

# The ABC of Computational Text Analysis

#1 INTRODUCTION +  
WHERE IS THE DIGITAL REVOLUTION?

Alex Flückiger  
Faculty of Humanities and Social Sciences  
University of Lucerne

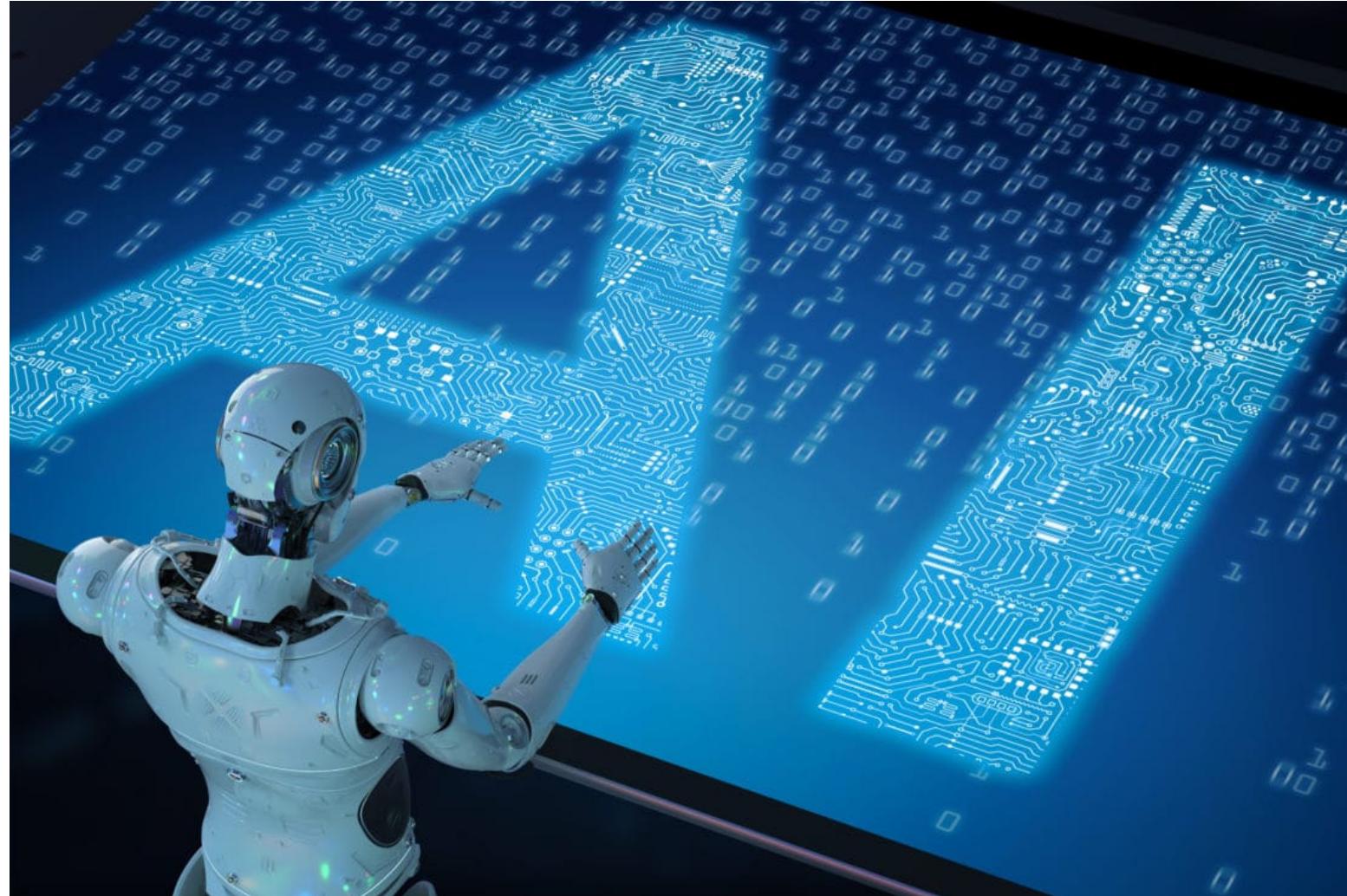
22 February 2024

# 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 transcription 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)

# ChatGPT is a tool...

... learn how to use it 

- use ChatGPT 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 traditional 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 Bart](#), [you.com](#)

A screenshot of a search interface. At the top, there is a search bar with the query "explain the background, action, and consequences of the peloponnesian war". Below the search bar, there is a "Research" section with a "Researching" button. Underneath, there are three search suggestions: "Actions during the Peloponnesian War", "Background of the Peloponnesian War", and "Consequences of the Peloponnesian War". The main content area is titled "The Peloponnesian War: Background, Action, and Consequences" and includes a "Background" section with text and a map of ancient Greece. The map shows various city-states and their alliances, with labels like "Athens", "Sparta", and "Corinth". Below the map, there is a section titled "Action" with more detailed information about the war's phases and events.

*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

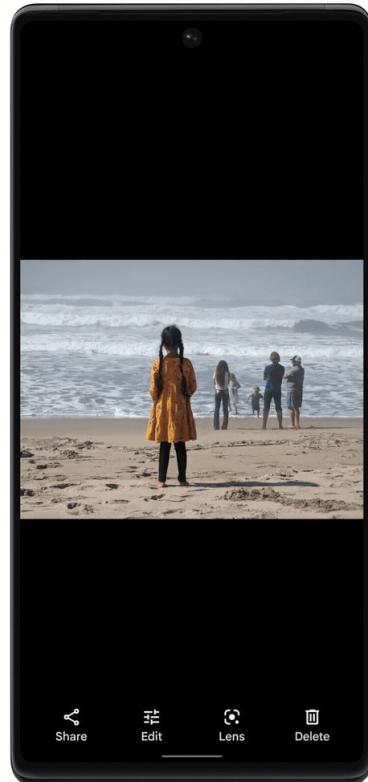
- **Generate** (Chang et al. 2023)
- **Edit** (Sheynin et al. 2023)
- **Explain**

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



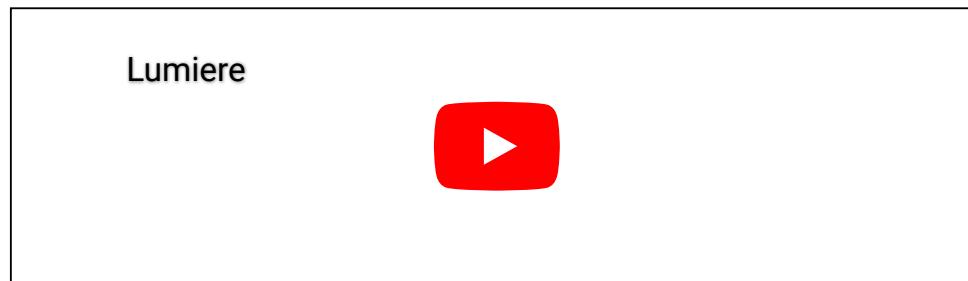
*Modify pictures thoroughly in [Google Photos](#)*

# From Image to Video Generation



Synthesize any content with ever increasing quality

- use words and images to synthesize new videos with [Lumiere](#) (Bar-Tal et al. 2024)
- [real-world example](#) of authentic dubbing



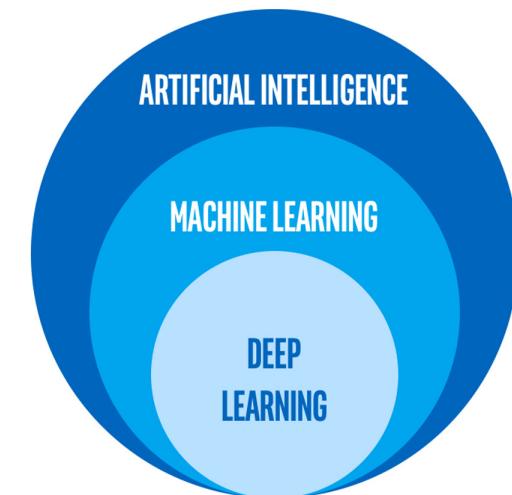
# Artificial Intelligence

## 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  
734878, 0.11679081, 0.06501815, 0.26310512, 0.42061658, 0.77389495, 0.38098379, 0.08868848, 0.46058002, 0.50690262, 0.59905786, 0.77119195, 0.68336732, 0.60541317, 0.45165225, 0.81831575, 0.31  
654246, 0.5173906, 0.06903216, 0.43235588, 0.61449073, 0.24023924, 0.49408374, 0.78123944, 0.33895859, 0.84212152, 0.9432899, 0.217333, 0.35219669, 0.05423672, 0.54828346, 0.33879539, 0.11  
479458, 0.32023267, 0.58926178, 0.72210584, 0.83532963, 0.76463754, 0.16937548, 0.90732891, 0.91315041, 0.10762946, 0.88444707, 0.37388686, 0.76169685, 0.52041133, 0.81258545, 0.53919545, 0.41  
647513, 0.73535647, 0.1745968, 0.98120302, 0.83087297, 0.11270352, 0.64186353, 0.04767055, 0.0485364, 0.12084652, 0.16909768, 0.79760446, 0.23634279, 0.98309046, 0.19054919, 0.41255494, 0.11  
164376, 0.66417077, 0.60103919, 0.47973376, 0.77044871, 0.37635039, 0.98989451, 0.42299366, 0.80863832, 0.33989656, 0.14969653, 0.24072135, 0.38481632, 0.07041355, 0.89827435, 0.03549646, 0.91  
712072, 0.45380595, 0.42559498, 0.29417609, 0.05121623, 0.27335799, 0.11510317, 0.12436115, 0.94166874, 0.43521343, 0.01574713, 0.47895682, 0.81542824, 0.55192919, 0.21376429, 0.83996156, 0.11  
62373, 0.70650595, 0.78218659, 0.09174559, 0.42847419, 0.25093282, 0.06408784, 0.89203029, 0.46310012, 0.90179843, 0.80303815, 0.13008473, 0.19678015, 0.99704098, 0.10606426, 0.466846, 0.51  
806803, 0.67975773, 0.96055286, 0.59973374, 0.45370415, 0.79636357, 0.07858557, 0.13911537, 0.52951605, 0.18976998, 0.5819224, 0.87121155, 0.38853649, 0.87593348, 0.00340097, 0.88076484, 0.41  
727308, 0.38427574, 0.67224633, 0.87825389, 0.29712081, 0.69115835, 0.92883539, 0.66834701, 0.69986855, 0.95275904, 0.87533499, 0.69071387, 0.84586047, 0.46363871, 0.50473321, 0.92366178, 0.51  
732677, 0.29516387, 0.45078105, 0.92830235, 0.25230561, 0.04264319, 0.26313922, 0.09366894, 0.46002723, 0.97870525, 0.14294762, 0.10765255, 0.20673146, 0.47924256, 0.05069769, 0.0026216, 0.21  
910217, 0.00194285, 0.70273429, 0.03229992, 0.59000182, 0.079867, 0.09900018, 0.24006025, 0.92607372, 0.86469472, 0.00259478, 0.90787125, 0.81865272, 0.11118454, 0.179951, 0.36991889, 0.61  
286492, 0.04814166, 0.1744895, 0.13555582, 0.28708137, 0.67201359, 0.27947508, 0.95646008, 0.5290694, 0.01663762, 0.72596267, 0.15579892, 0.99991186, 0.46833689, 0.31885293, 0.27407871, 0.61  
048462, 0.10562578, 0.59101146, 0.83803446, 0.1398754, 0.10693991, 0.54277255, 0.03858724, 0.37531373, 0.65770202, 0.70266899, 0.58797343, 0.43545992, 0.46832795, 0.99461625, 0.9568131, 0.51  
350683, 0.33606992, 0.66227064, 0.29304854, 0.80212152, 0.78558867, 0.11125733, 0.55933486, 0.47233518, 0.98970719, 0.07911327, 0.31502887, 0.33420011, 0.30765105, 0.43608741, 0.8278588, 0.41  
871894, 0.8583858, 0.93987607, 0.54778241, 0.69637408, 0.05521608, 0.46128916, 0.12033237, 0.25060302, 0.26122896, 0.78490366, 0.03564119, 0.88678632, 0.89983917, 0.14878763, 0.969423, 0.21  
843313, 0.62452422, 0.58236243, 0.73271648, 0.73036699, 0.90168095, 0.88147008, 0.11252588, 0.11121773, 0.29328988, 0.18093192, 0.87142164, 0.44432315, 0.54101688, 0.30702835, 0.31892811, 0.11  
356658, 0.06219605, 0.24396327, 0.80099756, 0.0710542, 0.85922124, 0.20631035, 0.19995689, 0.66998863, 0.89721627, 0.48586768, 0.51054386, 0.52999152, 0.22840026, 0.82319605, 0.05364585, 0.61  
546367, 0.51318129, 0.18104349, 0.21021156, 0.07461448, 0.5823082, 0.66050858, 0.98566374, 0.06621486, 0.38370994, 0.96703583, 0.46197723, 0.01985645, 0.09053363, 0.38859547, 0.3160512, 0.91  
417637, 0.4798936, 0.44743002, 0.60602532, 0.61861, 0.24021519, 0.37533, 0.55497277, 0.80948972, 0.843842, 0.0821775, 0.12409288, 0.37352616, 0.19829569, 0.84911379, 0.52988915, 0.81  
978047, 0.59791818, 0.27625787, 0.72964129, 0.071172, 0.077549, 0.81101, 0.37338, 0.042385, 0.273947, 0.711166, 0.077844, 0.218049, 0.5180963, 0.33859405, 0.81940022, 0.81  
752336, 0.61757252, 0.96335821, 0.42666803, 0.060548, 0.21401, 0.175050, 0.405696, 0.272052, 0.195953, 0.614277, 0.648683, 0.14444, 0.0317386, 0.65569092, 0.30585473, 0.91  
113604, 0.76622595, 0.37607333, 0.63521213, 0.4588226, 0.05808458, 0.95404138, 0.88581666, 0.25140532, 0.11844633, 0.77760293, 0.79442171, 0.0657761, 0.22341028, 0.69664054, 0.70206938, 0.01  
718003, 0.40667715, 0.02692516, 0.98866529, 0.61815532, 0.67766941, 0.67400353, 0.19405055, 0.10825144, 0.8036886, 0.38477034, 0.95783714, 0.68756525, 0.81158131, 0.93641847, 0.53451291, 0.81  
020479, 0.25554169, 0.64775627, 0.7560764, 0.32132667, 0.62019336, 0.53422944, 0.92716892, 0.45036567, 0.78308935, 0.14640807, 0.24196815, 0.24140617, 0.68670988, 0.87195675, 0.81932992, 0.71  
16652, 0.510018, 0.01662444, 0.46714092, 0.47612112, 0.21580927, 0.43071, 0.5816609, 0.382825, 0.14634585, 0.34055906, 0.23548654, 0.57817003, 0.9388773, 0.66448737, 0.59813936, 0.01  
517088, 0.27328868, 0.80745013, 0.58375266, 0.91247882, 0.53869737, 0.14297, 0.06371, 0.02216, 0.4501, 0.026, 0.47868176, 0.72358401, 0.75207502, 0.57294178, 0.97597007, 0.91  
096594, 0.15940259, 0.76178962, 0.31408877, 0.54548918, 0.52262982, 0.99954, 0.41729, 0.56177, 0.00739, 0.3618, 0.97240863, 0.70431727, 0.78710566, 0.88038121, 0.88483492, 0.91  
030175, 0.22472301, 0.09450736, 0.9487154, 0.30532446, 0.1414234, 0.17664314, 0.15982977, 0.9737627, 0.88838633, 0.671654, 0.88924914, 0.99750128, 0.34335852, 0.33949754, 0.4574135, 0.51  
522579, 0.07446491, 0.6527706, 0.45444521, 0.86250113, 0.51038866, 0.03444767, 0.88713232, 0.98610034, 0.57338999, 0.21504094, 0.08631724, 0.91087582, 0.10086746, 0.04856606, 0.12266554, 0.41  
36731, 0.01896768, 0.4426256, 0.98554742, 0.93512302, 0.09476145, 0.3475696, 0.48662246, 0.35574585, 0.02906274, 0.62512557, 0.72779561, 0.29036812, 0.87022702, 0.81238442, 0.3138893, 0.11  
219462, 0.1678605, 0.15434812, 0.23813711, 0.88883248, 0.37898002, 0.32673627, 0.59645067, 0.7234791, 0.93755561, 0.19861349, 0.20419817, 0.03589282, 0.30884502, 0.53066089, 0.34080309, 0.21  
207962, 0.5442396, 0.89734598, 0.19269938, 0.73404843, 0.28849353, 0.93539801, 0.49899802, 0.4781033, 0.2223823, 0.38173886, 0.29305289, 0.67520215, 0.56602555, 0.36687071, 0.49260917, 0.61  
938278, 0.28331053, 0.93684341, 0.33974298, 0.7031872, 0.78609146, 0.4564601, 0.88942624, 0.55393394, 0.90686845, 0.42534314, 0.02765051, 0.93154215, 0.67071709, 0.30005018, 0.77899115, 0.91  
524857, 0.53693479, 0.09774014, 0.3325974, 0.74690781, 0.58257695, 0.56617443, 0.16470804, 0.25931036, 0.86503644, 0.16349719, 0.85850551, 0.36944745, 0.11652745, 0.56587223, 0.26369511, 0.71  
842509, 0.62628536, 0.60294993, 0.10651657, 0.14863165, 0.4398803, 0.50674525, 0.27422641, 0.10323303, 0.39854659, 0.60515043, 0.78513435, 0.03993646, 0.87657498, 0.21632641, 0.86778243, 0.01  
44423, 0.59041854, 0.88131398, 0.24072836, 0.51311985, 0.98022862, 0.38983557, 0.86793385, 0.76403785, 0.42765071, 0.87729656, 0.07965547, 0.17378203, 0.35764046, 0.24408659, 0.29837998, 0.61  
456205, 0.19835696, 0.98637499, 0.99506722, 0.62058809, 0.31682388, 0.76524575, 0.42814961, 0.97169199, 0.41251292, 0.9400806, 0.4151149, 0.56583137, 0.39667195, 0.98073902, 0.54011904, 0.91  
350726, 0.46031599, 0.83459122, 0.18682743, 0.77831586, 0.76857211, 0.40289284, 0.55618379, 0.96411916, 0.32744293, 0.98256465, 0.92688416, 0.72177531, 0.06135222, 0.39145084, 0.00926561, 0.31  
717906, 0.94337418, 0.77225768, 0.98614231, 0.07953396, 0.94117132, 0.17013064, 0.63020399, 0.46456359, 0.48314658, 0.12407727, 0.01275128, 0.78190186, 0.68115999, 0.35187262, 0.69508548, 0.31  
516399, 0.0820243, 0.85843999, 0.95577906, 0.94229118, 0.9885269, 0.97376953, 0.50043274, 0.37493048, 0.54529709, 0.57576211, 0.55868575, 0.42363751, 0.9832678, 0.92408923, 0.44920966, 0.31  
338962, 0.19098382, 0.4832968, 0.82423524, 0.38948823, 0.16359862, 0.27052009, 0.24686862, 0.69082872, 0.56517825, 0.79584692, 0.94172521, 0.6666855, 0.74609502, 0.54789156, 0.24  
443603, 0.98945893, 0.56457943, 0.02849603, 0.07278765, 0.29675732, 0.40164173, 0.72768733, 0.77835769, 0.21474951, 0.80307205, 0.88074336, 0.1119304, 0.04230572, 0.4464518, 0.58364118, 0.31  
619102, 0.29209694, 0.27339425, 0.23318203, 0.48700466, 0.14080441, 0.15602402, 0.45488153, 0.2059769, 0.46624392, 0.34737895, 0.75438115, 0.35114957, 0.88838527, 0.50659062, 0.36747274, 0.41  
104512, 0.76891909, 0.19651005, 0.27184795, 0.84393332, 0.2346668, 0.15257668, 0.45093505, 0.47686787, 0.92540229, 0.55753801, 0.85730468, 0.18668896, 0.42050033, 0.72344403, 0.83930597, 0.91  
490435, 0.16136975, 0.34196028, 0.54035591, 0.7964559, 0.50385513, 0.47367413, 0.74437083, 0.22563819, 0.68055333, 0.97841587, 0.99648022, 0.06667557, 0.10857445, 0.0932683, 0.88942261, 0.91  
386458, 0.90469276, 0.0268146, 0.94106309, 0.53926666, 0.75440388, 0.71448794, 0.21650415, 0.69543818, 0.63877204, 0.64120112, 0.78008187, 0.93427463, 0.4444064, 0.36709441, 0.70256521, 0.91  
79161, 0.27795564, 0.4816038, 0.12269671, 0.7188782, 0.09066216, 0.14913997, 0.34626546, 0.74917799, 0.00397471, 0.81133724, 0.56197427, 0.86438034, 0.50195518, 0.81087441, 0.34517867, 0.01  
821386, 0.67496579, 0.40223558, 0.53809704, 0.50945166, 0.83124344, 0.90233734, 0.6017624, 0.34630596, 0.83825859, 0.87407229, 0.17935847, 0.03967245, 0.07094562, 0.55174193, 0.74973565, 0.51  
398436, 0.38600355, 0.8301068, 0.73287606, 0.53367008, 0.41585371, 0.4550718, 0.70436542, 0.01598325, 0.92547509, 0.05948388, 0.59772483, 0.77019315, 0.40899488, 0.0556999, 0.47415863, 0.11

# 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

A woman with long dark hair is shown from the waist up, wearing a red superhero-style cape. She is flying through a bright blue sky filled with white and grey clouds. Her arms are outstretched to her sides, and she has a determined expression. The background is a soft-focus view of the sky.

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	<a href="#">Introduction + Where is the digital revolution?</a>
29 February 2024	<a href="#">Text as Data</a>
07 March 2024	<a href="#">Setting up your Development Environment</a>
14 March 2024	<a href="#">Introduction to the Command-line</a>
21 March 2024	<a href="#">Basic NLP with Command-line</a>
28 March 2024	<a href="#">Introduction to Python in VS Code</a>
04 April 2024	<i>no lecture (Osterpause)</i>
11 April 2024	<a href="#">Working with (your own) Data</a>
18 April 2024	<a href="#">Data Analysis of Swiss Media</a>
25 April 2024	<a href="#">Ethics and the Evolution of NLP</a>
02 May 2024	<a href="#">NLP with Python</a>
09 May 2024	<i>no lecture (Christi Himmelfahrt)</i>
16 May 2024	<a href="#">NLP with Python II + Working Session</a>
23 May 2024	<a href="#">Mini-Project Presentations + Discussion</a>
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](mailto:alex.flueckiger@doz.unilu.ch)

# Assignment #1



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





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>.
- 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 Macroscope*. Open Draft Version. Under contract with Imperial College Press. <http://themacroscope.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>.
- Lundberg, Ian, Jennie E. Brand, and Nanum Jeon. 2022. "Researcher Reasoning Meets Computational Capacity: Machine Learning for Social Science." *Social Science Research* 108 (November): 102807. <https://doi.org/10.1016/j.ssresearch.2022.102807>.

..