Introduction to Machine Learning and Artificial Intelligence

Instructor: Xiaoqian Wang

8/21/2024

Summary

- **Term definition**
  - artificial intelligence (AI), machine learning
- **Brief history of machine learning**
- **Machine learning and AI applications**

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What is Artificial Intelligence?

“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 behaviour** – understanding language, learning, reasoning, solving problems, and so on.” (Barr & Feigenbaum, 1981)

What is Artificial Intelligence?

- **Acting humanly: The Turing test approach**
- **Thinking humanly: The cognitive modeling approach**
- **Thinking rationally: The “laws of thought” approach**
  - Example: *Socrates is a man and all men are mortal and concludes that Socrates is mortal*
- **Acting rationally: The rational agent approach**
  - Acts to achieve the best (expected) outcome

Source: Artificial Intelligence: A Modern Approach (4th Edition) by Stuart Russell, Peter Norvig, 2020.

Artificial Intelligence Topics in AAAI 2025

- Application Domains (APP)
- Cognitive Modeling & Cognitive Systems (CMS)
- Computer Vision (CV)
- Constraint Satisfaction and Optimization (CSO)
- Data Mining & Knowledge Management (DMKM)
- Game Theory and Economic Paradigms (GTEP)
- Humans and AI (HAI)
- Intelligent Robotics (ROB)
- Knowledge Representation and Reasoning (KRR)
- Machine Learning (ML)
- Multiagent Systems (MAS)
- Philosophy and Ethics of AI (PEAI)
- Planning, Routing, and Scheduling (PRS)
- Reasoning under Uncertainty (RU)
- Search and Optimization (SO)
- Natural Language Processing (NLP)

Source: https://aaai.org/aaai-conference/aaai-25-keywords/

What is Machine Learning?

“Machine Learning is the study of **computer algorithms** that improve automatically through experience.” (Mitchell & Hill, 1997).

Machine Learning Topics in ICML 2024

- General Machine Learning (active learning, clustering, online learning, ranking, reinforcement learning, supervised, semi- and self-supervised learning, time series analysis, etc.)
- Deep Learning (architectures, generative models, deep reinforcement learning, etc.)
- Learning Theory (bandits, game theory, statistical learning theory, etc.)
- Optimization (convex and non-convex optimization, matrix/tensor methods, stochastic, online, non-smooth, composite, etc.)
- Probabilistic Inference (Bayesian methods, graphical models, Monte Carlo methods, etc.)
- Trustworthy Machine Learning (accountability, causality, fairness, privacy, robustness, etc.)
- Applications (computational biology, crowdsourcing, healthcare, neuroscience, social good, climate science, etc.)

Source: https://icml.cc/Conferences/2024/CallForPapers

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Brief ML History

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- **Solving XOR with a neural network:** Hornik, K., Stinchcombe, M., & White, H. (1989). Multilayer feedforward networks are universal approximators. Neural networks, 2(5), 359-366.

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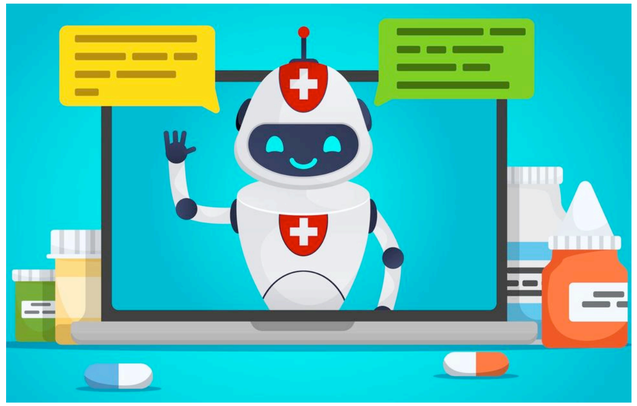
- ACM A.M. Turing Award 2018**:** Bengio, Hinton and LeCun Ushered in Major Breakthroughs in Artificial Intelligence

Machine Learning and AI Today

Autonomous Driving

https://www.tesla.com/autopilot



AI Chatbot

https://www.cancer.gov/news-events/cancer-currents-blog/2023/chatbots-answer-cancer-questions

Go

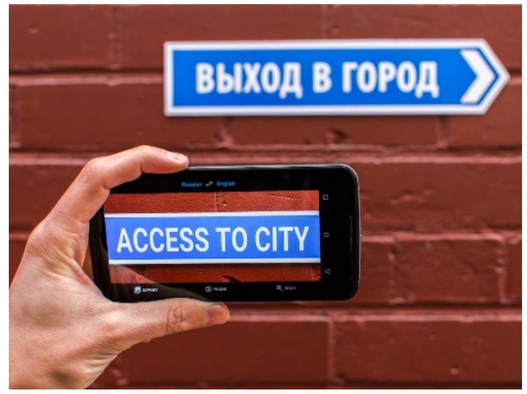
https://www.wsj.com/articles/googles-stream-runs-dry-in-china-while-its-alphago-battles-the-human-champion-of-go-1495541989

Protein Folding

https://www.artificialintelligence-news.com/2018/12/03/deepmind-ai-protein-folding-breakthroughs/

Disease Detection

Kermany, Daniel S., et al. "Identifying medical diagnoses and treatable diseases by image-based deep learning." Cell 172.5 (2018): 1122-1131.



Machine Translation

https://finance.yahoo.com/news/google-ceo-sundar-pichai-revealed-004138550.html

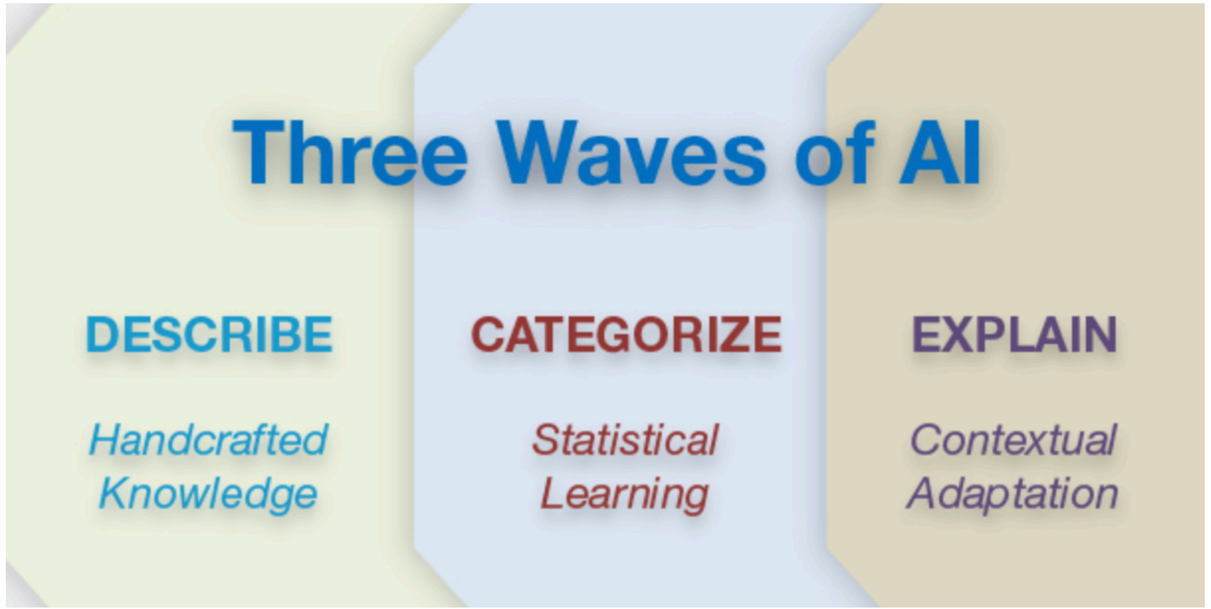
Defense Advanced Research Projects Agency (DARPA) Perspective of Artificial Intelligence

- Artificial intelligence is a programmed ability to process information
  - **perceive** rich, complex and subtle information
  - **learn** within an environment
  - **abstract** to create new meanings
  - **reason** to plan and to decide

Contents from https://www.darpa.mil/attachments/AIFull.pdf

DARPA Perspective of Artificial Intelligence

- Artificial intelligence is a programmed ability to process information
  - **perceive** rich, complex and subtle information
  - **learn** within an environment
  - **abstract** to create new meanings
  - **reason** to plan and to decide
- Three Waves in Artificial intelligence
  - Handcrafted Knowledge
  - Statistical Learning
  - Contextual Adaptation



Contents from https://www.darpa.mil/attachments/AIFull.pdf
figure from https://www.darpa.mil/about-us/darpa-perspective-on-ai

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Machine learning and AI application example

- **CNN** in a daily life application: image classification

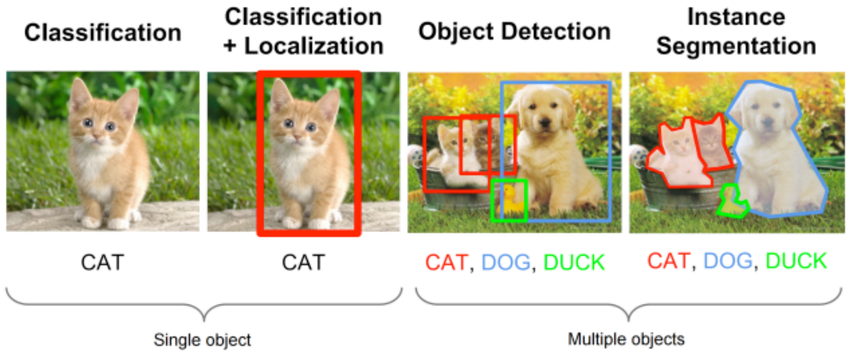


Image source: https://www.kdnuggets.com/2018/09/object-detection-image-classification-yolo.html

- **Clustering** in a daily life application: recommender system

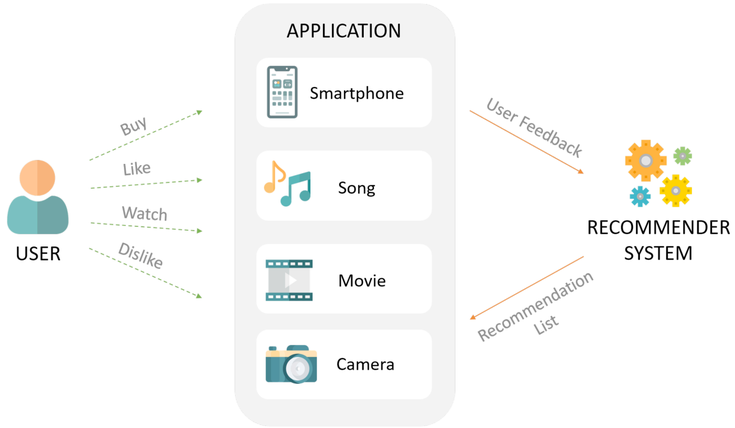
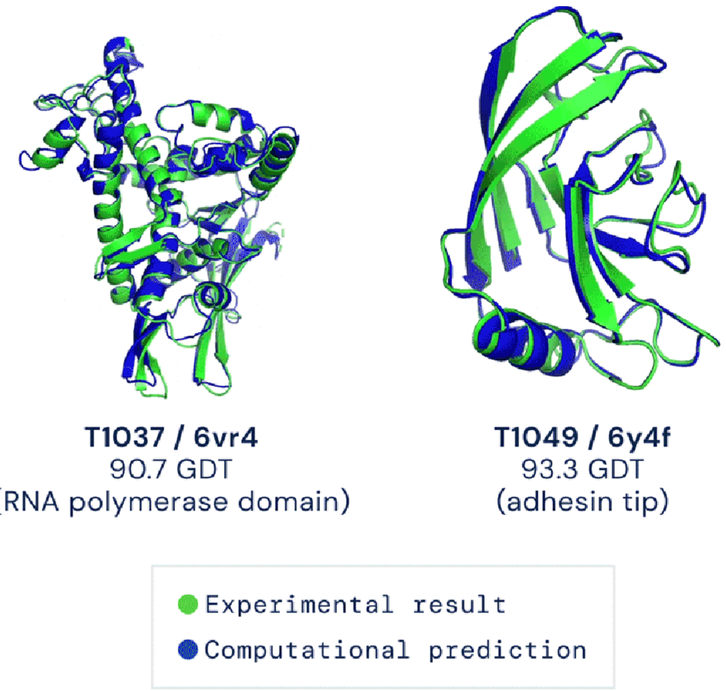


Image from Ferreira, Diana, et al. "Recommendation system using autoencoders." *Applied Sciences* 10.16 (2020): 5510.

Machine learning and AI application example

- **Transformer** in Alpha Fold: a solution to a 50-year-old grand challenge in biology

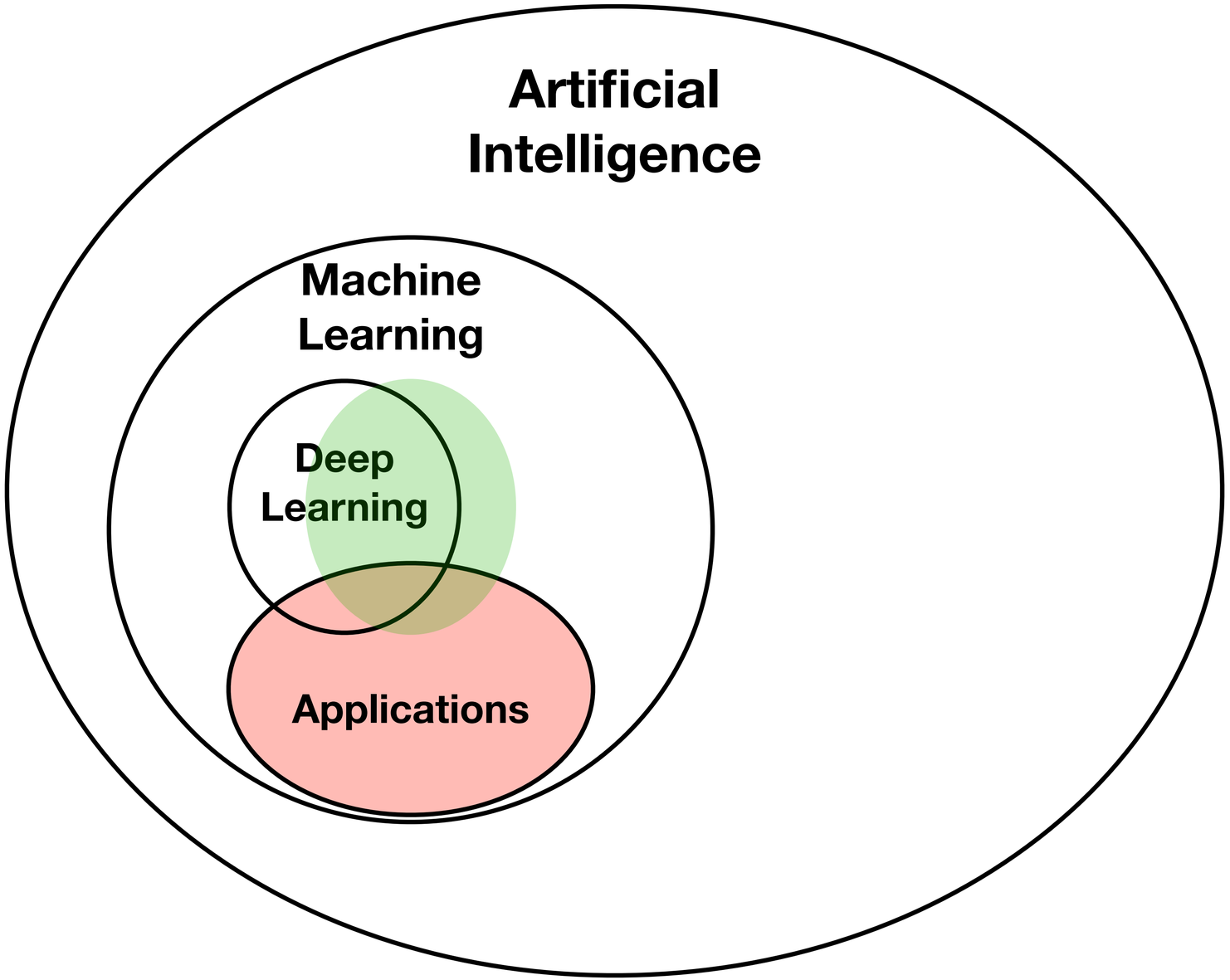
- Alpha Fold introduction video: https://www.youtube.com/watch?v=gg7WjuFs8F4



- **Transformer** in a daily life application: language translation

Image source: https://www.xsellco.com/resources/ecommerce-translation-tools/

Scope of This Course



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Rajkomar, A., Dean, J., & Kohane, I. (2019). Machine learning in medicine. New England Journal of Medicine, 380(14), 1347-1358.

Esteva, A., Robicquet, A., Ramsundar, B., Kuleshov, V., DePristo, M., Chou, K., ... & Dean, J. (2019). A guide to deep learning in healthcare. Nature medicine, 25(1), 24-29.

Kurenkov, A. (2020). A brief history of neural nets and deep learning. https://www.skynettoday.com/authors#andrey_kurenkov