

The ABC of Computational Text Analysis

#1 INTRODUCTION +
WHERE IS THE DIGITAL REVOLUTION?

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Outline

1. digital revolution or hype?
2. about us
3. goals of this course

AI: A non-standard introduction

The world has changed, hasn't it?



An era of Big Data + AI

Group discussion

What makes a computer looking intelligent?

AI is a moving target with respect to ...

- human capabilities
- technological abilities

Transfer of Human Intelligence

from static machines to more flexible devices

- mimicking intelligent behavior
 - perception: reading + seeing + hearing
 - generation: speaking + writing + drawing
- contextual adaptation
- many degrees of freedom

Seeing like a Human?



An image segmentation by Facebook's [Detectron2](#) (Wu et al. 2019)

Hearing like a Human?

Speech-to-Text (S2T)

Recognizing speech robustly (e.g. language, accent, noise)

- stunning transcriptions by Whisper (Radford et al. 2022)
[try it](#) in your browser
- transcription demo for Swiss German (Plüss et al. 2021)

Speaking like a Human?

Speech-to-Speech (S2S)

Synthesizing generic or personal voice

- [translation demo](#) by SeamlessM4T v2 (Duquenne et al. 2023)
- [samples of voice cloning](#) by VALL-E (Wang et al. 2023)

Outsmarting Humans?

Debunk some myths around ChatGPT

- is a brand, **large-language models (LLM)** is the technology
- generates fluent text, **not necessarily truthful**
- is highly **useful**, although it understands little
- is **English**-focused, multilinguality is limited
- generates **non-reproducible** outputs
- generated text **cannot be detected** (except verbatim parts)
- yesterday's **version** might be different than today's

Where does the smartness come from?

Number of words exposed (Timiryasov and Tastet 2023)

- ~100'000'000 for a typical 13-year old kid
- ~4'300'000'000 words in entire Wikipedia
- >1'000'000'000'000 for current LLMs 😱

An LLM is amazing but ...

... it is also a stochastic parrot.



(Bender et al. 2021)

LLMs are a tool...

... learn how to use it 

- use as interactive partner
- don't trust; try, refine and develop understanding
- speed up tasks, yet blind automation not feasible

The Future of Search

- ChatGPT challenges search engines
- Smart assistance rather than search only

answer with source attribution instead of ranked snippet
blurring the line between search and generation

[Microsoft Copilot](#), [Google Gemini](#), [you.com](#)

A explain the background, action, and consequences of the peloponnesian war

Research

Researching ^

Searching for Actions during the Peloponnesian War
Searching for Background of the Peloponnesian War
Searching for Consequences of the Peloponnesian War

The Peloponnesian War: Background, Action, and Consequences

Background

The Peloponnesian War was a monumental conflict that pitted Athens against Sparta, the two most powerful city-states in ancient Greece, from 431 to 405 B.C. ① ②. This war was rooted in the fear that Sparta and its allies had of the growing power and influence of Athens, which had become a cultural and economic powerhouse under the leadership of Pericles ③ ④. The Athenian Empire, also known as the Delian League, was a vast naval alliance that allowed Athens to dominate the Mediterranean Sea ⑤ ⑥.



The immediate causes of the war included Athenian intervention in a dispute between Corinth (Sparta's ally) and Corcyra, and the attempt by Theban soldiers, who were allied with Sparta, to take control of Potidea ⑦ ⑧. These events, among others, led to the breakdown of the Thirty Years' Peace and the start of the war ⑨.

Action

The Peloponnesian War was fought in three main phases. The first phase, known as the Archidamian War, saw Sparta invade Attica, while Athens used its superior ⑩ ⑪ to raid the Peloponnesian coast ⑫ ⑬. During this time, a devastating plague struck Athens, killing a significant portion of its population, including Pericles ⑭ ⑮.

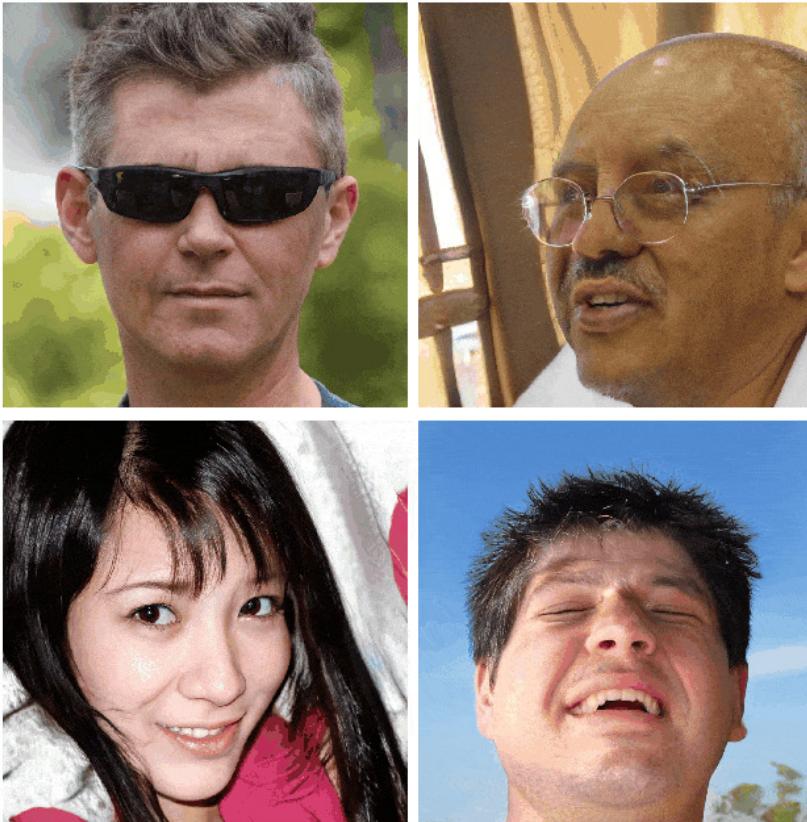
Research mode (beta)

More complex query on [you.com](#)

Trends towards Generative and Multimodal AI

These people do not exist

Generated Images by a Neural Network (Karras et al. 2020)



Faces generated by [StyleGAN](#). Generate [more](#) faces!

Multimodality and guidance

Guided generation of text, audio, images, video



A storefront with 'MUSE' written on it, in front of Matterhorn Zermatt.



A surreal painting of a robot making coffee.



A cake made of macarons in a unicorn shape.



Three dogs celebrating Christmas with some champagne.

Breakthrough by combining language processing and image generation with Muse (Chang et al. 2023)

Interact with images using text prompts

- **Generate** (Chang et al. 2023)
- **Edit** (Sheynin et al. 2023)
- **Explain**

Input image					
Editing output					
A Shiba Inu	A dog holding a football in its mouth	A basket of oranges	A photo of a cat yawning	A photo of a vase of red roses	

Editing pictures with Muse using natural language (Chang et al. 2023)

Erase or edit reality

For your Instagram or Politics



Modify pictures thoroughly in [Google Photos](#)

From Image to Video Generation



Synthesize any content with ever increasing quality

- use words and images to synthesize new videos (Bar-Tal et al. 2024; Brooks et al. 2024)
examples by [Sora](#) constituting the current research frontier
- [real-world example](#) of authentic dubbing

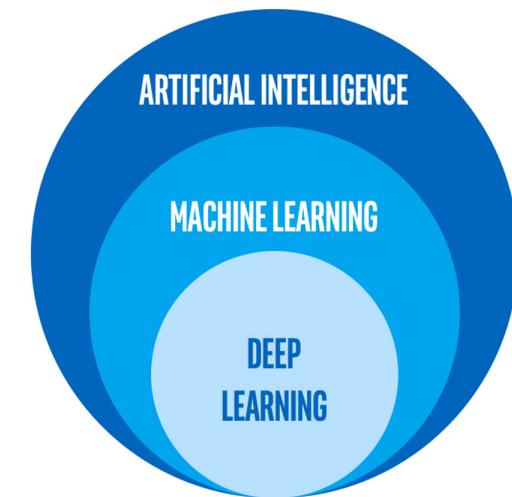
Artificial Intelligence

(Converging) Subfields

- Natural Language Processing (NLP)
- Computer Vision (CV)
- Robotics 

How does Computer Intelligence work?

- interchangeably (?) used concepts
Artificial Intelligence (AI), Machine Learning (ML), **Deep Learning** (DL)
- learn **patterns** from lots of data
more recycling than genuine intelligence
theory agnostically
- supervised **training** is the most popular
learn relation between input and output



AI is also hype 

```
AI = from humankind import solution
```

AI is different to Human
Intelligence

168772, 0.15200756, 0.38829451, 0.07418429, 0.66673773, 0.98018585, 0.16763814, 0.86710376, 0.55951162, 0.33785509, 0.02626346, 0.47175728, 0.23067162, 0.2773619, 0.11454822, 0.80790298, 0.51
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Why this matters for Social Science

Computational Social Science

data-driven research

- computational social science (Lazer et al. 2009, 2021; Salganik 2017)
Digital Humanities, Computational History, Data Science
- new, interdisciplinary approaches to long-standing questions
- machine learning empowers researchers (Lundberg, Brand, and Jeon 2022)
- early computational history already in 1960s (Graham, Milligan, and Weingart 2015)

Group discussion

What kind of data is there?

What data is relevant for social science?

- data as traces of social behaviour
 - tabular, text, image
- datafication
 - sensors of smartphone, digital communication
- much of human knowledge compiled as text

About the mystery of coding

coding is like...

- cooking with recipes
- superpowers



Women have coding
powers too!

Where the actual revolution is

Coding is a **superpower** ...

- flexible
- reusable
- reproducible
- inspectable
- collaborative

... to tackle complex problems on scale

About us

Personal example

directed country mentions in UN speeches

Goals of this course



What you learn

- collect and curate **data**
- **computationally analyze**, interpret, and visualize **texts**
- **digital literacy** + scholarship
- problem-**solving** capacity

Learnings from previous courses

- too much content, too little **practice**
- programming can be overwhelming
- **learning by doing**, doing by **googling (ChatGPT?!)**

Levels of proficiency

1. **awareness** of today's computational potential
2. **analyzing** existing datasets
3. **creating** + analyzing new datasets
4. applying advanced **machine learning**

How I teach

- computational **practises**
- **critical perspective** on technology
- lecture-style introductions
- hands-on coding sessions
- discussions + experiments in groups

Provisional schedule

Date	Topic
22 February 2024	Introduction + Where is the digital revolution?
29 February 2024	Text as Data
07 March 2024	Setting up your Development Environment
14 March 2024	Introduction to the Command-line
21 March 2024	Basic NLP with Command-line
28 March 2024	Introduction to Python in VS Code
04 April 2024	<i>no lecture (Osterpause)</i>
11 April 2024	Working with (your own) Data
18 April 2024	Data Analysis of Swiss Media
25 April 2024	Ethics and the Evolution of NLP
02 May 2024	NLP with Python
09 May 2024	<i>no lecture (Christi Himmelfahrt)</i>
16 May 2024	NLP with Python II + Working Session
23 May 2024	Mini-Project Presentations + Discussion
30 May 2024	<i>no lecture (Fronleichnam)</i>



There will be two digital lectures via Zoom.

TL;DR



You will be tech-savvy...
...yet no programmer applying fancy machine learning

Requirements

- no technical skills required 
- self-contained course
- laptop (macOS, Win11, Linux) 
 - update system
 - free up at least 15GB storage
 - backup files

Grading



- **2 assignments during semester**
no grades (pass/fail)
- **mini-project with presentation**
backup claims with numbers
work in teams
data of your interest
- **optional: writing a seminar paper**
in cooperation with Prof. Sophie Mützel

Organization

- seminar on Thursday from 2.15pm - 4.00pm
 - additionally, streaming via Zoom
- course website [KED2024](#) with slides + information
- readings on [OLAT](#)
- communication on [OLAT Forum](#)
 - forum for everything except personal
 - subscribe to notifications
 - direct: alex.flueckiger@doz.unilu.ch

Registration via UniPortal

In order to acquire credits for this course, registration via UniPortal within the registration period is mandatory.



Registration period: 5th February – 1st March 2024

Assignment #1



- get/submit via OLAT
 - starting tonight
 - deadline: 1 March 2024, 23:59
- discuss issues on OLAT forum

Course Website





Questions?

References

- Bar-Tal, Omer, Hila Chefer, Omer Tov, Charles Herrmann, Roni Paiss, Shiran Zada, Ariel Ephrat, et al. 2024. "Lumiere: A Space-Time Diffusion Model for Video Generation." January 23, 2024. <https://doi.org/10.48550/arXiv.2401.12945>.
- Bender, Emily M., Timnit Gebru, Angelina McMillan-Major, and Shmargaret Shmitchell. 2021. "On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? ." In *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, 610–23. Virtual Event Canada: ACM. <https://doi.org/10.1145/3442188.3445922>.
- Brooks, Tim, Bill Peebles, Connor Homes, Will DePue, Yufei Guo, Li Jing, David Schnurr, et al. 2024. "Video Generation Models as World Simulators." <https://openai.com/research/video-generation-models-as-world-simulators>.
- Chang, Huiwen, Han Zhang, Jarred Barber, A. J. Maschinot, Jose Lezama, Lu Jiang, Ming-Hsuan Yang, et al. 2023. "Muse: Text-To-Image Generation via Masked Generative Transformers." January 2, 2023. <https://doi.org/10.48550/arXiv.2301.00704>.
- Duquenne, Paul-Ambroise, Brian Ellis, Hady Elsahar, Justin Haaheim, John Hoffman, Hirofumi Inaguma, Christopher Klaiber, et al. 2023. "Multilingual Expressive and Streaming Speech Translation."
- Graham, Shawn, Ian Milligan, and Scott Weingart. 2015. *Exploring Big Historical Data: The Historian's Macroscopic*. Open Draft Version. Under contract with Imperial College Press. <http://themacroscopic.org>.
- Karras, Tero, Samuli Laine, Miika Aittala, Janne Hellsten, Jaakko Lehtinen, and Timo Aila. 2020. "Analyzing and Improving the Image Quality of StyleGAN." March 23, 2020. <https://doi.org/10.48550/arXiv.1912.04958>.
- Lazer, David, Eszter Hargittai, Deen Freelon, Sandra Gonzalez-Bailon, Kevin Munger, Katherine Ognyanova, and Jason Radford. 2021. "Meaningful Measures of Human Society in the Twenty-First Century." *Nature* 595 (7866, 7866): 189–96. <https://doi.org/10.1038/s41586-021-03660-7>.
- Lazer, David, Alex Pentland, Lada Adamic, Sinan Aral, Albert-László Barabási, Devon Brewer, Nicholas Christakis, et al. 2009. "Computational Social Science." *Science* 323 (5915): 721–23. <https://doi.org/10.1126/science.1167742>.