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TOMORROW TODAY

An Introduction to Artificial Intelligence and Data Science

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What is Artificial Intelligence?

Dartmouth Conference (1956)

- Naming: „Artificial Intelligence“
- Multi-disciplinary
  - Philosophy (z.B. Descartes, Leibnitz)
  - Logik / Mathematik (z.B. Gödel)
  - Informatik (z.B. Turing, von Neumann)
  - Psychologie / Kognitionswissenschaften (Wissensrepresentationen)
  - Biologie / Neuro-Wissenschaften (Konnektivismus, Neural Networks)
  - Evolution (Genetic Programming)

Academic Discipline / Computer Science

- *“Artificial Intelligence (AI) is the part of computer science concerned with **designing intelligent computer systems**, that is, systems that exhibit **characteristics we associate with intelligence in human behavior**”* (Barr & Feigenbaum, 1981)
  - Understanding language
  - Learning
  - Reasoning
  - solving problems
- ***Scientific Goal:*** To determine which ideas about knowledge representation, learning, rule systems, search, and so on, explain various sorts of real intelligence.
- ***Engineering Goal:*** To solve real world problems using AI techniques such as knowledge representation, learning, rule systems, search, etc.

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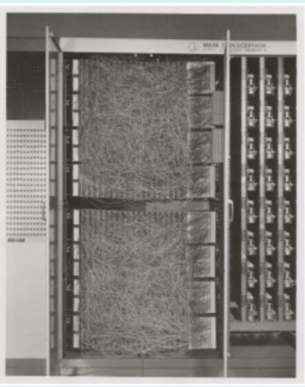
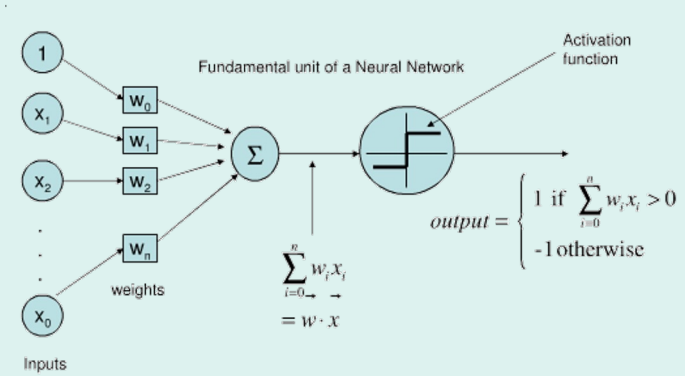




Perceptron (Frank Rosenblatt, 1958)

- Basic component of neural networks

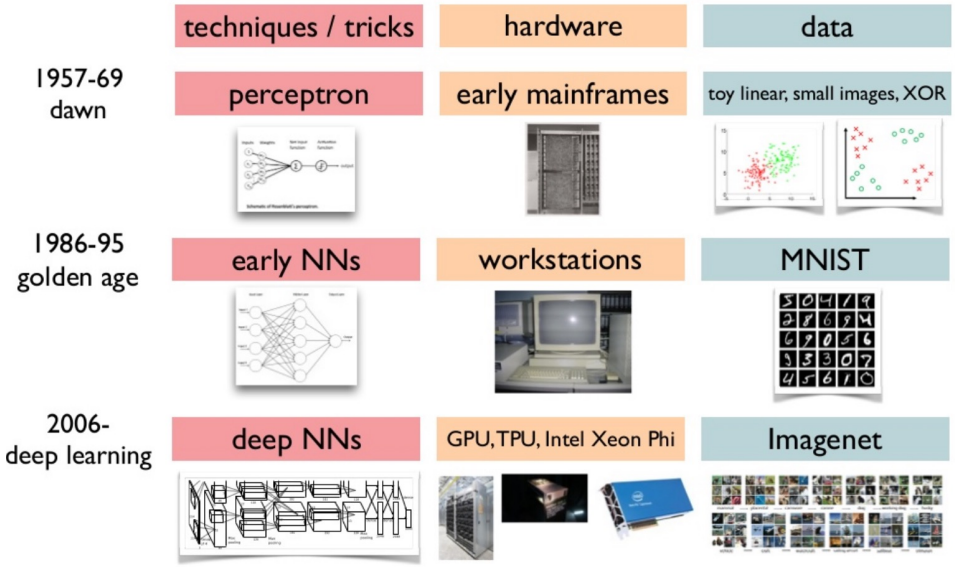
HISTORICAL OVERVIEW

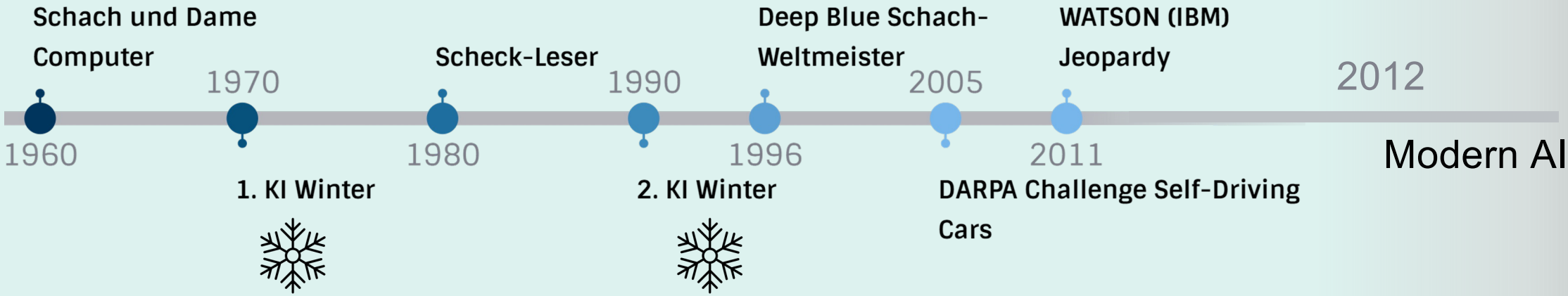
High expectations

- Major investment from the military
- Utopian ideas

Poor performance

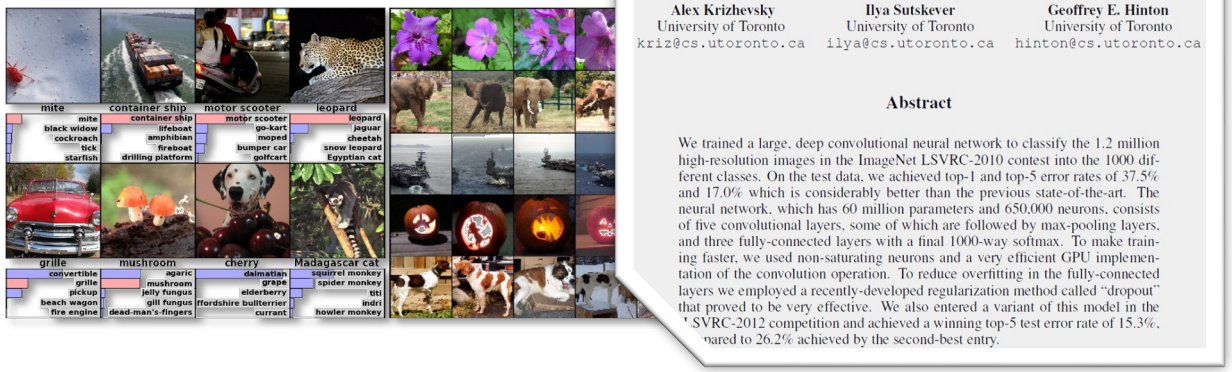
- Slow computers
- Small data sets / Expensive data storage
- Many problems not yet solved
- Too few "experts"





MODERN AI

AlexNet



ImageNet Classification with Deep Convolutional Neural Networks

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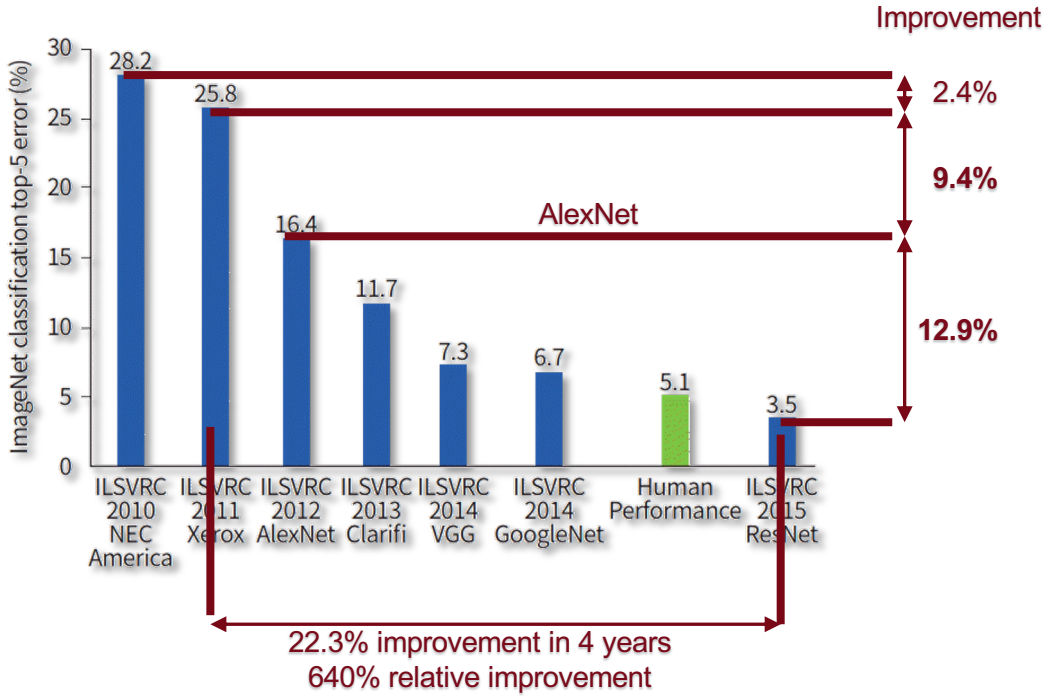
Abstract

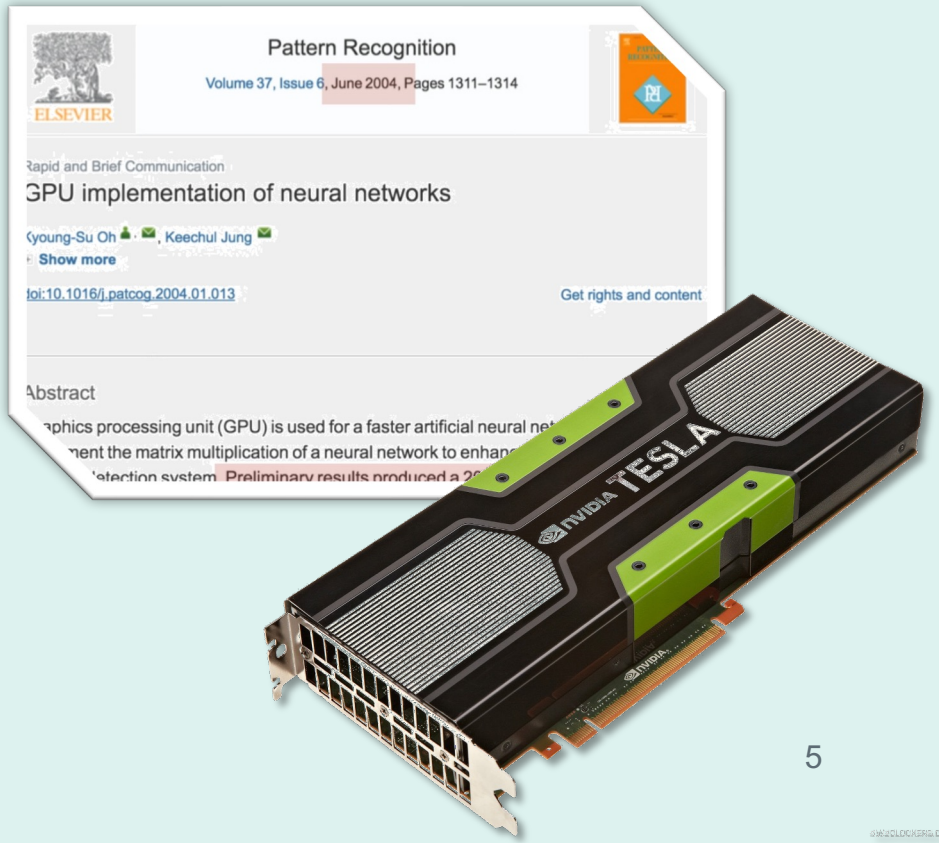
We trained a large, deep convolutional neural network to classify the 1.2 million high-resolution images in the ImageNet LSVRC-2010 contest into the 1000 different classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art. The neural network, which has 60 million parameters and 650,000 neurons, consists of five convolutional layers, some of which are followed by max-pooling layers, and three fully-connected layers with a final 1000-way softmax. To make training faster, we used non-saturating neurons and a very efficient GPU implementation of the convolution operation. To reduce overfitting in the fully-connected layers we employed a recently-developed regularization method called "dropout" that proved to be very effective. We also entered a variant of this model in the ILSVRC-2012 competition and achieved a winning top-5 test error rate of 15.3%, compared to 26.2% achieved by the second-best entry.



GPUs

Consumer Hardware

- Powerful hardware instead of supercomputers
- ➔ High computing power also for PhD students



What is Artificial Intelligence?

Definition by High-Level Expert Group on Artificial Intelligence (EU)

Artificial intelligence (AI) systems are **software** (and possibly also hardware) **systems** designed by humans(2) that, given a **complex goal**, act in the physical or digital dimension by **perceiving their environment through data acquisition**, **interpreting the collected structured or unstructured data**, **reasoning on the knowledge**, or processing the information, derived from this data and **deciding the best action**(s) to take to **achieve the given goal**. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions

Definition by Austrian Council for Robotics and Artificial Intelligence (AT)

"… artificial intelligence (AI) refers to **computer systems** that **exhibit intelligent behavior**, i.e., that are capable of performing tasks that **in the past required human cognition and decision-making skills**. Artificial intelligence-based systems **analyze their environment** and **act autonomously** to **achieve specific goals**. … They operate through rule knowledge created by experts or based on statistical models derived from data (machine learning, e.g., deep learning). The term AI includes both pure software, but can also include hardware, such as in the case of autonomous robots. …"

DEFINITION
ARTIFICIAL INTELLIGENCE

Table 1. AI domains and subdomains constituting one part of the operational definition of AI

	AI taxonomy	
	AI domain	**AI subdomain**
Core	**Reasoning**	Knowledge representation
		Automated reasoning
		Common sense reasoning
	Planning	Planning and Scheduling
		Searching
		Optimisation
	Learning	Machine learning
	Communication	Natural language processing
	Perception	Computer vision
		Audio processing
Transversal	**Integration and Interaction**	Multi-agent systems
		Robotics and Automation
		Connected and Automated vehicles
	Services	AI Services
	Ethics and Philosophy	AI Ethics
		Philosophy of AI

Samoili, S., López Cobo, M., Gómez, E., De Prato, G., Martínez-Plumed, F., & Delipetrev, B. (2020). AI Watch Defining Artificial Intelligence. Publications Office of the European Union.

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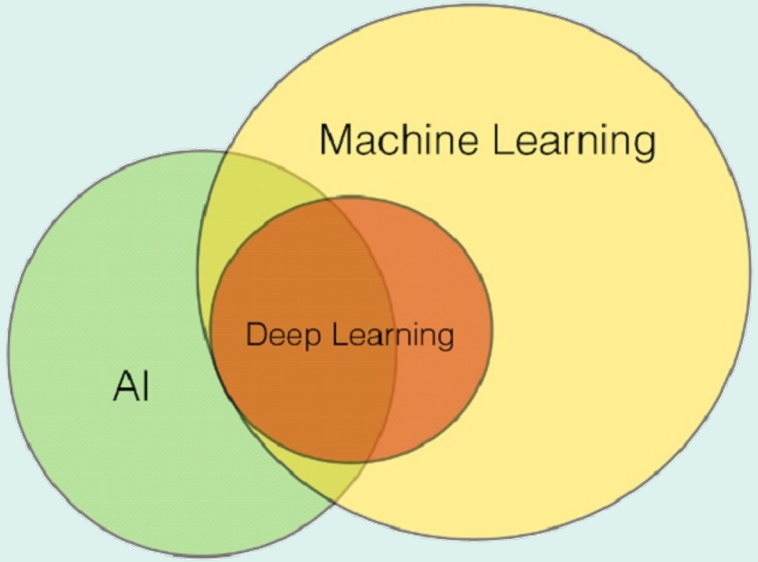
Machine Learning

- Methods which **leverage data** to **improve performance** on some set of **tasks**
- Statistical Machine Learning is dominant



Machine Learning vs. Deep Learning
Example: Object Detection

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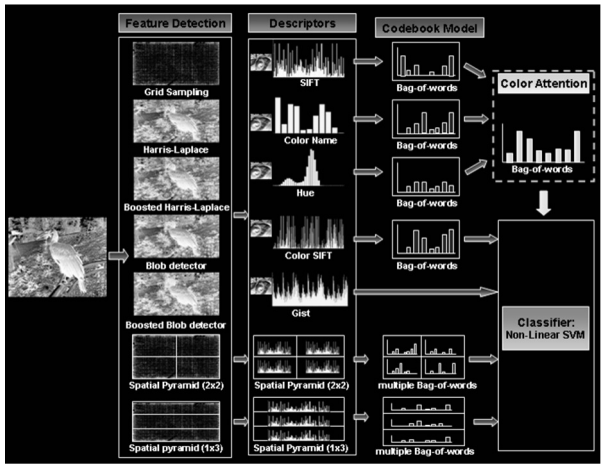
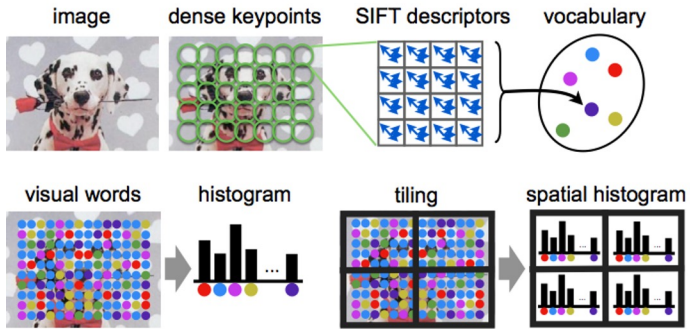
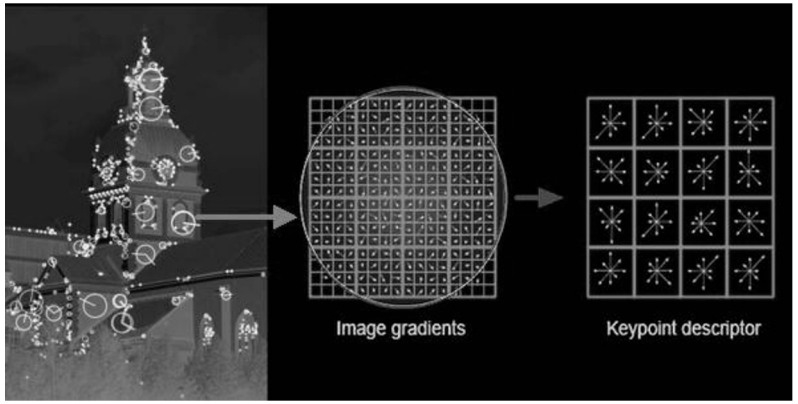
Traditional Computer Vision

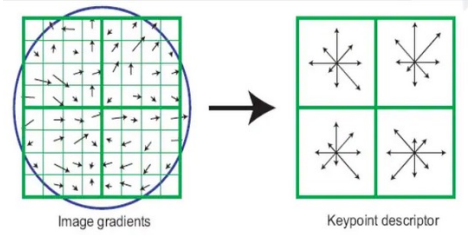
- Image features are defined by experts and extracted automatically
- Machine learning model trained on these features to recognize objects





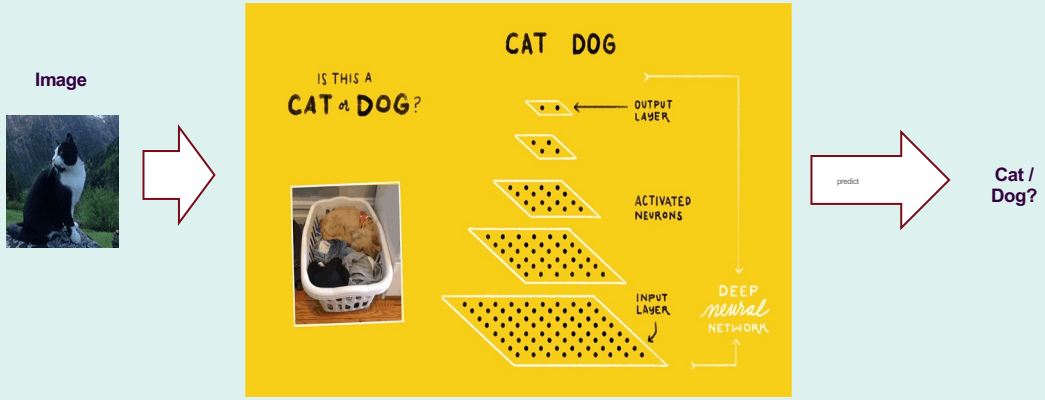
Ahuja, Sarthak, and Anchita Goel. "Scene Recognition using Bag-of-Words." Forest 100: 228.





Deep Learning

- Model learns features directly from sample data
- End-to-End training/prediction



DEEP LEARNING REQUIRES DATA

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Learning by examples

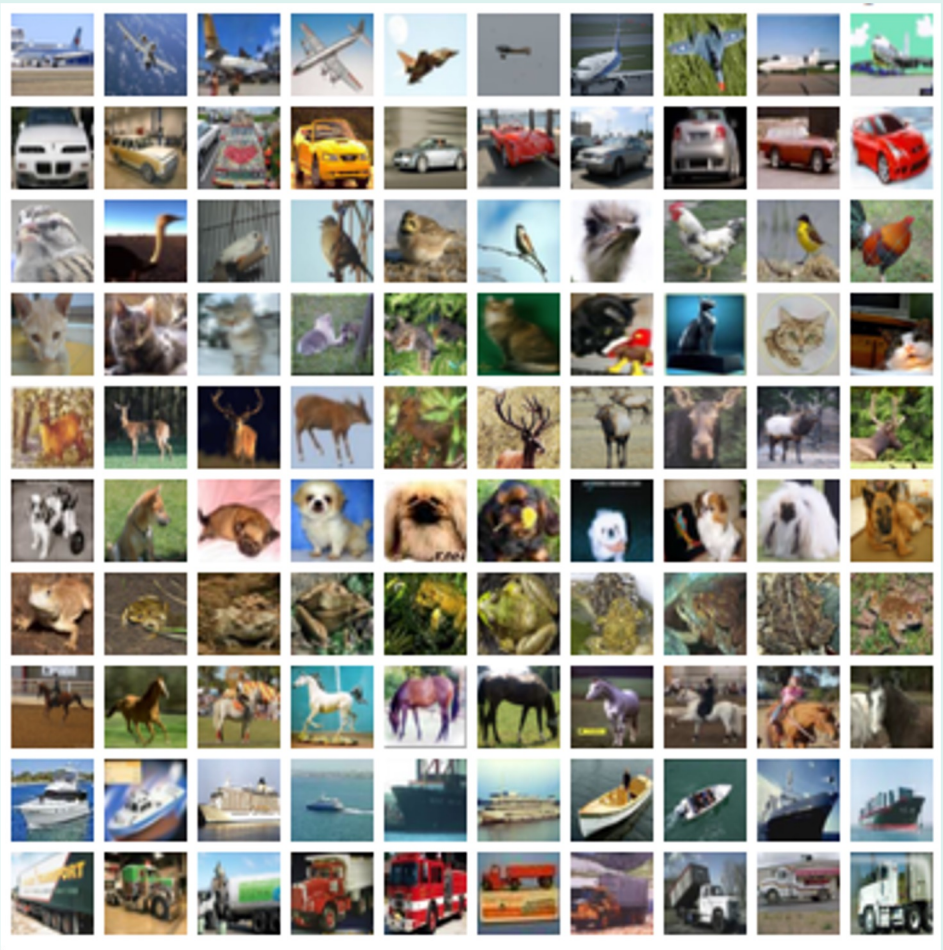
- Deep Learning requires a lot of diverse data to recognize the relevant features of an object.
  - Different dog breeds, car brands, bird species, clothing, etc.

Overfitting

- If a model "sees" only red cars, it assumes that cars are red.
- If the training data is not diverse enough, it cannot generalize to "unseen" data ("it does not recognize blue cars")

Problems

- Bias: Annotator's bias, prejudices, stereotypes, etc. are reflected in the annotation / data sampling process
- Personal Data: Identifying information in text, image, sound.
  - ➔ Anonymizing data, synthetic data
- Ethical implications: What data may be used (e.g., skin color, religion, sexual orientation, consumer behavior, etc.)?
  - ➔ Ethics guidelines, legal guidelines



DATA SCIENCE

Science in dealing with data / handling data

- „Data Science“ originates in the 1960s
  - importance of statistical data analysis for an understanding of data was foreseen in an article[1] in 1962
- Gained increased importance with „Big Data“

- **Focus**:
  - Not on the data itself
  - rather on the way in which the data is
    - processed, prepared, analysed
    - translated into decisions
- **Data science is concerned with**
  - purpose-oriented data analysis
  - systematic generation of decision-making aids, tools and bases
  - to achieve competitive advantages

Conceptual Framework	Introduction to Data
Data Collection	Data Discovery and Collection
	Evaluating and Ensuring Quality of Data and Sources
Data Management	Data Organization
	Data Manipulation
	Data Conversion
	Metadata Creation and Use
	Data Curation, Security and Re-Use
	Data Preservation
Data Evaluation	Data Tools
	Basic Data Analytics
	Data Interpretation (Understanding Data)
	Identifying Problems Using
	Data Visualization
	Presenting Data (Verbally)
	Data Driven Decisions Making (DDDM)
Data Application	Critical Thinking
	Data Culture
	Data Ethics
	Data Citation
	Data Sharing
	Evaluating Decisions based on Data

Abbildung 1: Data-Literacy-Kompetenzen nach Ridsdale et al.

Data Literacy und Data Science Education: Digitale Kompetenzen in der Hochschulausbildung. Policy Paper der Präsidiums-Task-Force „Data Science“ der Gesellschaft für Informatik e.V. in Zusammenarbeit mit Vertretern der Deutschen Mathematiker-Vereinigung e.V., der Deutschen Physikalischen Gesellschaft e.V. und der Gesellschaft Deutscher Chemiker e.V.

INTERSECTION: AI - DATA SCIENCE

- **Huge overlaps in application of**
  - Machine Learning
  - Data driven Modelling
- **Data Science contributions to AI**
  - Data collection, management, evaluation, application
  - Data literacy
- **AI contributions to Data Science**
  - Increased perceptual modelling
  - Complex cognitive task solving
  - Better predictions
  - High-level information extraction

Abbildung 3: Entwurf eines Data-Literacy-Kompetenzmodells

Data Literacy und Data Science Education: Digitale Kompetenzen in der Hochschulausbildung. Policy Paper der Präsidiums-Task-Force „Data Science" der Gesellschaft für Informatik e.V. in Zusammenarbeit mit Vertretern der Deutschen Mathematiker-Vereinigung e.V., der Deutschen Physikalischen Gesellschaft e.V. und der Gesellschaft Deutscher Chemiker e.V.

AI – AS A HYPE-TERM

Artificial Intelligence …

… Industry Interpretation

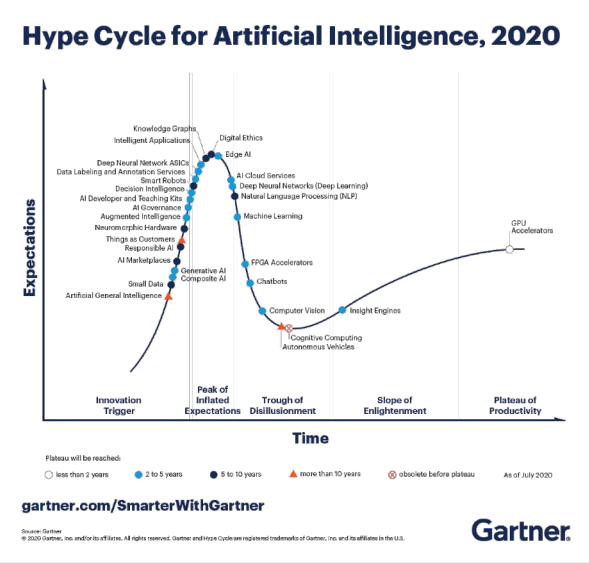
- Artificial Intelligence ⇔ Machine Learning ⇔ Automation

… Public Administration

- Artificial Intelligence ⇔ Digitalization New

… Advertisement

- The next Superlative
- Smart, Intelligent, …



Artificial Intelligence is …

… a political issue

- Hype Term
  - Associated with progress, innovation, etc.

… heavily misused

- Everyone has a best suiting definition of AI
- Advertisement, PR Departments, etc.

… BUT, a promising technology

- Currently delivers impressive results
- Potential application in many areas

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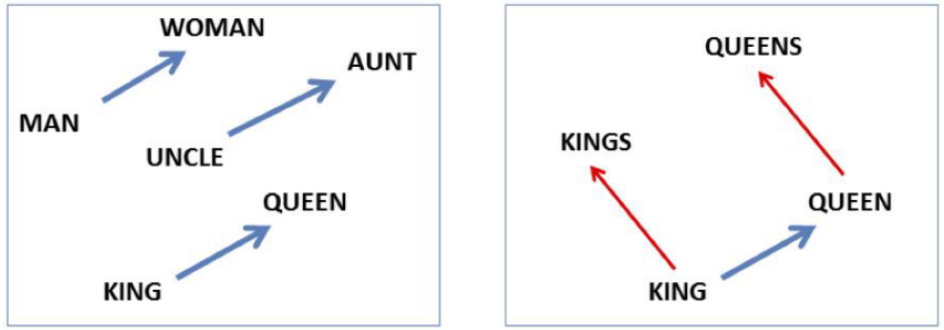
ChatGPT, GenAI, Large Language Models

In a Nutshell

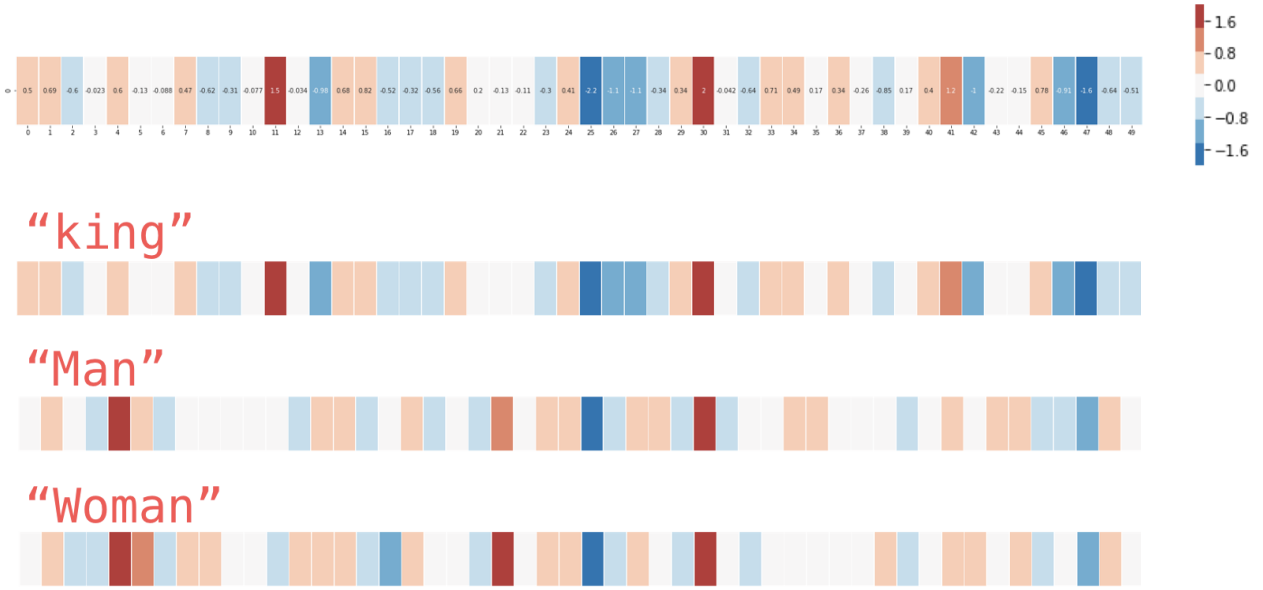
TEXT EMBEDDINGS

- **Embeddings** convert content (images, words, sentences, etc.) to a vector in a high-dimension space.
- **Machine Learning**

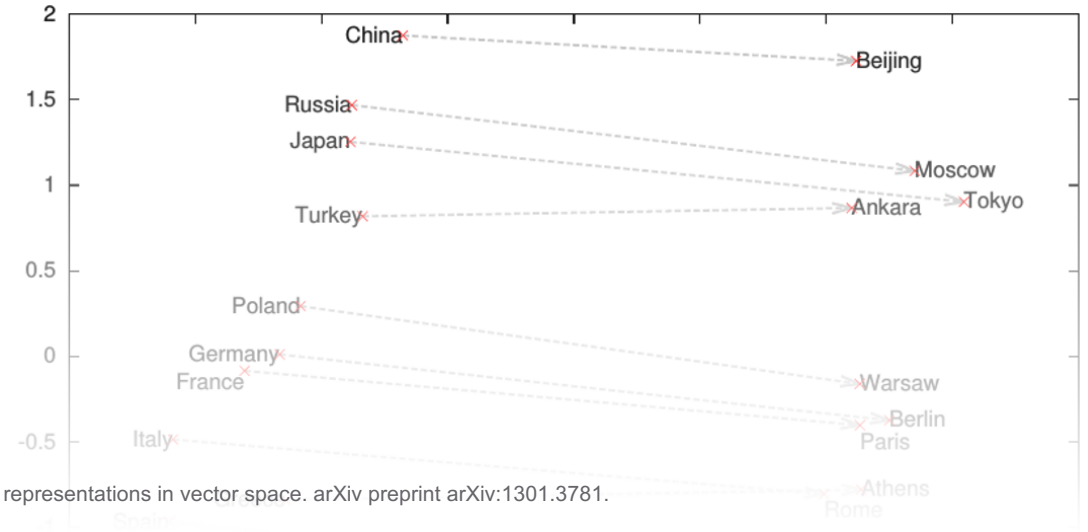
  = linear algebra + vectors, matrices, tensors



vector('king') - vector('man') + vector('woman') ≈ vector('queen')
vector('Paris') - vector('France') + vector('Italy') ≈ vector('Rome')

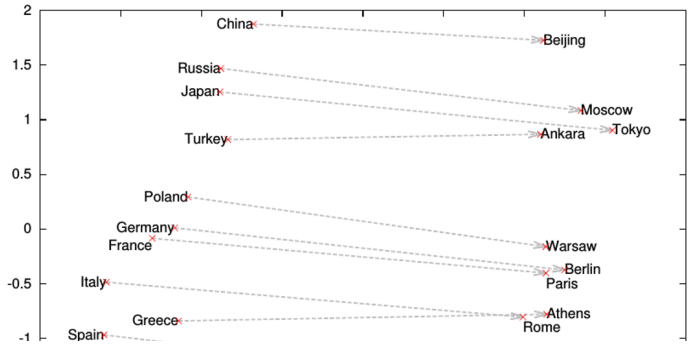


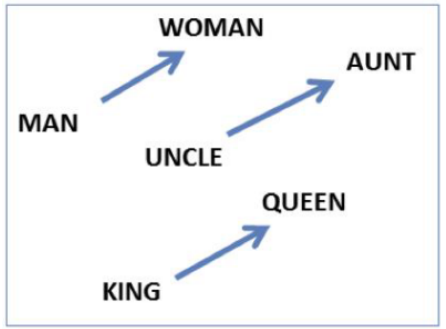
Images from: https://jalammar.github.io/illustrated-word2vec/

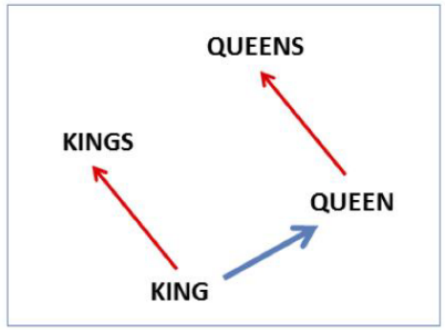


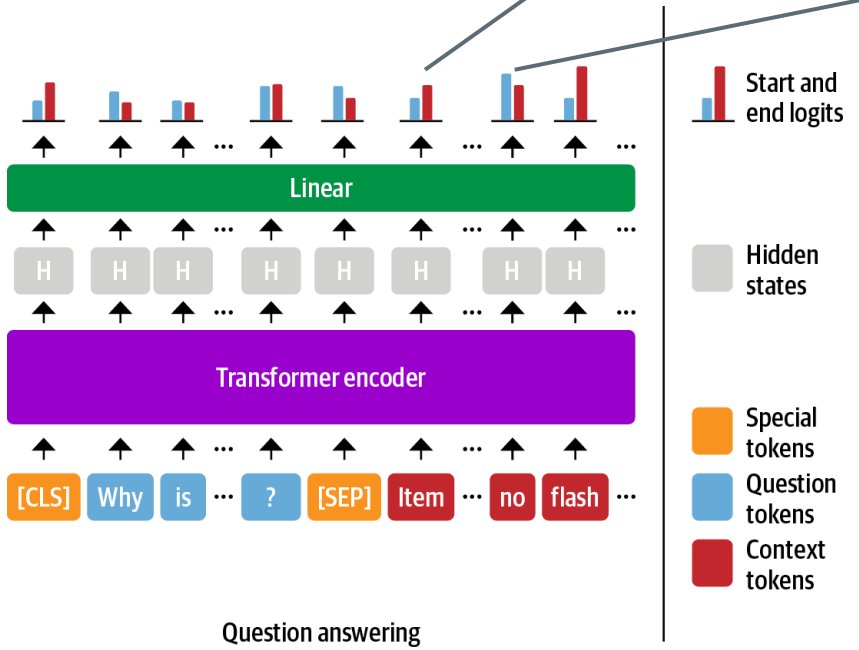
Mikolov, T., Chen, K., Corrado, G., & Dean, J. (2013). Efficient estimation of word representations in vector space. arXiv preprint arXiv:1301.3781.

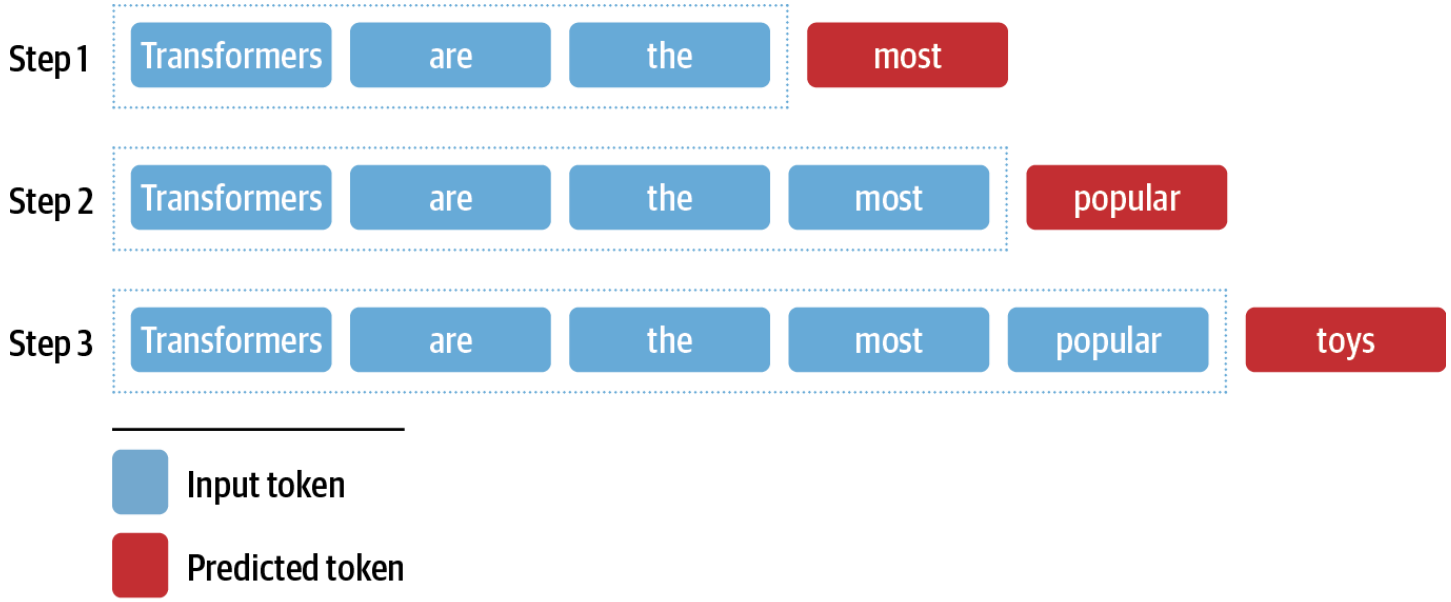
Generative AI / ChatGPT





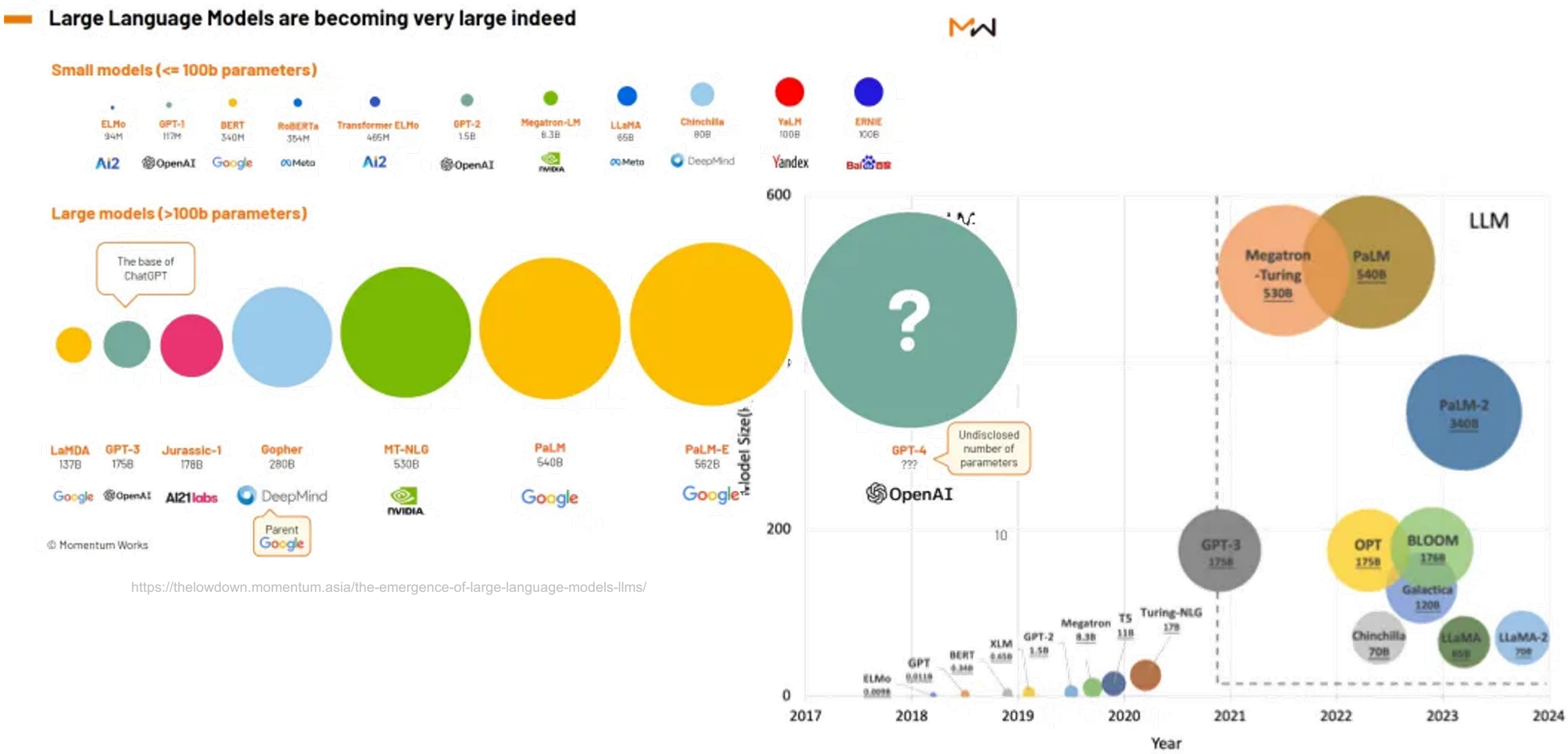






https://learning.oreilly.com/library/view/natural-language-processing/9781098103231/ch05.html#idm45992831868384

LARGE LANGUAGE MODELS



https://thelowdown.momentum.asia/the-emergence-of-large-language-models-llms/

https://medium.com/@yousra.aoudi/large-language-models-in-healthcare-a-new-frontier-7f25ff421568

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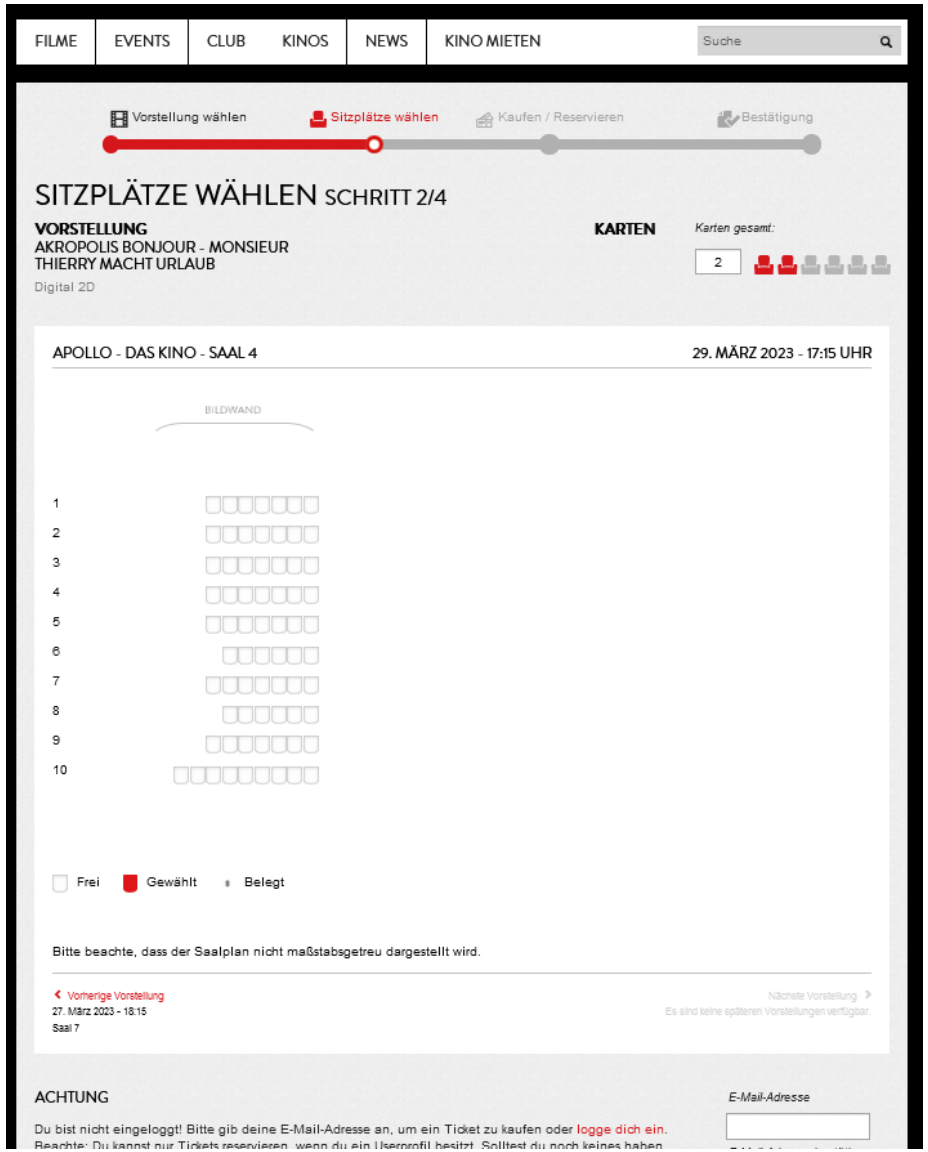
Why do we need AI Ethics?

A Case Study

TRADITIONAL COMPUTER SCIENCE



Software Engineering for traditional CS projects …

… Requirements Engineering

- Clear expectations

… SW Architecture

- Well established practices

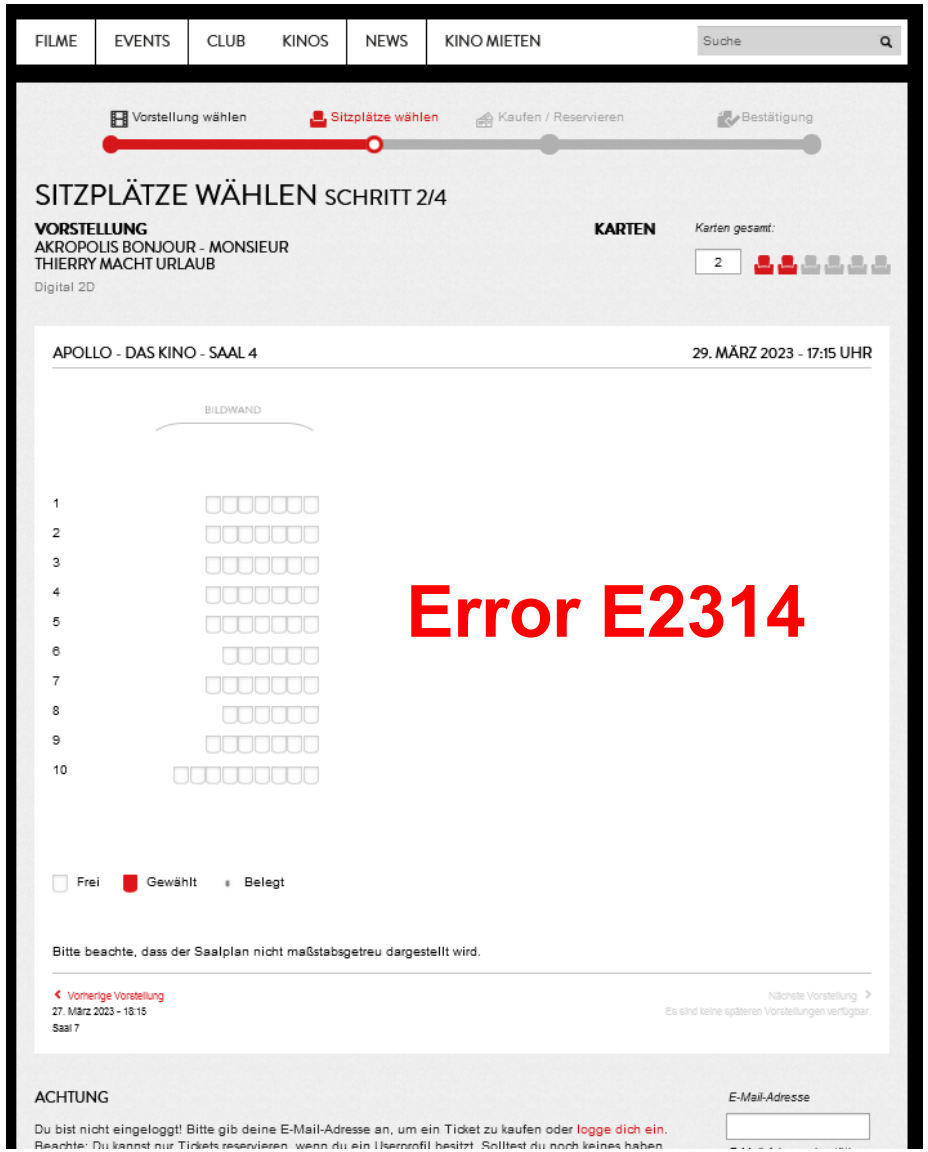
… SW Management Process

- Iterative, Agile, CI/CD

… SW Maintenance

- CI/CD, fast debugging

TRADITIONAL COMPUTER SCIENCE



… SW Risk Management

- Calculable
  - E.g., tickets not sold → 10€ loss
- Impact on society?
  - Low
- Impact on personal life
  - Low
- Impact on hosting company
  - Middle to low
- Impact on developing company
  - Middle to low

AI PROJECTS

VORARLBERG ONLINE VN ESSEN HIGHSPEED WEBMAIL VOLMOBIL JOB IMMO AUTO ANZEIGER | ANMELDEN

VOL.AT V+ Home Gemeinde TIPP geben News Sport LIVE Service Freizeit

ÖVP bremst Mietpreisbremse aus

POLITIK / 22.03.2023 • 17:47 Uhr / 7 Minuten Lesezeit

Mieten wird abermals teurer. ÖVP und Grüne konnten sich auf keine Mietpreisbremse einigen. APA/EVA MANHART

Stattdessen kommt als Kompromiss eine einmalige Wohnbeihilfe von etwa 200 Euro. Wer darauf Anspruch hat, setzen die Bundesländer fest.

Julia Schilly
julia.schilly@vn.at

WIEN Es kommt keine Mietpreisbremse. Das ist seit Mittwoch klar.

Fake News (58%)

Software Engineering for AI projects …

… Requirements Engineering

- Complex
- runaway expectations

… SW Architecture

- Wide, complex and relative new field
- Best practices not yet widely incorporated into teaching

… SW Management Process

- Best practices not yet widely incorporated into teaching

… SW Maintenance

- Slow and difficult debugging

AI PROJECTS

… AI Systems Risk Management

- **Extremly difficult to calculate**
  - multiple inter-disciplenary impacts
  - Competences often not covered by executing institutions (especially KMUs)
  - Knowledge about AI System management requirements not consolidated (AT, EU)
    - → difficult to estimate vendor/outcome reliability
- **Impact on society**
  - High to very high, e.g.
    - violation of personal rights
    - IT personel defining classification systems → becomes new reality/truth
    - Loss of trust in promising technology
- **Impact on personal lifes**
  - High to very high
  - E.g., damaged reputation, credits not granted
- **Impact on hosting company**
  - High
  - High visibility
  - Damaged reputation
  - Legal consequences
- **Impact on developing company**
  - High
  - Damaged reputation
  - Loss of funding, future comissioning
  - Legal consequences

HIGH AIMS

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Misinformation vs. Disinformation

- **Intentionally spreading misleading information**
  - How discreminate intention from lack of knowledge?
- **AI Systems needs vast amounts of (personal) data to decide**
  - Legal aspects
  - Ethical aspects
    - Do we want to become transparent for a computer system?
- **Personal & Fundamental rights**
  - Free speech, express opinion
- **Often even for humans difficult to decide**
  - We are thus careful in formulating our answer
  - Not to hurt anyone involved
  - We can say „I don‘t know“

Telegram: *"Tent city spotted in Burgenland. Could accommodate 5000 migrants"*

Background knowledge: “Tent hotel” Nova Rock Festival Nickelsdorf

Data Science & Artificial Intelligence

Center for Digital Safety & Security

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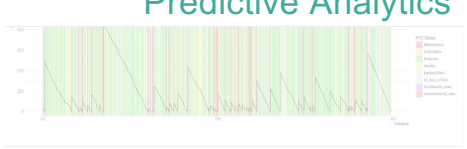
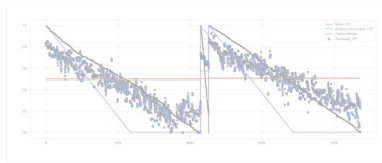
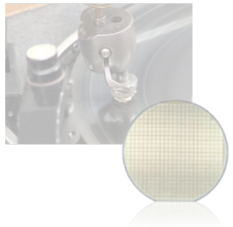
Predictive Analytics

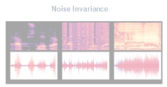


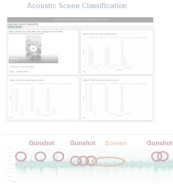


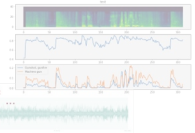


Multimedia Forensics

Civil Security







Disinformation Detection

Spatial Data Science

Our other research fields:

Thank You!

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