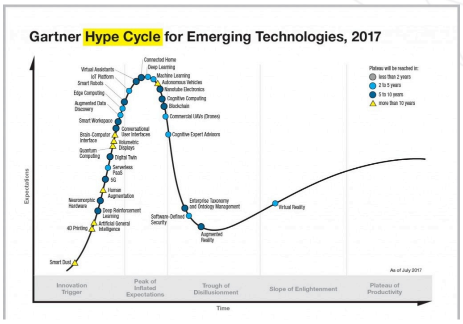
AI in Medicine: Where are we now?

Niels Peek
Health eResearch Centre
School of Health Sciences
The University of Manchester

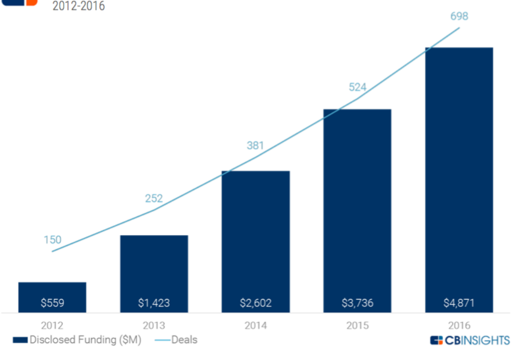
Cyclops workshop, Nottingham, 11th January 2018

Gartner Hype Cycle 2017: Artificial intelligence at peak hype, blockchain heads for disillusionment, but say hello to 5G

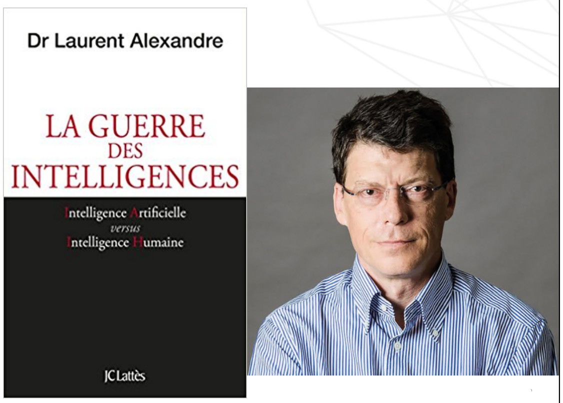


ARTIFICIAL INTELLIGENCE: ANNUAL FUNDING HISTORY

2012-2016



Dr Laurent Alexandre

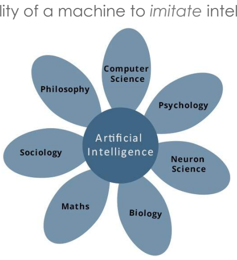


Definition of Artificial Intelligence

Merriam-Webster

1 : a branch of computer science dealing with the *simulation* of intelligent behaviour in computers

2 : the capability of a machine to *imitate* intelligent human behaviour



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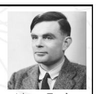
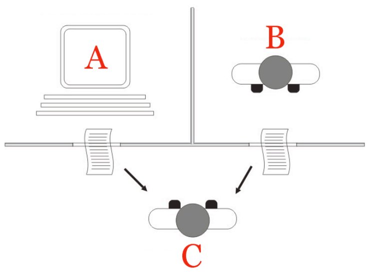
Turing test



Alan Turing
1912-1954



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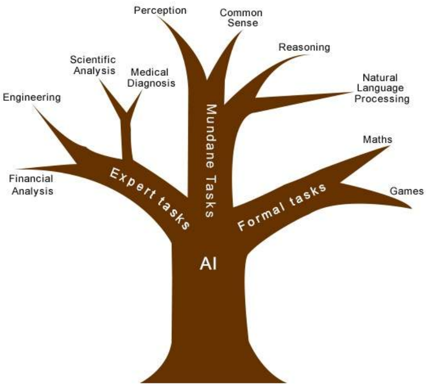

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A fundamental question

or:

Friedman CP JAMIA 2009;16(2):169-170

Menu

1. What is Artificial Intelligence?
2. History of AI in Medicine
3. Machine Learning
4. Where are we now?

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3 July 1959, Volume 130, Number 3366 **SCIENCE**

Reasoning Foundations of Medical Diagnosis

Symbolic logic, probability, and value theory aid our understanding of how physicians reason.

Robert S. Ledley and Lee B. Lusted

Towards the Simulation of Clinical Cognition

Taking a Present Illness by Computer

STEPHEN G. PAUKER, M.D.
G. ANTHONY GORRY, Ph.D.
JEROME P. KASSIRER, M.D.
WILLIAM B. SCHWARTZ, M.D.
Boston, Massachusetts

NAME: NEPHROTIC SYNDROME
IS-A-TYPE-OF: CLINICAL STATE
FINDING: LOW SERUM ALBUMIN CONCENTRATION
FINDING: HEAVY PROTEINURIA
FINDING: >5GRAMS/24HRS PROTEINURIA
FINDING: MASSIVE, SYMMETRICAL EDEMA
FINDING: EITHER FACIAL OR PERI-ORBITAL, AND SYMMETRICAL EDEMA
FINDING: HIGH SERUM CHOLESTEROL CONCENTRATION
FINDING: URINE LIPIDS PRESENT
MUST-NOT-HAVE:
PROTEINURIA ABSENT
IS-SUFFICIENT:
BOTH MASSIVE EDEMA AND >5GRAMS/24HRS PROTEINURIA
MAJOR-SCORING:
SERUM ALBUMIN CONCENTRATION
LOW: 1.0
HIGH: -1.0
PROTEINURIA:
>5GRAMS/24HRS: 1.0
HEAVY: 0.5
EITHER ABSENT OR LIGHT: -1.0
EDEMA:
MASSIVE AND SYMMETRICAL: 1.0
NOT MASSIVE BUT SYMMETRICAL: 0.3
ERYTHEMATOUS: -0.2
ASYMMETRICAL: -0.5
ABSENT: -1.0
MINOR-SCORING:
SERUM CHOLESTEROL CONCENTRATION:
HIGH: 1.0
NOT HIGH: -1.0
URINE LIPIDS:

Rule-based expert systems

```
STATUS RULE: STABLE HEMODYNAMICS
IF
   HEART RATE is ACCEPTABLE
   PULSE RATE does NOT CHANGE by 20 beats/min. in 15 min.
   MEAN ART BL PRESS is ACCEPTABLE
   MEAN ART BL PRESS does NOT CHANGE by 15 torr in 15 min.
   SYST BL PRESS is ACCEPTABLE
THEN
   the HEMODYNAMICS are STABLE
```

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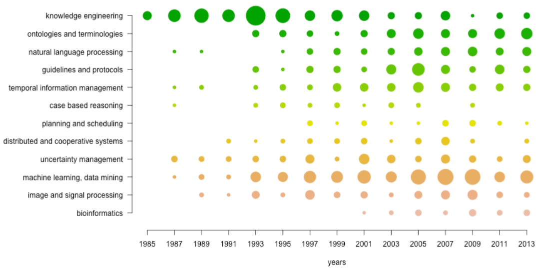
AI in Medicine conferences



http://aimedicine.info/aime/index.php/aime-conferences

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Machine Learning

A field of computer science that gives computers the ability to learn without being explicitly programmed

It can be easier to train a system by showing it examples of desired input-output behaviour than to program it manually

Recent progress in machine learning has been driven by
- development of new learning theory and algorithms
- the ongoing explosion in availability of data
- low-cost computation

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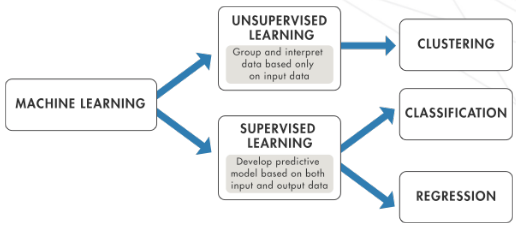

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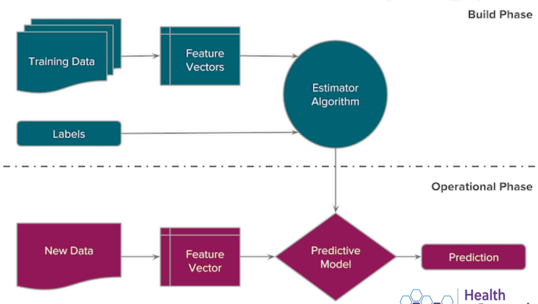
Supervised learning



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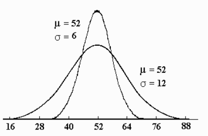
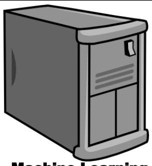
Machine Learning	Statistics
network, graphs	model
focus on prediction	focus on inference
weights	parameters
learning	fitting
generalization	test set performance
supervised learning	regression/classification
unsupervised learning	density estimation, clustering
large grant = $1,000,000	large grant = $50,000
nice place to have a meeting: Snowbird, Utah, French Alps	nice place to have a meeting: Las Vegas in August

http://statweb.stanford.edu/~tibs/stat315a/



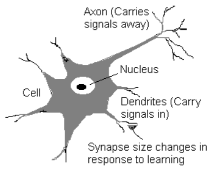


Statistics ⟷ **Machine Learning**

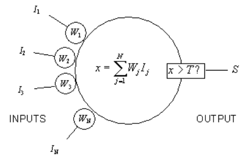
T-Test
Logistic Regression
Elastic Net
Gradient Boosting
Deep Learning

From a presentation by Tom Liptrot

The artificial neuron

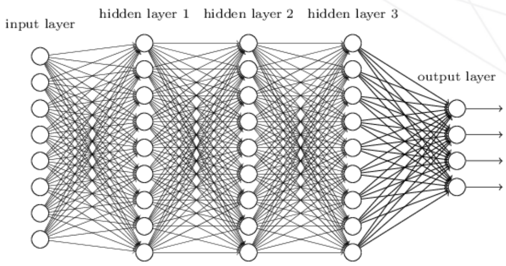


Valentin, 1836



McCulloch & Pitts, 1943

Deep neural networks



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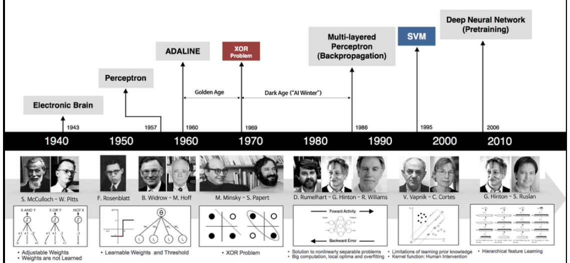
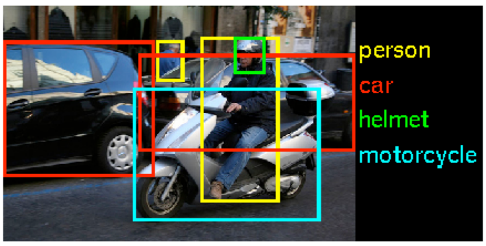
Deep learning history



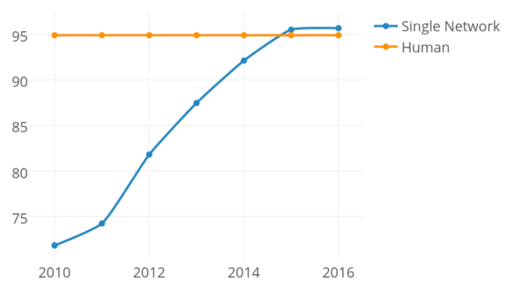
https://beamandrew.github.io/deeplearning/2017/02/23/deep_learning_101_part1.html

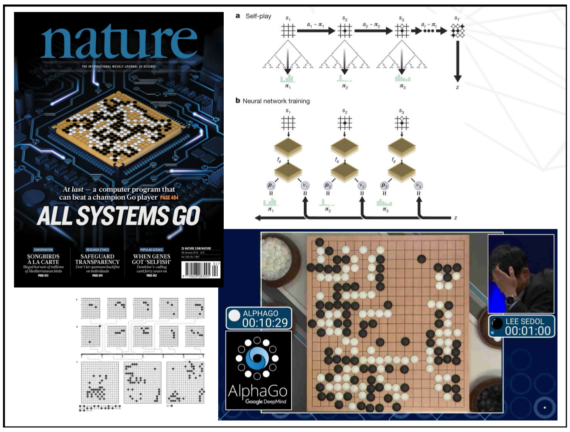
ImageNet Large Scale Visual Recognition Challenge

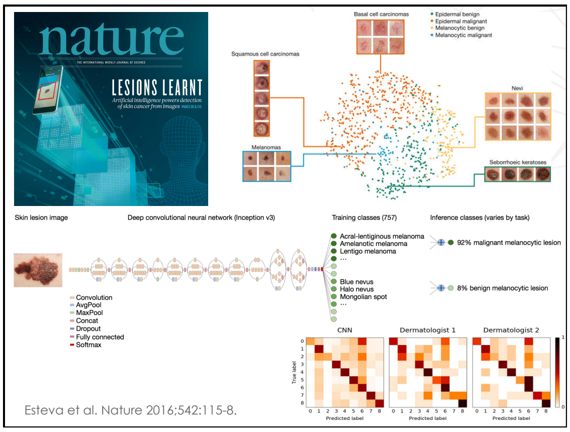


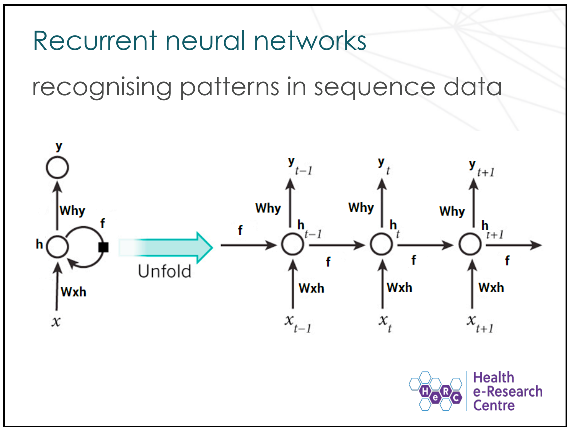
Farr

ImageNet Large Scale Visual Recognition Challenge Accuracy




nature
At last — a computer program that can beat a champion Go player
ALL SYSTEMS GO
a Self-play
b Neural network training
ALPHAGO 00:10:29
LEE SEDOL 00:01:00
AlphaGo


nature
LESIONS LEARNT
Skin lesion image
Deep convolutional neural network (Inception v3)
Training classes (757)
Inference classes (varies by task)
Convolution
AvgPool
MaxPool
Concat
Dropout
Fully connected
Softmax
92% malignant melanocytic lesion
8% benign melanocytic lesion
CNN
Dermatologist 1
Dermatologist 2
Esteva et al. Nature 2016;542:115-8.


Recurrent neural networks
recognising patterns in sequence data
Unfold
Why
Wxh
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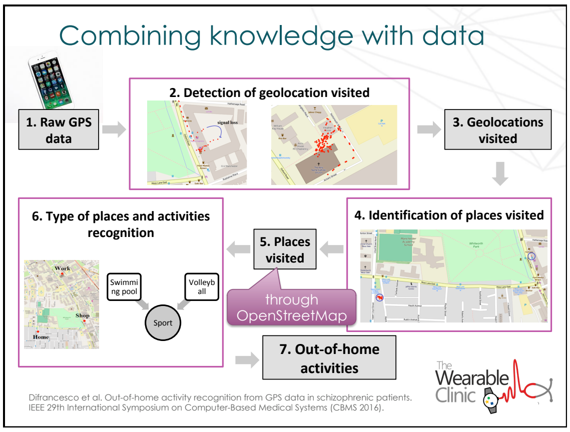
Combining knowledge with data
1. Raw GPS data
2. Detection of geolocation visited
3. Geolocations visited
4. Identification of places visited
5. Places visited
through OpenStreetMap
6. Type of places and activities recognition
7. Out-of-home activities
Work
Shop
Home
Swimming pool
Volleyball
Sport
The Wearable Clinic
Difrancesco et al. Out-of-home activity recognition from GPS data in schizophrenic patients. IEEE 29th International Symposium on Computer-Based Medical Systems (CBMS 2016).


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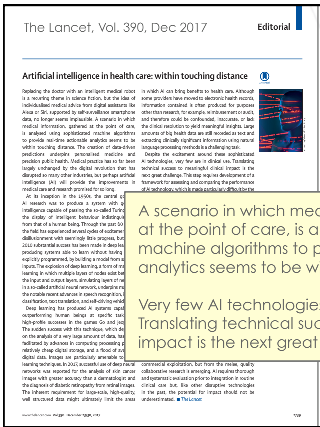
THE Sun
FOOTBALL SPORT TV & SHOWBIZ NEWS FABULOUS MONEY MOTORS TRAVEL TECH DEAR DEIDRE
All News UK News US News World News Politics Opinion Health News
DOCTOR WON'T SEE YOU SOON
Computers will replace doctors in just ten years, says Health Secretary Jeremy Hunt
Jeremy Hunt predicts patients will be diagnosed by machines by the time the NHS is 80 in 2028
By Shaun Wooller
MOST POPULAR
SNAPPER EXPOSED Seedy Terry Richardson 'makes Harvey Weinstein look like Bambi'

The Lancet, Vol. 390, Dec 2017



A scenario in which medical information, gathered at the point of care, is analyzed using sophisticated machine algorithms to provide real-time actionable analytics seems to be within touching distance

Very few AI technologies are already in clinical use. Translating technical success to meaningful clinical impact is the next great challenge

First and last mile problems

Enrico Coiera

The "first mile" problem
Without data and expert humans to train Machine Learning models, we have a production bottleneck that limits the rate of expansion of AI systems.

The "last mile" problem
An algorithm doesn't do anything on its own. Connecting it to the real world (e.g. delivering health care) is harder than building it in the first place.

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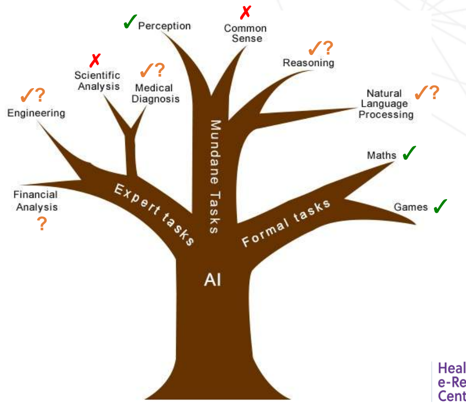

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Summary

- There is a long history of AI in medicine
- Recurring question is relationship between human and machine (+) >
- Few AI systems are in clinical use
- Important breakthroughs in machine learning during the last decade
- Extreme reliance on data unlikely to work
- First and last mile problems often overlooked

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Thank you

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