COSC 4368
Fundamentals of Artificial Intelligence

Lecture 1: Introduction
August 21st, 2023

Welcome to COSC4368

Teaching Team

Instructor:
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Today’s Agenda

- A brief introduction to AI

- Course overview

What is AI?

- There are many definitions of AI…

Systems that think like humans	Systems that think rationally
Activities that we associate with human thinking, activities such as decision-making, problem solving, learning … (Bellman, 1978)	*The study of the computations that make it possible to perceive, reason, and act (Winston, 1992)*
Systems that act like humans	**Systems that act rationally**
The study of how to make computers do things at which, at the moment, people are better (Rich and Knight, 1991)	*A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes (Schalkoff, 1990)*

A Modern Definition

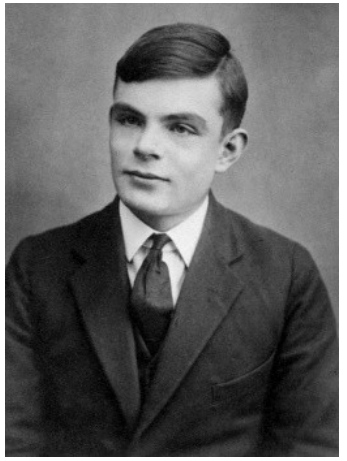
- AI is a branch of Computer Science, Engineering, and Mathematics that aims to create machines and software capable of performing tasks that usually require human intelligence

- AI centers on the simulation of human intelligence using computers

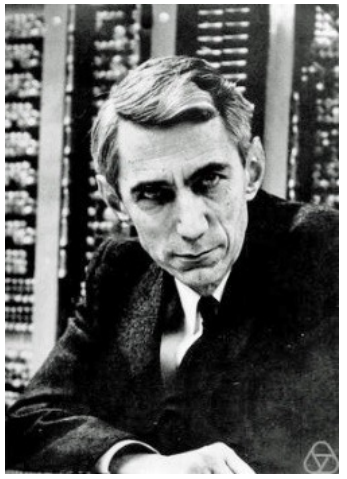
- Not a monolith, but hundreds of different things.

A Brief History of AI

- **Alan Turing:** One of the Founders of Modern CS and AI
  - Universal (Turing) Machine (1937)
    - A mathematical model of computation describing an abstract machine that manipulates symbols based on a table of rules
    - A model of a general-purpose computer
  - Turing Test or Imitation Game (1950)
    - If an artificial intelligent system is not distinguishable from a human being, it is definitely intelligent

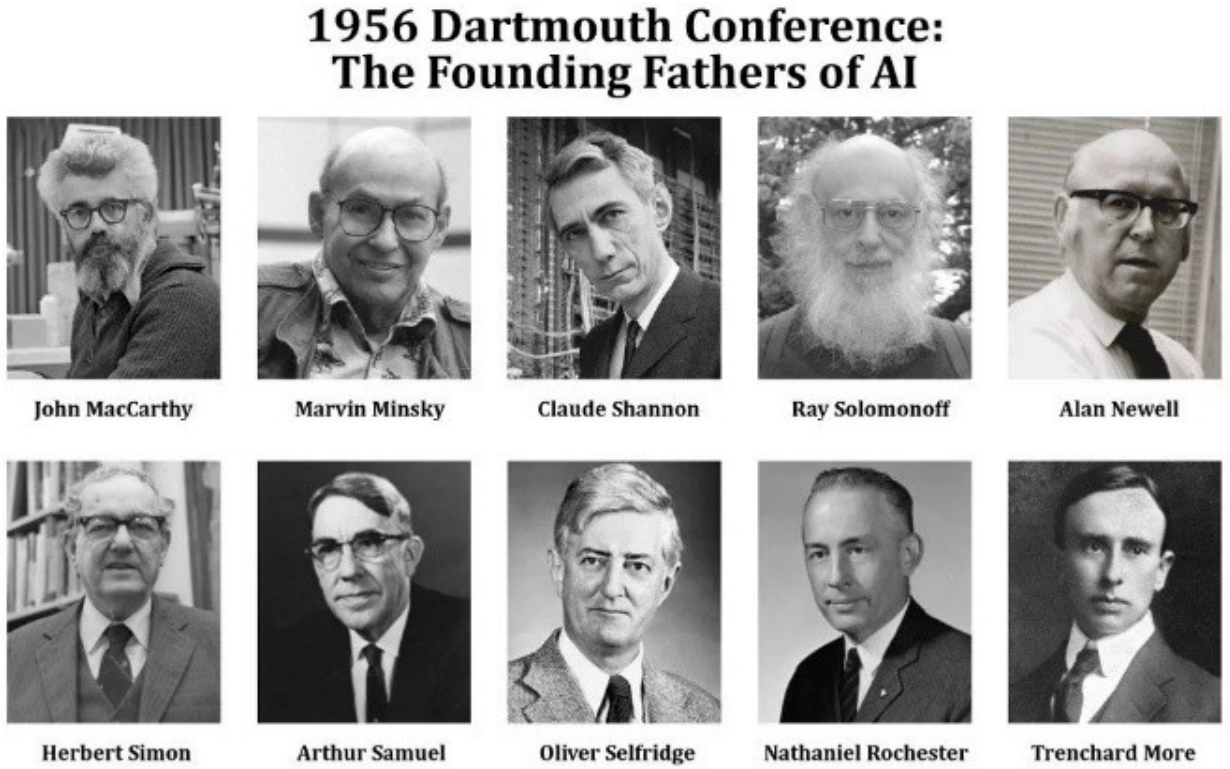


- **Claude Shannon:** Father of Information Theory (1940s)
  - Notion of Boolean algebra and digital circuits
  - Father of the Digital Age
    - No computers/communication systems would be possible without him



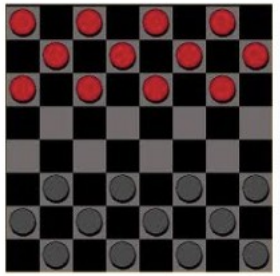
A Brief History of AI

- **Dartmouth Conference (1956):** often called the "Birthplace of AI"
  - John McCarthy organized the workshop and picked the name "Artificial Intelligence"
  - The workshop did not lead to any big breakthroughs, but it did introduce all the major figures to each other

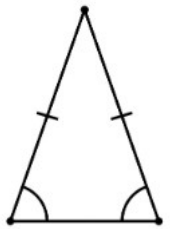


A Brief History of AI

- **Early Successes:**
  - **Checkers (1952):** Samuel's program learned weights and played at a strong amateur level

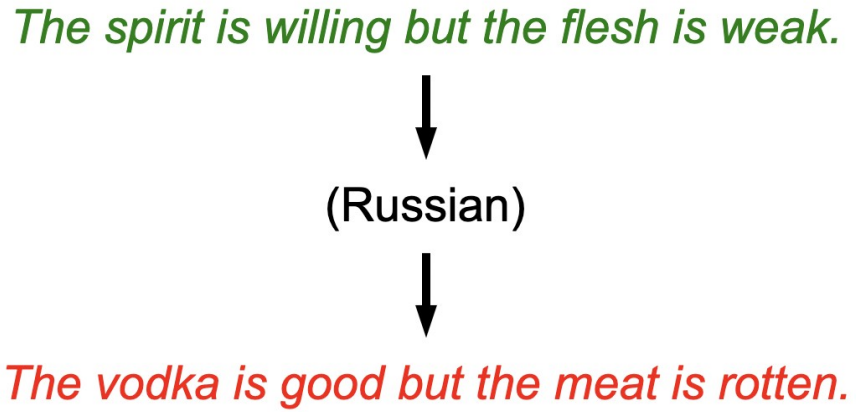


  - **Problem Solving (1955):** Newell & Simon's Logic Theorist: prove theorems in Principia Mathematica using search + heuristics; later, General Problem Solver (GPS), which promised to solve any proble ly encoded in logic)



A Brief History of AI

- **1960s-2000s:** Several AI Summers and Winters
- **First AI Winter:**
  - **Overwhelming optimism**
    - *Machines will be capable, within twenty years, of doing any work a man can do*. -- Herbert Simon
    - *Within 10 years the problems of artificial intelligence will be substantially solved*. -- Marvin Minsky
    - *I visualize a time when we will be to robots what dogs are to humans, and I'm rooting for the machines*. – Claude Shannon
  - **Underwhelming results**
    - Example: machine translation



- **1966:** Government funding was cut off for MT, first AI winter

A Brief History of AI

- **First AI Winter:**
  - **Problems**
    - **Limited computation:** search space grew exponentially, outpacing hardware
    - **Limited information:** complexity of AI problems (number of words, objects, concepts in the world)

A Brief History of AI

- **1970s-1980s:** Knowledge-based systems to combat the problems
  - **Expert systems:** a domain expert encodes the domain expertise in the systems in form of if-then rules

if [premises] then [conclusion]

A Brief History of AI

- **1970s-1980s:** Knowledge-based systems to combat the problems
  - **Wins:** build narrow practical systems in targeted domains, e.g., chemistry, medical diagnosis, business operations
    - Knowledge helped both the computation and information gap
    - First real application that impacted industry
  - **Problems**:
    - Deterministic rules couldn't handle the uncertainty of the real world
    - Rules quickly became too complex to create and maintain
  - **Second Winter:** The field collapsed again during the 80s (overpromising and underdelivering again)

A Brief History of AI

- **1960s-2000s:** Several AI Summers and Winters
  - Great promise followed by disappointment
    - AI never appeared to meet the sky-high expectations
  - Steady progress nonetheless
    - Foundational Advances in ML, expert systems, etc.
    - Deep Blue (IBM) beats the World Champion Garry Kasparov in Chess

- **2010 onwards:** AI starts to go mainstream
  - Computers become much faster and cheaper
  - Data rich environment Ⓟ explosion of ML
    - Recommender systems, apps, search engines, all use AI

- **2016-present:** Major Milestones for Deep Learning (DL) and Reinforcement Learning (RL) --- real break for deep neural networks

What success stories have you ever heard about AI?

https://techcrunch.com/2017/05/24/alphago-beats-planets-best-human-go-player-ke-jie/

https://www.deepmind.com/research/highlighted-research/alphafold

June 24, 2014

DeepFace: Closing the Gap to Human-Level Performance in Face Verification

Conference on Computer Vision and Pattern Recognition (CVPR)

By: **Yaniv Taigman**, Ming Yang, **Marc'Aurelio Ranzato**, **Lior Wolf**

Abstract

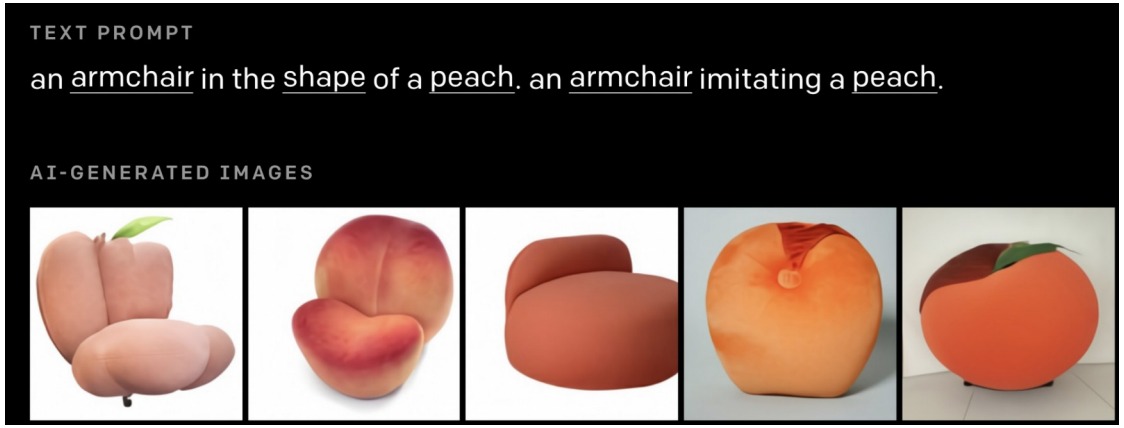
In modern face recognition, the conventional pipeline consists of four stages: detect => align => represent => classify. We revisit both the alignment step and the representation step by employing explicit 3D face modeling in order to apply a piecewise affine transformation, and derive a face representation from a nine-layer deep neural network. This deep network involves more than 120 million parameters using several locally connected layers without weight sharing, rather than the standard convolutional layers. Thus we trained it on the largest facial dataset to-date, an identity labeled dataset of four million facial images belonging to more than 4,000 identities.

Download Paper

Related

Publication

https://www.bosch.com/stories/experience-automated-driving/



https://openai.com/research/dall-e

https://intellectdata.com/the-role-of-ai-in-augmented-and-virtual-reality/

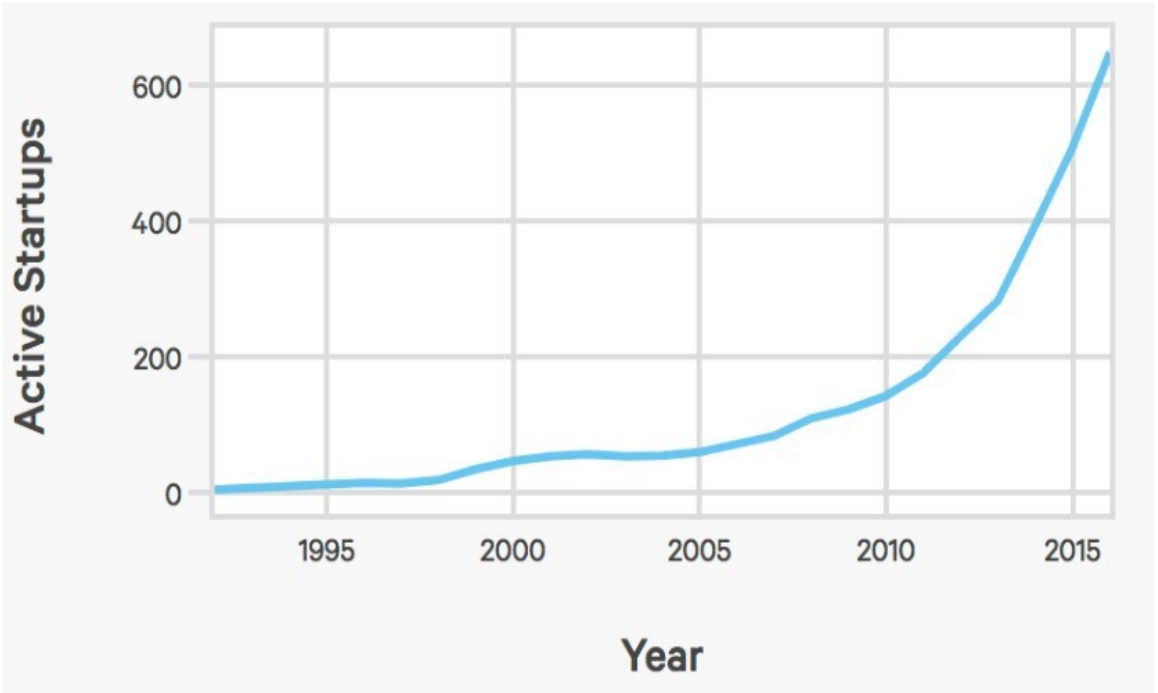
"Alexa"

"Ok Google"

"Hey Siri"

https://iphoneislam.com/en/2019/08/siri-shows-great-improvement-in-ai-test/74458

Industry



Uber, Salesforce, Baidu, Tencent, etc…

Governments

18 NSF AI Institute in the past two years ($20 million for each)

Understanding China's AI Strategy | Center for a New American Security (en-US) (cnas.org)

Released domestic strategic plan to become world leader in AI by 2030

https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html

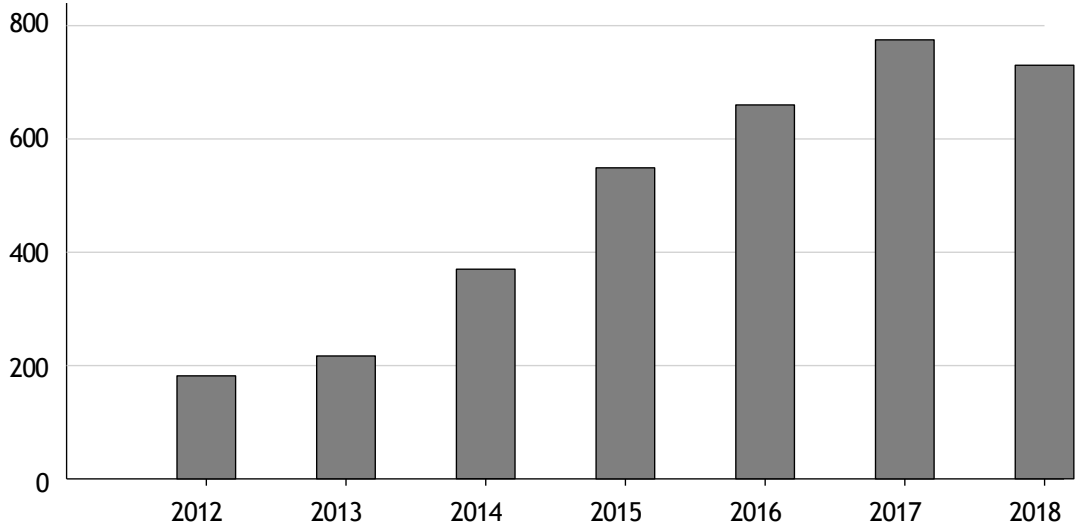
"Whoever becomes the leader in this sphere [AI] will become the ruler of the world" [Putin, 2017] https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world Russa's

https://yourstory.com/2018/02/budget-2018-artificial-intelligence-fuel-indian-economy/

etc……

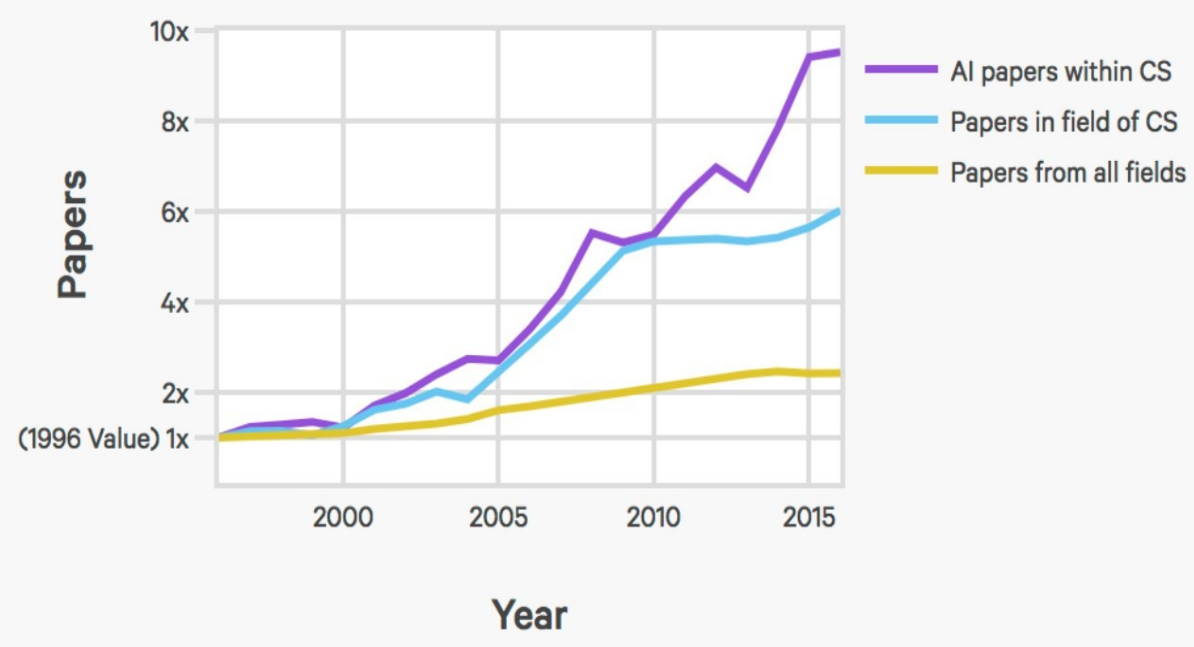
Universities

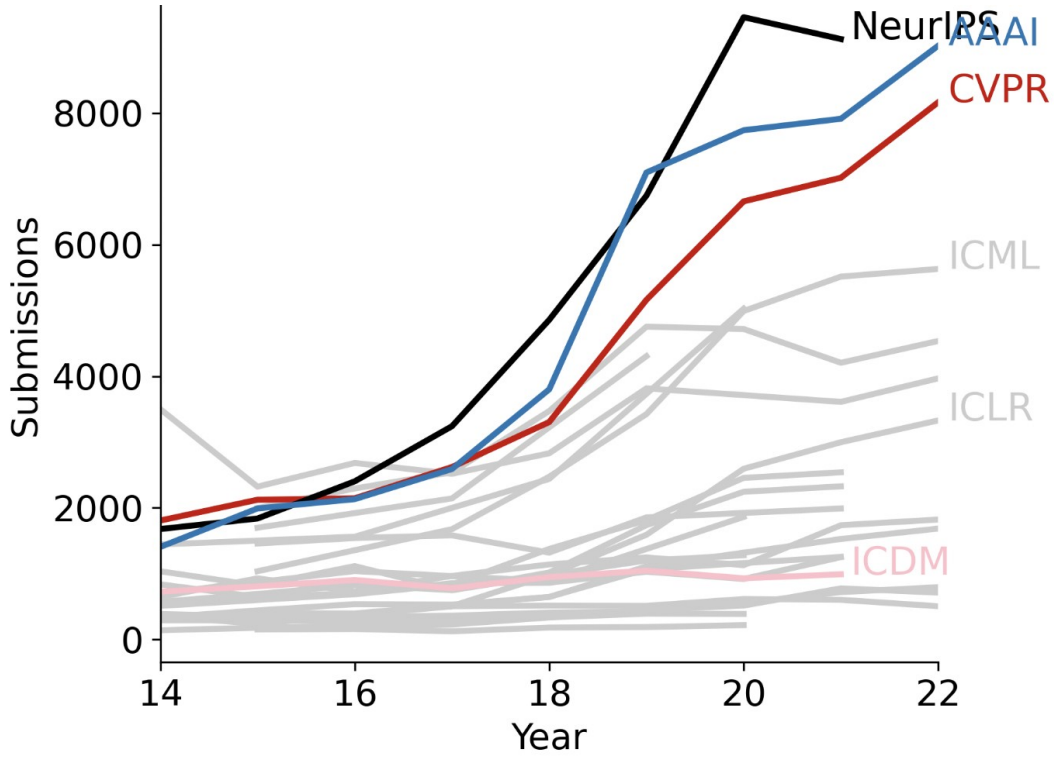
- A lot of universities have created new colleges and programs which center on AI and data science



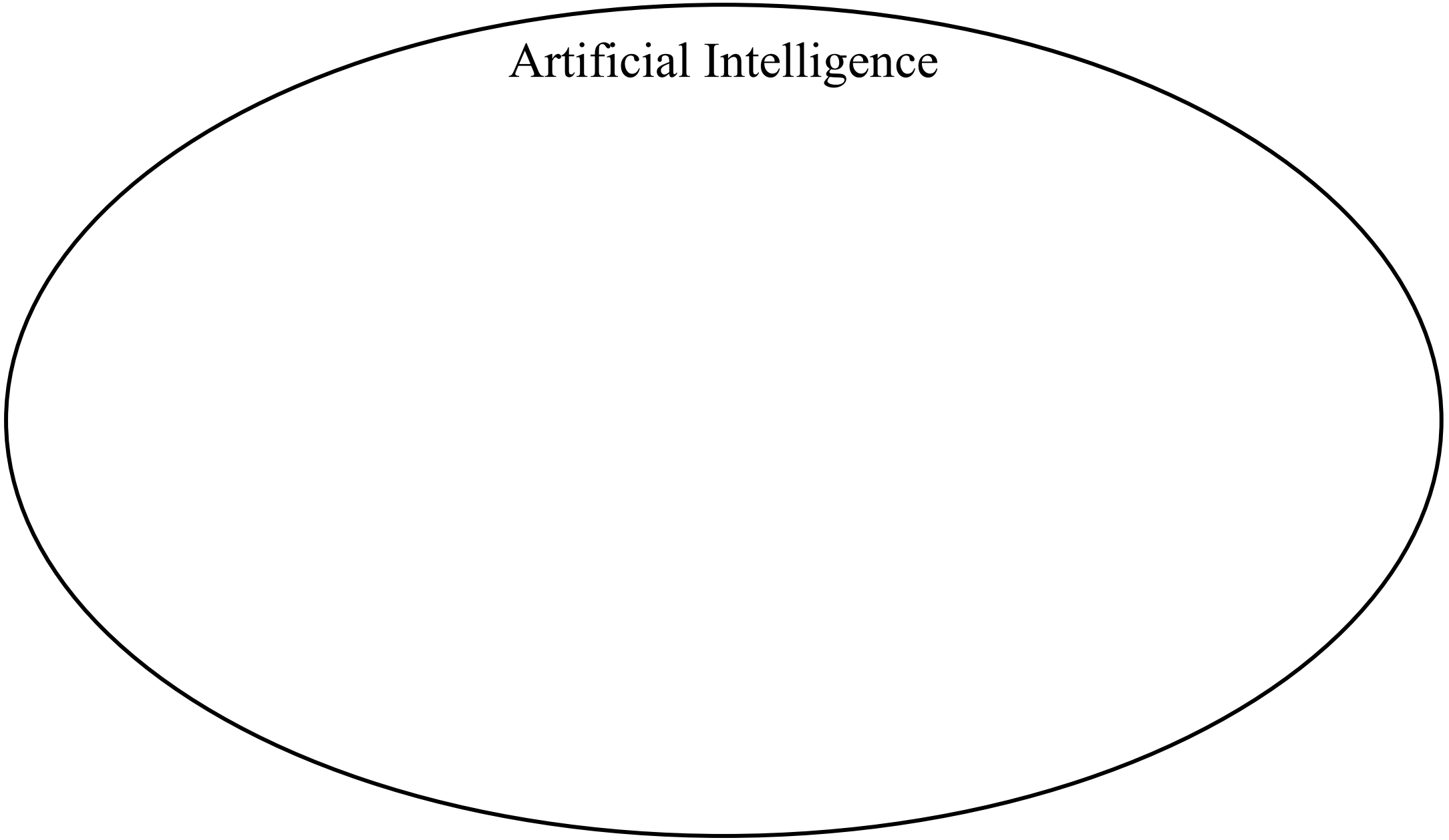
Stanford CS221 enrollments

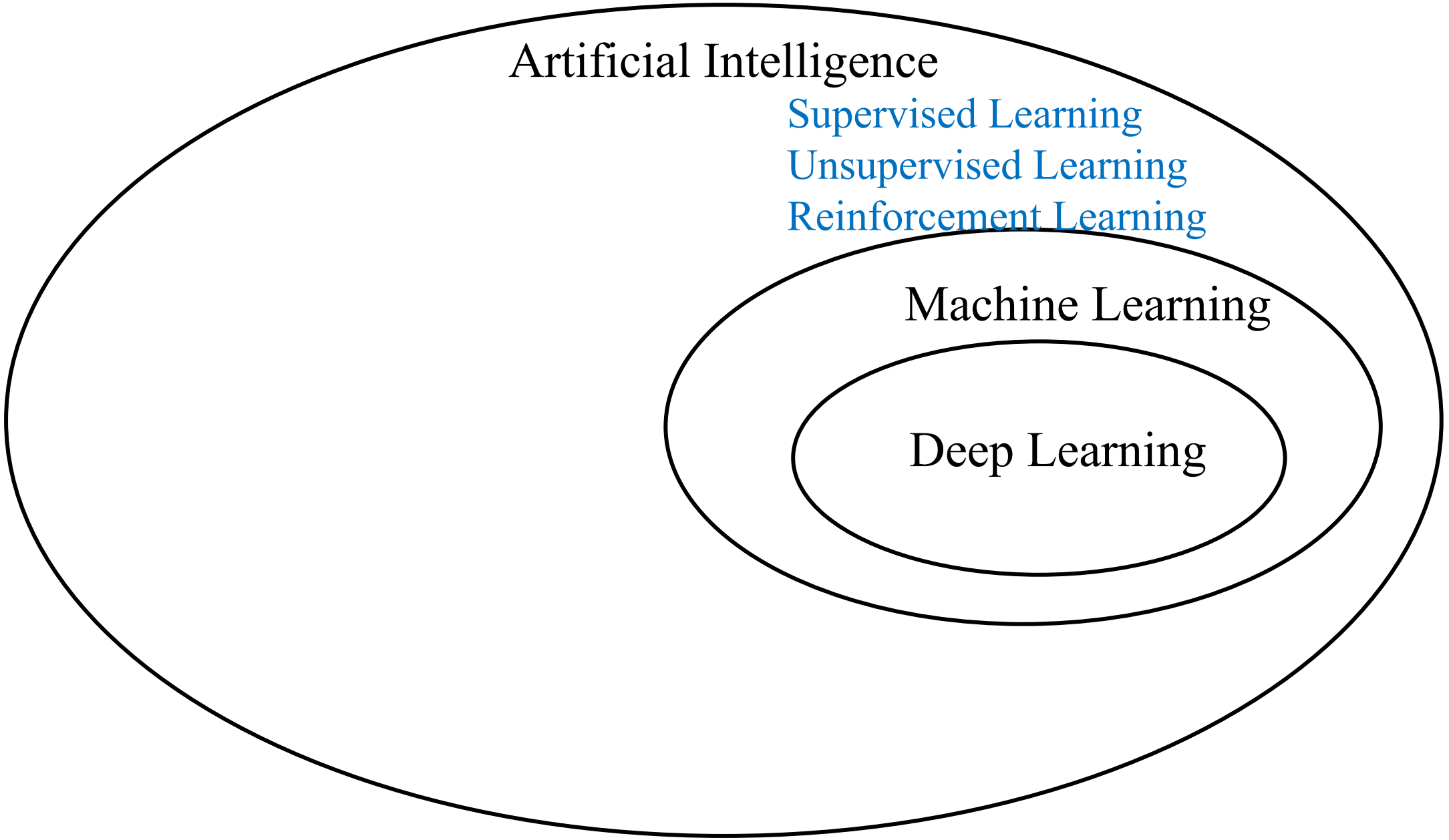
Publications

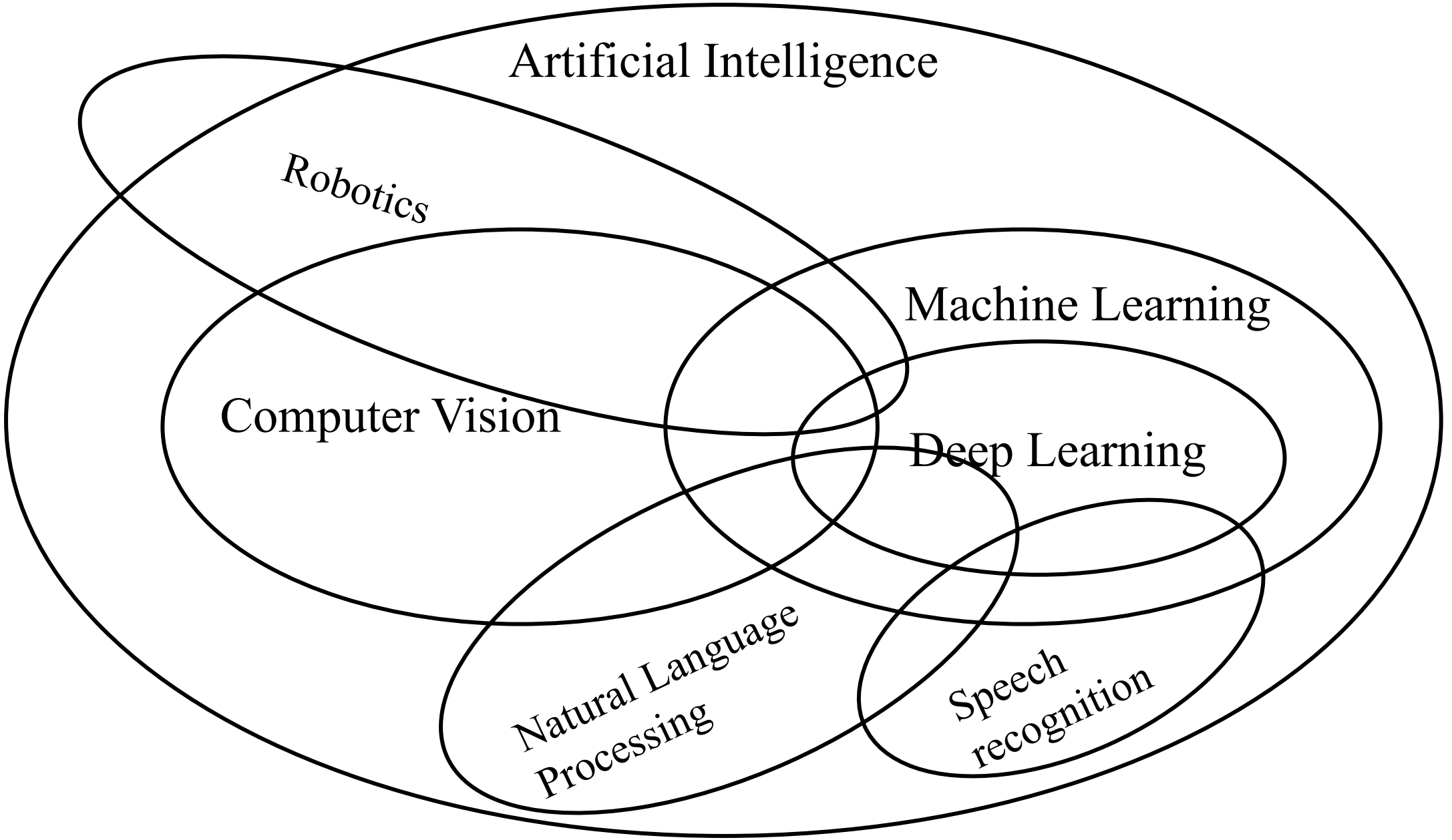


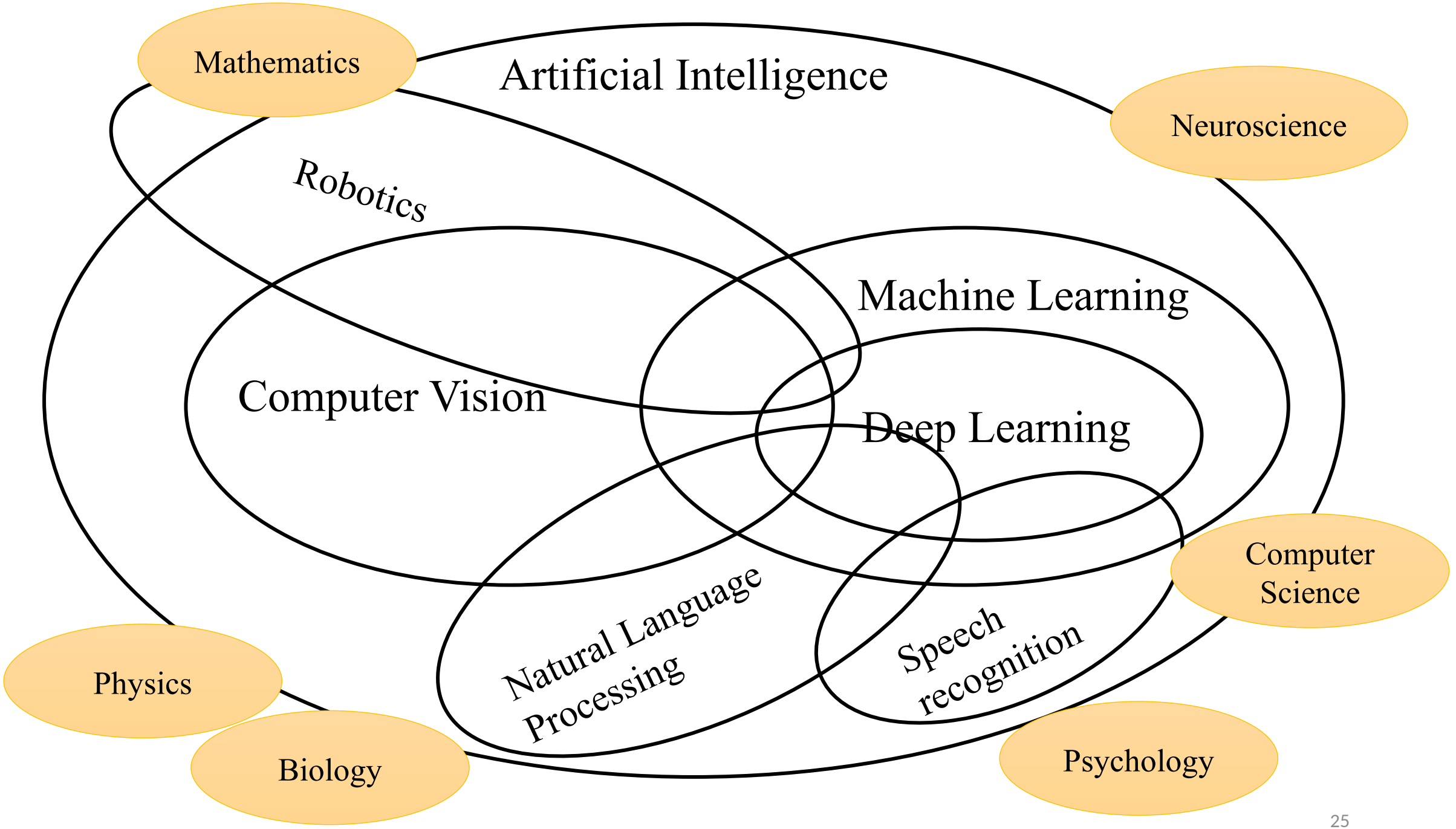


What AI techniques/subfields behind these success stories?


Artificial Intelligence


Artificial Intelligence
Supervised Learning
Unsupervised Learning
Reinforcement Learning
Machine Learning
Deep Learning


Artificial Intelligence
Robotics
Machine Learning
Computer Vision
Deep Learning
Natural Language Processing
Speech recognition


Mathematics
Artificial Intelligence
Neuroscience
Robotics
Machine Learning
Computer Vision
Deep Learning
Computer Science
Natural Language Processing
Speech recognition
Physics
Biology
Psychology

Topics Covered in COSC4368 (Tentative)

- Part I
  - Many search algorithms, Game Theory, Evolutionary Computing, Constraint Satisfaction Problems
- Part II
  - Supervised Learning, Reinforcement Learning
  - Deep Learning
- Part III
  - Societal and Ethical Aspects of AI
  - Decision Making and Reasoning in Uncertain Environments
  - Logical Reasoning and Planning

Prerequisite

- Prerequisite: COSC2320 or COSC2430
- Otherwise, the course is self-contained
  - Some experience in writing programs in some programming language (C, C++, Python, Java…)
    - ❖ Basic knowledge of data structures (particularly trees and graphs); what is taught in an introductory undergraduate data structure course, e.g., COSC2430;
    - ❖ No knowledge of other AI languages is required
  - Ability to deal with “abstract mathematical concepts”
  - Basic knowledge of probability theory is help

Recommended Textbook

- S. Russell and P. Norvig, *Artificial Intelligence, A Modern Approach*, Fourth Edition, Prectice Hall/Allyn&Bacon, 2021.

http://aima.cs.berkeley.edu/

- For specific topics of interest, the following books are recommended:
  - I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, 2015.
  - R. Sutton, A. Barto, *Reinforcement Learning*, Second Edition, MIT Press, 2018.

Course Elements

- ~30 Lectures
- 3 Problem Sets with 5-7 Individual Tasks (tasks that involve some programming, using AI-tools, and one essay writing)
- 1 Midterm Exam
  - Will be paper exams which you take in a UH classroom, likely our assigned classroom
  - Will be open notes/book
  - Will get a review list before the exam
  - Exams will center (80% or more) on material that was covered in the lecture

Course Elements

- 1 Final Group Project (up to 4 students for each group)
  - Include a project proposal, a final report and a group in-class presentation
  - Apply what you have learned to a problem of interest:
    - Apply the algorithms learned to specific problems
    - Develop a new algorithm/a new variant of existing algorithms, and apply it to solve general AI tasks
    - etc….
  - Check recent publications from top-tier conferences, e.g., NeurIPS, ICML, ICLR…

Grading

Assignment	Problem Sets	Midterm Exam	Final Project	Attendance
Percentage of Final Grade	45%	25%	27%	3%

- REMARK: Weights are subject to change…
- Late work
  - Submissions up to 24 hours late receive a 10% penalty; submissions 24 hours and 1 minute to 48 hours late receive a 25% penalty, and submissions received more than 48 hours late will not be graded.

General Information

- Office Hours: Monday 2:45-4:45pm, Wednesday 2:45-3:45pm
- Office: PGH 593
- Email: slin39@uh.edu

- TA Office Hours: …
- TA Email: aachowdhury3@uh.edu

- Canvas will be used for the teaching of this course, e.g., for course materials, announcements, assignments, etc.
- A Microsoft team called **H_20233_COSC_4368_26476** will be also used, likely for course discussions.

General Information

- UH Excused Absence policy applies for missing course exams; if you miss exams for other reasons, or you do not follow the procedures, outlined in the policy, you will receive a grade of ‘F’ for the missed exam.
- It is also necessary that you regularly check your cougar-net email which is associated with your MS Teams account (and also Canvas); not doing so may ask for trouble.
- You are encouraged to use MS Teams to chat about course related matters.
- However, please use email and not MS Teams chat to discuss personal matters with the instructor and/or the course TA.

The Honor Code

- Do collaborate and discuss together, but write up and code independently.
- You can discuss what is required to do with other students, but you cannot solve the problems jointly. A few course activities will be group activities.
- Do not look at anyone else's writeup or code.
- Do not show anyone else your writeup or code or post it online.
- We will run MOSS and similar tools which find similarities in submitted code periodically to detect plagiarism.
- If you use code/software/project ideas from the internet, you have to admit this fact in the reports you submit in COSC4368 by properly referencing the work you used. Not doing so represents a serious academic honesty violation!
- Academic honesty violations will be reported to the department, and to the college if the violation is a second offense of a particular student.

NOTE: PLAGIARISM IS NOT TOLERATED.

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Use **Navigate app** to select Appointments, Support services,

Success Workshops

Success workshops on note-taking, memory improvement, forming study habits, test anxiety, time mgt., and more. Learn strategies for success in your courses. Use Teams code **umt0dfa**.

This class uses Progress Report early alerts.

What is a Progress Report?

An “early alert” that you might be at risk of failing this course.

What happens when a Progress Report is submitted for me?

You will receive two emails:

1. The first telling you a progress Report has been submitted;

2. A second with directions about how you can get academic help.

What should I do?

Reflect! Think about your performance in class so far.

Review! Look at your syllabus, your grade, and remaining points available.

Respond! Follow the directions in the email so UH resources can help.

When will Progress Reports be submitted?

After 2nd Problem Set/Midterm Exam

Who else can help me?

An alert will be placed in your record - contact your advisor for guidance.

Click the Resources icon in your Navigate Student app. [Download Navigate Student in the app store]

How do we use AI to solve problems?

Paradigms

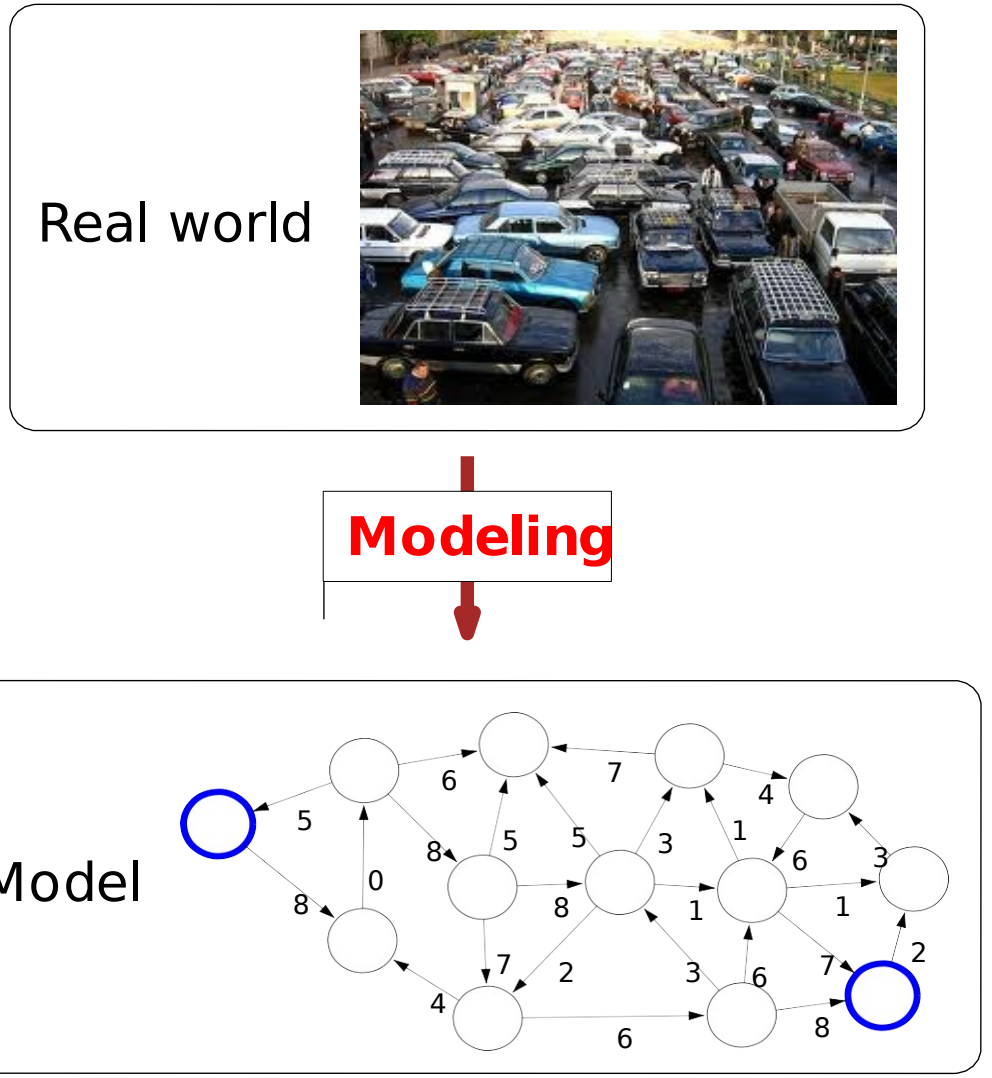
Modeling

Inference

Learning

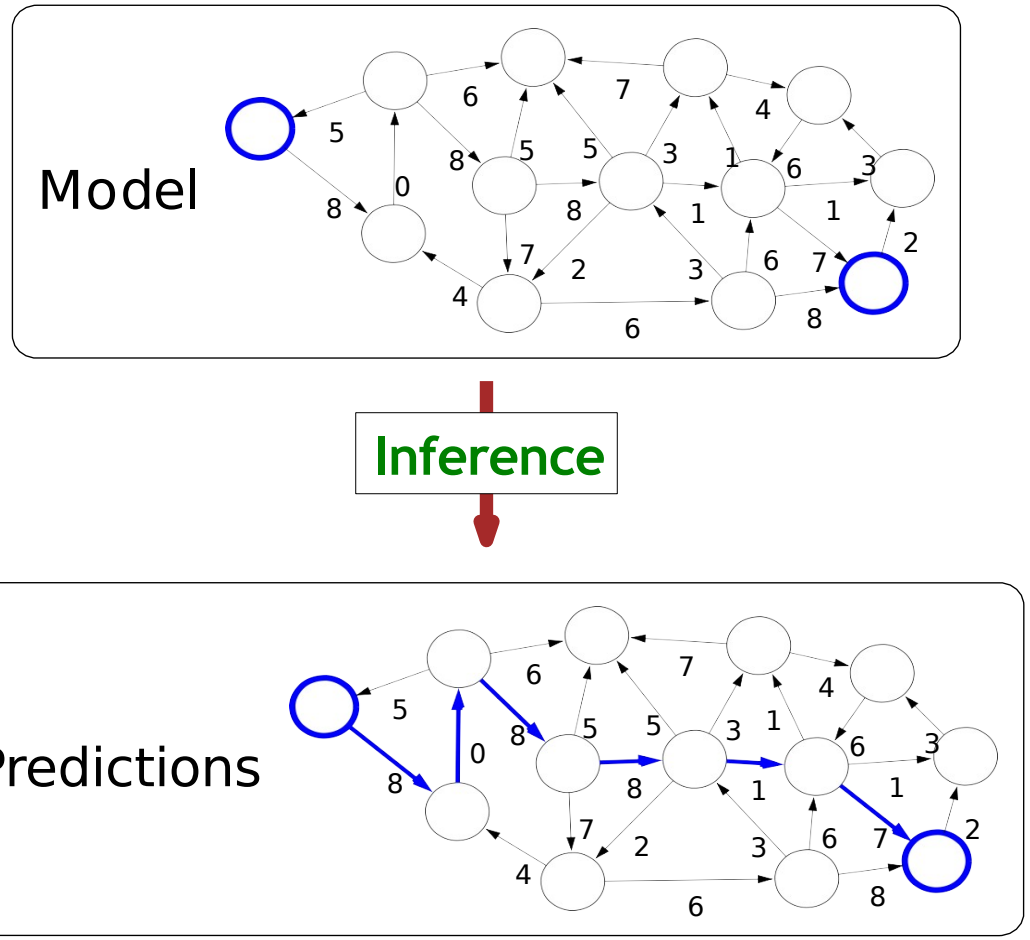
Paradigm: Modeling

- Transform complex real-world problems into formal mathematical objects (called models), which can be operated/analyzed by computers
- Modeling is lossy: the real world is rich, which generally can not be captured perfectly by a model



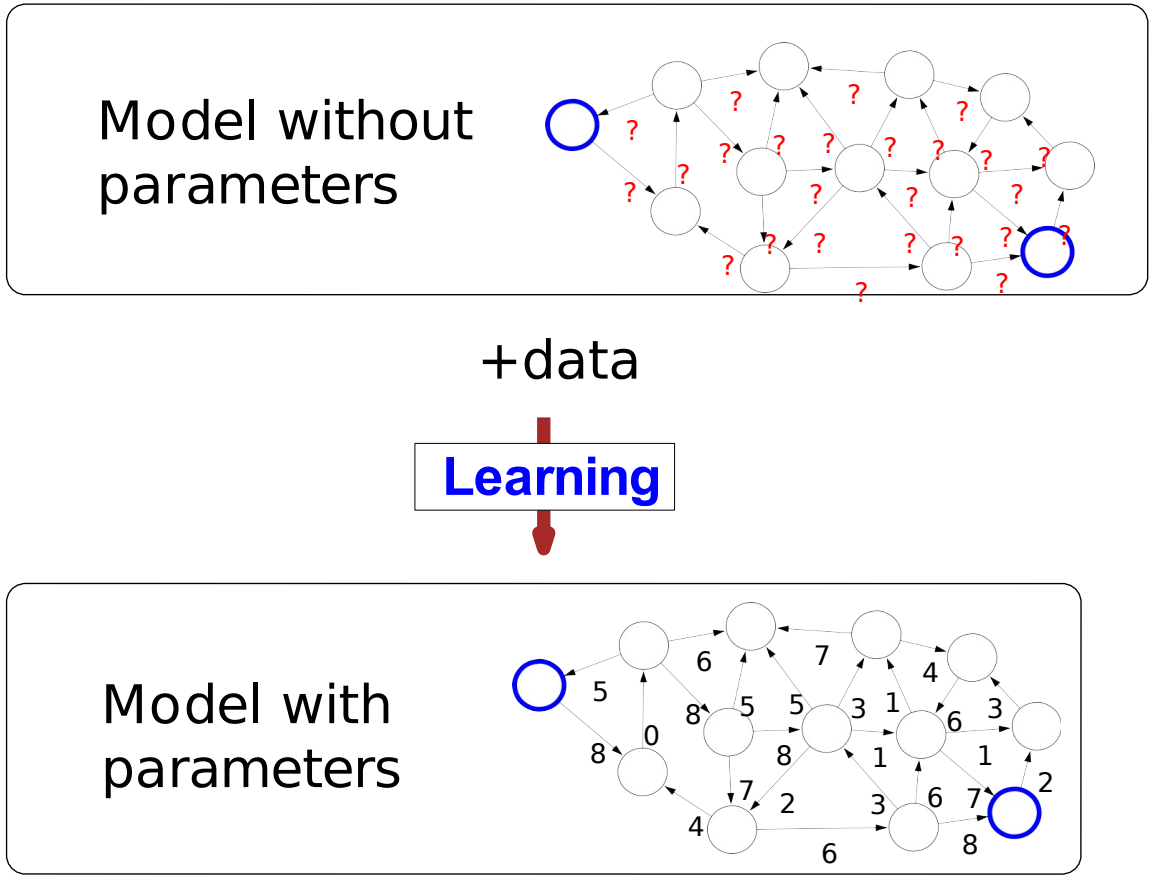
Paradigm: Inference

- Given a model, inference seeks to answer questions with respect to the model
- Efficiency of Inference: find efficient algorithms that can answer the questions



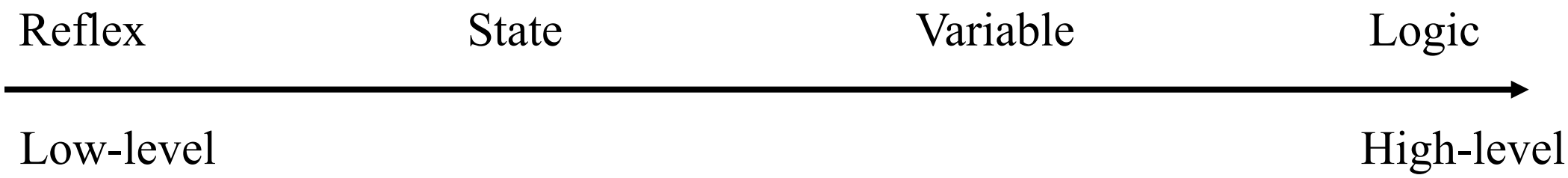
Paradigm: Learning

- But where does the model come from? We can't write down a rich model manually to capture the rich real world.
- AI solution: Learning from data
  - One can just construct a skeleton of model (a model family) without parameters
  - Use machine learning to learn the parameters from appropriate data



Modeling

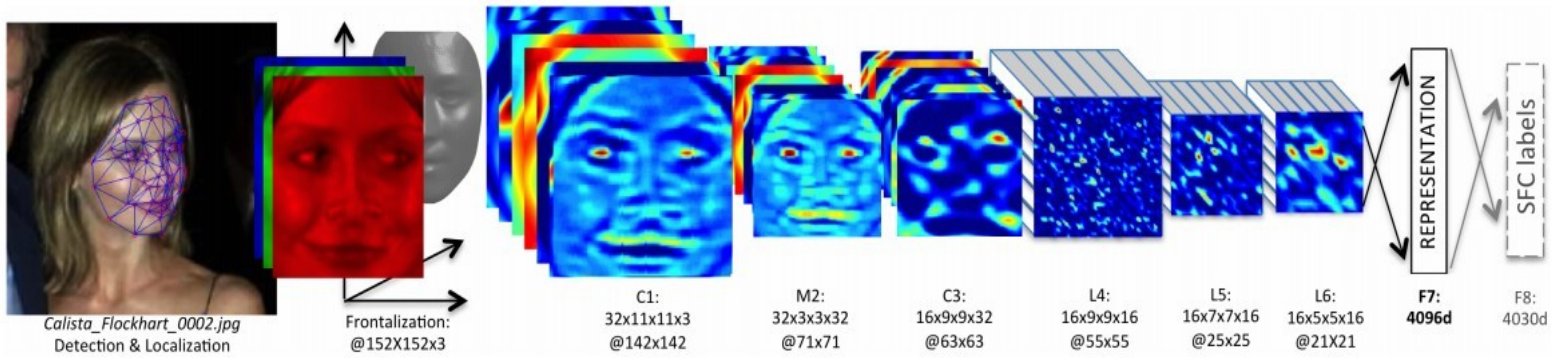
- Different types of models represent different types of real-world problems



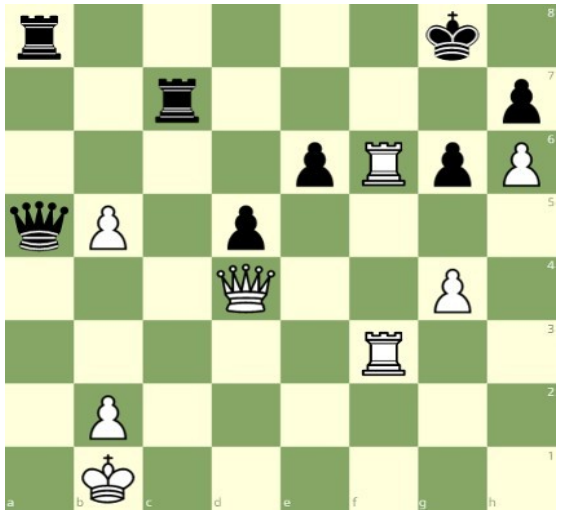
---- One classification strategy from Stanford CS221

Modeling ---- Reflex-based Models

- A reflex-based model simply performs a fixed sequence of computations on a given input
- Feed-forward; no backtracking
- Examples: linear classifiers, deep neural networks
- Inference is straightforward; fixed computations by passing through the model



Modeling ---- State-based Models

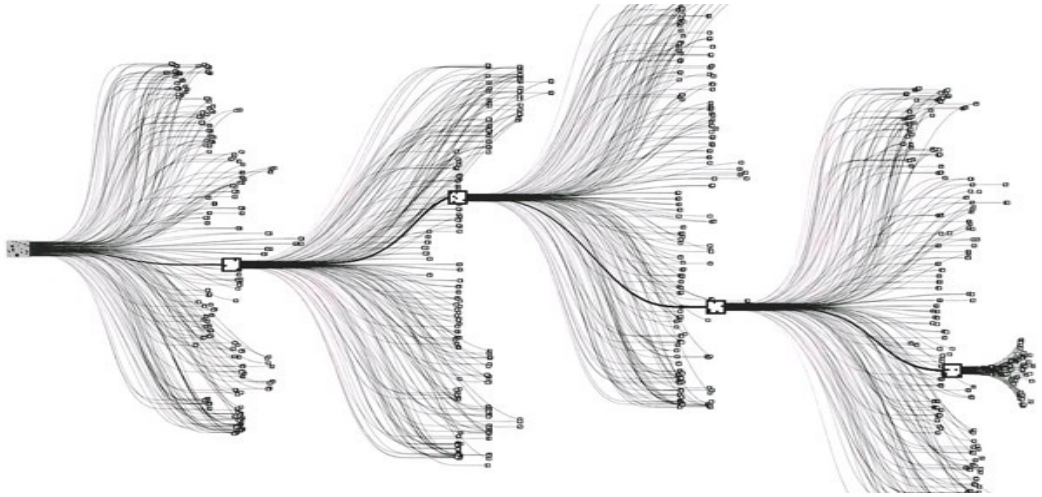


Consider the task of figuring out what move white should make given a particular chess position

- Reflex-based models are too simple for tasks that require more forethought, e.g., playing chess or planning a trip

Modeling ---- State-based Models

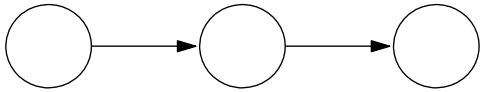
- State-based models can model the **state** of a world and **transitions between states** which are triggered by actions



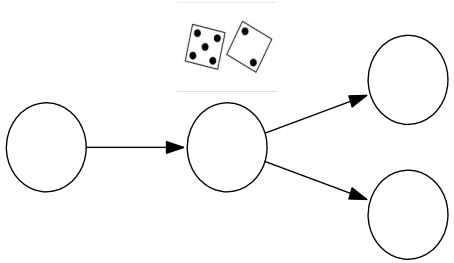
- Applications:
  - Games: Chess, Go, etc.
  - Robotics: control, motion planning
  - Natural Language Processing
  - etc...

Modeling ---- State-based Models

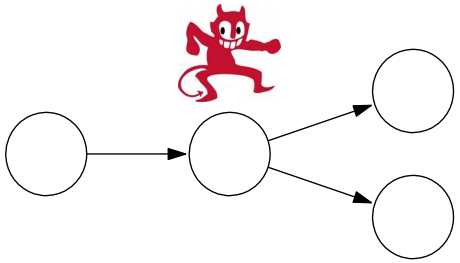
- Search problems: you control everything



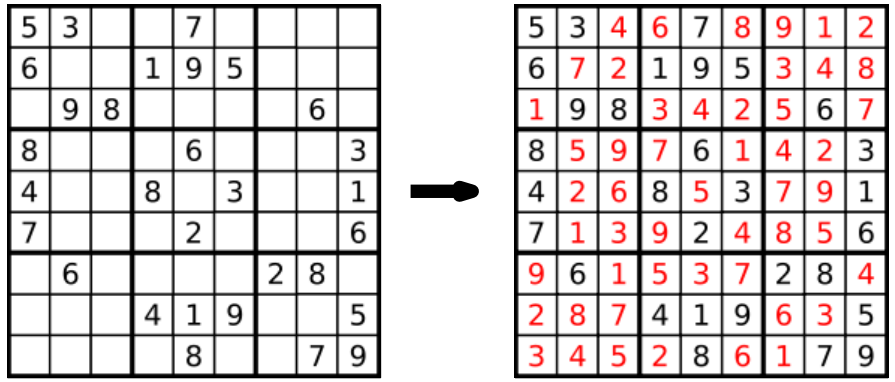
- Markov decision problems: against nature (e.g., robot moving)



- Adversarial games: against opponents (e.g., chess)



Modeling ---- Variable-based Models



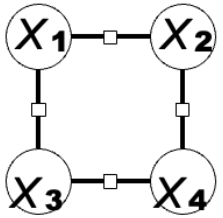
Sudoku

- Goal: put digits in blank squares so each row, column, and 3x3 sub-block has digits 1–9

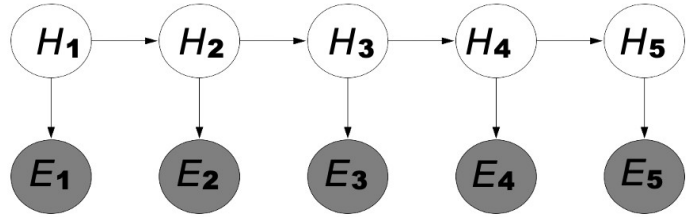
- Note: order of filling squares doesn't matter in the evaluation criteria!

Modeling ---- Variable-based Models

- In state-based models, we think in terms of states, actions, and costs/rewards
- In variable-based models, we think in terms of variables, factors, and weights
  - Constraint satisfaction problems: hard constraints (e.g., Sudoku, scheduling)



  - Bayesian networks: soft dependencies (e.g., tracking cars from sensors)



  - The dependency structure is given by the graph structure, which formally defines a joint probability distribution over all variables

  - Factor graph: capture (1) unknown values we seek to ascertain and (2) how the variables are related to one another

Modeling ---- Logic-based Models

- Think about a virtual assistant: remember what you told it and answer questions that require drawing inferences from its knowledge (characterized by logic rules)

Use natural language

Need to:

- Digest **heterogenous** information
- Reason **deeply** with that information
- Be **adaptive** to different scenarios

Paradigms

Modeling

simplifies the real world

Inference

answers questions
against the model

Learning

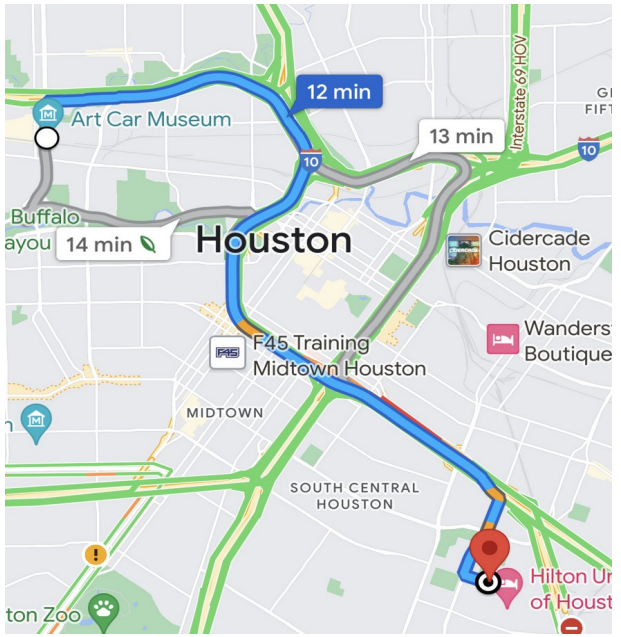
constructs the
model from data

- Each step can be challenging and require approximations

Examples of Problems Investigated by Different Subfields of AI

Search

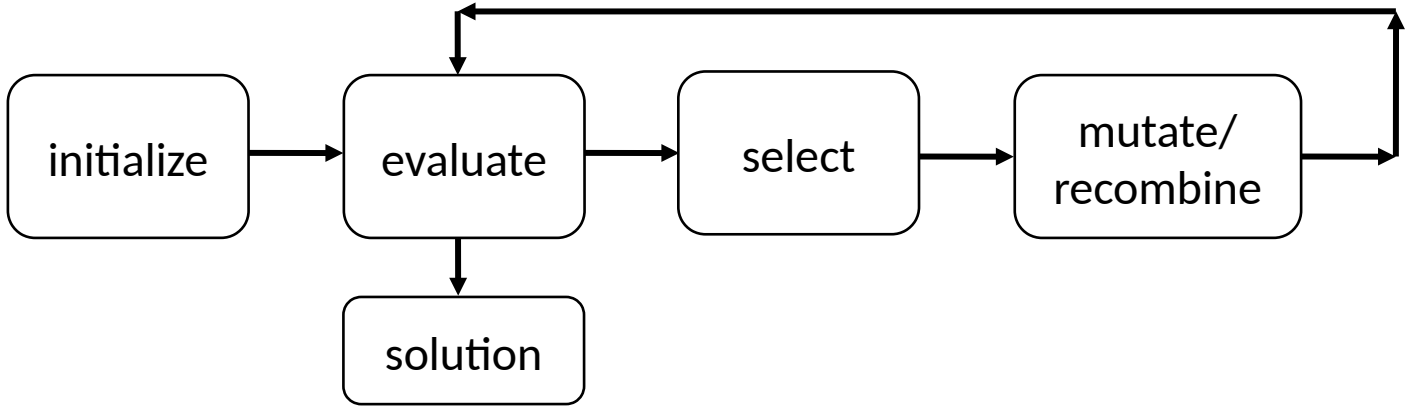
- Example: route finding
  - Output a sequence of actions that will take us from the source to the destination
- Objective: shortest? fastest? most scenic?
- Actions: go straight, turn left, turn right



- Search algorithms: search space reduction, ordering solutions intelligently, simplifications of computations

Evolutionary Computing

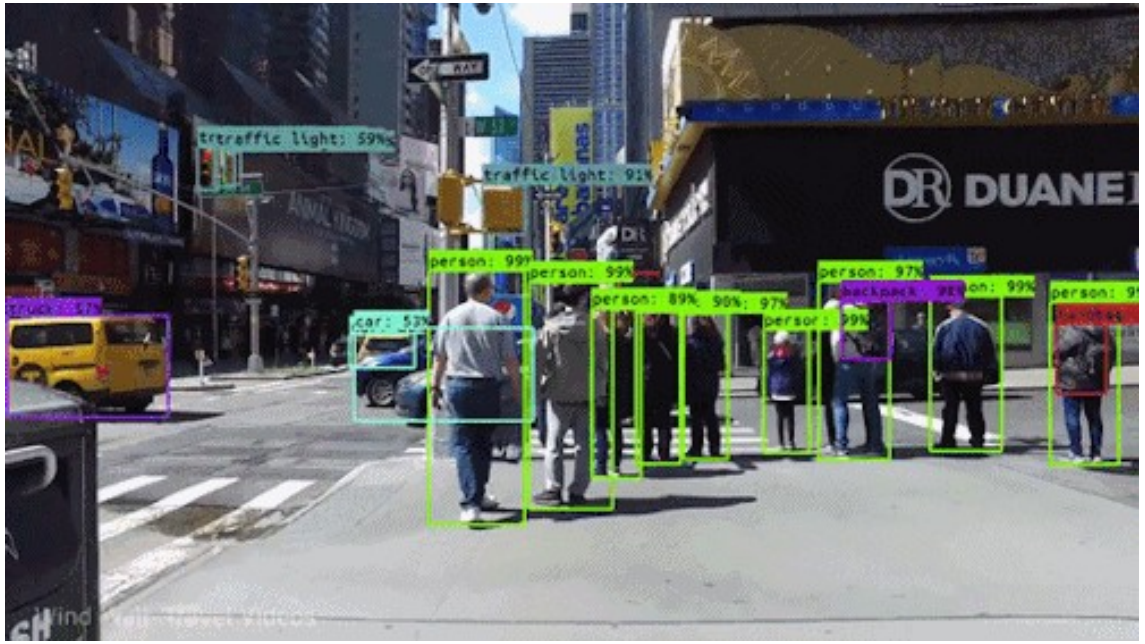
- Evolutionary algorithms are global search techniques, which are built on Darwin's theory of evolution by natural selection
- Numerous potential solutions are encoded in structures, called *chromosomes*.

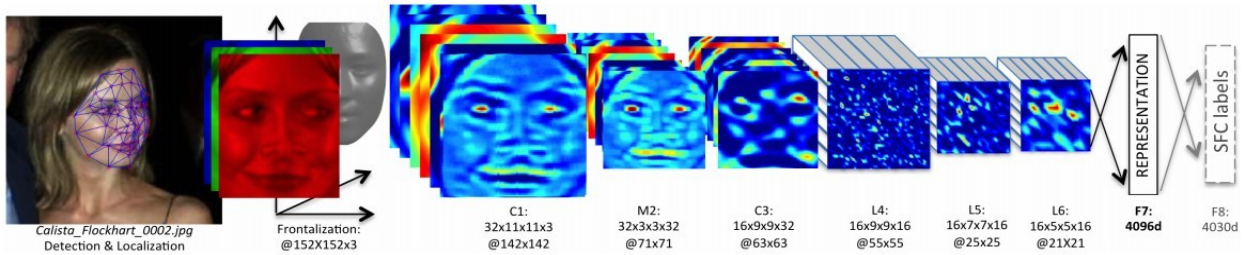


- During each iteration, the EA evaluates solutions and generates offspring based on the fitness of each solution in the task.
- Substructures, or *genes*, of the solutions are then modified through genetic operators such as mutation or recombination.
- *The idea*: structures that led to good solutions in previous evaluations can be mutated or combined to form even better solutions.

Computer Vision

- Example: object detection
- Object localization:
  - Locate the presence of objects in an image
- Image classification:
  - Predict the type/class of the located objects

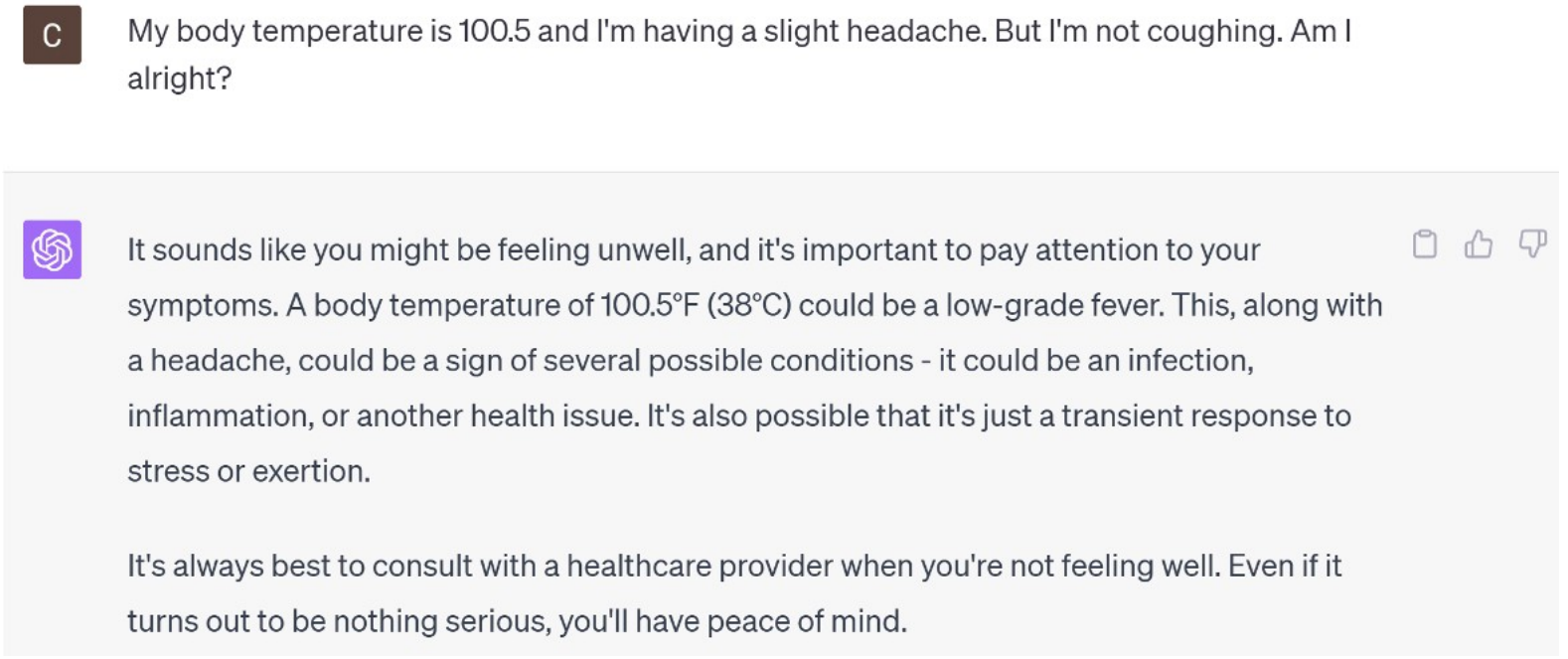




https://medium.com/@atharvahere/eyes-of-a-car-an-insight-on-self-driving-cars-and-object-detection-98a1595d2181

Natural Language Processing

- Generate text by predicting the next word in a sentence
  - Use the context of the conversation – the preceding words and sentences – to make these predictions
  - Capable of generating human-like text
  - Very important in a lot of applications, e.g., virtual assistant, chat robot
- Example: ChatGPT



Robotic Control

- Control robots to perform specific tasks in the environment
- Example: Flying SWARM Robots
- Requires:
  - Planning
  - Multi-Agent Systems and Distributed AI
  - Search
  - Reasoning in uncertain Environments
  - Machine Leaning
  - Computer Vision

http://arstechnica.com/science/2012/03/robots-swarm-the-stage-at-ted/

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Watch First 2 minutes. 4:30, 10:15. 15:30