OVERVIEW OF AI

ECS170 Spring 2018
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MAP OF COMPUTER SCIENCE

COMPUTATIONAL COMPLEXITY

DOES P≠NP?

NXN CHESS PSPACE NXN GO

NP COMPLETE: TRAVELLING SALESMAN, MAP COLOURING

NP: GRAPH ISOMORPHISM

BQP: DISCRETE LOGARITHM, FACTORING

EFFICIENT FOR A QUANTUM COMPUTER

P: TESTING IF PRIME, GRAPH CONNECTIVITY

EFFICIENT FOR A COMPUTER

INFORMATION THEORY

0100110100011001

COMPRESSION

ENTROPY

ERROR CORRECTION

PARITY CHECKING

CODING THEORY

CRYPTOGRAPHY

PUBLIC KEY

ALL THE SECRETS

PRIVATE KEY

HARDWARE

MONITOR

SOUND

SSD

GPU

RAM

POWER

INPUT

CPU

MOTHERBOARD

SCHEDULING

PROCESSES

SCHEDULER

CPU 1 CPU 2 CPU 3 CPU 4

MULTIPROCESSING

COMPUTER ARCHITECTURE

CPU

INPUT

CENTRAL PROCESSING UNIT

CONTROL UNIT

ARITHMETIC/LOGIC UNIT

MEMORY UNIT

OUTPUT

GPU

MULTIPROCESSORS

FPGA

LOGIC BLOCK

INTERCONNECTION

INPUT/OUTPUT

SWITCH BOX

CONNECT BLOCK

THEORETICAL COMPUTER SCIENCE

COMPUTABILITY THEORY

ALAN TURING

TURING MACHINE

STATE REGISTER

1: MOVE LEFT
2: MOVE RIGHT
3: FLIP DIGIT
123: STOP

INFINITELY LONG TAPE

HEAD

LAMBDA CALCULUS

DATA STRUCTURES

LINKED LIST

TREE

GRAPH

STACK

HASHING

FORMAL METHODS

START

POSSIBLE STATES

ALERT 1

ALGORITHMS

BUBBLESORT(A)
1: GO FROM LEFT TO RIGHT.
2: COMPARE EACH PAIR.
3: IF LEFT ONE HIGHER, SWITCH.
4: DO UNTIL NO MORE SWITCHES.

BUBBLE SORT O(n²)

1 2 3 4 5 6 7 8

MERGE SORT O(n log n)

1 2 3 4 5 6 7 8

ANALYSIS OF ALGORITHMS

ALGORITHMIC COMPLEXITY

LOGIC

ZERO ONE NOT OR AND XOR NAND

GRAPH THEORY

COMPUTATIONAL GEOMETRY

AUTOMATA THEORY

QUANTUM COMPUTATION

AND MORE

PARALLEL PROGRAMMING

MAIN JOB

JOB 1 JOB 2 JOB 3 JOB 4

SMALLER JOBS

COMPUTER ENGINEERING

SOFTWARE AND PROGRAMMING LANGUAGES

PYTHON JAVASCRIPT PERL PHP SWIFT SQL JAVA C# C++ C ASSEMBLY

WEB APPS
BROWSER
APPLICATIONS
OPERATING SYSTEM
BIOS
SILICON
MACHINE CODE

JAVASCRIPT COMPILER
C++ COMPILER
C COMPILER
ASSEMBLY COMPILER

COMPILERS

DATA MANAGEMENT

DATABASES SQL DATACENTRES

NETWORKING

CONCURRENT/DISTRIBUTED/PARALLEL/SYSTEMS

SOFTWARE ENGINEERING

FORMAL METHODS

UNIT TESTING

VERSION CONTROL

OBJECT ORIENTED DESIGN

OPERATING SYSTEMS

iOS

macOS

PERFORMANCE

COMPUTER ANALYSIS

BENCHMARKING

MACHINE LEARNING

SUPERVISED UNSUPERVISED REINFORCEMENT

NEURAL NETWORK

CAT

OPTIMISATION

FINANCE

LEAGUE OF LEGENDS

AMAZON WAREHOUSE

BOOLEAN SATISFIABILITY

x_1 OR x_2 OR $\bar{x}_3$ (SAT)

$\bar{x}_1$ OR x_2 OR x_3

$\bar{x}_1$ OR $\bar{x}_2$ OR $\bar{x}_3$

$\bar{x}_1$ OR x_2 OR x_3

SUPER COMPUTING

COMPUTER GRAPHICS

COMPUTATIONAL SCIENCE

COMPUTATIONAL PHYSICS

NUMERICAL ANALYSIS

BIOINFORMATICS

COMPUTATIONAL CHEMISTRY

HACKING

ARTIFICIAL INTELLIGENCE

A.I.

ROBOTICS

COMPUTER VISION

FIND THE HUMANS

APPLICATIONS

VIRTUAL REALITY

SIMULATION

BIG DATA

NATURAL LANGUAGE PROCESSING

CHATBOTS

- HEY
- ARE U A ROBOT?
- HELLO THERE
- YES
- WAIT, I MEAN NO
- PROVE IT!
- CALCULATING...
- I MADE YOU CAKE

SCONES TEA FLOUR BUTTER BIRTHDAY CAKE FOOD BACON CELEBRATION PANCAKE BREAKFAST

KNOWLEDGE REPRESENTATION

TELEPRESCENCE

AUGMENTED REALITY

YOUTUBE DOMAIN OF SCIENCE MAP OF COMPUTER SCIENCE

HUMAN COMPUTER INTERACTION

IMAGE PROCESSING

INTERNET OF THINGS

What is AI?

"the science and engineering of intelligent machines"

-- McCarthy 1956

Modern:

The study and design of intelligent agents.

Critique?

Why "artificial intelligence"?

Why this term?

Why artificial?

Why intelligence?

What alternatives are there?

Why "artificial intelligence"?

Why this term?

Why artificial?

Why intelligence?

What alternatives are there?

Computational Intelligence

Machine Intelligence

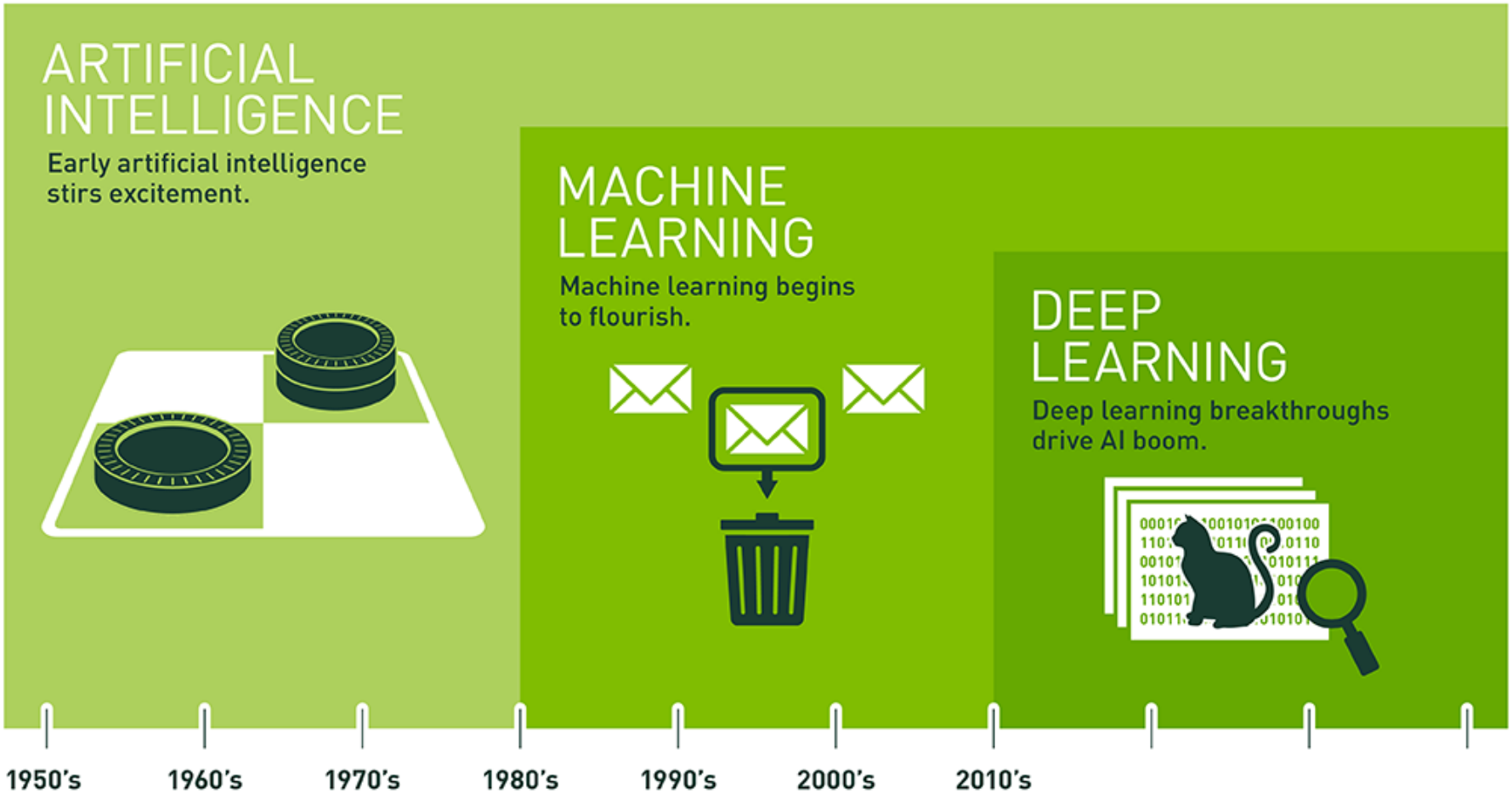
Synthetic Intelligence

Computational Rationality

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)
"[The automation of] 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)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998)
"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

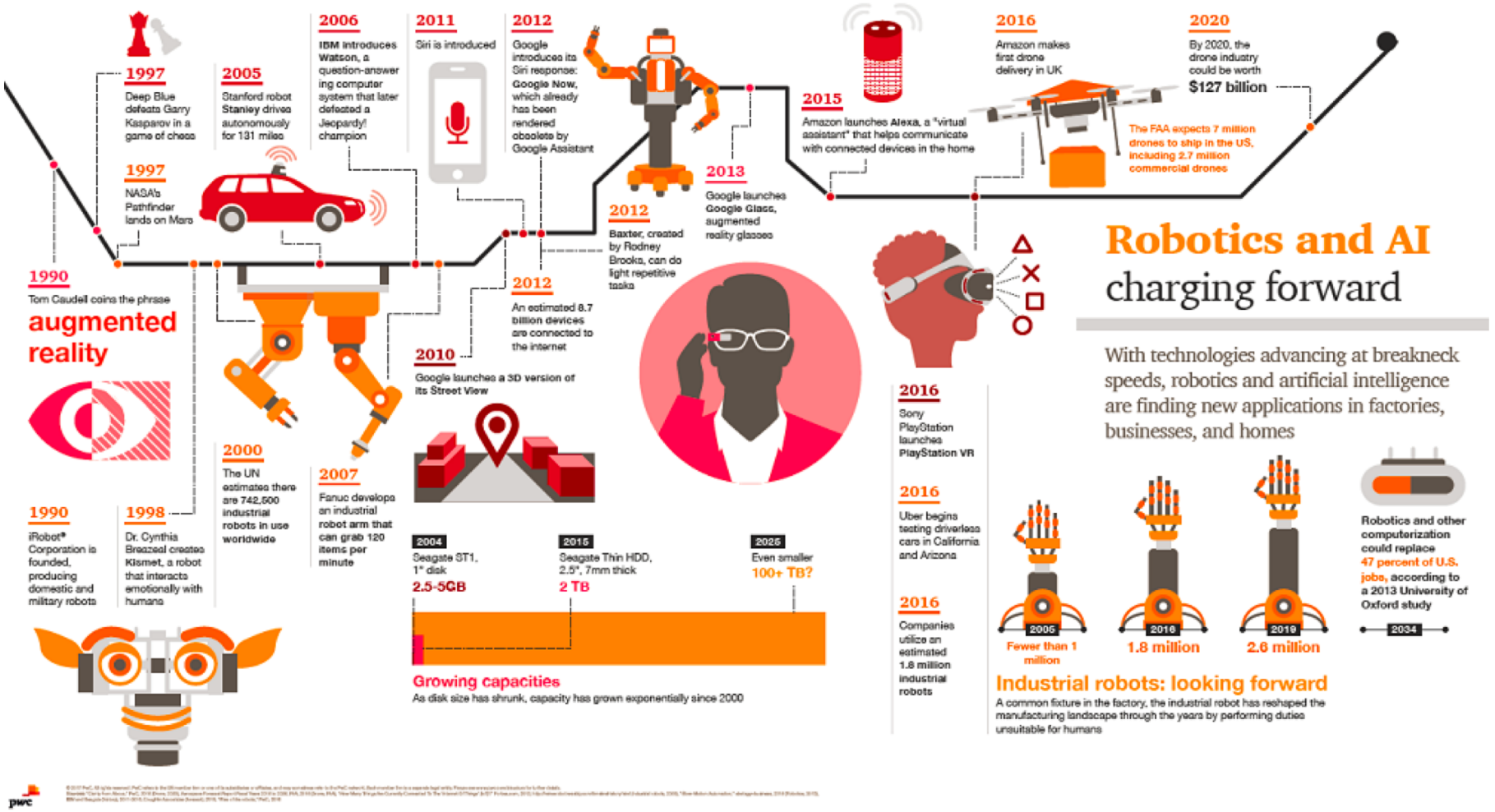
Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Common Viewpoint

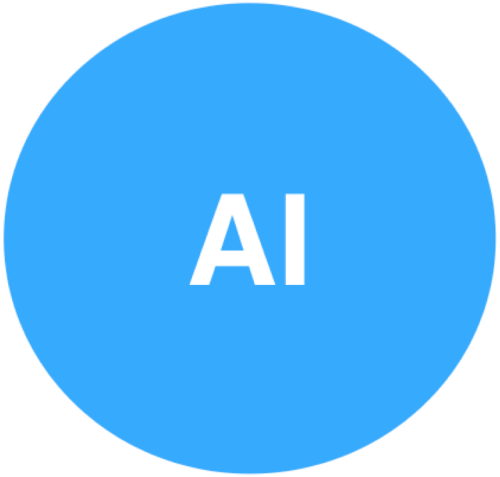


Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Robotics


1997
Deep Blue defeats Garry Kasparov in a game of chess
2005
Stanford robot Stanley drives autonomously for 131 miles
2006
IBM introduces Watson, a question-answering computer system that later defeated a Jeopardy! champion
2011
Siri is introduced
2012
Google introduces its Siri response: Google Now, which already has been rendered obsolete by Google Assistant
2016
Amazon makes first drone delivery in UK
2020
By 2020, the drone industry could be worth $127 billion
1997
NASA's Pathfinder lands on Mars
2015
Amazon launches Alexa, a "virtual assistant" that helps communicate with connected devices in the home
The FAA expects 7 million drones to ship in the US, including 2.7 million commercial drones
2012
Baxter, created by Rodney Brooks, can do light repetitive tasks
2013
Google launches Google Glass, augmented reality glasses
1990
Tom Caudell coins the phrase
augmented reality
2012
An estimated 8.7 billion devices are connected to the internet
2010
Google launches a 3D version of its Street View
2000
The UN estimates there are 742,500 industrial robots in use worldwide
2007
Fanuc develops an industrial robot arm that can grab 120 items per minute
1990
iRobot® Corporation is founded, producing domestic and military robots
1998
Dr. Cynthia Breazeal creates Kismet, a robot that interacts emotionally with humans
2004
Seagate ST1, 1" disk
2.5-5GB
2015
Seagate Thin HDD, 2.5", 7mm thick
2 TB
2025
Even smaller
100+ TB?
Growing capacities
As disk size has shrunk, capacity has grown exponentially since 2000
2016
Sony PlayStation launches PlayStation VR
2016
Uber begins testing driverless cars in California and Arizona
2016
Companies utilize an estimated 1.8 million industrial robots
Robotics and AI
charging forward
With technologies advancing at breakneck speeds, robotics and artificial intelligence are finding new applications in factories, businesses, and homes
2005
Fewer than 1 million
2016
1.8 million
2019
2.6 million
Industrial robots: looking forward
A common fixture in the factory, the industrial robot has reshaped the manufacturing landscape through the years by performing duties unsuitable for humans
Robotics and other computerization could replace 47 percent of U.S. jobs, according to a 2013 University of Oxford study
2034

Snarky Look

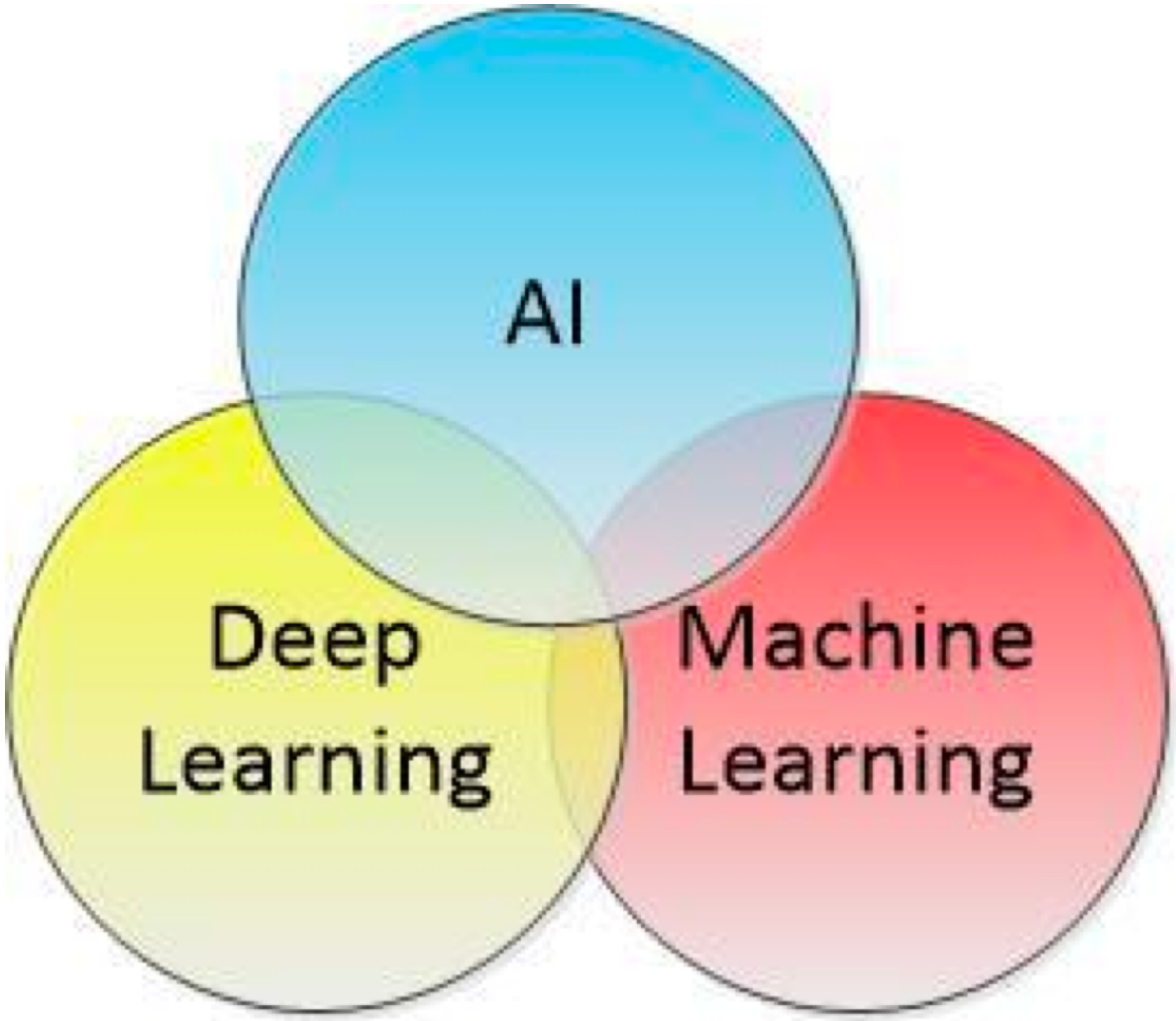


- sounds sexy
- gets us money from VCs
- what we all hope is the future

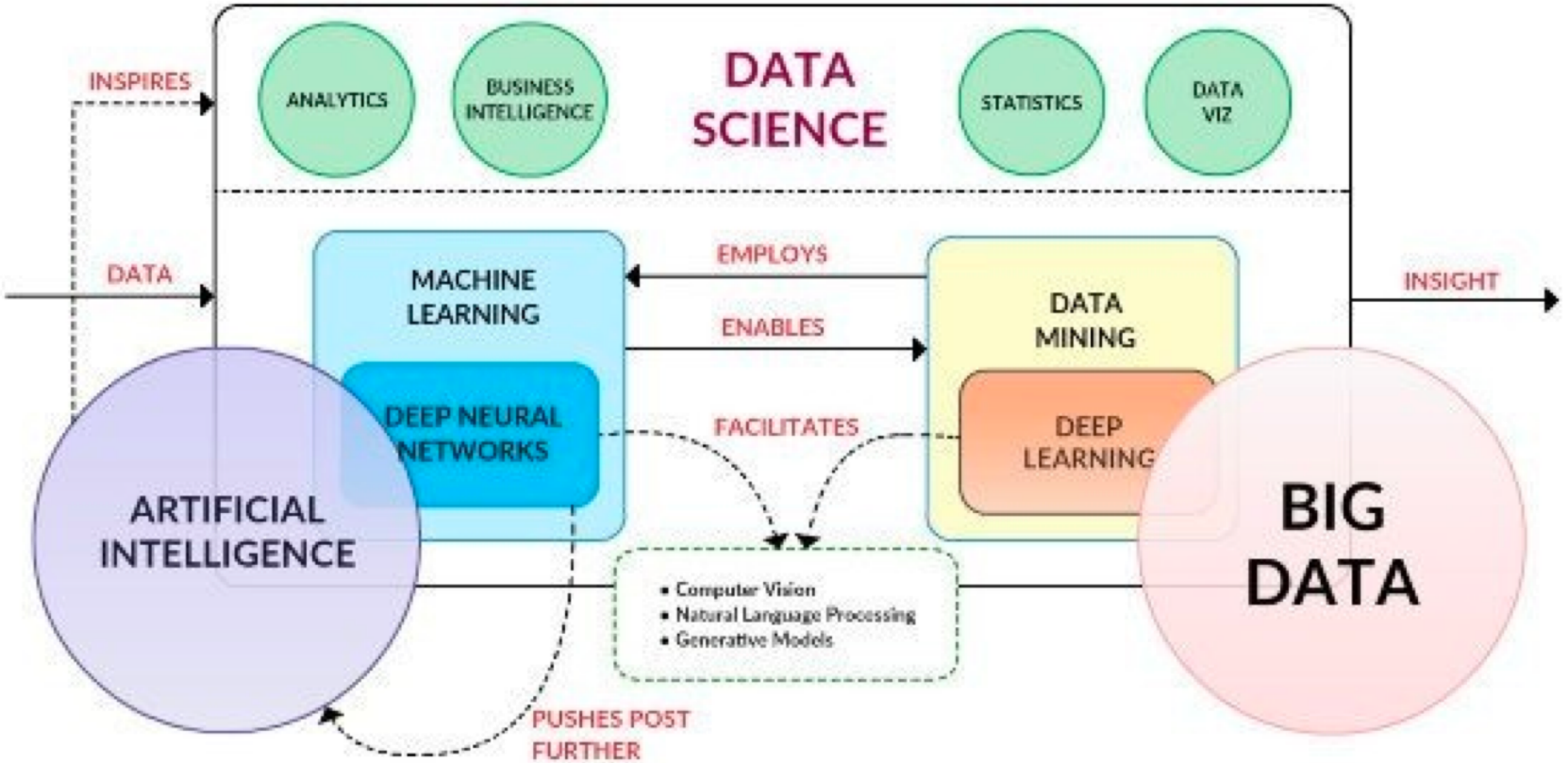
- the only real “AI”
- traditionally an academic discipline
- not concerned with real-world software

- applies machine learning to create actual products
- deals with real-world complexity

Neo-ML Centric



Some Data Scientists



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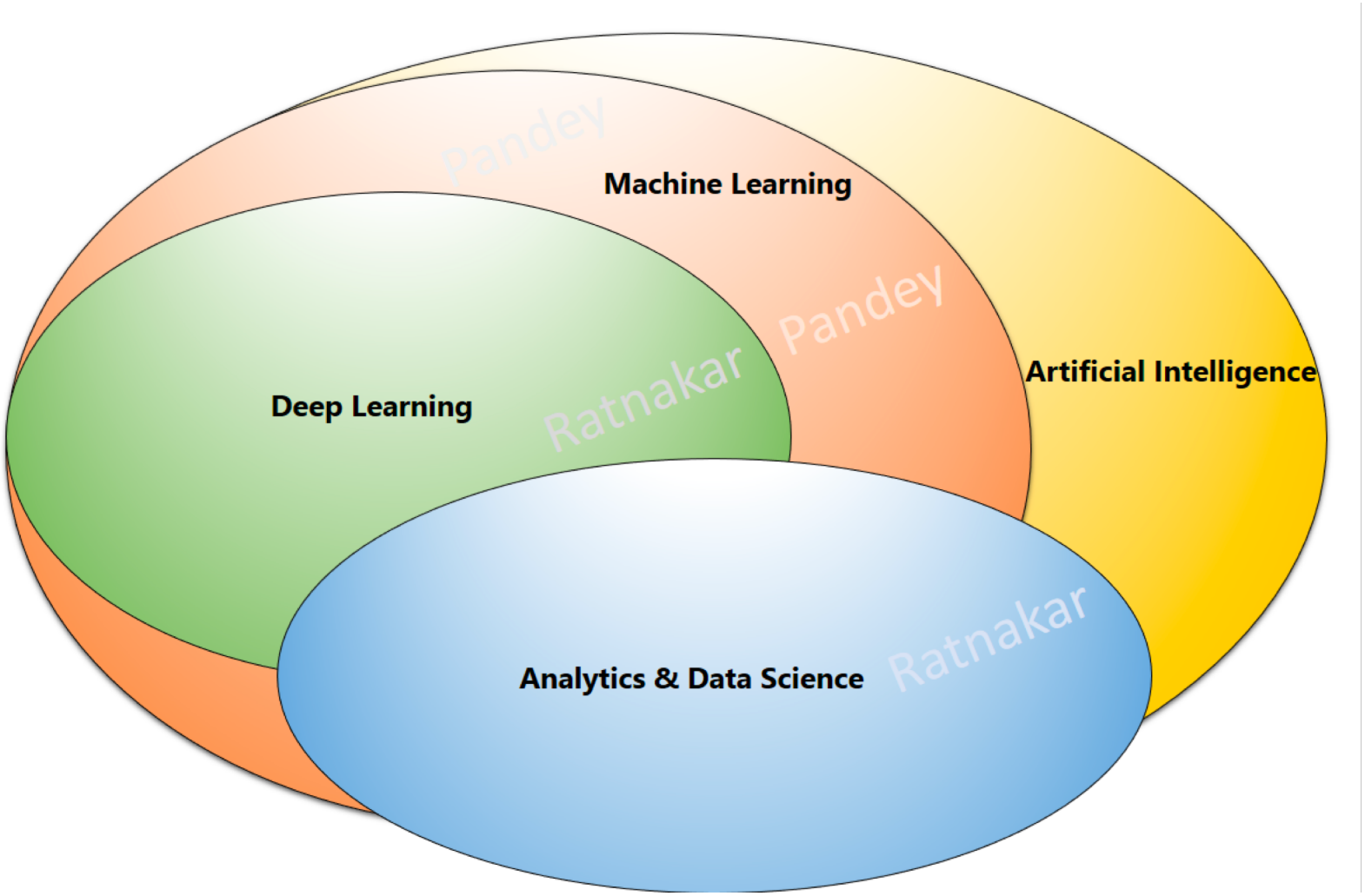
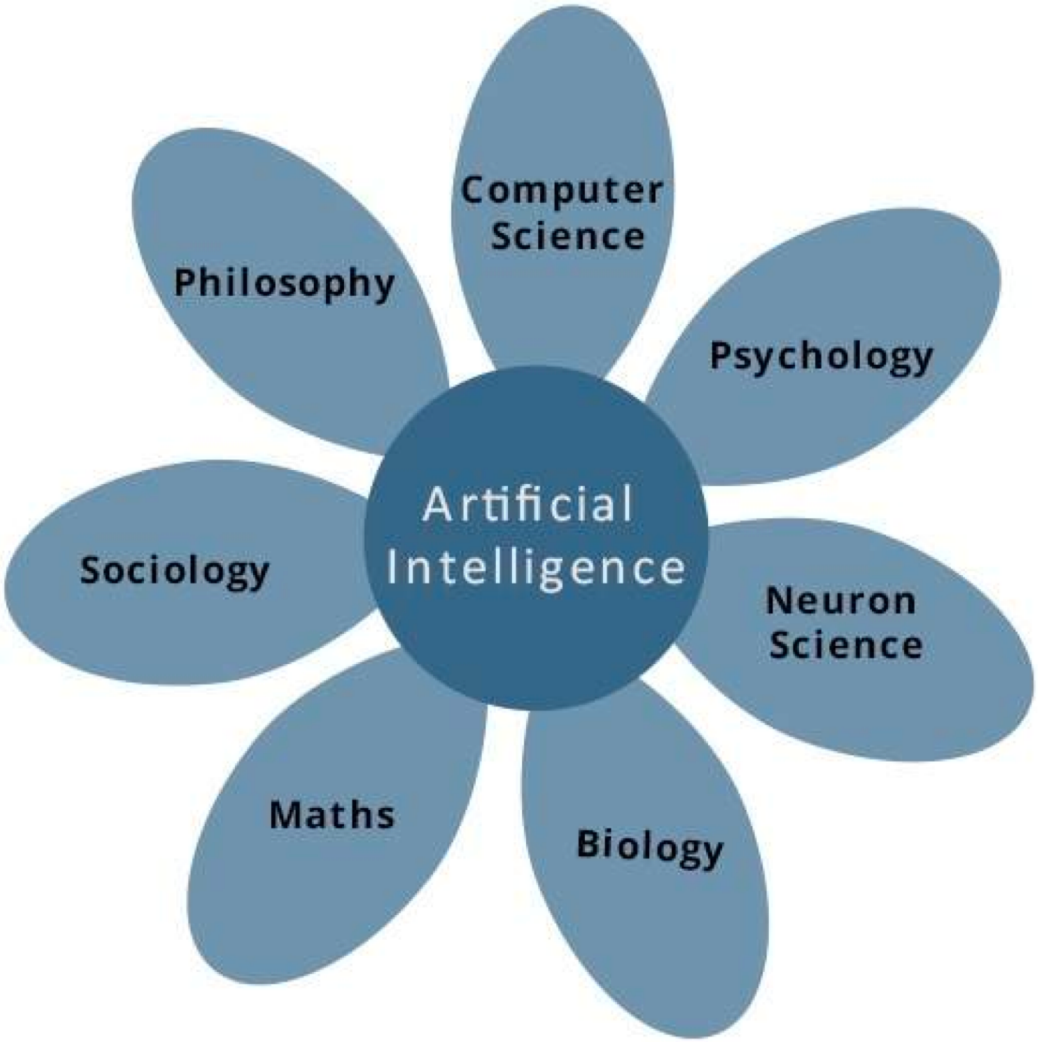
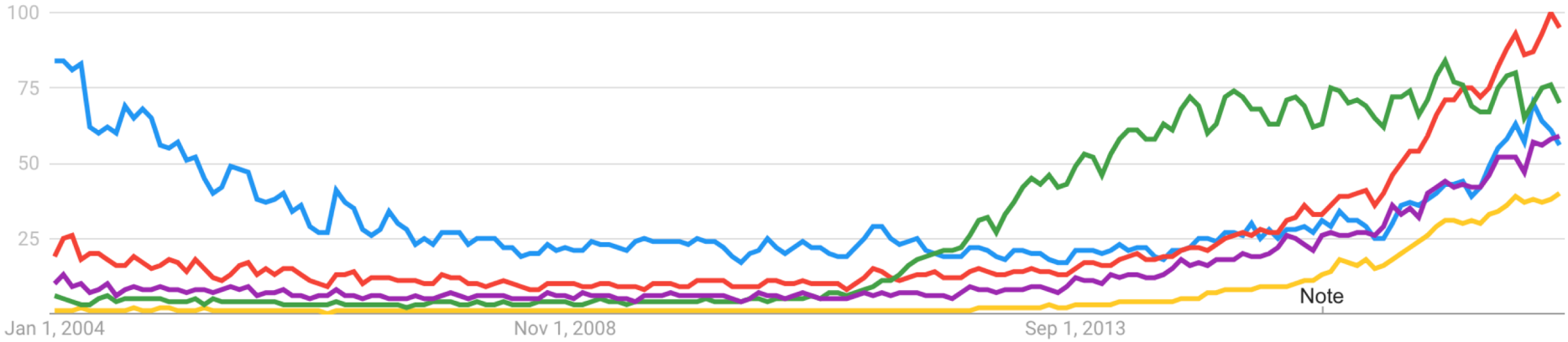


Inclusive Model



Trends



https://trends.google.com/trends/explore?date=all&q=artificial%20intelligence,Machine%20Learning,deep%20learning,big%20data,data%20science

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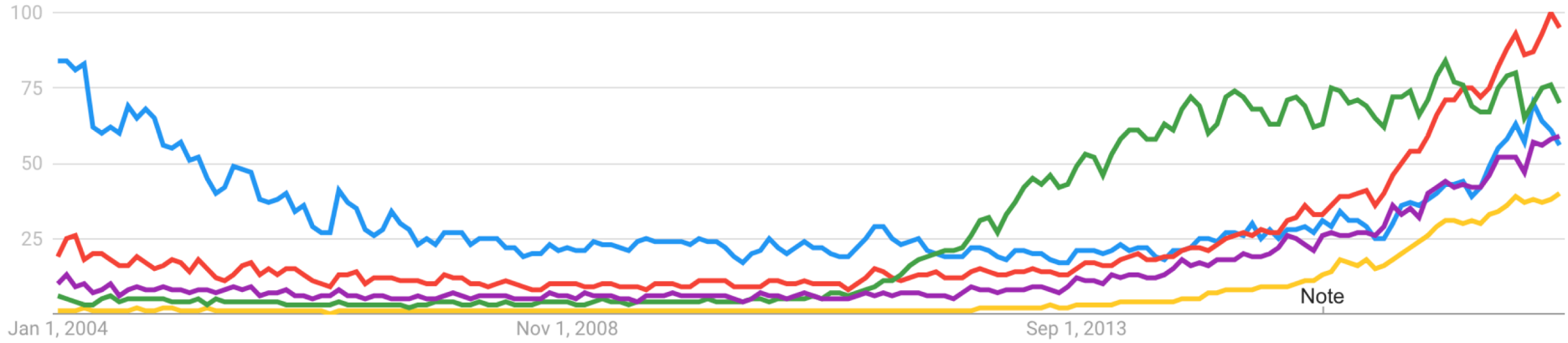

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Computation

	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10^{14}	10^{10}	10^{14}

Figure 1.3 A crude comparison of the raw computational resources available to the IBM BLUE GENE supercomputer, a typical personal computer of 2008, and the human brain. The brain's numbers are essentially fixed, whereas the supercomputer's numbers have been increasing by a factor of 10 every 5 years or so, allowing it to achieve rough parity with the brain. The personal computer lags behind on all metrics except cycle time.

Computation

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	National Supercomputing Center in Wuxi China	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway NRCPC	10,649,600	93,014.6	125,435.9	15,371
2	National Super Computer Center in Guangzhou China	**Tianhe-2 (MilkyWay-2)** - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P NUDT	3,120,000	33,862.7	54,902.4	17,808
3	Swiss National Supercomputing Centre (CSCS) Switzerland	**Piz Daint** - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 Cray Inc.	361,760	19,590.0	25,326.3	2,272
4	Japan Agency for Marine-Earth Science and Technology Japan	**Gyoukou** - ZettaScaler-2.2 HPC system, Xeon D-1571 16C 1.3GHz, Infiniband EDR, PEZY-SC2 700Mhz ExaScaler	19,860,000	19,135.8	28,192.0	1,350
5	DOE/SC/Oak Ridge National Laboratory United States	**Titan** - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x Cray Inc.	560,640	17,590.0	27,112.5	8,209
6	DOE/NNSA/LLNL United States	**Sequoia** - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom IBM	1,572,864	17,173.2	20,132.7	7,890
7	DOE/NNSA/LANL/SNL United States	**Trinity** - Cray XC40, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect Cray Inc.	979,968	14,137.3	43,902.6	3,844
8	DOE/SC/LBNL/NERSC United States	**Cori** - Cray XC40, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect Cray Inc.	622,336	14,014.7	27,880.7	3,939

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thinking perception action

models targeting
thinking perception action

representations that support
models targeting
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expose constraints of
representations that support
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thinking perception action

to make algorithms

expose constraints of
representations that support
models targeting
thinking perception action

to make algorithms
that end up in programs

RIKLS Classic Subdomains

- R
- I
- K
- L
- S

RIKLS Classic Subdomains

- Retrieval
- Inference
- Knowledge Representation
- Learning
- Search

Problems and Goals

Problems and Goals

- Knowledge Representation
- Planning
- Learning
- Natural Language Processing
- Vision
- Sensing
- Robotics
- General AI
- Commonsense Reasoning

Problems and Goals

- Knowledge Representation
- Planning
- Learning
- Natural Language Processing
- Vision
- Sensing
- Robotics
- General AI
- Commonsense Reasoning
- Neuroscience
  - Brain Modeling
- Transhumanism
- The Singularity
- Art
- Understanding the human condition
- Philosophy
- Free humanity from wage slavery
- Ultimate Profit

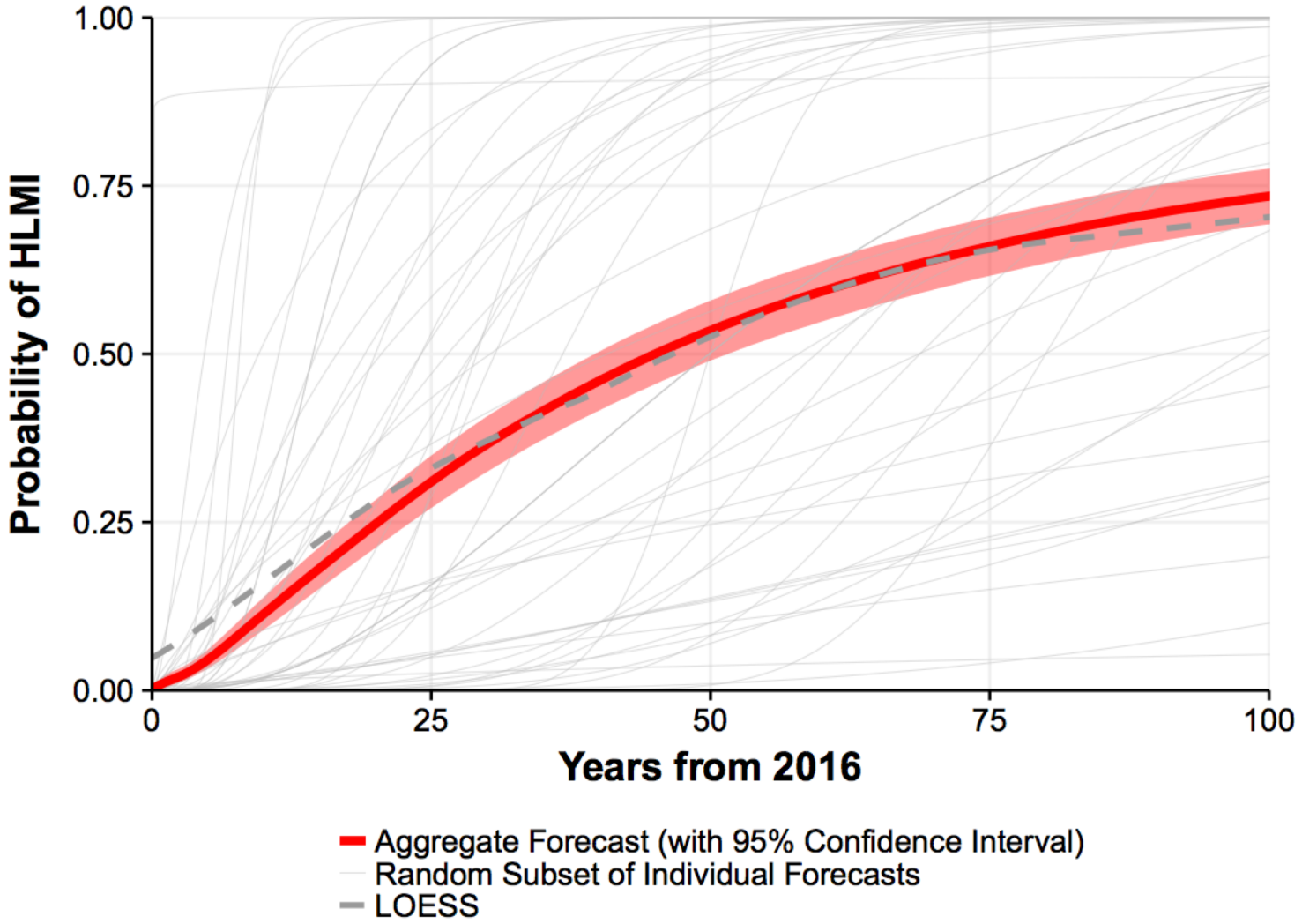
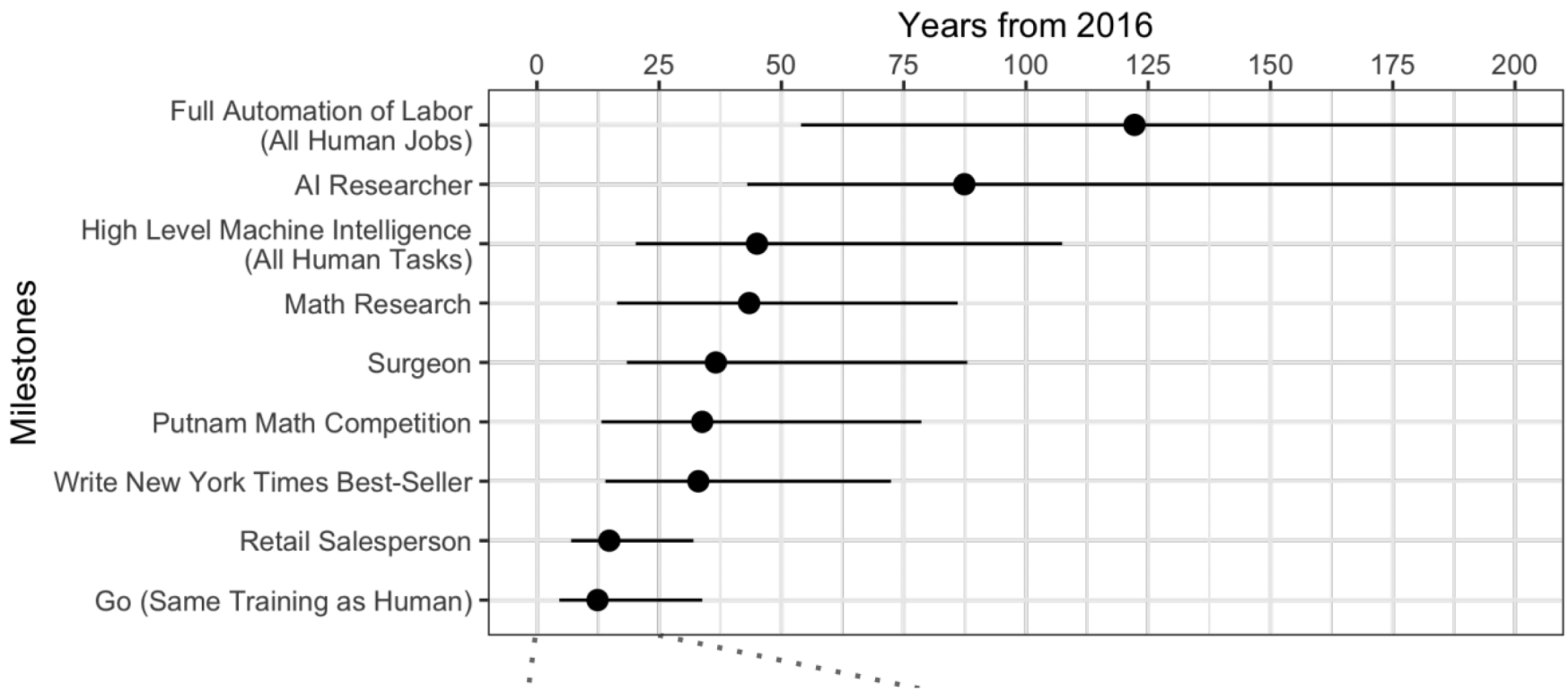
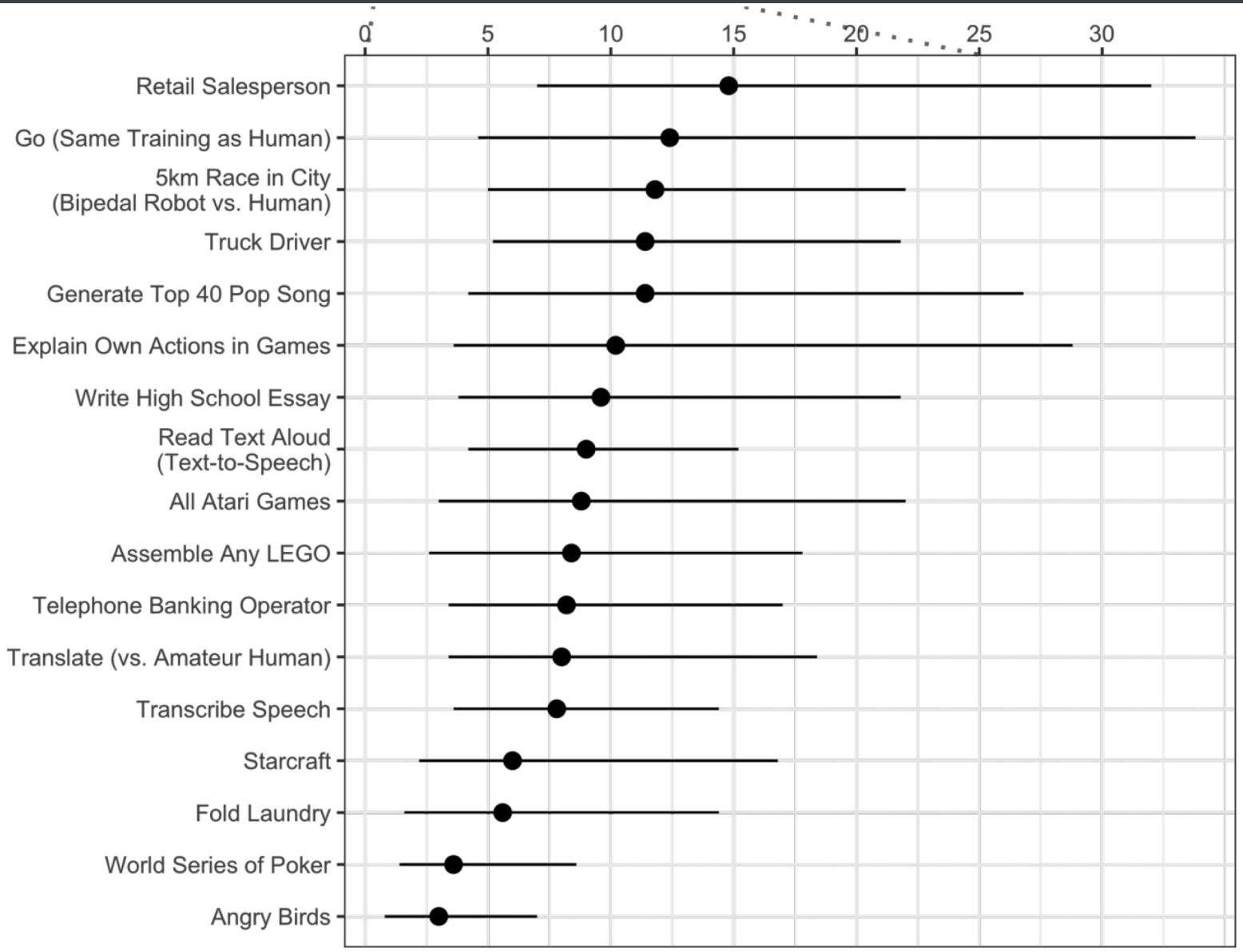


Figure 1: Aggregate subjective probability of 'high-level machine intelligence' arrival by future years. Each respondent provided three data points for their forecast and these were fit to the


Years from 2016
0
25
50
75
100
125
150
175
200
Milestones
Full Automation of Labor
(All Human Jobs)
AI Researcher
High Level Machine Intelligence
(All Human Tasks)
Math Research
Surgeon
Putnam Math Competition
Write New York Times Best-Seller
Retail Salesperson
Go (Same Training as Human)


0
5
10
15
20
25
30
Retail Salesperson
Go (Same Training as Human)
5km Race in City
(Bipedal Robot vs. Human)
Truck Driver
Generate Top 40 Pop Song
Explain Own Actions in Games
Write High School Essay
Read Text Aloud
(Text-to-Speech)
All Atari Games
Assemble Any LEGO
Telephone Banking Operator
Translate (vs. Amateur Human)
Transcribe Speech
Starcraft
Fold Laundry
World Series of Poker
Angry Birds