

Introduction to AI and machine learning

AI for environmental data, Uppsala University

Olof Mogren, RISE Research Institutes of Sweden



World UK Climate crisis Ukraine Environment Science Global development Football Tech Business Obituaries

News

Environment

Human-made global warming 'caused two in three heat deaths in Europe this summer'

Researchers from Imperial College London say 6,500 deaths caused by hot weather brought on by greenhouse gases





+1.5°



+2°

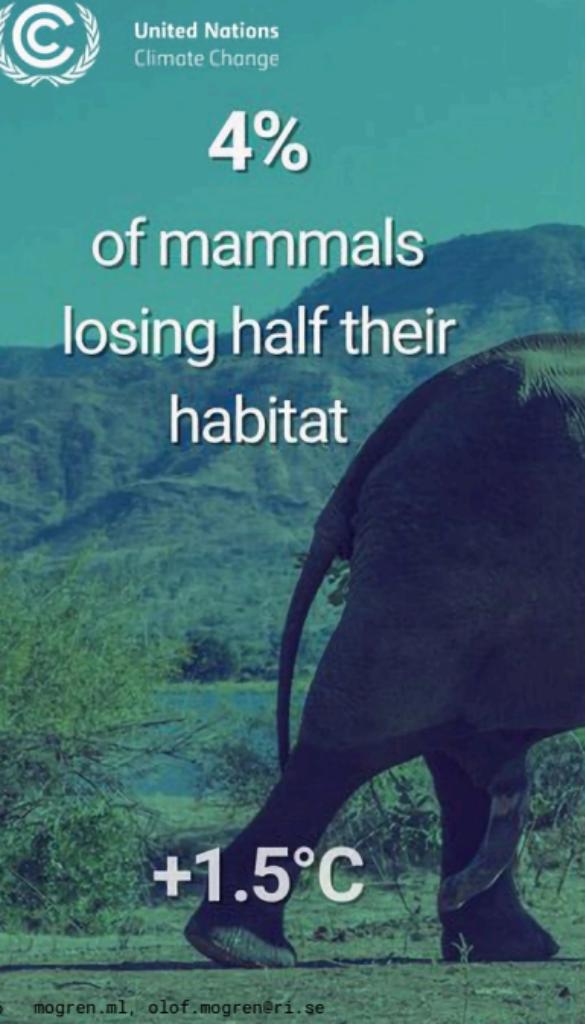




4%

of mammals
losing half their
habitat

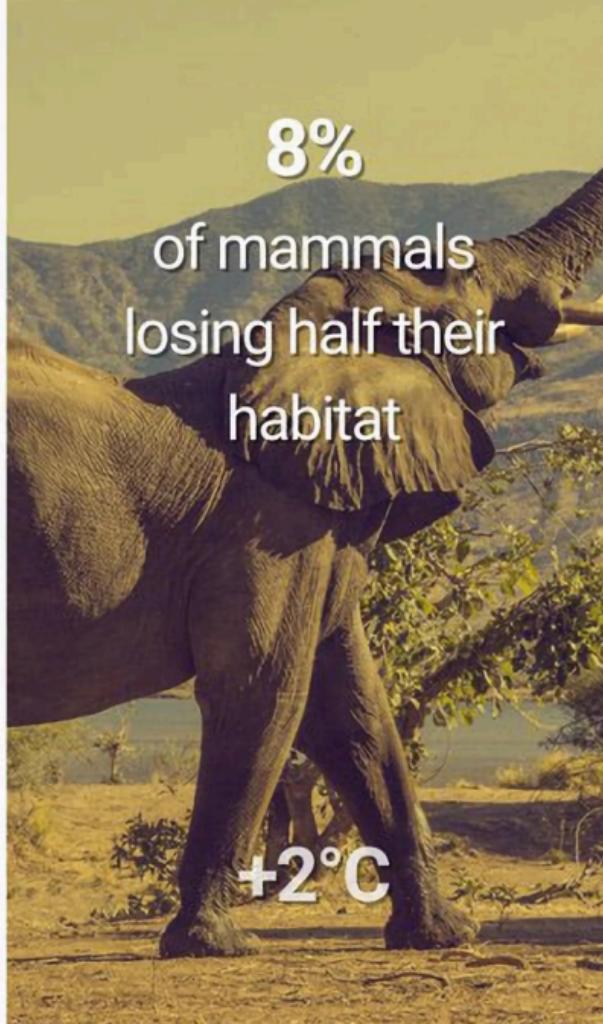
+1.5°C



8%

of mammals
losing half their
habitat

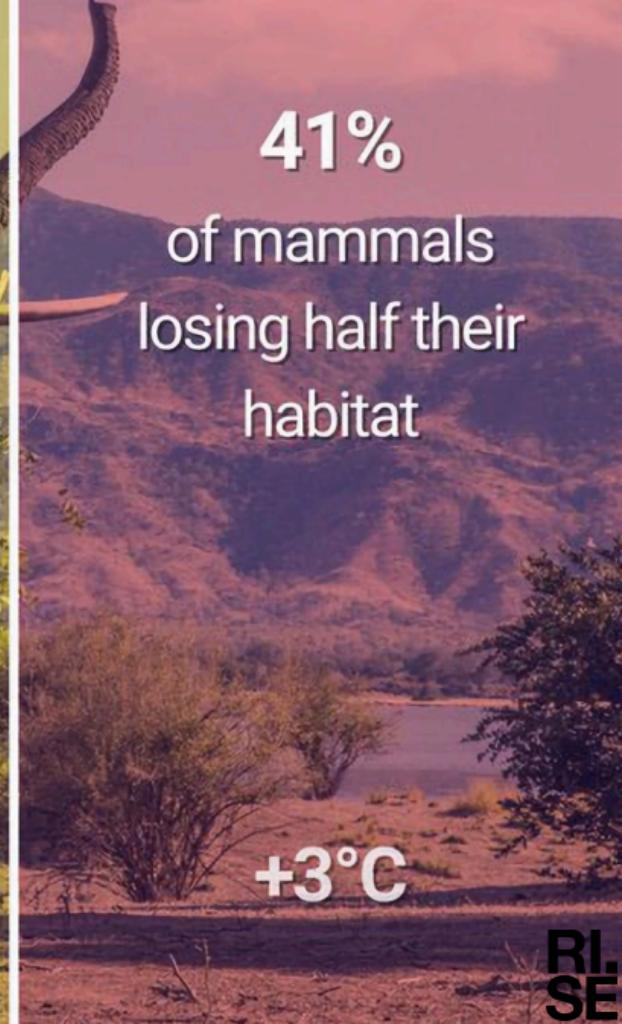
+2°C



41%

of mammals
losing half their
habitat

+3°C



R.
I.
SE

AI is not the solution!

AI can, however, help

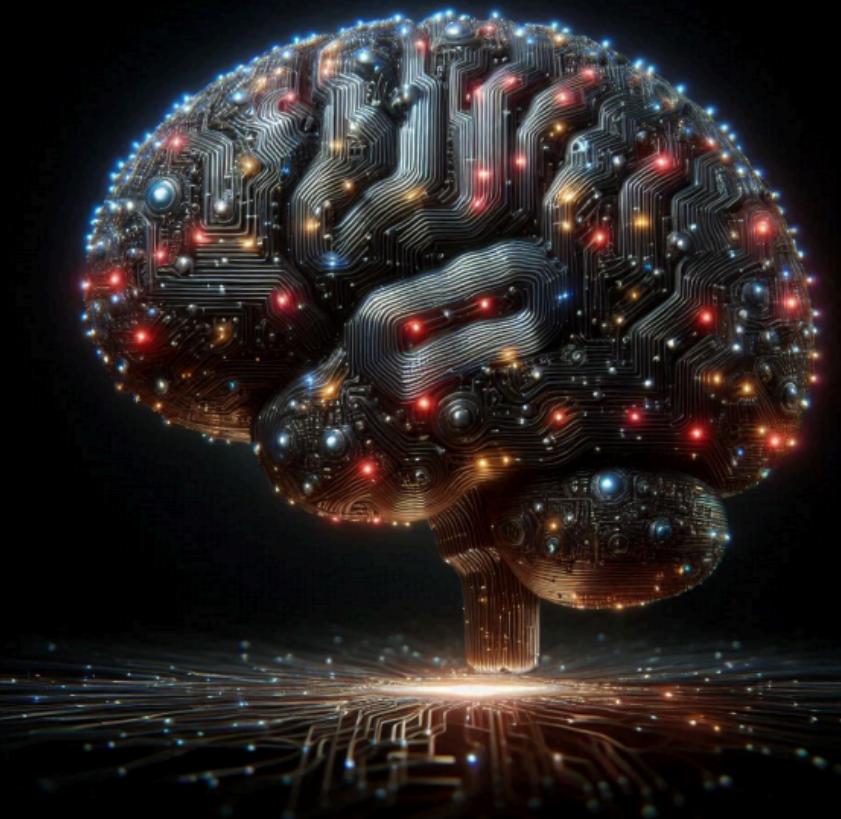
Tracking and quantifying the environment

Optimizing prediction and transport

Help construct new, more sustainable materials and chemicals

Help make decisions for climate adaptation

Forecasting





Independent
Greenhouse Gas
Emissions
Tracking
**SPACE
INTELLIGENCE**

Bringing Integrity To The Carbon Markets

We Support Nature-Based Solutions Developers
And Investors Worldwide With The Highest Quality
Nature Mapping Data.

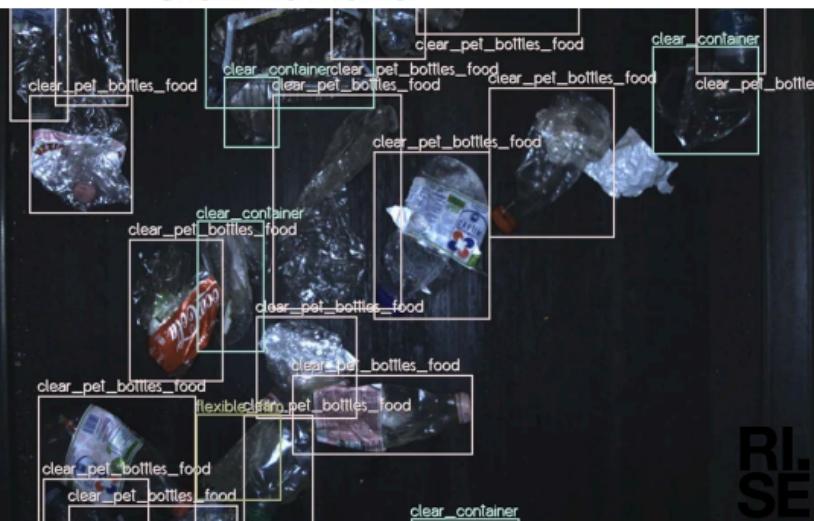
mogren.m1, olof.mogren@ri.se



Amundsen Sea

APPLICATIONS

**AI maps icebergs
10,000 times faster
than humans**



R
I
SE

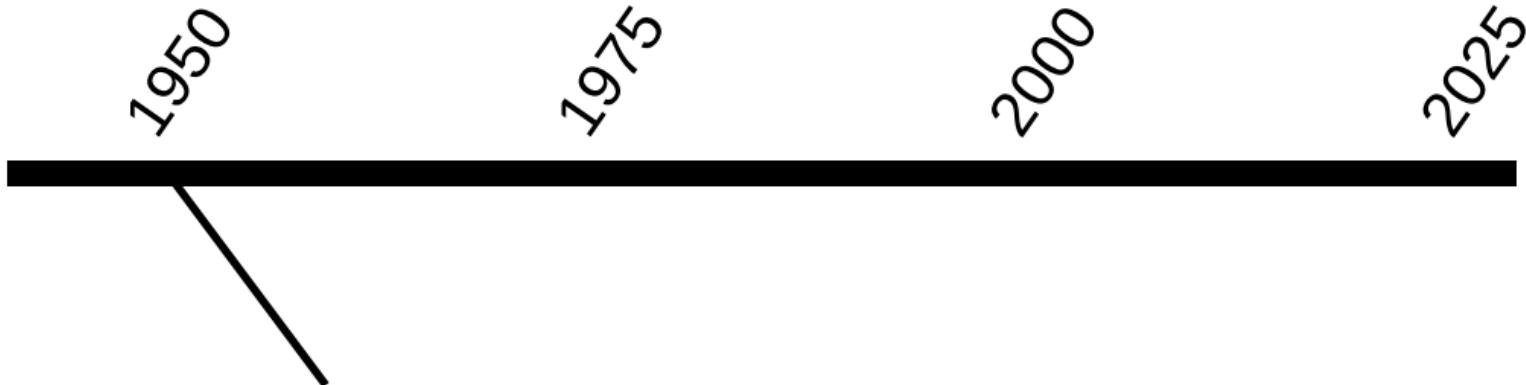
AI



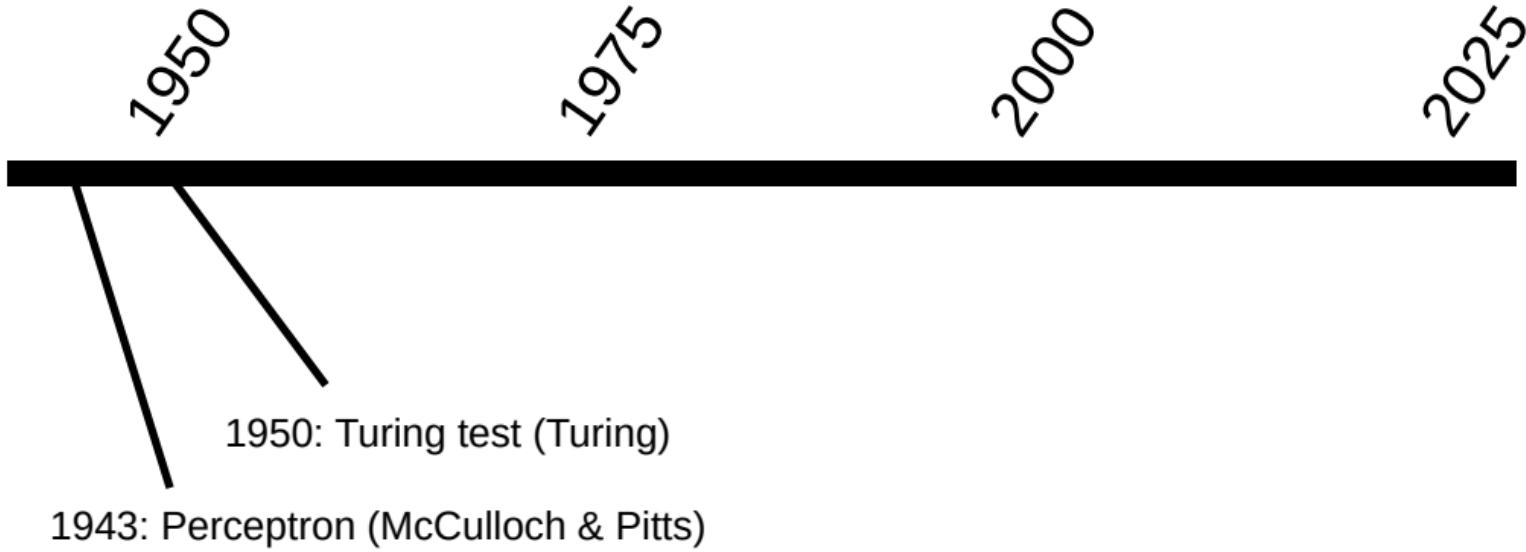
RI
SE

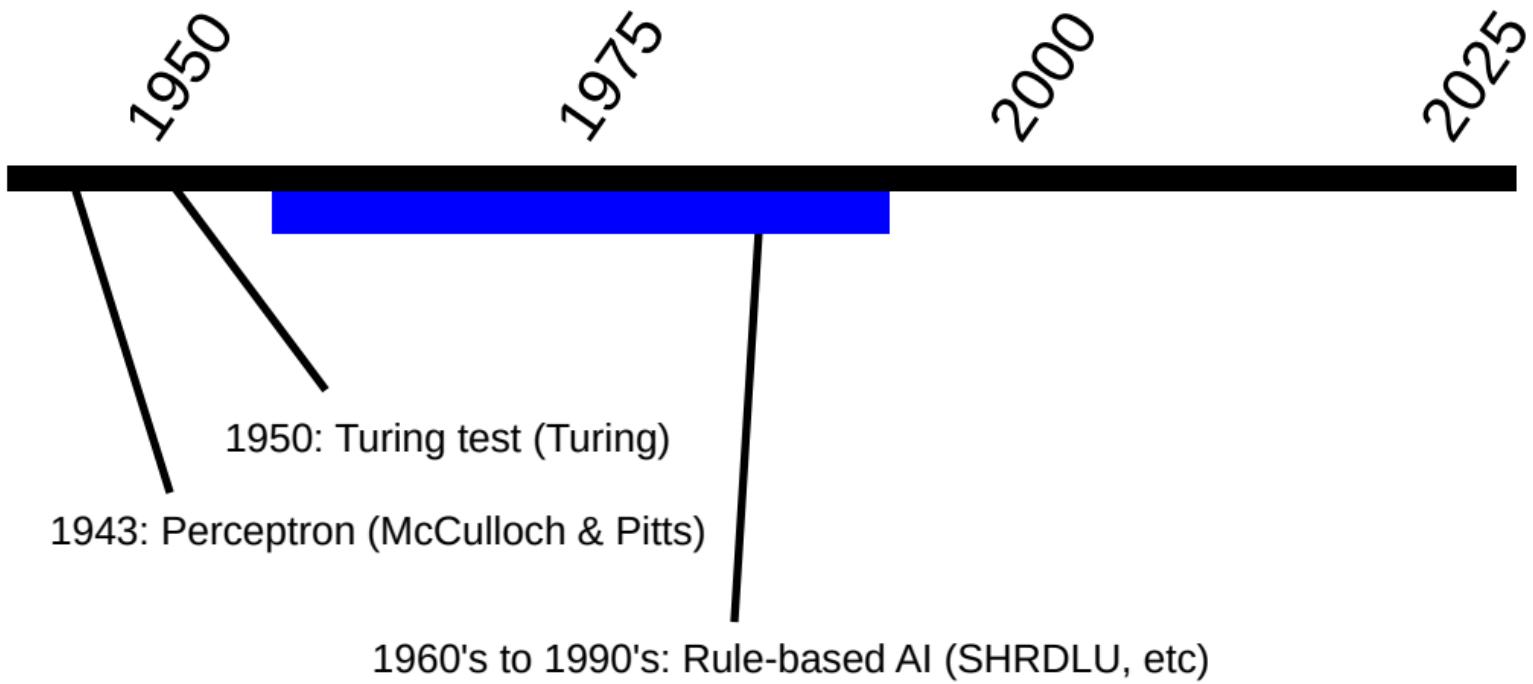
Also AI

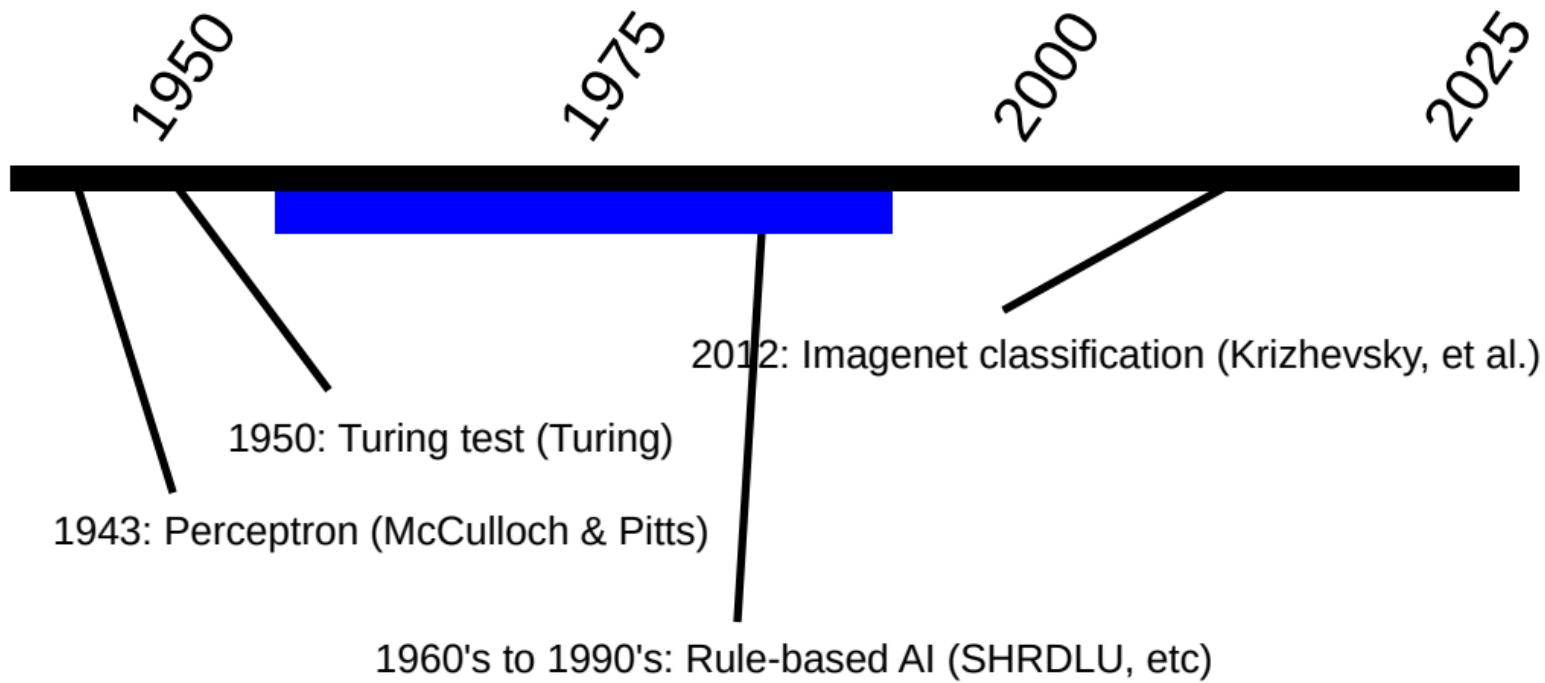
$$\begin{aligned}\mathbf{a} &= W\mathbf{x} + \mathbf{b} \\ \mathbf{o} &= \sigma(\mathbf{a})\end{aligned}$$

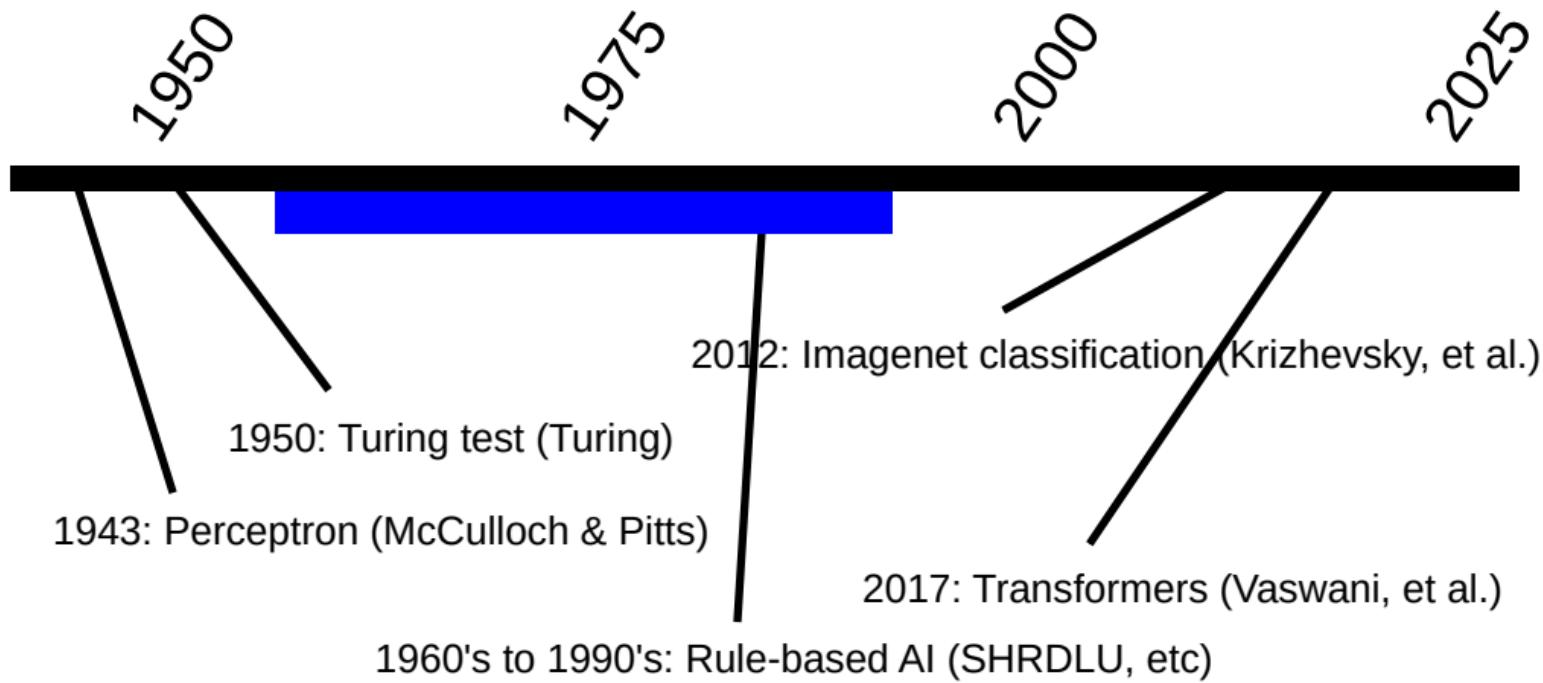


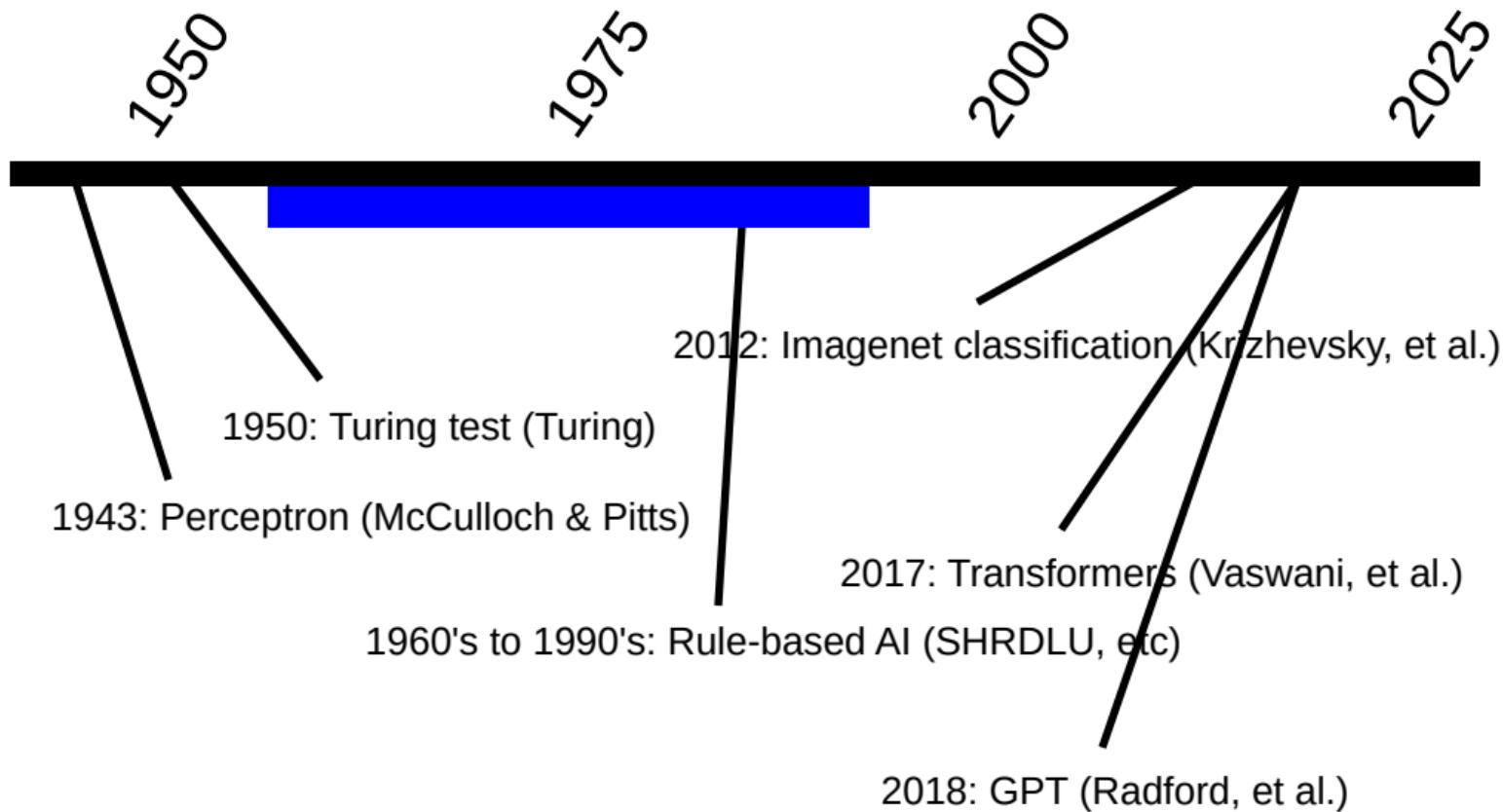
1950: Turing test (Turing)

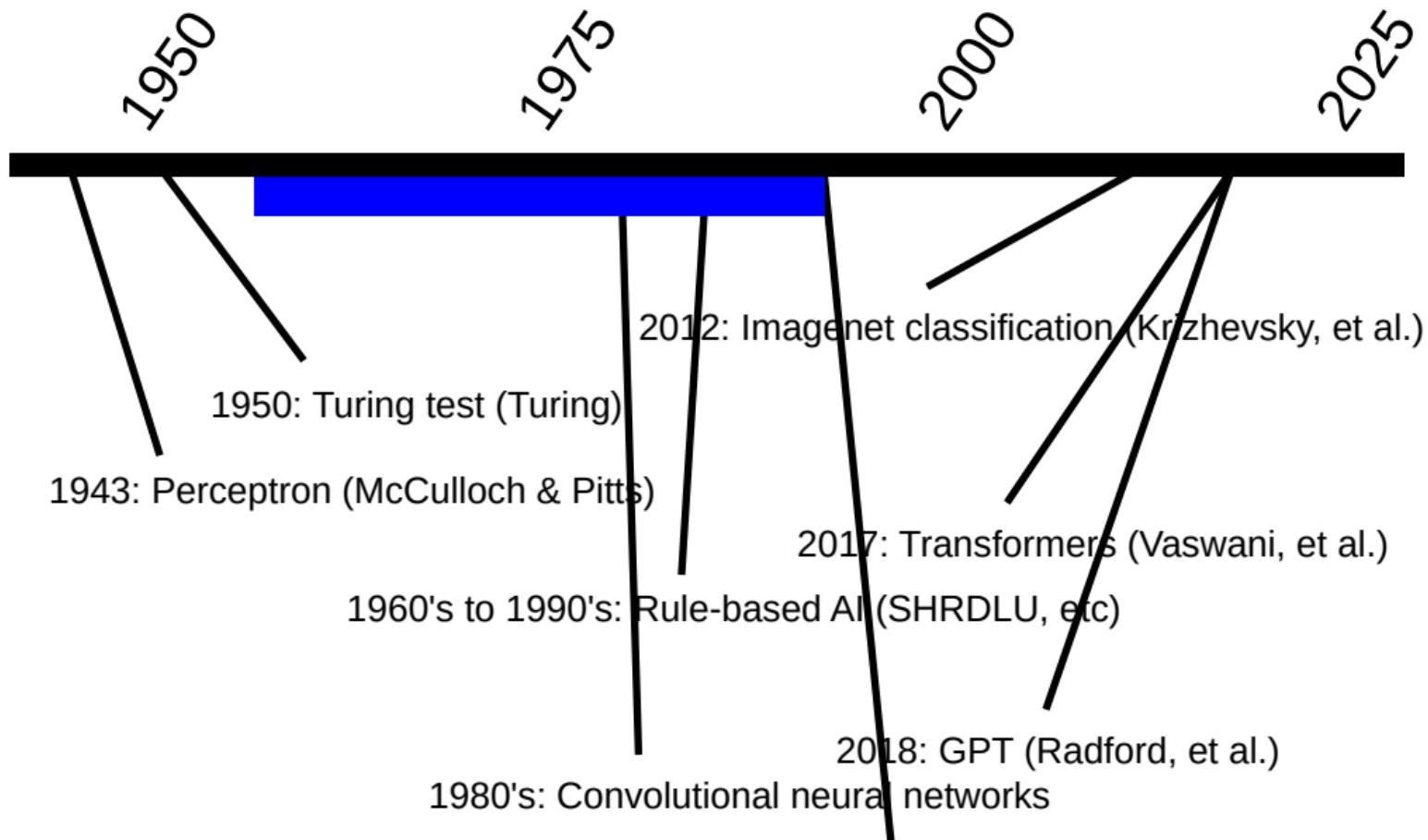




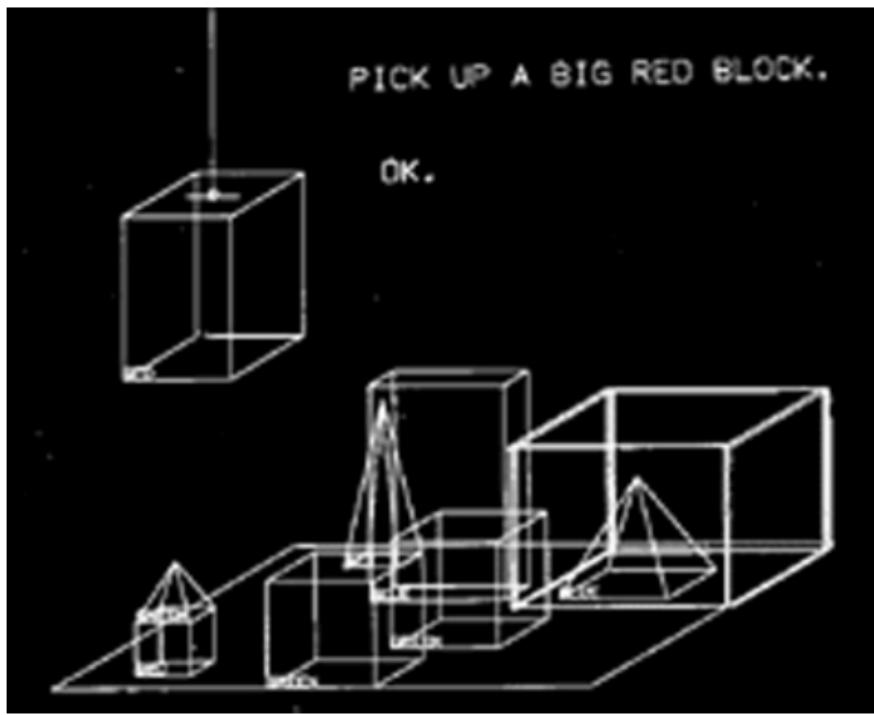


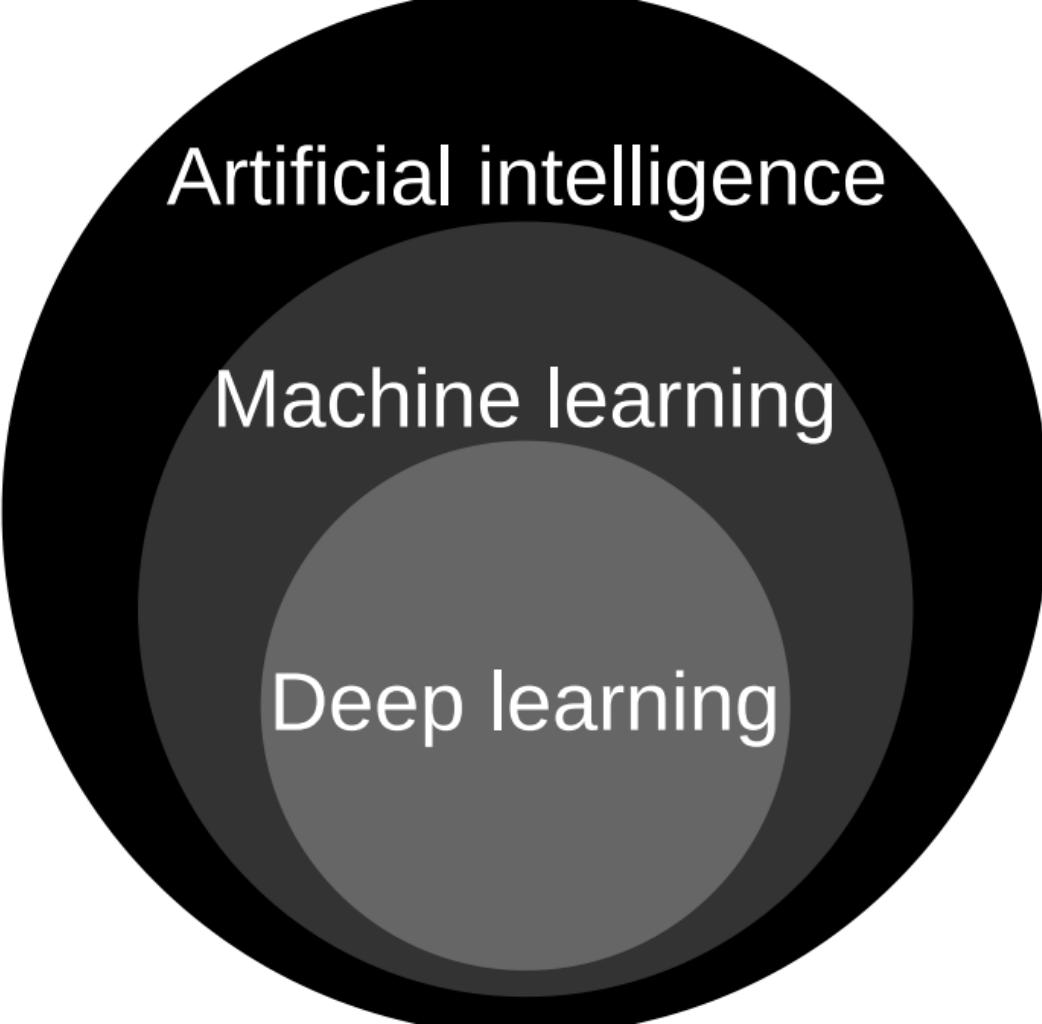






What is AI?





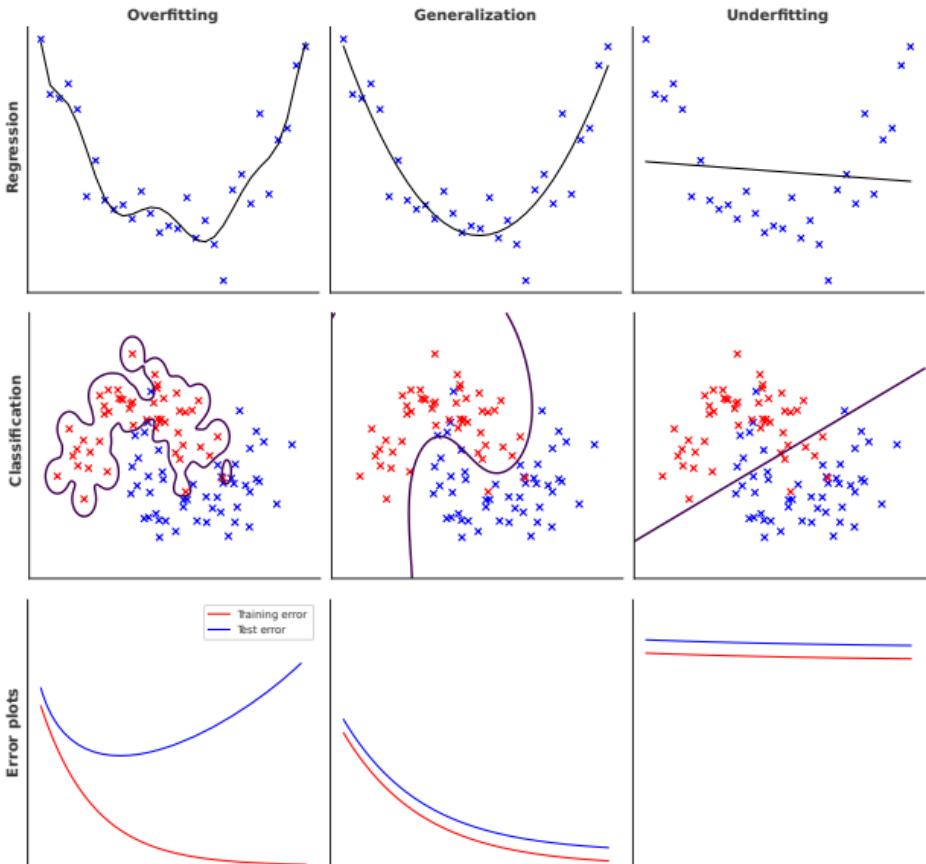
Artificial intelligence

Machine learning

Deep learning

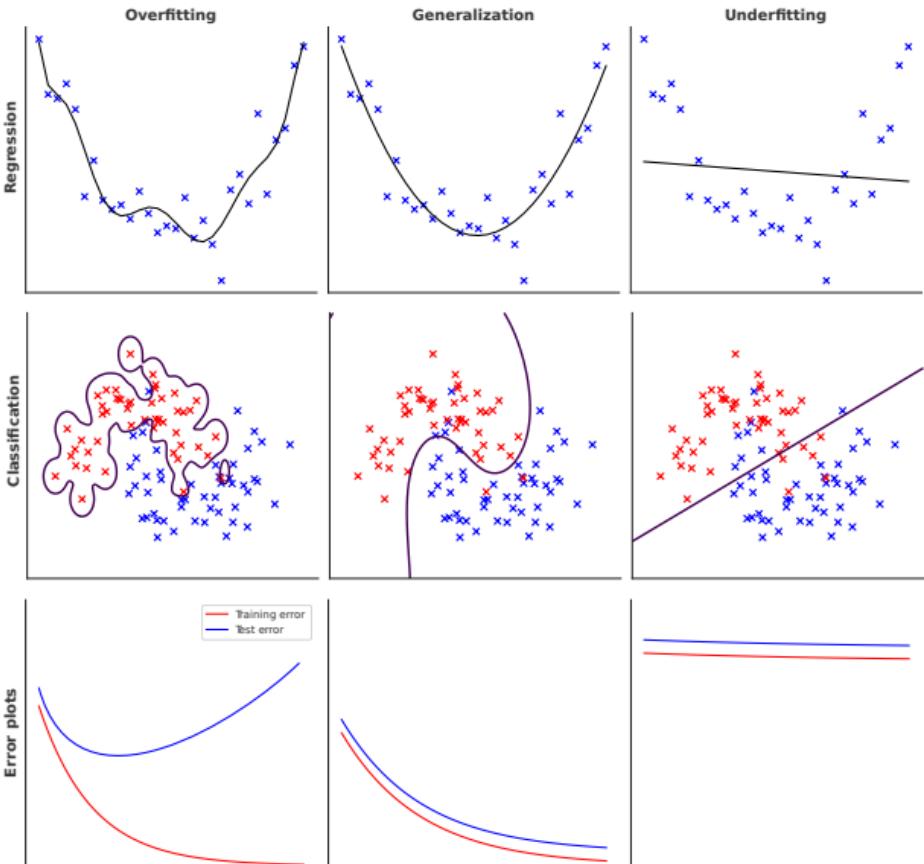
Generalization

- Crucial to learning and reasoning



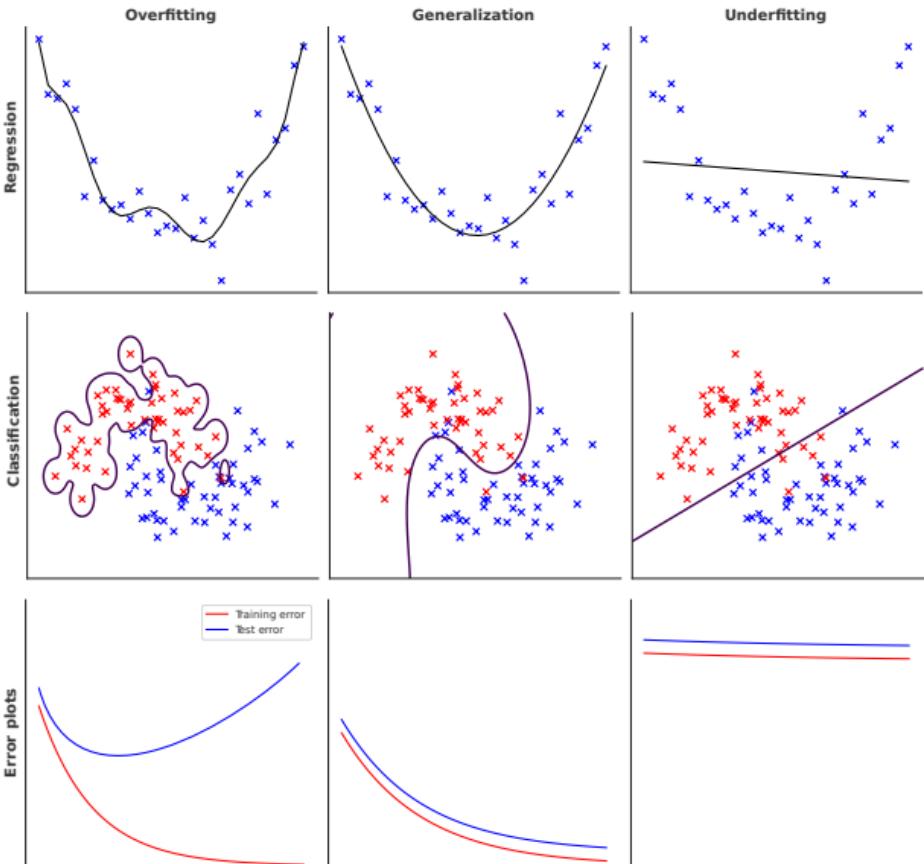
Generalization

- Crucial to learning and reasoning
- Allows transfer of knowledge to new situations



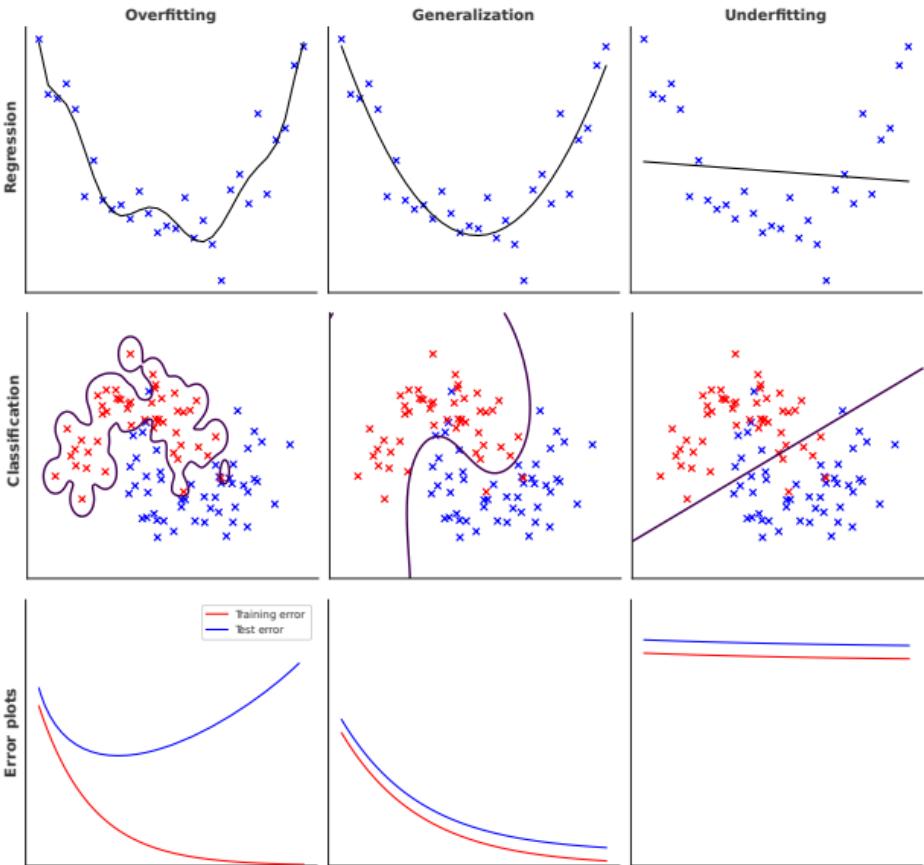
Generalization

- Crucial to learning and reasoning
- Allows transfer of knowledge to new situations
- True generalization error can not be known



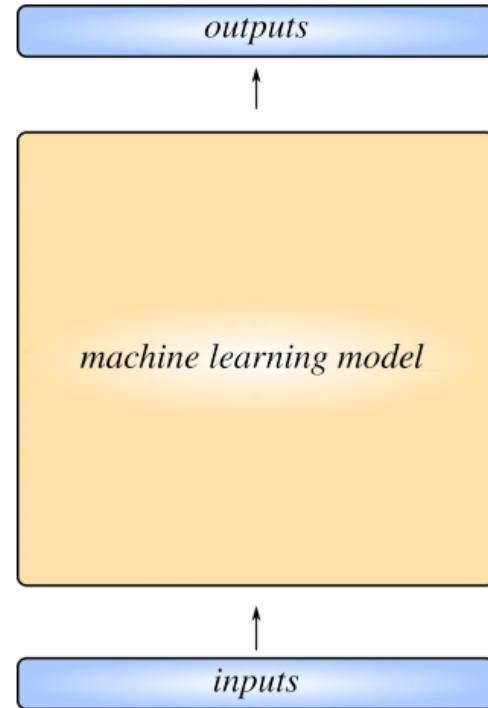
Generalization

- Crucial to learning and reasoning
- Allows transfer of knowledge to new situations
- True generalization error can not be known
- Use held-out test set



Machine learning

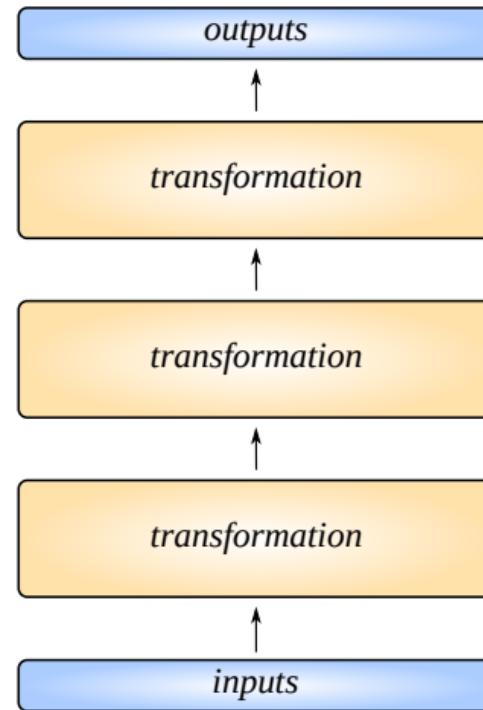
- Learn from data
 - Inputs
 - Outputs
- Generalize to unseen data
- Common classical machine learning
 - Support vector machines
 - Logistic regression
 - Linear regression
 - Decision trees
- Deep learning
 - Artificial neural networks



Deep learning

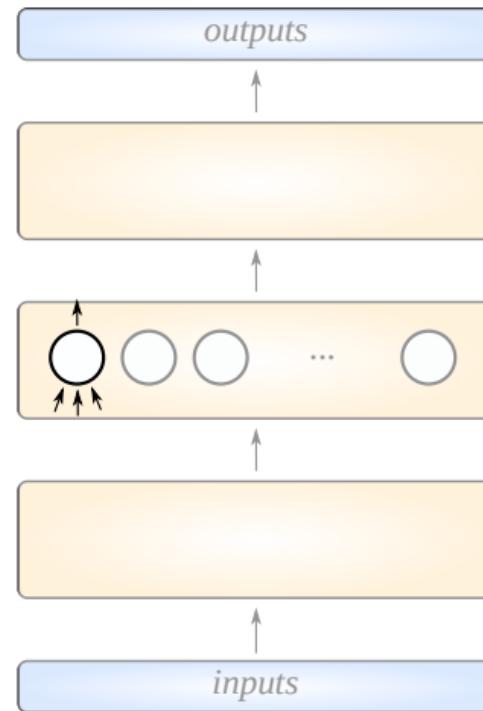
Deep artificial neural networks

- Sequential transformations of data
- Trained together (backpropagation)
- Transformations are gradually changed



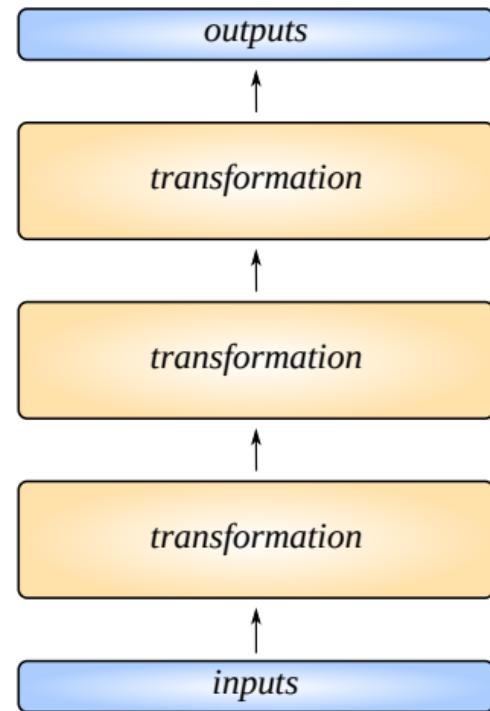
The artificial neuron

- Inspired by biological neurons
- Each layer in network:
 - a collection of neurons
- Each neuron: $o = a(w * x + b)$
- w, b : trainable parameters
- A pattern as input
- A value (scalar) as output

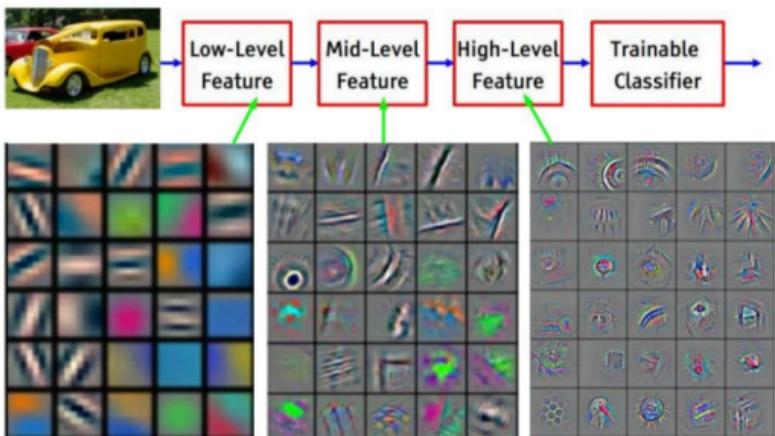
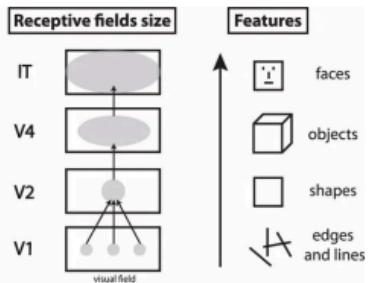
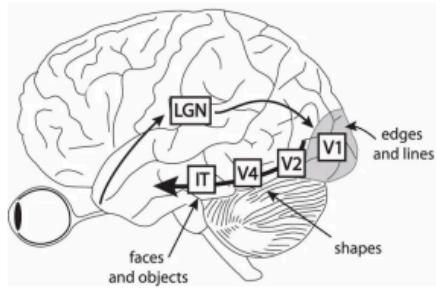


Hierarchical representations

- Each layer outputs a vector
- Deeper into network:
 - more abstract concepts



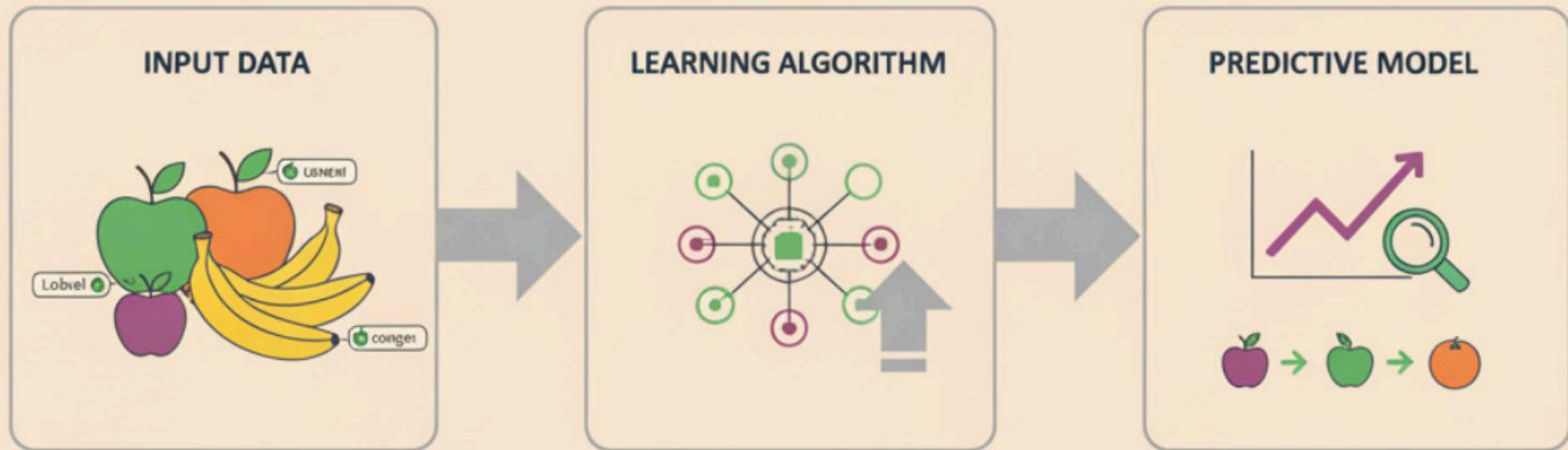
Levels of abstractions



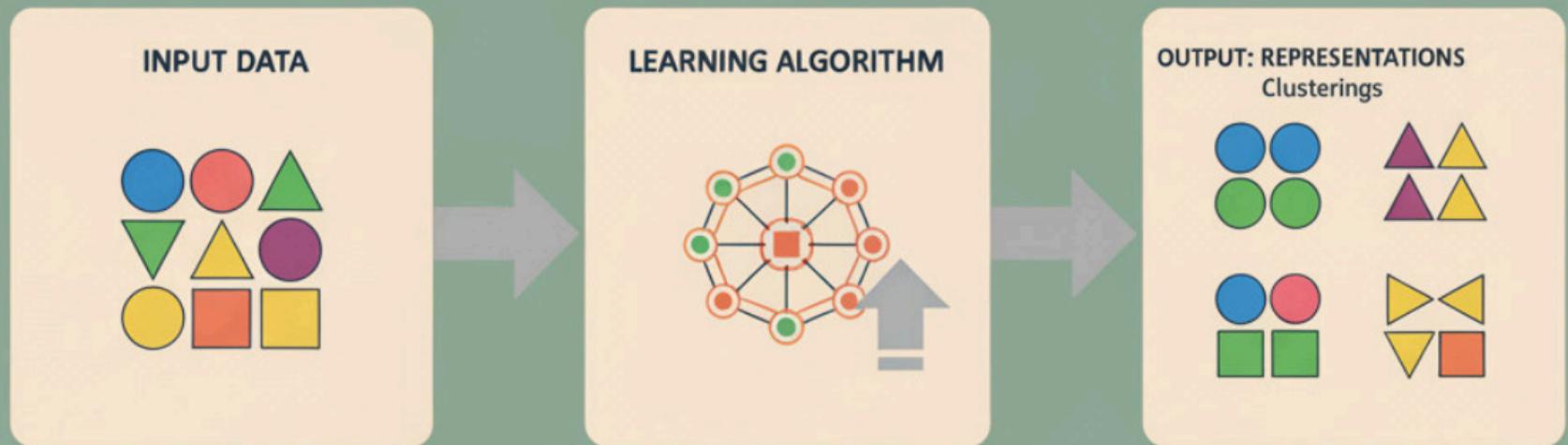
Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

Enough units → universal approximation

Supervised learning

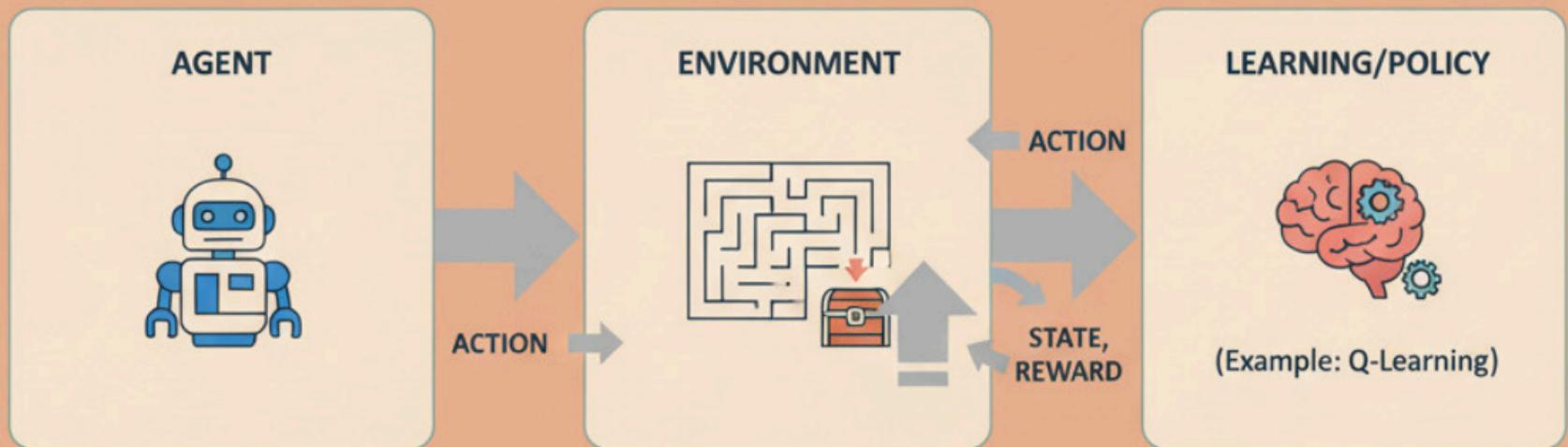


Unsupervised learning



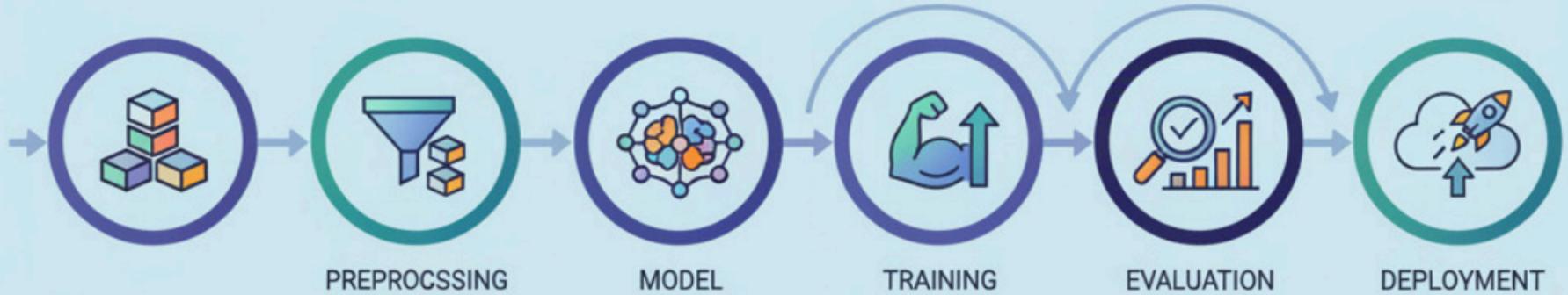
Discovering Patterns in Unlabeled Data

Reinforcement learning



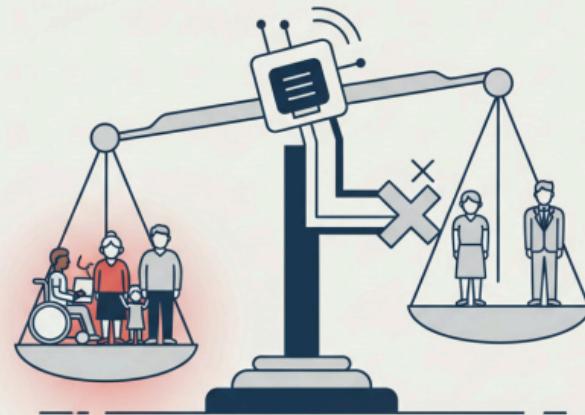
Learning through interaction

The ML workflow



Challenges, limitations, and risks

- Bias, "hallucinations"
- Interpretability
- Explainability/trust
- Energy use of AI
- Data quality
- Uncertainty quantification

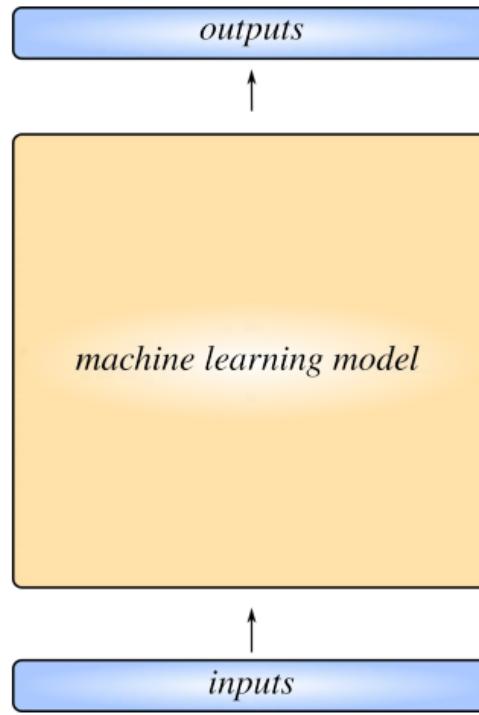


Images, sounds, language, other sensors

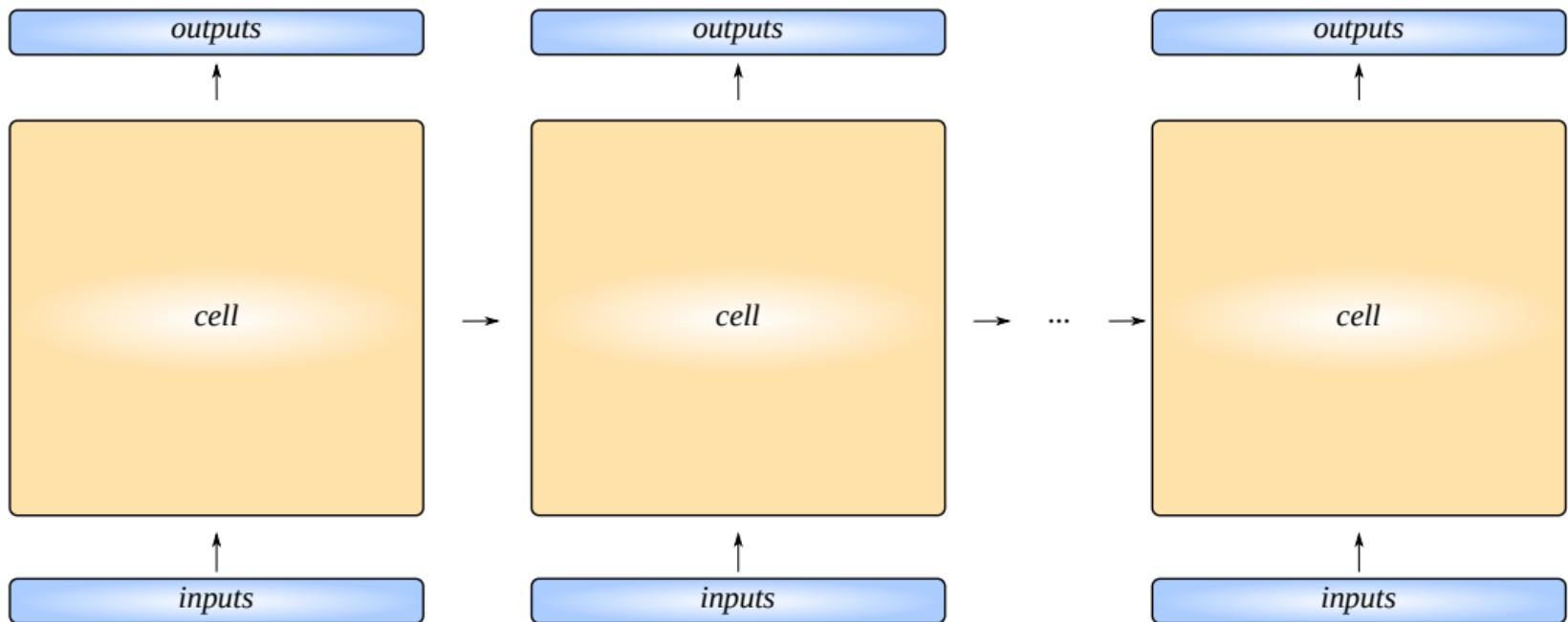
- Remote sensing
 - Satellite imagery
 - Drone footage
- Sound recordings
 - Passive acoustic devices
- Video data
 - Camera traps
- Other sensors
 - Water flow sensors
 - Atmospheric measurements



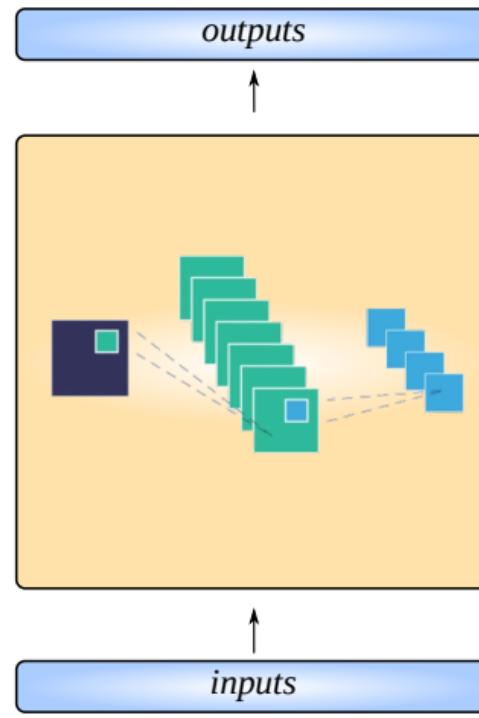
MLP



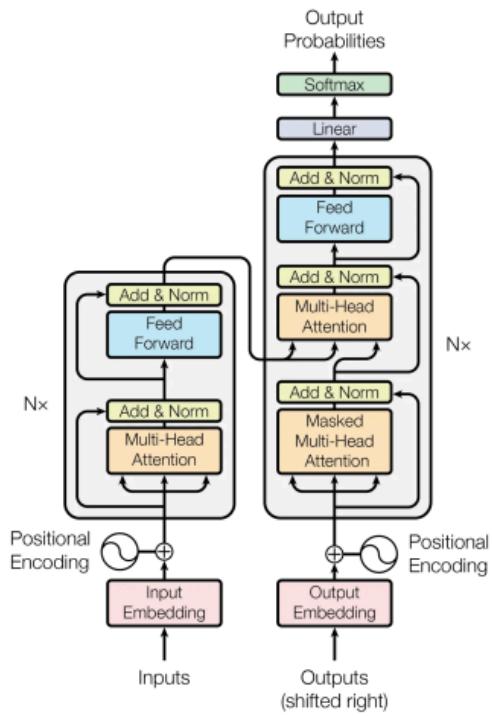
RNN



CNN

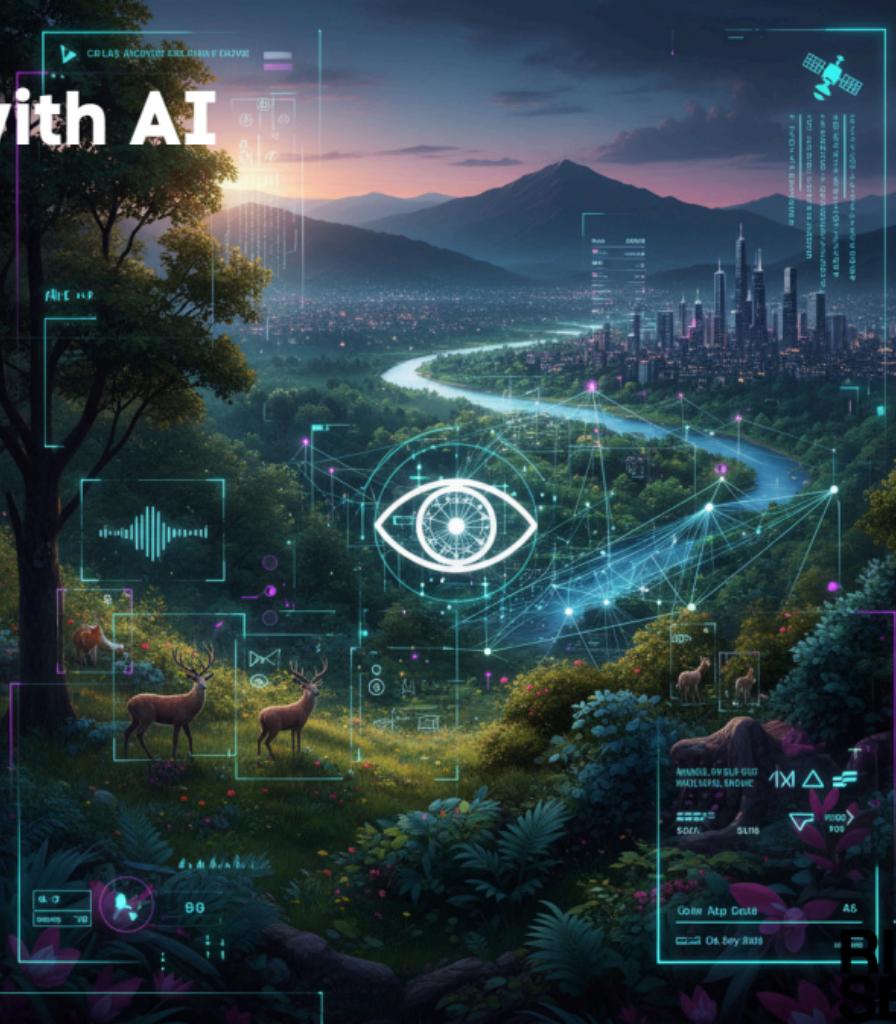


Transformer



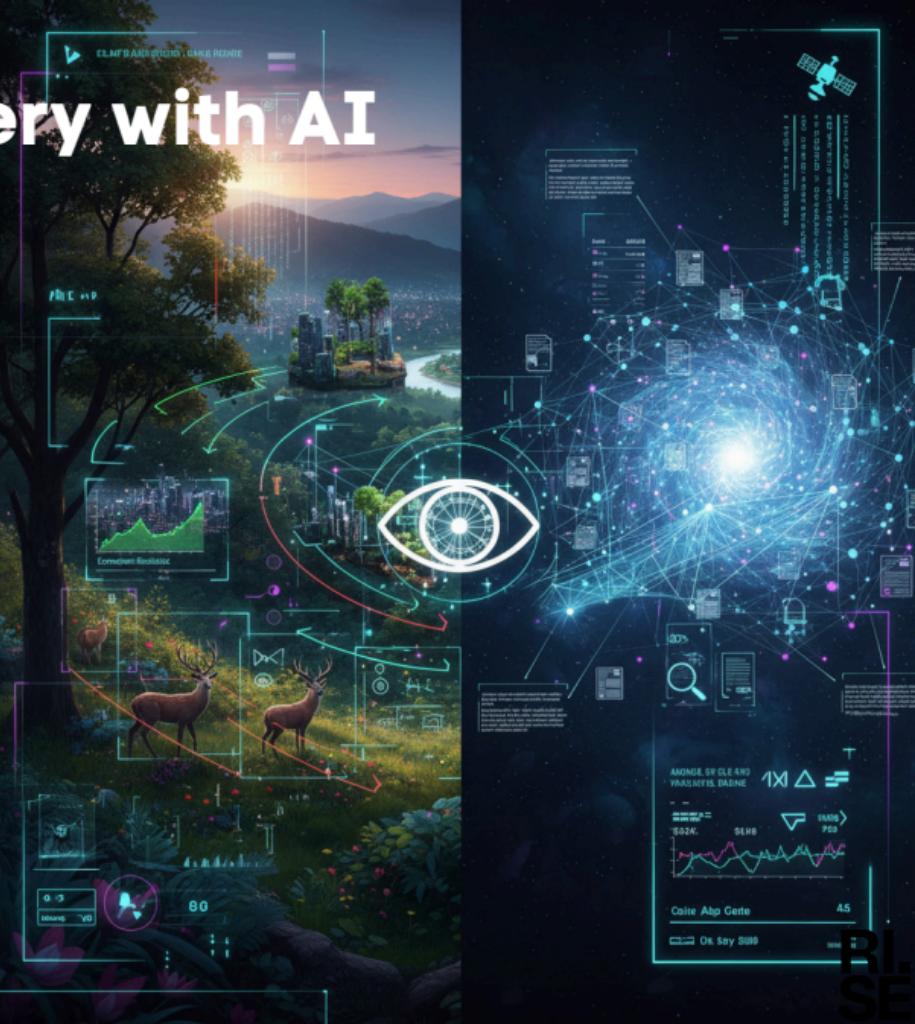
Percieving the world with AI

- Computer Vision
 - Classification, segmentation, object detection, image generation
- Machine Listening
 - Event detection, species identification, etc
- Sensor Modelling



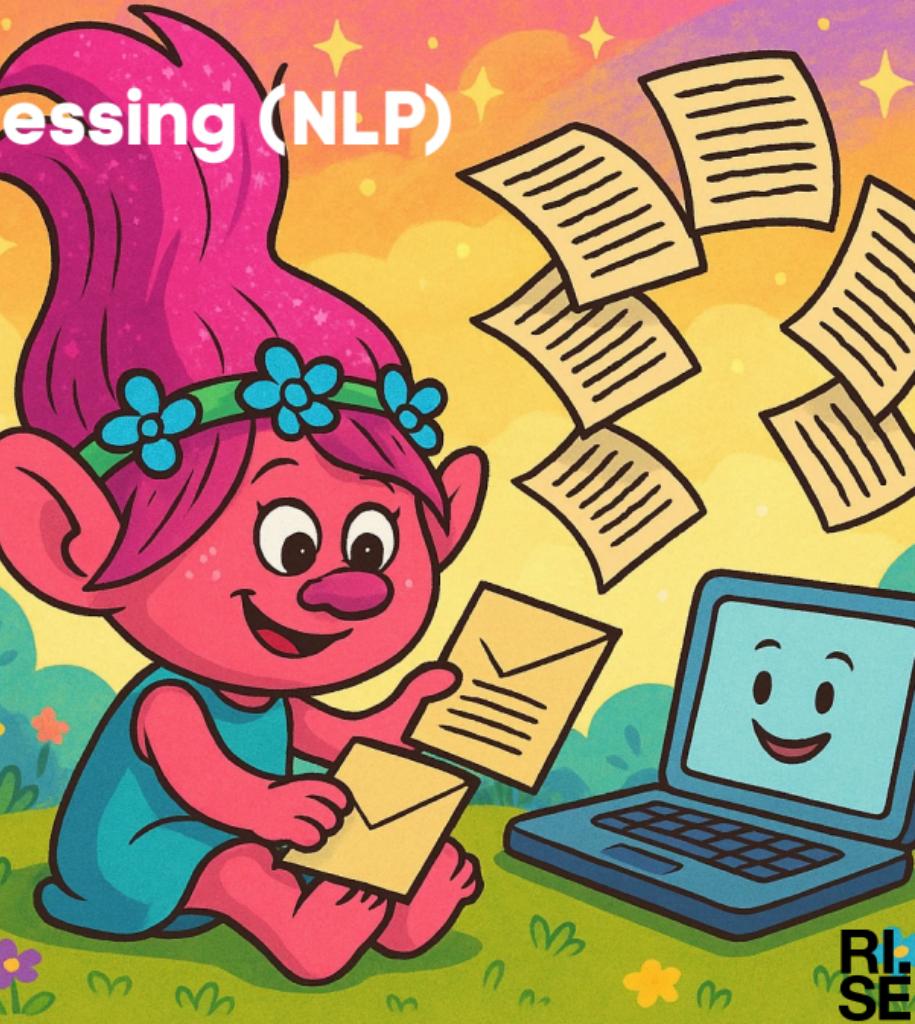
Prediction and discovery with AI

- Short-term prediction, e.g. flood risk
- Long-term, e.g. climate modeling
- Knowledge and natural language processing
 - e.g. data mining, aggregating environmental data,
 - summarization, information extraction



Natural language processing (NLP)

- Translation
- Summarization
- Generating text
- Information extraction
- Conversational AI



Schedule

Today:

- 10: Introduction to AI and Machine Learning
 - Olof Mogren
- 11: **Introduction and Brief History of Natural Language Processing (NLP)**
 - Murathan Kurfali
- 13: AI for Climate Adaptation and Mitigation
 - Olof Mogren
- 14: Exercises

Tomorrow:

- 10: AI for Environmental Monitoring
 - Olof Mogren
- 11: AI for Prediction and Earth System Modelling
 - Olof Mogren
- 13: Using NLP and Large Language Models: General Concepts and Climate Applications
 - Murathan Kurfali
- 14: Exercises

