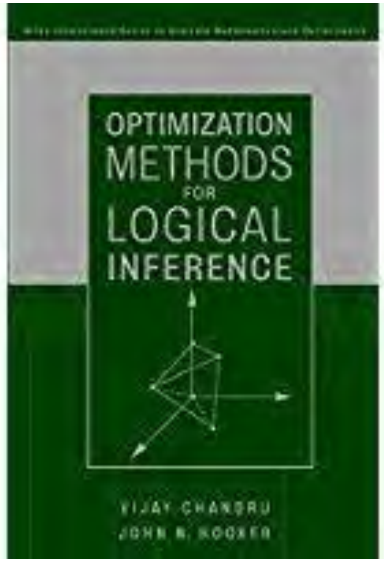
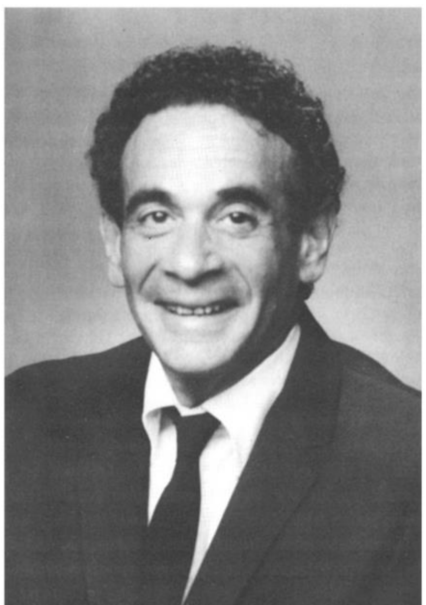


My Induction Lecture

IASc July 1997



Eating Sauerkraut with Chopsticks

The Second Half of the Leibniz Program

Alan Mathison Turing
(1912-1954)

The Turing Test

Alan Mathison Turing (1912-1954), logician and coding theorist, is also regarded as the founder of artificial intelligence by many computer scientists. In a landmark paper, Computing Machinery and Intelligence *Mind*, October 1950, 59: 433-460, Turing turned to the question *Can machines think*? Rather than being caught in a web of definitions of 'machine' and 'think' (as many android epistemologists do), he chose to focus on an operational translation of this question and formulated a brilliantly simple and unambiguous test, described in the form of a game.

The Imitation Game : H, C and R denote a human, a computer and a human interrogator respectively positioned in separate rooms. R interrogates the occupants of Room X and Room Y via a teleprinter. R does not know which room contains the computer. We can assume that the content of all teletyped questions and answers is visible to H, C and R (a teletyped conference call!). Each round of the game ends with R declaring which room contains the computer. The objective of H is to get R to make the correct choice and the objective of C is just the opposite.

Turing had already formulated an abstract model of a universal digital computer (*the Turing Machine,* see next article). Thus the question "Can machines think?" is replaced by an unambiguous one: Will there ever be a digital computer that makes the interrogator R choose wrongly about half the time?. Turing pointed out that the game actually favoured man over machine since it is possible that machines 'think' in a different way from man. Clearly, if a man were to try to pretend to be the machine, he would be given away at once by slowness and inaccuracy in arithmetic. So if a machine passes this biased test, it will be all the more reason to believe that machines can think.Turing was confident that "in about fifty years' time it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70 per cent chance of making the right identification after five minutes of questioning". He was also in favour of approaching the quest for an intelligent machine in two stages. First program a "child machine" and then make it 'learn'.

Imagine the following exchange:
R: Do you play chess? X: Yes.
R: I have K at my K1, and no other pieces. You have only K at K6 and R at R1. It is your move. What do you play?
X: (After a pause of 15 seconds) R-R8 mate.

This example of an exchange in the imitation game was given by Turing to demonstrate how a chess playing computer might respond (Turing had actually programmed such a machine). In the second game of the recent chess contest between Kasparov and Deep Blue played on May 4, 1997 in New York (see Anjaneyulu's article in this issue), some commentators have claimed that Deep Blue passed the Turing test in the world of chess. Kasparov had played a game of closed positions, a strategic game where sheer combinatorial enumeration has little advantage, a game favouring a human grandmaster. Yet Kasparov lost and one grandmaster said that he didn't know where Kasparov went wrong. Deep Blue seemed to have learned strategy from its programmed strength in tactics.

But this was only in a game of chess. As Turing put it, "We can only see a short distance ahead, but we can see plenty there that needs to be done".

Vijay Chandru

Computers vs Humans

- Faster, more powerful, particularly in groups acting in parallel
- More systematic, no motivational problems, no boredom, no error

Deep Blue vs Kasparov 1996-97

Deep Thinking: Kasparov is now a Professor at the *Future of Humanity School* at Oxford University. His program of research is Machines and Humans working in concert to achieve **Intelligence Augmentation**.

My Superannuation Lecture

IASc November 2018

strand

New Generation Healthcare

Sciences of the Artificial

Promise and Reality

Vijay Chandru

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INAE Distinguished Technologist

Indian Institute of Science

Nitin Pandit

nitinspandit@gmail.com

Computational Ecologist

ATREE

"As with many phrases that cross over from technical **academic fields into general circulation**, there is significant misunderstanding accompanying the use of the phrase **Artificial Intelligence**. But this is not the classical case of the public not understanding the scientists—**here the scientists are often as befuddled as the public.**"

- Prof Michael Jordan, UC Berkeley

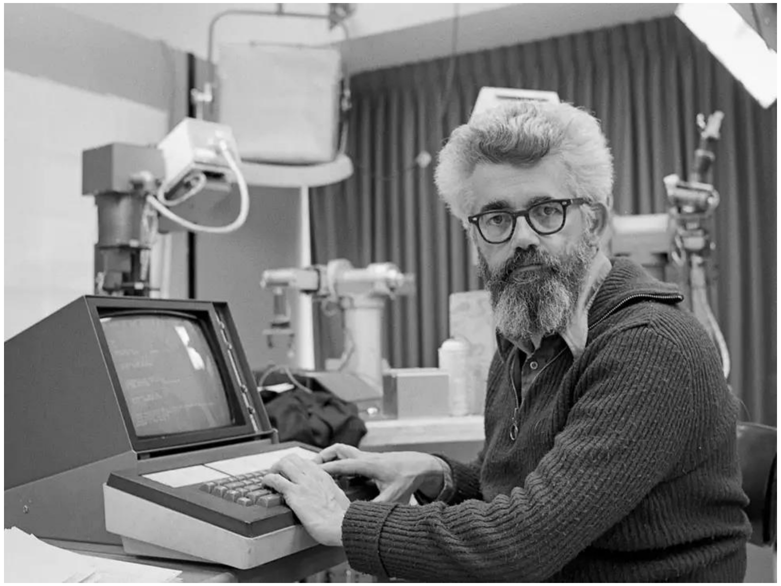
What’s in a name? Artificial Intelligence

To explore ways to make a machine that could reason like a human, was capable of abstract thought, problem-solving and self-improvement… Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.

– *Preamble to the First Conference on Artificial Intelligence, Dartmouth 1956*

- John McCarthy (Research Fellow MIT 1956) came up with “AI,” to differentiate with the “Cybernetics” of Norbert Wiener. McCarthy emphasized the ties to logic to solving the imitation game of Alan Turing.

- **It is ironic that Wiener’s intellectual agenda is selling today under the banner of McCarthy i.e., as Artificial Intelligence.**



John McCarthy
Stanford University

The Sciences of the Artificial
Herbert A Simon
1962-1968

- **What of artificial sciences?** Knowledge about artificial objects and phenomena. Artificial as in “produced by art / man-made rather than natural”
  - Artificial things are synthesized
  - Artificial things may imitate the natural
  - Artificial things have function, goals, adaptation
  - Artificial things are designed by descriptors and imperatives
  - Artificiality and the limits of rationality in administration
  - Artificiality and Complexity: Systems Hierarchy

75 YEARS OF INTELLIGENCENT SYSTEMS

1940s

Turing Computing Abstractions, Coding, Logistics of military operations

1950s-60s

Intellectual foundations of Operations Research, Cybernetics, Statistical Decision Theory, Sciences of the Artificial, The Imitation Game (Turing Test)

1970s-80s

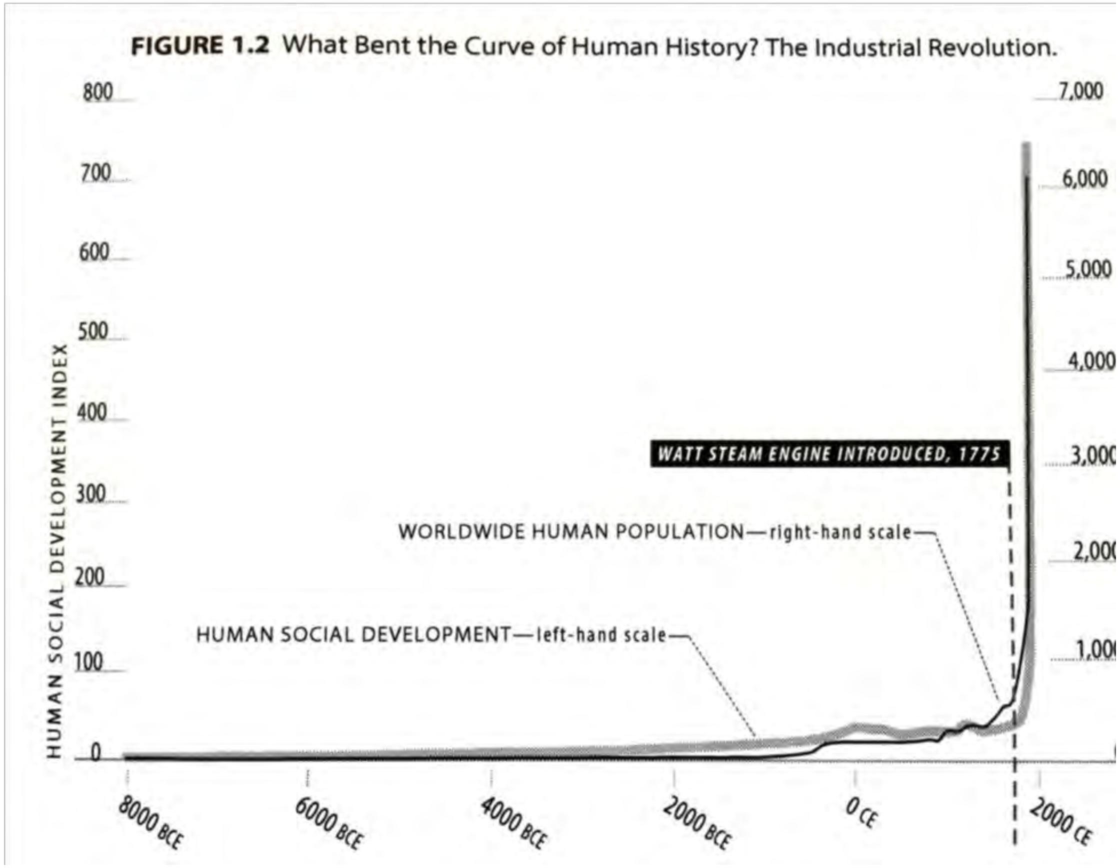
Computing machines drive translation of mathematics into effective military, civilian and industrial applications

1990s

Internet technologies and advances in smart sensors, big data, communications, computing, and social networking

2010s

Cognitive - new insights and understanding when huge amounts of data are integrated and mined.



Numerically, most of human history was boring!

- **Industry 1.0**

Steam Engine
Locomotion 1760-1840

- **Industry 2.0**

Factories, Electricity

19th-20th Centuries

- **Industry 3.0**

Computing Automation
1960s-2015

- **Industry 4.0**

Cognitive 2015 -

Are we riding a singularity?

The advances we've seen in the past few years

- **cars that drive themselves,**
- **useful humanoid robots,**
- **speech recognition and synthesis systems,**
- **3D printers,**
- **Jeopardy champion computers**

are not the crowning achievements of the computer era.
They're the warm-up acts.

-Brynjolfsson & McAfee, The Second machine Age

The Hype is typically 10 years ahead of reality

Intelligence: the ability to solve problems well

- **Intelligent Systems** – Cybernetics, Decision Sciences, Operations Research, Theorem Proving, Rule Based Systems, Pattern Recognition, Machine learning, Deep Learning, …
- **Collective Intelligence** – Emergent hyperconnectivity, Superminds
- **Artificial Intelligence** – Kurzweil 2029

THE UNREASONABLE EFFECTIVENESS OF ~~MATHEMATICS~~ MACHINE LEARNING IN THE ~~NATURAL~~ SCIENCES OF THE ARTIFICIAL

WIGNER / GEOFFREY HINTON – ANDREW YAN-TAK NG 吳恩達

IS AI RIDING A ONE TRICK PONY?

A real intelligence does not break when you slightly change the problem!

A **black box** cannot **explain** why a solution found is good or a why a prediction makes sense.

CHINA's AI AWAKENING

China's quest for AI leadership:

In 2017, the Chinese Government unveiled a plan to develop the country into the world's primary innovation centre for artificial intelligence (AI) by 2030.

Peking University Hospital Shenzhen

India’s mess of complexity is just what AI needs!

“The country’s diversity of scripts, dialects, dress and cultureis a challenge that will make artificial intelligence more resilient”

- *Varun Agarwal, Technology Review July/August 2018*

NITI Aayog releases national strategy on Artificial Intelligence, identifies these 5 focus areas

NITI Aayog has identified five sectors -- healthcare, agriculture, education, smart cities and infrastructure and transportation -- to focus its efforts towards implementation of artificial intelligence (AI) to serve societal needs.

By IANS | New Delhi | Published: June 4, 2018 7:35 PM

We are committed to having AI strategy executed: Amitabh Kant, CEO ...

AI can help double income of rural people with same efforts: Amitabh ...

Amitabh Kant on Twitter: "Artificial Intelligence: Nimble startups can ...

Amitabh Kant on Twitter: "Artificial intelligence has d power 2 ensure ...

NITI Aayog, Google Partner to Foster India's Artificial Intelligence ...

Accolades at the KDD Cup

Challenge of Pulmonary Emboli Detection

Pulmonary embolism (PE) is a condition that occurs when an artery in the lung becomes blocked. In most cases, the blockage is caused by one or more blood clots that travel to the lungs from another part of your body. While PE is not always fatal, it is nevertheless the third most common cause of death in the US, with at least 650,000 cases occurring annually.1 The clinical challenge, particularly in an Emergency Room scenario, is to correctly diagnose patients that have a PE, and then send them on to therapy. This, however, is not easy, as the primary symptom of PE is dysapnea (shortness of breath), which has a variety of causes, some of which are relatively benign, making it hard to separate out the critically ill patients suffering from PE.

Task 3: One of the most useful applications for CAD would be a system with very high (100%?) Negative Predictive Value. In other words, if the CAD system had zero positive candidates for a given patient, we would like to be very confident that the patient was indeed free from PE's. In a very real sense, this would be the "Holy Grail" of a PE CAD system.

KDD

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Intro Tasks Rules Data Results FAQ Contacts **KDD Cup 2006**

- **Best Student Entry:** Zhang Cas (IA, PKU)

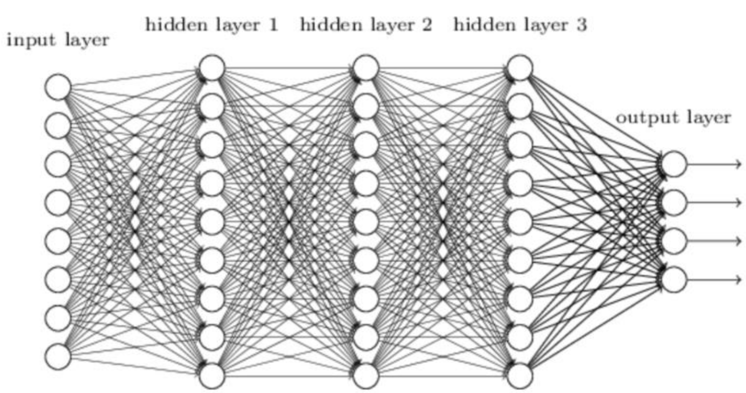
Winners of KDD Cup 2006: Task 3 - Negative Predictive Value

- **First Place:** William Perrizo and Amal Shehan Perera (DataSURG Group, North Dakota State University)
- **Runner Up: Nimisha Gupta and Tarun Agarwal (Strand Life Sciences Pvt. Ltd.)**
- **Best Student Entry:** Karthik Kumara (team leader), Sourangshu Bhattacharya, Mehul Parsana, Shivramkrishnan K, Rashmin Babaria, Saketha Nath J, and Chiranjib Bhattacharyya (Indian Institute of Science)

KDD CUP 2006

- KDD Cup 2005
- KDD Cup 2004
- KDD Cup 2003
- KDD Cup 2002
- KDD Cup 2001
- KDD Cup 2000

Searching for the right Curve



ANNs

Chapter 37

Algorithms for the Optimal Loading of Recursive Neural Nets

V. Chandru[*] A. Dattasharma[†] S. S. Keerthi[‡] N. K. Sancheti[§] V. Vinay[¶]

Abstract

We address the problem of choosing synaptic weights in a recursive (Hopfield) neural network so as to "optimize" the performance of the network on the recognition of binary strings. The problem has been called the net loading (or learning) problem in the literature [10]. The objective is to maximize the basins of attraction around the desired fixed points (binary strings) of the net. It is known that it is $\mathcal{NP}$-hard to evaluate even the two-step radius of attraction of a recursive neural net [3]. We focus on the radius of direct (one-step) attraction and will refer to this as the loading problem. We have both theoretical and computational results on this problem, that we summarize below.

- A proof that the net loading problem can be solved in polynomial time using linear programming techniques. This resolves a standing problem in the complexity of recursive neural networks [10].
- An alternate formulation of the net loading problem as a proximity problem in high-dimensional convex geometry.
- The design and implementation of a hybrid algorithm for the said proximity problem.
- Successful solution of large scale test problems including the optimal solution to a 900×900 Hopfield net with approximately 4×10^5 synaptic weights.

It may be noted that our experiments indicate that the radius of direct attraction is actually a very good proxy of the intractable (multi-step) radius of attraction. In all the test problems that we have solved, the synaptic weights obtained as a a solution to the maximum radius of direct attraction also maximize the radius of (multi-step) attraction. In this sense the message of this paper is that the effective design of large-scale associative memory based on recursive neural networks is possible.

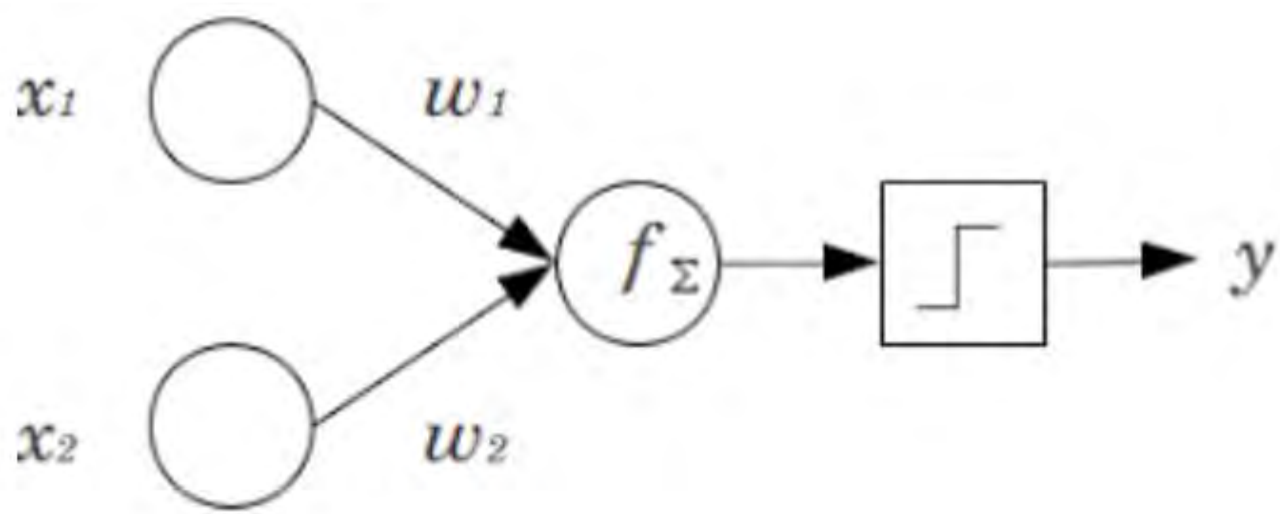
trix. These networks are of interest because of their use as associative memory in classification and pattern recognition. Given a specified set of binary vectors $\{y^1, y^2, \cdots, y^p\}$ the network behaves as an associative memory if it eventually reproduces as its output one of the inputs, say y^i, when triggered at the input by a vector z which is sufficiently close to y^i. Here "sufficiently close" means that the Hamming distance between z and the fixed point y^i, i.e. the number of unequal components of the two bipolar strings, is no more than the radius of the basin of attraction around y^i.

The dynamical behaviour of recursive neural network makes it difficult to analyse the radius of attraction around a given pattern. It has been shown by Floreen and Orponen [3] that it is $\mathcal{NP}$-hard to evaluate even the two-step radius of attraction of a recursive neural net. We present exact algorithms to synthesize recursive neural networks that optimize the radius of direct attraction.

(Net Loading) *Given vectors $y^1, ..., y^p$, where each y^i is an $n-$ dimensional vector whose components are $\{+1, -1\}$, construct a weight matrix, W, such that the resulting network has maximum radius of direct attraction about the y^i.*

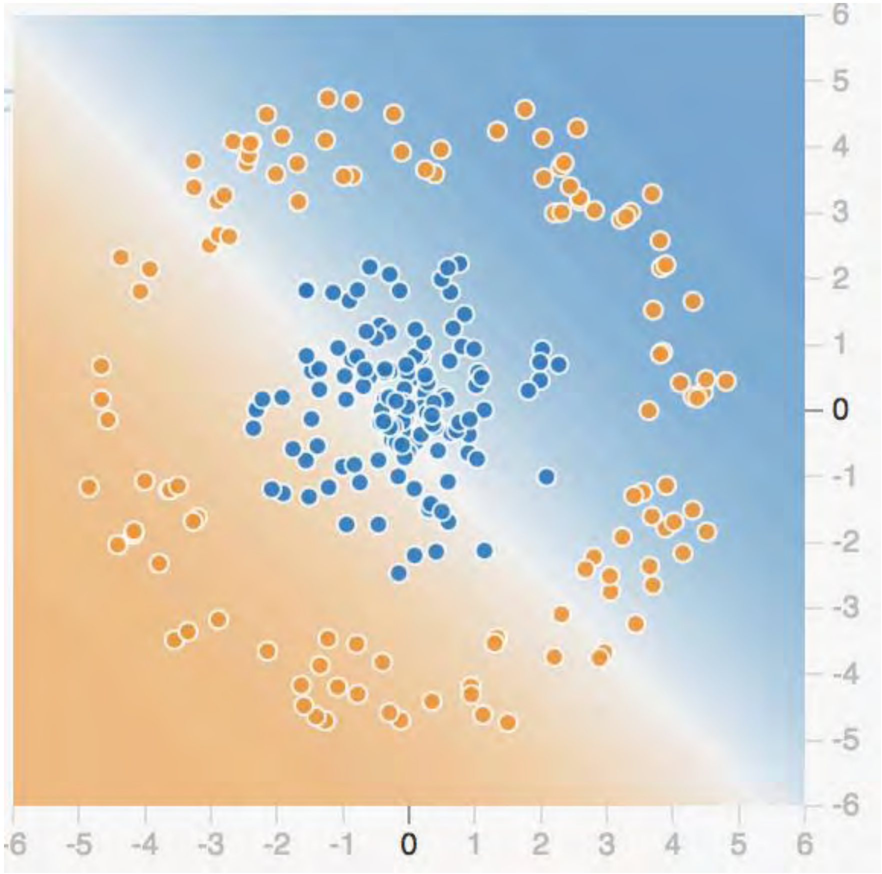
We shall see, from both theoretical and computational perspectives, that this problem is tractable.

A Single Neuron - Perceptron

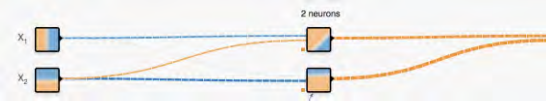


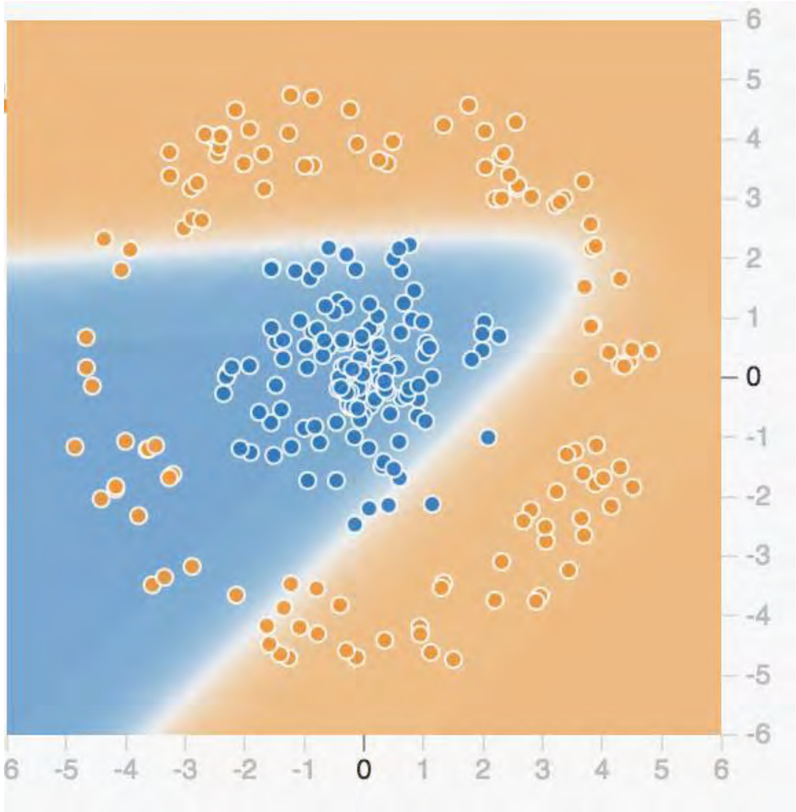
Ack: Ramesh Hariharan FASc

Example I

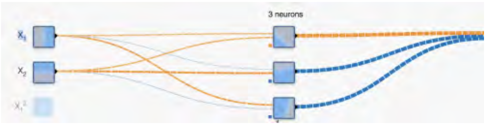


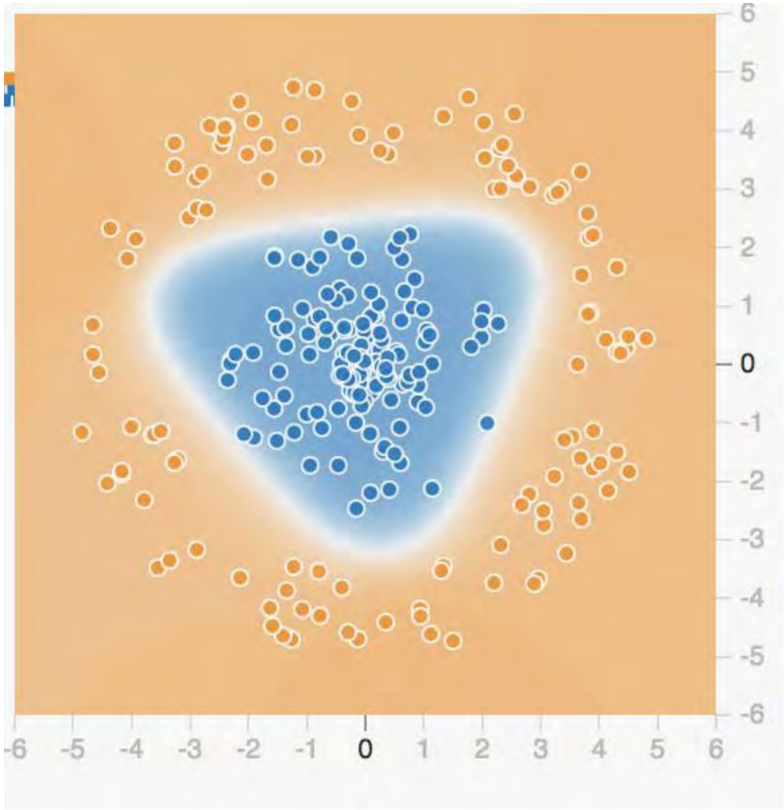
1 Layer, 2 Neurons



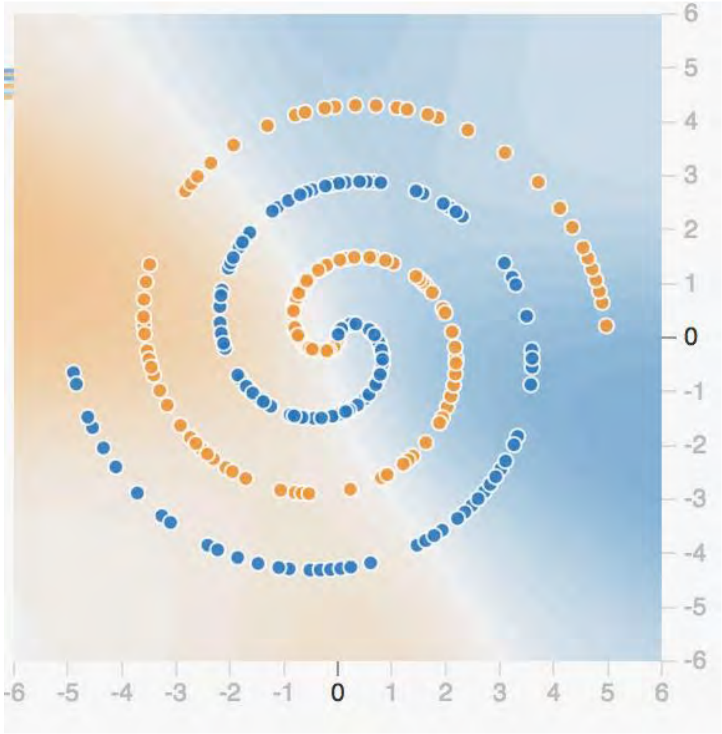


1 Layer, 3 Neurons

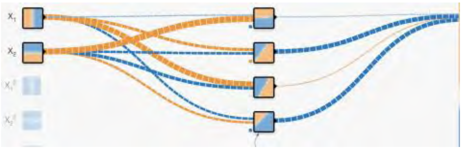


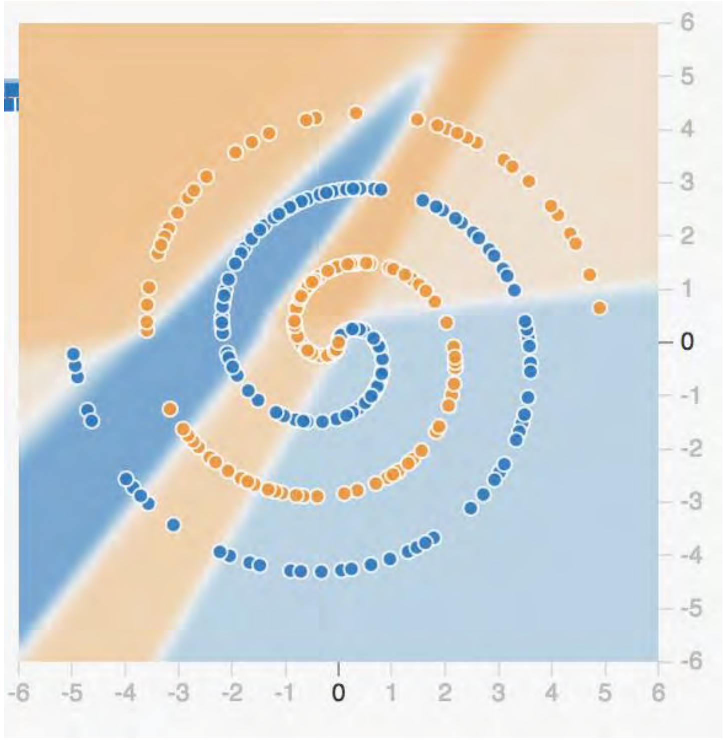


Example II: Harder

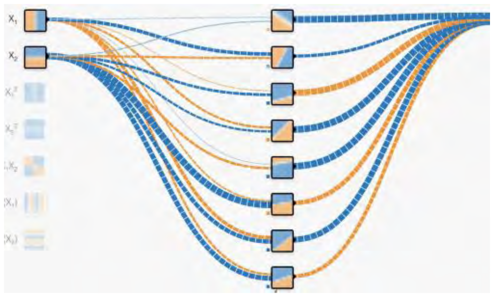


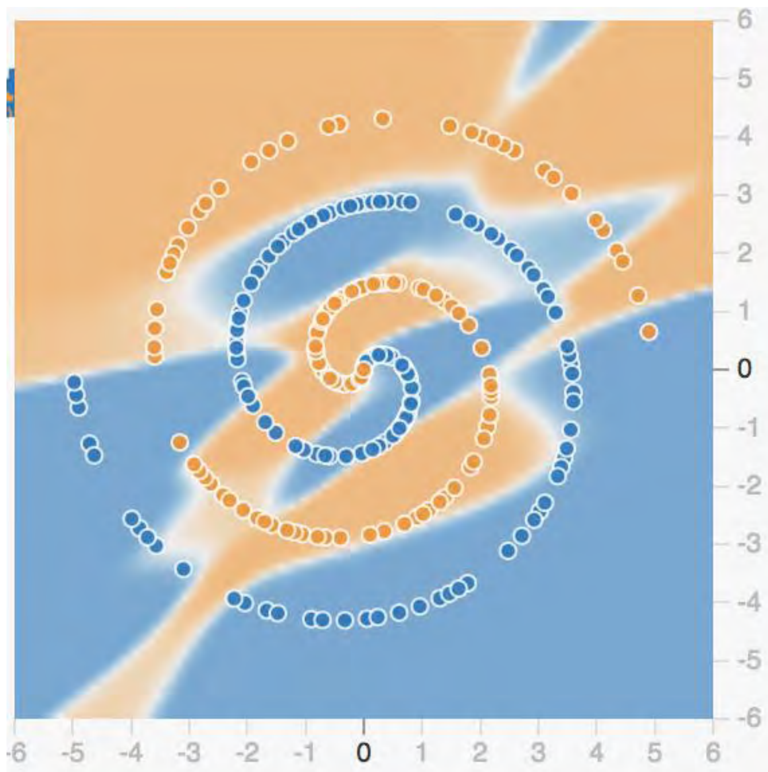
1 Layer, 4 Neurons



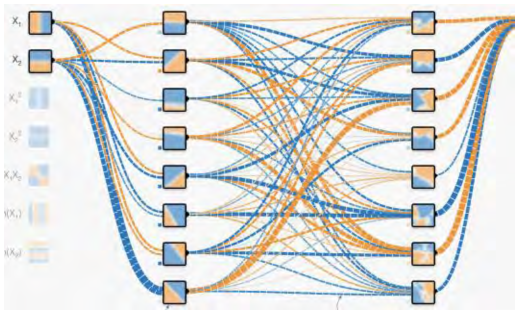


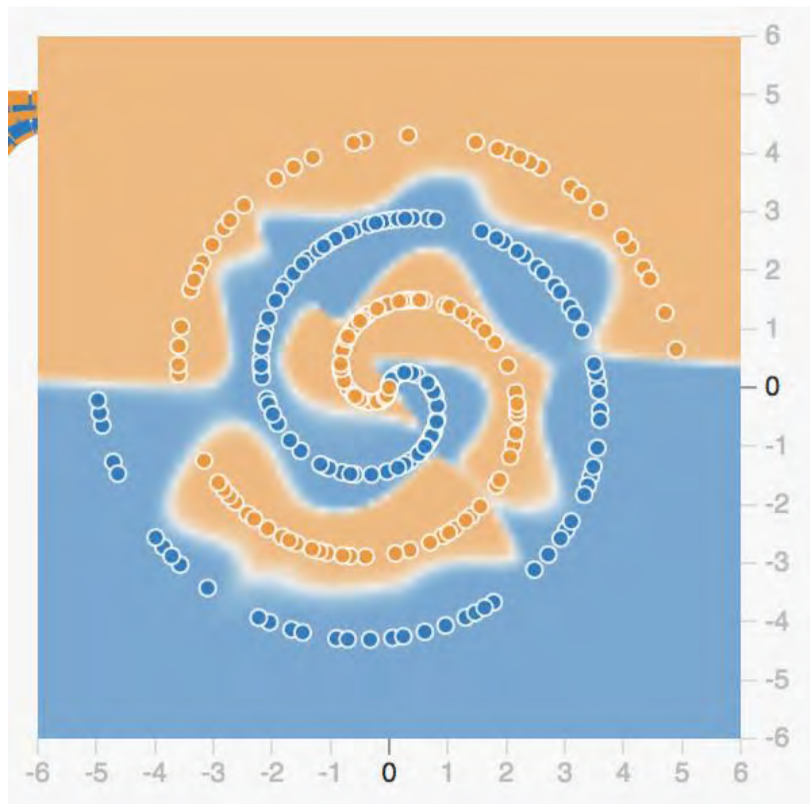
1 Layer, 8 Neurons





2 Layers, 8 Neurons Each





Facebook's DeepFace

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

Yaniv Taigman   Ming Yang   Marc'Aurelio Ranzato   Lior Wolf

Facebook AI Research
Menlo Park, CA, USA
{yaniv, mingyang, ranzato}@fb.com

Tel Aviv University
Tel Aviv, Israel
wolf@cs.tau.ac.il

Who are these celebrities?

Now You Know

Massive Scale

Abstract

*In modern face recognition, the conventional pipeline consists of four stages: detect $\Rightarrow$ align $\Rightarrow$ represent $\Rightarrow$ 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. The learned representations coupling the accurate model-based alignment with the large facial database generalize remarkably well to faces in unconstrained environments, even with a simple classifier. Our method reaches an accuracy of 97.35% on the Labeled Faces in the Wild (*LFW*) dataset, reducing the error of the current state of the art by more than 27%, closely approaching human-level performance.*

The New AI World

- Handcrafted Intelligence vs Deep Learnt Intelligence

- Huge Training Sets

- Huge Compute Power for Training

Life Sciences - Healthcare, Heritage Science, Algorithmic Trading

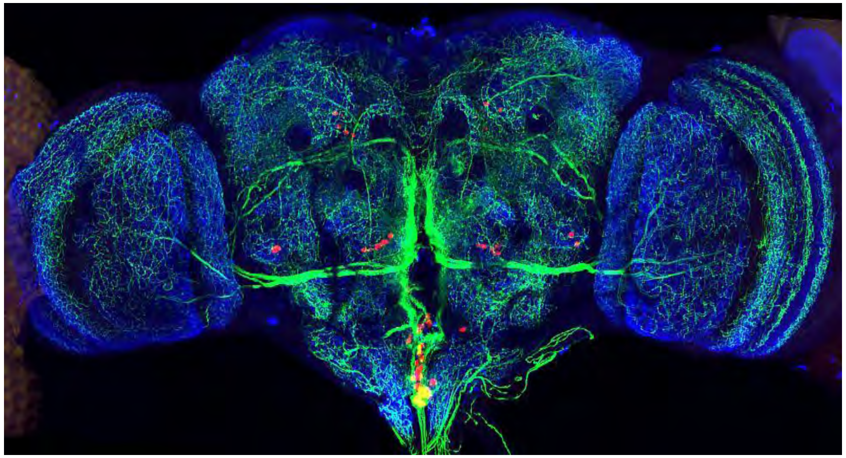
MORE ARTIFICIAL INTELLIGENCE VIGNETTES

Computer Science is not about Computers any more

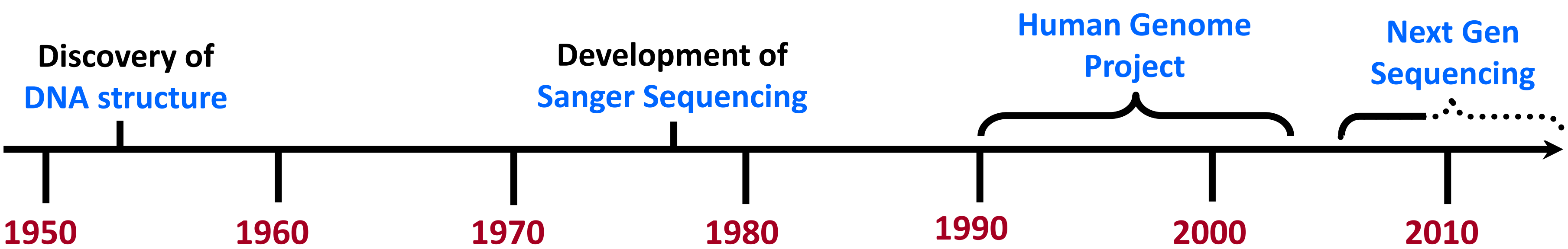
The Universe

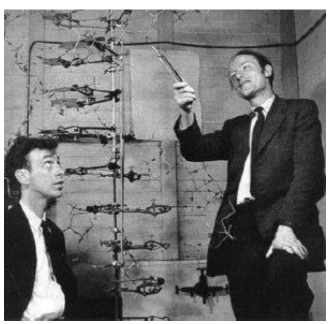
The Internet

Biology

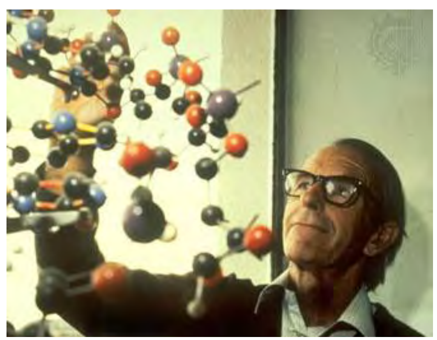


The Genomics Revolution Timeline





Watson & Crick
The Code



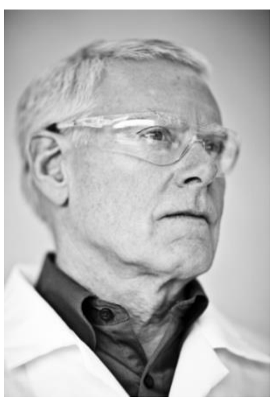
Frederick Sanger
Sequencing DNA

Presidential Initiative
Human Genome Project

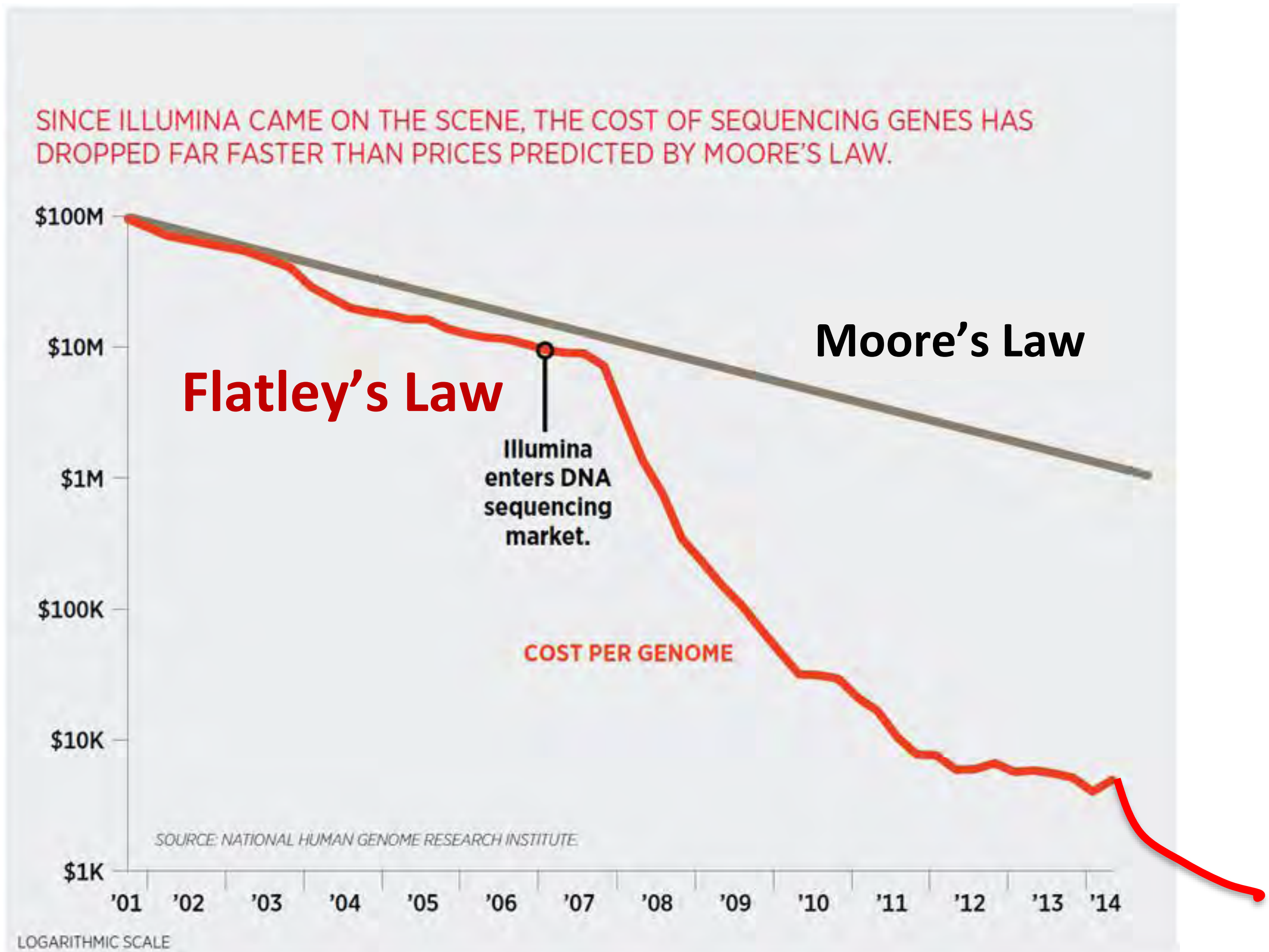
Presidential Initiative
Precision Medicine

Exponential Laws in Technology

Gordon Moore
Chairman Emeritus, Intel



Jay Flatley
CEO, Illumina



Ref: Forbes, 2014

Second Half Technologies

Moore's Law (Electronics)

- Semi-conductors 1958
- Doubles every 18 months
- Second Half 2^{32} by **2006**
- ***IMPACT*: Robotics, Deep Learning, Autonomous Vehicles, Intelligence Augmentation, Watson, …..**

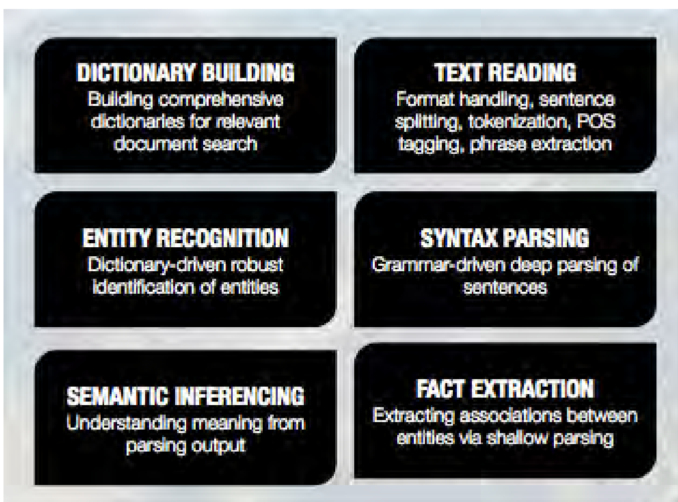
Flatley's law (Genomics)

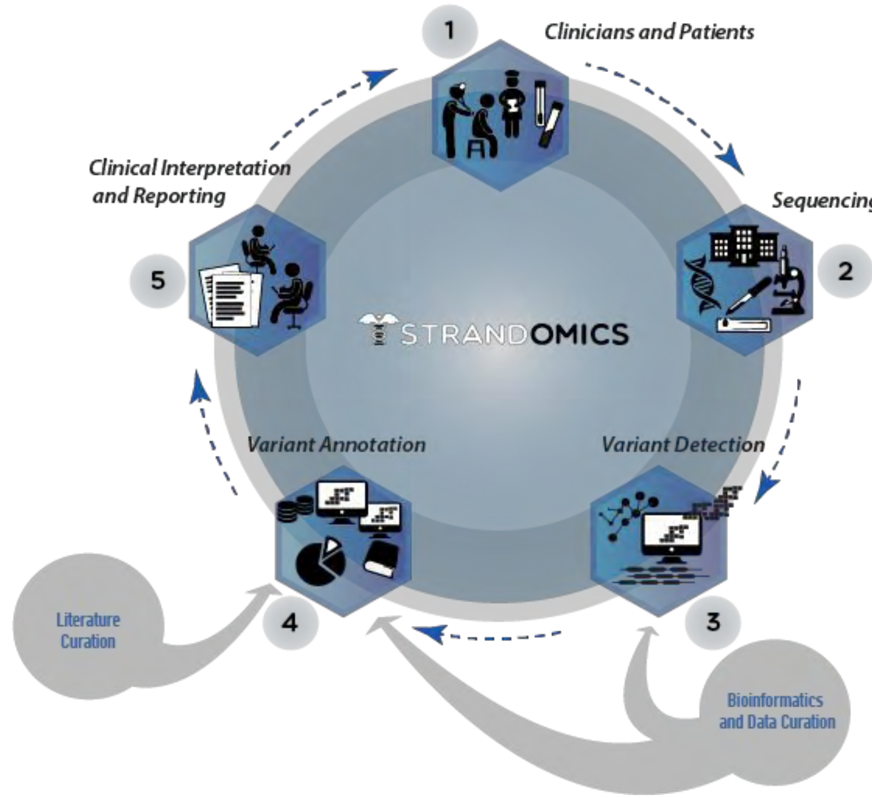
- Sanger/CalTech 1985
- 18 month (Moore's law)
  - 1985-2008 2^{16}
- NGS (Solexa-Illumina)
  - 2008-**2017** 2^{32}
  - NovaSeq $100 Whole Genome
- **IMPACT: Precision (medicine, health, farming, gene therapies, …)**

Personalized Medicine
The Ramanujan Augmented Intelligence Stack

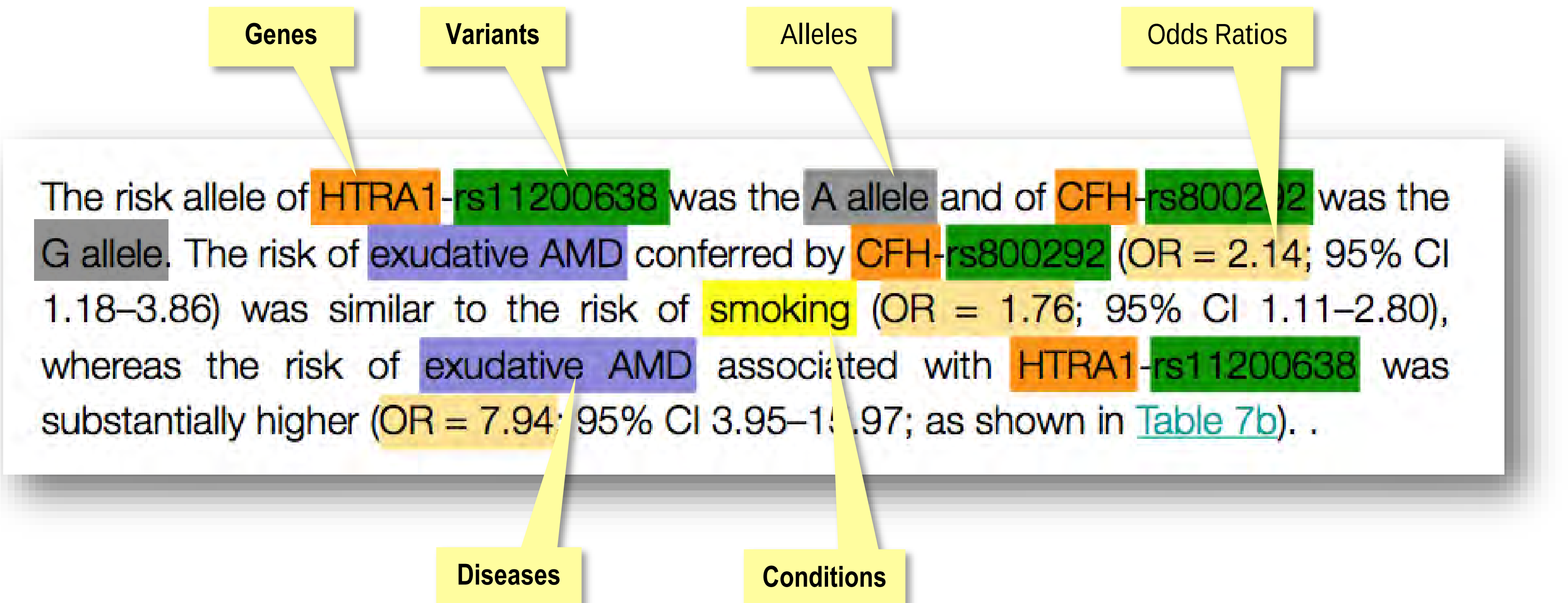
- **Data Analytics** for extracting more out of data

- **Natural Language Processing** for extracting knowledge from vast amounts of literature



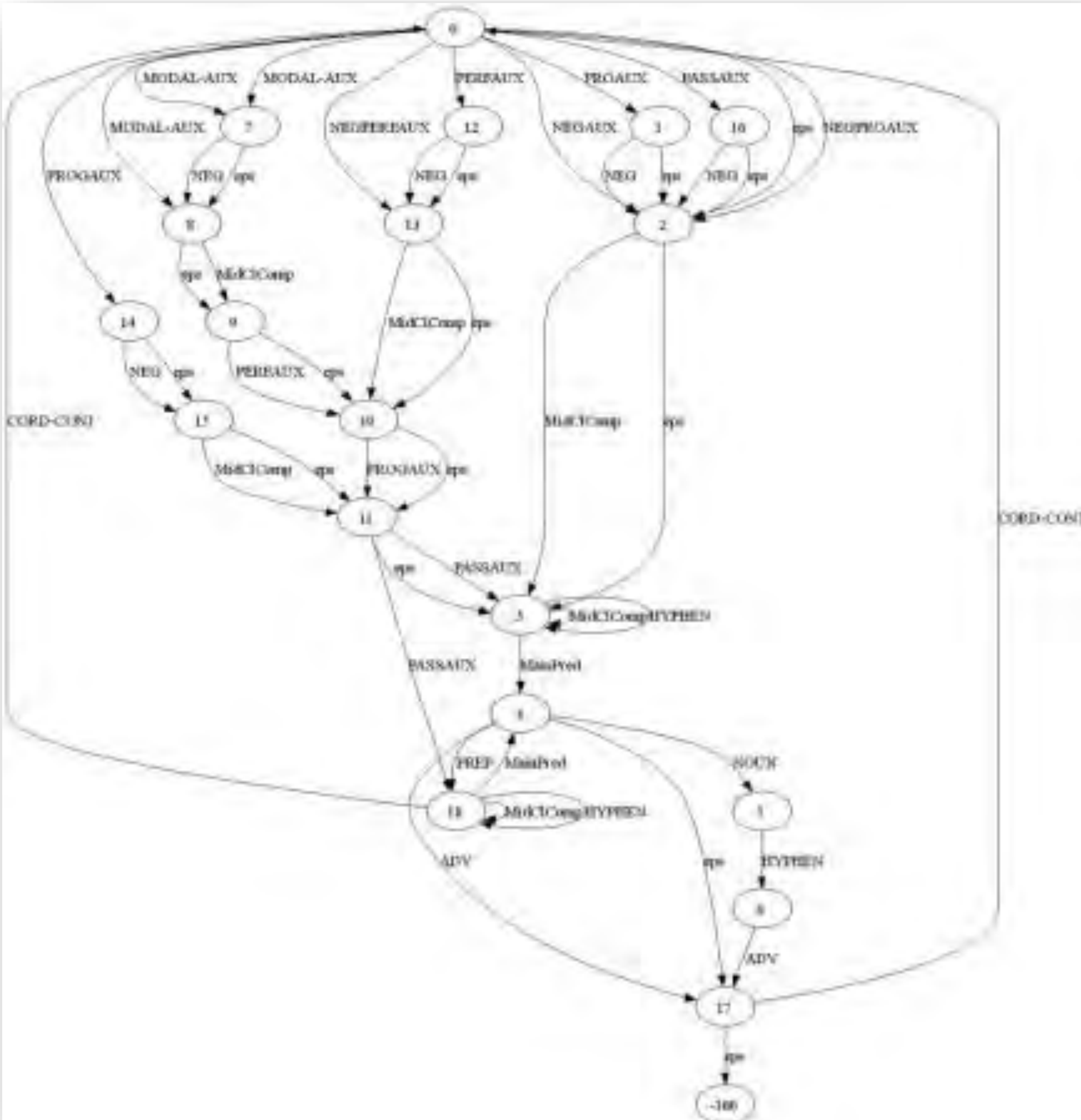


Automatic Extraction from Text



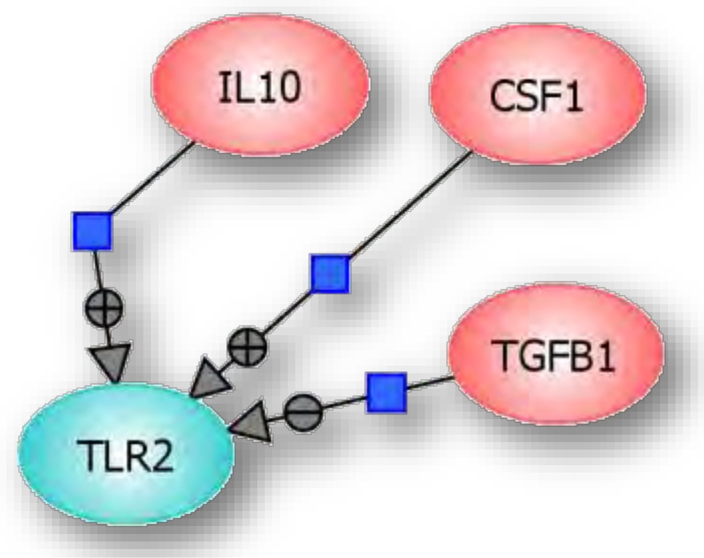
The risk allele of HTRA1-rs11200638 was the A allele and of CFH-rs8002[illegible]2 was the G allele. The risk of exudative AMD conferred by CFH-rs800292 (OR = 2.14; 95% CI 1.18–3.86) was similar to the risk of smoking (OR = 1.76; 95% CI 1.11–2.80), whereas the risk of exudative AMD associ[illegible]ted with HTRA1-rs11200638 was substantially higher (OR = 7.94[illegible] 95% CI 3.95–1[illegible].97; as shown in Table 7b). .

The Grammar for a Verb!

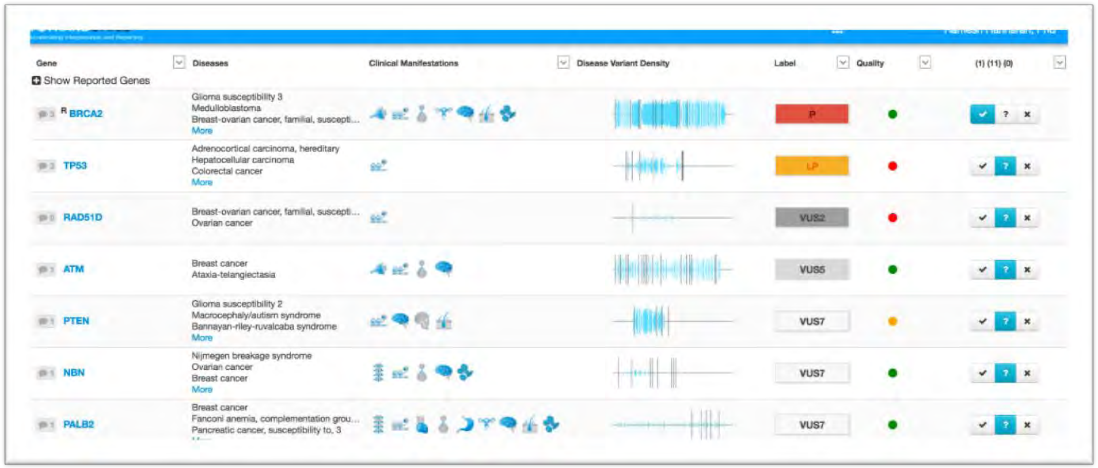


Automatic Relationship Extraction

"TLR-2 expression on monocytes was enhanced by macrophage colony-stimulating factor (M-CSF) and interleukin-10 (IL-10), but was reduced by transforming growth factor beta1."



Intelligent Systems Platforms



Strand IRIS

A powerful and easy-to-use web-based tool
for automated clinical reporting of NGS-based diagnostic tests in solid tumors.

✓ AMP compliant variant categorisation ✓ HIPAA compliant ✓ Prioritized clinical trials

✓ Customisable templates ✓ Option to request manual review

✓ Drug class based reporting ✓ Report generation in minutes.

The StrandOmics Platform

- Algorithms, databases, curated content, dashboards for variant interpretation and reporting
- Honed over 10s of thousands of reports
- In constant usage by an experienced team of 30+
- Drives our costs of reporting down to 10% or less of costs in comparable labs.

New Generation Healthcare

India’s Precision Medicine Leader

The first academic spin-off in India from the Indian Institute of Science, the premier post-graduate research institute in India, in the year 2000

Over 1M Tests/year, ~900 employees, 27 Labs across India - mix of Computer Scientists, Life Scientists, Geneticists, and Pathologists

Algorithmic Trading

Jim Simons, Mathematician
Renaissance Technologies

David Shaw, Computer Scientist
D. E. Shaw & Co.

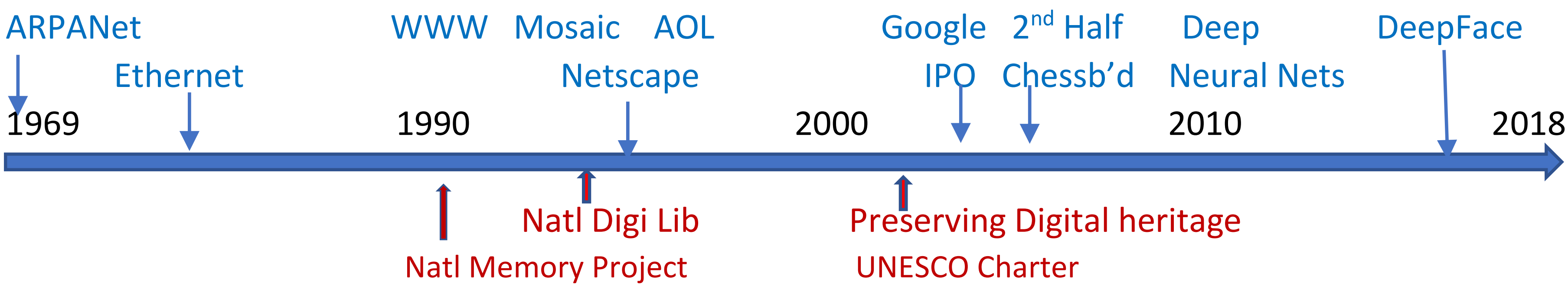
Digital Hampi: Cultural Heritage

International Institute for Art, Culture & Democracy

Vizara Technologies Pvt Ltd

सत्यमेव जयते
Department of Science and Technology
Ministry of Science and Technology
Government of India

Digital Heritage Science



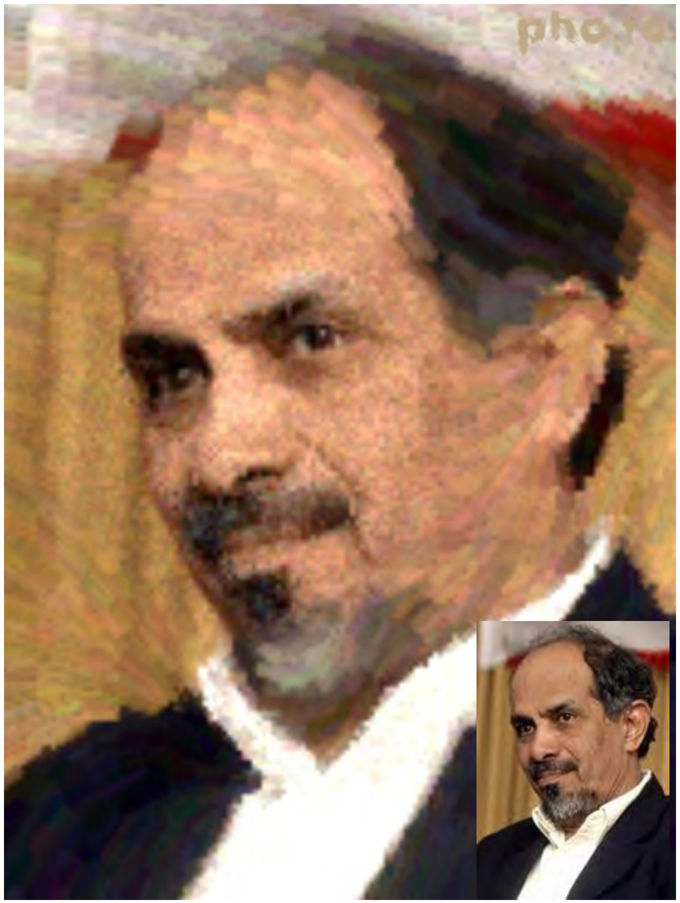
The Cognitive Era Technological Advances

- Deep Learning Pattern Classification and Feature Extraction
- Natural Language Processing and Knowledge Acquisition
- Ontologies / Reasoning and Curatorial Bots
- Robots as Artists – new genres at the click of a button

Computational Positivism

‘computational positivism’, which considers observation and computation as the only things that matter

dṛk to **ga. itā** to **siddhā-antha**



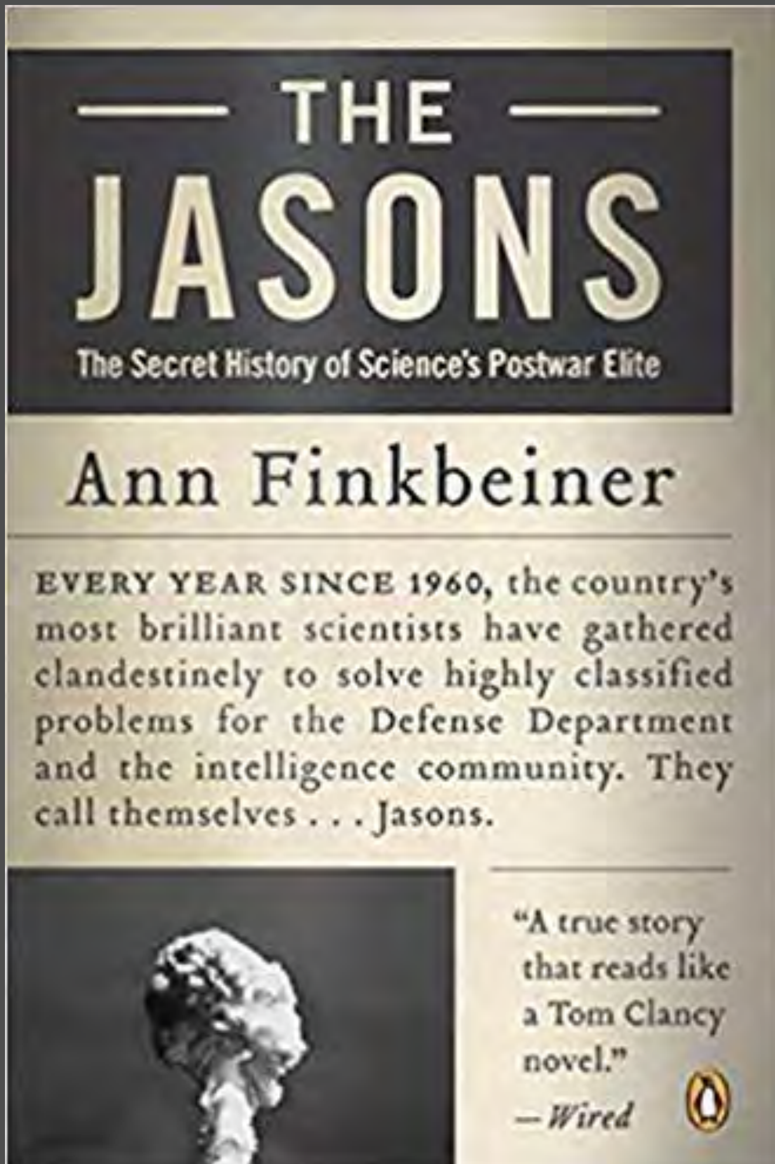
Dialogue

We need to realize that the current public dialog on AI, which focuses on a narrow subset of industry and a narrow subset of academia, risks blinding us to the challenges and opportunities that are presented by the full scope of

AI(Artificial Intelligence)

IA (Intelligence Augmentation)

II (Intelligence Infrastructure CPS)



Finkbeiner's book also carries a message for those who fear we are entering an anti-science age, in which right-wing politicians, religious fundamentalists, Luddites and postmodernists challenge science's authority. Some scientists are circling the wagons, depicting science as the embodiment of enlightenment and all its critics as knaves or buffoons. But science is and always has been as morally fallible as any other human activity. Indeed, because of its immense potential for altering our lives for good or ill, science needs critics like Finkbeiner now more than ever.