

Artificial Intelligence and the Singularity

piero scaruffi

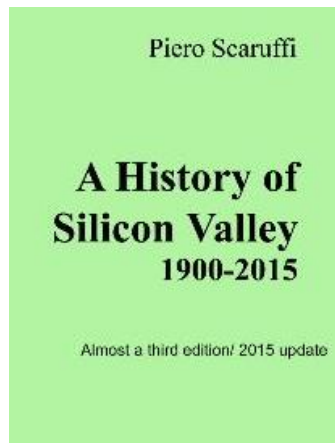
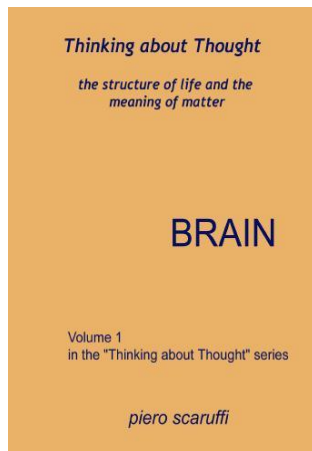
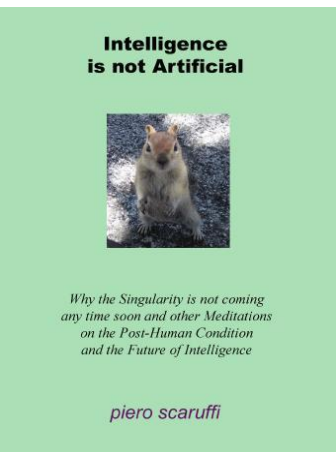
www.scaruffi.com

October 2014 - Revised 2016

*"The person who says it cannot be done should not
interrupt the person doing it" (Chinese proverb)*

Piero Scaruffi

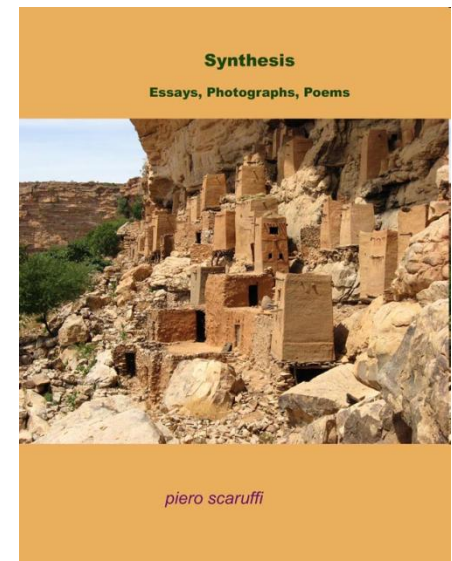
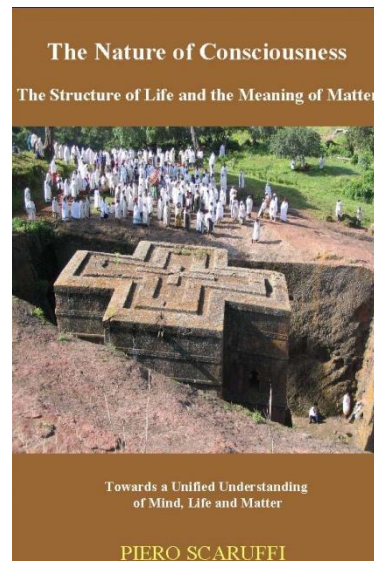
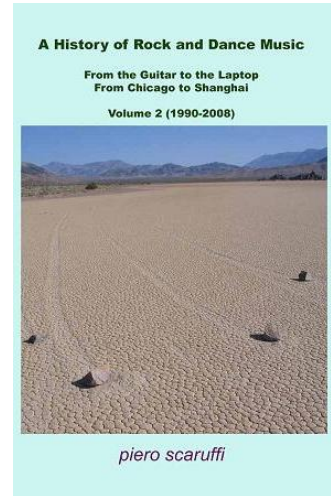
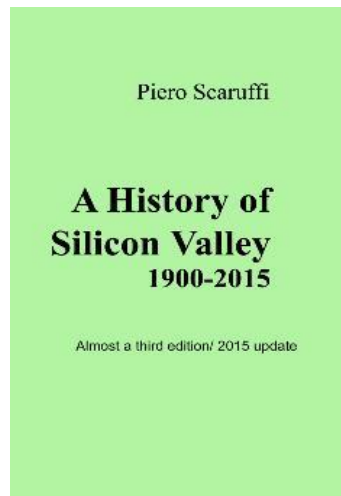
- piero scaruffi
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Olivetti AI Center, 1987

Piero Scaruffi

- Cultural Historian
- Cognitive Scientist
- Blogger
- Poet
- www.scaruffi.com



This is Part 9

- See <http://www.scaruffi.com/singular> for the index of this Powerpoint presentation and links to the other parts
 1. Classic A.I. - The Age of Expert Systems
 2. The A.I. Winter and the Return of Connectionism
 3. Theory: Knowledge-based Systems and Neural Networks
 4. Robots
 5. Bionics
 6. Singularity
 7. Critique
 8. The Future
 9. Applications
 10. Machine Art
 11. The Age of Deep Learning

A.I. Applications

AI Applications

Finance

Fraud detection

Cybersecurity

Search

Industrial robotics

Consumer robots

Caretaking robots

Medical images analysis

Drug discovery

Law

Business Analytics/ Data Mining

Recommendation engines/

Advertising engines

Autonomous vehicles

Scientific discovery

Virtual Assistants

Summary and story generation

Art and Music

Translation

Customer support

Conversational User Interfaces

A.I.-driven Innovation

Blockchain: decentralized intelligence

Augmented reality: “small data”

3D Scanning/Printing: personal manufacturing

IoT: Predictive analytics, Prescriptive analytics, Adaptive analytics

CNC: Autotuning, Quality Control,...

Smart cities: peace technology

Etc



When to use Deep Learning

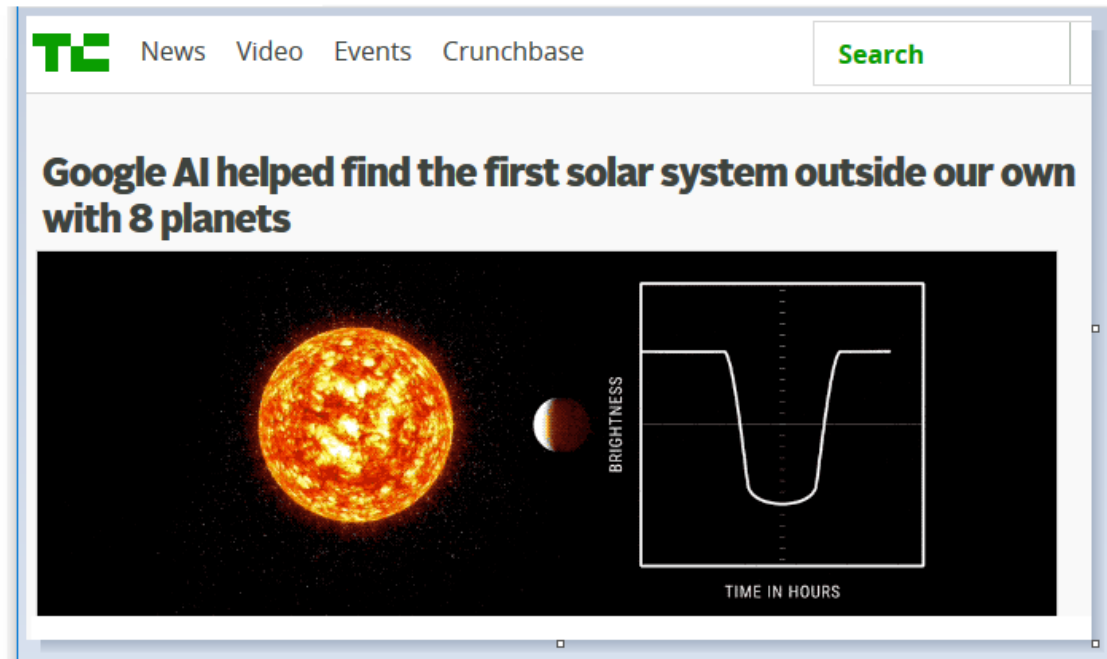
- When to use Deep Learning
 - Large dataset
 - Clean/balanced data
 - Modeling time-series data
 - Statistical methods don't work
- When NOT to use Deep Learning
 - Small dataset
 - Data not balanced
 - The goal is insight
 - Your boss told you to do it because it's popular

When to use Deep Learning

- A good example: NASA + Google (2017): discover patterns hidden in a large dataset of astronomical observations

CHRISTOPHER J. SHALLUE¹ & ANDREW VANDERBURG^{2,3} arXiv:1712.08547v1 [astro-ph]
¹ Google Brain, 1600 Amphitheatre Parkway, Mountain View, CA 94043
² Department of Astronomy, The University of Texas at Austin, 2515 Speedway, Stop C1400, Austin, TX 78712
³ Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138

December 2017



Examples: Medical

What are the unsolved problems?

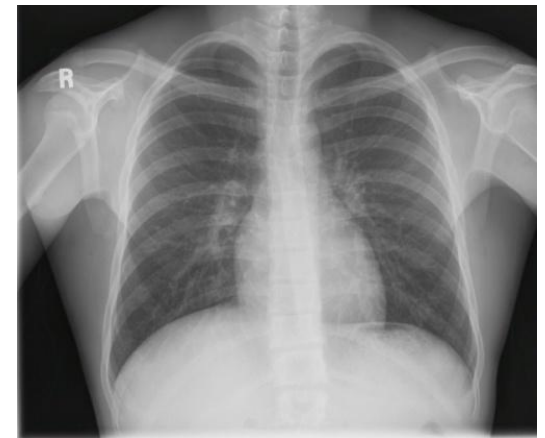
Medical Applications

- *Analysis of medical images*

X-Rays, MRIs, Computed Tomography (CT), etc

Philips Health Care: 135 billion medical images, 2 million new images every week

Helping radiology, cardiology and oncology departments understand images

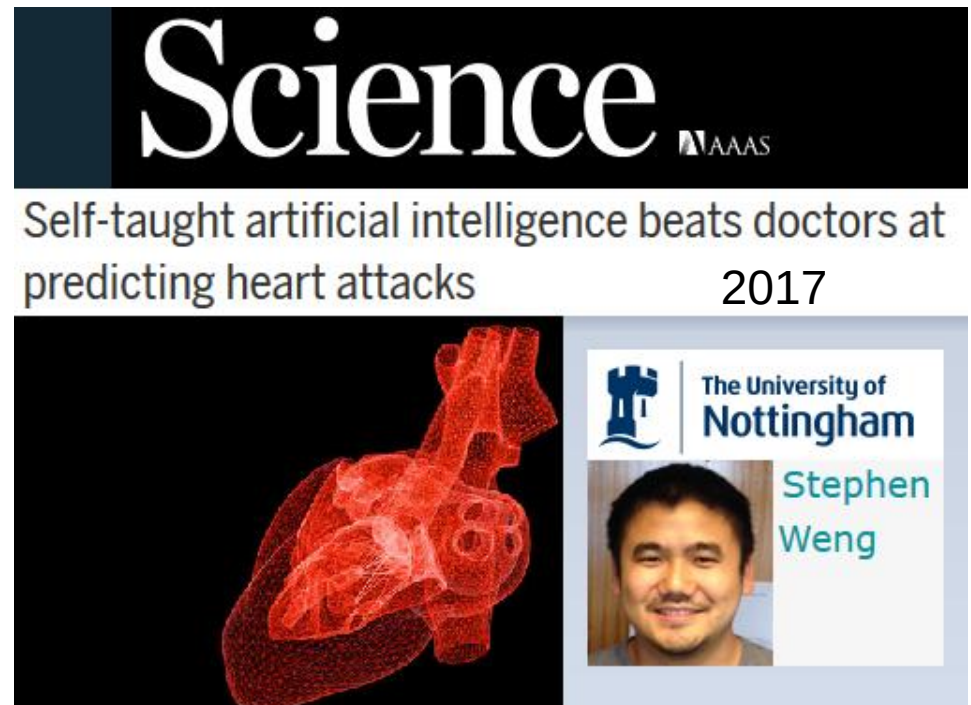


Medical Applications

- *Analysis of medical images*

Sebastian Thrun

Stephen Wang



Medical Applications

- *Analysis of medical images*

Varun Gulshan & Lily Peng (Google, 2016)

Lyle Palmer's student Luke Oakden-Rayner
(University of Adelaide, 2016)

Scientists have developed a new way to predict when you'll die

Precision Radiology: 

Predicting longevity using feature engineering and deep learning methods in a radiomics framework



Luke Oakden-Rayner
Nascimento, Andrew



Bessen, Jacin
December 2016

GOOGLE'S AI READS RETINAS TO PREVENT BLINDNESS IN DIABETICS

December 13, 2016

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan,

Lily Peng



Medical Applications

- *Analysis of medical images*

Paul Bentley (Imperial College London, 2018)

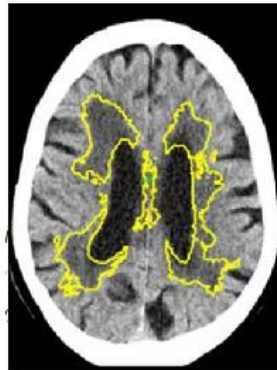
Artificial Intelligence Improves Stroke and Dementia Diagnosis in Brain Scans

NEUROSCIENCE NEWS × MAY 17, 2018

Imperial College
London



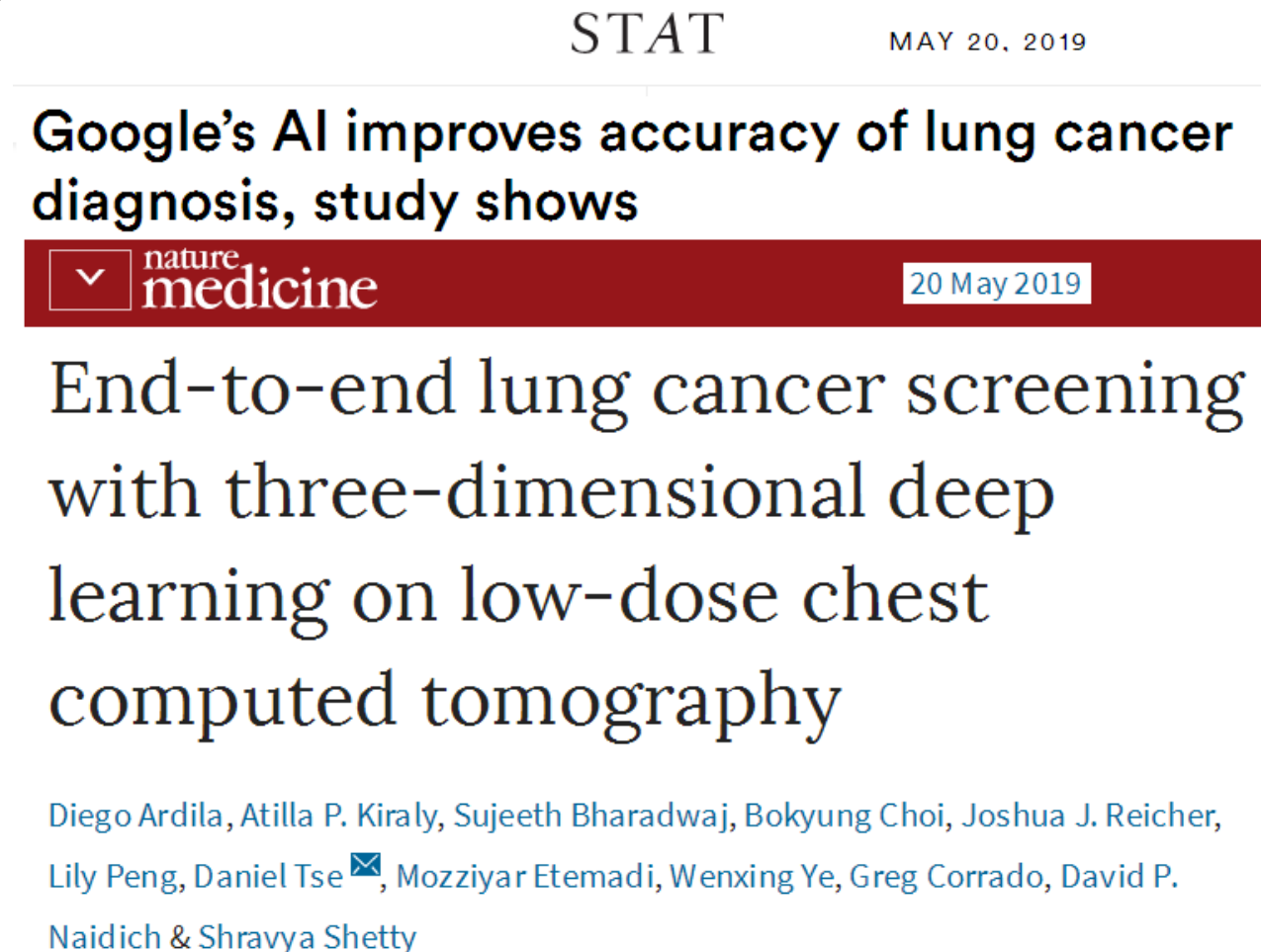
Paul Bentley



Medical Applications

- *Analysis of medical images*

Google (2019)



Medical Applications

- *Analysis of medical images*

The FDA approves the first A.I. system for medical use

Diagnostic system for heart conditions made by Arterys, a spinoff of Stanford University's StartX accelerator

15 seconds to produce a result which would normally take an hour by a professional cardiologist



A.I. in Biotech/Medical

- *Longevity*

2013: Craig Venter's Human Longevity Inc

2013: Google's Calico ("longevity lab")



A.I. in Biotech/Medical

- *Longevity*

1993: Cynthia Kenyon (UCSF): **Daf-2** gene

1999: Leonard Guarente (MIT): the longevity gene in yeast is **sir2**

2000: Shinichiro Imai: the action of sirtuins depends on **NAD**

2013: David Sinclair: **NMN** reverses muscle aging in mice

2003: Fritz Muller (Freiburg): suppressing **TOR** prolongs the life of worms

2010: Rochelle Buffenstein (Univ of Texas): **NRF2** protects the body against aging

2012: Kiev Univ: the hydra is “immortal” due to the **FoxO** gene



A.I. in Biotech/Medical

- *Longevity*

Which genes do they have in common?

Jeanne Calment ^[1]	122 years, 164 days
Sarah Knauss ^[2]	119 years, 97 days
Lucy Hannah ^[3]	117 years, 248 days
Marie-Louise Meilleur ^[4]	117 years, 230 days
Violet Brown ^[5]	117 years, 189 days
Emma Morano ^{[5][6]}	117 years, 137 days
Nabi Tajima ^[5]	117 years, 119 days
Misao Okawa ^[5]	117 years, 27 days
María Capovilla ^[7]	116 years, 347 days
Susannah Mushatt Jones ^[5]	116 years, 311 days

Examples: Law

What are the unsolved problems?

A.I. in Law

- *Analysis of legal documents*

Harvard Law School: CaseLaw
Access Project to digitize the entire
historical record of court opinions



HARVARD LAW SCHOOL

**Library
Innovation
Lab**

Caselaw Access Project

A.I. in Law

- *Analysis of legal documents*

ROSS Intelligence: automatically process millions of pages, understand a query's context, and draft a memo on its findings

JP Morgan's COIN (2017)

Zapproved

ROSS

Supercharge lawyers
with artificial intelligence.



Zapproved Raises \$15M For its Cloud-Based eDiscovery Service

Posted Feb 2, 2015 by [Frederic Lardinois \(@fredericl\)](#)



JPMorgan Software Does in Seconds What Took Lawyers 360,000 Hours

by [Hugh Son](#)

February 27, 2017, 6:31 PM CST Updated on February 28, 2017, 6:24 AM CST



Examples: Smart City

What are the unsolved problems?

A.I. in Smart Cities

- *Smart Cities*



A.I. in Smart Cities

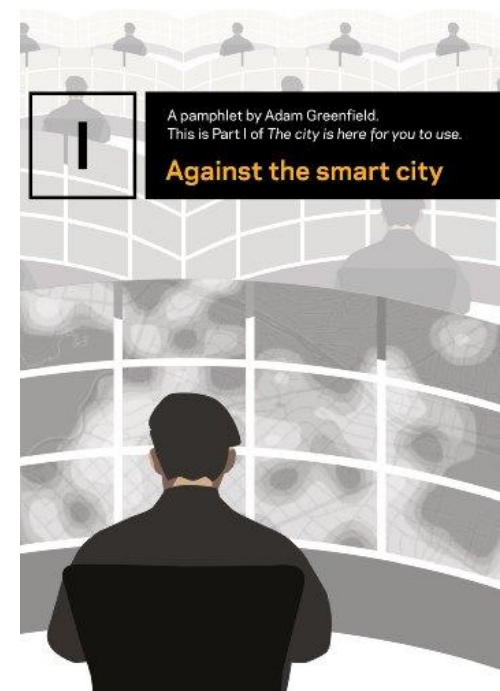
- *Smart Cities*

Adam Greenfield's book *"Against the Smart City"*: cities are products of specific geographies and economies (2013)

Michael Batty: *"The image of the smart city which comes from the corporate world betrays a level of ignorance about how cities function that is woeful and dangerous"* (2014)



Michael Batty, Director of the Centre for Advanced Spatial Analysis at University College London s, author of "The New Science of Cities"



A.I. in Smart Cities

- *Smart Cities*

Edward Glaser: “Technology lets us hold virtual meetings, and the Internet keeps us in touch 24/7, but neither can be a **substitute** for the social cues” (2011)

Shannon Mattern: “**A city is not a computer**” (2017)



Engines of Innovation

Most of humanity now lives in a metropolis. That simple fact helps to fuel our continued success as a species

(Scientific American, 2011)

By Edward Glaeser



A.I. in Smart Cities

- *Smart Cities*

A city is not made only of buildings, cars and streets.

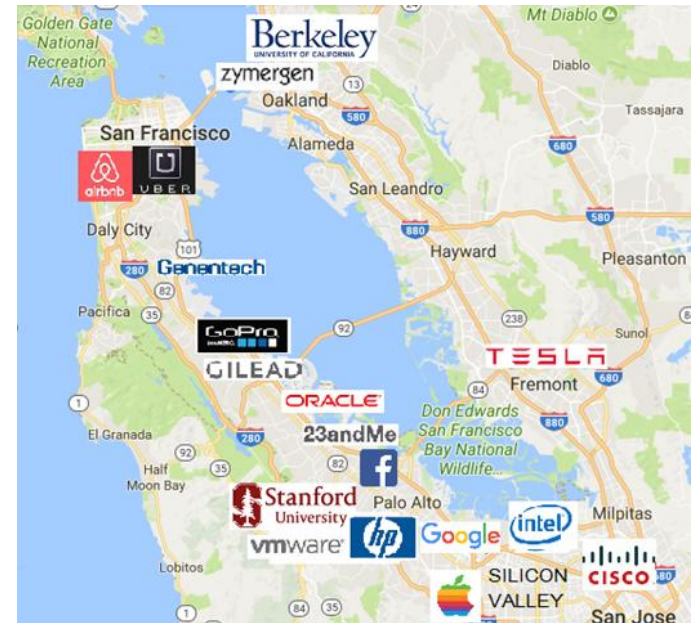
There are also people!



A.I. in Smart Cities

- *Smart Cities*

Beyond the Smart city: a city that gives inspiration, that motivates its inhabitants to create, an incubator of constant ubiquitous innovation



Examples: Manufacturing

What are the unsolved problems?

A.I. in Manufacturing

- *Product Design*

Industry 4.0: Automation +
Internet of Things + Big Data
+ Cloud Computing

Industry 5.0: + 3D Printing +
Crowdfunding + Robotic
warehouses + A.R. + A.I.

A.I.:

Predict market needs

Identify market opportunities



A.I. in Manufacturing

- *Product Design*
Combinatorial design



Project Dreamcatcher

What if a CAD system could generate thousands of design options that all meet your specified goals?



Adobe Sensei puts artificial intelligence at the center of amazing customer experiences.

A.I. in Manufacturing

- *Process and Quality*

Process optimization (e.g. power consumption)

Visual inspections to find imperfections in products (e.g., Landing.ai)

**MIT
Technology
Review**

December 14, 2017

**Andrew Ng Says
Factories Are AI's Next
Frontier**



LANDING.AI

A.I. in Manufacturing

Organization

A.I. can

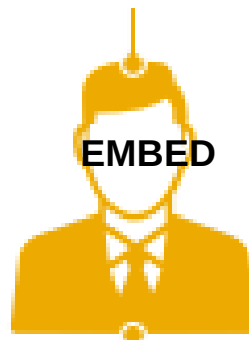
- answer questions,
- suggest decisions
- monitor progress



Virtual Assistant

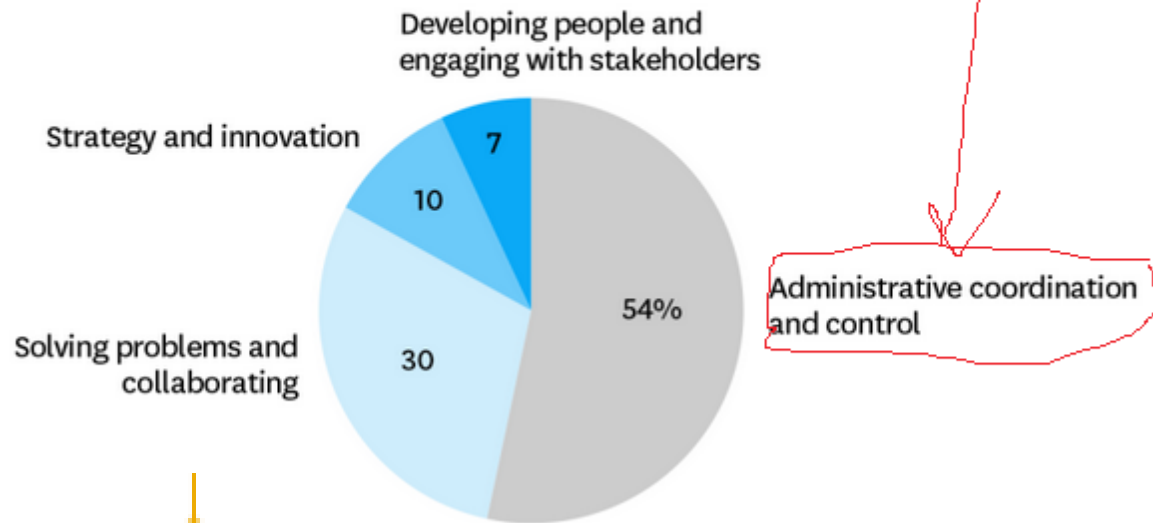


Big Data Analytics



Monitoring "bots"

How Managers Spend Their Time



A.I. in Manufacturing

2018: First time DRL applied to CNC

Siemens and startup Bonsai create autotuning CNC machine using AI

May 02, 2018



A.I. in Manufacturing

2017: Okuma applies Deep Learning to CNC

machining
news.

January 9, 2017



Examples: Architecture

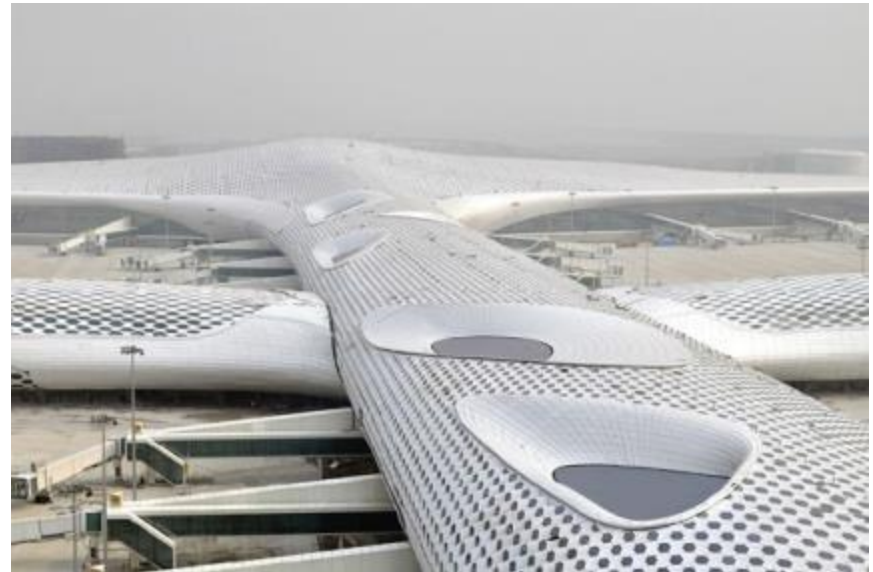
What are the unsolved problems?

A.I. in Architecture

- *Parametricism 2.0*

Parametricism (2008):
computational architecture

Parametricism 2.0: “precision architecture” based on big data and domain knowledge (geographic, economic, social, cultural, religious... factors)



Examples: Human-machine Interaction

What are the unsolved problems?

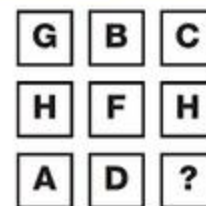
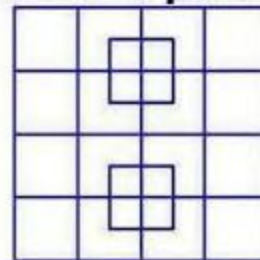
A.I. in Human-machine interaction

- *Human-machine interaction*

Machines are very stupid

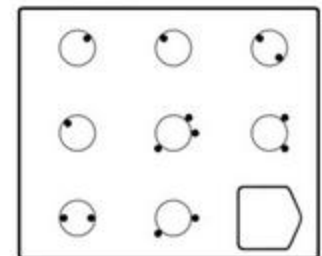
If AlphaGo took a normal I.Q. test, it would get a zero: it can only do one thing. In fact, it can't even answer questions!

How many squares are in this picture?



**Can You Solve This?
Viral "IQ Test"**

$$\begin{aligned} 1 + 4 &= 5 \\ 2 + 5 &= 12 \\ 3 + 6 &= 21 \\ 8 + 11 &= ? \end{aligned}$$



A.I. in Human-machine interaction

- *Human-machine interaction*

Spending on pets in the USA: \$62.75 billion (2016)

Why do we keep pets?

They are useful for

- security
- education
- socializing
- ...



The machine as a pet that never disobeys

A.I. is about building machines that are like pets

A.I. in Human-machine interaction

- *Human-machine interaction*

Today's machines are very stupid,
much more stupid than a dog or
cat

Today's machines are the evolution
of the hammer



A.I. in Human-machine interaction

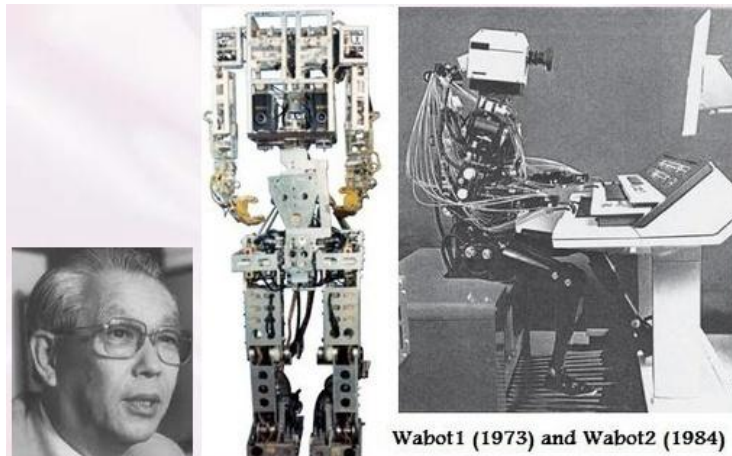
- *Human-machine interaction*

We need:

- Conversational user interfaces so that the owner can speak to its machine
- Face recognition so that the machine can recognize its owner
- Mobility so that machine can do chores for us



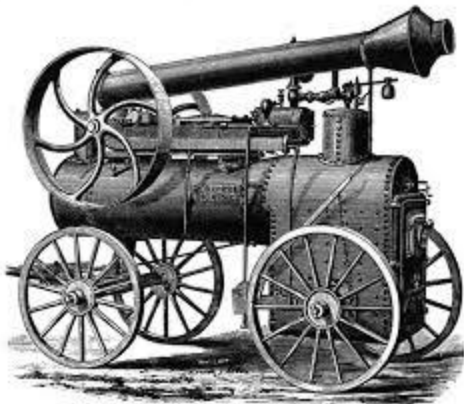
Between May 2016 and May 2017, Siri lost 7.3 million monthly users



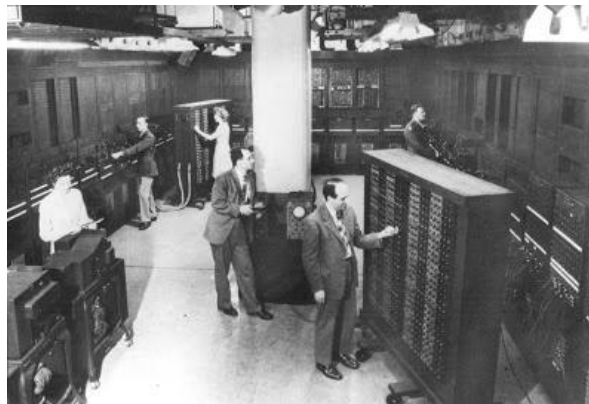
A.I. in Human-machine interaction

- *Human-machine interaction*

Machines
that cannot
be
programmed



Machines
that can be
programmed
to perform
many tasks



Machines
that
program
themselves

AI

Examples: Fintech

What are the unsolved problems?

A.I. in Fintech

- Lots of Talk, Little Action
- Innovation impulse in Fintech is not the same as in Biotech (Francesco Corea, Complexity scientist, in Medium magazine, Oct 2017)
- Blockchain is not A.I.
- P2P lending is not A.I.



WIRED

**WIRED Money 2017:
fintech's greatest
innovators**

WIRED Money 2017 | 17 Jan 2017

A.I. in Fintech

- Increasing Security: AI can analyze large volumes of security data and detect frauds with higher accuracy
- More insights on financial data, especially for trading
 - Euclidean, Quantestain, Renaissance Technologies, Walnut Algorithms, EmmaAI, Aidyia, Binatix, Kimerick, Pit.ai, Sentient, Tickermachine, Clone Algo, Algoriz, Alpaca, Portfolio123, Sigopt, ...

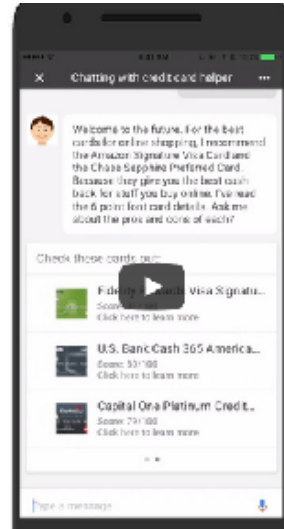


A.I. in Fintech

- Chatbots in consumer services
- Financial Wellness: optimizing financial assets (the "robo-advisor")
- Starbutter, Kasisto, Trim, Penny, Cleo, Acorns, Fingenius, Wealthfront, SigFig, Betterment, LearnVest, Jemstep, Aire, TypeScore, CreditVidya, ZestFinance, Applied Data Finance, Wecash,
- *“I think the biggest change is that people are going to receive financial help before they even know it”* (Nick Hungerford, CEO of Nutmeg - Wired magazine 2017)

Starbutter AI

AI chat agents



A.I. in Fintech

- Markets Intelligence (information extraction or insights generation)
 - Indico, Acuity Trading, Lucena, Dataminr, Alphasense, Kensho, Aylien, I Know First, Alpha Modus, ArtQuant,



Examples: Internet of Things

What are the unsolved problems?

A.I. and IoT

- The Internet of Things generates more than 2.5 quintillion bytes of data daily
- Deep learning algorithms for IoT analytics is not any faster or accurate than traditional statistical analysis (regression, clustering, decision trees, PCA...)

A.I. and IoT

- Data Science for IoT is different from traditional data science
 - ❖ Data from wildly distributed machines are chaotic and have a temporal element (i.e. time series data)
 - Edge computing: the data don't reside on the cloud
 - The world changes all the time: AI-powered devices don't adapt quickly to changes
 - Sensor fusion (security cameras, microphones, electric meters, etc): fusing different A.I. systems designed for different patterns is difficult
 - Real-time response is difficult for AI + IoT + Cloud

A.I. and IoT

- AI Appliance
 - Interactor (Silicon Valley)
- Data analytics
 - Alluvium (New York, 2015)
- Industrial IoI
 - Falkonry (Silicon Valley, 2012)
 - Arundo (Texas, 2015)
 - Canvas (Toronto, 2016)

Counter-examples

Non-problems

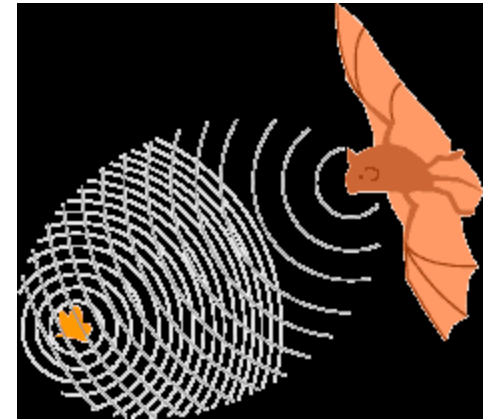
- *Example: Robots that see*

Sonar navigation is cheap, efficient and reliable

GPS and sensors are cheap, efficient and reliable

LIDAR and WAAS GPS are also precise

In many cases a machine doesn't need vision to navigate



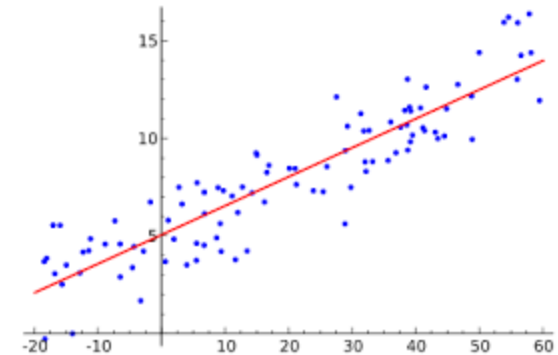
Non-problems

- *Example: “Machine learning”*

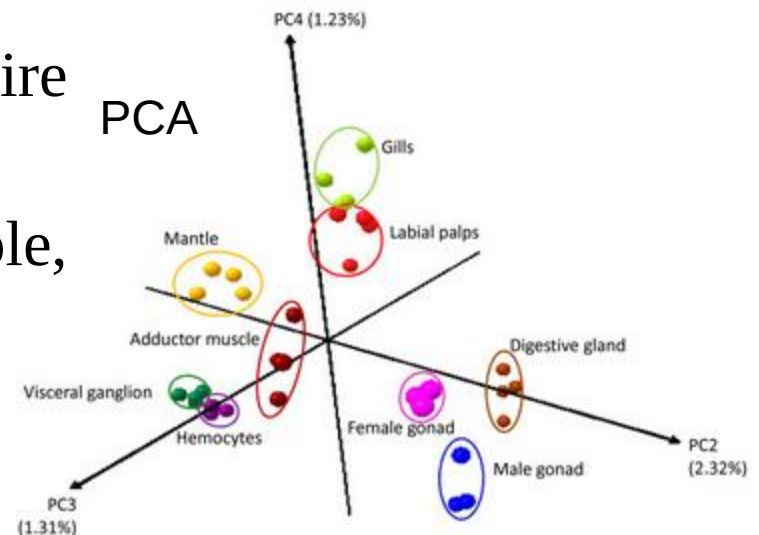
Statistical methods to classify data have existed for more than a century

Neural networks are only approximators but often less accurate than statistics and require more expensive hardware

Sometimes they are worth the trouble, sometimes not



Linear regression



AI's #1 application

- Today's #1 application of A.I.: to make people buy things that they don't need
- Tomorrow's #1 application of A.I.: to make people buy things that they don't need (and that sometimes kill them)



The Washington Post

/www.toutiao.com

The chatbots are coming — and they want to help you buy stuff

今日头条

By Sarah Halzack April 13



Wei Zexi's parents (2016)

AI's #1 application

- Where A.I. is truly successful...
 - *"The best minds of my generation are thinking about how to make people click ads"* (former Facebook research scientist Jeff Hammerbacher in 2012)
 - So far A.I. has not created better doctors or engineers, but better salesmen



AI's #1 application

- Google RankBrain and Facebook DeepTextAI

Google's using a machine learning technology called RankBrain to help deliver its search results. Here's what's we know about it so far.

Danny Sullivan on October 27, 2016 at 7:09 am



Facebook's new DeepText AI categorizes everything you write

Posted Jun 1, 2016 by Josh Constine (@joshconstine)



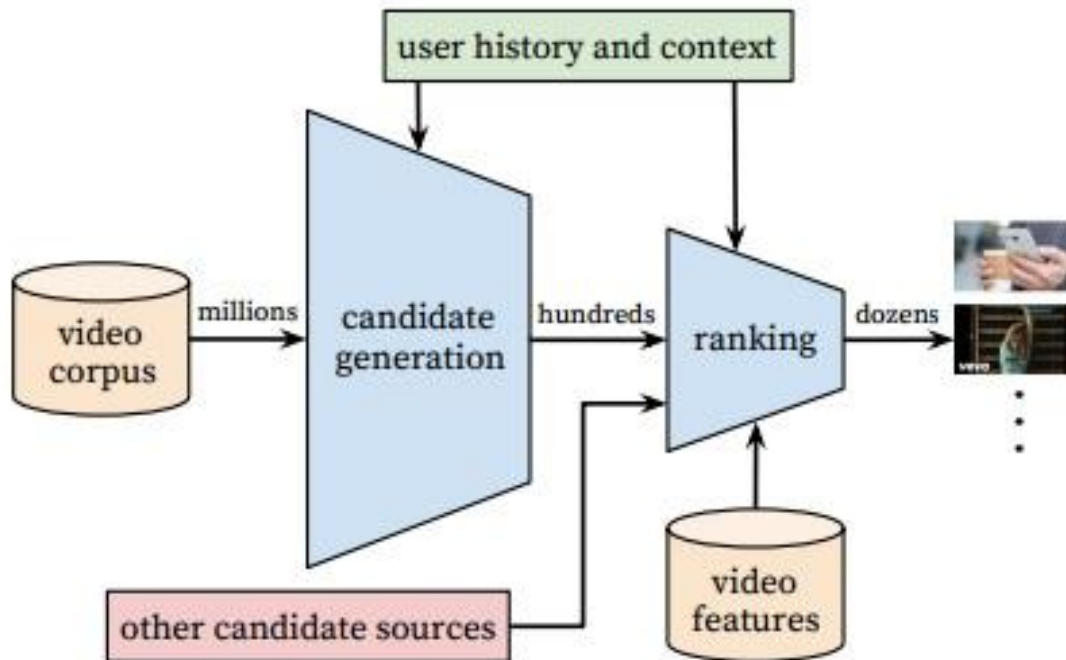
AI's #1 application

- Recommendation systems

Deep Neural Networks for YouTube Recommendations

Paul Covington, Jay Adams, Emre Sargin
Google

2016



Autonomous Cars

- Self-driving cars



Autonomous Cars

- Driver assistant (eg, Otto, founded by an ex-Googler)

JACK STEWART TRANSPORTATION 06.17.16 12:01 AM

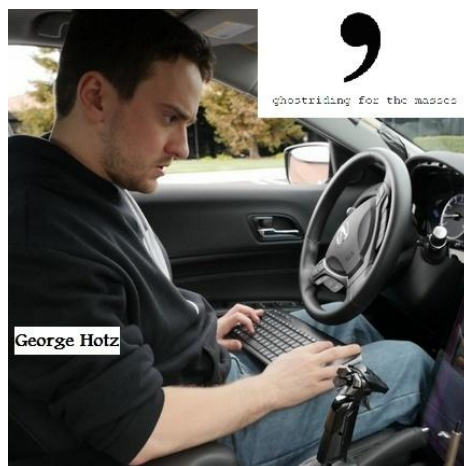
\$30K RETROFIT TURNS DUMB SEMIS INTO SELF-DRIVING ROBOTS

WIRED



Autonomous Cars

- Computer-vision chips
 - Autopilot and collision-avoidance for existing cars
 - Vision for drones and robots
 - Mobileye (Israel, 1999)
 - Movidius (Ireland, 2005)



Autonomous Cars

- Kits for self-driving features
 - Comma.ai (San Francisco, 2015)
 - Nvidia + Mercedes (announced in 2017)



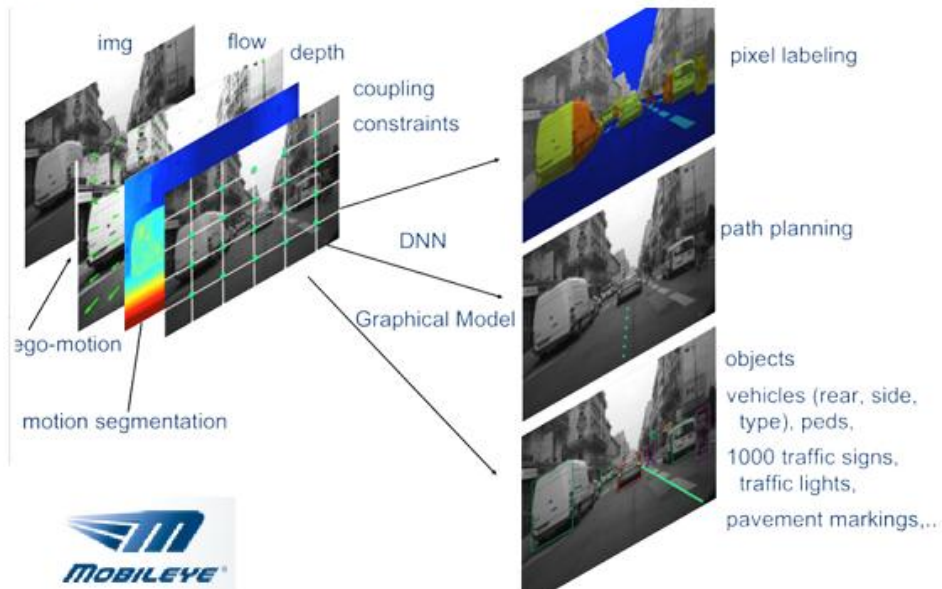
Nvidia and Mercedes-Benz to bring an AI car to market within a year



Autonomous Cars

- Tesla (2016)

Tesla's Autopilot, powered by Mobileye, is the world's first DNN deployed on the road

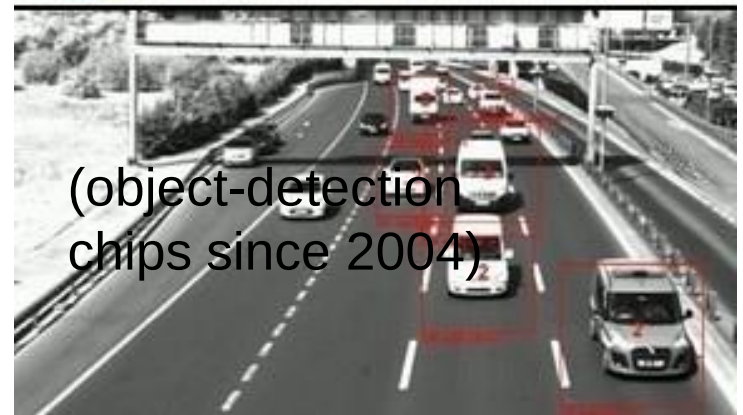


Self-driving Add-ons

- Oculii



ghostriding for the masses



Nvidia and Mercedes-Benz to bring an AI car to market within a year



Self-driving Add-ons

- Remote driving assistance
 - Phantom Auto (Mountain View, 2017, founded by Shai Magzimof, Andrew Gryaznov and Ohad Dvir)



Self-driving Add-ons

- Remote driving assistance

WIRED

01.05.17 07:00 PM

NISSAN'S PATH TO SELF-DRIVING CARS? HUMANS IN CALL CENTERS



~~My prediction hope of 2015
was...~~

Image Analysis

- Analysis of medical images: X-Rays, MRIs, Computed Tomography (CT), etc
 - Philips Health Care: 135 billion medical images, 2 million new images every week
 - Helping radiology, cardiology and oncology departments understand images
- Enlitic (San Francisco)
- Arterys (Stanford)
- Zebra Medical Vision (Israel)

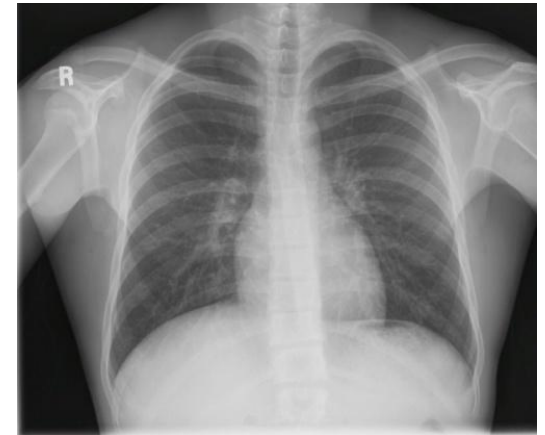


Image Analysis



IBM
Watson Oncology

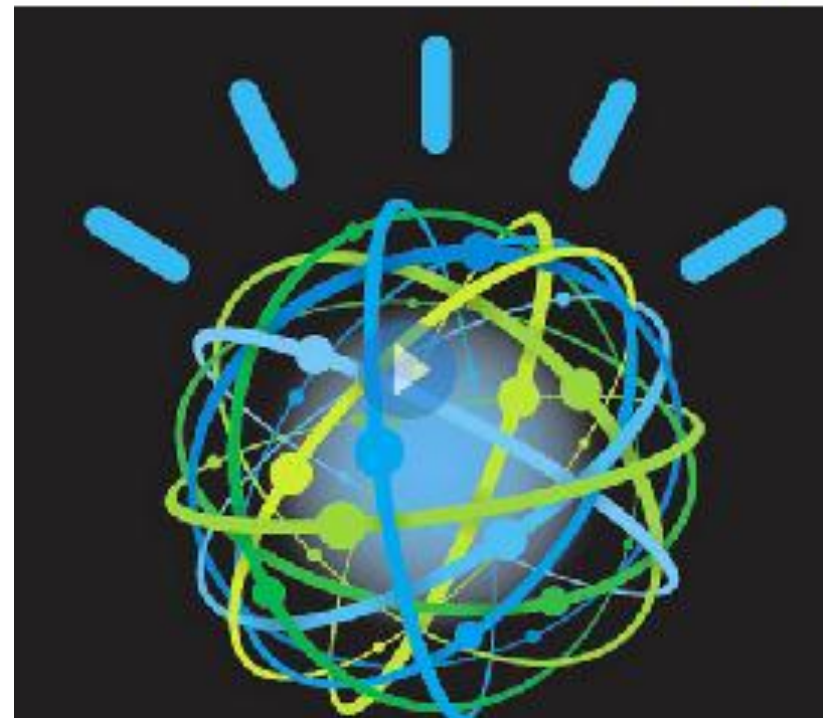


Image Analysis

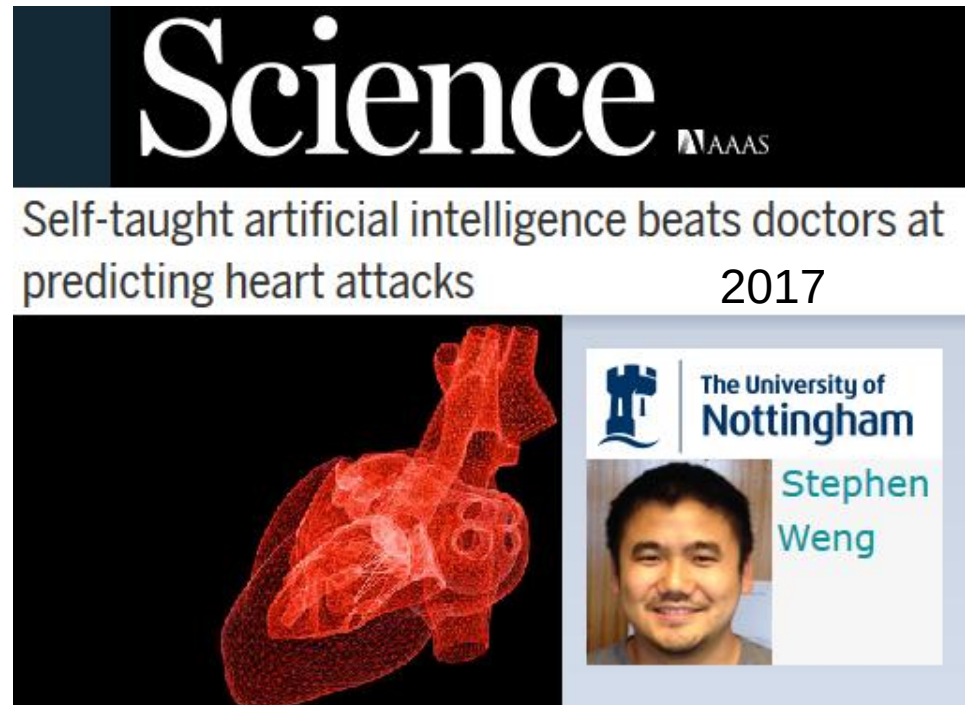


Image Analysis

GOOGLE'S AI READS RETINAS TO PREVENT BLINDNESS IN DIABETICS

December 13, 2016

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan,

Lily Peng



Scientists have developed a new way to predict when you'll die

Precision Radiology: 

Predicting longevity using feature engineering and deep learning methods in a radiomics framework

Luke Oakden-Rayner
Nascimento, Andrew



Bessen, Jacin

December 2016



Image Analysis

FDNA

FACE2GENE

FACING RARE DISEASES
HEAD ON

Genomic insights through artificial intelligence



Image Analysis

2016: the FDA approves the first deep-learning system for medical use.

- Diagnostic system for heart conditions made by Arterys, a spinoff of Stanford University's StartX accelerator
- Sold in conjunction with General Electric's MRI scanners as ViosWorks
- 15 seconds to produce a result which would normally take an hour by a professional cardiologist



Medical Appliances

- A new class of appliances

SRI International Spins Off
Superflex, Inc. to Help People
Achieve Their Physical Potential

April 21,
2016



Hear and Now



BioBeats (2016): app
that takes data from
several wearables
and uses A.I. to
deliver health advice.

Medical Applications



Annals of Internal Medicine

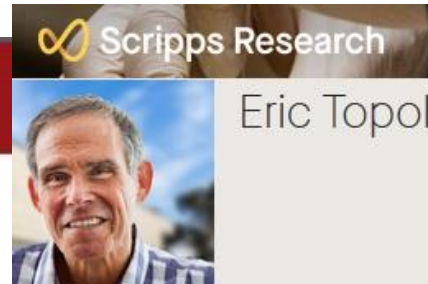
155,000 physicians

100 million visits



Medical Applications

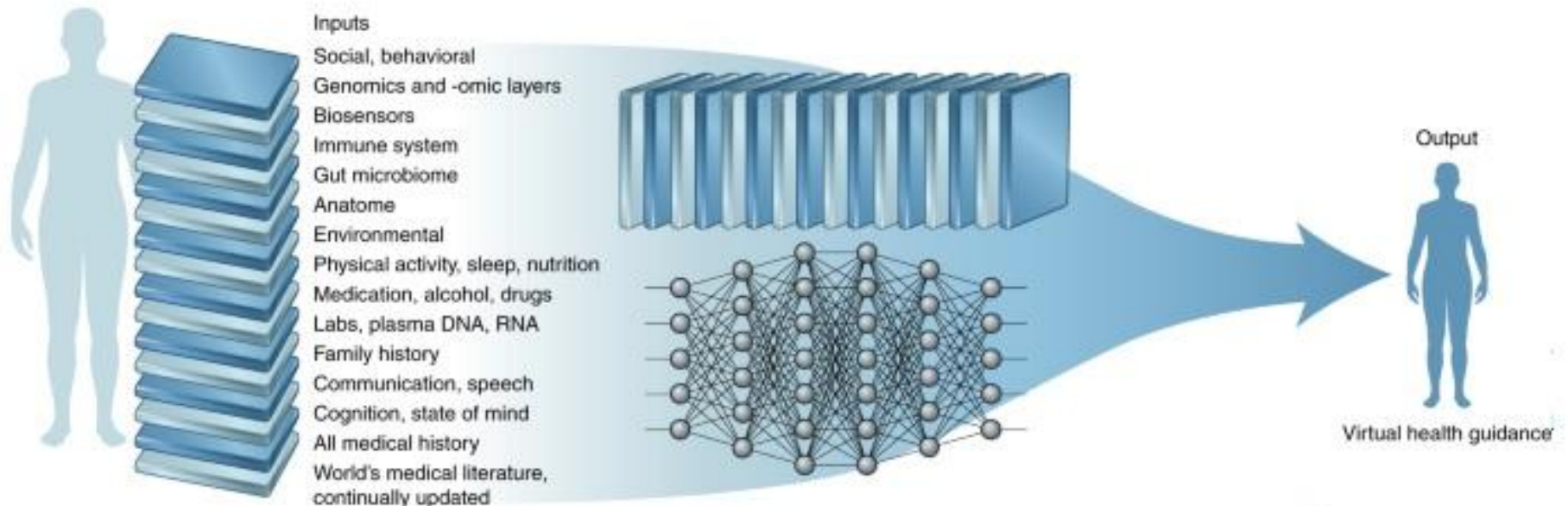
naturemedicine



Review Article | Published: 07 January 2019

High-performance medicine: the convergence of human and artificial intelligence

Eric J. Topol 



Medical Applications



Turning your smartphone
into a medical device

 Healthy.io

 Scanwell

 mira
inui

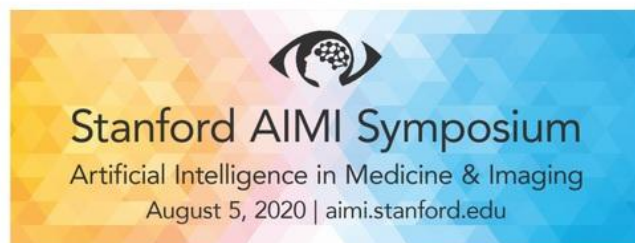

testcard

Medical Applications

Stanford University



Center for Artificial
Intelligence in Medicine &
Imaging



Session 3: Technical Advancements in Clinical Machine Learning - What's New in 2020

Applying Self-supervised Transfer Learning to Medical Vision and NLP Tasks

Jeremy Howard - Founder, fast.ai; Research Scientist, UCSF

Translational AI Methods for Musculoskeletal Imaging

Sharmila Majumdar - Margaret Hart Surbeck Distinguished Professor in Advanced Imaging & Vice Chair for Research, Department of Radiology & Biomedical Imaging, Professor of Orthopedic Surgery & Bioengineering & Therapeutic Sciences, UCSF

Upstream AI: What is it?

Shreyas Vasanawala - Professor of Radiology; Associate Director of Image Acquisition, Center for Artificial Intelligence in Medicine and Imaging, Stanford

Machine Learning for Medical Imaging: fastMRI Case Study

Nafissa Yakubova - Program Manager, Facebook AI Research Team

Collaborative Learning: Improving Model Robustness Without the Need for Data Sharing

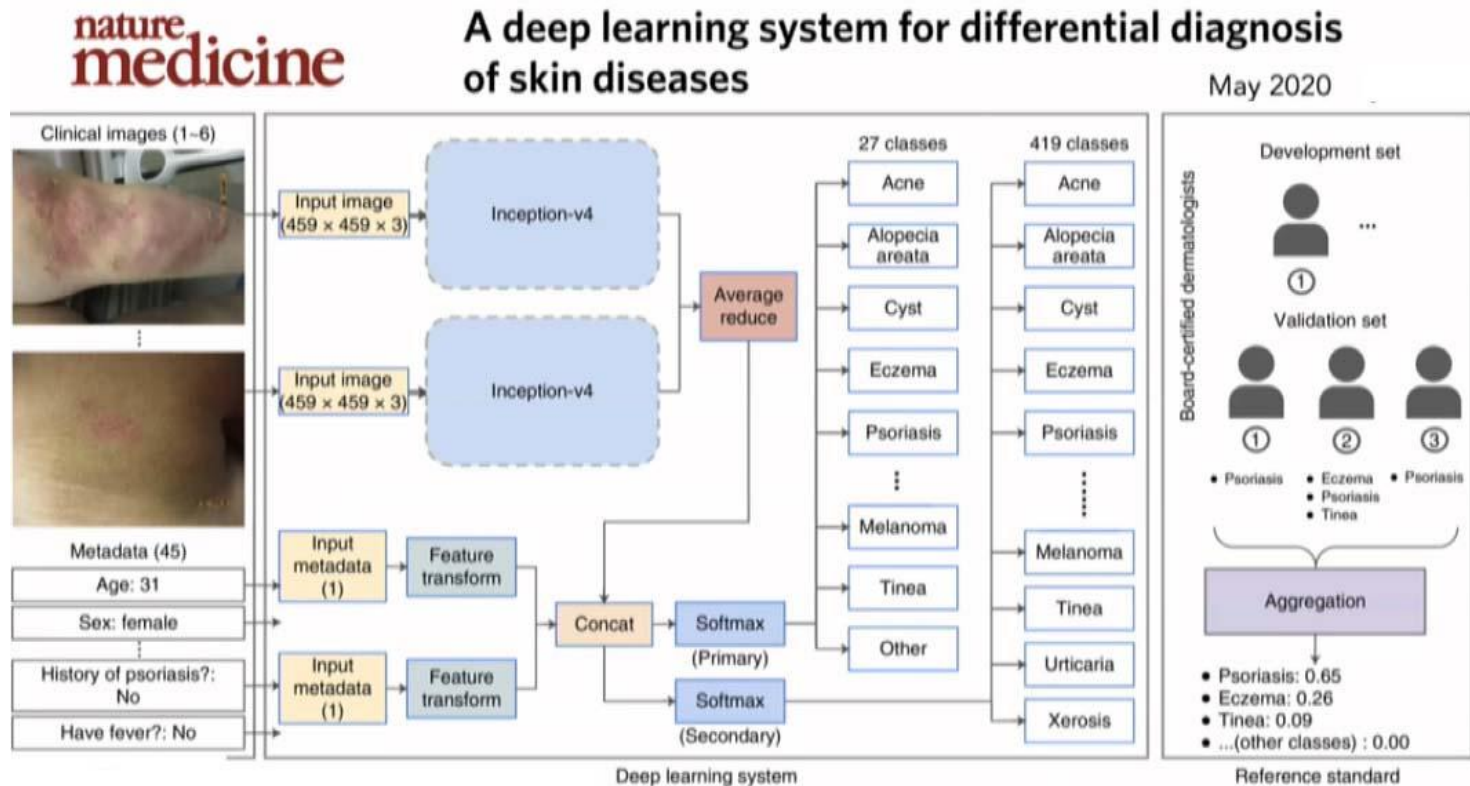
Jayashree Kalpathy-Cramer - Director, QTIM lab and Center for Machine Learning at the Athinoula A. Martinos Center for Biomedical Imaging, Harvard Medical School

Medical Applications

- Skin conditions affect an estimated 1.9 billion people worldwide
- Shortage of dermatologists
- Diagnostic accuracy of general practitioners has been reported to be only 0.24-0.70 (compared to 0.77-0.96 for dermatologists)

Medical Applications

- GoogleHealth (2020): Identifies 26 skin conditions that represent ~80% of skin conditions seen in primary care, achieving 0.71 to 0.93 accuracies



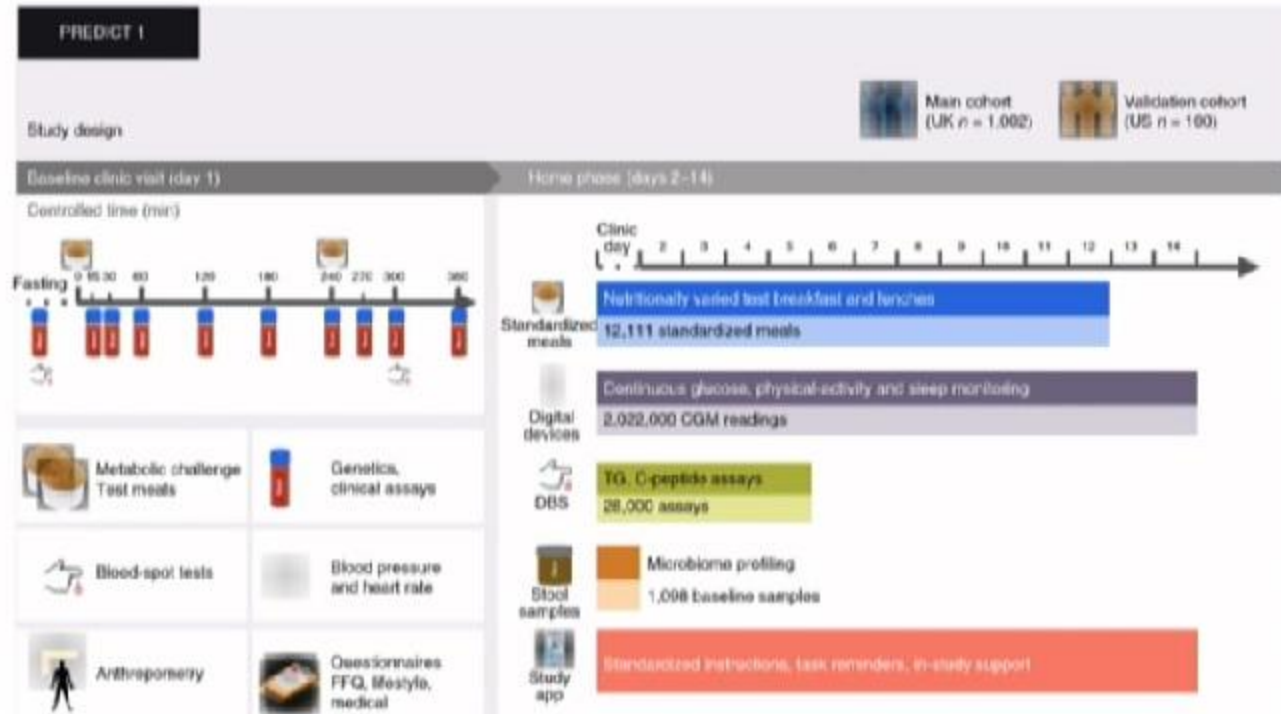
Medical Applications

- AI for diet (Univ of Nottingham, 2020)

**nature
medicine**

June 2020

Human postprandial responses to food and potential for precision nutrition



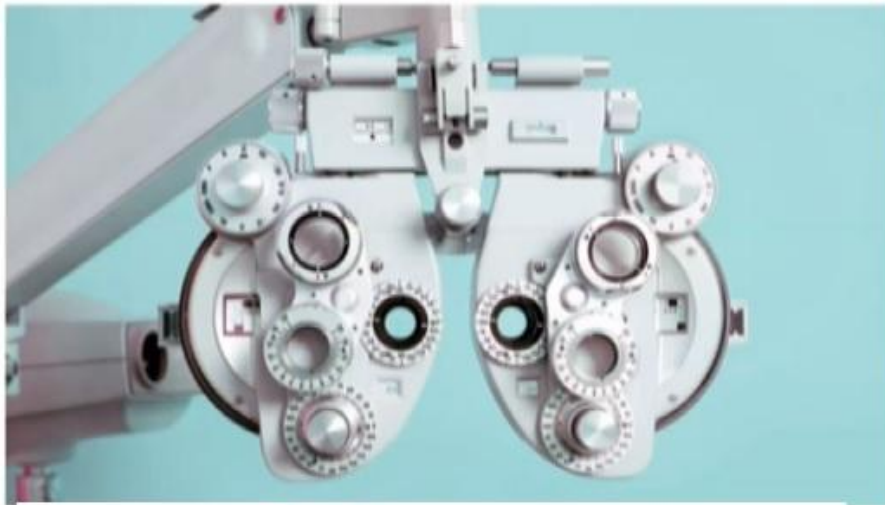
Sarah E. Berry, Ana M. Valdes, Nicola Segata, Paul W. Franks, Tim D. Spector.
School of Medicine, University of Nottingham, Nottingham, UK

Medical Applications

- AI for testing eyesight (Stanford, 2020)

Eye, robot: Artificial intelligence dramatically improves accuracy of classic eye exam

By [Marina Wang](#) Jun. 3, 2020, 10:45 AM



Science

The Stanford Acuity Test: A Precise Vision Test Using Bayesian Techniques and a Discovery in Human Visual Response

<https://myeyes.ai>

Measuring visual acuity:

- 1 Take an eye exam on this website
- 2 Connect your phone
- 3 Visualize the math

The composite image illustrates the StAT vision testing process. On the left, a screenshot of the 'Left Eye' test interface shows a large 'E' character and a progress bar at 75%. In the center, a graph titled 'StAT Algorithm' displays the 'Likelihood of Acuity Scores vs. Threshold' as a bell curve, with parameters: N items: 15, MAP acuity: 2.3 arcmin, Interval: [2.1, 2.6] arcmin. On the right, a smartphone screen shows the test instructions: 'Swipe up', 'Swipe left', 'Swipe right', and 'Swipe down' around a central 'E' character.

StAT: Reduced errors by 74% vs the classic Snellen test (from 1862)

Search Assistants

- Industry-specific virtual assistants
- Chatbots that replace search engines

THE WALL STREET JOURNAL.

Google Plans New, Smarter Messaging App

Users will be able to text friends or a chatbot that will scour the Web and other sources to answer a question

By [ALISTAIR BARR](#)

Updated Dec. 22, 2015 7:42 p.m. ET

The Near Future

- Unsupervised learning/ Data mining
 - Discover causes and correlations

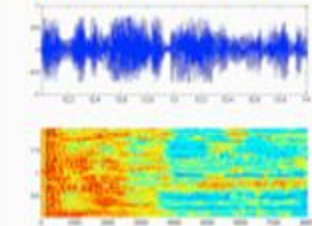
Images & Video



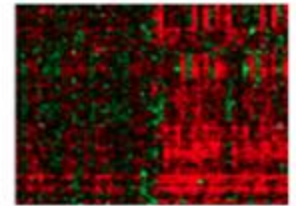
Text & Language



Speech & Audio



Gene Expression



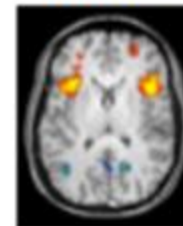
Product Recommendation



Relational Data/
Social Network



fMRI



Tumor region

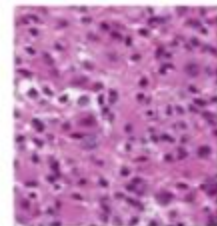


Image Analysis

- Analysis of medical images

Scientists have developed a new way to predict when you'll die

Precision Radiology: 

Predicting longevity using feature engineering and deep learning methods in a radiomics framework



Luke Oakden-Rayner
Nascimento, Andrew



Bessen, Jacin

December 2016

GOOGLE'S AI READS RETINAS TO PREVENT BLINDNESS IN DIABETICS

December 13, 2016

Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan,

Lily Peng



Microsoft and partners combine the cloud, AI, research and industry expertise to focus on transforming health care

Posted February 16, 2017 By [Peter Lee](#)

Corporate Vice President, Microsoft Research NExT

Precision Medicine

- Precision medicine: to deliver the right drugs in the right dose for the right person
 - Precision Medicine Initiative (2015): collect and study the genomes of one million people



Banking

- Credit assessment
- Legal documents (eg JP Morgan's COIN, for Contract Intelligence)

Bloomberg
Markets ▼

JPMorgan Software Does in Seconds What Took Lawyers 360,000 Hours

By **Hugh Son**

February 27, 2017, 4:31 PM PST

Updated on February 28, 2017, 4:24 AM PST

Forecasting Energy Use

- Texas Sustainable Energy Research Institute (2005)



Applying support vector machines to predict building energy consumption in tropical region

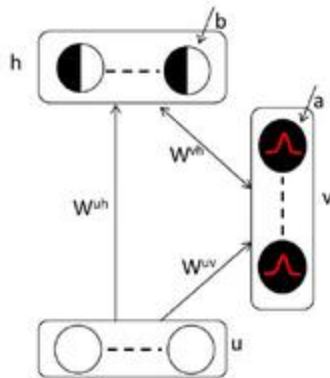
Bing Dong, Cheng Cao, Siew Eang Lee

May 2005

Forecasting Energy Use

- Elena Mocanu (Eindhoven University of Technology, Netherlands)

CRBM: Building Energy prediction



Inference for CRBM

$$p(h = 1 | \mathbf{u}, \mathbf{v}) = \text{sig}(\mathbf{u}^T \mathbf{W}^{uh} + \mathbf{v}^T \mathbf{W}^{vh} + \mathbf{b}^h)$$

$$p(\mathbf{v} | \mathbf{h}, \mathbf{u}) = \mathcal{N}(\mathbf{W}^{uv^T} \mathbf{u} + \mathbf{W}^{vh} \mathbf{h} + \mathbf{b}^v, \sigma^2)$$

Total energy

$$E(\mathbf{v}, \mathbf{h}, \mathbf{u}; \mathbf{W}) = -\mathbf{v}^T \mathbf{W}^{vh} \mathbf{h} - \mathbf{v}^T \mathbf{b}^v - \mathbf{u}^T \mathbf{W}^{uv} \mathbf{v} - \mathbf{u}^T \mathbf{W}^{uh} \mathbf{h} - \mathbf{h}^T \mathbf{b}^h$$



Elena Mocanu

Forecasting Energy Use

- Malaysia (2014)



Renewable and Sustainable Energy Reviews

Volume 33, May 2014, Pages 102–109



A review on applications of ANN and SVM for building electrical energy consumption forecasting

February 2014

A.S. Ahmad^a, M.Y. Hassan^a,  , M.P. Abdullah^a, H.A. Rahman^a, F. Hussin^a, H. Abdullah^a, R. Saidur^b

^a Centre of Electrical Energy Systems (CEES), Faculty of Electrical Engineering, University Technology of Malaysia (UTM), 81310 Skudai, Johor, Malaysia

^b Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

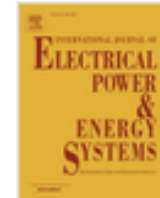
Forecasting Energy Use

- Turkey (2015)



International Journal of Electrical Power &
Energy Systems

Volume 67, May 2015, Pages 431–438



Forecasting electricity consumption: A comparison of regression analysis, neural networks and least squares support vector machines

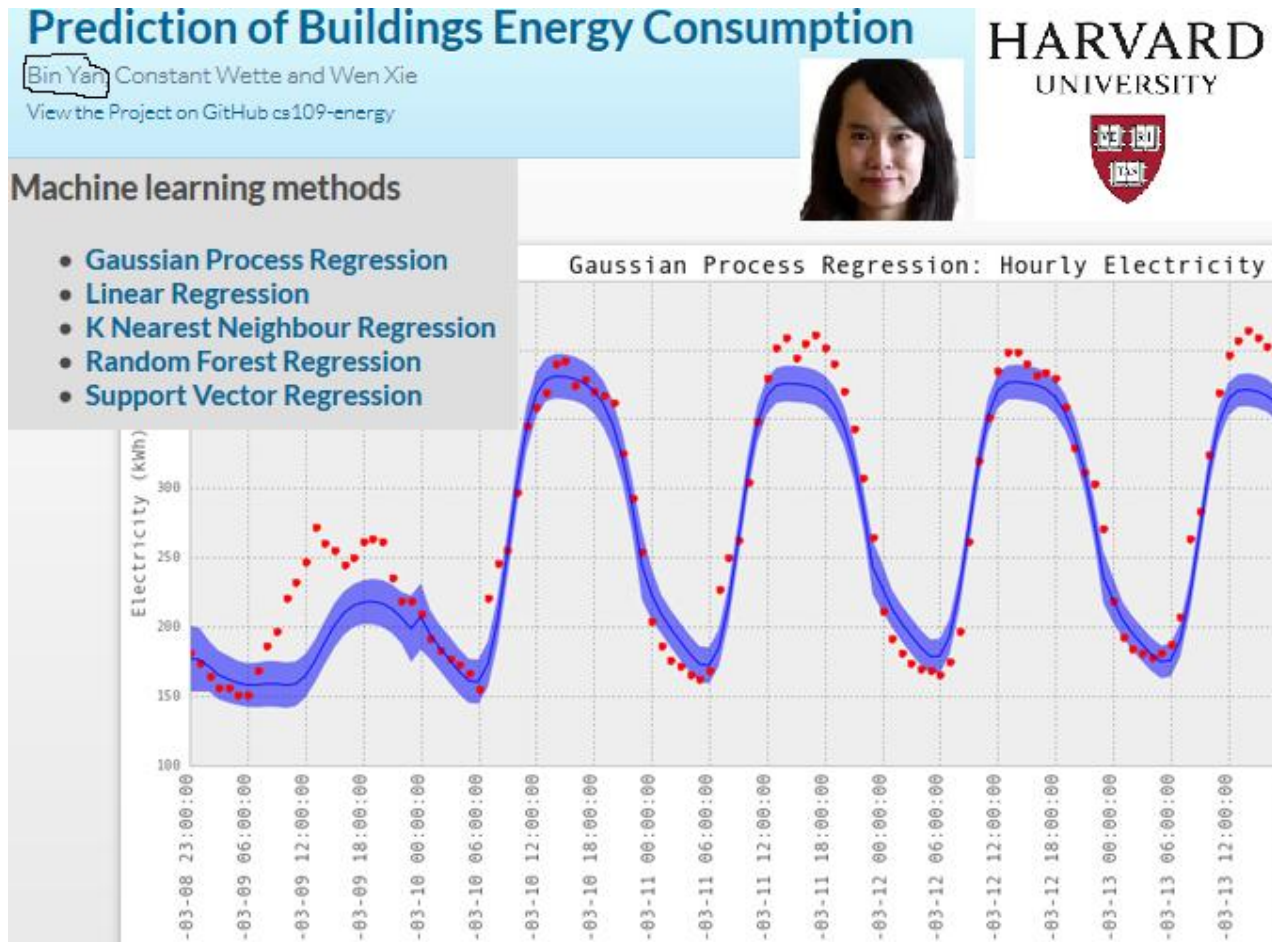
Fazil Kaytez^a,  , M. Cengiz Taplamacioglu^a,  , Ertugrul Cam^b, Firat Hardalac^a

^a Gazi University, Faculty of Engineering, Electrical & Electronics Engineering Department, 06750 Maltepe, Ankara, Turkey

^b Kirikkale University, Faculty of Engineering, Electrical & Electronics Engineering Department, 71450 Kirikkale, Turkey

Forecasting Energy Use

- Harvard (2015)



Forecasting Energy Use

- Stanford (2015)

Machine Learning in Energy

Fayadhoi Ibrahima

December 6, 2015

Submitted as coursework for [PH240](#), Stanford University, Fall 2015

Forecasting Energy Use

- Jiaotong (2015)

Towards Statistical Modeling and Machine Learning Based Energy Usage Forecasting in Smart Grid



Wei Yu^{*}, Dou An[§], David Griffith[†], Qingyu Yang[§], and Guobin Xu^{*}

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wyu@towson.edu
gxu2@students.towson.edu

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Xi'an, Shaanxi, China
adkaka.an@gmail.com
yangqingyu@mail.xjtu.edu.cn

[†]National Institute of
Standards and Technology
Gaithersburg, MD 20899
david.griffith@nist.gov

Forecasting Energy Use

- Univ of Washington (2015)

Demand Estimation with Machine Learning and Model Combination
Patrick Bajari, Denis Nekipelov, Stephen P. Ryan, and Miaoyu Yang
NBER Working Paper No. 20955
February 2015
JEL No. C14,C53,C55

Patrick Bajari
University of Washington
331 Savery Hall
UW Economics Box 353330
Seattle, Washington 98195-3330
and NBER
Bajari@uw.edu

Miaoyu Yang
Department of Economics
University of Washington

Forecasting Energy Use

- Imperial College of London (2015)

Neural NILM: Deep Neural Networks Applied to Energy Disaggregation

Jack Kelly

Department of Computing
Imperial College London

180 Queen's Gate, London, SW7 2RH, UK
jack.kelly@imperial.ac.uk

William Knottenbelt

Department of Computing
Imperial College London

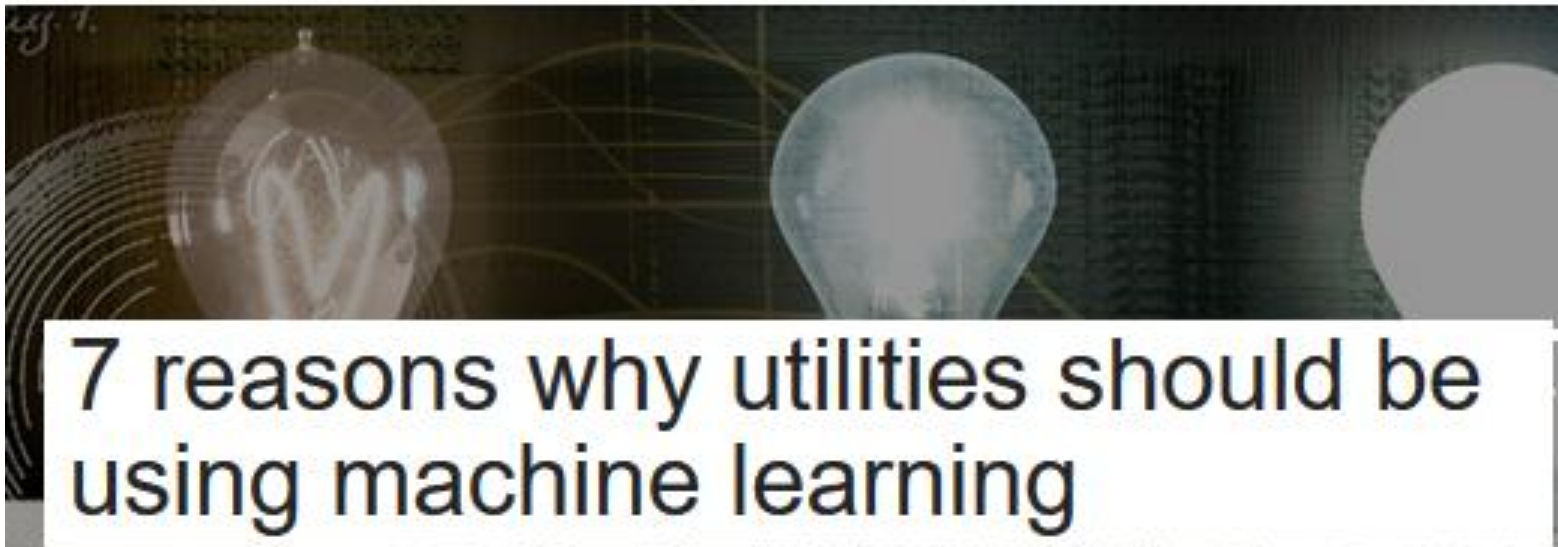
180 Queen's Gate, London, SW7 2RH, UK
w.knottenbelt@imperial.ac.uk

Forecasting Energy Use

- Oracle (2015)

ORACLE
UTILITIES

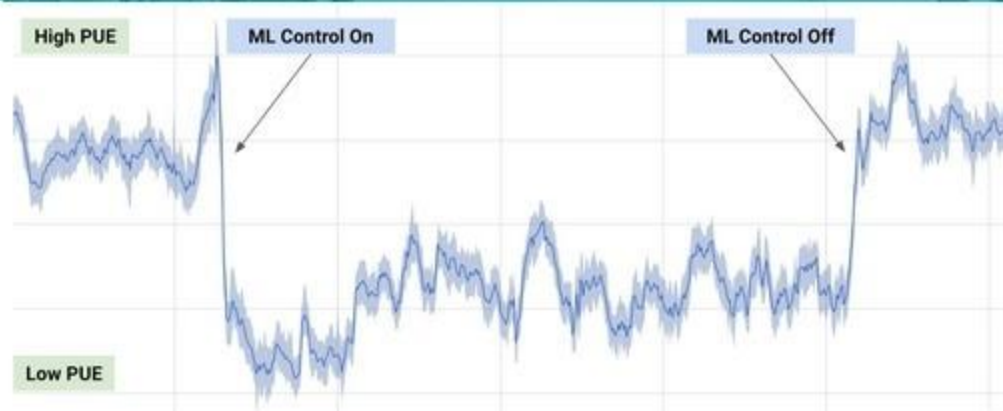
March 24, 2015



Forecasting Energy Use

- Google DeepMind (2016)

DeepMind AI Reduces Google Data Centre Cooling Bill by 40%



Biotech

Deep Learning in Bioinformatics

Help!

- 2016: more than 1.2 million papers were published in life science journals alone, on top of the 25 million already in print
- A new article is being published every 30 seconds
- On average a scientist reads about 264 papers per year
- More than 70,000 papers have been published on the tumor suppressor p53



Piero Scaruffi is one of the victims of information overload

Data Analytics/Diagnostics

Sophia Genetics (Switzerland)

DNAlytics (Belgium)

Innoplexus (Germany)



This Belgian Startup is building the Next Generation of Diagnostic Tests

04/05/2017

DNAlytics changes the diagnosing game. The company builds in vitro diagnosis tests

innoplexus



We are The Intelligence Machine™

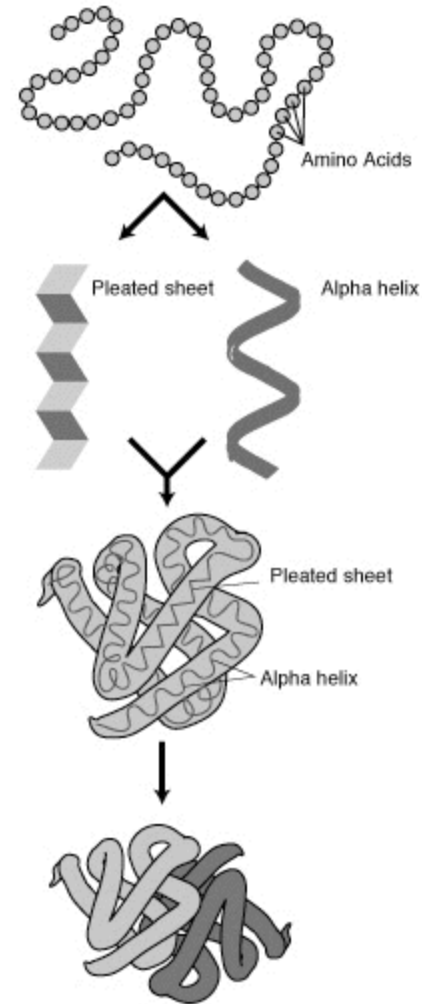
Using Artificial Intelligence to cut drug development time, from synthesis to approval

DL in Bioinformatics

- “Omics” research (genomics, transcriptomics, epigenomics, proteomics, metabolomics, etc)
 - Protein structure prediction
 - Primary structure (sequence of amino acids)
 - Secondary structure (Linus Pauling, 1951)
 - Tertiary structure (three-dimensional structure)
 - Gene expression regulation
 - Protein classification

DL in Bioinformatics

- Predicting the structure of proteins
 - Problem: tertiary structure predictions are increasingly demanded due to the rapid discovery of proteins; tertiary structure prediction depends on secondary structure prediction
 - Protein SS prediction has been extensively studied to predict both 3-state SS and a few to predict 8-state SS



DL in Bioinformatics

- Predicting the structure of proteins
 - Ning Qian & Terrence Sejnowski (1987)
 - David Jones developed the two-stage neural network method PSIPRED (1999)

Journal of Molecular Biology

Volume 202, Issue 4, 20 August 1988, Pages 865-884

Predicting the secondary structure of globular proteins using neural network models

Ning Qian, Terrence J. Sejnowski

Department of Biophysics The Johns Hopkins University Baltimore, MD

Journal of Molecular Biology

Volume 292, Issue 2, 17 September 1999, Pages

195-202

Communication

Protein secondary structure prediction based on position-specific scoring matrices ¹

David T Jones ^a ✉

DL in Bioinformatics

- Predicting the structure of proteins
 - Three-state accuracy of SS prediction :
69.7% by PHD in 1993
76.5% by PSIPRED in 1999
80% by Structural Property prediction with Integrated Neural nEtwork (SPINE) in 2007 - Ofer Dor & Yaoqi Zhou, State University of New York at Buffalo
82% by Structural Property prediction with Integrated DEep neuRal network 2 (SPIDER2) in 2015 - Yaoqi Zhou's team, Griffith University in Australia
84% by Deep Convolution Neural Field network (DeepCNF) in 2015 – Jianlin Cheng

	Q3
Jpred4	0.751
SPINE X	0.769
PSIPRED 3.3	0.780
SCORPION	0.805
SPIDER2	0.798
PORTER 4.0	0.798
DeepCNF	0.821

DL in Bioinformatics

- Predicting the structure of proteins
 - SPIDER2 (2015)

SCIENTIFIC REPORTS

OPEN

Improving prediction of secondary structure, local backbone angles, and solvent accessible surface area of proteins by iterative deep learning

Received: 04 March 2015

Accepted: 19 May 2015

Published: 22 June 2015

Rhys Heffernan¹, Kuldip Paliwal¹, James Lyons¹, Abdollah Dehzangi^{1,2}, Alok Sharma^{2,3}, Jihua Wang⁴, Abdul Sattar^{2,5}, Yuedong Yang⁵ & Yaoqi Zhou^{4,6}

DL in Bioinformatics

- Predicting the structure of proteins
 - Problem: challenging to predict the tertiary structure of proteins that do not have a close homolog with known structure (“ab initio”); accuracy stagnated at 65%
 - Jianlin Cheng (2015, Univ of Missouri): DNSS, a deep learning approach to 3-state SS prediction
 - 1425 proteins from the Protein Data Bank

IEEE/ACM Trans Comput Biol Bioinform. 2015 ; 12(1): 103–112. doi:10.1109/TCBB.2014.2343960.

A Deep Learning Network Approach to *ab initio* Protein Secondary Structure Prediction

Jianlin Cheng

Department of Computer Science, University of Missouri, Columbia, MO 65211.

DL in Bioinformatics

- Predicting the structure of proteins
 - Jian Zhou and Olga Troyanskaya (2014, Princeton Univ): ICML2014 deep learning approach to 8-state SS prediction

Deep Supervised and Convolutional Generative Stochastic Network for Protein Secondary Structure Prediction

Jian Zhou

Olga G. Troyanskaya

Princeton University Princeton, NJ 08540 USA

DL in Bioinformatics

- Predicting the structure of proteins
 - Sheng Wang and Jian Peng (University of Chicago) in collaboration with Toyota Technological Institute (2015)
 - DeepCNF (Deep Convolutional Neural Fields) for both 3-state and 8-state SS prediction.
 - Datasets: (1) CullPDB53 of 6125 proteins, (2) CB513 of 513 proteins, (3) CASP1054 and (4) CASP1155 datasets containing 123 and 105 domain sequences, respectively, and (5) CAMEO
 - DeepCNF pushed the 8-state accuracy to beyond 70%.

Protein Secondary Structure
Prediction Using Deep
Convolutional Neural Fields

Sheng Wang , Jian Peng, Jianzhu Ma & Jinbo Xu 

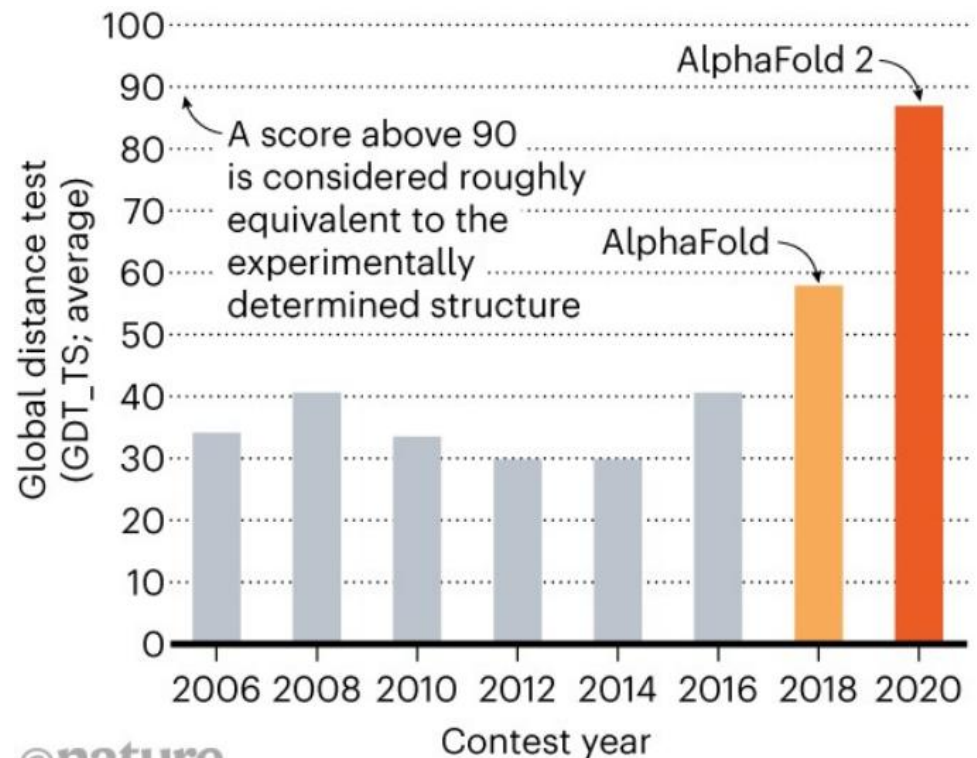
DL in Bioinformatics

- Predicting the structure of proteins: AlphaFold

nature

30 NOVEMBER 2020

**'It will change everything':
DeepMind's AI makes gigantic
leap in solving protein structures**



DL in Bioinformatics

- Gene expression regulation
 - Problem: DNA- and RNA-binding proteins play a central role in gene regulation and knowing their sequence is important to explain the regulatory processes and for investigating the genetic causes of diseases
 - Babak Alipanahi (2015, University of Toronto): DeepBind for DNA-protein binding
 - Training: datasets of DNA binding in vivo and in vitro + RNA binding in vitro

DL in Bioinformatics

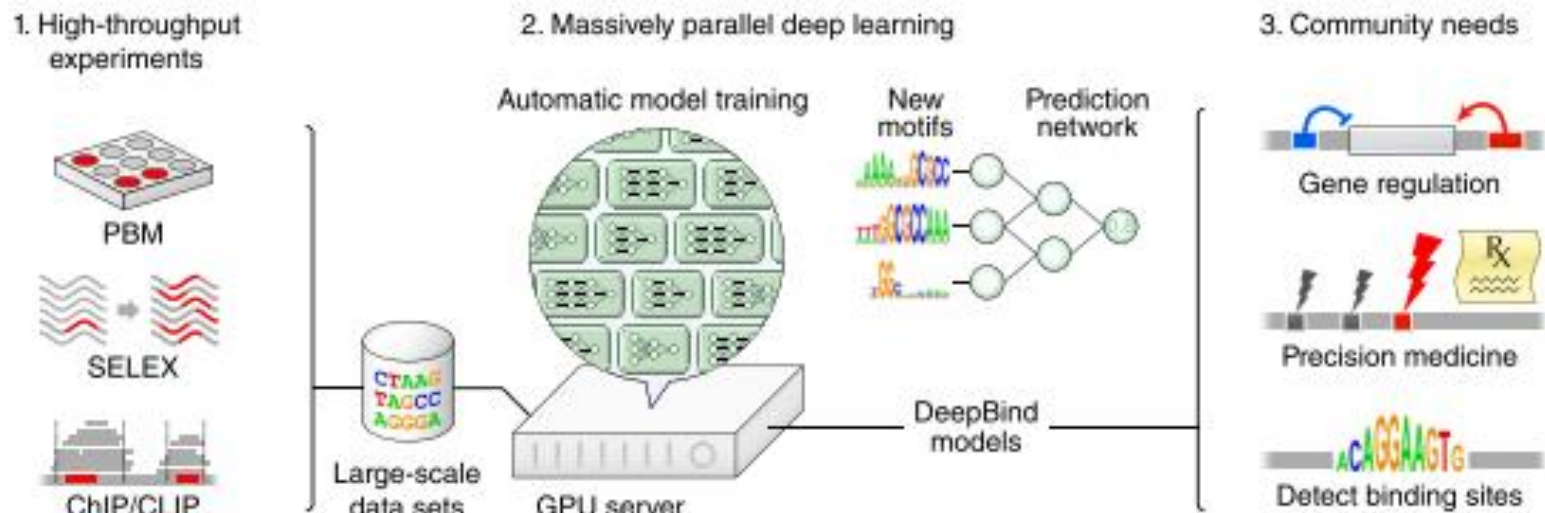
Nature Biotechnology **33**, 831–838

Received: 28 November 2014

Predicting the sequence specificities of DNA- and RNA-binding proteins by deep learning

Babak Alipanahi, Andrew Delong, Matthew T Weirauch & Brendan J Frey

- Gene expression regulation
 - Babak Alipanahi : DeepBind



DL in Bioinformatics

- The authors founded Deep Genomics (2015)...
- ... it helps to have good neighbors



DL in Bioinformatics

- Gene expression regulation
 - Problem: NIH's Library of Integrated Network-Based Cellulanaures or LINCS: to save costs, profile the expression of only ~1000 landmark genes from the Connectivity Map (CMap) project and inferring the expression of remaining target genes (whose gene expression is correlated to the landmark genes) via linear regression. This way the LINCS program has generated ~1.3 million gene expression profiles, but LR ignores the nonlinearity within gene expression profiles.

DL in Bioinformatics

- Gene expression regulation
 - Xiaohui Xie (2016, UC Irvine): D-GEX to infer the expression of target genes from the expression of the “landmark” genes
 - Dataset: Gene Expression Omnibus dataset (111,000 expression profiles)

Gene expression

February 3, 2016

Gene expression inference with deep learning

Yifei Chen^{1,4,†}, Yi Li^{1,†}, Rajiv Narayan², Aravind Subramanian² and Xiaohui Xie^{1,3,*}

¹Department of Computer Science, University of California, Irvine, CA 92697, USA, ²Broad Institute of MIT And Harvard, Cambridge, MA 02142, USA, ³Center for Complex Biological Systems, University of California, Irvine, CA

DL in Bioinformatics

- Gene expression regulation
 - Problem: regulation depends on promoters and enhancers, but detecting the locations of promoters and enhancers (a focus of bioinformatics for twenty years) is not trivial.
 - Wyeth Wasserman (2016, Univ of British Columbia): DECRES for the identification of enhancer and promoter regions in the human genome
 - Datasets: Encyclopedia of DNA Elements (ENCODE) and the Functional Annotation of the Mammalian Genome (FANTOM)

Genome-Wide Prediction of *cis*-Regulatory Regions Using
Supervised Deep Learning Methods

Yifeng Li^{1,2}, Wenqiang Shi¹, and Wyeth W. Wasserman^{*1}

¹Centre for Molecular Medicine and Therapeutics, Child and Family Research Institute,
Department of Medical Genetics, University of British Columbia, Vancouver

DL in Bioinformatics

- Gene expression regulation
 - Problem: MicroRNAs (miRNAs) are short sequences of ribonucleic acids that control the expression of target messenger RNAs (mRNAs) by binding them
 - Robust prediction of miRNA-mRNA pairs is important to understand gene regulation
 - Seoul National University (2016): DeepTarget for microRNA-mRNA prediction

**deepTarget: End-to-end Learning Framework for microRNA
Target Prediction using Deep Recurrent Neural Networks**

Aug 2016

Byunghan Lee
Seunghyun Park

Junghwan Baek
Sungroh Yoon*

Seoul National University[~]

DL in Bioinformatics

- Gene expression regulation
 - Problem: noncoding variants are statistically associated with human disease, but determining their mechanism is not trivial
 - Jian Zhou and Olga Troyanskaya (2015, Princeton Univ): DeepSEA to predict the functional effects of noncoding variants from DNA sequence

Nat Methods. 2015 October ; 12(10): 931–934. doi:10.1038/nmeth.3547.

Predicting effects of noncoding variants with deep learning–based sequence model

Jian Zhou^{1,2} and Olga G Troyanskaya^{1,3,4}

¹Lewis-Sigler Institute for Integrative Genomics, Princeton University, Princeton, New Jersey, USA

²Graduate Program in Quantitative and Computational Biology, Princeton University, Princeton, New Jersey, USA

³Department of Computer Science, Princeton University, Princeton, New Jersey, USA

DL in Bioinformatics

- Gene expression regulation
 - David Kelley (2016, Harvard): open-source deep-learning framework Basset to learn functional activities of DNA sequences, annotate every mutation in the genome with its influence, etc
 - Databases from ENCODE Project Consortium and Roadmap Epigenomics Consortium

Basset: Learning the regulatory code of the accessible genome with deep convolutional neural networks.

David R. Kelley¹ Department of Stem Cell and Regenerative Biology, Harvard University,
Jasper Snoek²
John L. Rinn¹

DL in Bioinformatics

- Gene expression regulation
 - Problem: RNA splicing is a critical step in gene expression whose disruption contributes to many diseases, including cancers and neurological disorders; and tens of thousands of genetic variants may alter splicing
 - Hui Xiong, Babak Alipanahi, Leo Lee (2015, Univ of Toronto) predict the splicing activity of individual exons (in particular, the genetic basis of spinal muscular atrophy, hereditary nonpolyposis, colorectal cancer and autism)

Science. 2015 January 9; 347(6218): 1254806. doi:10.1126/science.1254806.

The human splicing code reveals new insights into the genetic determinants of disease

Hui Y. Xiong^{1,2,3}, Babak Alipanahi^{1,2,3}, Leo J. Lee^{1,2,3}, Hannes Bretschneider^{1,3,8}, Daniele Merico^{4,5,6}, Ryan K.C. Yuen^{4,5,6}, Yimin Hua⁷, Serge Gueroussov^{2,6}, Hamed S. Najafabadi^{1,2,3}, Timothy R. Hughes^{2,3,6}, Quaid Morris^{1,2,3,6}, Yoseph Barash^{1,2,9}, Adrian R. Krainer⁷, Nebojsa Jojic¹⁰, Stephen W. Scherer^{3,4,5,6}, Benjamin J. Blencowe^{2,4,6}, and Brendan J. Frey^{1,2,3,4,6,8,10,@}

¹Department of Electrical and Computer Engineering, University of Toronto

DL in Bioinformatics

- Gene expression regulation
 - Hui Xiong, Babak Alipanahi, Leo Lee (2015, Univ of Toronto)

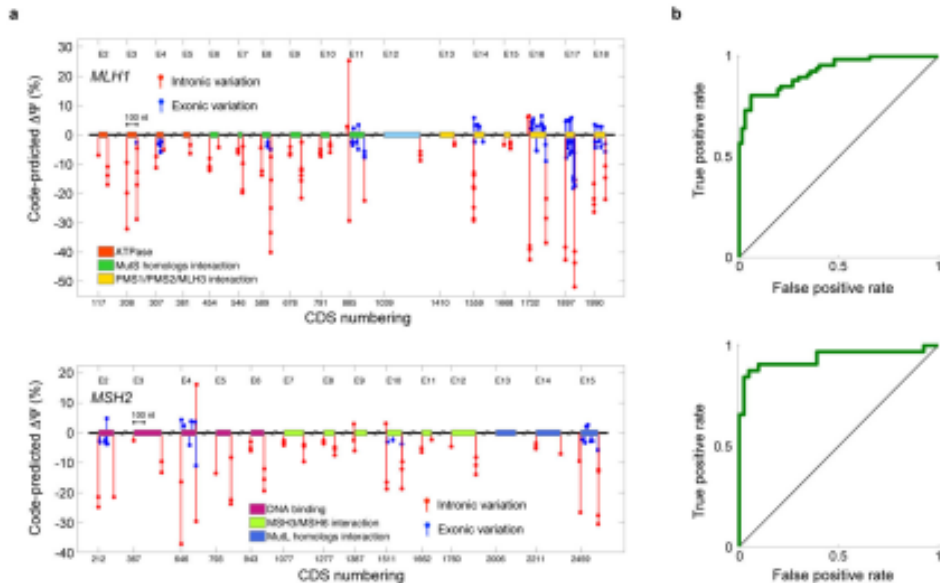


Figure 6. The mutational landscape of nonpolyposis colorectal cancer

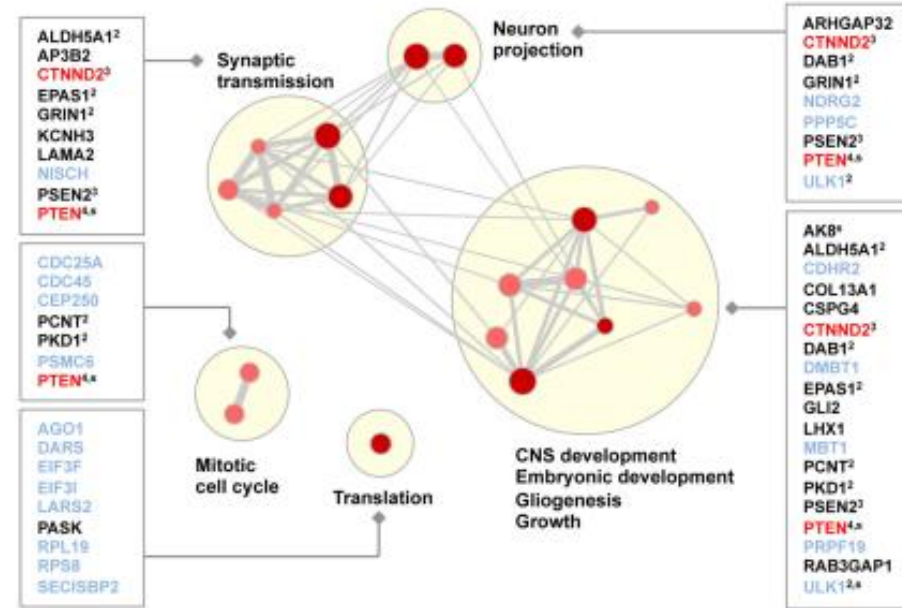


Figure 8. Misregulated genes and functional categories enriched in individuals with autism

DL in Bioinformatics

- Protein classification
 - Problem: a general representation that can be employed in a wide array of bioinformatics research such as family classification, protein visualization, structure prediction, protein-protein interaction prediction, etc
 - Ehsaneddin Asgari and Mohammad Mofrad (2015, UC Berkeley): ProtVec to classify 324,018 protein sequences from Swiss-Prot belonging to 7,027 protein families



Continuous Distributed Representation of Biological Sequences for Deep Proteomics and Genomics

Ehsaneddin Asgari¹, Mohammad R. K. Mofrad^{1,2*}

¹ Molecular Cell Biomechanics Laboratory, Departments of Bioengineering and Mechanical Engineering, University of California, Berkeley, California 94720, United States of America, ² Physical Biosciences

Designing Babies

1978: First baby born via IVF (in vitro fertilization)

1990: First baby born via PGD (Alan Handyside's lab)

Two ways to create human stem cells

Shinya Yamanaka (2007)

Shoukhrat Mitalipov (2013)

Basically, it's a way to turn back the biological clock: the DNA of the cell is reprogrammed to the embryonic state



Designing Babies

Rabinowitz-Shendure PGD (2015)



Published online 2015 Apr 8.

doi: [10.1186/s13073-015-0160-4](https://doi.org/10.1186/s13073-015-0160-4)

Whole genome prediction for preimplantation genetic diagnosis

[Akash Kumar](#),[#] [Allison Ryan](#),[#] [Jacob O Kitzman](#), [Nina Wemmer](#),
[Matthew W Snyder](#), [Styrmir Sigurjonsson](#), [Choli Lee](#), [Milena Banjevic](#),
[Paul W Zarutskie](#), [Alexandra P Lewis](#), [Jay Shendure](#),[✉] and [Matthew Rabinowitz](#)[✉]

Reproductive testing



Natera[®] is driven by a passion for elevating the science of reproductive testing. We offer highly accurate solutions for noninvasive prenatal testing (NIPT), genetic-carrier screening, preimplantation genetic testing (PGD/PGS), and miscarriage testing.

Designing Babies

Katsuhiko Hayashi (2015): IVG on mice
("easy PGD"): we can make eggs and
sperm from skin cells



Designing Babies

HumanCode (2017, Denver):
predict babies' height
without AI

Stephen Hsu (2017): predict
babies' height with AI



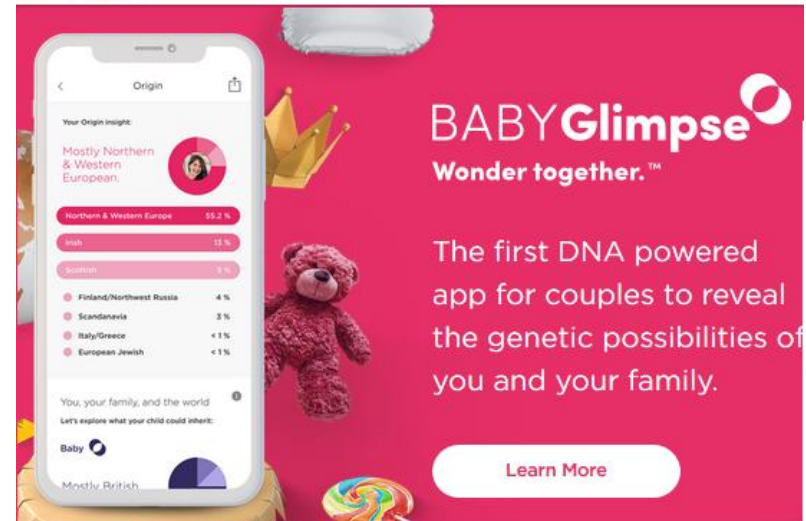
Physicist Stephen Hsu developed a genetic "predictor" that uses machine learning to estimate height, to within three centimeters, from a person's DNA.

MICHIGAN STATE UNIVERSITY

Accurate Genomic Prediction Of Human Height

Louis Lello, Steven G. Avery, Laurent Tellier, Ana Vazquez, Gustavo de los Campos, Stephen D.H. Hsu

(Submitted on 19 Sep 2017)



Will A.I. help parents "design" their babies?

MIT
Technology
Review

by Antonio Regalado November 1, 2017

Eugenics 2.0: We're at the Dawn of Choosing Embryos by Health, Height, and More

Science Translational Medicine

Disruptive reproductive technologies

J. Glenn Cohen^{1,*}, George Q. Daley^{2,3} and Eli Y. Adashi⁴



Hank Greely



NAUTILUS

OCTOBER 16, 2014

Super-Intelligent Humans Are Coming

Genetic engineering will one day create the smartest humans who have ever lived.

BY STEPHEN HSU



MICHIGAN STATE UNIVERSITY

Drug Discovery

According to the Tufts Center for the Study of Drug Development, it takes an average of 12 years and about \$2.6 billion to put a new drug on the market.

Drug Discovery

Automating and accelerating the process of drug discovery



Science 10 OCTOBER 2014
VOL 346, ISSUE 6206

Special Issue **Robots**

POLICY FORUM | ARTIFICIAL INTELLIGENCE

Amplify scientific discovery
with artificial intelligence

Four small, square portrait photographs of individuals are arranged in a horizontal row at the bottom of the section. From left to right, they show a woman with glasses, a man with a beard, a man with glasses, and a man with a beard and glasses.

Drug Discovery

Rein Vos' "*The Enigma of Drug Discovery*" shows that the process of drug discovery can be modeled, and therefore automated



Can it be accelerated?

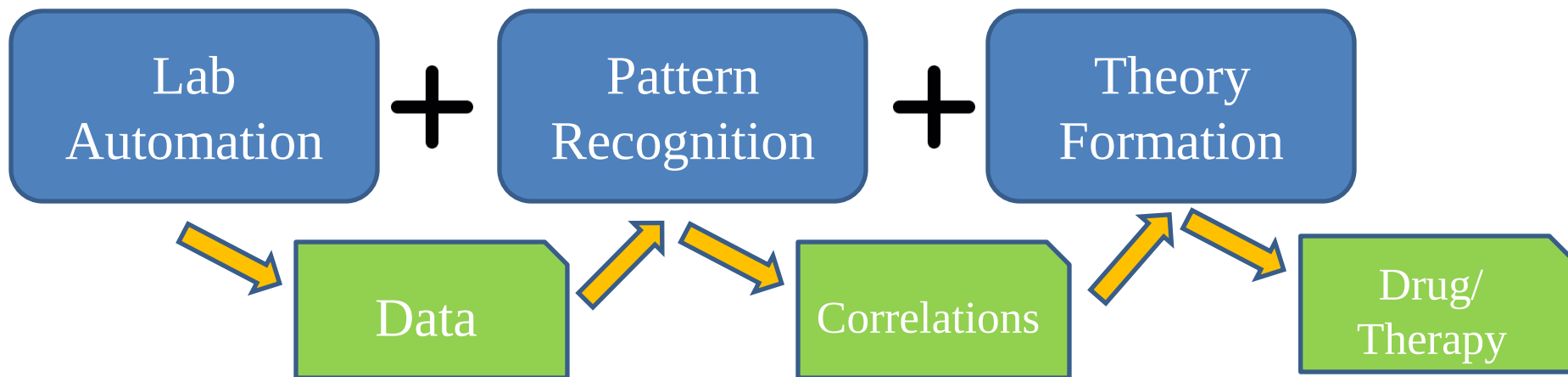
Can we design better molecules, enzymes, peptides to cure diseases?

OXFORD GLOBAL
Artificial Intelligence in Drug
Development Congress
27-28 September 2017, London, UK



Drug Discovery

Automation and acceleration of drug discovery



A.I. in Biotech/Medical

- *Accelerate drug discovery*

Towards “Precision Medicine”: A.I. could mark the end of the mass-produced drug

It could discover the specific drug that works best for your specific case

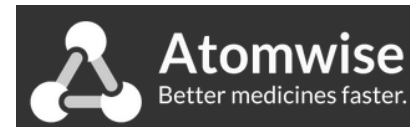
THE PRECISION MEDICINE INITIATIVE

2015



A.I. in Biotech/Medical

- *Accelerate drug discovery*



Drug Discovery

- Exscientia (Britain) 
- Berg (Boston) 
- Numerate (Bay Area) 
- BenevolentAI (Britain) 
- Atomwise (San Francisco) 
- Insilico Medicine (Baltimore) 
- Desktop Genetics (Britain) 
- Sophia (Switzerland) 
- PathAI (Boston) 
- Recursion (Utah) 
- Insitro (Daphne Koller, South San Francisco, 2018) 

Drug Discovery

- Exscientia (2012, Britain): rapid-prototyping platform that automates drug design via an expert system that is equipped with a repertory of best practices acquired from experts of the sector. This system can design millions of novel compounds and calculate for each how effective it is likely to be for a specific project. Then it can select the best ones for experiments.
- Collaborations with GSK, Sanofi and Evotec



Exscientia Announces EUR250 Million Collaboration for a Multiple-Product Development and Licence Option Agreement with Sanofi

May 09, 2017,



EXSCIENTIA ENTERS STRATEGIC DRUG DISCOVERY COLLABORATION WITH GSK

Drug Discovery

- Atomwise (2012, San Francisco): neural network AtomNet to combine millions of molecular structures and infer the most likely to target a disease
- Working with IBM Watson
- Projects ranging from multiple sclerosis to ebola
- Collaborations with Merck



Merck is working with Atomwise to explore the frontiers of drug discovery using artificial intelligence and machine learning.



Dr. Abraham Heifets Dr. Izhar Wallach Alexander Levy Misko Dzamba

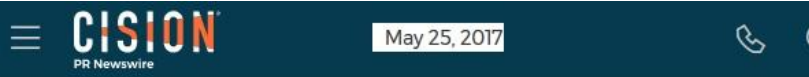


YC Alum Atomwise Raises \$6 Million To Further The Advancement Of Artificial Intelligence In Drug Discovery

Posted Jun 3, 2015 by [Sarah Buhr \(@sarahbuhr\)](#)

Drug Discovery

- BenevolentAI (2013, Britain)
 - Analyzing scientific papers
 - Nvidia's DGX-1 supercomputer
 - \$800 million deal in 2014 to deliver two Alzheimer drug candidates to bigpharma
 - 2017: 24 drug candidates



Positive Results in Research Delaying Onset of Motor Neurone Disease Announced by Sheffield University and British Artificial Intelligence Firm BenevolentAI

Encouraging early results for the drug candidate discovered by artificial intelligence



Enabling 21st Century scientific innovation

BenevolentAI is the world leader in the development and application of artificial intelligence for scientific innovation. We are the largest private AI company in Europe and one of the top five private AI companies in the world.



Drug Discovery

- Berg (2006, Boston): analyze genomic and clinical data about a disease and then infers the network of protein interactions that cause the disease
- Collaboration with AstraZeneca (2017) to discover new treatments for Parkinson's disease and other neurological disorders.



AstraZeneca taps AI for drug discovery in deal with Berg



BERG
Back to Biology for a Healthier Tomorrow

Drug Discovery

- Desktop Genetics



DESKGEN™ CRISPR Libraries

AI-designed for more effective and affordable guides, with fewer false negatives.

Drug Discovery

- Insilico Medicine (2014, Baltimore)
 - looks at drugs that are already safe to use and see if they can be re-purposed for other uses
 - Used a neural network to discover molecules that can fight cancer



The cornucopia of meaningful leads: Applying deep adversarial autoencoders for new molecule development in oncology

Artur Kadurin^{1,2,3,4}, Alexander Aliper², Andrey Kazennov^{2,7}, Polina Mamoshina^{2,5}, Quentin Vanhaelen², Kuzma Khrabrov¹, Alex Zhavoronkov^{2,6,7}

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²Pharmaceutical Artificial Intelligence Department, Insilico Medicine, Inc., Emerging Technology Centers, Johns Hopkins University at Eastern, Baltimore, Maryland, USA

³Big Data and Text Analysis Laboratory, Kazan Federal University, Kazan, Republic of Tatarstan, Russia

⁴St. Petersburg Department of V.A. Steklov Institute of Mathematics of the Russian Academy of Sciences, Petersburg, Russia

⁵Department of Computer Science, University of Oxford, Oxford, UK

⁶The Biogerontology Research Foundation, Trevissome Park, Truro TR4 8UN, UK

⁷Moscow Institute of Physics and Technology, Dolgoprudny, Russia

Correspondence to: Alex Zhavoronkov, **email:** alex@insilicomedicine.com

Keywords: generative adversarial networks, adversarial autoencoder, deep learning, drug discovery, artificial intelligence

Received: June 14, 2016

Accepted: November 24, 2016

Published: December 22, 2016

Drug Discovery

- TwoXAR (Silicon Valley, 2014): identified a potential drug for liver cancer in just four months by screening 25,000 potential candidates in a joint project with Stanford (the only treatment approved by the FDA took five years to develop).



ARTIFICIAL INTELLIGENCE-DRIVEN DRUG DISCOVERY



Screening compound libraries for efficacy against a disease or list of diseases



Identifying new drug candidates from a public library



Identifying biologic targets from the elucidation of novel biology

Drug Discovery

- Numerate (2007, Bay Area) can “virtually assay 25 million compounds from a library of 1 trillion compounds against a handful of accurate activity, selectivity and ADME models at a cost of one-one hundredth of a penny per compound, in about one week”



DATA-DRIVEN DRUG DESIGN®

Using the power of cutting-edge artificial intelligence (AI) to revolutionize small molecule drug design



Our Platform

Our platform offers cloud-scale artificial intelligence support for every design decision at each stage of drug discovery

Drug Discovery

- Recursion (2013, Utah): computer vision to look at cells and analyze more than 1,000 features to determine whether a sick cell is being "cured" by the compounds that it massively produces.
- image-processing software developed by Anne Carpenter at the Broad Institute
- committed to discovering 100 disease treatments by 2025
- 2017: identified 15 potential treatments for rare diseases
- 2016: partnership with Sanofi



We're aiming for 100 new treatments by 2025

**MIT
Technology
Review**

January 24, 2017

Machine Vision Helps Spot New Drug Treatments

A startup uses algorithms that understand the anatomy of cells to discover new uses for existing drugs.

Drug Discovery

- PathAI (2016, Boston): end-to-end data-driven pathology analysis + clinical decision support tools
- Andrew Beck at Stanford built one of the earliest A.I. systems for cancer pathology
- Working with Philips to diagnose breast cancer



Andrew Beck
Aditya Khosla



PHILIPS

News center

March 29, 2017

Philips and PathAI team up to
improve breast cancer diagnosis
using artificial intelligence
technology in 'big data' pathology
research

Drug Discovery

- 2015: Michael Levin's evolutionary algorithm reverse-engineers the regeneration mechanism of planaria (which had eluded human scientists for over 100 years)
- Planaria can regenerate its organs



Planarian Regeneration Model ered by Artificial Intelligence

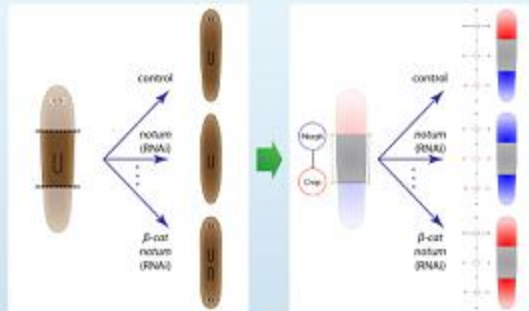
Computer A.I. Solves 120-Year-Old Biological Mystery

JUNE 9, 2015

A computer has developed a new scientific theory using only its artificial intelligence, without any help from humans. Continue reading →

Physical experiments

Perform physical experiments and formalize them in a functional dataset based on a mathematical ontology.



Candidate regulatory networks

Generate candidate networks: random first, then cross and mutate existing ones.



Return discovered network

Return the candidate network that reaches zero error, explaining all physical experiments.



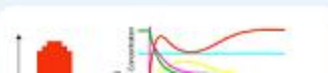
Error scoring and selection

Score simulation result errors of each candidate network and discard the networks with highest errors.



Simulation

Simulate the physical experiments with the new candidate networks.



Drug Discovery



IBM Watson

- 2016: IBM Watson discovers ALS genes
- It analyzed all published literature related to ALS and ranked genes based on the probability that they would be responsible for the proteins known to be associated with the disease: eight of the top ten genes are indeed associated with the disease, and five of them were previously not suspected.

Mashable

IBM's Watson
supercomputer discovers 5
new genes linked to ALS

DEC 15, 2016

Barrow Neurological Institute



Drug Discovery

- 2017: GlaxoSmithKline + Lawrence Livermore Lab + National Cancer Inst form ATOM consortium to transform drug discovery from the slow, sequential and failure-prone process that is today into a rapid and accurate process (from target to patient-ready in less than one year).



Lawrence Livermore National Laboratory

SAN FRANCISCO, Oct 27, 2017

Public-private consortium aims to cut preclinical cancer drug discovery from six years to just one



Accelerating Therapeutics for Opportunities in Medicine

Drug Discovery

- 2017: First A.I. based system approved by FDA (a medical imaging platform by Arterys to detect heart problems)
- Not quite "biotech", but an important first step towards accepting A.I. as a "cure".

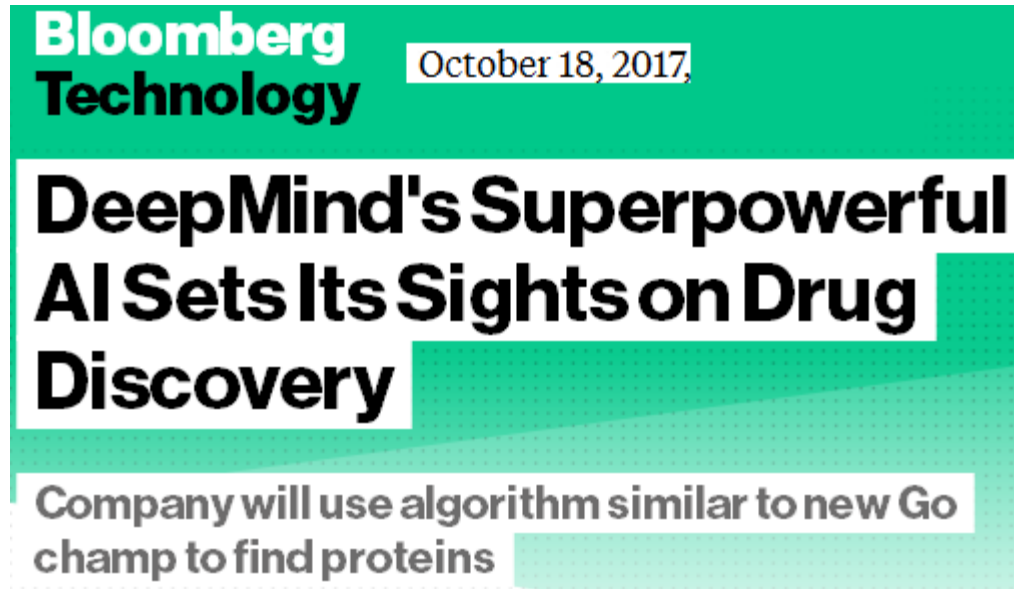
JAN 20, 2017

First FDA Approval For
Clinical Cloud-Based
Deep Learning In Healthcare



Drug Discovery

- 2017: AlphaGo Zero



Drug Discovery

- 2020: Discovery of covid-19 antibodies (Yang An-suei @ Academia Sinica, 2020)



Published: Monday, 09 March 2020 09:30

**Catching Virus Fast! Academia Sinica
discovered useful antibodies for
developing rapid immune based test kit of
SARS-CoV-2 coronavirus**



Yang An-suei (楊安綏)
Physical & Computational Genomics

nature

Yang's group accomplished the feat in just 19 days, by working with artificial-intelligence models of antibody–antigen interactions, which they used to generate artificial antibody libraries.

Towards Precision Medicine

*A.I. could mark the end of the mass-produced drug
It could discover the specific drug that works best for
your specific case*

Towards Precision Medicine

- Mendel.ai (2016, San Francisco): provide customize treatments to cancer patients based on the latest published data (NLP tech to analyze medical publications and ANN to compare content with a patient's medical record)



**Find breakthrough treatments
for your cancer**

Search by medical records

Cancer Type

Type your cancer type

Location

City, state

Age

Type your age



Gender

Pick gender

Psychology

- Historical surveys:
 - <https://pdfs.semanticscholar.org/5626/d3a613f3ff2a3e64f3b5cf47ef616c174549.pdf>
 - <https://www.ai-therapy.com/articles/computers-and-therapy>
 - <https://medium.com/one-future/ai-and-the-future-of-psychotherapy-d0593b827a44>
 - <http://ct.counseling.org/2015/03/the-end-of-counseling-as-we-know-it/>

Psychology

- Tess
 - <https://www.newyorker.com/tech/annals-of-technology/the-chatbot-will-see-you-now>
 - <https://www.theguardian.com/society/2018/apr/25/meet-tess-the-mental-health-chatbot-that-thinks-like-a-therapist>
- Woebot, created by two Stanford clinical psychologists AND supported by one of the most famous AI scientists, Andrew Ng
 - <https://woebot.io>
 - <https://www.technologyreview.com/s/609142/andrew-ng-has-a-chatbot-that-can-help-with-depression/>
 - <https://medium.com/@andrewng/woebot-ai-for-mental-health-d0e8632b82ba>

Psychology

- Ellie (2015) at USC <https://futurism.com/uscs-new-ai-ellie-has-more-success-than-actual-therapists>
- TEVI (2018) at UCLA
<https://mashable.com/2018/02/22/worlds-first-ai-therapist/>
- AI Therapy <https://www.ai-therapy.com> started by an Oxford researcher based on a project from Univ of Sydney

Law

- ClearAccessIP: automatically analyze patent portfolios
- LawGeex
- ROSS Intelligence: automatically process millions of pages, understand a query's context, and draft a memo on its findings.



Law

- JP Morgan's COIN (2017)
- CaseMine
- Zapproved
- Harvard Law School: CaseLaw Access Project to digitize the entire historical record of court opinions



HARVARD LAW SCHOOL
**Library
Innovation
Lab**

Caselaw Access Project



Forbes

JUN 14, 2017 @ 03:49 AM 8,615



Can Robots Replace Lawyers? This Indian AI Startup Is Making A Case For Legal Tech



Zapproved Raises \$15M For Its Cloud-Based eDiscovery Service

Posted Feb 2, 2015 by Frederic Lardinois (@fredericl)



Job Hiring & Job Search

- Automated recruiting assistant (eg FirstJob's Mya, HireVue)
- Automated resume assembler
- Internet crawler to search for best talents to fit openings

Customer Support

- Callers' tone analyzer (eg Mattersight)
- Travel assistant

Mattersight[®]
The Chemistry of Conversation

Cybersecurity

- 2010s: Boom in cyber crime
- Cost of cybersecurity: \$106.1bn (IDC, 2017)
- More than 70% of attacks exploit known vulnerabilities for which there are available patches (Verizon Data Breach Report)
- Warning: if you can use it to defend yourself, the attacker can use it to attack you

Cybersecurity

- CB Insights report (2016)

NOVEMBER 2, 2016



Cybersecurity's Next Step: Artificial Intelligence Is Helping Predict, Prevent, And Defeat Attacks



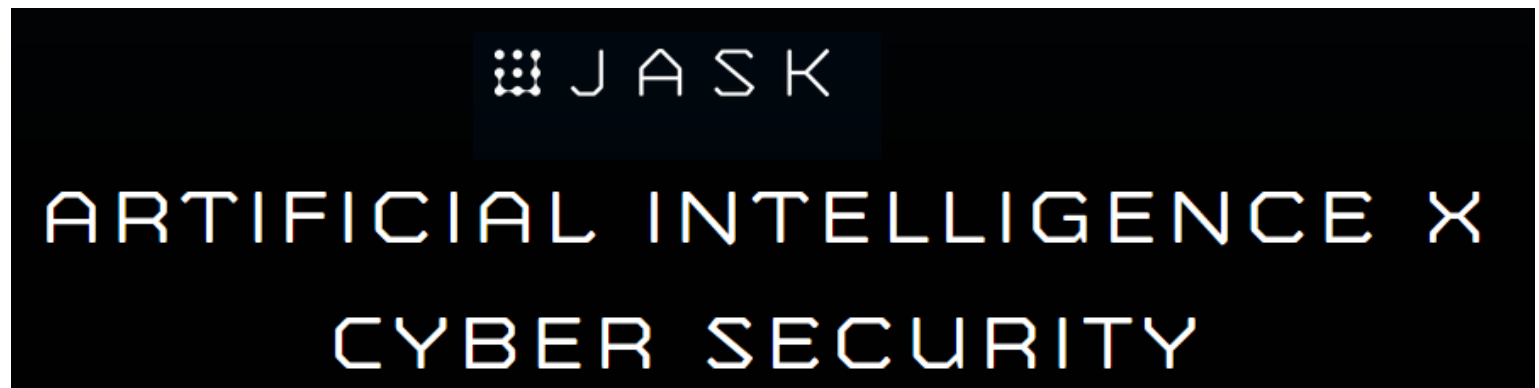
Cybersecurity

- Products



Darktrace Antigena Launched: New Era as Cyber AI Fights Back

📍 Cambridge (UK) and San Francisco 📅 Tuesday April 4, 2017



Cybersecurity

- Feb 2017: IBM launches its Watson for Cyber Security platform



Cybersecutiry

- Defense from cyber-attacks (eg Kalyan Veeramachaneni's AI², 2016)



MIT builds Artificial Intelligence system that can detect 85% of Cyber Attacks

Tuesday, April 19, 2016

System predicts 85 percent of cyber-attacks using input from human experts



Virtual artificial intelligence analyst developed by the Computer Science and Artificial Intelligence Lab and PatternEx reduces false positives by factor of 5.



It's a great example of how even the most advanced AI still needs humans to truly learn

Cybersecurity

- Conferences

The AAI-17 Workshop on

Artificial Intelligence for Cyber Security

February 4, 2017, San Fransisco, California, USA

Journalism

- Headlines generation
- Summary generation

Generating News Headlines with Recurrent Neural Networks



Konstantin Lopyrev

Stanford
University

Dec 2015

OpenAI's GTP3 (2020)

Title: United Methodists Agree to Historic Split
Subtitle: Those who oppose gay marriage will form their own denomination
Article: After two days of intense debate, the United Methodist Church has agreed to a historic split - one that is expected to end in the creation of a new denomination, one that will be "theologically and socially conservative," according to The Washington Post. The majority of delegates attending the church's annual General Conference in May voted to strengthen a ban on the ordination of LGBTQ clergy and to write new rules that will "discipline" clergy who officiate at same-sex weddings. But those who opposed these measures have a new plan: They say they will form a separate denomination by 2020, calling their church the Christian Methodist denomination.
The Post notes that the denomination, which claims 12.5 million members, was in the early 20th century the "largest Protestant denomination in the U.S.," but that it has been shrinking in recent decades. The new split will be the second in the church's history. The first occurred in 1968, when roughly 10 percent of the denomination left to form the Evangelical United Brethren Church. The Post notes that the proposed split "comes at a critical time for the church, which has been losing members for years," which has been "pushed toward the brink of a schism over the role of LGBTQ people in the church." Gay marriage is not the only issue that has divided the church. In 2016, the denomination was split over ordination of transgender clergy, with the North Pacific regional conference voting to ban them from serving as clergy, and the South Pacific regional conference voting to allow them.

Figure 3.14: The GPT-3 generated news article that humans had the greatest difficulty distinguishing from a human written article (accuracy: 12%).

Engineering Issues

- Very few real-world AI applications, despite all the hype, eg

Why isn't AI X-ray systems widely deployed? Generalization and Robustness

A model that works according to a published paper often does not work in a production setting.



Huge gap between what works in a research lab vs. what will run in production.
This is true not just for healthcare.

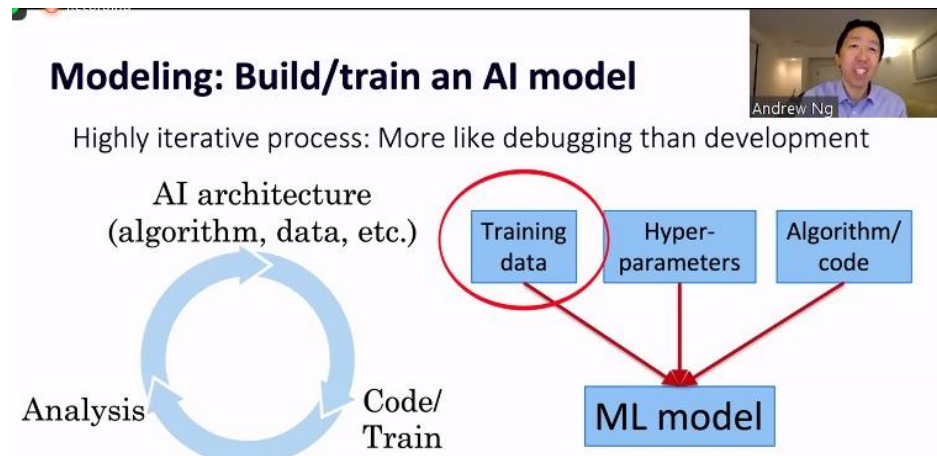
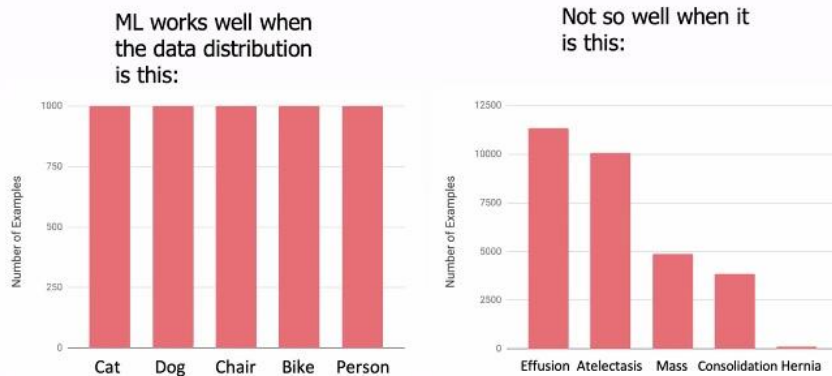
Will your model generalize to a different dataset than what it was trained on?

Engineering Issues

- Very few real-world AI applications, despite all the hype
 - Datasets



Small data and rare occurrences



Neuroscience

Yamins D & DiCarlo JJ (2016). Using goal-driven deep learning models to understand sensory cortex doi:10.1038/nn.4244

Nice paper on deep learning applied to understanding the retina
<https://www.biorxiv.org/content/10.1101/340943v4>

Bill Newsome's lab at Stanford: machine learning to track latent decision variables from neural population recordings in real time while monkeys perform a simple visual discrimination task <https://www.biorxiv.org/content/10.1101/681783v1>

~~My prediction hope of 2017~~
is...

Augmented Intelligence for Insoluble Problems

- "Population and gross product are increasing at a considerable rate, but the complexity of problems grows still faster" (Doug Engelbart, 1962)

Augmented Intelligence for Insoluble Problems

- Augmented Intelligence for “wicked problems” and “messes”
 - Horst Rittel and Melvin Webber: “wicked problems” (1972)
 - Russell Ackoff: “messes” (1974)
 - Wicked problems are not isolated, they are sets of problems, each one influencing others
 - Sustainable solution to wicked problems: a phase transition of the system



Robert E. Horn



Visiting Scholar
Stanford University

Brief bio

CV

Recent speeches &
articles

rbob@earthlink.net

Visual Analytics for Public Policy

A research program to model, communicate, and
resolve complex issues

What is visual analytics?

NASA
Project on Strategic
Science Policy



GLOBAL STRUGGLE
OF NARRATIVES
Project



Discriminate
Force Project



National Missile
Defense Debates



Genetically Modified
Food Project



HUMAN COGNOME Initiative
National Science Foundation



Social Messes

Helping groups get started
and stay on the same page in dealing with
seemingly intractable "wicked" problems
For more info



What are
Social
Messes?

Social Mess
Projects

Summaries of My Current Work

Thinking
Bigger
Thoughts

Connecting
the
Smudges

My other interests and writings

Visual language, human-computer
interface, knowledge mapping

Philosophy, cognitive science, artificial
intelligence

Information Mapping® , structured writing,
reusable learning objects, hypertext

Simulation gaming /scenarios

Educational research & methods

Argumentation
mapping

Art and
information
design

Electronic
democracy,
governance

INFO-MURALS / PUBLIC ART

STRATEGY for dealing with RADIOACTIVE WASTE



ARGUMENTATION MAPS about RADIOACTIVE WASTE



Avian Flu
Pandemic
Scenario Info-
Mural



Are
Info-
Murals
New
Genre?
A New
Article

STRATEGIC POLICY OPTIONS for GLOBAL CLIMATE CHANGE

Current project -
watch this space



CARNEGIE TRUST
Info-Mural
Convention on the
Rights of the Child
watch this space

My Primary Tools (These Days)

Book

Visual
Language



To order

Visual Analytics™ Workshops

Visual Thinking
and Visual
Communication



For more
info

Mess
Mapping®
Process



For more
info

Argumentation
Mapping for Public
Policy Debates



For more
info

Posters

Can
Computers
think?



To order

Info-murals

For Public
Policy



For more
info

History of
Cybernetics and
Systems Science
Info-Mural

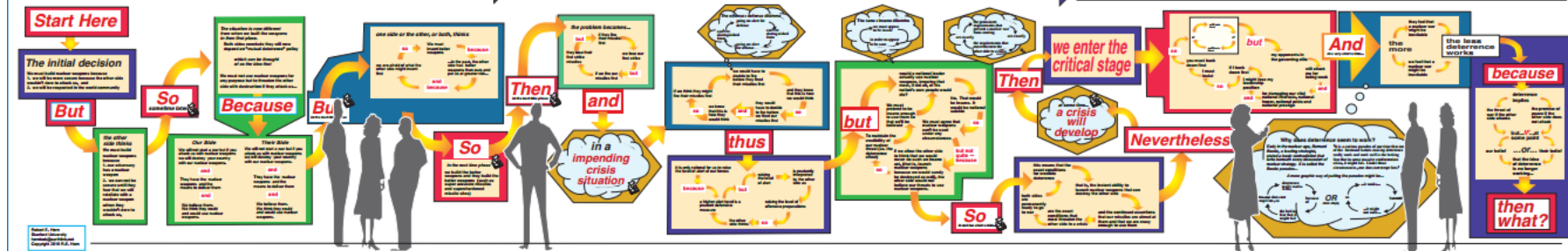
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XPLANE

Copyright 2005 Robert E. Horn

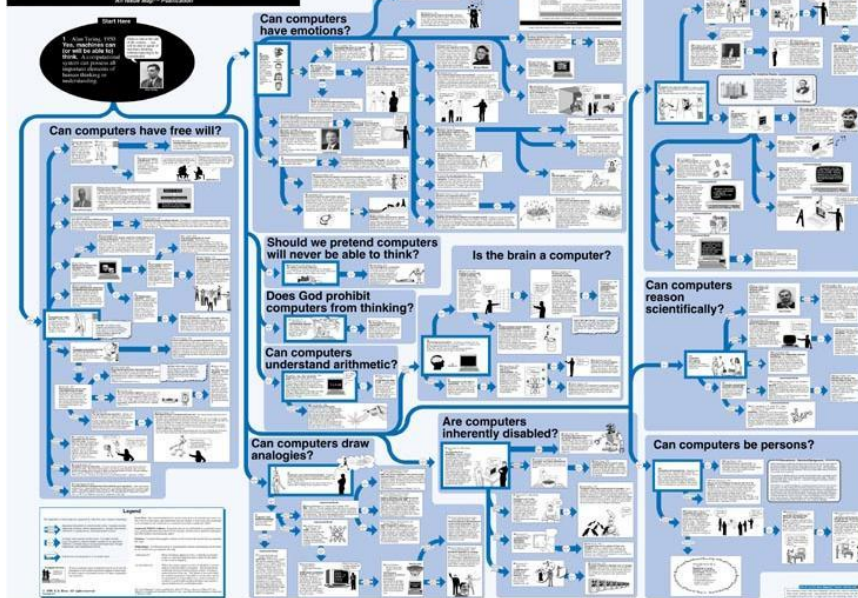
Bob Horn's digital murals

Wicked Problems and Messes

The concept of nuclear deterrence was carefully thought out in the Cold War – and it looked (more or less) like this – but we're safer now, aren't we...
Both sides initially believe "if we build nukes we will be safer"... ...however, if a crisis situation develops, the paradoxes accumulate... ...and in the critical stage, the paradoxes can't be resolved...



1 Can Computers Think? The History and Status of the Debate — Map 1 of 7



Robert E. Horn
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Brief bio
CV
Recent speeches & articles
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Visual Analytics for Public Policy

A research program to model, communicate, and resolve complex issues

What is visual analytics?

NASA Project on Strategic Science Policy

Global Struggle of Narratives Project

Discriminate Fence Project

National Missile Defense Debates

Genetically Modified Food Project

Can computers be persons?

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Can computers be persons?

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Social Messes

Helping groups get started and stay on the same page in dealing with seemingly intractable "wicked" problems. For more info

What are Social Messes? Social Mess Projects

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Argumentation mapping

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Mess Mapping: Process

Argumentation Mapping for Public Policy Debates

Can Computers think?

For Public Policy

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watch this space

History of Cybernetics and Systems Science Info-Mural

My publishers MacroVU @, Inc. XPLANE

For more info

To order

For more info

To order

For more info

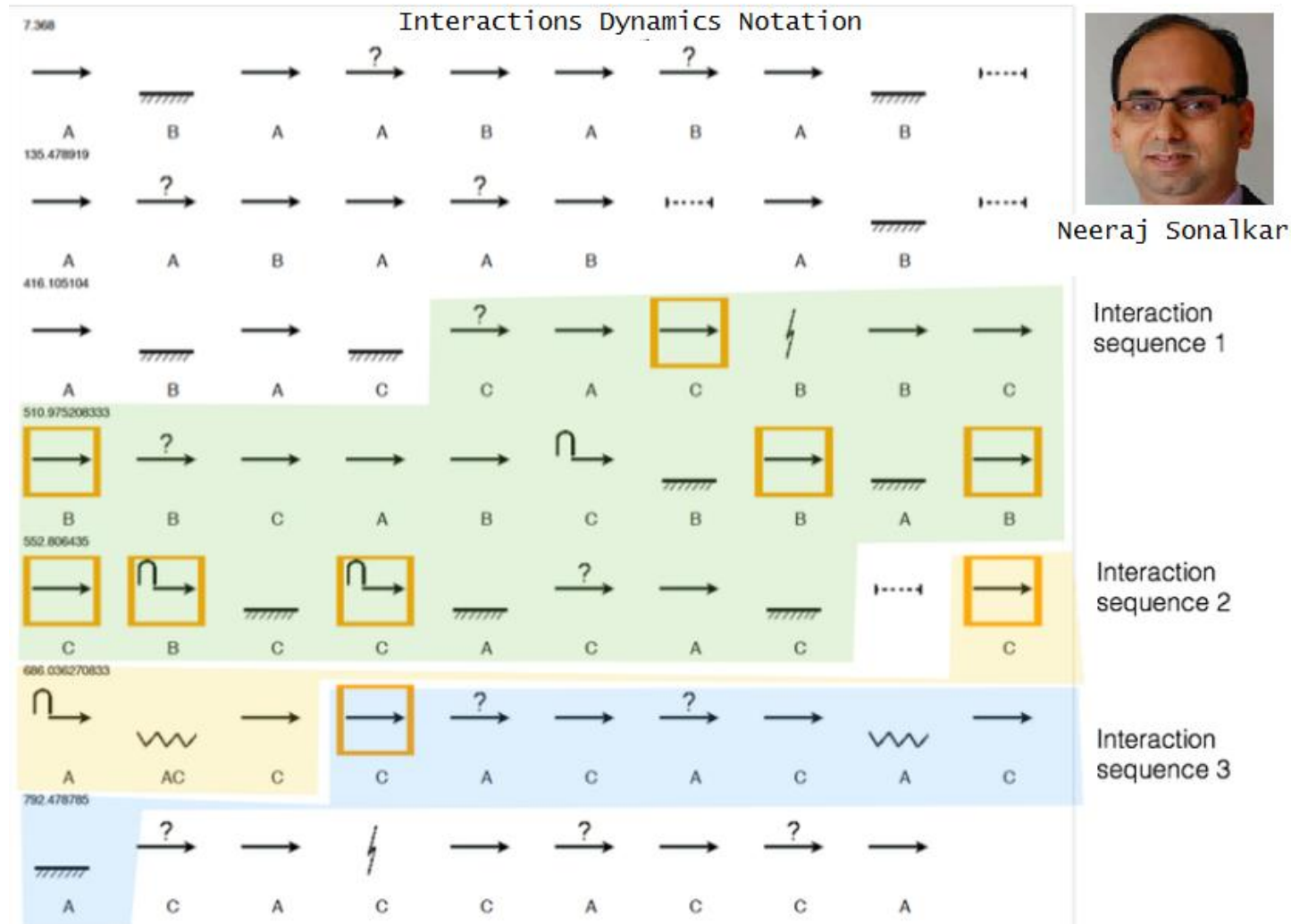
To order

For more info

To order

Bob Horn's digital murals

Wicked Problems and Messes



Peace Innovation Lab

- From Computational Social Science to Technology Park:
 - A methodology to discover needs in society
 - A factory of 100s of startups
 - A social innovation park



Stanford P.I.L.

Start a “peace technology lab” in your city...



We speak Chinese...

Contact:

Jinxia Niu

dearnarnia@qq.com

Wechat: 18367115526



Stanford Peace Innovation Lab

- Solving intractable problems



German chancellor Angela Merkel visiting the Berlin Peace Innovation Lab



Computational Social Science

- A.I. for Social Science
- Wicked Problems and Messes
- First time in history that we have large datasets of interactions between individuals (social media and sharing apps)
- Discover patterns
- Behavior design

Next...

- See <http://www.scaruffi.com/singular> for the index of this Powerpoint presentation and links to the other parts

