AI: What opportunities for energy efficiency

Luigi Troiano [University of Salerno]

Smart Efficiency - L'Efficienza Energetica intelligente: metodologie, soluzioni e tecnologie

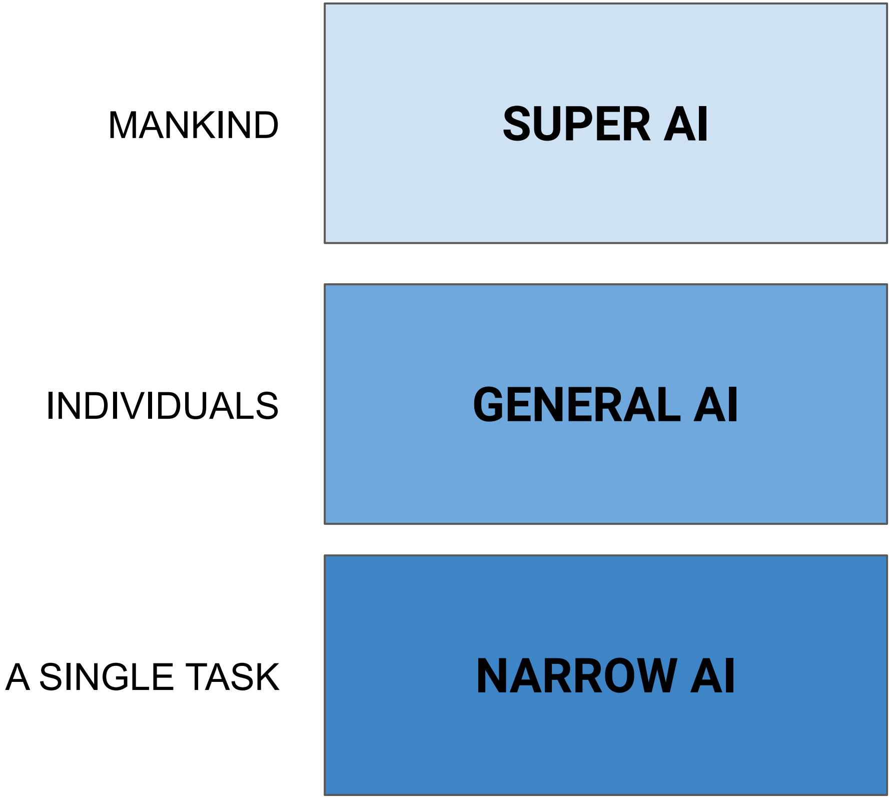
Online, 25th November 2020


What it takes to end an AIDS epidemic
Polar bears suffer through lean summers
Sperm produced in ovary of mutant fish
Science
$10 17 JULY 2015 sciencemag.org
AAAS
SPECIAL ISSUE
ARTIFICIAL INTELLIGENCE
Forbes
AI: The Killer App for Your Business
TERADATA
INSIDE: A 14-PAGE SPECIAL REPORT ON FINANCIAL TECHNOLOGY
The Economist
Artificial Intelligence
The promise and the peril
Revolution in Egypt
TIME
2045
The Year Man Becomes Immortal
Harvard Business Review
ITALIA
È L'ORA DELL'INTELLIGENZA ARTIFICIALE
L'innovazione aumenta a ritmi esponenziali. Così la rivoluzione delle macchine cambia le aziende e il modo di lavorare. PAG. 11
Strategiqs
nature
LEARNING CURVE
SHARE DATA IN OUTBREAKS
A GIANT IN THE EARLY UNIVERSE
TELEPORTATION FOR TWO
MIT Technology Review
The Artificial Intelligence Issue
TEMPI
SCACCO ALL'UMANO
Dai laboratori della Silicon Valley all'industria delle armi, dalle braccia meccaniche delle catene di montaggio alla suggestiva distopia di Blade Runner. L'Intelligenza Artificiale si sta prendendo i nostri corpi, ma punta all'anima
OLIMPIADI COSÌ SI VINCONO LE MEDAGLIE
SCOPRIRE E CAPIRE IL MONDO
Focus
L'INTELLIGENZA ARTIFICIALE CI CAMBIERÀ LA VITA
ECCO COME
GLI STRUZZI E I LORO CUGINI CATTIVI
GLI STRANI DISEGNI VISIBILI SOLO DAL CIELO
SESSO: QUELLI CHE NON LO FANNO MAI
San Francisco Chronicle
FRIDAY, SEPTEMBER 7, 2007
WHEN MACHINES THINK
Real brains are gathering in San Francisco to ponder the future of artificial intelligence
POPULAR SCIENCE
SPECIAL EDITION
THE NEW ARTIFICIAL INTELLIGENCE
THE FUTURE OF NANOBOTS
DETECTING CANCER
KILLER ROBOTS?
JOHN MCAFEE'S LAST STAND
WIRED
The ROBOTS TAKE OVER!
Internazionale
L'intelligenza artificiale dominerà il mondo?
Antonio Genna Blog
VANITY FAIR
Conquistare Ivanka per arrivare a Trump
Samantha Cameron ex First Lady felice
Beauty
Maria Sharapova
L'intelligenza artificiale di Elon Musk

WHAT IS AI?

The field of computer science that studies the methods and technologies to replicate with machines those cognitive capabilities associated to human, animal or life intelligence, such as learning, reasoning, adapting and self-organizing skills in the context of partial information and limited resources.

THE AI LEVELS



#1 - AI will understand more, so it can do more - Breakthrough techniques will help AI learn with less data, better understand human language.

#2 - AI won’t take your job, but it will change how you work - AI will take on easily automated tasks, while workers lean into soft skills

#3 - AI will engineer AI for trust - Component will infuse trust throughout the AI lifecycle, building confidence in AIs recommendations

#4 - AI’s appetite for energy demands greener tech - The material and software AI is based on will be designed for energy efficiency

#5 - AI-powered lab assistants will discover new materials - AI will drive breakthroughs for new industry products

Sriram Raghavan - Vice President, IBM Research AI

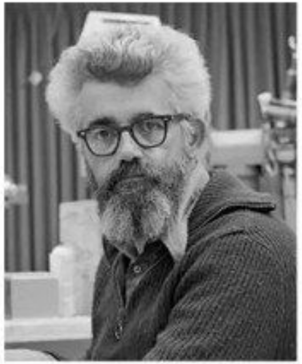
John McCarthy

September 4, 1927 – October 24, 2011

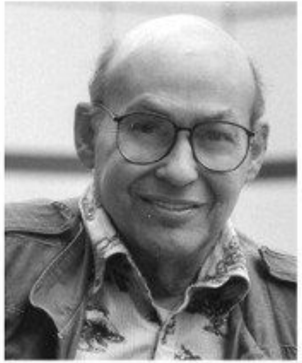
Dartmouth Summer Research Project on Artificial Intelligence (1956)

1. Ray Solomonoff
2. Marvin Minsky
3. John McCarthy
4. Claude Shannon
5. Trenchard More
6. Nat Rochester
7. Oliver Selfridge
8. Julian Bigelow
9. W. Ross Ashby
10. W.S. McCulloch
11. Abraham Robinson
12. Tom Etter
13. John Nash
14. David Sayre
15. Arthur Samuel
16. Kenneth R. Shoulders
17. Shoulders' friend
18. Alex Bernstein
19. Herbert Simon
20. Allen Newell

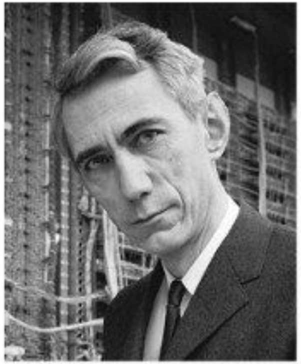
1956 Dartmouth Conference: The Founding Fathers of AI



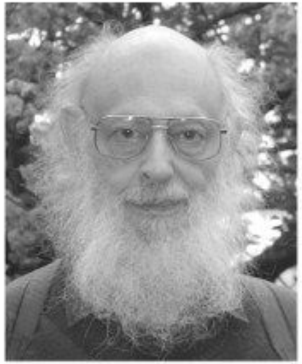
John MacCarthy



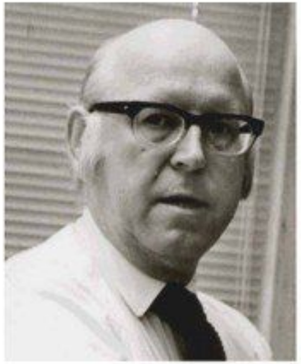
Marvin Minsky



Claude Shannon



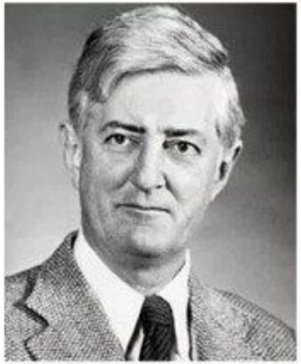
Ray Solomonoff



Alan Newell

Herbert Simon

Arthur Samuel



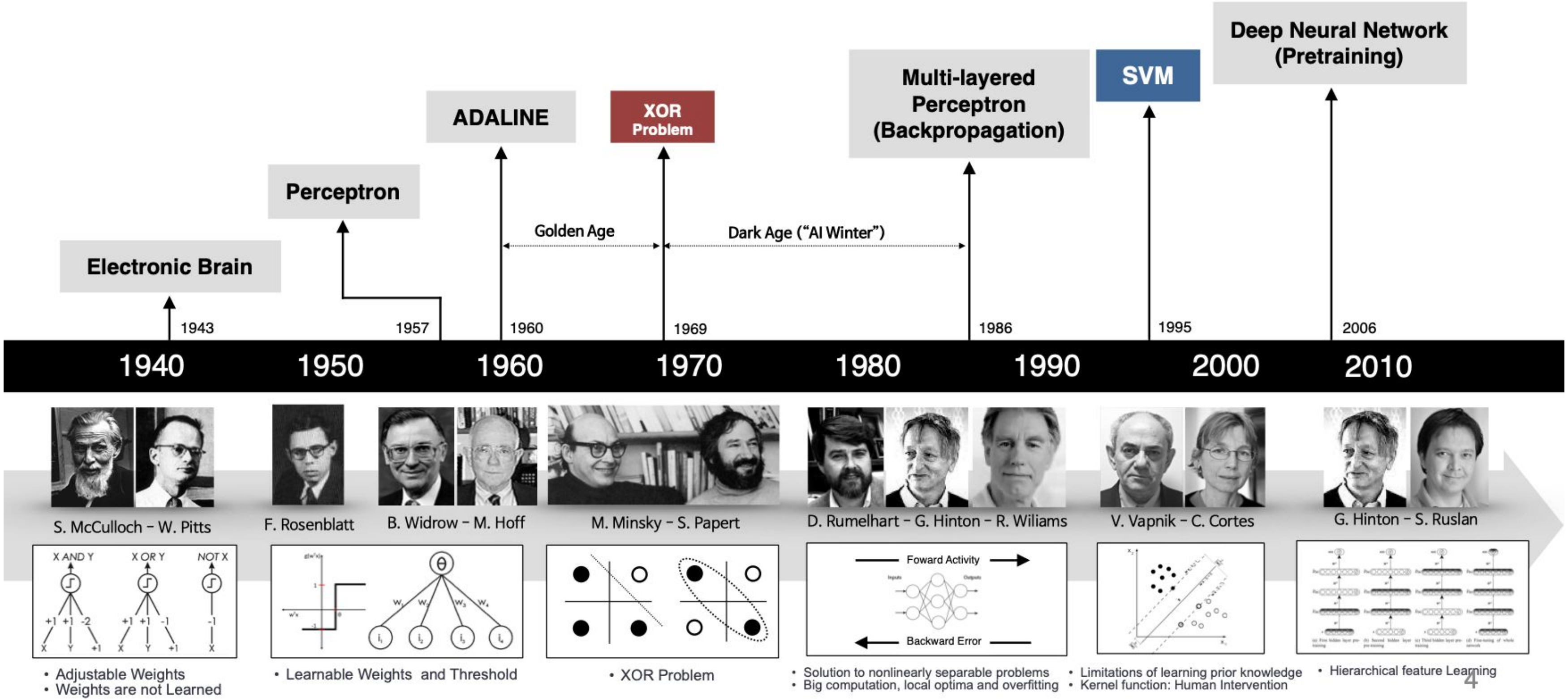
Oliver Selfridge

Nathaniel Rochester

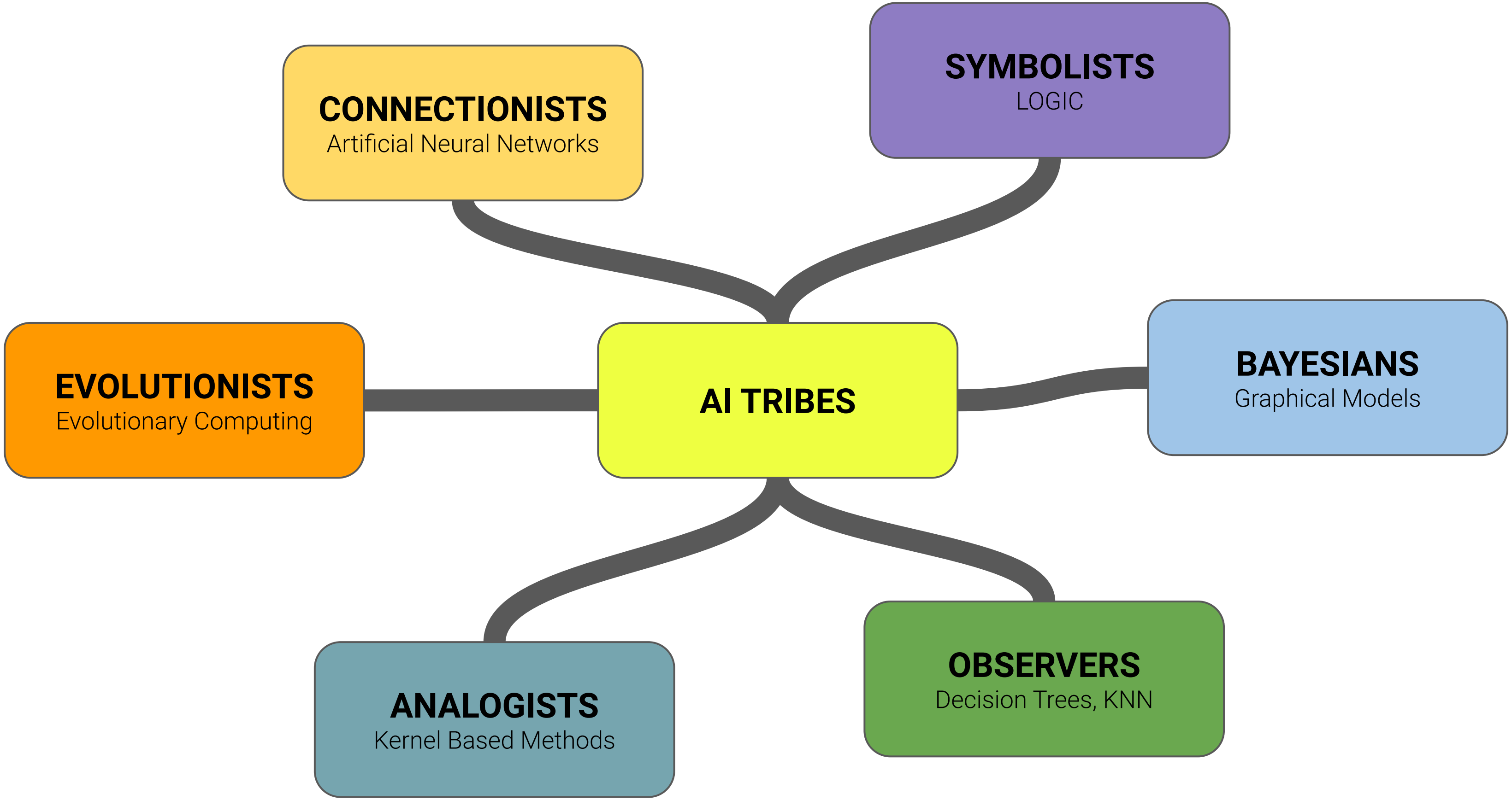
Trenchard More

Brief History of Neural Network

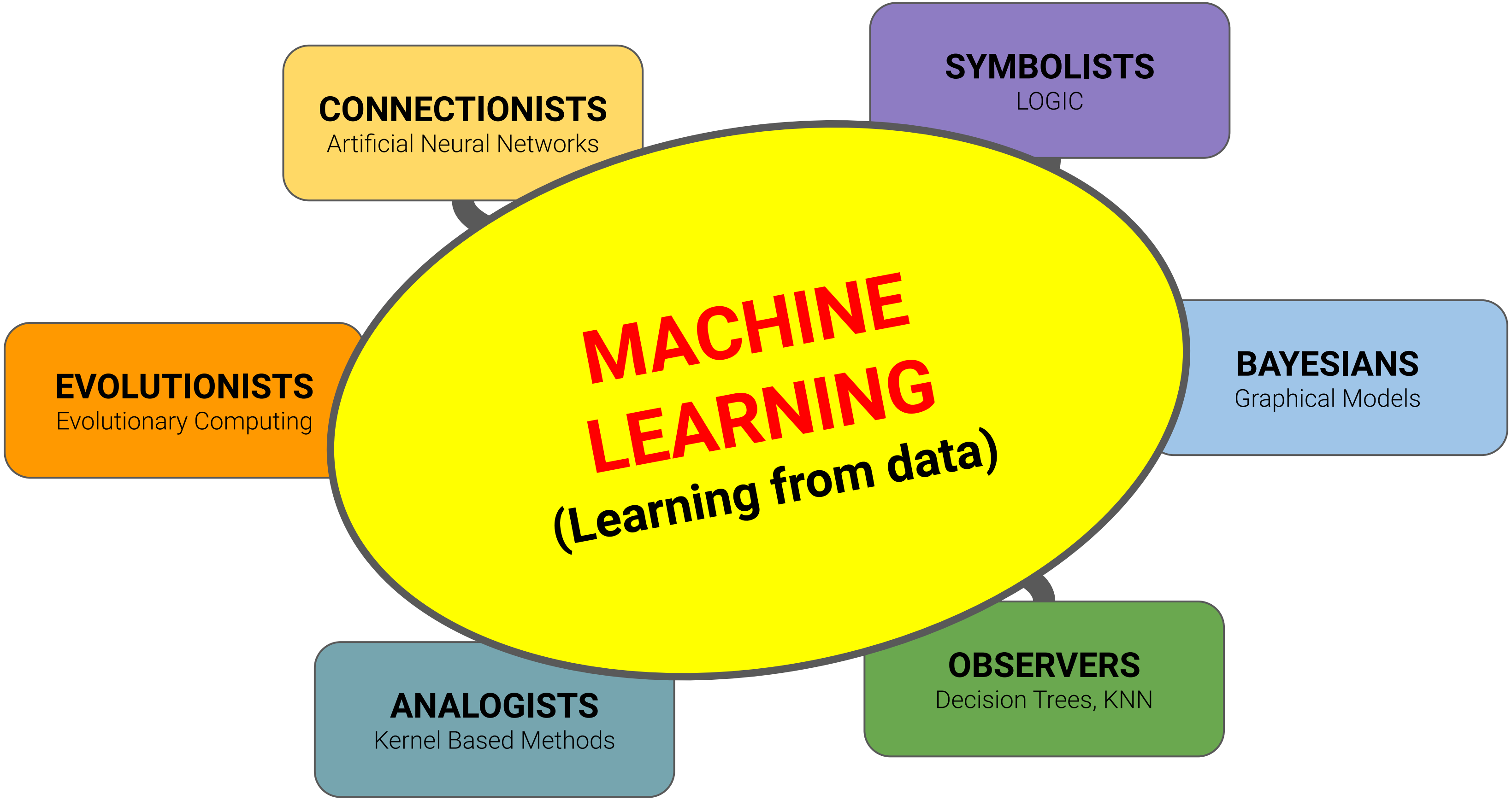
DEVIEW 2015



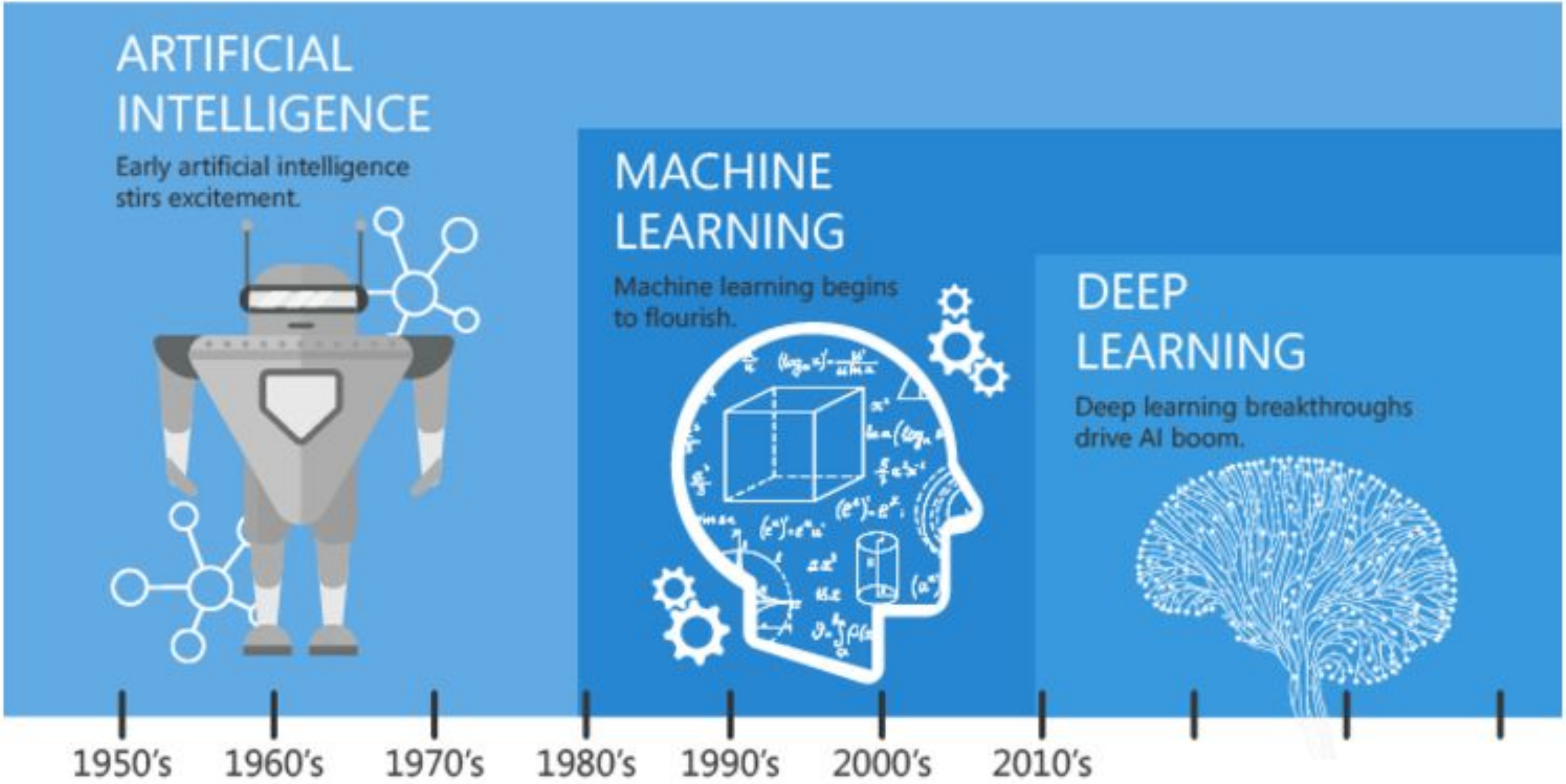
THE AI TRIBES



DATA DRIVEN MODELS




Arthur Samuel
December 5, 1901 – July 29, 1990

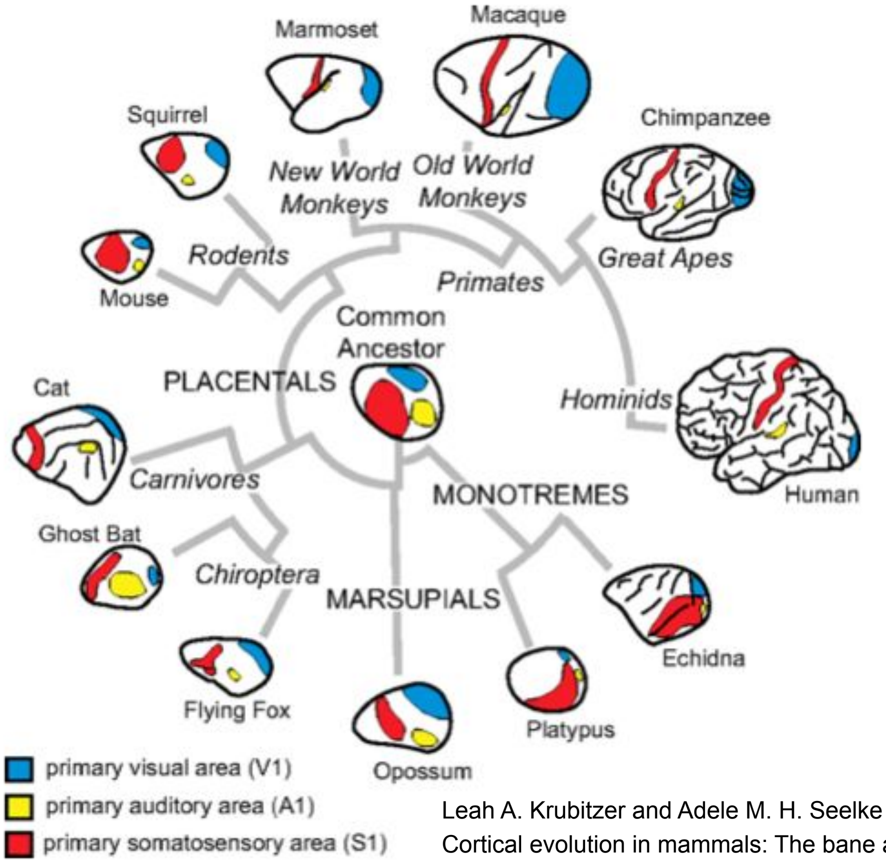


Since an early flush of optimism in the 1950's, smaller subsets of artificial intelligence - first machine learning, then deep learning, a subset of machine learning - have created ever larger disruptions.

THE EXPANDING UNIVERSE OF MODERN AI

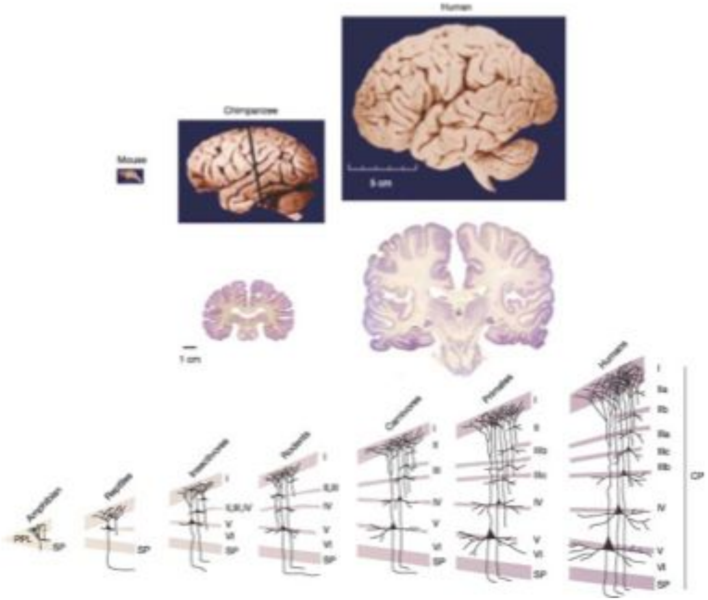

Joeffrey Hinton
December 6, 1947

THE CORTEX



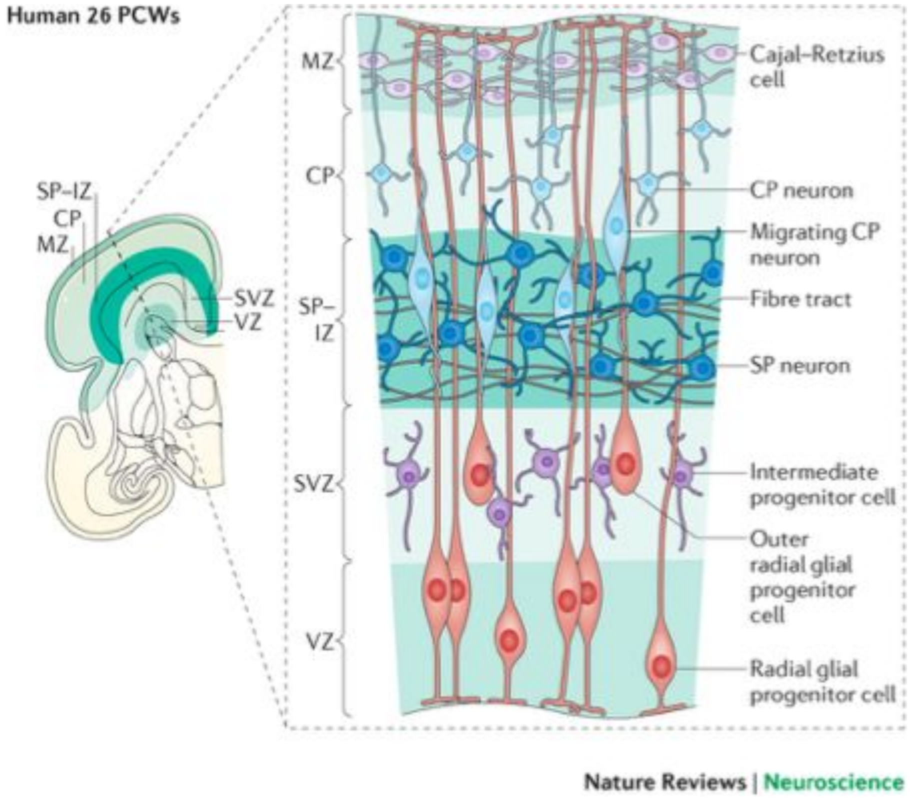
Leah A. Krubitzer and Adele M. H. Seelke
Cortical evolution in mammals: The bane and beauty of phenotypic variability
PNAS 2012 109 (Supplement 1) 10647-10654

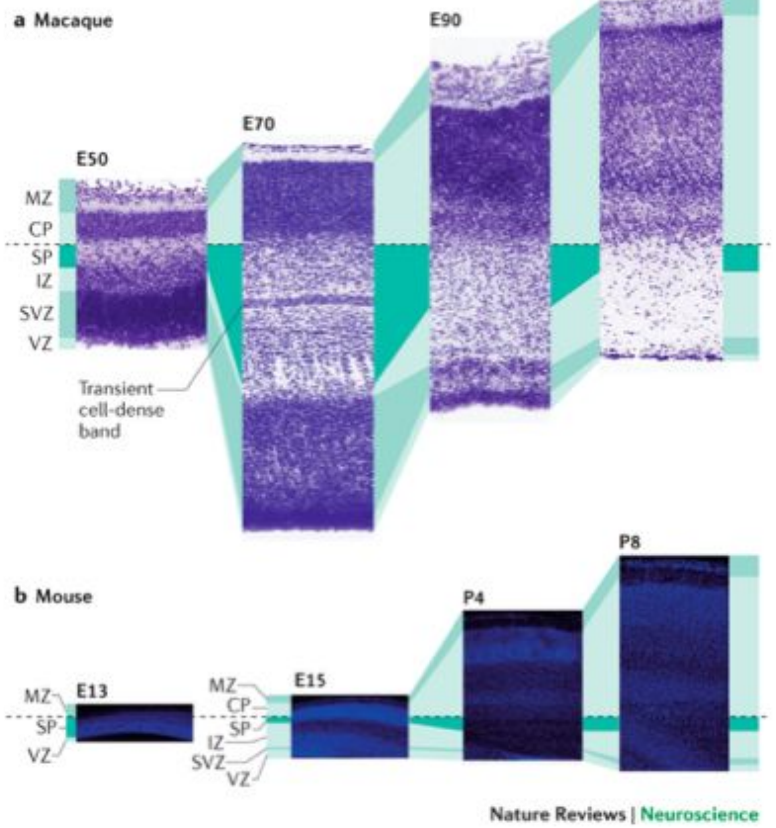
Receptive Fields (Huber & Wiesel, 1959)



Hill, R. S. and Walsh, C. A. Molecular insights into human brain evolution. Nature 437, 64-67 (2005)

THE CORTEX





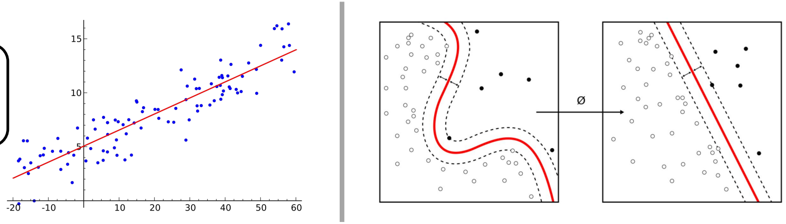
Hoerder-Suabedissen A. and Molnár Z. Development, evolution and pathology of neocortical subplate neurons. Nature Reviews Neuroscience 16, 133–146 (2015)

A CHANGE IN THE WORKFLOW

Classic Machine Learning [1990 : now]

Input → Hand Designed **Features** → Model / Mapping → Output

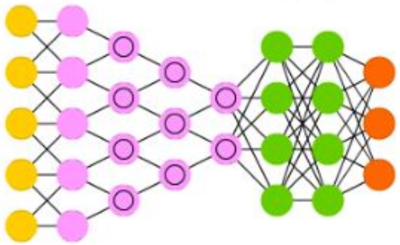
Examples [Regression and SVMs]



Deep/End-to-End Learning [2012 : now]

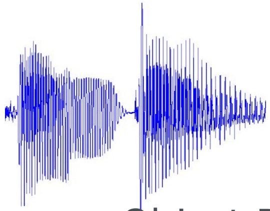
Input → Simple Features → Complex Features → Model/ Mapping → Output

Example [Conv Net]



ARCHITECTURE OF "MAINSTREAM" PATTERN RECOGNITION SYSTEMS

- Modern architecture for pattern recognition
  - Speech recognition: early 90's – 2011



MFCC → Mix of Gaussians → Classifier →

fixed | unsupervised | supervised

  - Object Recognition: 2006 - 2012

SIFT HoG → K-means Sparse Coding → Pooling → Classifier →

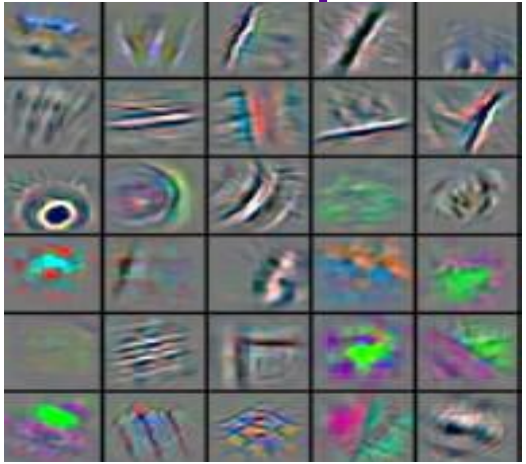
fixed | unsupervised | supervised

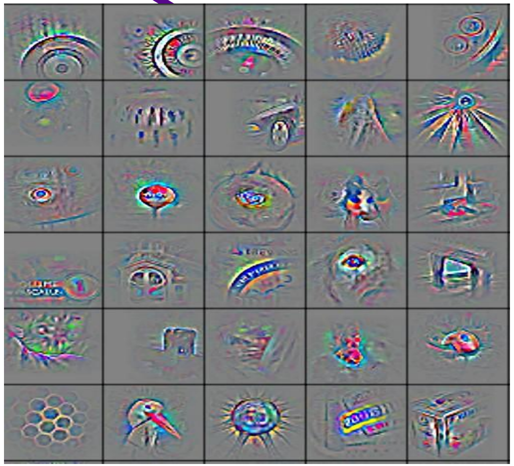
Low-level Features | Mid-level Features

DEEP LEARNING = LEARNING HIERARCHICAL REPRESENTATIONS

It's deep if it has more than one stage of non-linear feature transformation

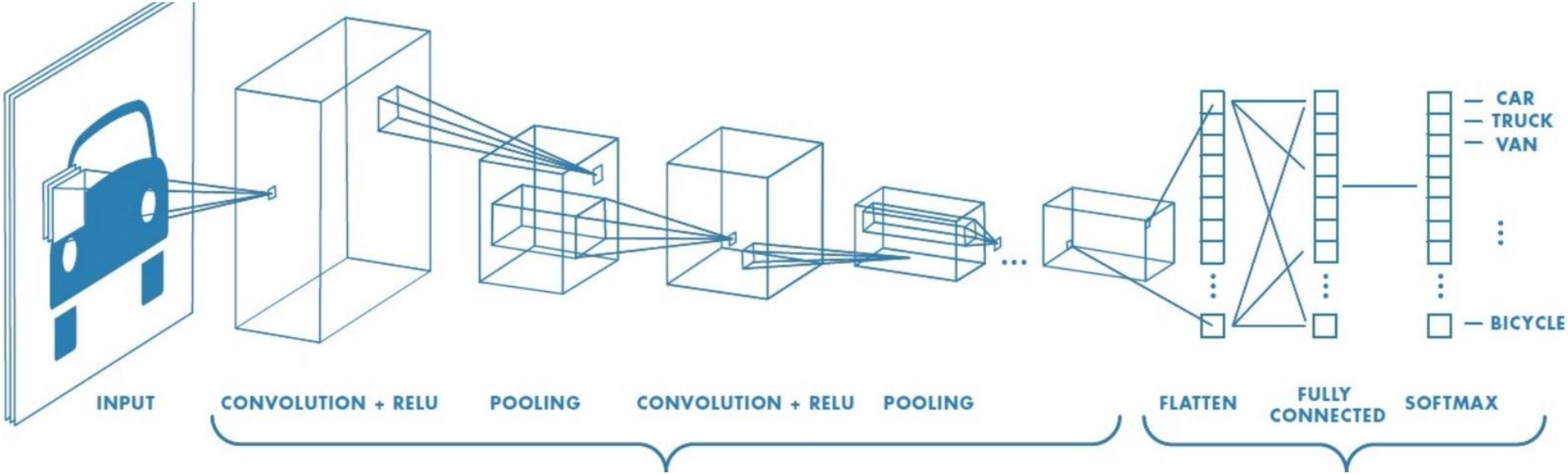
Low-level feature → Mid-level feature → High-level feature → Trainable classifier





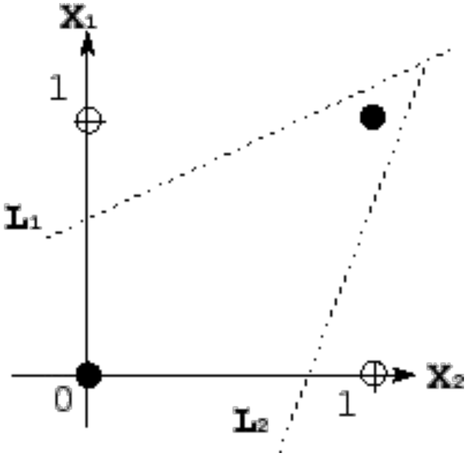
Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

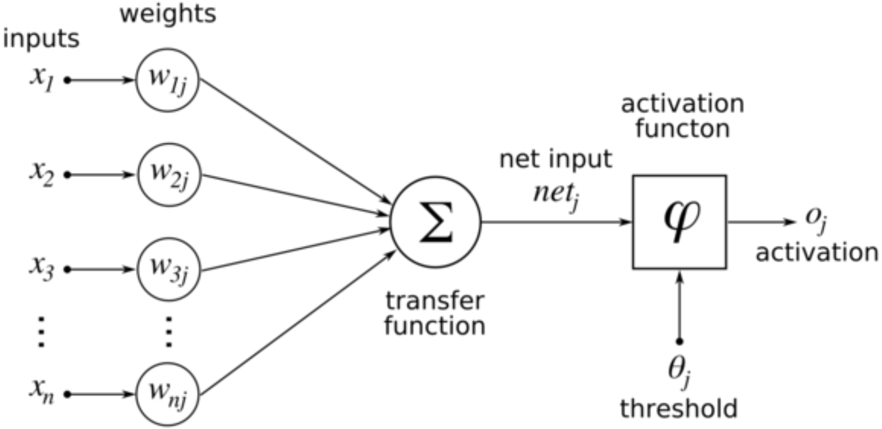
CONVOLUTIONAL NEURAL NETWORK (CNN)

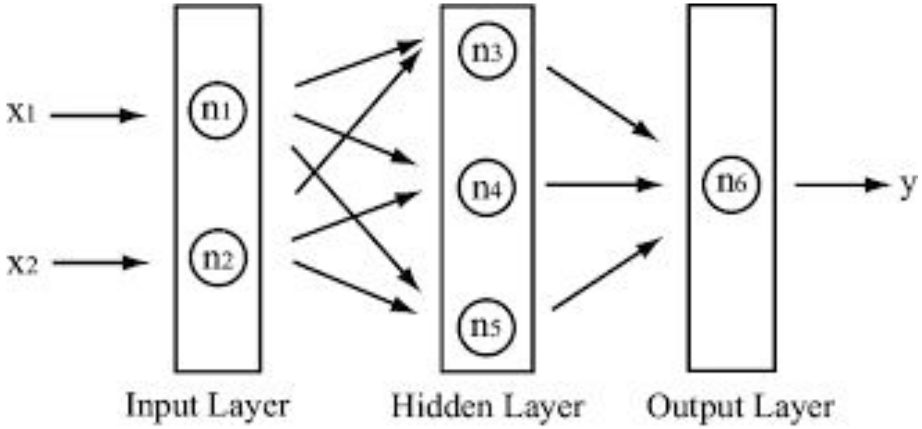


X_1	X_2	Y
0	0	0
0	1	1
1	0	1
1	1	0

$$Y = X_1 \oplus X_2$$

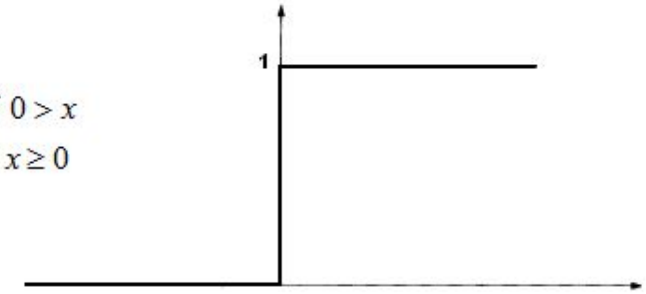






Unit step (threshold)

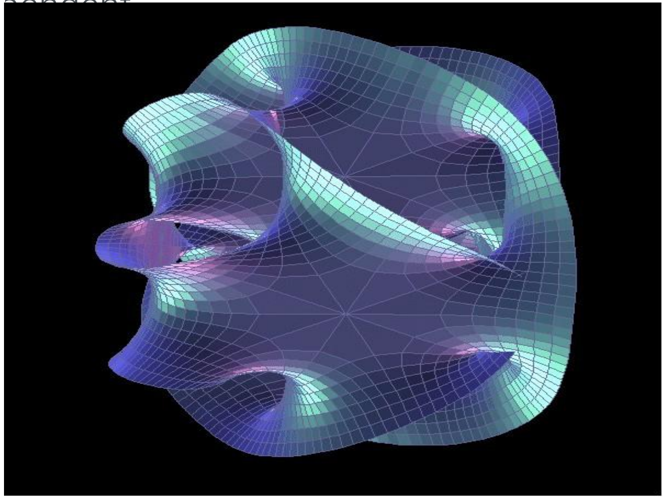
$$f(x) = \begin{cases} 0 \text{ if } 0 > x \\ 1 \text{ if } x \geq 0 \end{cases}$$



The manifold hypothesis

Discovering the hidden structure in high-dimensional data

- Learning representations of data:
    - Discovering & disentangling the independent explanatory factors
- The manifold hypothesis:
    - Natural data lives in a low-dimensional (non-linear) manifold



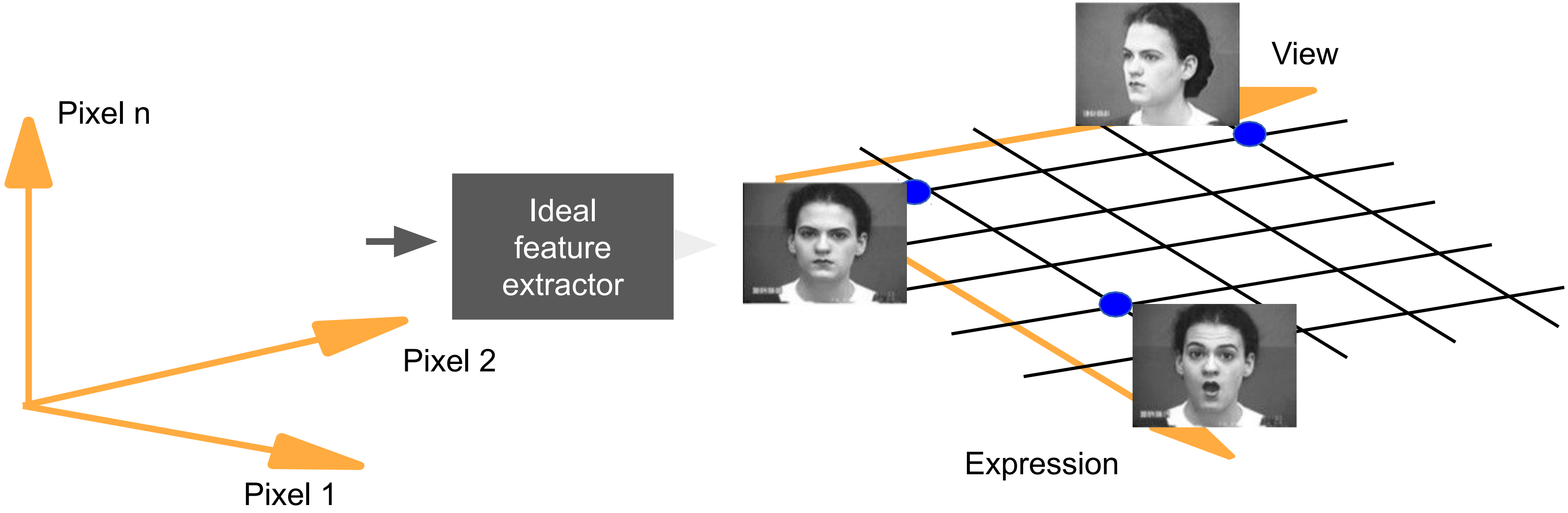
Discovering the hidden structure in high-dimensional data

- Example: all face images of a person
  - 1000x1000 pixels = 1,000,000 dimensions
  - But the face has 3 Cartesian coordinates and 3 Euler angles and humans have less than about 50 muscles in the face
  - Hence the manifold of face images for a person has <56 dimensions
- The perfect representations of a face image:
  - Its coordinates on the face manifold
  - Its coordinates away from the manifold
- We do not have good and general methods to learn functions that turns an image into this kind of representation

→ Ideal feature extractor →

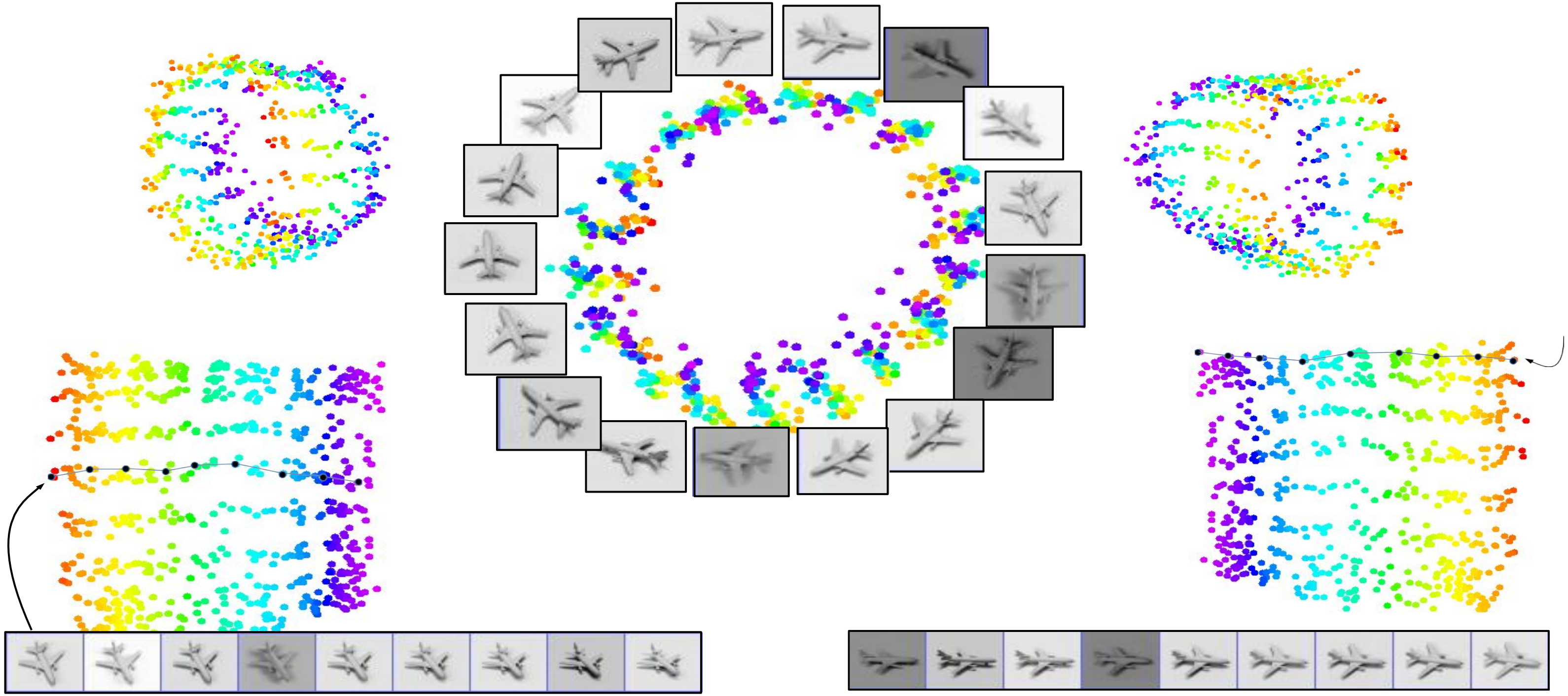
1.2	Face/not face
-3	Pose
0.2	Lighting
-2…	Expression

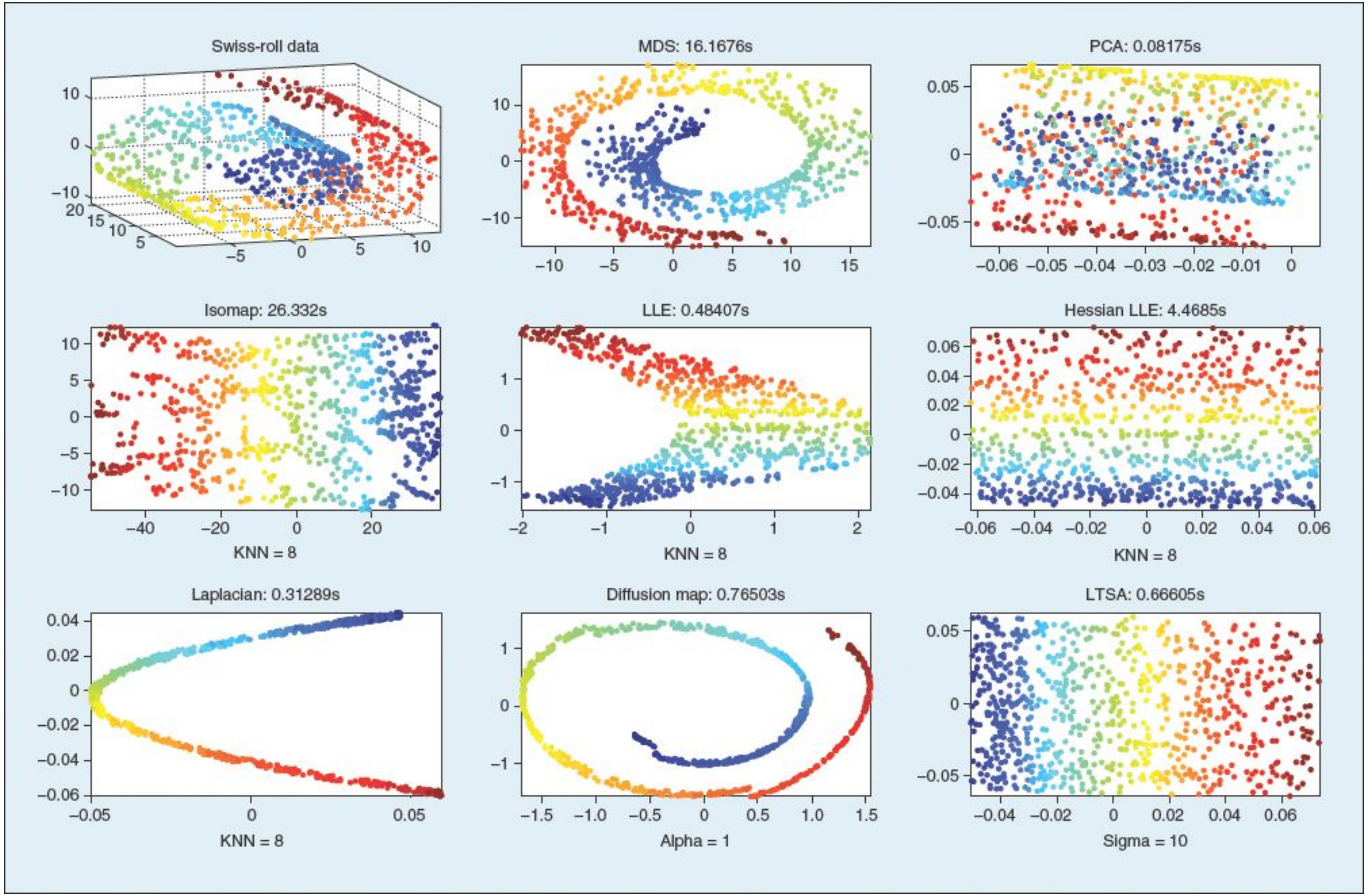
Disentangling factors of variation
The ideal disentangling feature extractor



Data manifold & invariance: Some variations must be eliminated

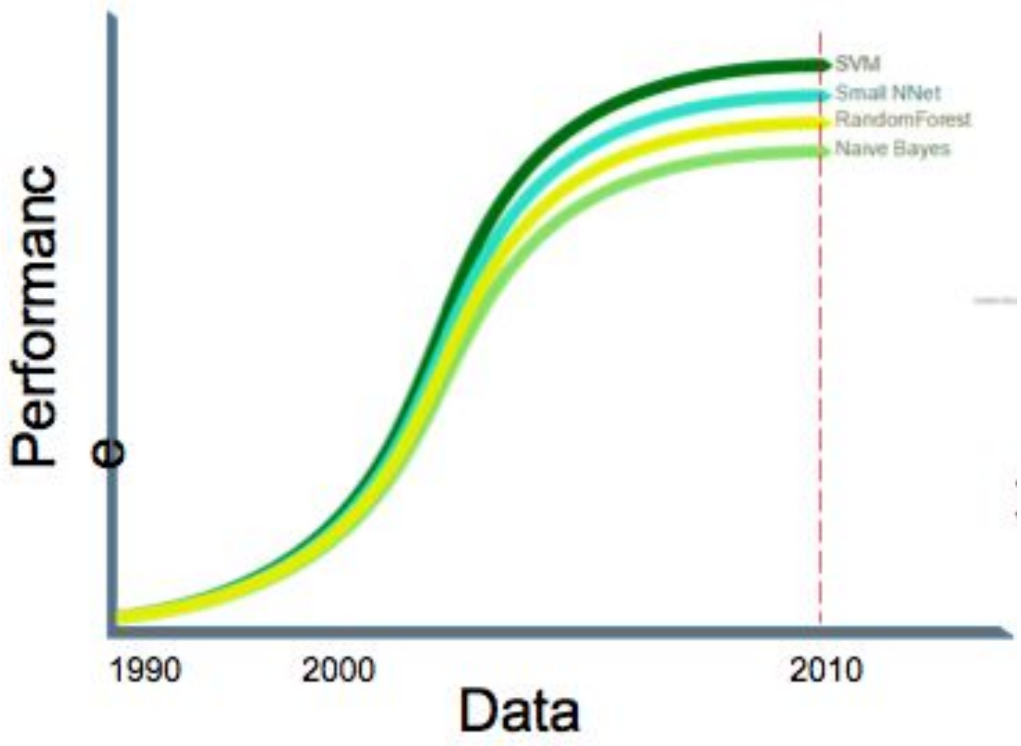
– Azimuth-Elevation manifold. Ignores lighting. [Hadsell et al. CVPR 2006]



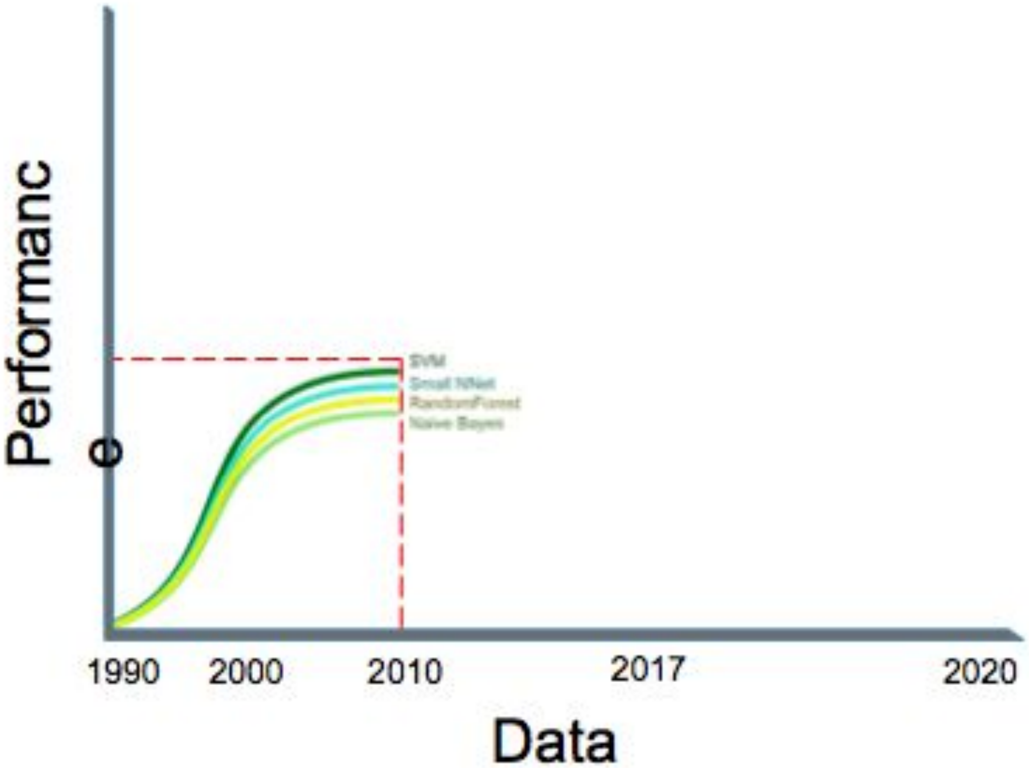


Swiss-roll data
MDS: 16.1676s
PCA: 0.08175s
Isomap: 26.332s
KNN = 8
LLE: 0.48407s
KNN = 8
Hessian LLE: 4.4685s
KNN = 8
Laplacian: 0.31289s
KNN = 8
Diffusion map: 0.76503s
Alpha = 1
LTSA: 0.66605s
Sigma = 10

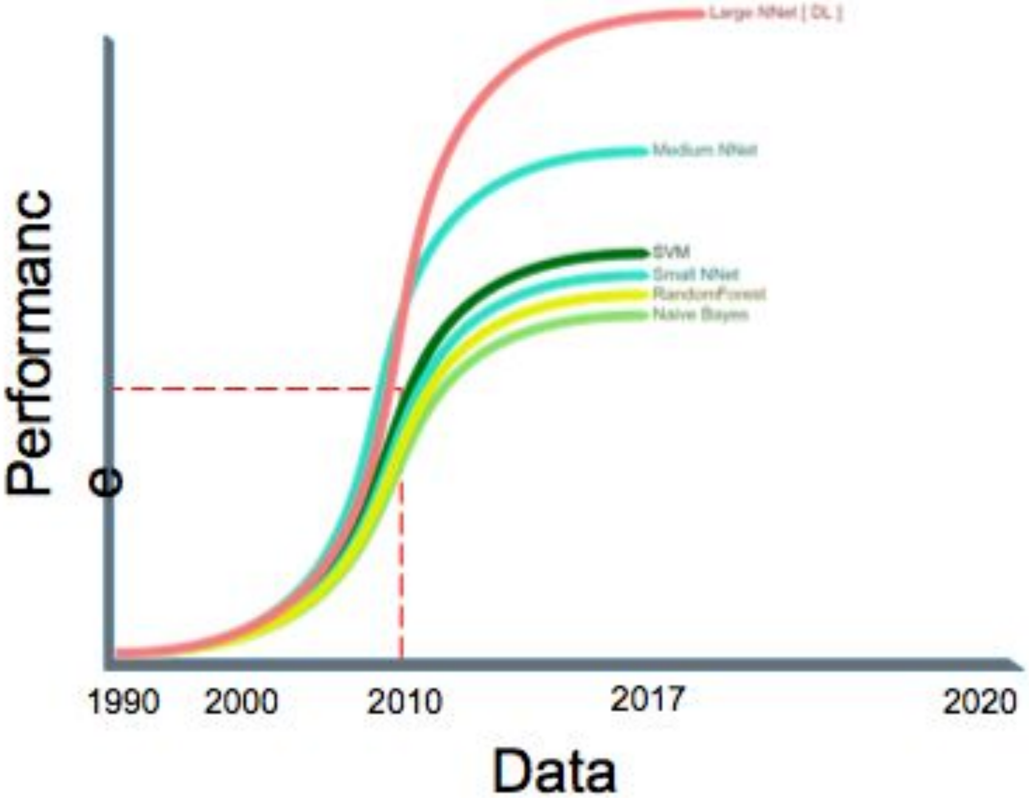
THE EXPONENTIAL GROWTH OF DATA



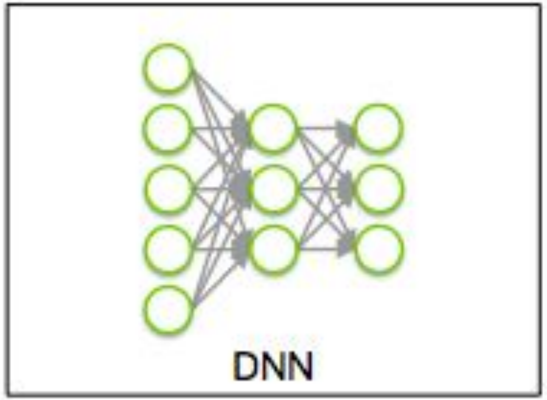
THE EXPONENTIAL GROWTH OF DATA



THE EXPONENTIAL GROWTH OF DATA



THE BIG BANG IN MACHINE LEARNING



WIRED

LARGE SCALE SUCCESS APPLICATION

- COMPUTER VISION
- NATURAL LANGUAGE PROCESSING
- GAMES
- REALISTIC REPRODUCTION

OPPORTUNITIES FOR ENERGY EFFICIENCY

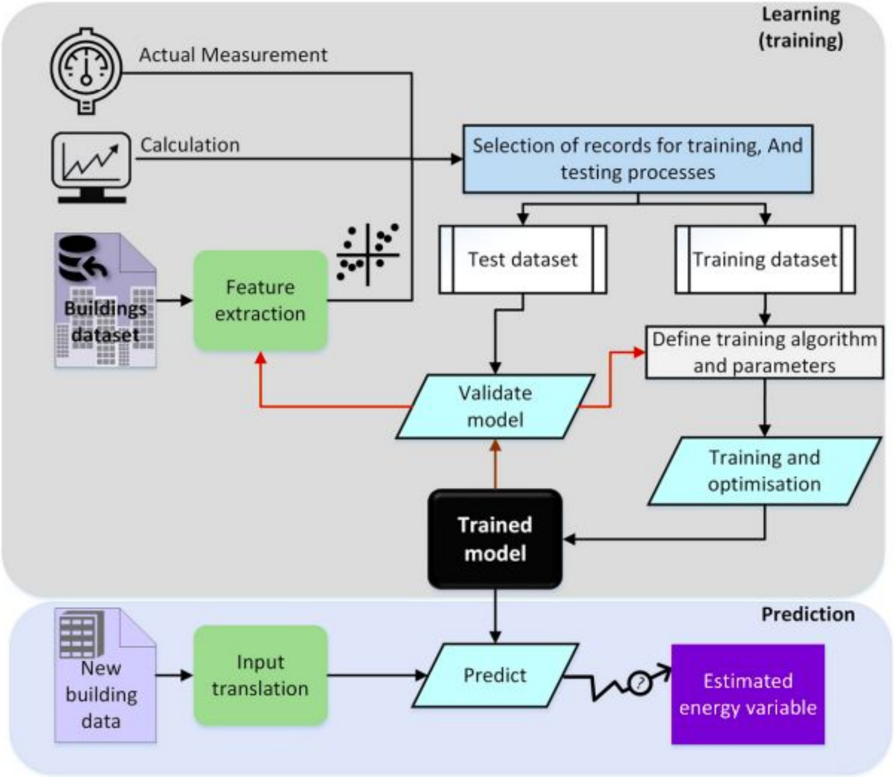
AI can help to:

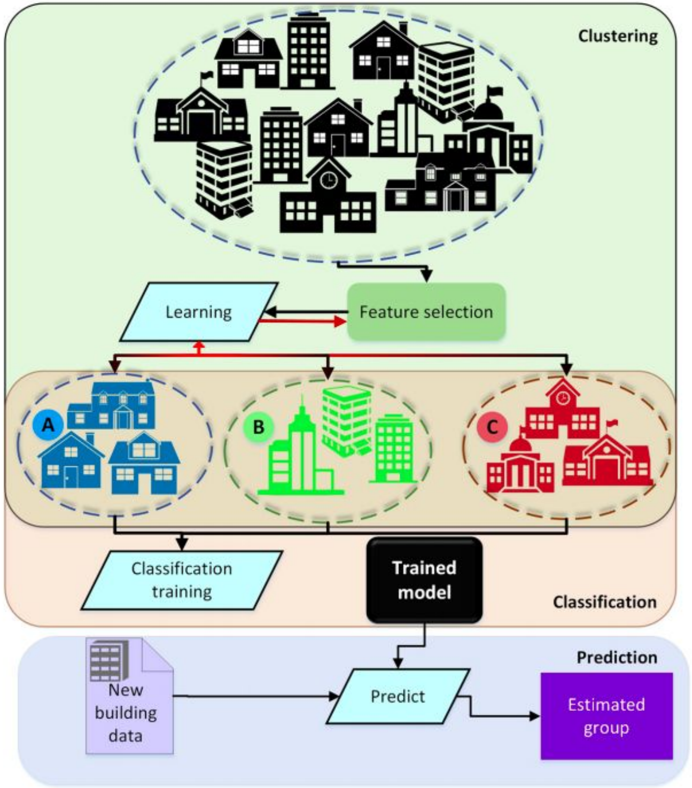
1. Efficiently monitor and analyse the energy consumption and conditions of a building
2. This identifies where improvements can be made for energy and costs savings
3. AI solutions can also optimise the indoor comfort and conditions

<u>Areas of application:</u>

- Building Diagnostics
  - Understanding the energy profile of buildings
- Building Design
  - Assisting the designer in making choices
- Building Supply
  - Optimization of the energy provisioning,
- Building Automation
  - Control of electrical, heating and other systems

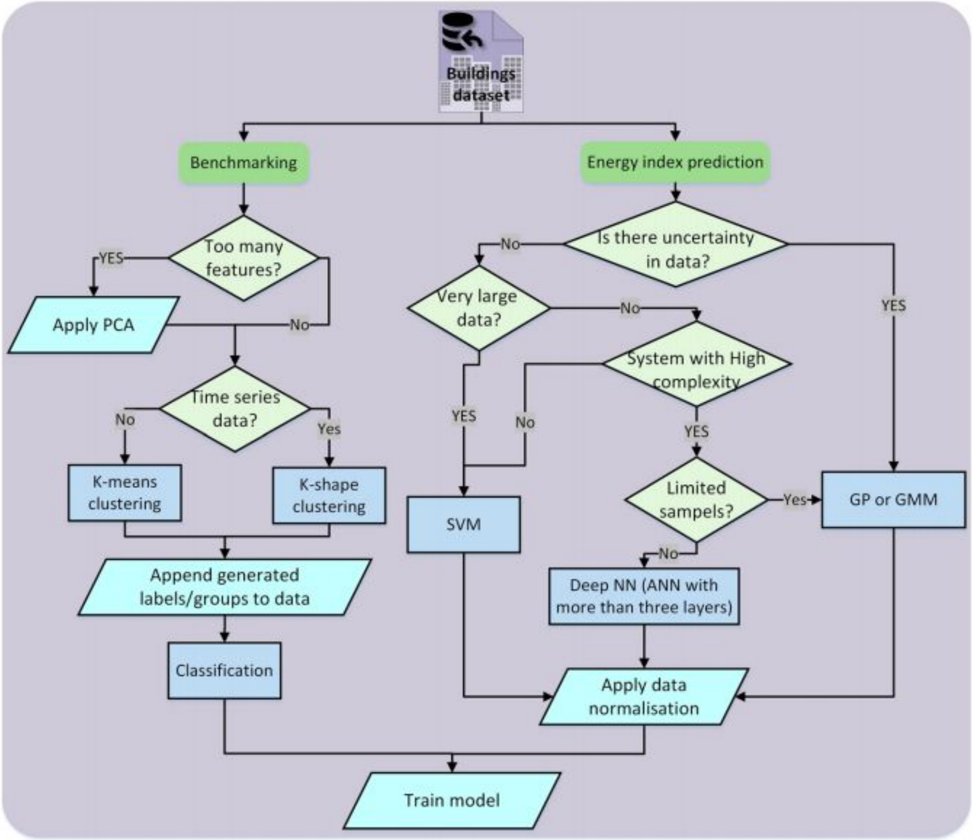
MODELS IN PRACTICE





Seyedzadeh, S., Rahimian, F., Glesk, I. et al. Machine learning for estimation of building energy consumption and performance: a review. Vis. in Eng. 6, 5 (2018). https://doi.org/10.1186/s40327-018-0064-7

APPLICATION



Seyedzadeh, S., Rahimian, F., Glesk, I. et al. Machine learning for estimation of building energy consumption and performance: a review. Vis. in Eng. 6, 5 (2018). https://doi.org/10.1186/s40327-018-0064-7

CHALLENGES

A MODERN ENTERPRISE HAS TO CONSIDER

- SKILLS
- STRATEGY
- ENVIRONMENT

SKILLS

AN AI SCIENTIST IS PROFICIENT IN:

- Data Science (***)
- Coding (**)
- IT Architecture (*)
- Domain (***)
- HPC (**)

AI ADOPTION IN DIFFERENT COUNTRIES BY INDUSTRY

EXHIBIT 2 | Across countries, technology companies are leaders in leveraging AI

Share of active players in AI by country/industry cluster

	China	USA	France	Germany	Switzerland	Austria	Japan	Total
Consumer	84%	41%	57%	39%	65%	32%	35%	50%
Energy	86%	73%	48%	50%	n.a.	67%	38%	67%
Financial services	86%	61%	45%	34%	67%	22%	42%	52%
Health care	83%	49%	51%	43%	38%	33%	23%	49%
Industrial	83%	49%	43%	60%	35%	44%	32%	55%
Technology, media, telecom	89%	65%	63%	64%	43%	67%	60%	71%
Total	85%	51%	49%	49%	46%	42%	39%	55%

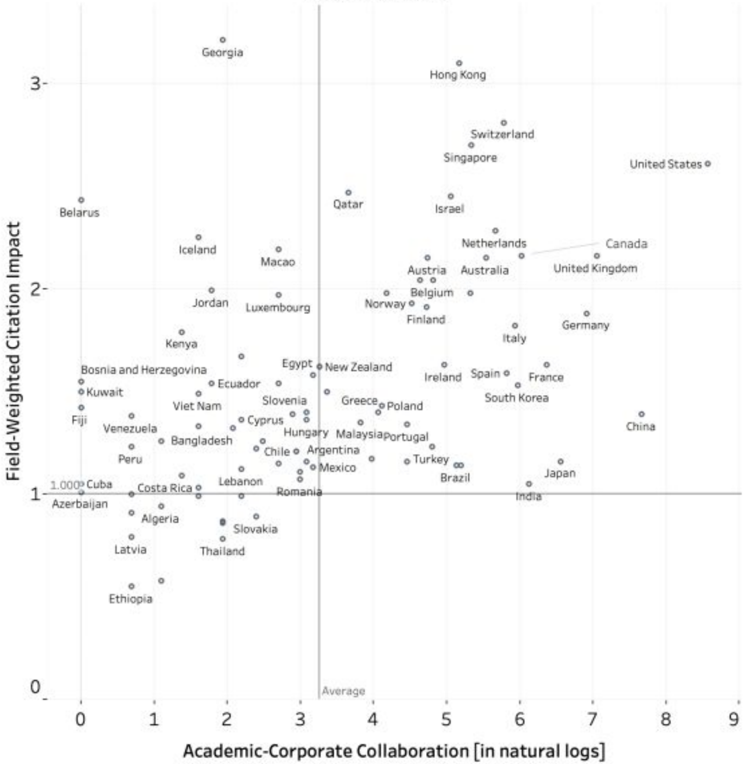
Note: Values denote the percentage share of active players in each country and/or industry. Colors highlight their relative positioning. "n.a." denotes clusters with insufficient survey statistics.[3]

https://www.forbes.com/sites/louiscolumbus/2018/12/16/how-china-is-dominating-artificial-intelligence/#7570f5a22b2f

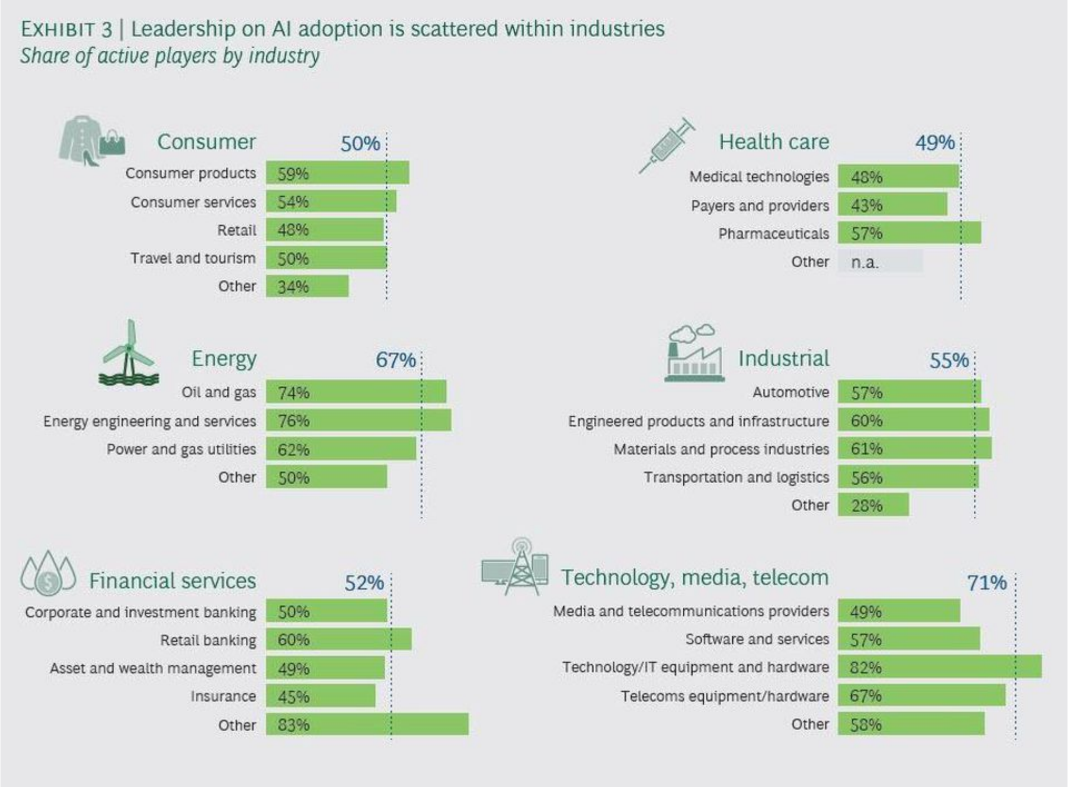
ENVIRONMENT

Four Quadrants for Overall AI Citation Impact (vertical axis) and the Total number of Academic-Corporate AI Papers (horizontal axisSource)

Source: Scopus, 2019.



AI ADOPTION BY INDUSTRY



https://www.forbes.com/sites/louiscolumbus/2018/12/16/how-china-is-dominating-artificial-intelligence/#7570f5a22b2f

Let's be inspired by nature, but not too much

- It's nice imitate Nature,
- But we also need to understand
  - How do we know which details are important?
  - Which details are merely the result of evolution, and the constraints of biochemistry?
- For airplanes, we developed aerodynamics and compressible fluid dynamics.
  - We figured that feathers and wing flapping weren't crucial
- QUESTION: What is the equivalent of aerodynamics for understanding intelligence?

L'Avion III de Clément Ader, 1897

(Musée du CNAM, Paris)

His Eole took off from the ground in 1890, 13 years before the Wright Brothers, but you probably never heard of it.

SCHOOLS OF THOUGHTS

Daniel Newman (Futurum) identifies 5 schools of thoughts concerning AI attitude:

- Utopian Thought
- Dystopian Thought
- Tech-Optimistic Thought
- The Realist Thought
- Lack of Productivity Thought

https://www.forbes.com/sites/danielnewman/2018/02/27/there-are-5-schools-of-thought-on-ai-which-one-are-you-in/#2a7669617368

WHAT I WOULD LIKE BY AI SYSTEMS

- ACCOUNTABILITY
- TRANSPARENCY
- TESTABILITY
- RELIABILITY
- SAFETY

"Assuming the computer industry can keep producing better hardware, I think 'business as usual' is going to take us a long way. Obviously, if we get big conceptual breakthroughs, it'll take us further. I think one of the big breakthroughs that's going to come is we're going to understand the brain."

Geoffrey Hinton (2016)

https://www.linkedin.com/in/**luigitroiano**/

THANK YOU