A. I. for All Bootcamp

rtificial ntelligence

Research and Industrial Conclave 2023

About Us

PhD Scholars, IITG

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Mechanical

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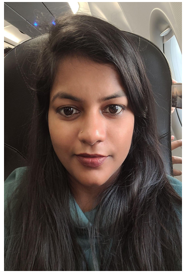

Shifali Agrahari
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Brijesh Yadav
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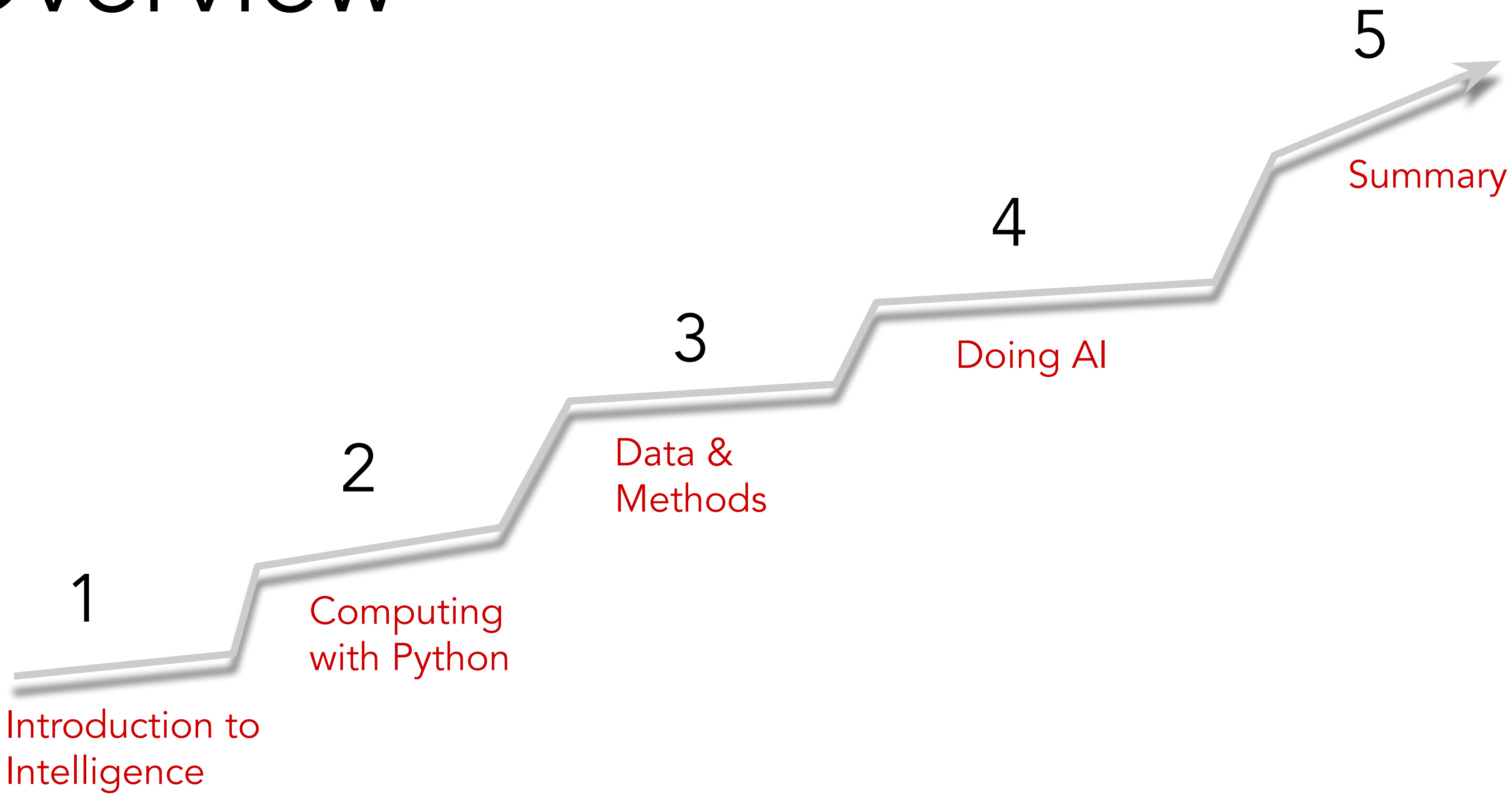
Faculty, IITG

Neeraj Sharma

Overview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Introduction to Intelligence
2
Computing with Python
3
Data & Methods
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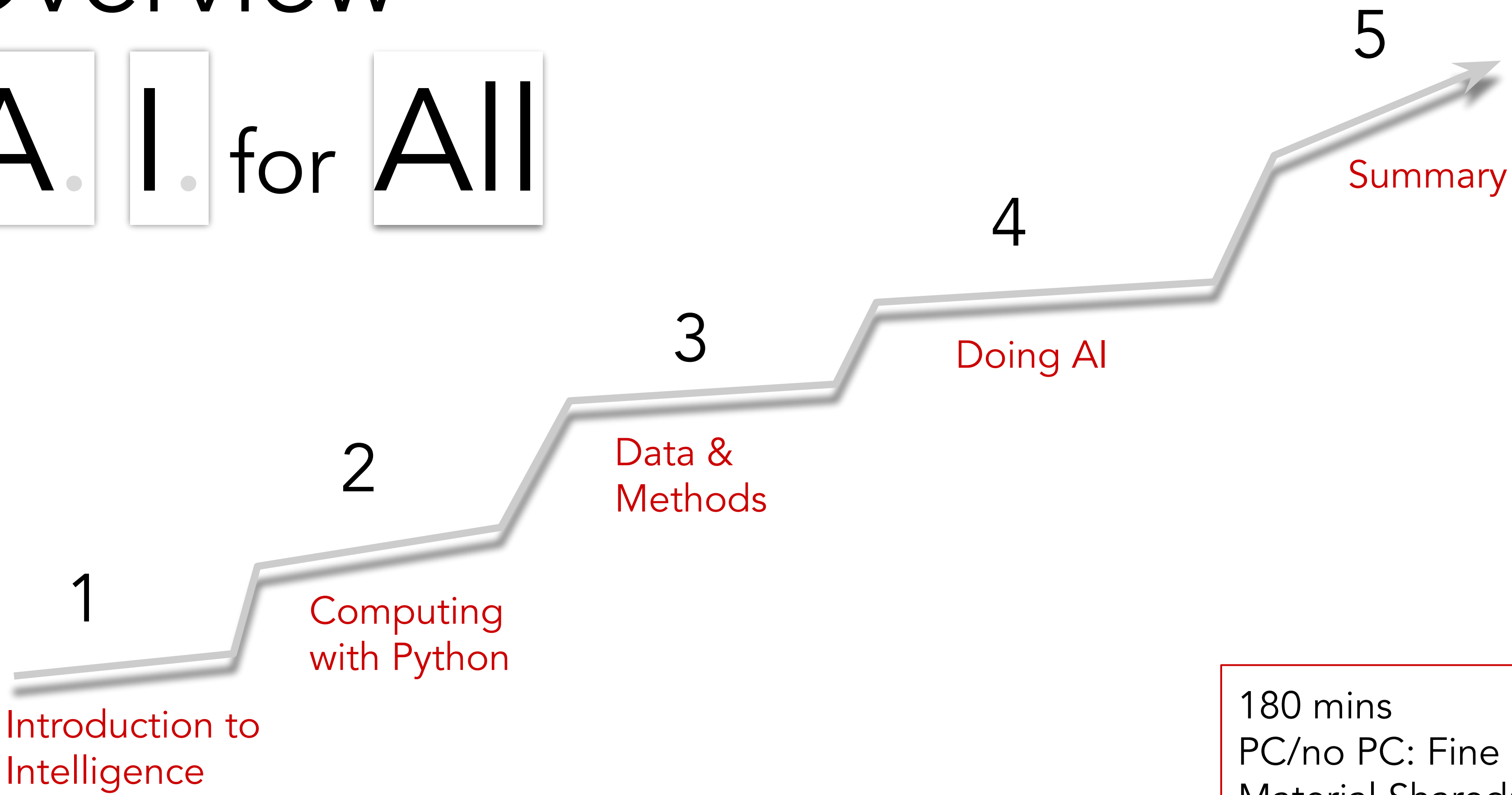
Doing AI
5
Summary

Overview

A. I. for All



180 mins
PC/no PC: Fine
Material Shared: Yes

Let’s begin …

Introduction to Intelligence

By Neeraj Sharma

Contents

Intelligence

Ability to make predictions

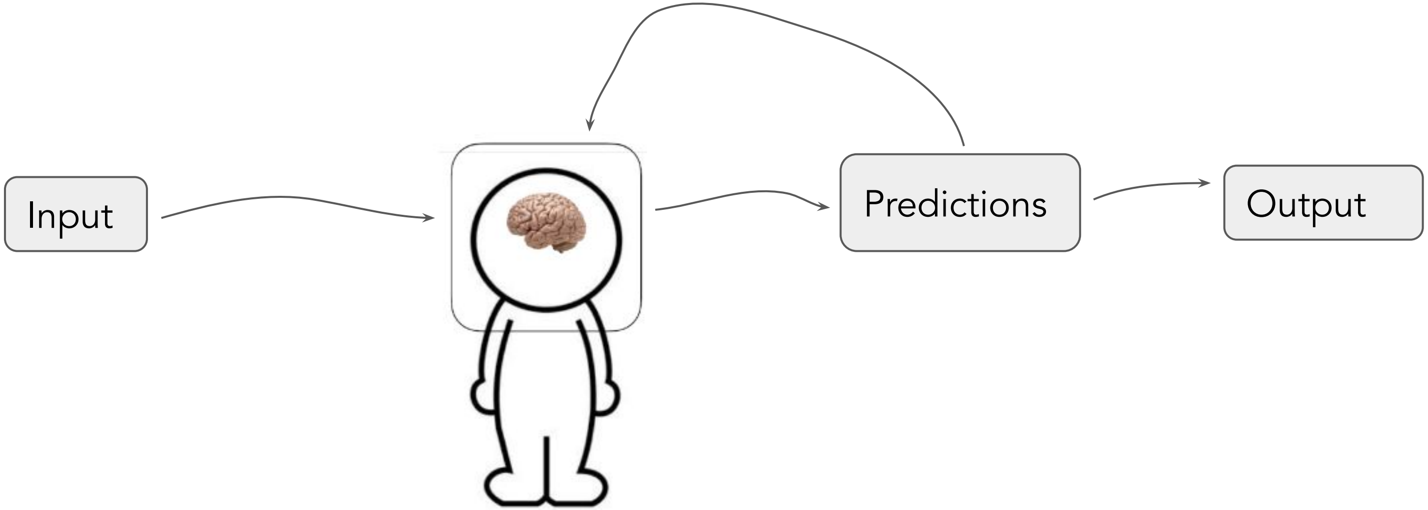
Intelligence

Soundscape

Visual
Imagery

Ability to make predictions

Let's understand from the context of humans.



Intelligence

<u>Ability</u> to make <u>predictions</u>

Input

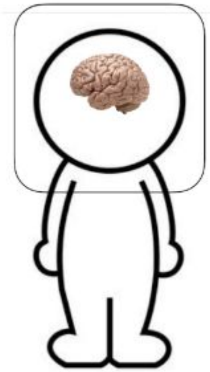
Soundscape

Visual Imagery

Somatosensory
(touch, temperature, …)

Olfactory

and more…

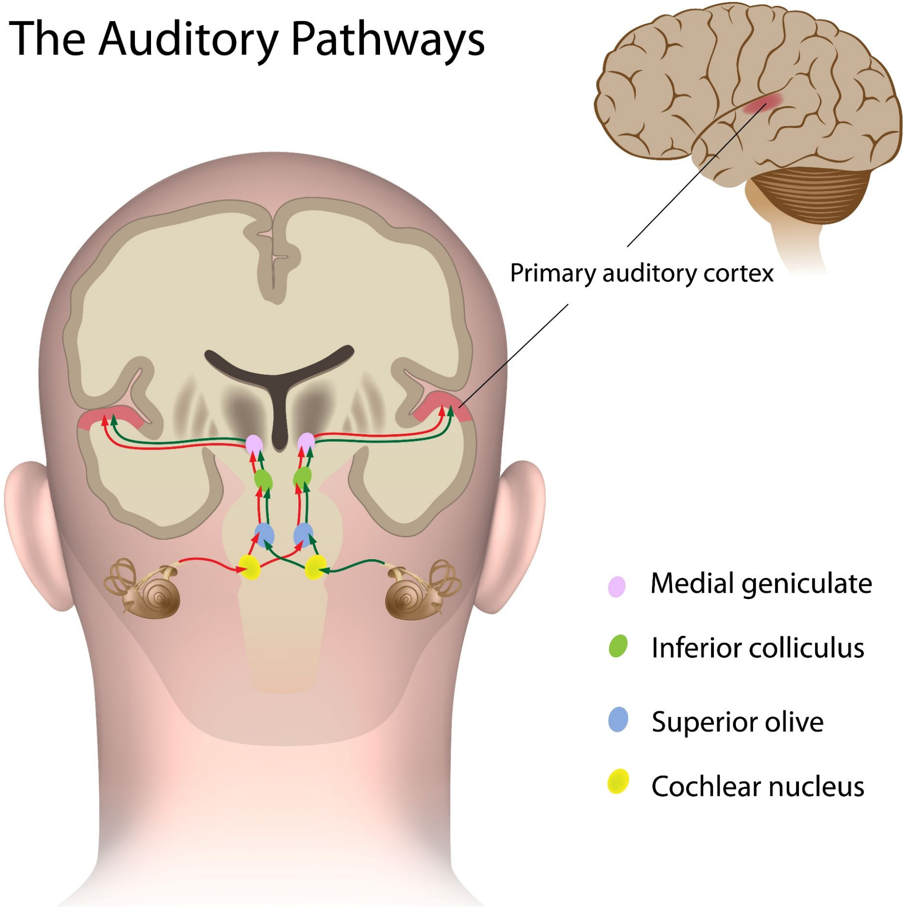


Sensing

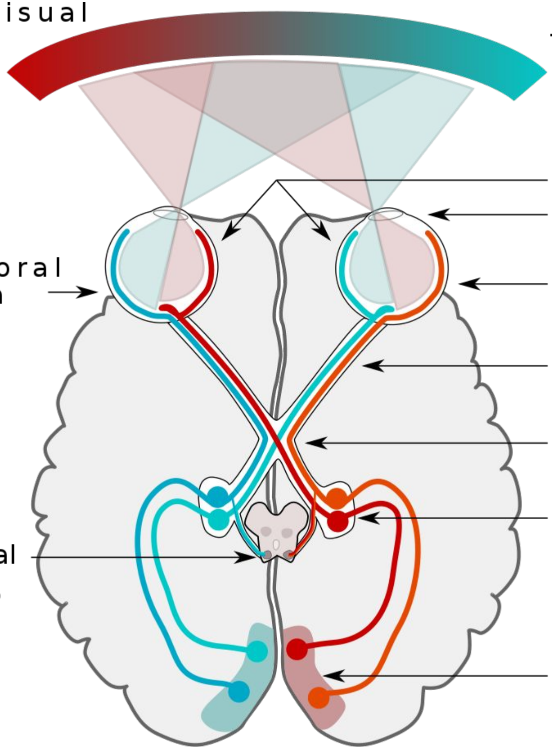
Input → Sensors

Soundscape
Visual Imagery
Somatosensory
(touch, temperature, …)
Olfactory
and more…

The Auditory Pathways



Sensing


Left visual field
Right visual field
Nasal retina
Optical lens
Temporal retina
Eye
Temporal retina
Optic nerve
Optic chiasma
Lateral geniculate nucleus (LGN)
Pretectal nucleus
Primary visual cortex

Variations in signals

Soundscape

Visual Imagery

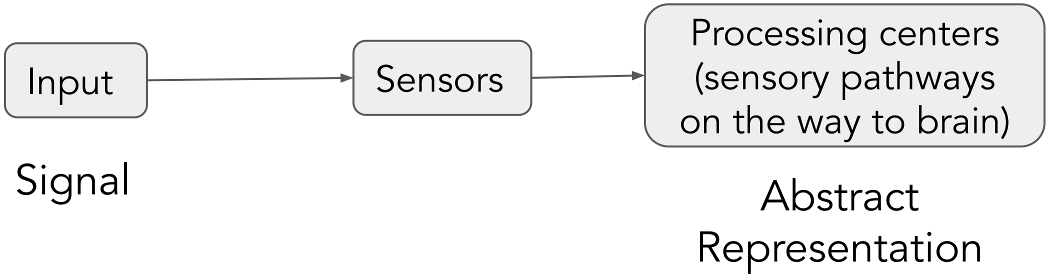
Somatosensory
(touch, temperature, …)

Olfactory

and more…

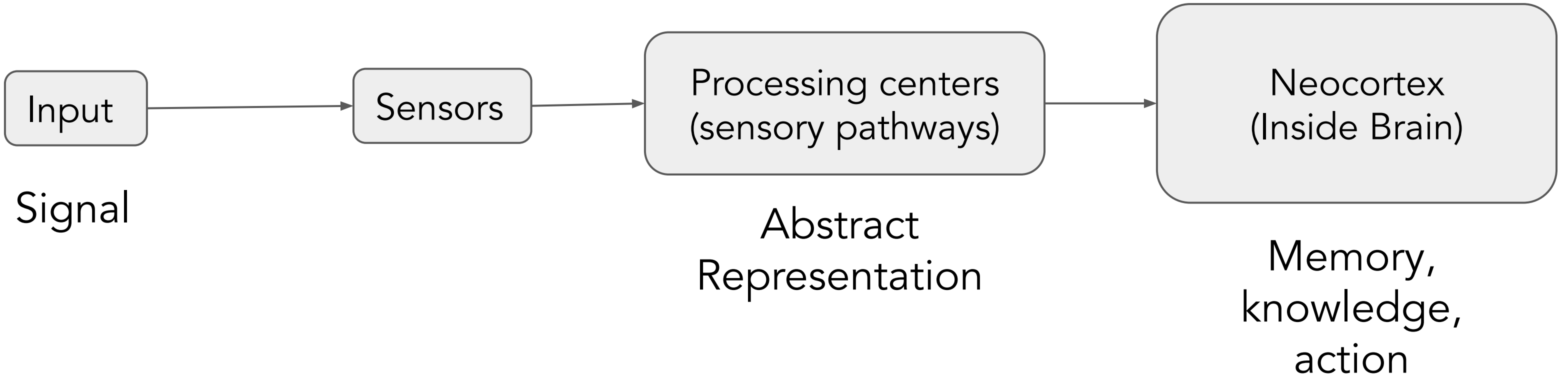
Most signals sensed by us show a spatio-temporal variation

Representation



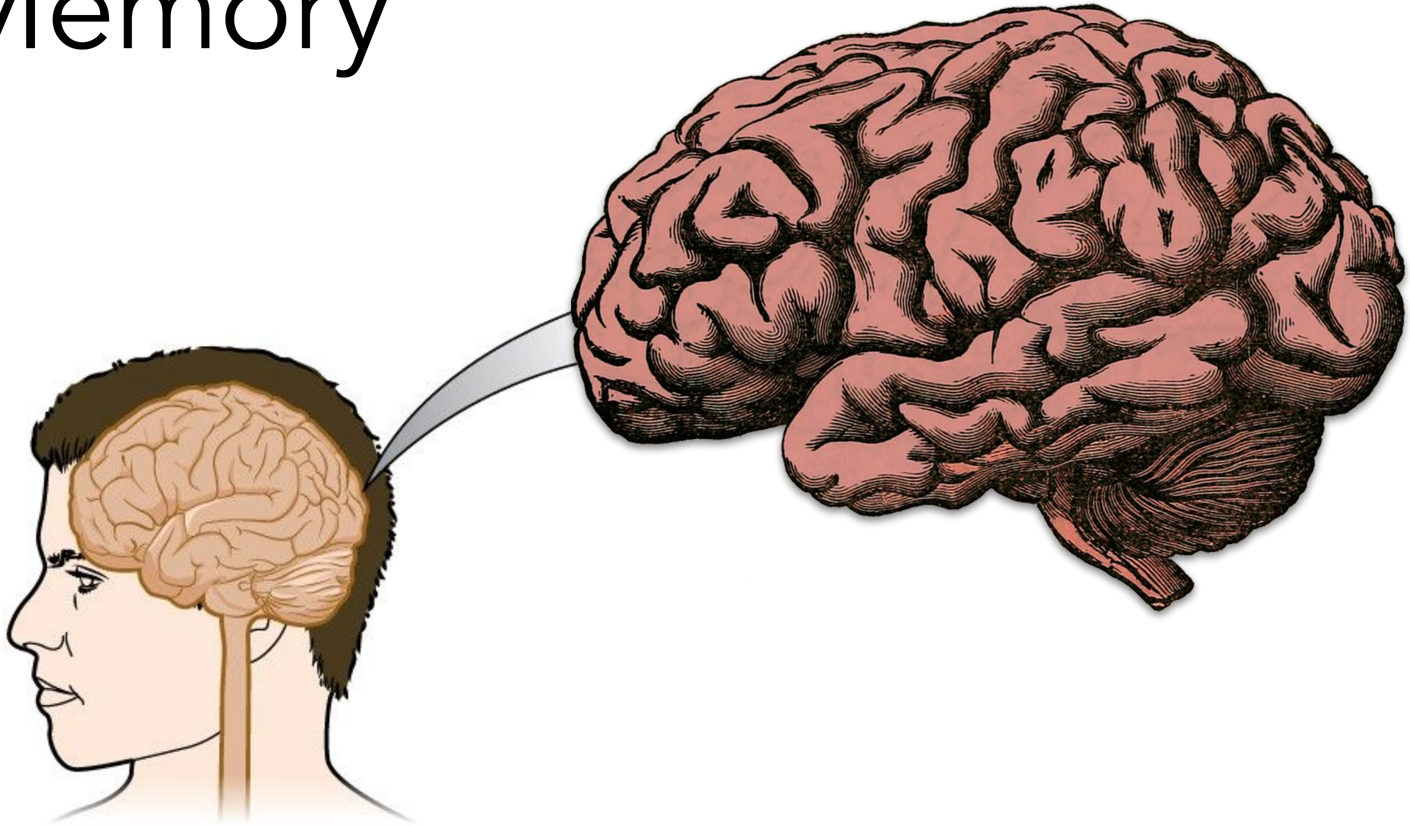
- Invariant representation of signals

Representation



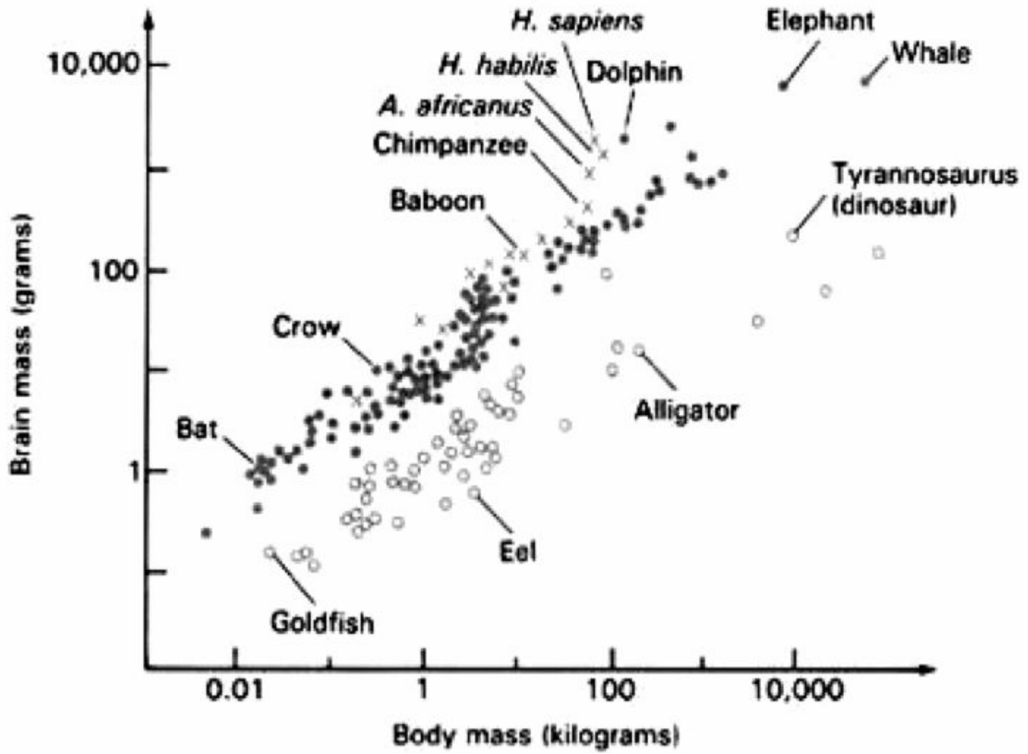
- Invariant representation of signals
- Storage of sequence of patterns
- Hierarchical storage of patterns
- Recalling patterns auto-associatively

Memory



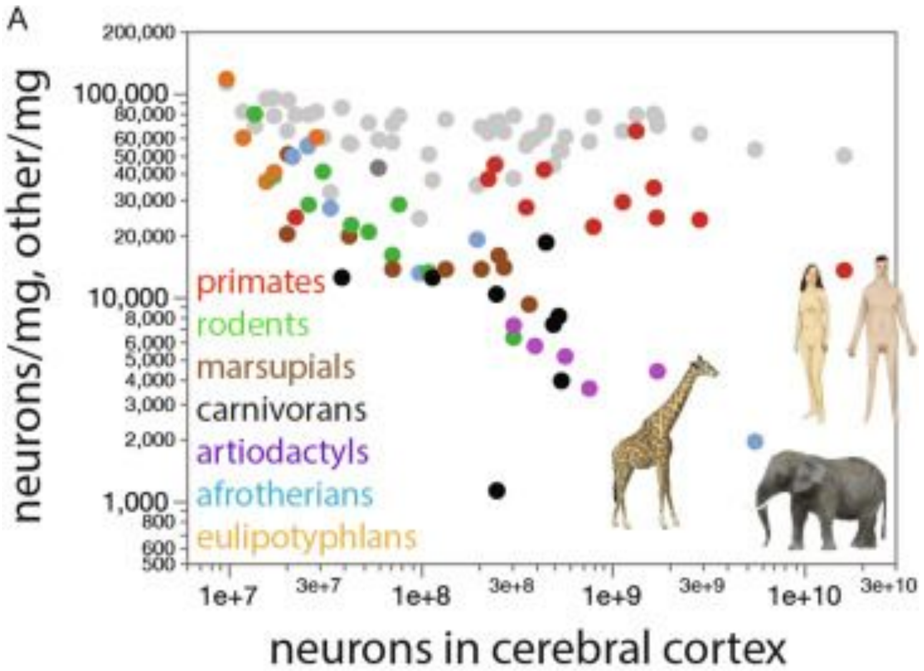
[Image Source: National Institutes of Health]

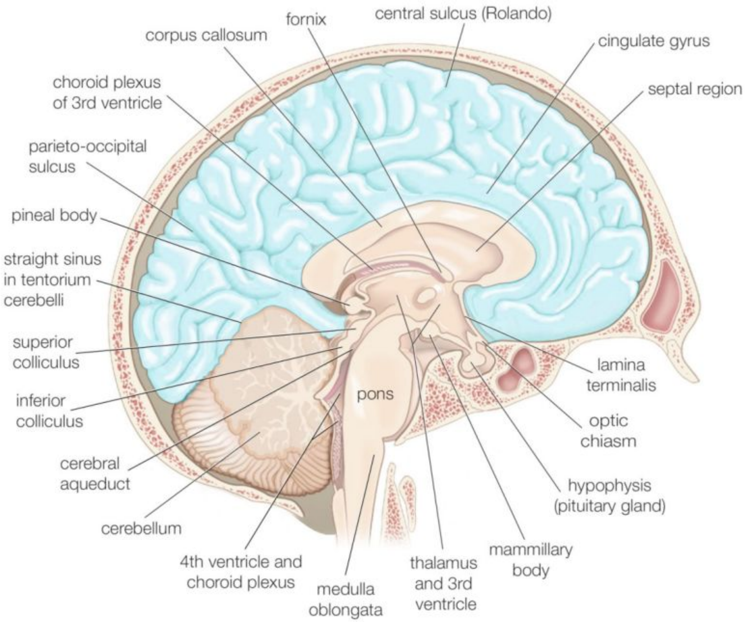
Brain size across animals



[Image Source: National Institutes of Health]

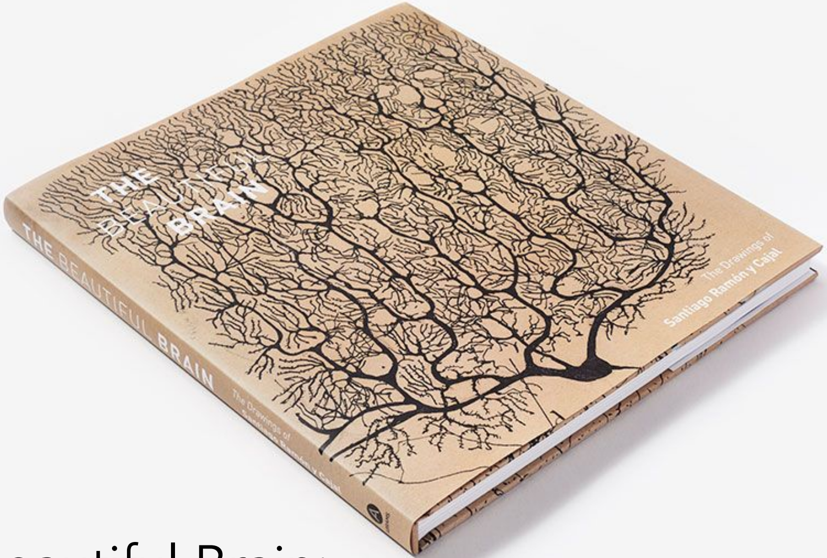
Neuron count





Ref: https://doi.org/10.1016/bs.pbr.2019.06.001

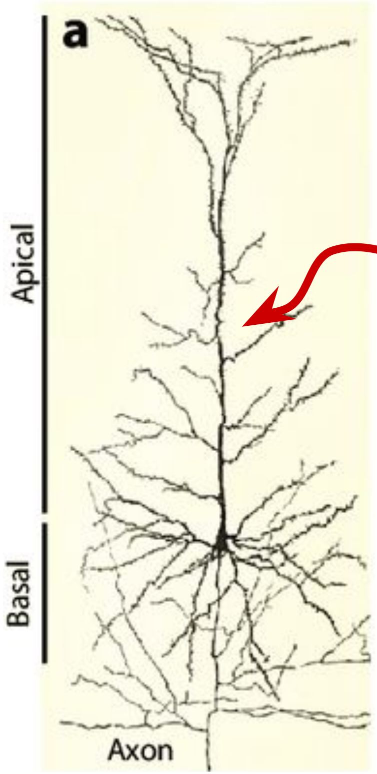
Zooming into brain tissue



The Beautiful Brain:
The Drawings of Santiago Ramon y Cajal

Spain, 1906 Nobel Prize in Physiology

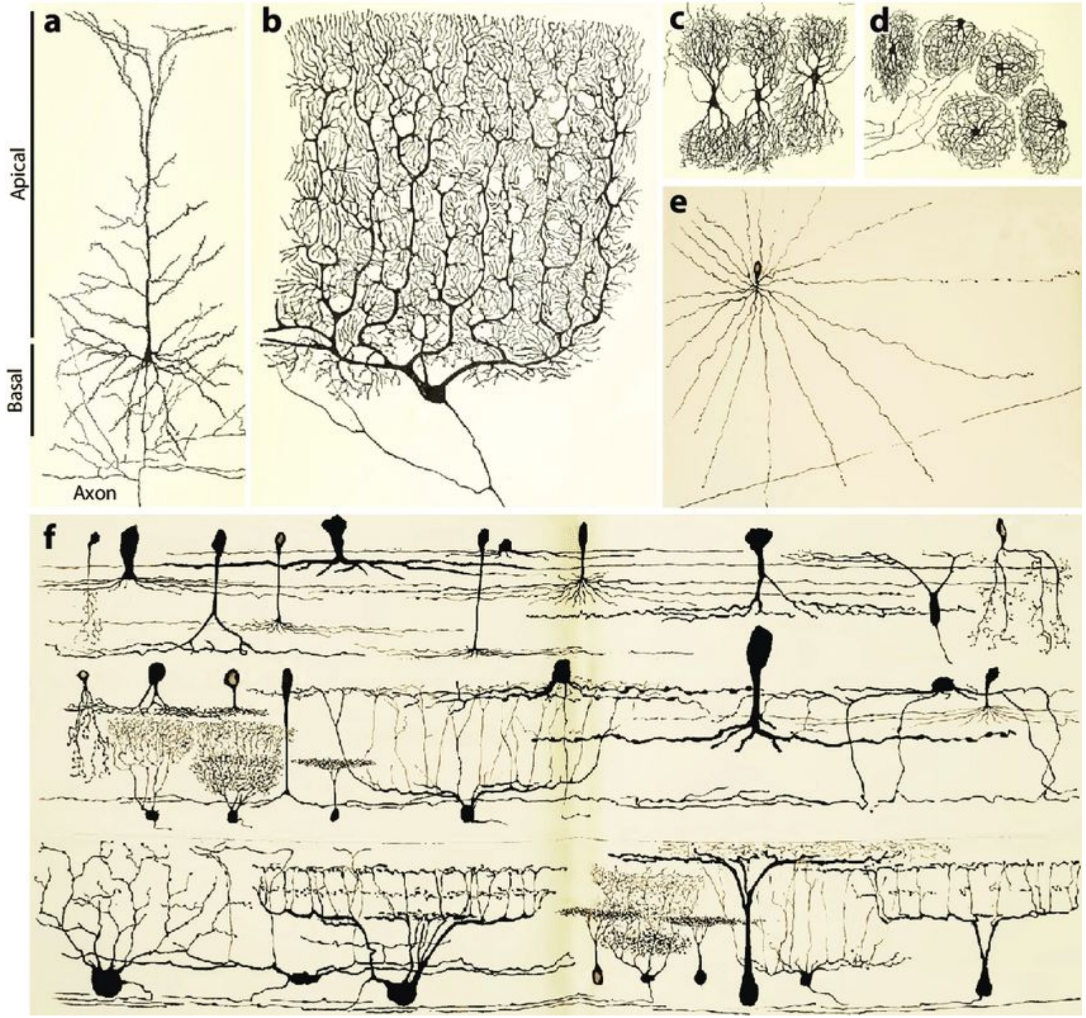
Zooming into brain tissue



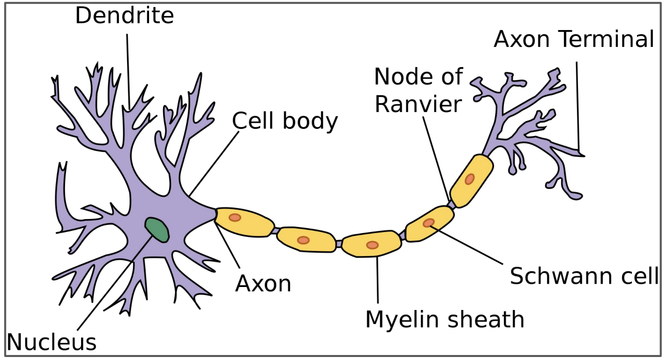
Cell - referred to as Neuron

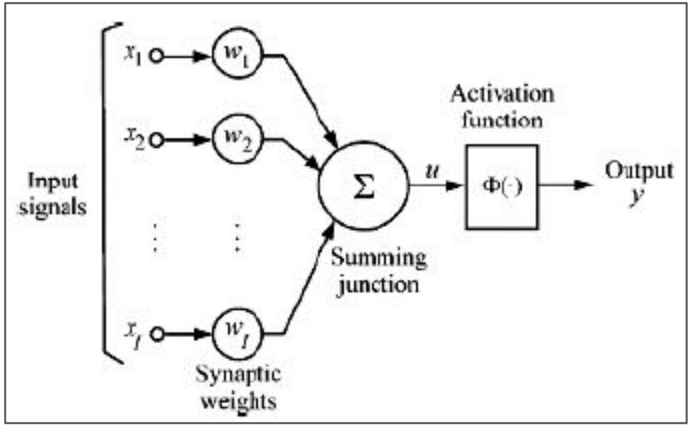
Neurons

- Neurons of different types.
- Some more in count than others
- Distributed in a layer-wise fashion



Modeling does a neuron do





Intelligence - Human view

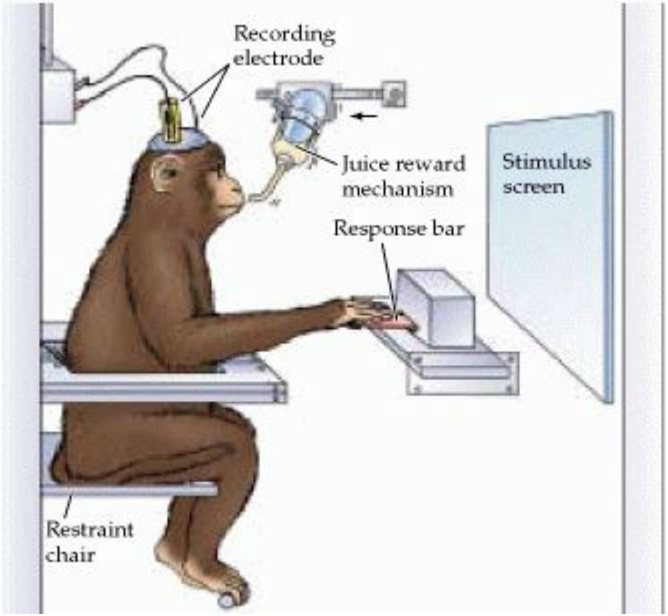
- Brain uses vast amounts of neurons to build memory of a “world model”
- This memory helps predict future events
- <u>Ability to make these prediction is intelligence</u>

Location

- Neocortex is the seat for memory and processing of this memory
- Different parts responsible for touch, vision, hearing, or language etc.
- One algorithm for all processing

Understanding Intelligence

Invasive experiments



Understanding Intelligence

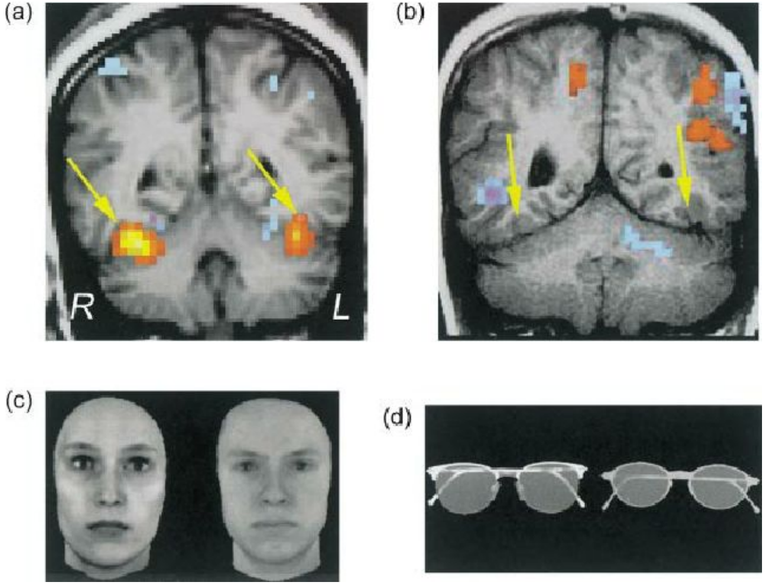
Invasive experiments

a

Understanding Intelligence

Non-invasive experiments

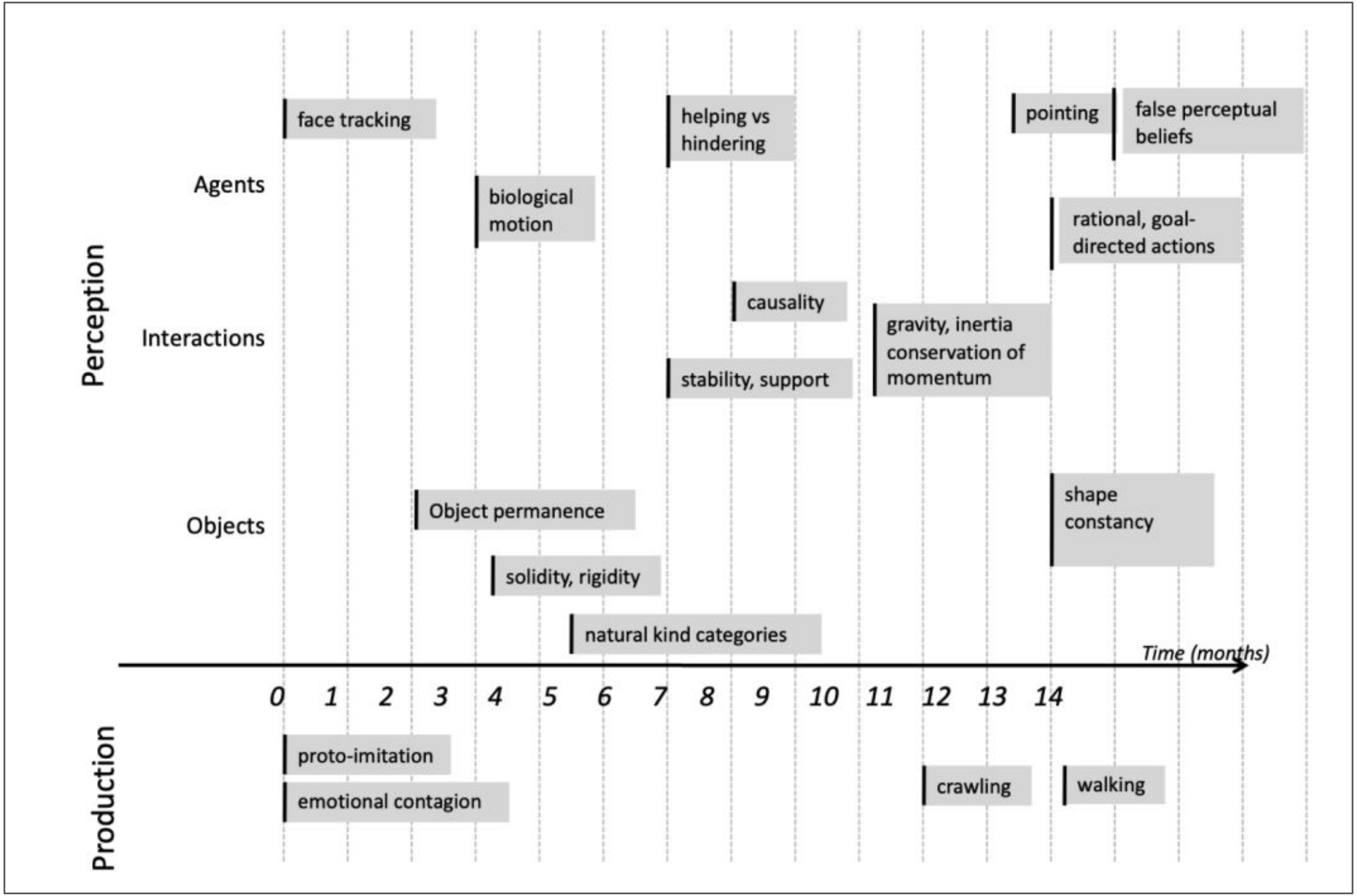
EEG, MEG, MRI experiments



Understanding Intelligence

Non-invasive experiments
Behavioral psychology experiments

Instagram filters - what do design



E. Dupoux et al., IntPhys 2019: A Benchmark for Visual Intuitive Physics Understanding, IEEE PAMI, 2022

Artificial Intelligence

What going on Earth?

Google books

About Google Books
- Overview

Google Books Library Project – An enhanced card catalog of the world's books

Google books

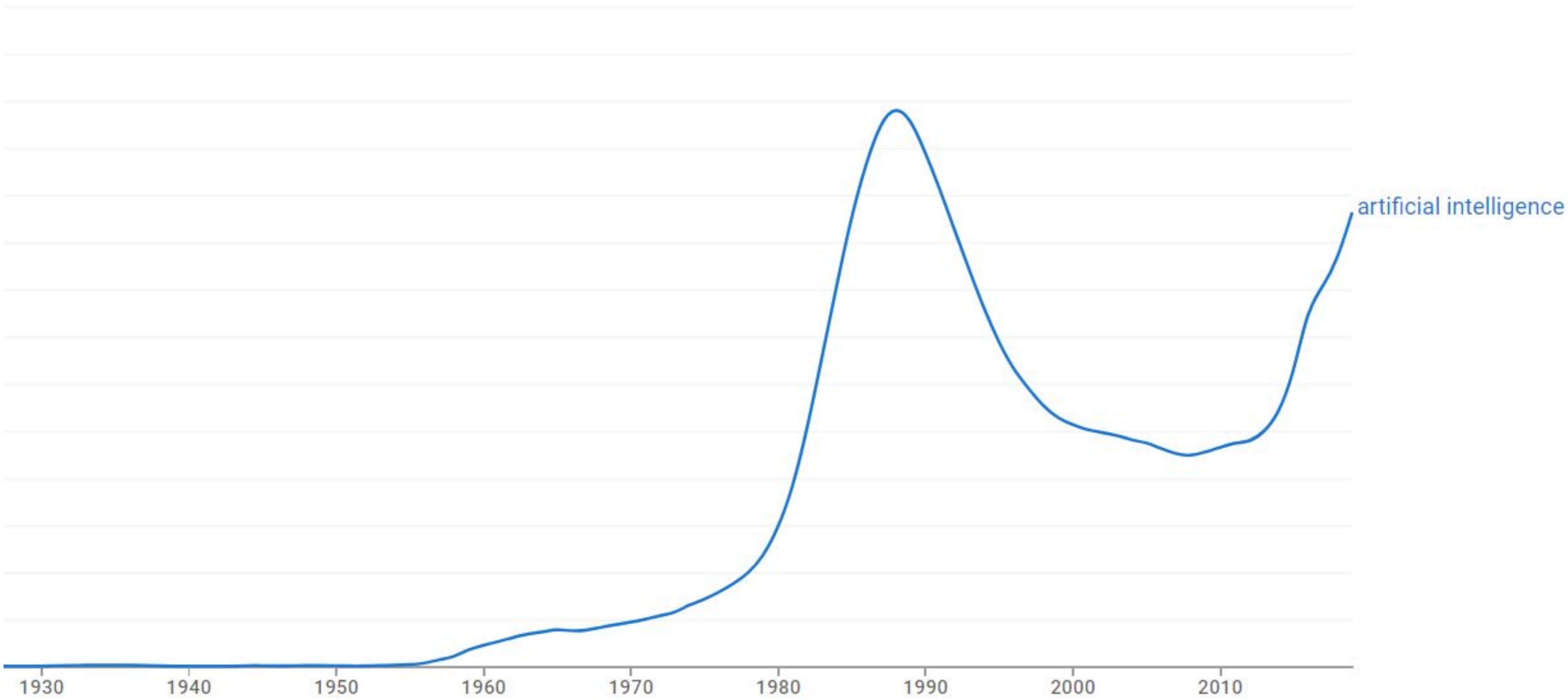
About Google Books
• Overview

Google Books Library Project – An enhanced card catalog of the world's books

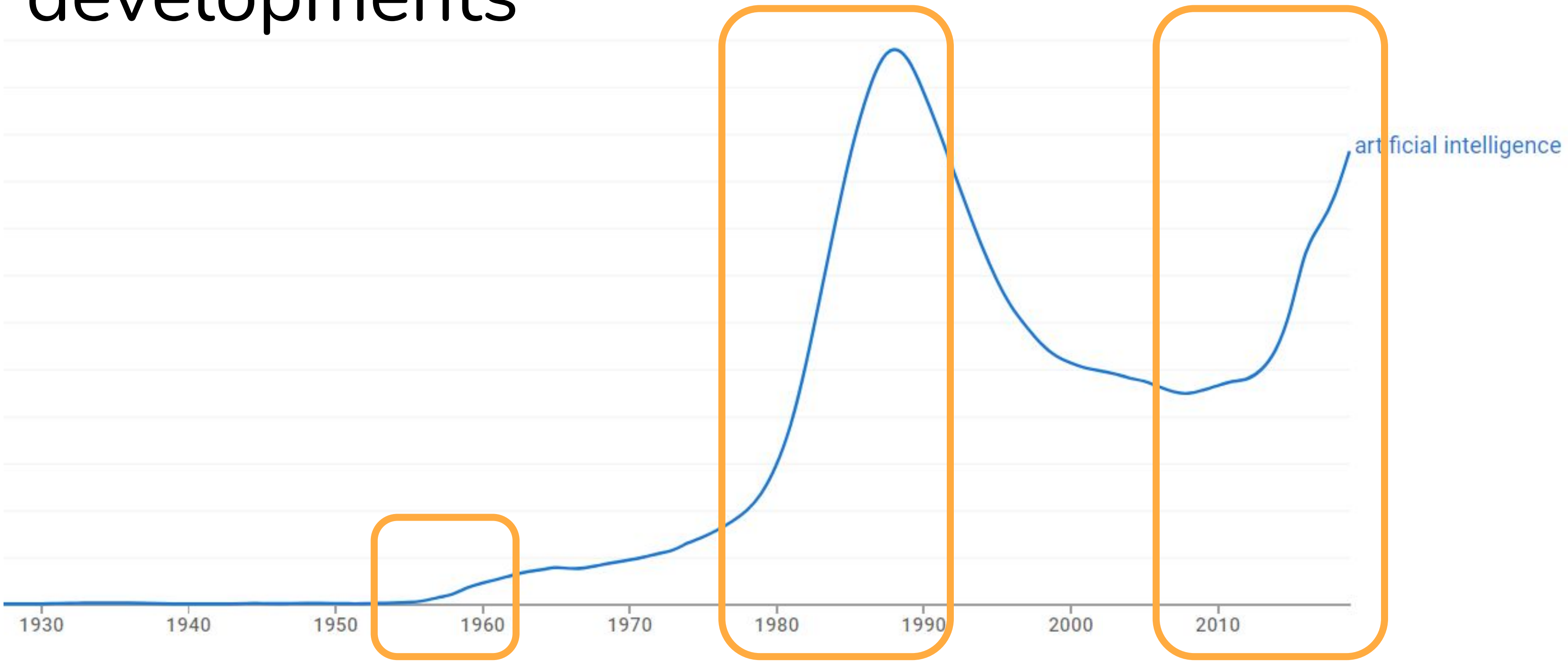
Google Books Ngram Viewer

artificial intelligence

1800 - 2019 ▾ English (2019) ▾ Case-Insensitive Smoothing ▾

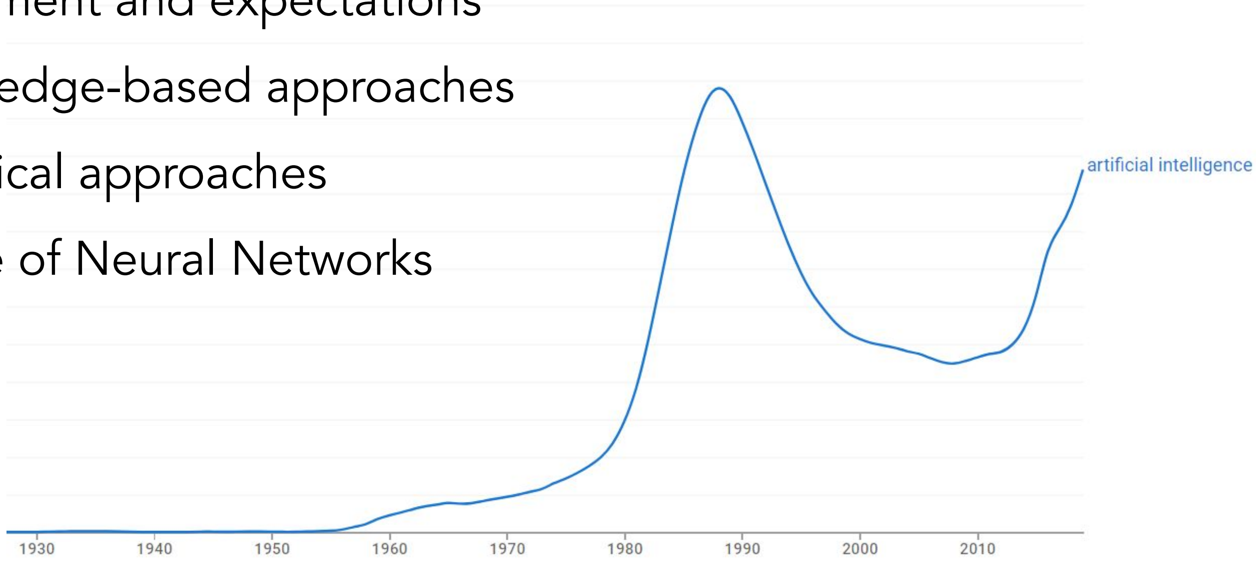

artificial intelligence
1930
1940
1950
1960
1970
1980
1990
2000
2010

Phases of AI developments



AI History

- 1940 - 1950: Early days
- 1950 - 1970: Excitement and expectations
- 1970 - 1990: Knowledge-based approaches
- 1990 - 2005: Statistical approaches
- 2005 - Present: Rise of Neural Networks



1940-1950: Early days

1940-1950: Early days

- McCulloh and Pitts: Boolean circuit model of brain
- Turing's work on computing machines and defining intelligence

1950-1969: Excitement

- 1950s: Early AI programs demonstrating success in games like checkers program
- 1956: Dartmouth meeting:"Artificial Intelligence" term used
- 1958: Rosenblatt invents the perceptron
  - Lot of hype and excitement!
- 1965: Robinson's complete algorithm for logical reasoning
- 1966-1974: AI discovers computational complexity

By the 1970s, however, AI research ran into some strong headwinds. In the United States, Defense Advanced Research Projects Agency (DARPA) funding had been substantially reduced from its 1960s levels.[5] And in 1973, the United Kingdom saw the publication of the Lighthill report, in which Sir James Lighthill, Lucasian Professor of Mathematics at Cambridge University, argued that AI's "grandiose objectives" remained largely unmet, and called for a virtual halt to all AI research in Britain.[6]

1970-1990: Knowledge-based approaches

- 1969: Neural network research almost disappears after a paper by Minsky and Papert
- 1969-1979: Early development of knowledge-based systems
- 1980-1988: Expert systems industrial boom

1990-2005: Statistical Approaches

- 1985 - 1995: Neural networks continue crawling
- 1988 - 2000: Probability, analysis, theoretical bounds, VC dimensions, SVMs
- 1988-: Bayesian approach continues to crawl

another, led to uncannily capable behavior. Writing for *Time* magazine in 1996, Kasparov observed: "I had played a lot of computers but had never experienced anything like this. I could feel – I could smell – a new kind of intelligence across the table."[11] Our attribution of intelligence to the machine is a recurrent feature

2000 - : Data, Compute, Open-source revolution

- 2000 - : Training multi-layer neural networks (GPUs)
- 2000 - : Internet boom - lots of data
- 2010 - : Open source code, develop and share

Forms of doing AI

Symbolic AI Rule first -“Learning or any other feature of intelligence can be so precisely described in terms of rules (and logic) that a machine can be made to simulate it”

Statistical AI Math first - Probability and everything around it

Neural Networks AI Results first

Future direction of AI

sibilities. We need to continue to interrogate our understanding of the concept of intelligence. For the foreseeable future, no variety of AI will have a reasonable claim to a sufficient range of attributes for us to ascribe them general intelligence. But this cannot be an in-principle embargo.

"From So Simple a Beginning": Species of Artificial Intelligence

Nigel Shadbolt

Summary

- Developments have been happening since 1900s
    - Neuronal networks: work of Santiago Ramóny Cajal
    - McCulloh and Pitts circuit model for neuron
    - Turing’s Test and theory for computing
    - …
- These developments can be identified with rise, fall, rise of interest in building AI agents
- Glimpse of the timeline: 1940s to now
- Understanding intelligence is a multidisciplinary topic
- We are in times when AI development is again on the rise!

Knowledge Engineering for Medical Decision Making: A Review of Computer-Based Clinical Decision Aids

EDWARD H. SHORTLIFFE, BRUCE G. BUCHANAN, AND EDWARD A. FEIGENBAUM

Abstract—Computer-based models of medical decision making account for a large portion of clinical computing efforts. This article reviews representative examples from each of several major medical computing paradigms. These include 1) clinical algorithms, 2) clinical databanks that include analytic functions, 3) mathematical models of physical processes, 4) pattern recognition, 5) Bayesian statistics, 6) decision analysis, and 7) symbolic reasoning or artificial intelligence. Because the techniques used in the various systems cannot be examined exhaustively, the case studies in each category are used as a basis for studying general strengths and limitations. It is noted that no one method is best for all applications. However, emphasis is given to the limitations of early work that have made artificial intelligence techniques and knowledge engineering research particularly attractive. We stress that considerable basic research in medical computing remains to be done and that powerful new approaches may lie in the melding of two or more established techniques.

I. Introduction

AS EARLY as the 1950's, physicians and computer scientists recognized that computers could assist with clinical decision making [63] and began to analyze medical diagnosis with a view to the potential role of automated decision aids in that domain [61]. Since that time a variety of techniques have been applied, accounting for at least 800 references in the clinical and computing literature [112]. In this article

1979

Published: 06 October 2005

Robots rev up for Grand Challenge

Mark Peplow

Nature (2005) | Cite this article

25 Accesses | Metrics

They're back, and this time they actually work.

Robots, start your engines. A US$2-million prize awaits the first autonomous vehicle to complete a high-speed cross-country trek this weekend, over some 240 kilometres of rough terrain.

YouTube: DARPA Grand Challenge: First Round

2005

AI beats human champ in board game GO

Published: 27 January 2016

Mastering the game of Go with deep neural networks and tree search

David Silver, Aja Huang, Chris J. Maddison, Arthur Guez, Laurent Sifre, George van den Driessche, Julian Schrittwieser, Ioannis Antonoglou, Veda Panneershelvam, Marc Lanctot, Sander Dieleman, Dominik Grewe, John Nham, Nal Kalchbrenner, Ilya Sutskever, Timothy Lillicrap, Madeleine Leach, Koray Kavukcuoglu, Thore Graepel & Demis Hassabis

Nature **529**, 484–489 (2016) | Cite this article

439k Accesses | **7078** Citations | **3076** Altmetric | Metrics

Abstract

The game of Go has long been viewed as the most challenging of classic games for artificial intelligence owing to its enormous search space and the difficulty of evaluating board positions and moves. Here we introduce a new approach to computer Go that uses ‘value

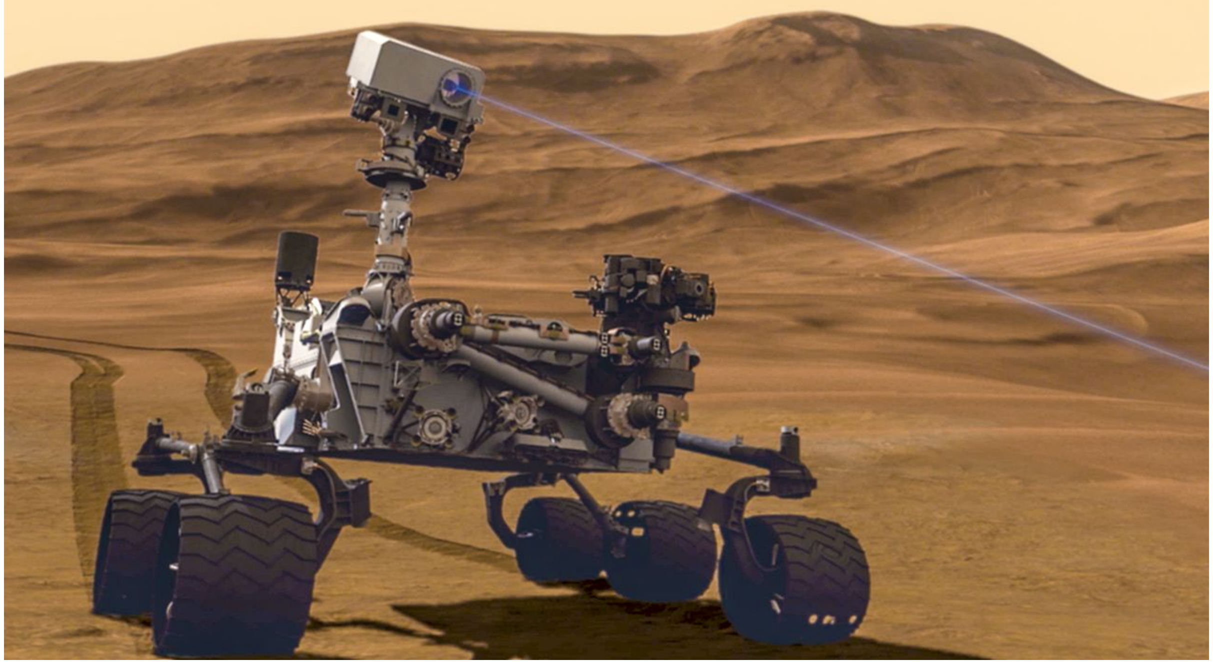
YouTube: AlphaGo playing the game

2016

Curiosity rover decides—by itself—what to investigate on Mars

New software lets Curiosity take science into its own hands

21 JUN 2017 • BY MATTHEW HUTSON



Uses AI to find promising targets for its ChemCam.

Compared with the estimated 24% success rate of random aiming at picking out outcrops—a prime target for investigation

the current version of AEGIS lets the rover find them 94% of the time

2016

Article | Published: 23 December 2020

Mastering Atari, Go, chess and shogi by planning with a learned model

Julian Schrittwieser, Ioannis Antonoglou, Thomas Hubert, Karen Simonyan, Laurent Sifre, Simon Schmitt, Arthur Guez, Edward Lockhart, Demis Hassabis, Thore Graepel, Timothy Lillicrap & David Silver

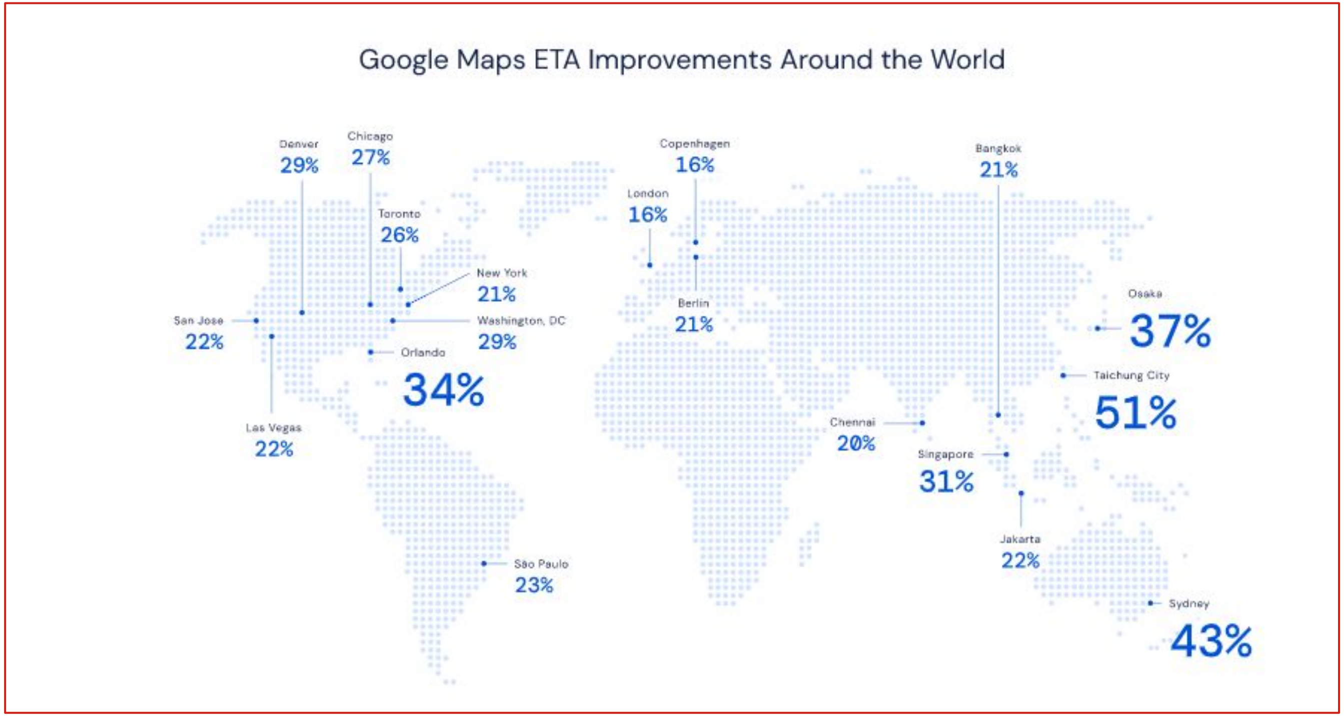
Nature **588**, 604–609 (2020) | Cite this article

Abstract

Constructing agents with planning capabilities has long been one of the main challenges in the pursuit of artificial intelligence. Tree-based planning methods have enjoyed huge success in challenging domains, such as chess[1] and Go[2], where a perfect simulator is available. However, in real-world problems, the dynamics governing the environment are often complex and unknown. Here we present the MuZero algorithm, which, by combining a tree-based search with a learned model, achieves superhuman performance in a range of challenging and visually complex domains, without any knowledge of their underlying dynamics. The MuZero algorithm learns an iterable model that produces predictions relevant

2020

Researchers at DeepMind have partnered with the Google Maps team to improve the accuracy of real time ETAs by up to 50% in places like Berlin, Jakarta, São Paulo, Sydney, Tokyo, and Washington D.C. by using advanced machine learning techniques including Graph Neural Networks, as the graphic below shows:



2020

Article | Open Access | Published: 15 July 2021

Highly accurate protein structure prediction with AlphaFold

John Jumper, Richard Evans, Alexander Pritzel, Tim Green, Michael Figurnov, Olaf Ronneberger, Kathryn Tunyasuvunakool, Russ Bates, Augustin Žídek, Anna Potapenko, Alex Bridgland, Clemens Meyer, Simon A. A. Kohl, Andrew J. Ballard, Andrew Cowie, Bernardino Romera-Paredes, Stanislav Nikolov, Rishub Jain, Jonas Adler, Trevor Back, Stig Petersen, David Reiman, Ellen Clancy, Michal Zielinski, ... Demis Hassabis

+ Show authors

Nature **596**, 583–589 (2021) | Cite this article

Abstract

Proteins are essential to life, and understanding their structure can facilitate a mechanistic understanding of their function. Through an enormous experimental effort[1,2,3,4], the structures of around 100,000 unique proteins have been determined[5], but this represents a small fraction of the billions of known protein sequences[6,7]. Structural coverage is

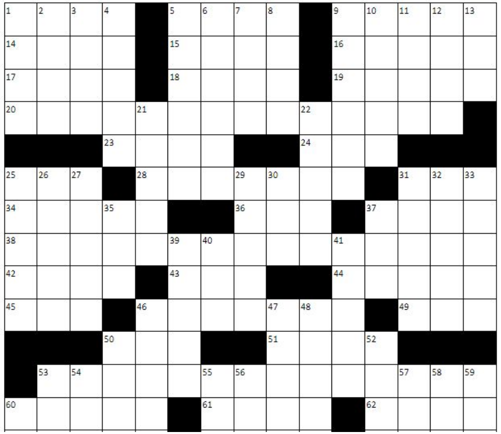
AI accelerating biology.

2021

The Berkeley Crossword Solver

Eric Wallace* Nicholas Tomlin* Albert Xu* Kevin Yang*
Eshaan Pathak* Matthew L. Ginsberg Dan Klein
{ericwallace, nicholas_tomlin, albertxu3}@berkeley.edu

Paper GitHub



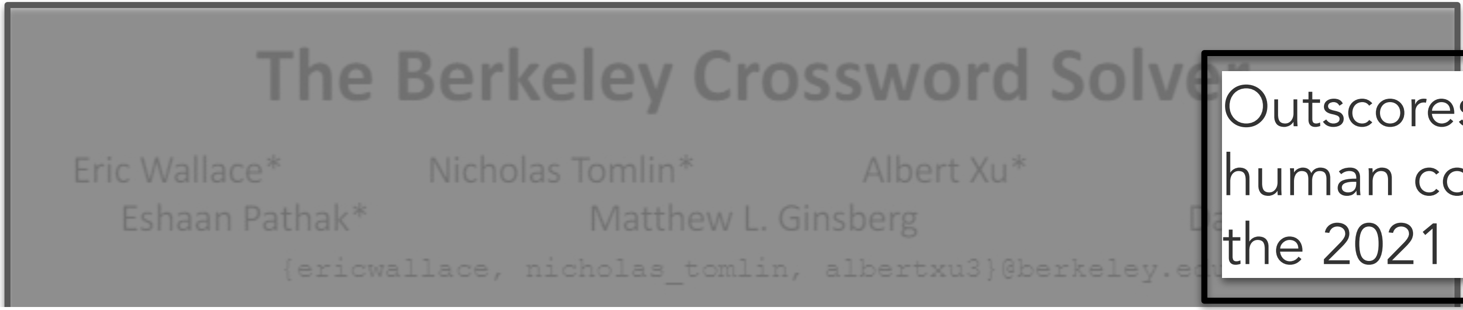
Across

1 With 68-Across, what the trio in this puzzle's clues is trying to promote
5 Enthusiasts
9 Cries of pain
14 Fencing blade
15 Israeli airline
16 Bothered, as one's conscience
17 Tax IDs
18 Past the deadline
19 Full of gristle, say
20 The first member of the trio said he'd ...
23 Like a ship on an ocean floor
24 The "I" of FWIW
25 Lead-in to gender
28 Ability to keep one's balance on a ship
31 Companion of Frodo in "The Lord of the Rings"
34 Move stealthily

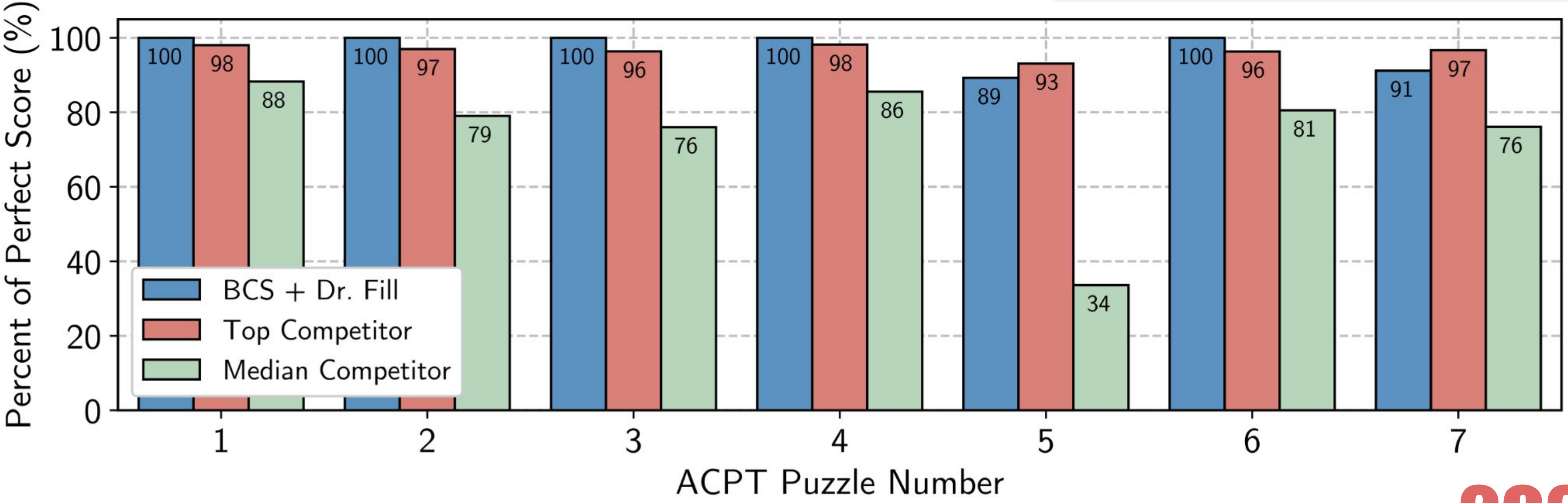
Down

1 Jokey comment
2 Lhasa ___ (dog)
3 Greek philosopher known for paradoxes
4 Twists of lemon or lime
5 Catlike
6 Home of 17 of the 20 highest peaks in the U.S.
7 Post-W.W. II alliance
8 Whole lot
9 Leisure boats
10 Community spirit
11 Unwelcome look
12 One of 16 in a chess set
13 Pigpen
21 Coverings on ears of corn
22 When to stargaze
25 Network for watching Congress

2021



Outscores all 1033 human competitors in the 2021 ACPT



2021

Spoken/Natural Language

- Helps communicate, learning, teaching
- Organizing people and taking political actions
- Conveying emotions and complexities of our lives

Language Understanding

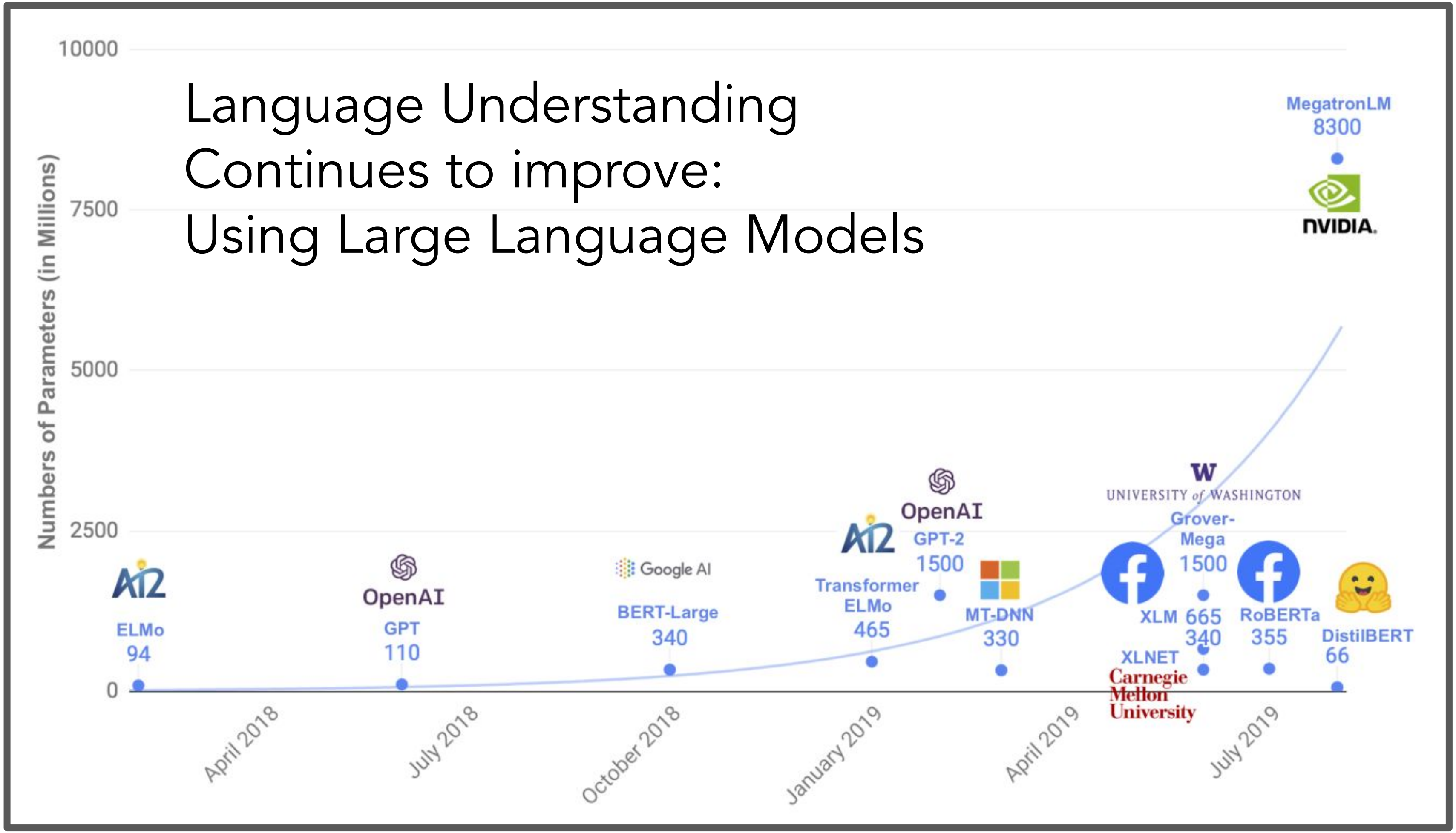
Using Language models

- Analyze colossal amounts of language data

- Resulting in ML models that can be adapted to an impressively wide range of tasks.

2022-23

DistilBERT, a distilled version of BERT: smaller, faster, cheaper and lighter
Victor SANH, Lysandre DEBUT, Julien CHAUMOND, Thomas WOLF



AI - borrows and benefits multiple fields?

Philosophy: logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.

Mathematics: formal representation and proof, algorithms, computation

Psychology: adaptation, phenomena of perception and motor control, psychophysics.

Neuroscience: plastic physical substrate for mental activity.

Linguistics: knowledge representation, grammar.

Control theory and Robotics: homeostatic systems, stability, simple optimal agent designs

and more!

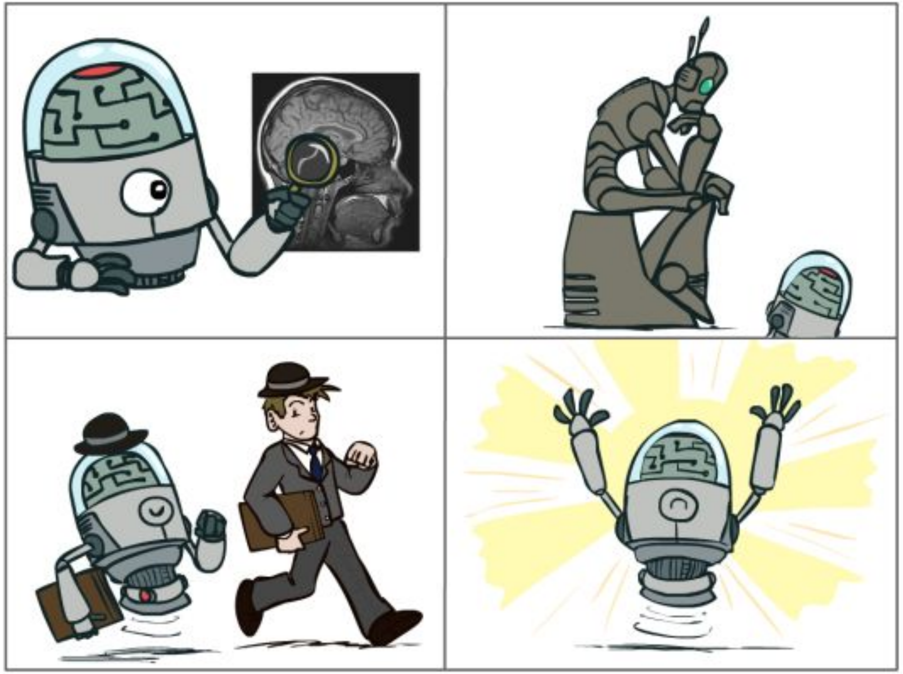
Summary

- Philosophy behind building AI
    - Focus on (tough) practical problem which relate to human intelligence
    - Follow with abstraction - obtain representations - helps remove complexities of real-world
    - Compare solution against benchmarks
- One AI for Everything: Dream Goal
    - Example, humans (?)
    - Distinct regions of brain process different sensory modality
    - These regions can adapt to other modality as well
    - Incentive is helps
- Make AI solutions problem specific
    - Examples across time

The science of making machines that:

Think like people

Think rationally



Act like people

Act rationally

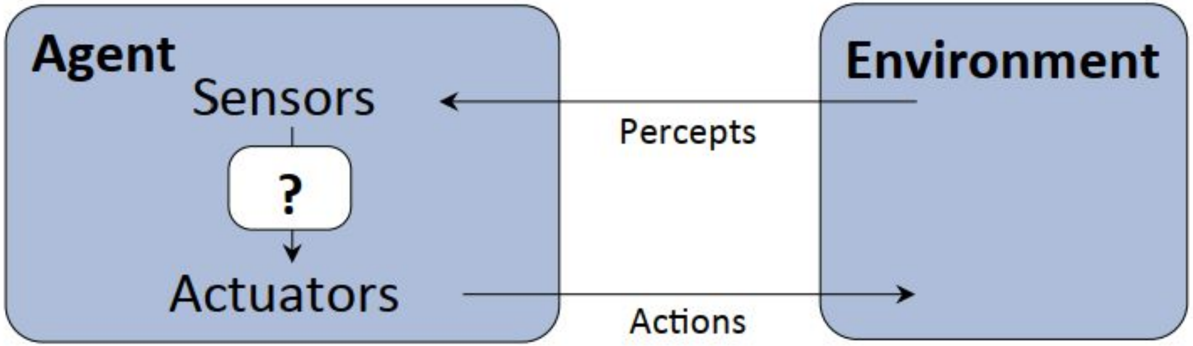
These slides were adapted from Dan Klein and Pieter Abbeel's CS188: Intro to AI at UC Berkeley.

Rationality?

We'll use the term **rational** in a very specific, technical way:

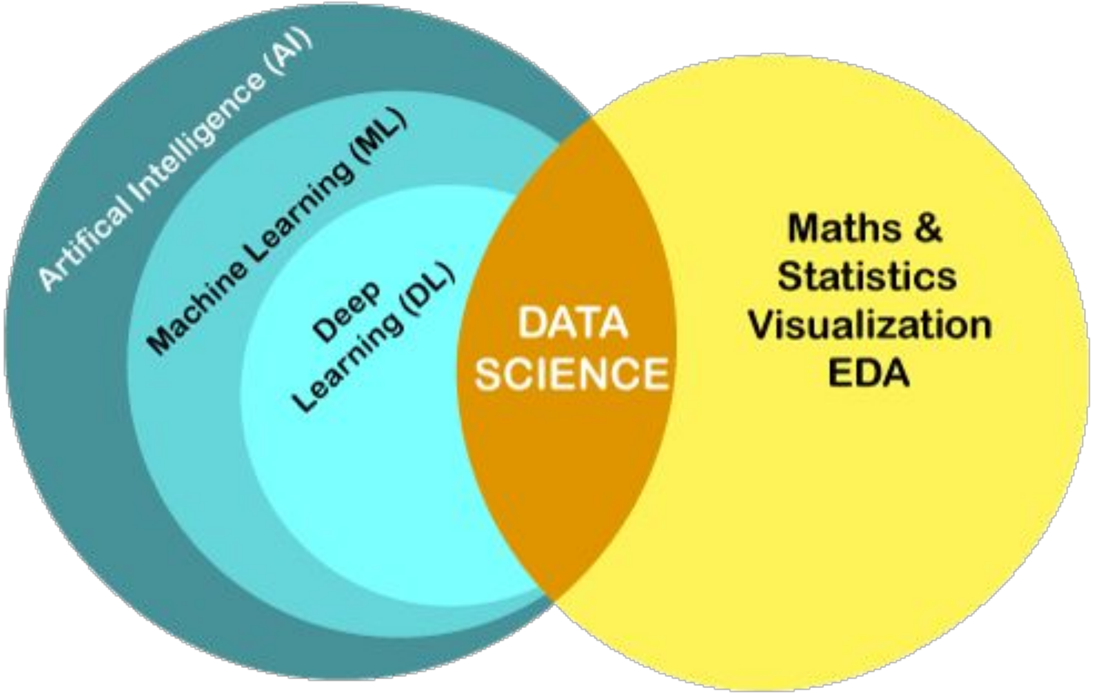
- Rational: maximally achieving pre-defined goals
- Rationality only concerns what decisions are made (not the thought process behind them)
- Goals are expressed in terms of the **utility** of outcomes
- Being rational means **maximizing your expected utility**

Designing Rational Agents



- Types of environments
- Types of agent
- Types of agent programs

AI, ML, DL, Data Science ...



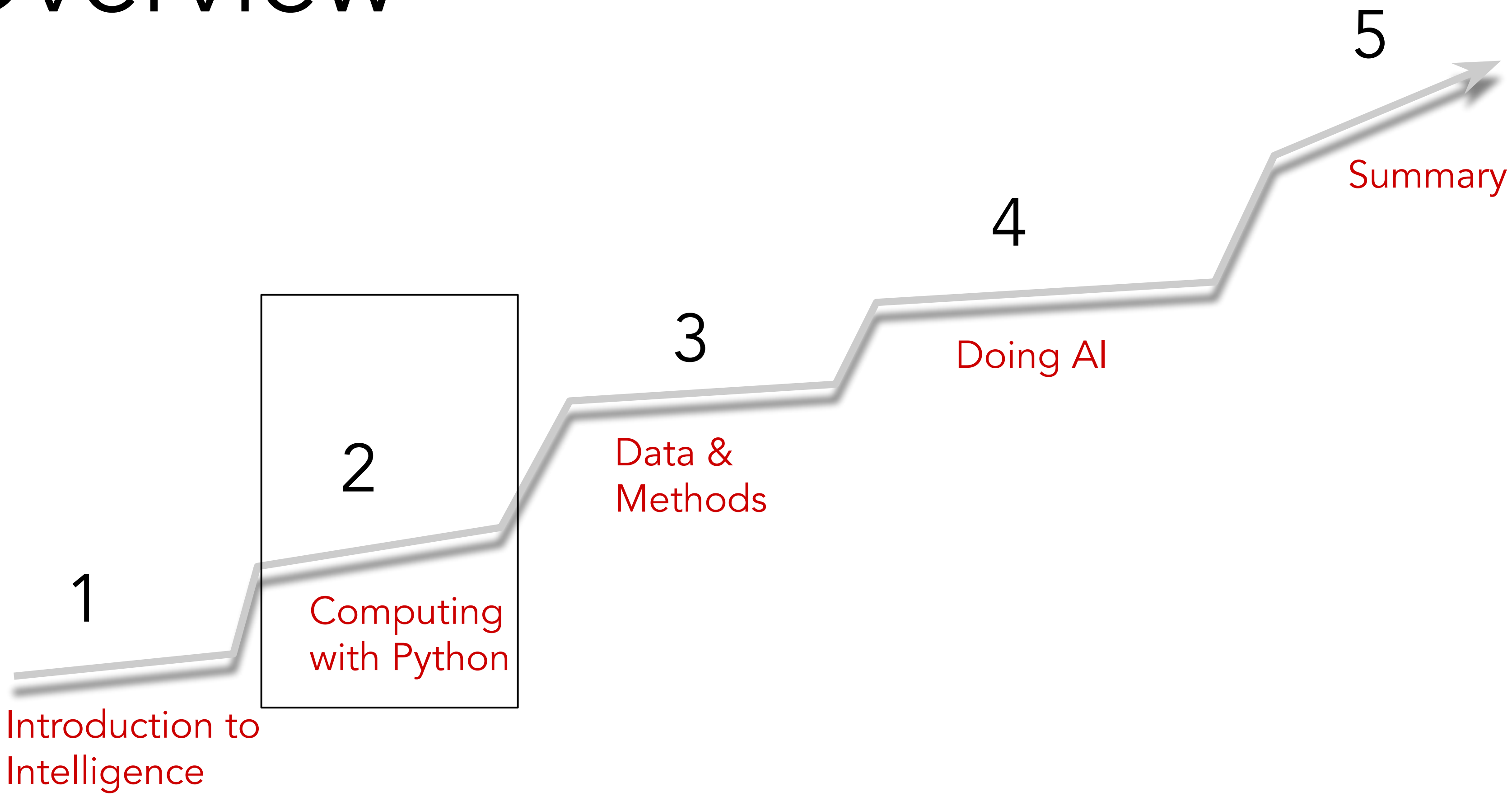
AI, ML, DL, Data Science …

The terms have been used vaguely in media, research papers, talks and funding

Summary

- Defined intelligence
- Introduced to how brain represents it
- Time lapse of the field of AI
- Games have been key
- Building AI agents

Overview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