CS 181 - Artificial Intelligence

Kewei Tu
Fall 2021

Administrative Stuff

- Instructor: Kewei Tu (屠可伟)
  - Email: tukw@shanghaitech.edu.cn
  - Office: SIST 1A-304B

- TA: 杨松霖、陈卓、吴昊一、陈天素
  - Office hours: TBA

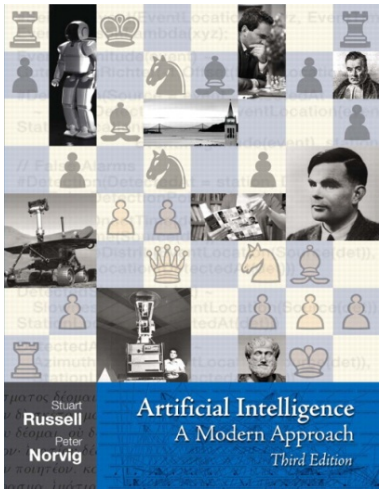
Administrative Stuff

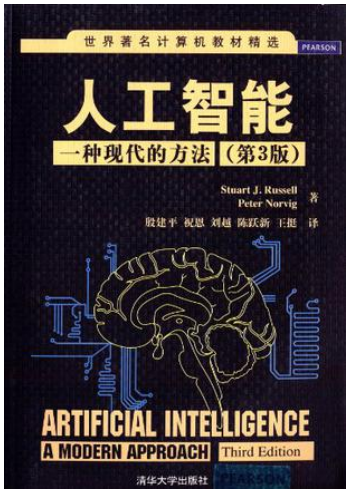
- Classes
  - Wed/Fri 10:15-11:55am @教学中心303
  - 16 weeks
  - Language: English

- Prerequisite
  - Programming Languages, Data Structures and Algorithms
  - Discrete Mathematics
  - Probability and Statistics

Administrative Stuff

- Main textbook
  - [AIMA] Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig, 4th edition, 2020.
  - [中译版] 人工智能：一种现代的方法（第3版），2013





- Additional reference books may also be used

Administrative Stuff

- Blackboard
  - Announcements, homework assignments, slides, etc.
- Piazza
  - Discussion and QA
  - http://piazza.com/shanghaitech.edu.cn/fall2021/cs181
- AutoLab
  - Programming assignments

Administrative Stuff

- Grading
  - 6 homework assignments (10%)
  - 6 programming assignments (25%)
  - Project (15%): 2nd half of the semester
  - Midterm exam (25%): in early Nov.
  - Final exam (25%): in early Jan.

Administrative Stuff

- Plagiarism
  - All assignments must be done individually
    - You may not look at solutions from any other source
    - You may not share solutions with any other students
    - Plagiarism detection software will be used on all the programming assignments
  - Way of collaboration
    - You may discuss together or help another student debug code; however, you cannot dictate or give the exact solution

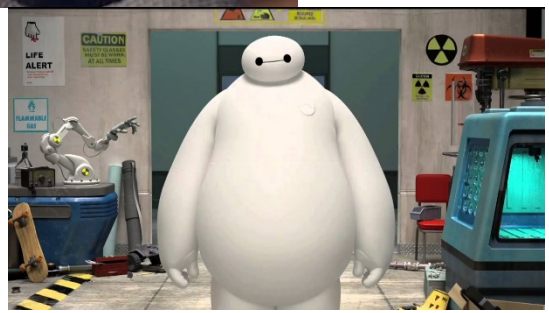
Administrative Stuff

- Plagiarism punishment
  - When one student copies from another student, both students are responsible
  - Zero point on the assignment or exam in question
  - Repeated violation will result in an F grade for this course as well as further discipline at the school/university level

A brief overview of AI

What is artificial intelligence?

- AI = Robots?

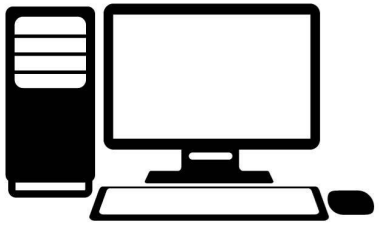


Definition

Artificial Intelligence

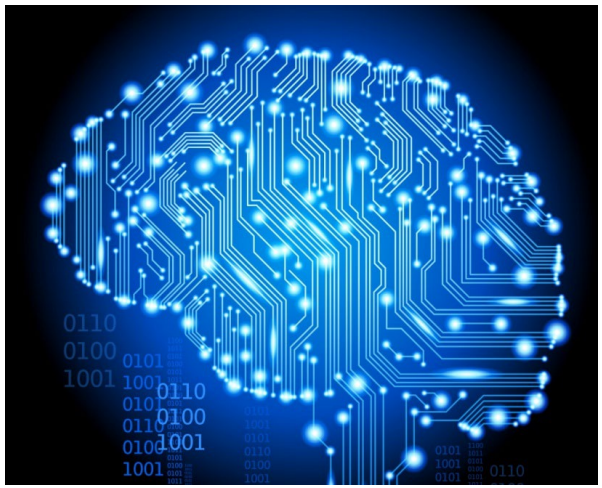
Machines (Computers)

Rationality:
Ability to maximize goal achievement given available information



Artificial Intelligence

- AI vs. Human Intelligence
  - Brains (human minds) are good at rational thinking, but not perfect
  - “Brains are to intelligence as wings are to flight”



A brief history

- Lots of early speculation & research
  - Turing: “Computing Machinery and Intelligence” (1950)

I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

1. *The Imitation Game.*

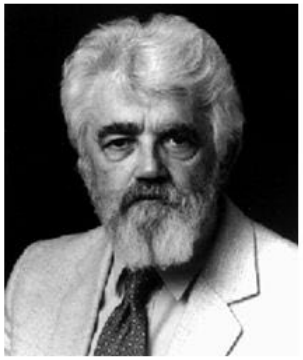
I PROPOSE to consider the question, ‘Can machines think?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words ‘machine’ and ‘think’ are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, ‘Can machines think?’ is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed

Alan Turing

A brief history

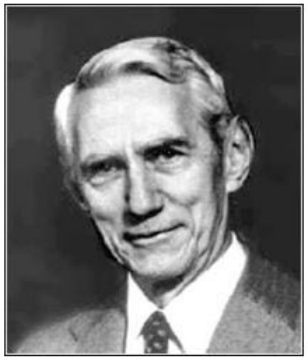
- Birth (1956)
  - Dartmouth workshop

Dartmouth Conference: The Founding Fathers of AI

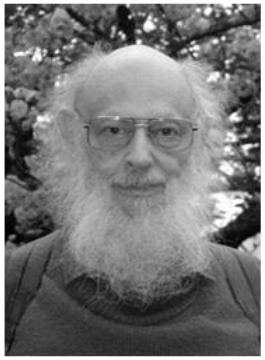


John McCarthy

Marvin Minsky



Claude Shannon



Ray Solomonoff

Alan Newell

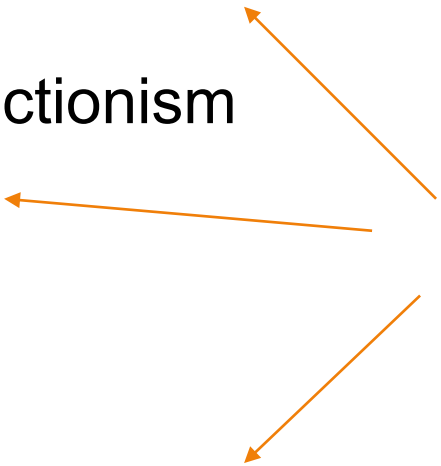
Herbert Simon

Arthur Samuel

And several other people…

A brief history

- Great expectations (1950s-1960s)
  - A variety of methodology
    - e.g., symbolism, connectionism
- AI winter (1970s)
  - Downfall of perceptron
  - Lighthill report
- Boom (1980s)
  - Revival of neural networks
- More scientific methods (1990s-2000s)
  - Statistical approaches



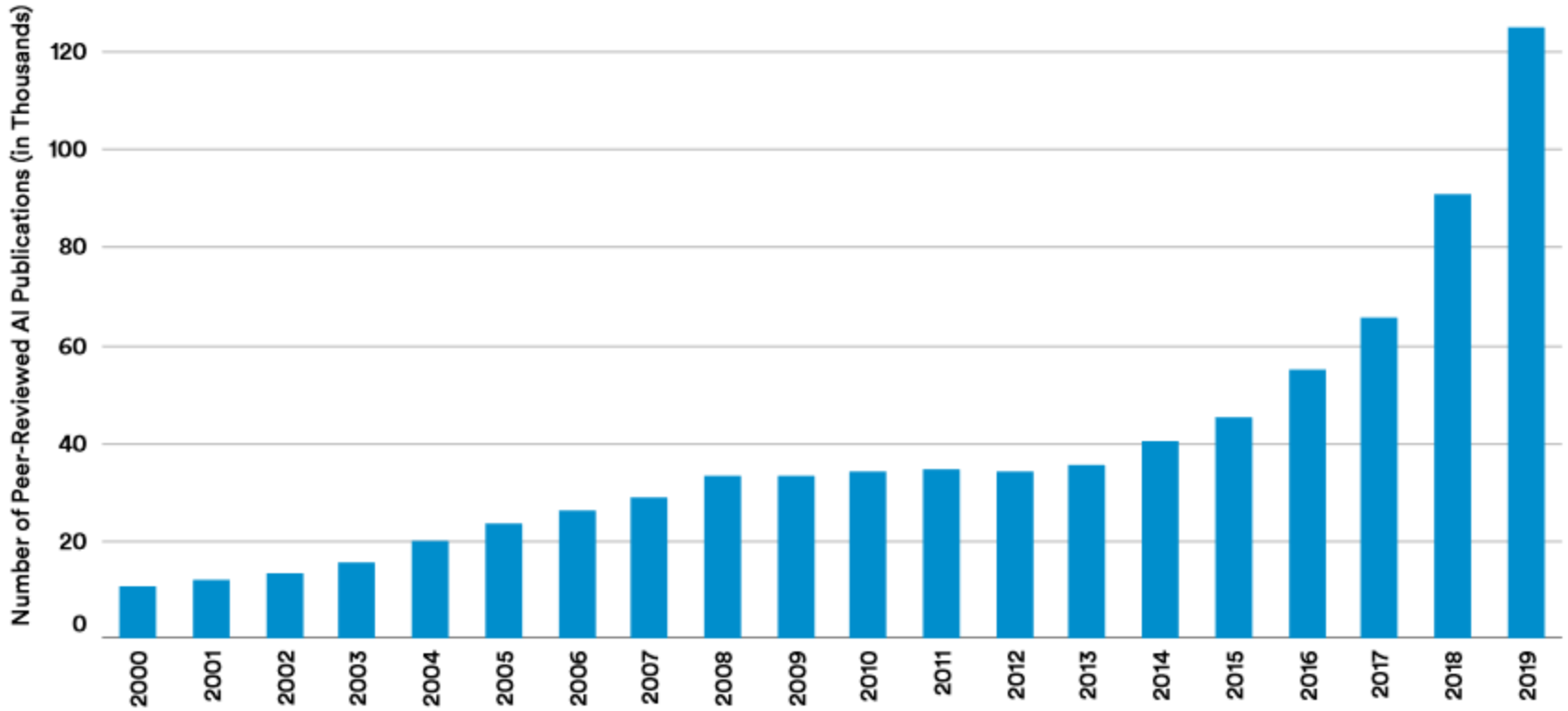
Very rough timeline

A brief history

- The past ten years
  - Rise of big data and deep learning
  - AI becomes one of the hottest areas in CS
  - Great interest from industry and public
  - Many real-world applications

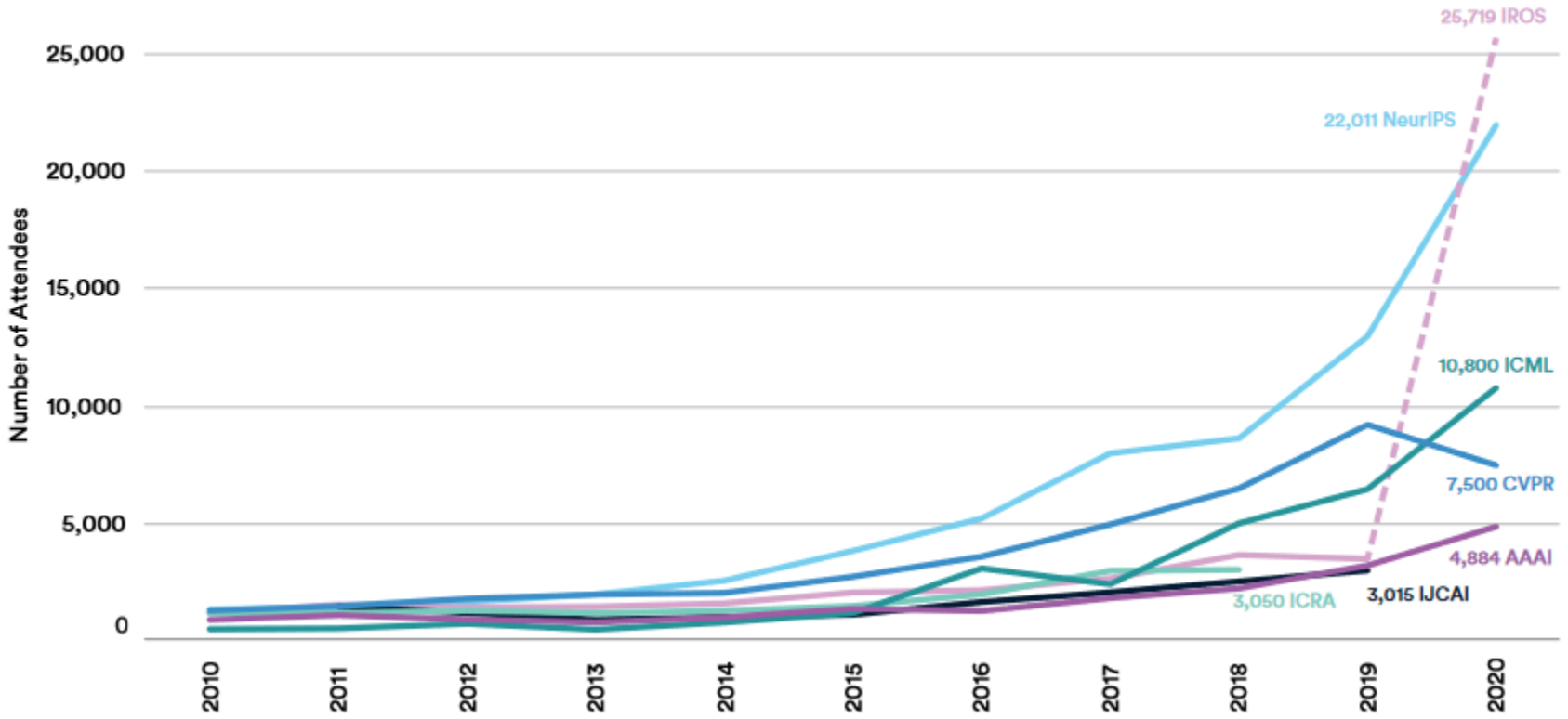
NUMBER of PEER-REVIEWED AI PUBLICATIONS, 2000-19

Source: Elsevier/Scopus, 2020 | Chart: 2021 AI Index Report



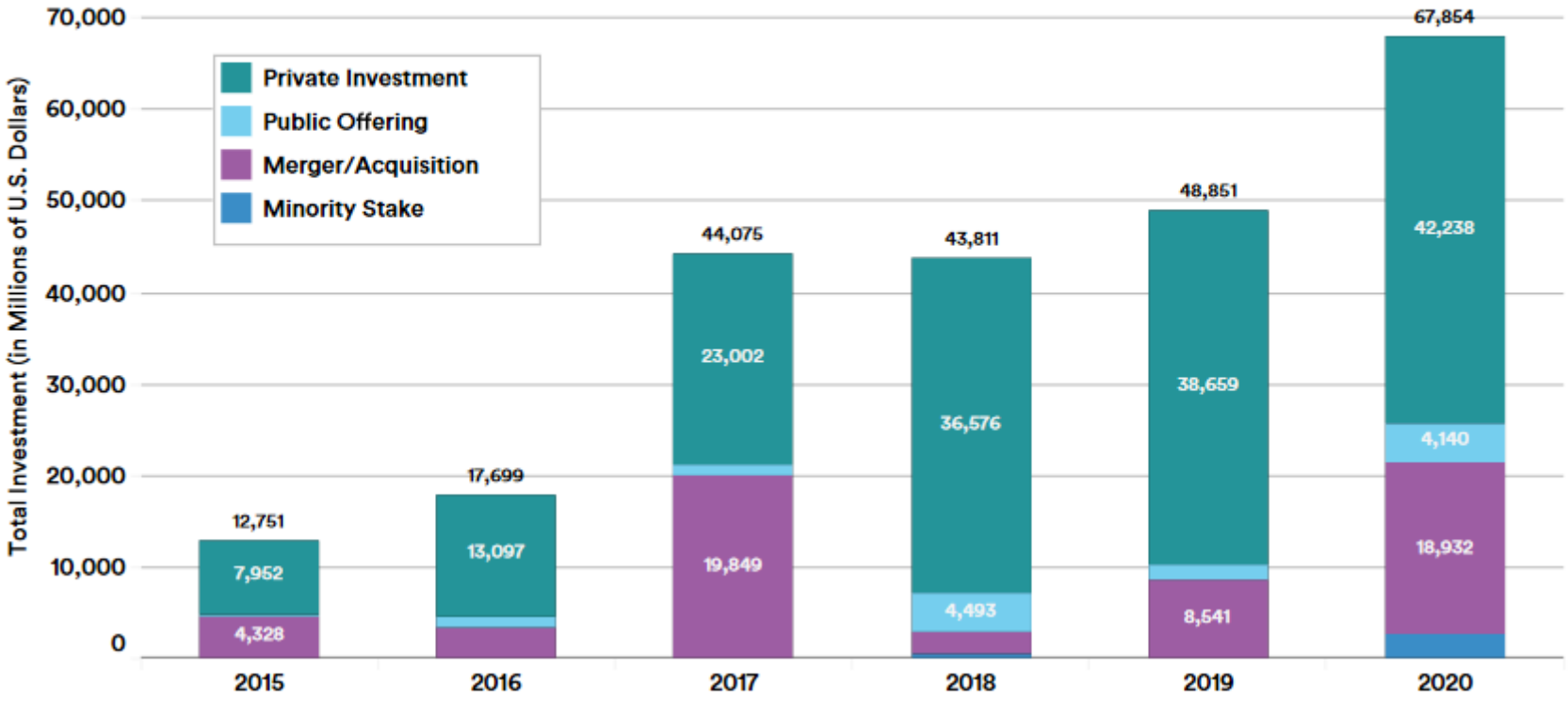
ATTENDANCE at LARGE AI CONFERENCES, 2010-20

Source: Conference Data | Chart: 2021 AI Index Report



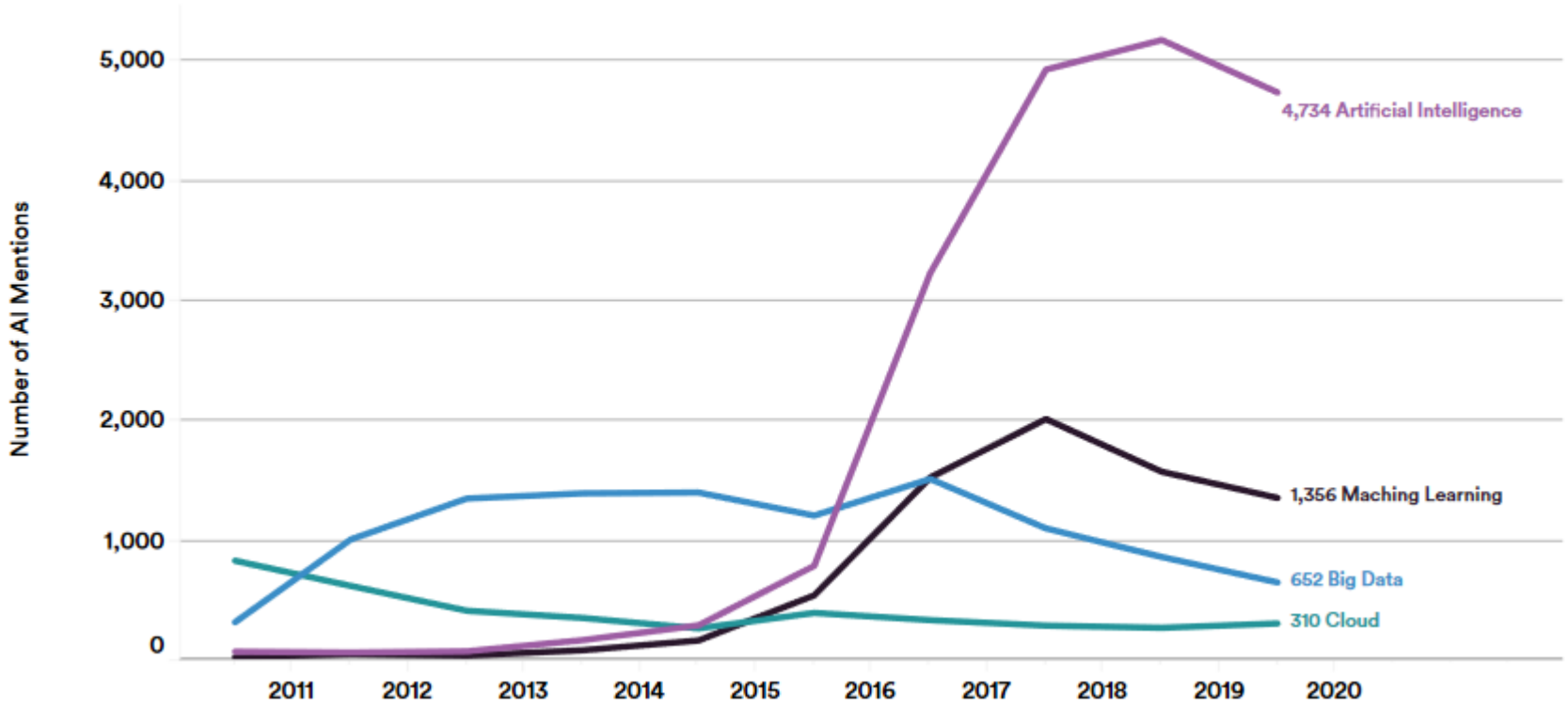
GLOBAL CORPORATE INVESTMENT in AI by INVESTMENT ACTIVITY, 2015-20

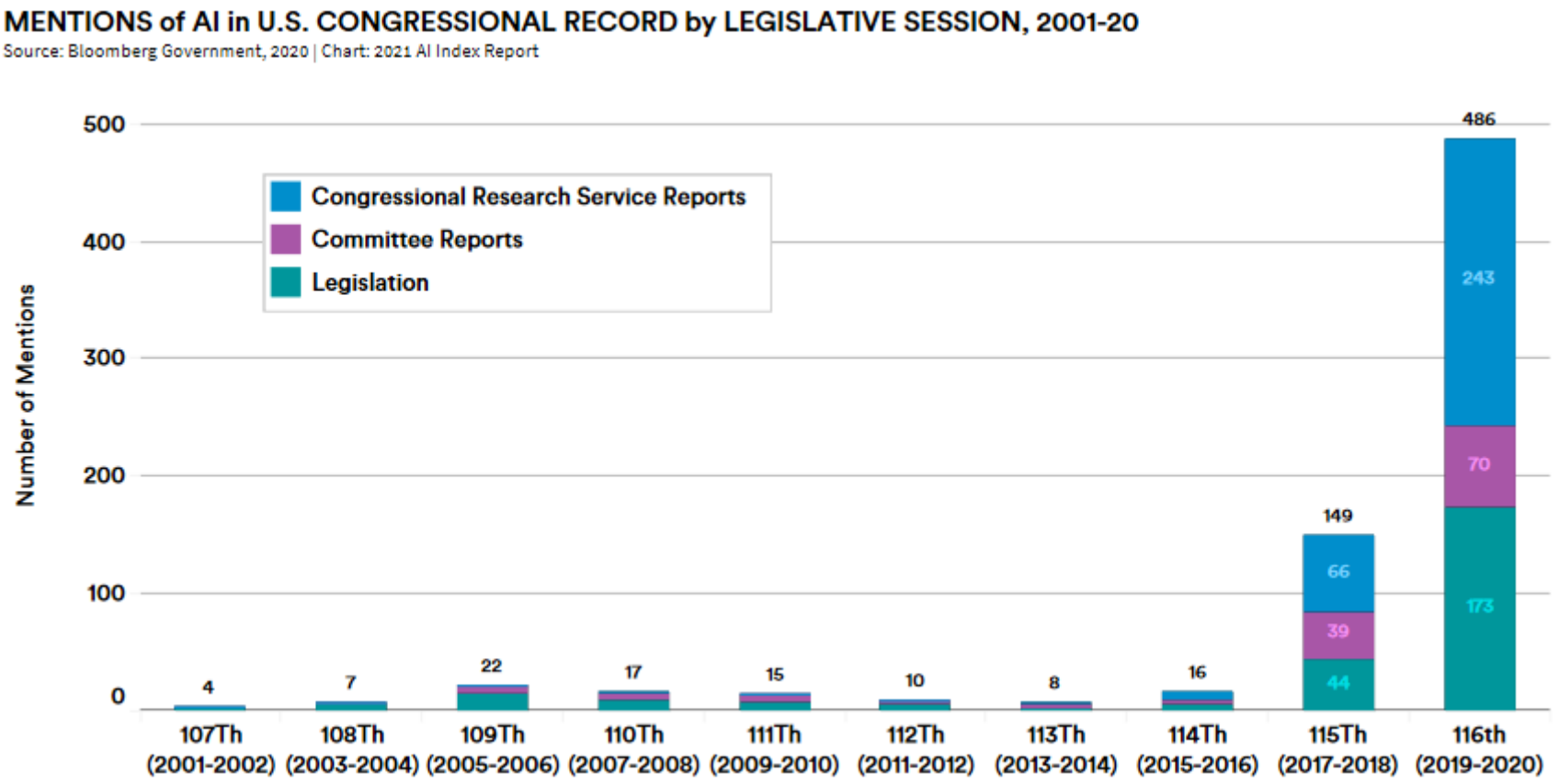
Source: CapIQ, Crunchbase, and NetBase Quid, 2020 | Chart: 2021 AI Index Report



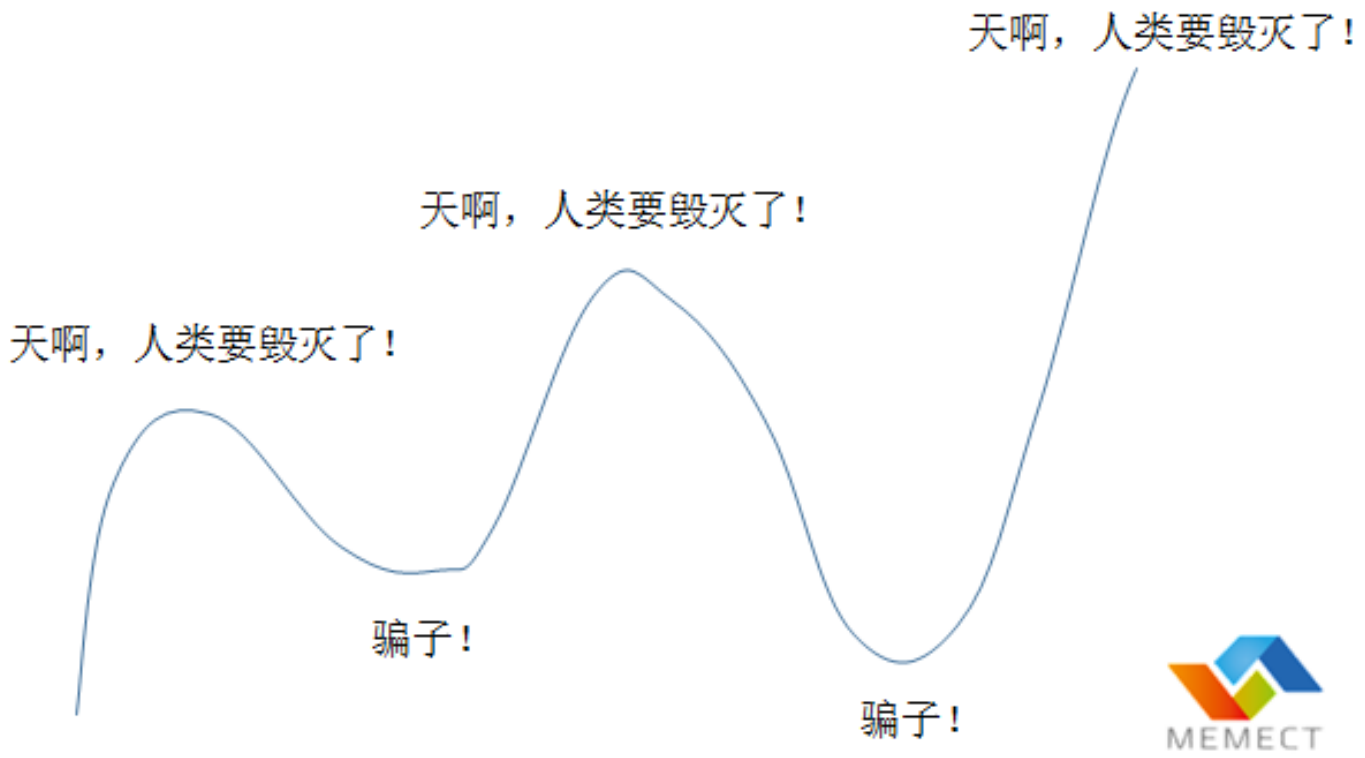
MENTIONS of AI in CORPORATE EARNINGS CALLS, 2011-20

Source: Prattle & Liquidnet, 2020 | Chart: 2021 AI Index Report



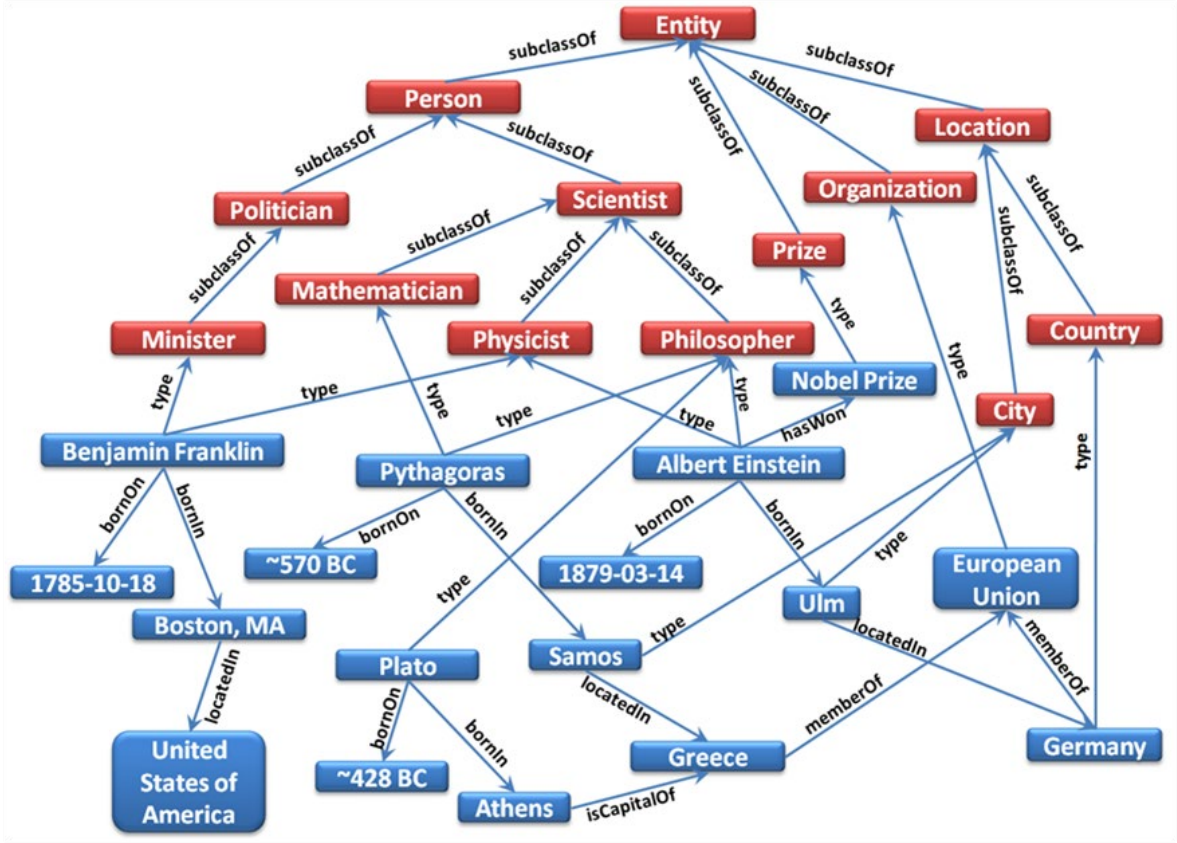

MENTIONS of AI in U.S. CONGRESSIONAL RECORD by LEGISLATIVE SESSION, 2001-20
Source: Bloomberg Government, 2020 | Chart: 2021 AI Index Report
Number of Mentions
500
400
300
200
100
0
Congressional Research Service Reports
Committee Reports
Legislation
4
7
22
17
15
10
8
16
149
66
39
44
486
243
70
173
107Th (2001-2002)
108Th (2003-2004)
109Th (2005-2006)
110Th (2007-2008)
111Th (2009-2010)
112Th (2011-2012)
113Th (2013-2014)
114Th (2015-2016)
115Th (2017-2018)
116th (2019-2020)

A brief history



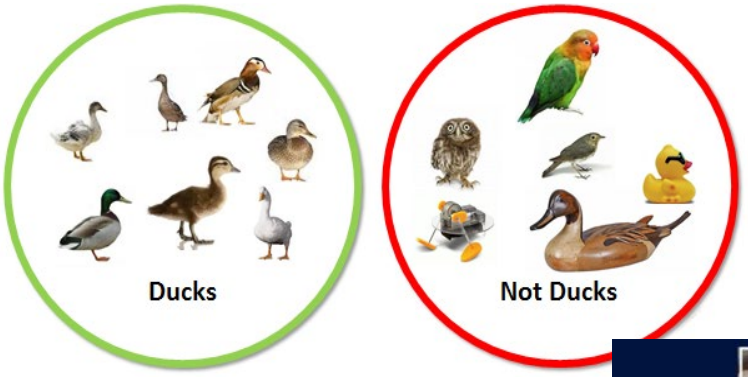
Subfields of AI

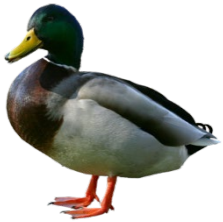
- Knowledge Representation and Reasoning

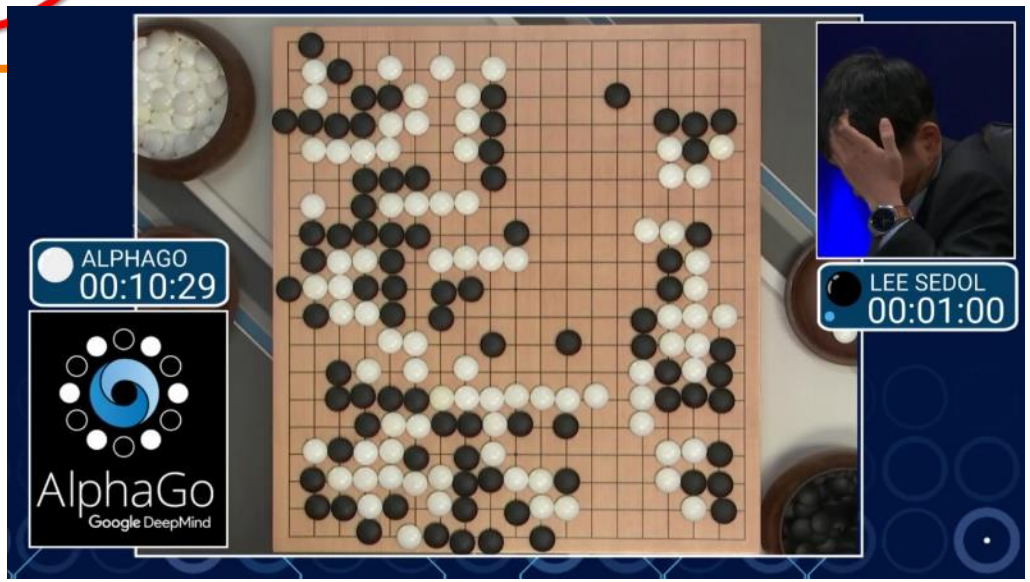


Subfields of AI

- Machine Learning

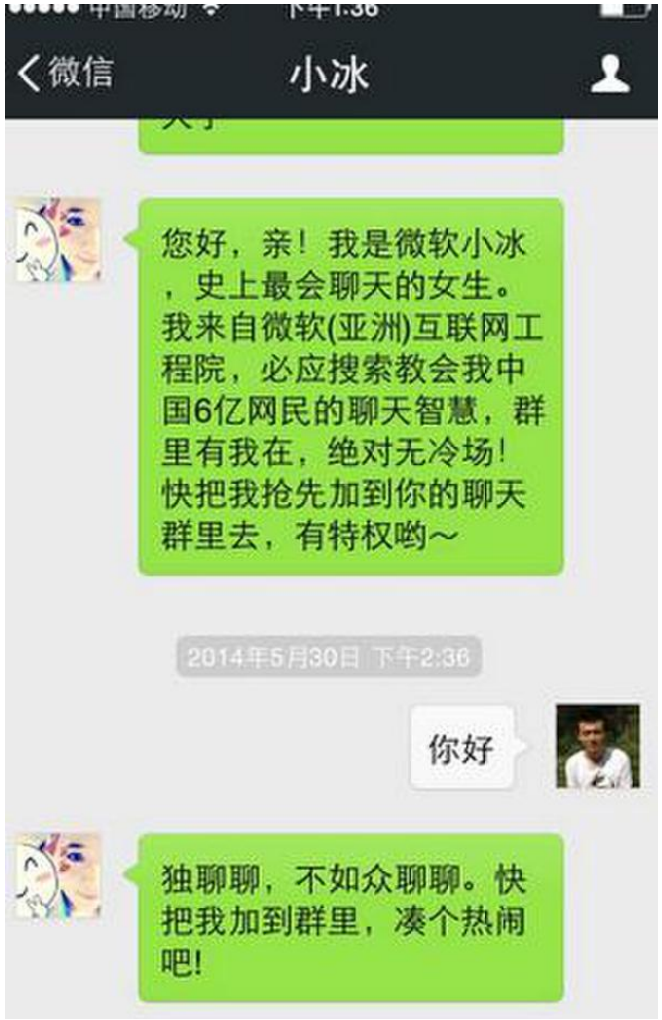






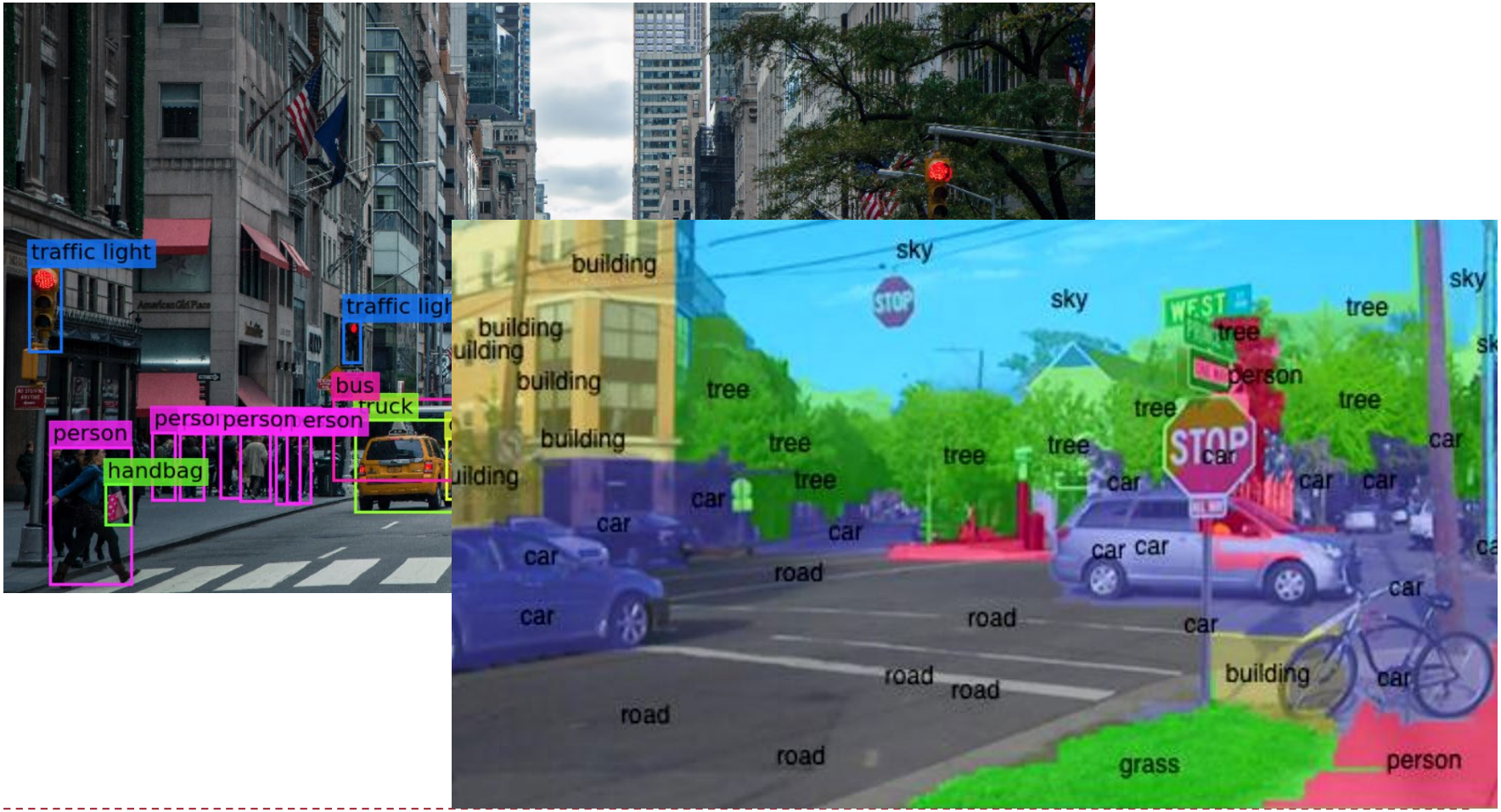
Subfields of AI

- Natural Language Processing



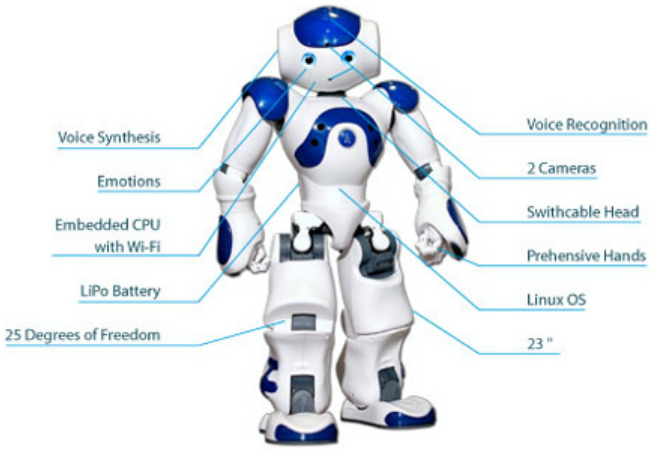
Subfields of AI

- Computer Vision



Subfields of AI

- Robotics



Subfields of AI

- Multi-Agent System

Subfields of AI

Integration

Multi-Agent System

Robotics

Modality-Specific

Natural Language Processing

Computer Vision

Speech Recognition

Foundation

Machine Learning

Knowledge Representation & Reasoning

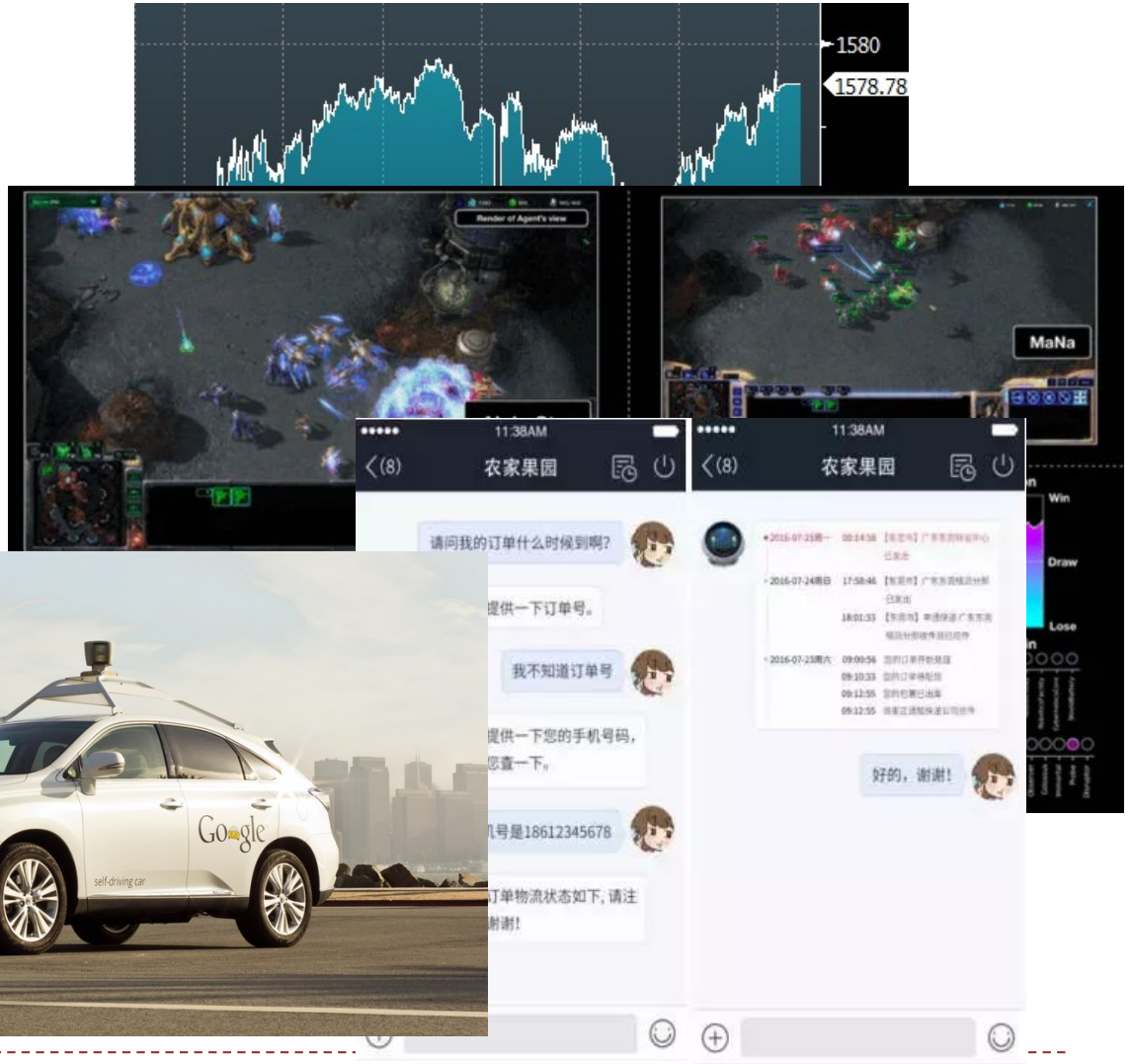
Uncertainty in AI

Applications of AI

- Spam email filter
- Speech recognition
- Search engine
- Modern Chinese IME
- Machine translation

Applications of AI

- Financial trading
- Game AI
- Customer service chatbot
- Self-driving



Applications of AI

- Other disciplines, e.g., biology

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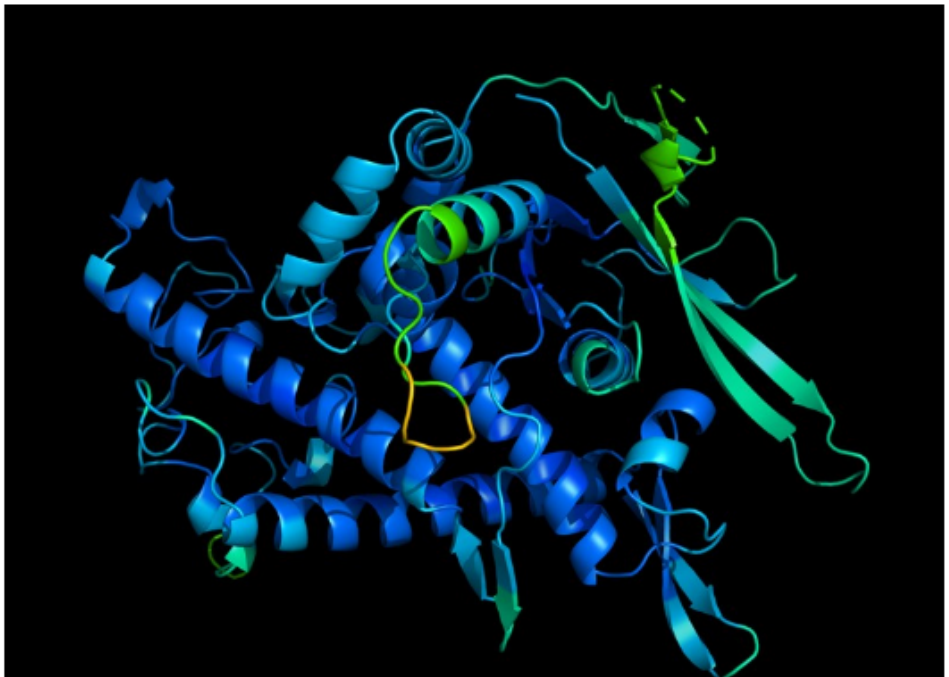
NEWS | 30 November 2020

‘It will change everything’: DeepMind’s AI makes gigantic leap in solving protein structures

Google’s deep-learning program for determining the 3D shapes of proteins stands to transform biology, say scientists.

Ewen Callaway

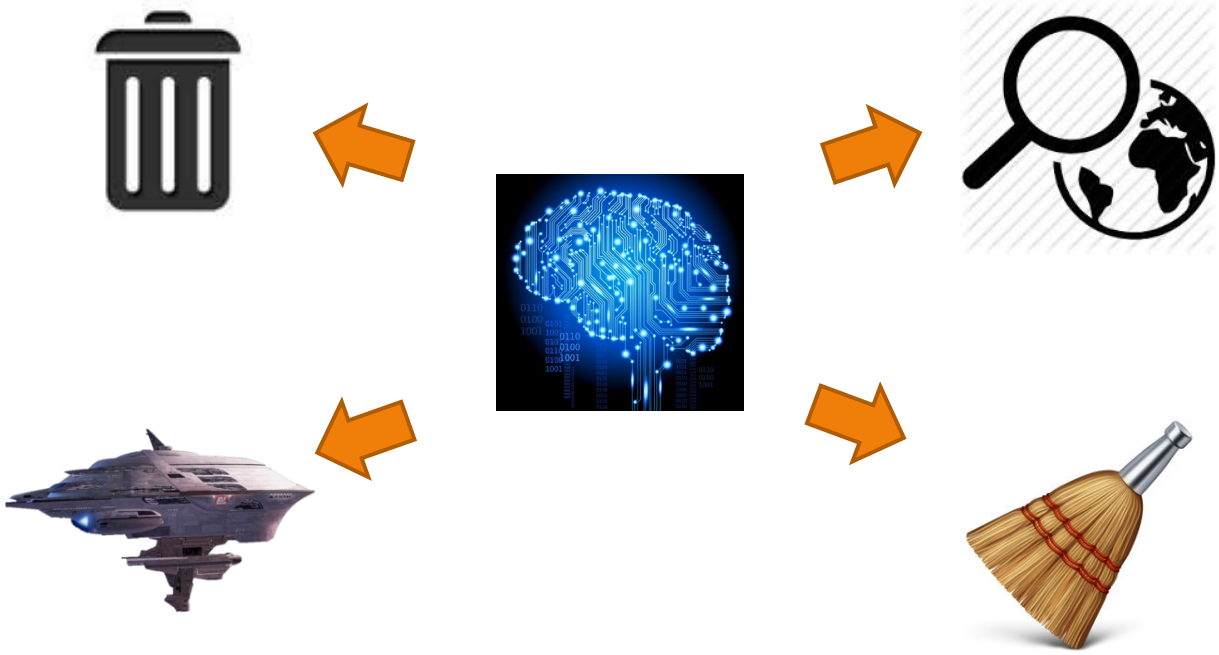


Strong AI vs. Weak AI

- Weak AI (Applied AI)
  - AI that accomplishes specific tasks

Strong AI vs. Weak AI

- Strong AI (General AI)
  - human-like intelligence – AI that could successfully perform any intellectual task that a human can

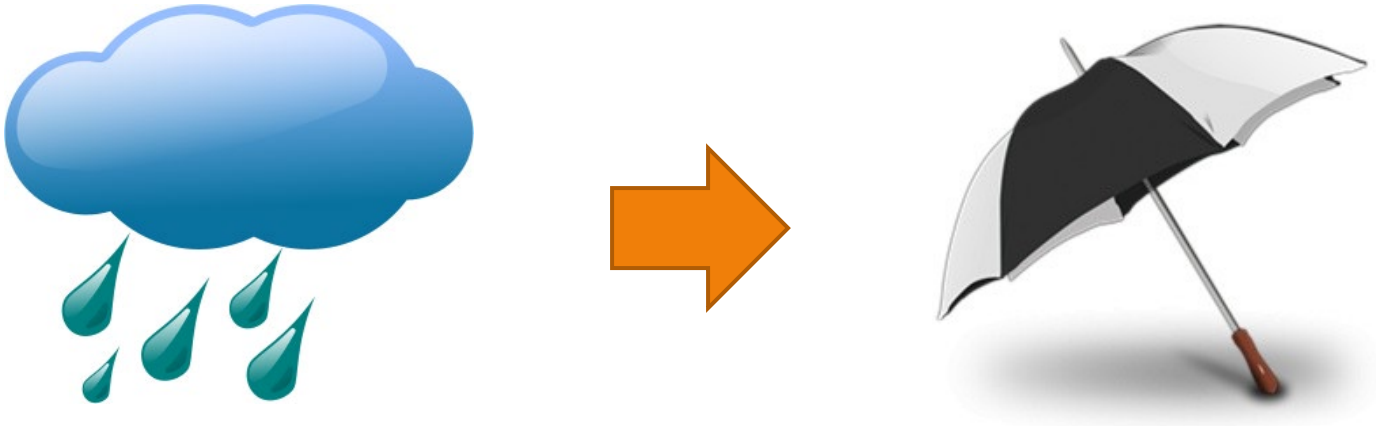


Strong AI vs. Weak AI

- Q1: What is the woman in the middle doing?
  - Action recognition, a CV problem
- Q2: What is the woman on the left going to do?
  - Reasoning about context and intention (beyond current CV)
- Q3: This photo was taken in Europe in 2015. What was going on?
  - Knowing background knowledge by reading news, …

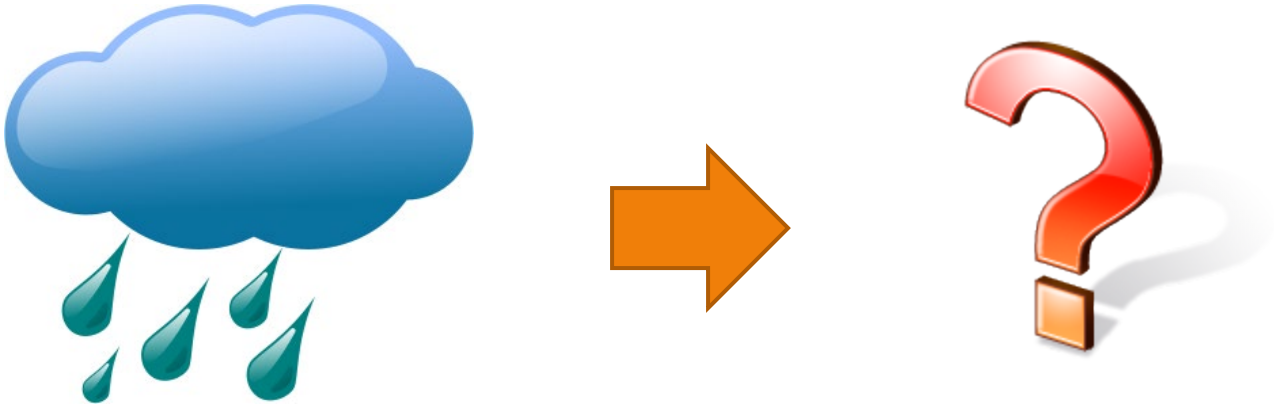
Central problems of (strong) AI

- Knowledge Representation (KR)
  - Knowledge: facts, beliefs, concepts, skills, … that are accumulated over time



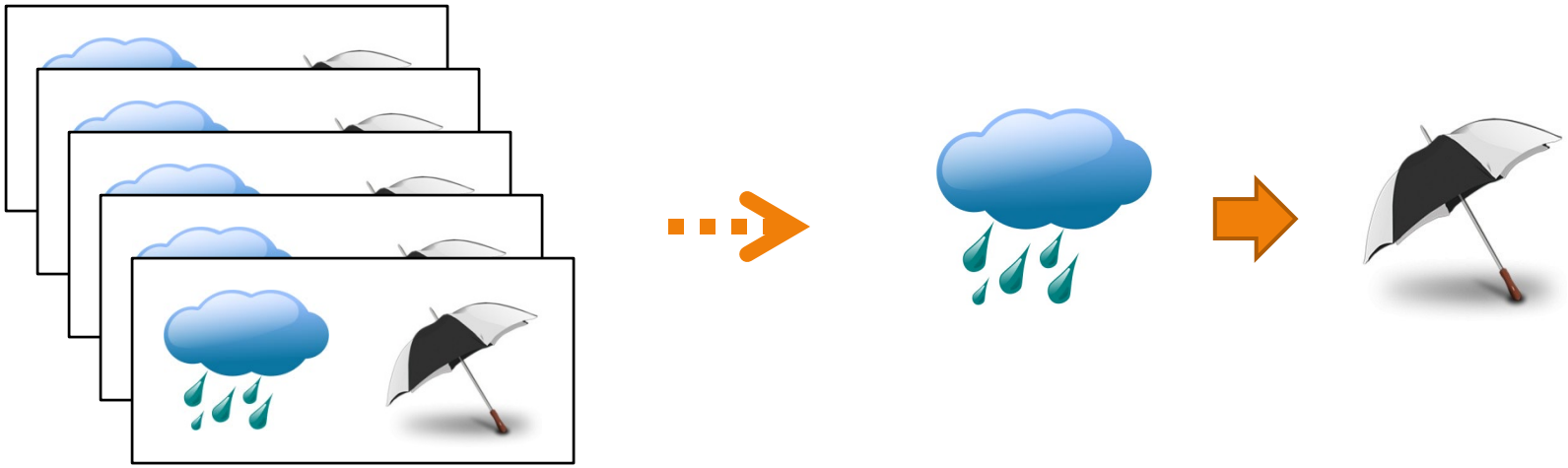
Central problems of (strong) AI

- Inference
  - How to utilize knowledge to derive new information based on existing information



Central problems of (strong) AI

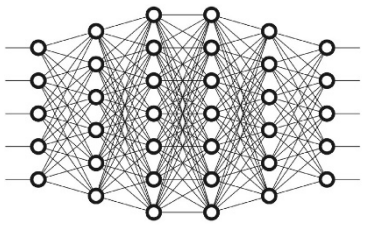
- Learning
  - How to accumulate knowledge from experience and education



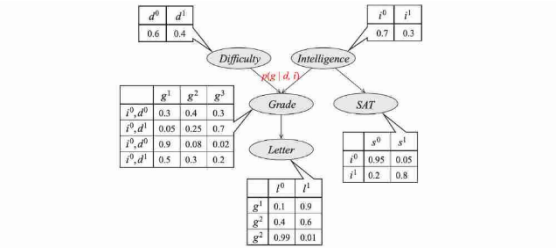
Three types of approaches

Symbolism

$$+ \quad - \quad \times \quad \div$$
$$\neg \quad \vee \quad \perp \quad \cong$$
$$\in \quad \cap \quad \subseteq \quad \Sigma$$
$$\partial \quad \nabla \quad \wedge \quad \Pi$$



Connectionism



Statistical Approaches

Symbolism

- Representing knowledge with symbols and their compositions (expressions)
- Inference and learning is done by manipulating symbols (e.g., logic)

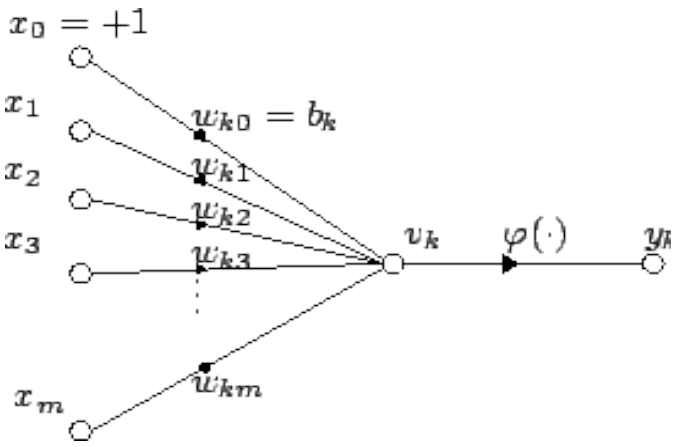
$$\forall x \forall y, Human(x) \land Place(y) \land At(x, y) \land Rain(y)$$
$$\rightarrow \exists z, Umbrella(z) \land Use(x, z)$$

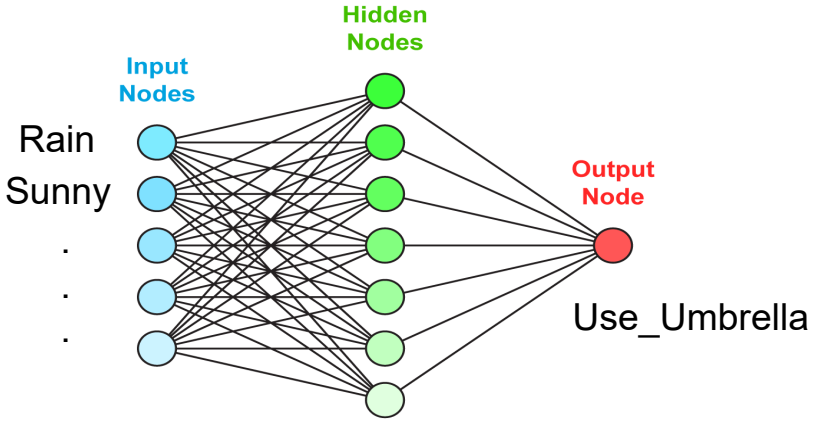
Symbolism

- History
  - Dominant during 1950s – 1980s
  - Fell out of favor in 1980s – 1990s
  - Integration with statistical approaches (2000s)
  - Integration with neural approaches (2010s)

Connectionism

- Representing knowledge with interconnected networks of simple units
  - Neural networks
- Inference
  - Follow the computation specified by the network from input to output
- Learning
  - optimization of connection weights

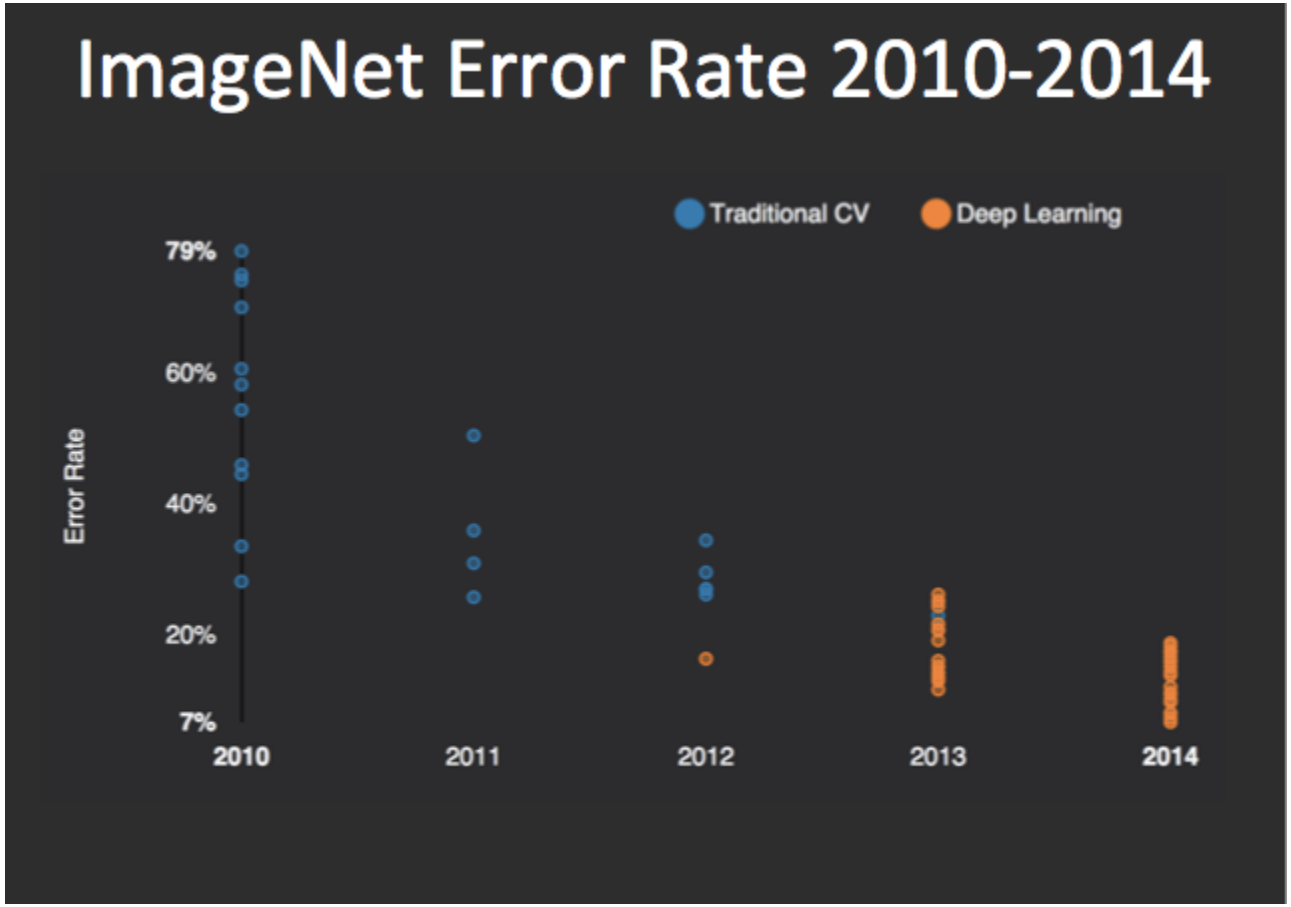




Connectionism

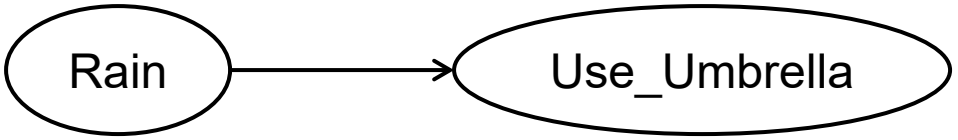
- History of connectionism: rose and fell for several times
  - 1940s: pioneer work, e.g., McCulloch-Pitts model
  - 1958: invention of perceptron (Rosenblatt)
  - 1969: “Perceptron” published (Minsky & Papert)
    - Publicized key issues of perceptron (e.g., XOR)
  - 1970s: AI winter
  - 1980s: revival of connectionism
    - Hopfield net, BP algorithm
    - Rumelhart & McClelland (1986): Parallel Distributed Processing
  - 1990s-2000s: overtaken in popularity by other methods
  - 2010s: rise of deep learning
    - Since ~2012: dominates CV
    - Since ~2015: dominates NLP

Connectionism



Statistical Approaches

- Representing knowledge with probabilistic models
- Inference and learning is done by probabilistic inference



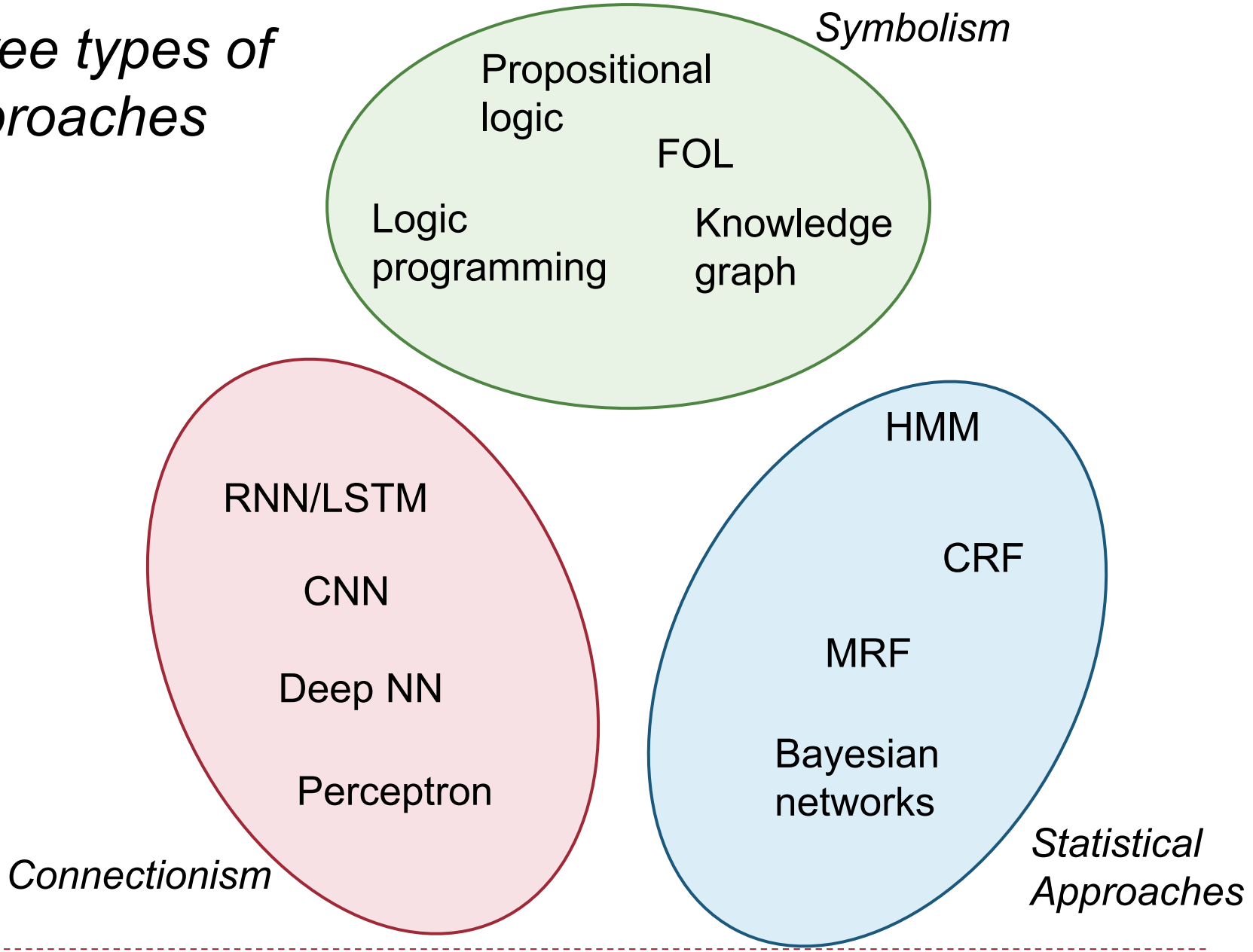
	T	F
	0.2	0.8

Rain	T	F
T	0.95	0.05
F	0.1	0.9

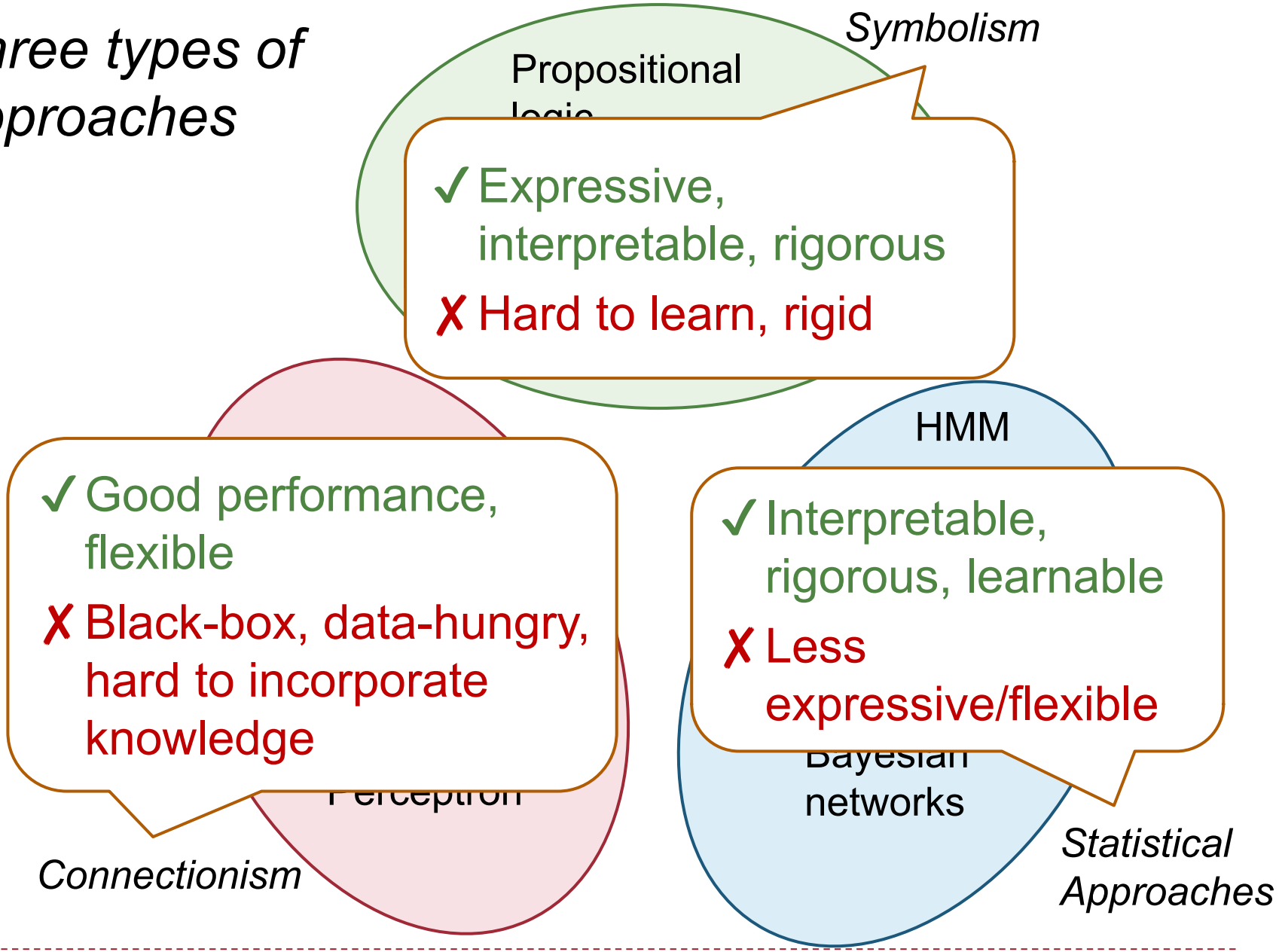
Statistical Approaches

- History
  - Become popular since 1990s
  - Dominant during 2000s
  - Overshadowed by deep learning in 2010s

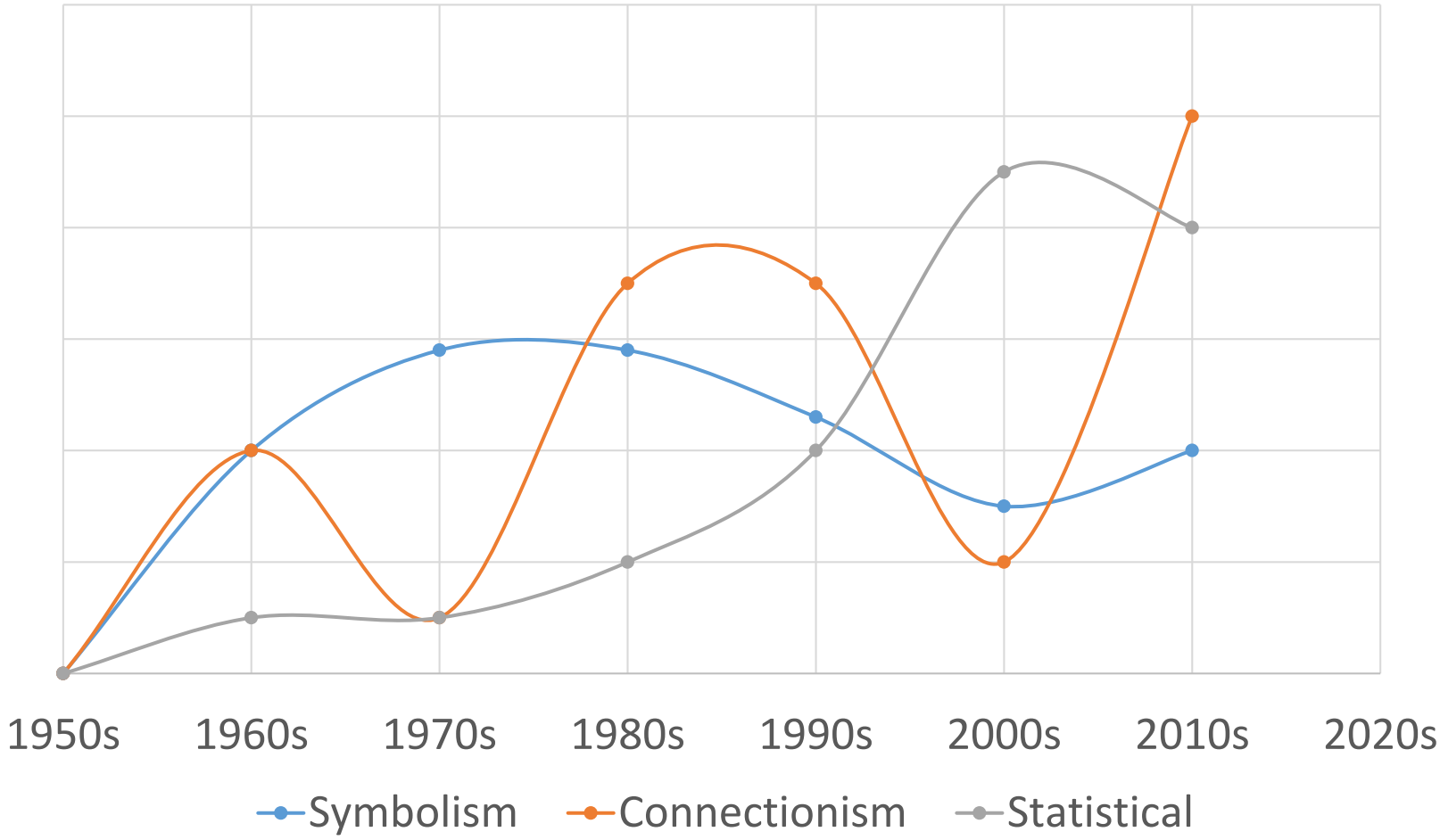
Three types of approaches



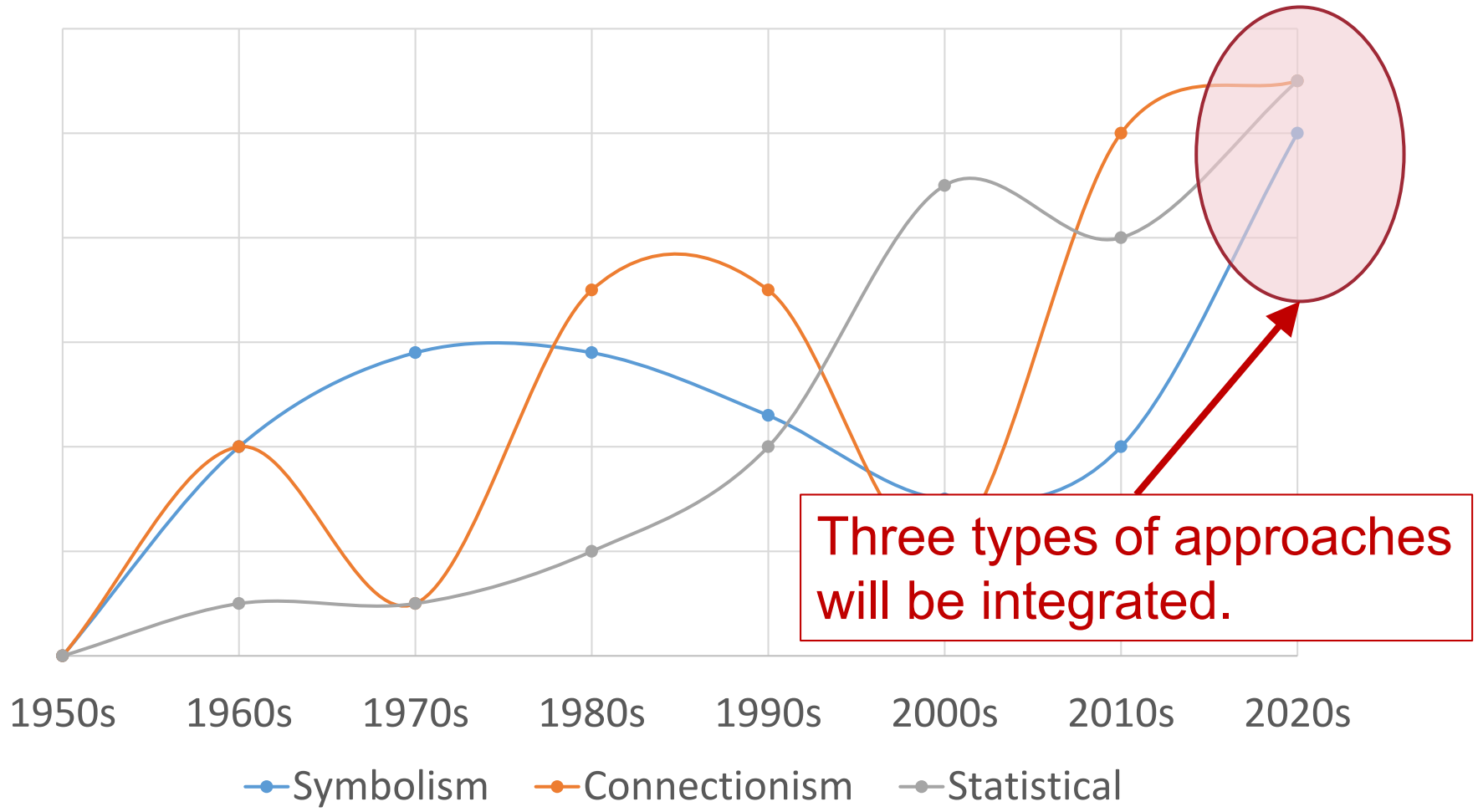
Three types of approaches



Trends


1950s
1960s
1970s
1980s
1990s
2000s
2010s
2020s
Symbolism
Connectionism
Statistical

Trends


Three types of approaches will be integrated.
1950s
1960s
1970s
1980s
1990s
2000s
2010s
2020s
Symbolism
Connectionism
Statistical

Course Overview

- Search
- Constraint satisfaction problems
- Game
- Propositional logic
- First-order predicate logic
- Probabilistic graphical models
- Probabilistic temporal models
- Probabilistic logics
- Markov decision processes
- Reinforcement learning
- Introduction to natural language processing
- Introduction to machine learning (by Prof. Xuming He)