Big Data, Analytics and AI for Health: A Short History

John Crawford
Digital Health Consultant, UK

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Declaration of interests

European Society of Cardiology (Digital Health Committee)

Eriksholm Research Centre (Scientific Advisory Board)

HIMSS (International Advisory Group)

Royal Free Foundation (Committee on the Future of the NHS)

National Centre for Universities and Business (Task force - Digital Health and Care)

Alzheimers Research UK (Task force - Early Detection of Neurological Disease)

University of Edinburgh School of Medicine (Global Public Health – occasional lectures)

‘Big Data’ for health in the 1850’s – Mortality data registers

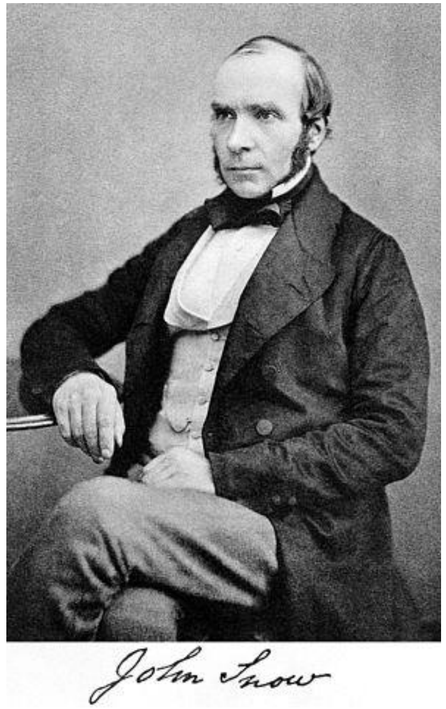
William Farr

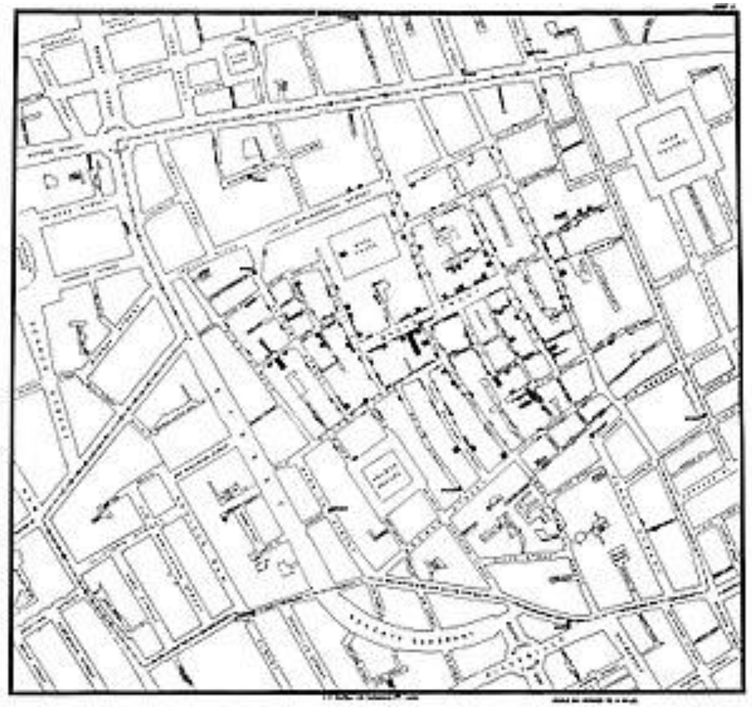
- In 1849, an outbreak of cholera in London killed 15,000 people – the way it spread was not understood – the most commonly held idea was ‘miasma theory’
- In 1852 William Farr compiled a mortality dataset, using statistical methods to test 8 explanatory variables
- Based on this, he concluded that elevation above the river Thames was was the most important factor

‘The science of epidemiology, that Farr helped to found, has continued to advance. Had logistic regression been available to Farr, its application to his 1852 data set would have changed his conclusion’. (1)

1 - John Snow, William Farr and the 1849 outbreak of cholera that affected London: a reworking of the data highlights the importance of the water supply. Bingham P[1], Verlander NQ, Cheal MJ - Public Health. 2004 Sep;118(6):387-94.

‘Big Data’ for health in the 1850’s – Mapping cholera outbreaks





- Following the 1854 cholera outbreak in London, John Snow used dot maps to visualise the spread of cholera across Soho (a Voronoi diagram)
- This indicated that cholera was transmitted through water, and pointed to a single water pump as the primary source

- This helped to disproved the ‘miasma theory’ of disease transmission in favour of the ‘germ theory’ of disease

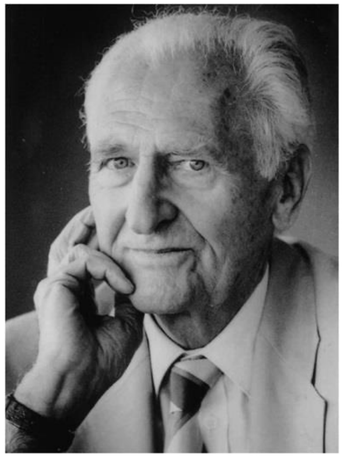
‘Big Data’ in the 1950’s - Statistical analysis of health outcomes

- 1952 – Sir Austin Bradford Hill, Richard Doll

  Randomised control clinical trials
  Case-control studies
  Retrospective & prospective cohort studies

Smoking as a risk factor in lung cancer (1952-2000)

Similar endeavours – Framingham Heart Study, Nurses Health Study, Cochrane Collaboration




Garry Kasparov vs IBM Deep Blue
11 May 1997

Mainstream press confirms that AI is a key disruptive force in healthcare today

Artificial Intelligence Will Redesign Healthcare

- Medical Futurist[1]

Big wave of artificial intelligence and machine learning coming to healthcare, University Hospitals of Cleveland CEO says *- Healthcare IT News[2]*

Artificial intelligence and the coming health revolution

- Phys.org[3]

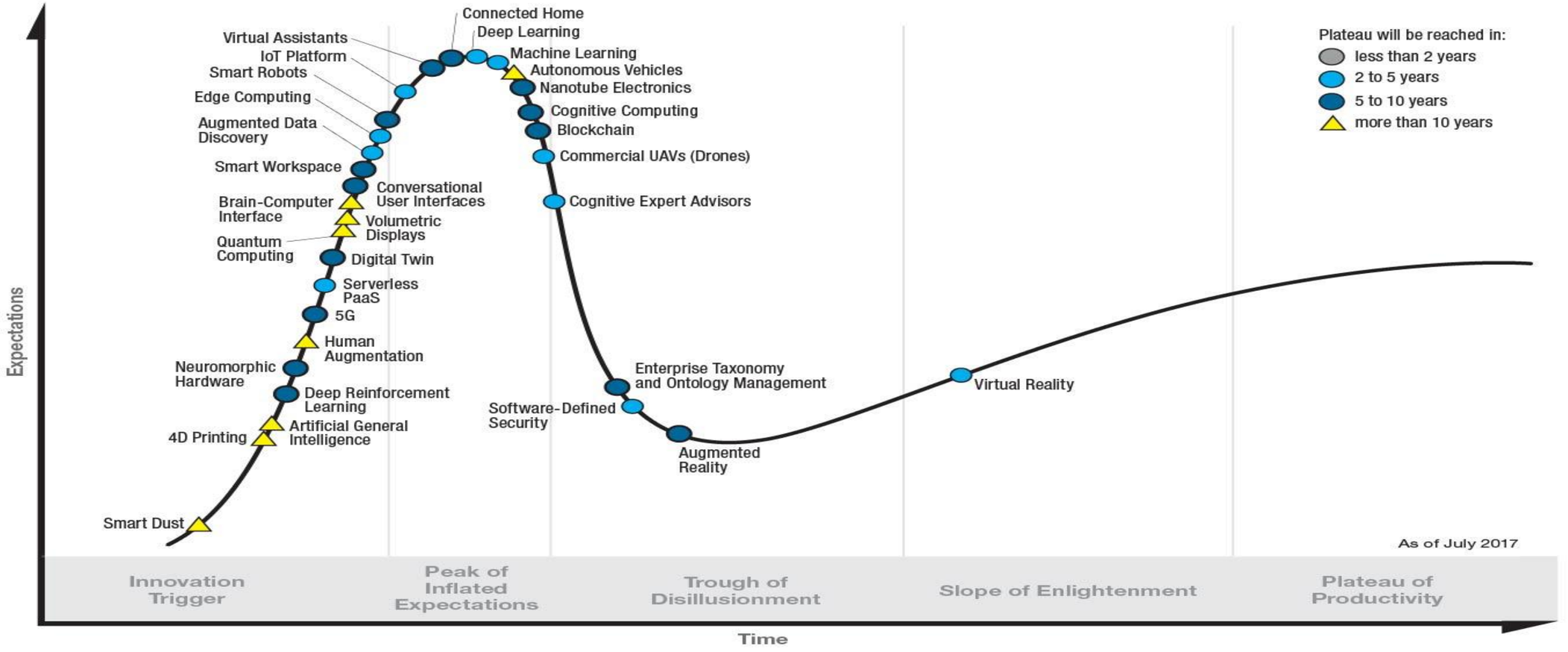
How AI is transforming healthcare and solving problems in 2017 *- Healthcare IT News[4]*

Artificial intelligence takes on medical imaging

- Modern Healthcare[5]

[1] http://medicalfuturist.com/artificial-intelligence-will-redesign-healthcare/
[2] http://www.healthcareitnews.com/news/big-wave-artificial-intelligence-and-machine-learning-coming-healthcare-university-hospitals
[3] https://phys.org/news/2017-06-artificial-intelligence-health-revolution.html
[4] http://www.healthcareitnews.com/slideshow/how-ai-transforming-healthcare-and-solving-problems-2017?page=1
[5] http://www.modernhealthcare.com/article/20170708/TRANSFORMATION03/170709944

Gartner Hype Cycle for Emerging Technologies, 2017



gartner.com/SmarterWithGartner

Source: Gartner (July 2017)

Gartner

Artificial Intelligence (AI) is powered by Algorithms

Categories of algorithms:

- Prioritisation: Making an ordered list (Google Search, Netflix, Deep Blue)
- Classification: Picking a category (Facebook, YouTube, advertising etc)
- Association: Finding links (Amazon, Spotify, OKCupid etc)
- Filtering: Isolating what's important (Siri, Alexa, Cortana, Twitter etc)

Paradigms for creation of algorithms:

- Rule-based algorithms – Instructions constructed by humans

- Machine-learning algorithms – Inspired by how living creatures learn

Taken from 'Hello World – How to be Human in the Age of the Machine' by Hannah Fry, Transworld Publishers, 2018 – ISBN 9780857525246

In 2015, scientists gave 16 novice testers a touch screen monitor sho
wing pathology and radiology images of breast tissue.

After a short training period they were asked to identify cancerous
tissues from the images.

The results were impressive.

Pigeons (Columba livia) as trainable observers of pathology and radiology breast cancer images

Individual performance up to 85% accuracy

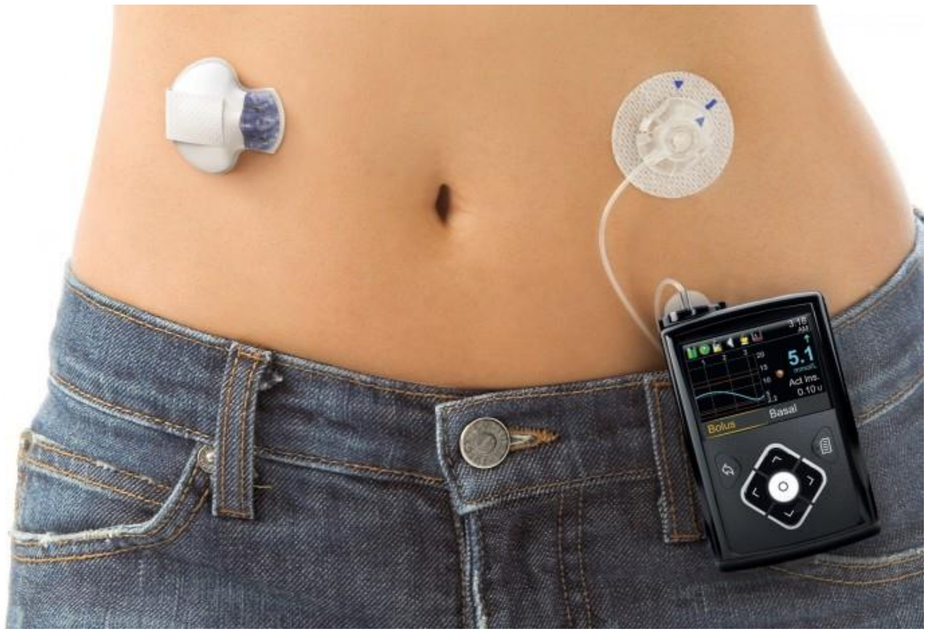
Pooled performance (ensemble method) 99% accuracy

Levenson et al, published: November 18, 2015 https://doi.org/10.1371/journal.pone.0141357

Algorithms to detect heart arrhythmias: Alivecor KardiaMobile

1-lead ECG using algorithms on smartphone to detect Atrial Fibrillation in 30 seconds and capture ECG trace

First ‘artificial pancreas’: Medtronic Minimed 670G (launched 2017)



Continuous glucose monitoring and connected automated insulin pump

‘Bionic pancreas’:
Beta Bionics iLet (FDA trials began May 2018)

Continuous glucose monitoring, dual insulin/glucagon pump and machine learning algorithms

Ken Jennings vs Watson vs Brad Rutter, Jeopardy, 13-14 February 2011

It begins with the power of Watson

- Understands, reasons, learns and interacts
- Extracts and derives meaning from structured and unstructured content – at scale
- Provides analyses across vast arrays of criteria to transform decision-making
- Dynamically updates hypotheses based on variable chains of evidence
- Harnesses entire bodies of knowledge

Google Deepmind: AlphaGo Zero (19/10/17)

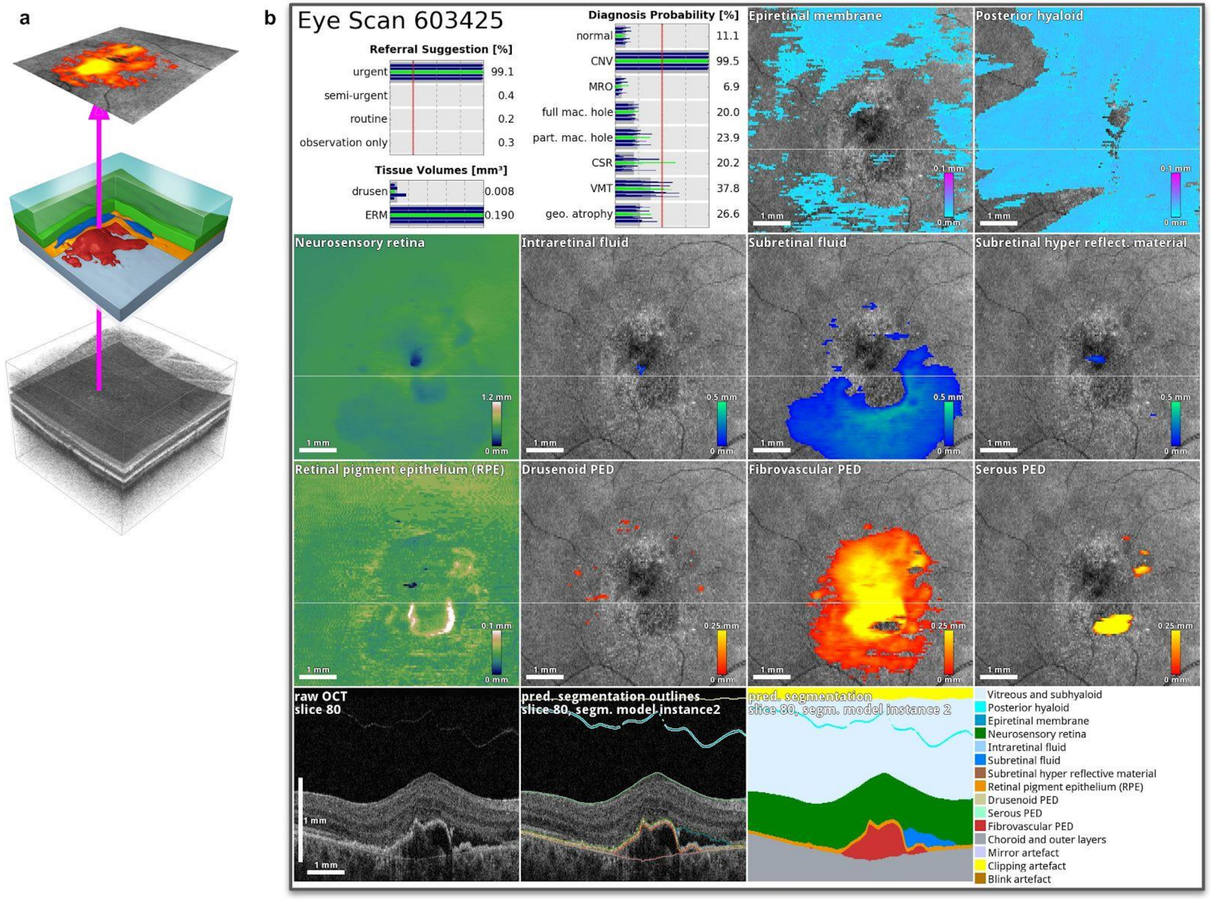
Previous versions of AlphaGo initially trained on thousands of human amateur and professional games to learn how to play Go. AlphaGo Zero skips this step and learns to play simply by playing games against itself, starting from completely random play. In doing so, it quickly surpassed human level of play and defeated the previously published champion-defeating version of AlphaGo by 100 games to 0.

It is able to do this by using a novel form of reinforcement learning, in which AlphaGo Zero becomes its own teacher.

This technique is more powerful than previous versions of AlphaGo because it is no longer constrained by the limits of human knowledge. Instead, it is able to learn tabula rasa from the strongest player in the world: AlphaGo itself.

https://deepmind.com/blog/alphago-zero-learning-scratch/

Google Deepmind: Clinically applicable deep learning for diagnosis and referral in retinal disease (13/8/18)



Here, we apply a novel deep learning architecture to a clinically heterogeneous set of three-dimensional optical coherence tomography scans from patients referred to a major eye hospital. We demonstrate performance in making a referral recommendation that reaches or exceeds that of experts on a range of sight-threatening retinal diseases after training on only 14,884 scans.

https://deepmind.com/research/publications/clinically-applicable-diagnosis-and-referral-retinal-disease/

Many issues are raised by AI

- Privacy – how can we protect ourselves from exploitation and prejudice
- Safety and efficacy – do we need stronger regulation of AI algorithms?
- Transparency – can we really trust AI systems to be unbiased?
- Legal – can we hold algorithms (and the companies behind them) to account?

Centaur Chess (Advanced Chess) – Not ‘Man versus Machine’ but ‘Man Plus Machine’

Garry Kasparov 2007