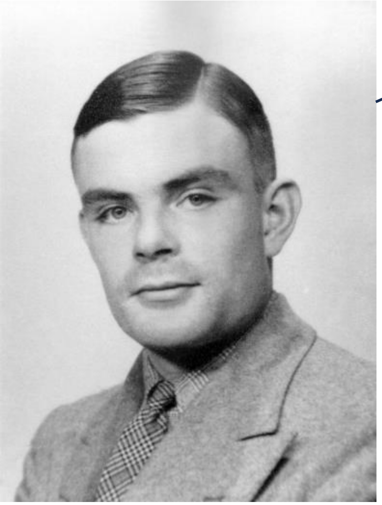
CS 4710 Artificial Intelligence

Chen-Yu Wei

What is (Artificial) Intelligence?

Alan Turing's Perspective



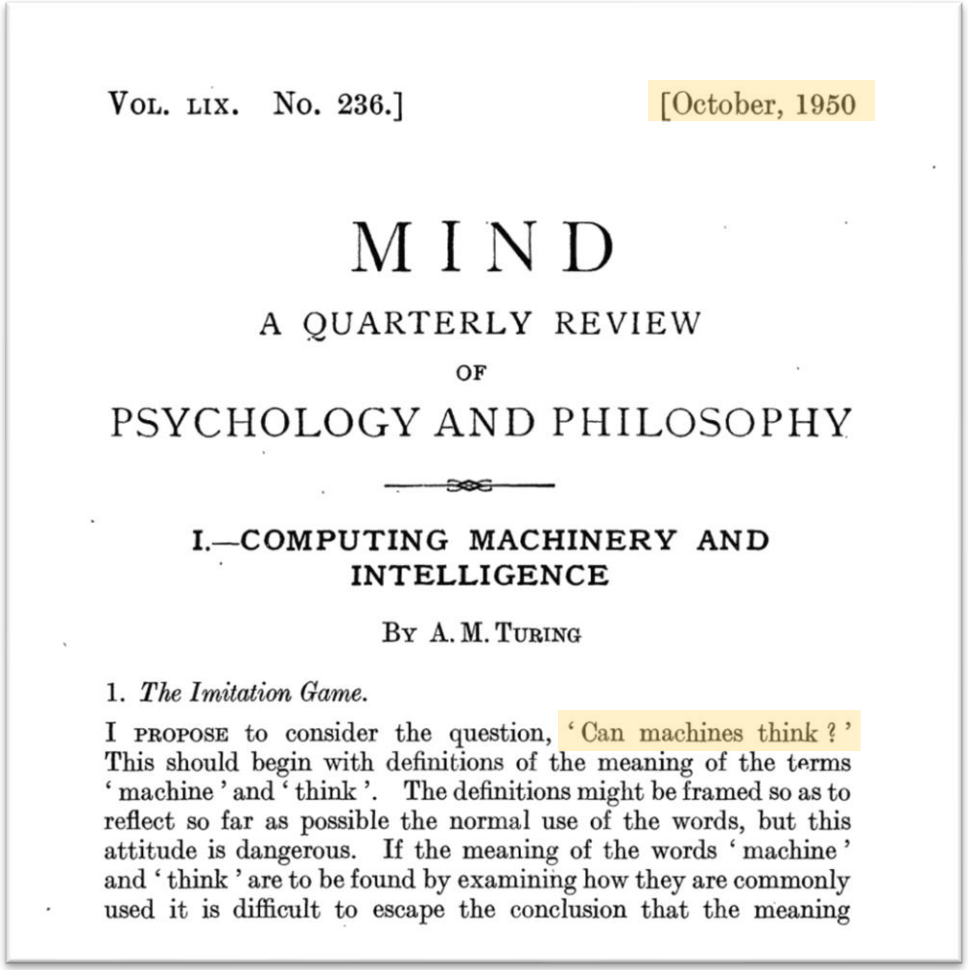
Alan Turing
(1912-1954)

Let's change the question from

"Can machines think?"

to

"Can machines win the **imitation game**?"



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MIND
A QUARTERLY REVIEW
OF
PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

BY A. M. TURING

1. *The Imitation Game.*

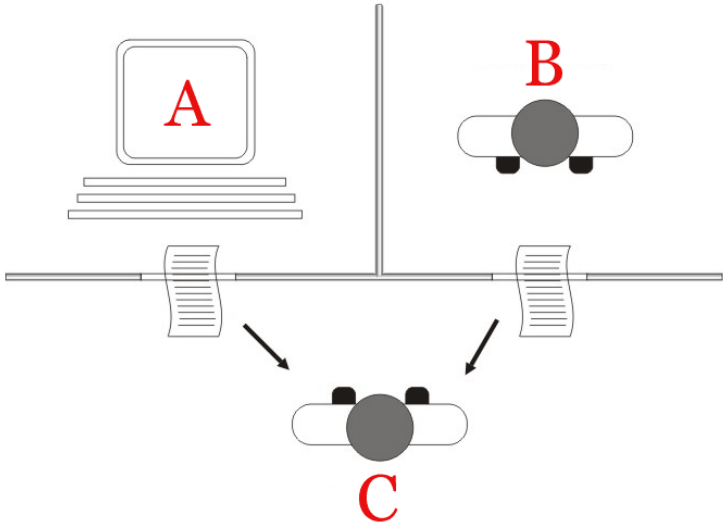
I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning

Turing Test (Imitation Game)

- C (human evaluator) interacts with A (machine) and B (human) through natural languages.

- C tries to tell which one is the machine.

- If C cannot reliably tell, then the machine wins.



Different Goals of AI

Behave like human

Neural Art

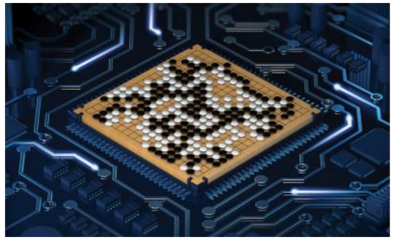
Speech synthesis

ChatGPT

Chatbot

Behave rationally

AutoTrader



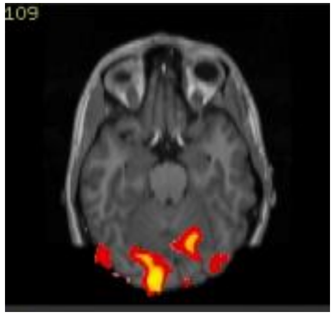
AlphaGo

Healthcare

Different Goals of AI

Disciplines studying “**how human thinks**”:

- Psychology
- Neuroscience



So far, AI in computer science focuses more on machine’s **behaviors** than **human-like thinking**.

- Similar behaviors could be achieved by different mechanisms.
- Currently, we know little about our brains.

A History of AI

(also an overview of the topics to be covered in the course)

References:

https://www.youtube.com/watch?v=z8fEXuH0mu0 Percy Liang

https://www.youtube.com/watch?v=_cQITY0SPiw Henry Kautz

https://www.youtube.com/watch?v=R3YFxF0n8n8

AI Summers and Winters

- First Summer (1950-1966)
- First Winter (1967-1977)
- Second Summer (1978-1987)
- Second Winter (1988-2011)
- Third Summer (2012-Present)

First AI Summer (1950-1966)

- Turing Machine (1936)
- Modern computer development during WWII
- Turing Test (1950)
- The Dartmouth workshop (1956) – a two-month workshop at Dartmouth College
  - Initiated by John McCarthy
  - Coined down the term “Artificial Intelligence”

The Dartmouth Workshop (1956)

Proposal (the beginning):

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

https://raysolomonoff.com/dartmouth/boxa/dart564props.pdf

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People at Summer research project.

Solomonoff
Marvin Misky MIT Lincoln
John McCarthy IBM, Dartmouth
Claude Shannon MIT, Bell
Trench More IBM, MIT
Nat Rochester IBM Poughkeepsie
Oliver Selfridge MIT Lincoln
Julian Bigelow IAS
W. Ross Ashby Barnwood house (?)
W.S. McCulloch, MIT, RLE
Abraham Robinson Monteal logic
Tom Etter
John Nash MIT
David Sayre IBM New York
Samuals IBM on checkers
Shoulders MIT (RLE or Lincoln) components man
. . . . . . -(with Shoulders)
Alex Bernstein IBM (New York) on chess
Herbert Simon : U of Pa (?)
Allen Newell : Rand

First AI Summer (1950-1966)

- Logic Theorist (Newell, Simon, Shaw, 1956)
  - Proves math theorems
  - Proves 38 out of 52 theorems in *Principia Mathematica*
- The First Computer Chess (Bernstein, 1957)
  - Can defeat an inexperienced player
- Symbolic Automatic INTegrator (Slagle, 1961)
  - Calculates (symbolic) integration
  - Solves 52 out of 54 problems in MIT's freshman final

based on **search** algorithms

$$\int \frac{x^4}{(1-x^2)^{5/2}}\,dx = \frac{1}{3}\tan^3(\arcsin x) - \tan(\arcsin x) + \arcsin x$$

Alex Bernstein’s Chess Machine

- https://www.youtube.com/watch?v=iT_Un3xo1qE

ELIZA – The First Chatbot

- https://www.youtube.com/watch?v=RMK9AphfLco

First AI Winter (1967-1977)

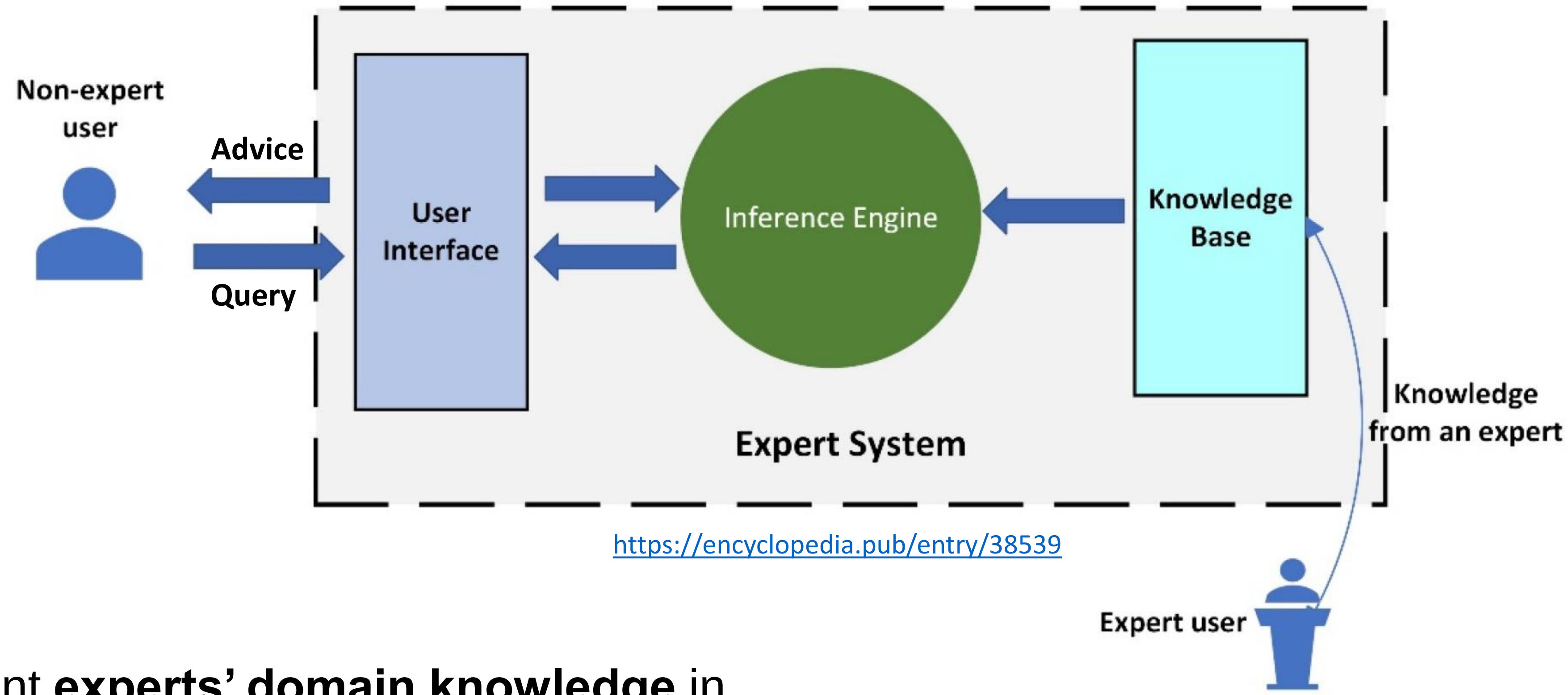
https://en.wikipedia.org/wiki/AI_winter

- ALPAC report (1966)
  - AI failed in machine translation between English and Russian.
- Lighthill report (1973)
  - AI research failed to address combinatorial explosion in real-world problems.
- Funding agencies (Defense Advanced Research Projects Agency, National Research Council) cutoff fundings for AI research.

Lessons from the First Wave of AI

- Tasks that seem easy for human may be difficult for machines.
- On the other hand, tasks that seem difficult for human might actually accomplished with simple rules.

Second AI Summer (1978-1987): Expert Systems

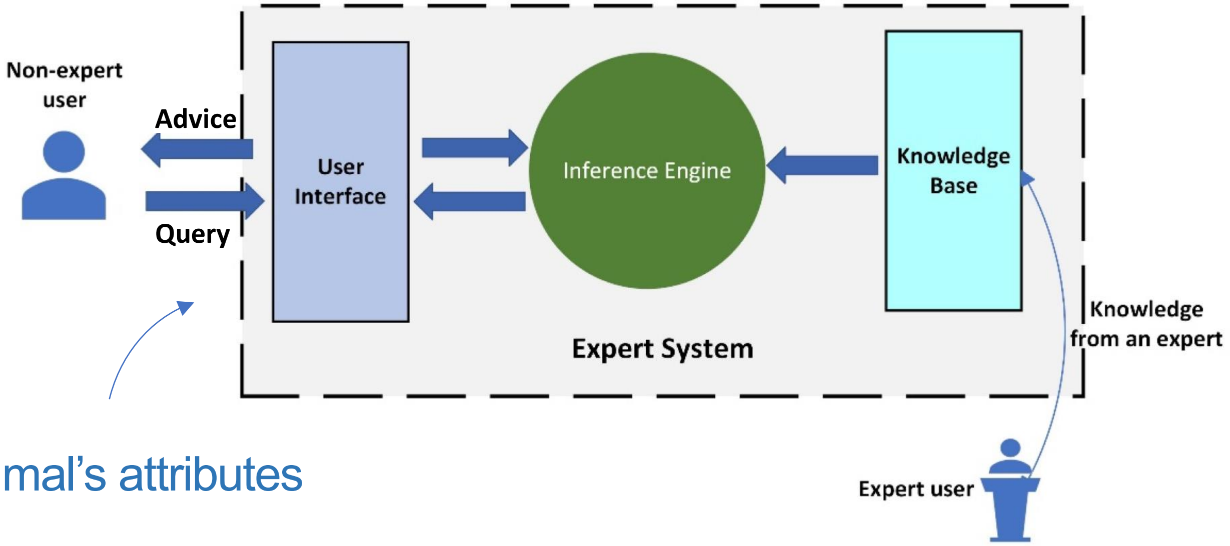


https://encyclopedia.pub/entry/38539

Represent **experts' domain knowledge** in the from of rules:

```
If [premises] then [conclusion]
```

A Toy Expert System: Animal Identification



Animal's attributes

Knowledge Base

If **has_hair**, then **mammal**.
If **mammal** and **has_hooves**, then **ungulate**.
If **has_feathers**, then **bird**.
If **mammal** and **carnivore** and **has_dark_spots**, then **cheetah**.
If **mammal** and **carnivore** and **has_black_stripes**, then **tiger**.
If **bird** and **does_not_fly** and **has_long_neck**, then **ostrich**.
......

User Interface

File Edit Settings Run Debug Help

```
Welcome to SWI-Prolog (threaded, 64 bits, version 9.2.6)
SWI-Prolog comes with ABSOLUTELY NO WARRANTY. This is free software.
Please run ?- license. for legal details.

For online help and background, visit https://www.swi-prolog.org
For built-in help, use ?- help(Topic). or ?- apropos(Word).

?- go.
Does the animal have hair? yes.

Does the animal eat meat? |: no.

Does the animal have pointed teeth? |: no.

Does the animal have hooves? |: yes.

Does the animal have a long neck? |: yes.

Does the animal have long legs? |: yes.

I guess that the animal is: giraffe
true.

?-
```

Related topics:
Logic and **Knowledge Representation**

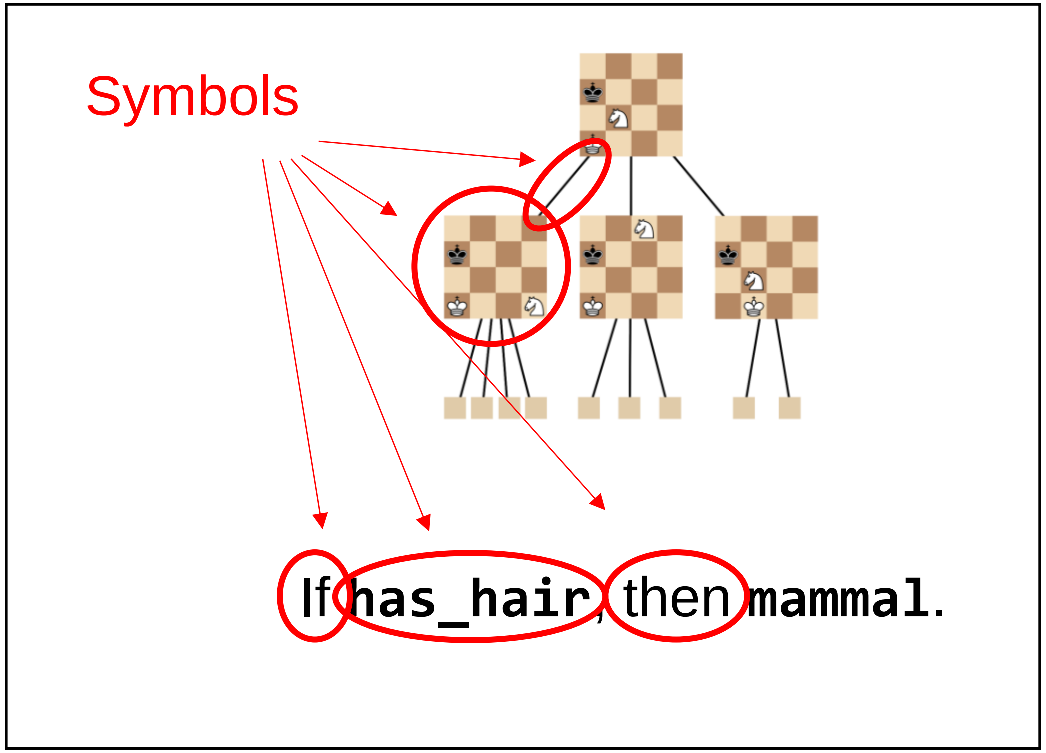
Second AI Summer (1978-1987): Expert Systems

- DENDRAL (1968)
  - Predict molecular structure based on spectrographic data
- MYCIN (1975)
  - Diagnose blood infections
  - Better than junior doctor
- XCON (1978)
  - Select computer system components based on customer’s need
  - Save ~$25M a year
- Many companies built expert systems and software/hardware specialized for their purpose.

Second AI Winter (1988-)

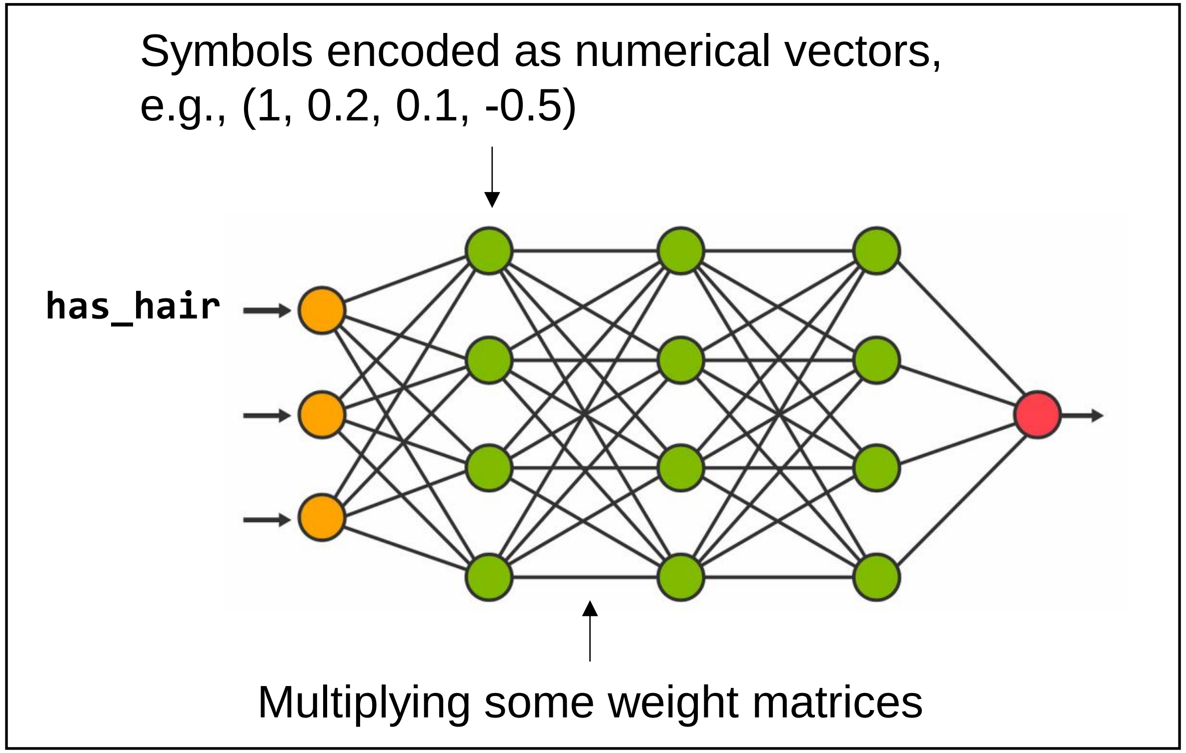
- Difficult to build and maintain expert systems for complex domains
  - Uncertainty
  - Could not learn from data
- Companies fell as they failed to meet their extravagant promises

Symbolic vs. Subsymbolic AI



Symbols usually directly correspond to real-world concepts or relationships.

Symbolic AI



Using numerical / distributed representations for concepts and relationships.

Subsymbolic AI

Subsymbolic AI

- The “rules” (e.g., the weights in neural networks) are usually **learned from data** rather than assigned by human.
  - Less interpretable
  - But can represent more complex rules, e.g., natural languages rules

- Better in dealing with **uncertainty**
  - It hard / complex for human to write rules with uncertainty

- Learning from data → **Statistical Learning**

Statistical Learning

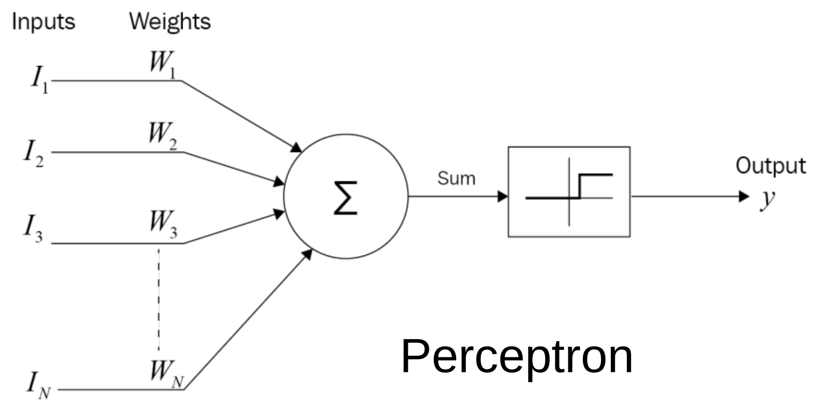
- Learning from **data**
- Methods
  - Linear regression (Galton, 1894)
  - Hidden Markov Model (Baum, 1960s)
  - Bayesian Network (Pearl, 1985)
  - Support Vector Machine (Cortes & Vapnik, 1995)

Modeling uncertainty

- SVM is a dominant approach in 2000-2010 for many tasks:
  - Image classification
  - Speech recognition (combined with HMM)
  - Text categorization
  - …

Artificial Neural Networks (NN)

- Perceptron (McCullough & Pitts, 1943)
  - Inspired by biological neuron
  - Can simulate logic gates



Perceptron

- Perceptron algorithm (Rosenblatt, 1958)
  - Learning single-layer NN
- Backpropagation (Linnainmaa, 1970; Rumelhart et al., 1986)
  - Learning multi-layer NN
- Convolutional Neural Network (Fukushima, 1980; LeCun et al., 1989)
  - Handwritten digit recognition for USPS

Third AI Summer (2012-Present): Deep Learning

- ImageNet (Fei-Fei Li et al., 2009)
  - Large-scale image dataset: 14 million images, ~20000 classes
  - Annual image recognition contest (ILSVRC) since 2010
- AlexNet (Krizhevsky, Sutskever, and Hinton, 2012)
  - Won ILSVRC by >10% margin
  - Revolutionize computer vision and spark the use of deep learning in many domains
- AlphaGo (Deepmind, 2016)
  - Won Lee Sedol (world champion of Go) 4 out of 5 games
- Transformer (Google, 2017)
  - Revolutionize natural language processing and other domains
  - Generative Pre-trained Transformer (GPT)

Topics Covered in the Course

Topics

- Search
- Logic and Knowledge Representation
- Statistical Learning
  - Probabilistic models (Bayesian Network, HMM)
  - Linear/kernel models (SVM)
  - Deep learning
- Reinforcement Learning
- Generative AI
- Safety in AI, Ethics in AI

Related UG Courses in UVA

- CS 4774 Machine Learning
- CS 4501 Special Topics – Reinforcement Learning
- CS 4501 Special Topics – Natural Language Processing
- CS 4501 Special Topics – Machine Learning in Image Analysis
- CS 4501 Special Topics – Autonomous Vehicles: Perception, Planning & Control
- David Evans's "Risks and Benefits of Generative AI and LLMs" in Fall 2023.

Prerequisite

- Data Structure and Algorithms 2
- Calculus, Probability
- Python

Grading

- Homework: 40%
- Midterm Exam: 25%
- Final Exam: 35%

Homework (40%)

- 6 assignments
  - Multiple choices questions
  - Programming tasks
- Late policy
  - 5 free late days distributed as desired
  - Every additional late day costs 10% in the **semester's** homework grade
- Collaboration policy
  - May discuss the ideas, but should work on the problems/coding individually
  - Acknowledge the collaborators in the homework

Exam

- Midterm and final exams
- Open notes
  - No books or electronic devices

Communications

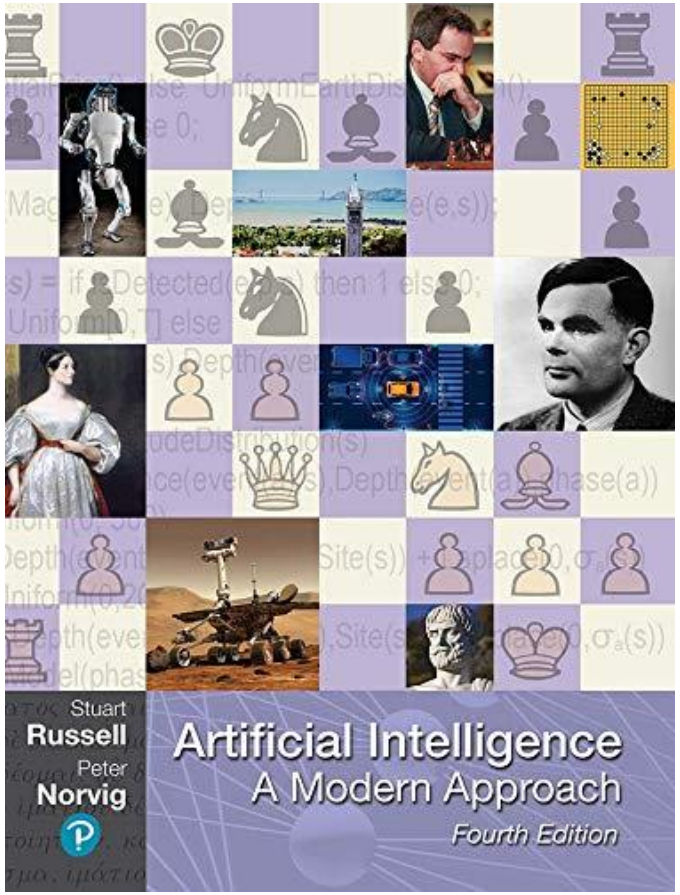
- Course website: slides, recommended reading
- Piazza: discussions
- Gradescope: homework submissions
- Office Hours
  - Matthew Landers: 4-5pm Olsson Hall 225
  - Haolin Liu: 2-3pm Rice Hall 232
  - Chen-Yu Wei: 3:30-4:30pm Rice Hall 409
  - Xuhui Kang: 5-6pm Rice Hall 232

Online Resource

- Introduction to Artificial Intelligence at UC Berkeley
- Artificial Intelligence: Principles and Techniques at Stanford University
- Artificial Intelligence at MIT

Books (Optional)

- Artificial Intelligence: A Modern Approach, 4th Edition
  - by Stuart Russell and Peter Norvig



Next Lecture

- Search