ARTIFICIAL INTELLIGENCE REVOLUTION

Eray Özkural, PhD
Founder, Celestial Intellect Cybernetics

OUTLINE

- Philosophical Perspective
- Scientific Perspective
- Business Perspective
- Future of AI

PHILOSOPHICAL PERSPECTIVE

- Turing:
  - 1948: The brain as a computer
  - 1950: The imitation game (Turing Test)
- Carnap: Logical Positivism
- Ray Solomonoff: 1956
  - 1956-60: Inductive Inference
- Dennett 1991: Consciousness Explained
- AI Critics:
  - Harnad: Symbol Grounding
  - Searle: Chinese Room
  - French: Limitations of Turing Test
- AI Scare / Neo-luddism:
  - Bostrom: AI will kill us all

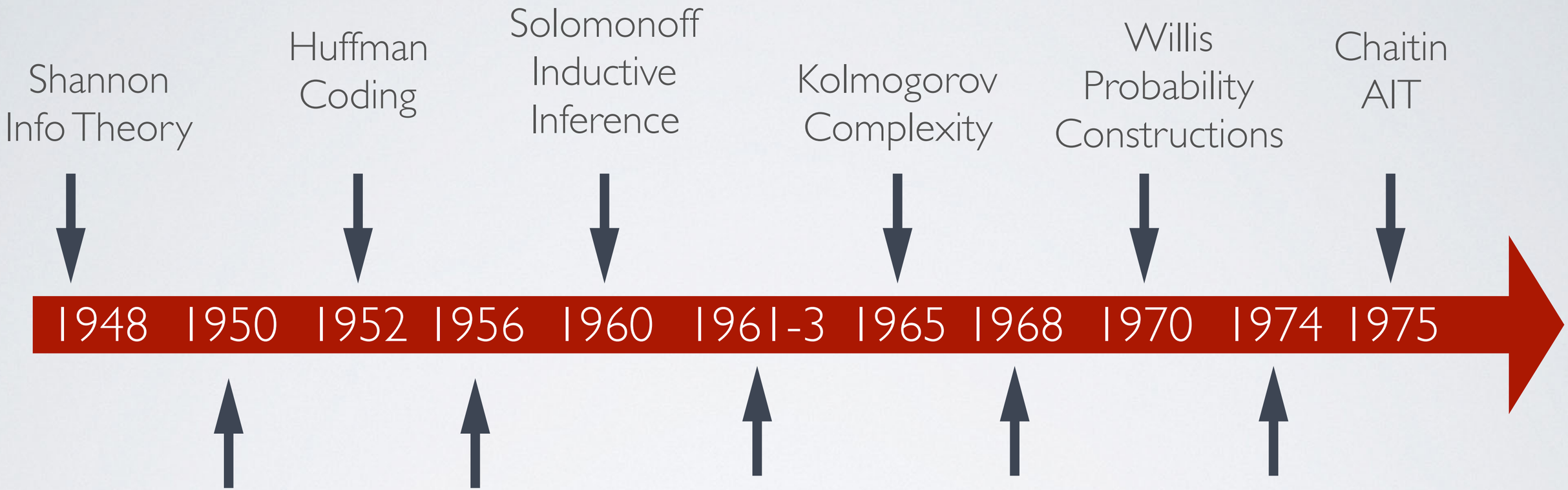
THE VINDICATION OF POSITIVISM

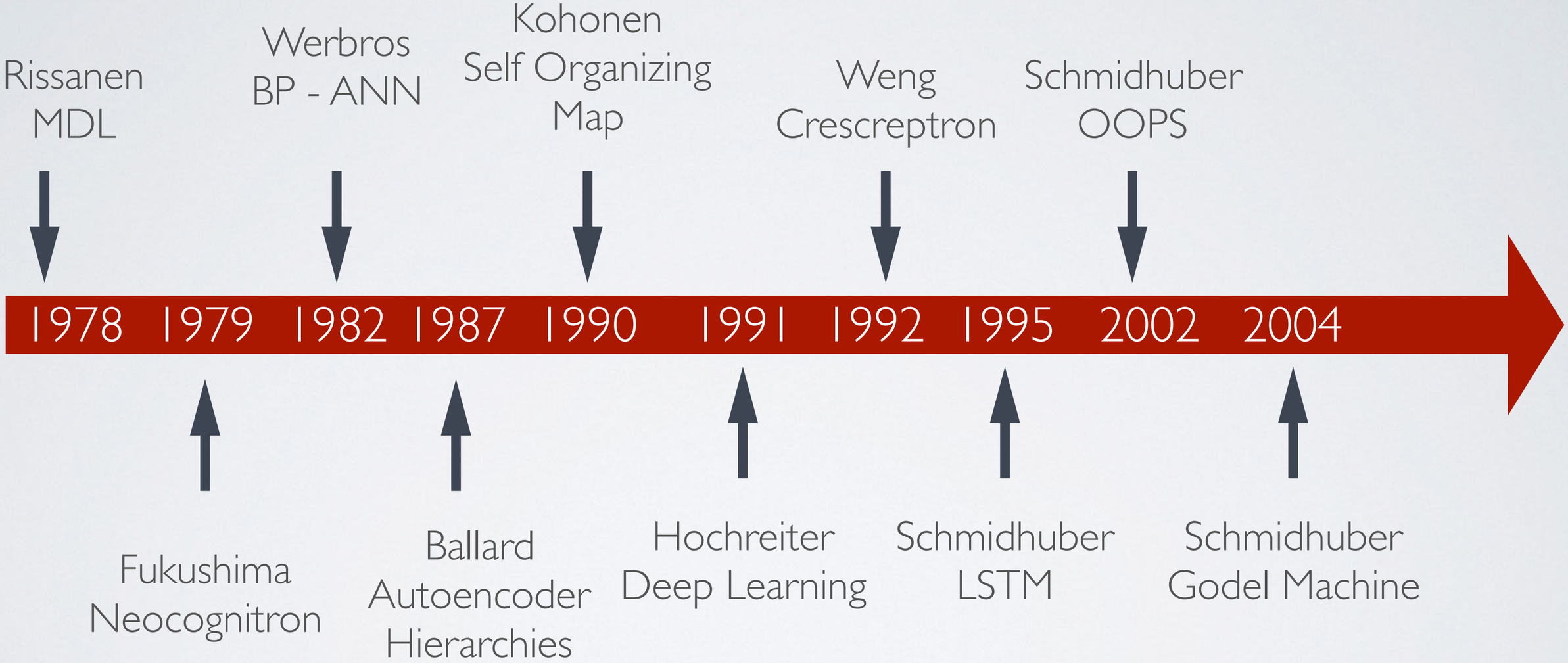
- Algorithmic information theory realizes two main tenets of logical positivism:
  - a finite cognitive procedure for inductive inference
  - a unified language for science (AI's private language)
- Analytic-synthetic distinction?
  - not strictly required: ALP can invent & revise logic
  - however, computation has some analytic character

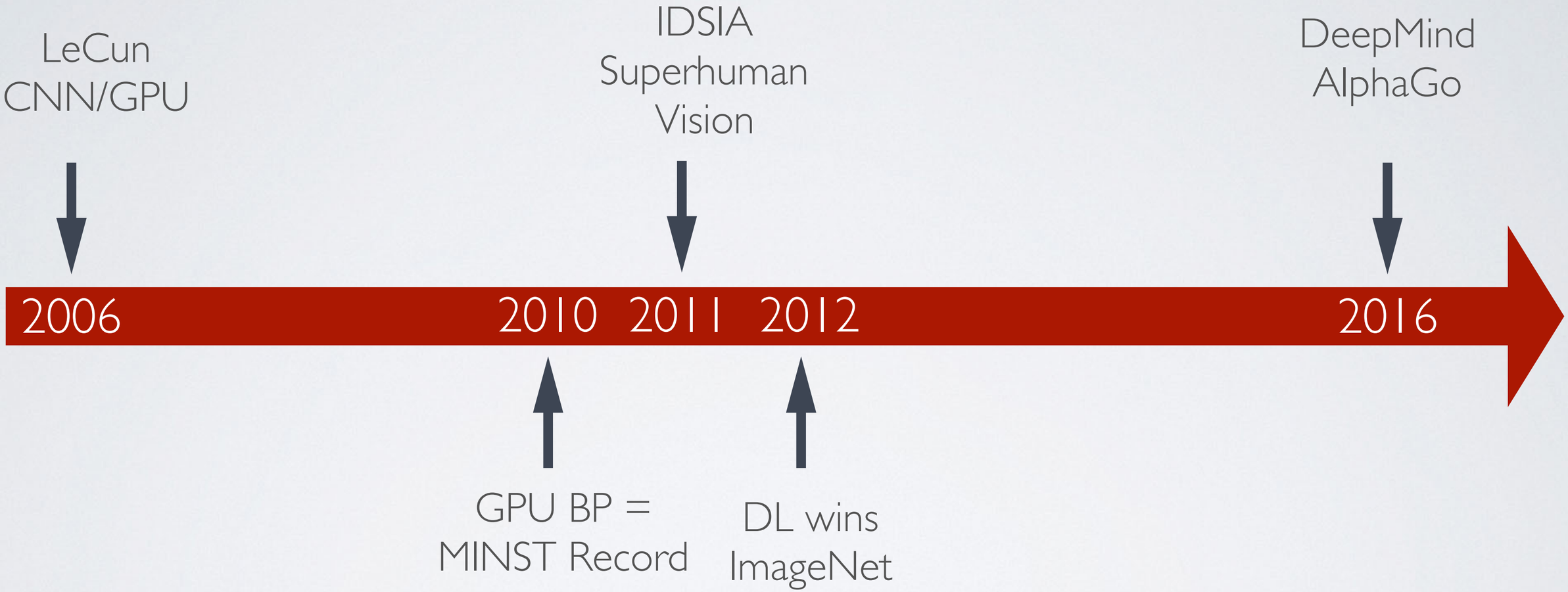
SCIENTIFIC PERSPECTIVE

- AI Timeline
- Axiomatization of AI

AI TIMELINE


Shannon
Info Theory
Huffman
Coding
Solomonoff
Inductive
Inference
Kolmogorov
Complexity
Willis
Probability
Constructions
Chaitin
AIT
1948
1950
1952
1956
1960
1961-3
1965
1968
1970
1974
1975
Carnap Logical
Foundations of
Probability
Chomsky
Generative
Grammar
Minsky
MIT AI Lab
Wallace
MML
Cover
Betting Theorem


Rissanen
MDL
Werbros
BP - ANN
Kohonen
Self Organizing
Map
Weng
Crescreptron
Schmidhuber
OOPS
1978
1979
1982
1987
1990
1991
1992
1995
2002
2004
Fukushima
Neocognitron
Ballard
Autoencoder
Hierarchies
Hochreiter
Deep Learning
Schmidhuber
LSTM
Schmidhuber
Godel Machine


LeCun
CNN/GPU
IDSIA
Superhuman
Vision
DeepMind
AlphaGo
2006
2010
2011
2012
2016
GPU BP =
MINST Record
DL wins
ImageNet

AXIOMATIZATION OF AI: BASIC AXIOMS

- These three (four) axioms are **absolutely** necessary
- **AI0**: AI possesses a universal computer U
  - e.g.: probabilistic universal comp., quantum comp.
- **AI1**: AI can learn any model expressed in U
- **AI2**: AI uses probabilistic prediction (Bayes' theorem)
- **AI3**: AI applies a principle of induction
- Physics envy? Perhaps so!

INCREMENTAL LEARNING

- Without any memory, machine learning is infeasible
  - Solution: incremental machine learning
  - Every common bit ~ 2x speedup
- **AI4**: AI must use incremental machine learning

- Practical incremental ML systems:
  - Teramachine: faster than human for simple seqs
  - OOPS: solved towers of hanoi problem

COGNITIVE ARCHITECTURE

- A simple Levin Search algorithm may be insufficient
  - Brain is equipped with a lot of innate information
- **AI5**: AI must be arranged so that it can improve itself
  - This must hold in *practice*, not just on paper
- Promising cognitive architectures:
  - Alpha: functional, higher-order, general, probabilistic
  - Gödel Machine: agent, self-reflective, logical
- Modularity means Architecture

BUSINESS PERSPECTIVE

- AI Landscape
- Labor Automation

AI 100 2017

100 STARTUPS USING ARTIFICIAL INTELLIGENCE TO TRANSFORM INDUSTRIES

CONVERSATIONAL AI/ BOTS

MindMeld · semantic machines · Maluuba · Mobvoi 出门问问 · KITT.AI · snips · clara · AUTOMAT · X.

VISION

clarifai · Chronocam · Orbital Insight · pilot.ai · Captricity · GROKSTYLE

AUTO

nuTonomy · drive.ai · AIMOTIVE · nauto · nexar · ∠⋈X

ROBOTICS

UBTECH · anki · Rokid · dispatch

CYBERSECURITY

CYLANCE · sift science · sparkcognition · deepinstinct · Shift Technology · DARKTRACE

BUSINESS INTELLIGENCE & ANALYTICS

DataRobot · TRIFACTA · rapidminer · tamr · SIGOPT · Paxata · context relevant · Dataminr · CrowdFlower · logz.io

AD, SALES, CRM

TalkIQ · deep gram · [PERSADO] · Qppier · CHORUS · INSIDE SALES.COM · drawbridge · DigitalGenius · RESCI

CORE AI

affectiva · PETUUM · ALGORITHMIA · $H_2O.ai$ · loop ai COGNITIVE COMPUTING · CognitiveScale · sentient · Voyager Labs · Numenta · SI SCALED INFERENCE · skymind · vicarious · Digital Reasoning · bonsai · AYASDI

HEALTHCARE

freenome · CLOUD MEDX · zebra · enlitic · twoXAR · iCarbonX · Atomwise · deep genomics · BabyLon · BenevolentAI · Lunit

THE AI 100 2017

TEXT ANALYSIS/ GENERATION

textio · fido.ai · cortical.io · NarrativeScience

IOT/IIOT

nanit · KONUX · VERDIGRIS · SIGHT MACHINE

COMMERCE

bloomreach · mode.ai

FINTECH & INSURANCE

CAPE ANALYTICS · KENSHO · NUMERAI · alphasense · Kasisto

OTHER

GIGSTER · prospera · Citrine · BLUE RIVER TECHNOLOGY · ROSS · zymergen · Descartes Labs · gradescope · talla

LABOR AUTOMATION

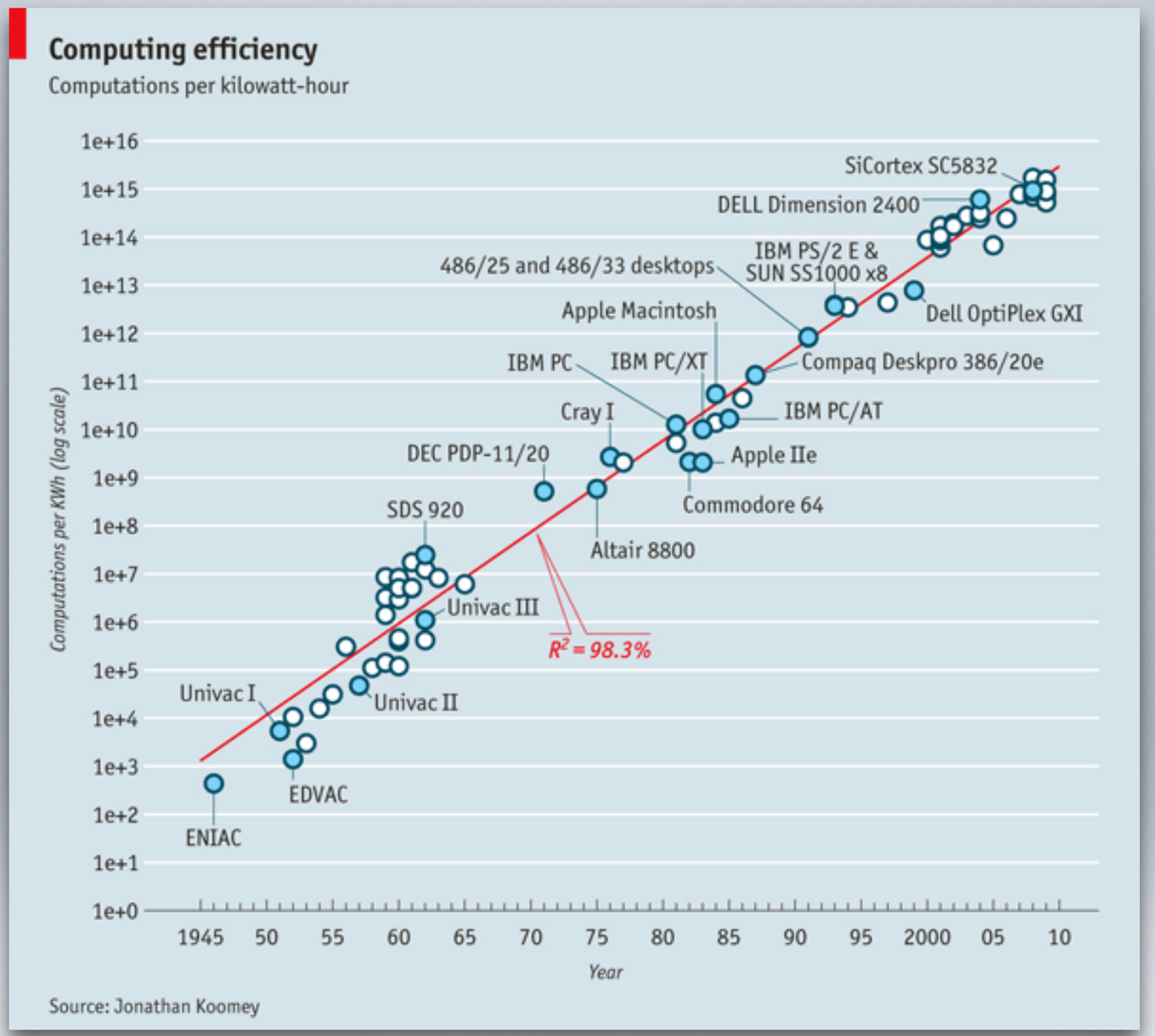
- Concepts for Taxonomy of Labor Tasks:
  - Low/High Intelligence-Intensive
  - Low/High Data-Intensive
  - Low/High Knowledge-Intensive
  - Low/High Creativity
  - Low/High Skill
  - Low/High Interaction
  - Low/High Linguistic Competence
  - Low/High Repetitiveness

LABOR AUTOMATION TRENDS

- Automation timeline
  - Clerks
  - Artisans, intermediate art.
  - Engineering/research assistance
  - Finance workers
  - Science/Engineering automation
- Robotics, the elephant in the room
  - Transportation
  - Factory automation
  - Personal Robotics

FUTURE OF AI: INFINITY POINT AND BEYOND

- Infinity Point (Solomonoff 85):
  - AI improves efficiency of computing at fixed energy
  - More efficient computing accelerates AI
  - Positive feedback: infinite acceleration in finite time!
  - In practice, infinity cannot be reached
- AI milestone G: an AI several times smarter than the entire CS community, 2040's?
- Ray Kurzweil:
  - Law of Accelerating Returns
  - Singularity: 2045


Computing efficiency
Computations per kilowatt-hour
Computations per KWh (log scale)
1e+16
1e+15
1e+14
1e+13
1e+12
1e+11
1e+10
1e+9
1e+8
1e+7
1e+6
1e+5
1e+4
1e+3
1e+2
1e+1
1e+0
1945
50
55
60
65
70
75
80
85
90
95
2000
05
10
Year
SiCortex SC5832
DELL Dimension 2400
IBM PS/2 E &
SUN SS1000 x8
486/25 and 486/33 desktops
Dell OptiPlex GXI
Apple Macintosh
Compaq Deskpro 386/20e
IBM PC
IBM PC/XT
IBM PC/AT
Cray I
Apple IIe
DEC PDP-11/20
Commodore 64
SDS 920
Altair 8800
Univac III
$R^2 = 98.3\%$
Univac I
Univac II
EDVAC
ENIAC
Source: Jonathan Koomey

KOOMEY'S LAW

A WEAK ECONOMIC CONDITION

- Suppose we cannot write the right program:
  - Brain simulation is bio-info based AI
- Energy efficiency of computing:
  - NVIDIA P100: 37 gigaflops/watt
  - Human brain: max.192 teraflops/watt
- Human neocortex: max. 3.8 teraflop/sec

- By 2030: GPU's match human efficiency
- Cheap intellectual work drives brain simulation
- Rapid offloading of human labor to silicon after 2030
- 2025: EU Human Brain Project final date
  - First whole brain simulation

INFINITY POINT BY 2035

- R=1 in Solomonoff's theory
  - Amount of money invested every year matches intelligence of CS community
  - Negligible cost: 20W of AI processor enough for every CS researcher
- Massive acceleration occurs, in 4.62 years, Infinity Point is projected
- In practice, there are many bottlenecks, like experiment speed, and physical limits
  - 21st century: we still expect ~100x speedup in technological progress

THANKS FOR LISTENING

Please send your questions to examachine@gmail.com