zoom ID on Canvas)
What is Natural Language Processing (NLP)?

- NL ∈ {Mandarin Chinese, Hindi, Spanish, Arabic, English, … Inuktitut, Njerep}

- Automation of NLs:
  - analysis of (“understanding”) what a text means, to some extent (NL → R)
  - generation of fluent, meaningful, context-appropriate text (R → NL)
  - acquisition of R from knowledge and data
Communication with machines

- ~1950s-1970s
Communication with machines

- ~1980s

```
00001 /* EXECL */
00002 /* TIMMIES FACTOR - COMPOUND INTEREST CALCULATOR */
00003 /* */
00004 /* */
00005 /* AUTHOR: PAUL GAMBLE */
00006 /* DATE: DEC 1/2007 */
00007 /* */
00008 /* */
00009 /* */
00010 /* */
00011 /* */
00012 say '***************'
00013 say 'Welcome Coffee drinker.'
00014 say '***************'
00015 do while datatype(coffeew) /= 'NUM'
00016 say 'What is the price of your coffee?'
00017 ' (e.g. 1.99 or 91.99)'
00018 parse pull coffeew
00019 end
00020 /* */
00021 do while datatype(coffeewk) /= 'NUM'
00022 say 'How many coffees a week do you have?'
00023 parse pull coffeewk
00024 end
00025 /* */
00026 do while datatype(rate) /= 'NUM'
00027 say 'What annual interest rate would you like to see on that money?'
00028 ' (e.g. 0 = 0%)'
00029 parse pull rate
00030 end
00031 rate = rate * 0.01 /* CHG TO DECIMAL NUMBER */
```
NLP: Communication with machines

- Today

What can I help you with?
“Play a good song”
Sorry, I couldn’t find ‘a good song’ in your music.

“I need a dinner reservation for Valentine’s Day.”
I’ll see if any restaurants have a table for one.
“No, I need a reservation for two.”
Why? Is your mother in town?
Language technologies
What technologies are required to write such a program?

"I need a dinner reservation for Valentine's Day."

I'll see if any restaurants have a table for one.

"No, I need a reservation for two."

Why? Is your mother in town?
Language Technologies

A conversational agent contains

- Speech recognition
- Language analysis
- Dialog processing
- Information retrieval
- Text to speech
Natural Language Processing

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**
Personal assistants
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

<table>
<thead>
<tr>
<th>Chinese</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>我学习深度学习和机器学习</td>
<td>I study deep learning and machine learning.</td>
</tr>
</tbody>
</table>

*Google Translate table showing various language options.*
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.
Sentiment analysis + information extraction

Type in a word and we'll highlight the good and the bad

"united airlines"

Sentiment analysis for "united airlines"

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

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

**EMLandPRGbelgium**: EML/PRG fly with Q8 united airlines and 24seven to an exotic destination. [http://t.co/Z9QloAjiF](http://t.co/Z9QloAjiF)

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

An earthquake struck Haiti on January 12, 2010

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

- Translation

- 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 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

An earthquake struck Haiti on January 12, 2010

Most local services failed, but most cell-towers remained functional.

Lopital Sacre-Coeur ki nan vil Okap, pre pou li rezevwa 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."
Hate speech detection
Covid19 misinformation

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
  - ...
Where are we now?

Language Technology

making good progress

mostly solved

Spam detection
- Let's go to Agra!
- Buy VIAGRA ...

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...

Information extraction (IE)
- You're invited to our dinner party, Friday May 27 at 8:30

still really hard

Question answering (QA)
- Q: How effective is ibuprofen in reducing fever in patients with acute febrile illness?

Paraphrase
- XYZ acquired ABC yesterday
- ABC has been taken over by XYZ

Summarization
- The Dow Jones is up
- The S&P 500 jumped
- Economy is good

Dialog
- 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**

Translate

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

**French → English**

Translate

Vous devrez trouver un moyen de le surmonter.

Did you mean: Vous **devrez** trouver un moyen de le surmonter.
Machine translation

English $\rightarrow$ Swahili

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

Swahili $\rightarrow$ 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 → Swahili

Swahili → English
GPT-3
Chat bots

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

Towards a Human-like Open-Domain Chatbot Adiwardana et al. arXiv preprint 2020
Al chatbot is REMOVED from Facebook after saying she 'despised' gay people, would 'rather die' than be disabled and calling the #MeToo movement 'ignorant'

- 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’
Bias in machine translation

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

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

- 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
Course structure

please read the syllabus

https://courses.cs.washington.edu/courses/cse447/22sp/
Readings

- +additional readings posted weekly
Course website

- [https://courses.cs.washington.edu/courses/cse447/22sp/](https://courses.cs.washington.edu/courses/cse447/22sp/)
- Office hours, announcements, calendar, etc.
Deliverables & grading

- **Homework projects - 90%**
  - 3 programming assignments, 30% each
  - “Semi-autograded” – Most of the grades (~80%) come from replicating reference outputs in a given Jupyter notebook. You would usually know this part of your grades before submitting your assignments. The rest of the grades would involve things like write-ups, algorithm performance on hidden test sets, etc.
  - We’ll discuss the setup in detail in the next lecture

- **Quizzes - 10%**
  - 8 simple quizzes on Wednesdays
  - 10 minutes in the beginning of the class
  - Starting from the 3rd week
  - 5 best quizzes, 2% each

- **Participation in course discussions - 10% bonus**
  - Respond to HW questions and discussions from your classmates
  - Contribute insightful discussions on Ed - 5% extra credit per 3 responses (10% max)
Homework assignments

- **Project 1: Text classification**
  - We will build a system for automatically classifying song lyrics comments by era. Specifically, we build machine learning text classifiers, including both generative and discriminative models, and explore techniques to improve the models.

- **Project 2: Sequence labeling**
  - We focus on sequence labeling with Hidden Markov Models and some simple deep learning based models. Our task is part-of-speech tagging on English and Norwegian from the Universal Dependencies dataset. We will cover the Viterbi algorithm which could require a little bit prior knowledge of dynamic programming.

- **Project 3: Dependency parsing**
  - We will implement a transition-based dependency parser. The algorithm would be new and specific to the dependency parsing problem, but the underlying building blocks of the method are still some neural network modules covered in P1 and P2.
Homework submission

- Submit via Gitlab
  - We will pull your code for submission (with an assignment tag) and check the commit time.
  - A detailed grading rubric would be specified in the main Jupyter notebook of each assignment.

- Late policy
  - Each student will be granted **5 late days** to use over the duration of the quarter.
  - You can use a **maximum of 3 late days on any one project**.
  - Weekends and holidays are also counted as late days.
  - Late submissions are automatically considered as using late days.
  - Using late days will not affect your grade.
  - However, projects submitted late after all late days have been used will receive no credit. Be careful!
Communications with instructors

- You should be able to see yourselves be added to the Ed discussion board of CSE 447 / CSE M 547 22 sp. Please contact the staff if you are not.

- **Discussion Board (EdSTEM)** will be used to answer questions related to lectures and assignments
  - We really encourage you to ask/discuss higher level questions on the discussion board.
  - We encourage that generic questions should be posted as “Public” so that other classmates would also got benefited from it.
  - Please do not post detail about your solutions (detail ideas, codes, etc.) on public threads. Private discussion should be used for these posts.

- For grading issues, please email the instructor team directly.
Class participation

- Lectures and homework assignments complement each other
- Lecture materials are broader
- Homework assignments will go deeper into three important topics
- Try to attend the lectures
- Quizzes are designed to encourage you to do so
- But if you miss a lecture – you can watch a recording, or read assigned book chapters
- Participate in class discussions, 10% bonus is an incentive
  - But don’t just provide code solutions to questions on homework projects– those are for individual work!
  - Provide insights, theoretical background, references to readings
- Your questions are always welcome!
Office hours

- Yulia – Thu 3:30 - 4:30pm @ zoom [https://washington.zoom.us/j/92241001365](https://washington.zoom.us/j/92241001365) (and by appointment)
- Thai - Tues 2:00 - 3:00pm @ Zoom (Zoom ID on Canvas)
- Han - Mon 11am-12pm @ zoom [https://washington.zoom.us/my/xhan77](https://washington.zoom.us/my/xhan77)
- Kaiser - Mon 12:20pm - 1:20pm @ zoom (Zoom ID on Canvas)
- Ivy - Wed 4:30-5:30pm [https://washington.zoom.us/my/ivyguo](https://washington.zoom.us/my/ivyguo)
- Leroy - Fri 11:30am - 12:30pm [https://washington.zoom.us/my/lrywng](https://washington.zoom.us/my/lrywng)
Quizzes

- 8 quizzes, students can drop 3
- Each quiz has 5 simple multiple-choice questions, autograded
- Quizzes are on Canvas, open during the lecture time
- Quiz time - 10 minutes in the beginning of the class
- Starting from the 3rd week
- Grading on 5 best quizzes, 2% each
More course logistics

We care that you learn!

Your questions are always welcome.

Questions?

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