Day 1: Overview and Introduction to Data Science

ME314: Introduction to Data Science and Big Data Analytics
LSE Methods Summer Programme
30 July 2018

Emerging trends

Technologies

Computing paradigm shifts

From calculation to delegation to personalisation

Big changes…

St Peter's Square 2005

In too little a time…

St Peter's Square 2013

Concept of Data Science

Data Scientist:

The Sexiest Job of the 21st Century

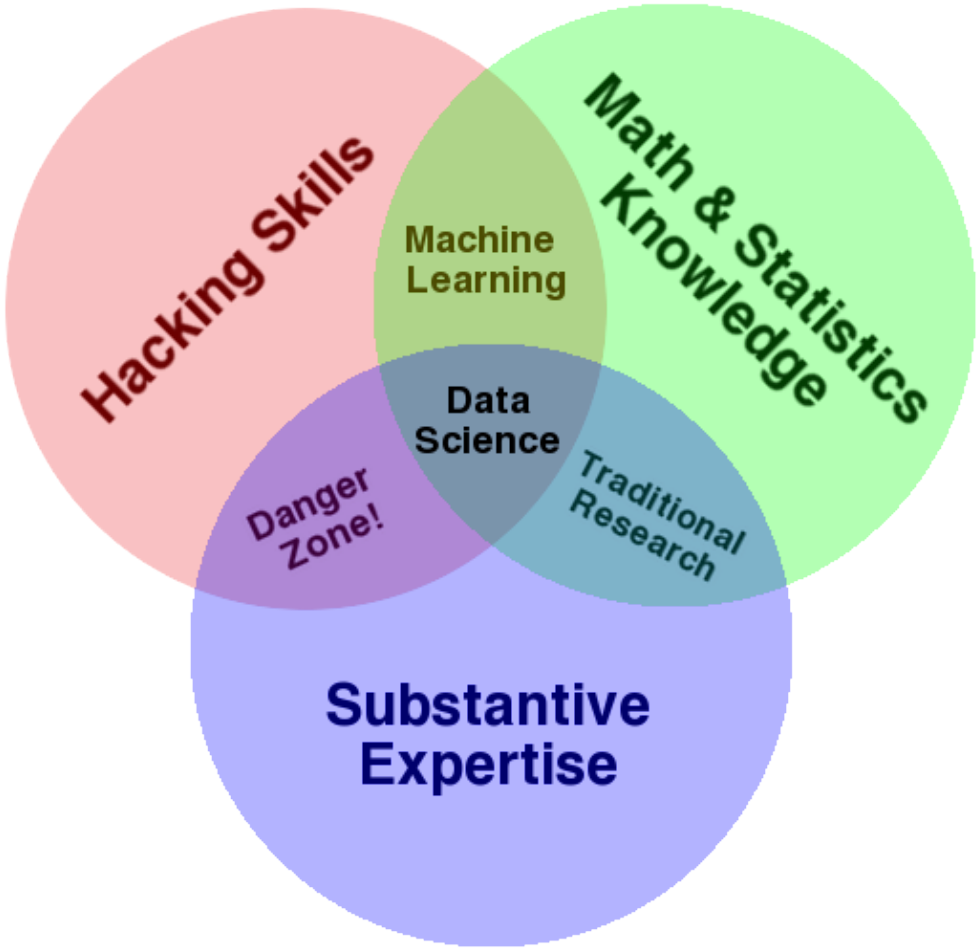
Meet the people who can coax treasure out of messy, unstructured data.

by Thomas H. Davenport and D.J. Patil

W

`I keep saying the sexy job in the next ten years will be statisticians. People think I'm joking, but who would've guessed that computer engineers would've been the sexy job of the 1990s?'' Hal Varian (Chief Economist at Google, 2009).

What is Data Science?



Drew Conway

LOOKING BACKWARD AND FORWARD

FIRST THERE WAS BUSINESS INTELLIGENCE

Deductive Reasoning

Backward Looking

Slice and Dice Data

Warehoused and Siloed Data

Analyze the Past, Guess the Future

Creates Reports

Analytic Output

NOW WE'VE ADDED DATA SCIENCE

Inductive and Deductive Reasoning

Forward Looking

Interact with Data

Distributed, Real Time Data

Predict and Advise

Creates Data Products

Answer Questions and Create New Ones

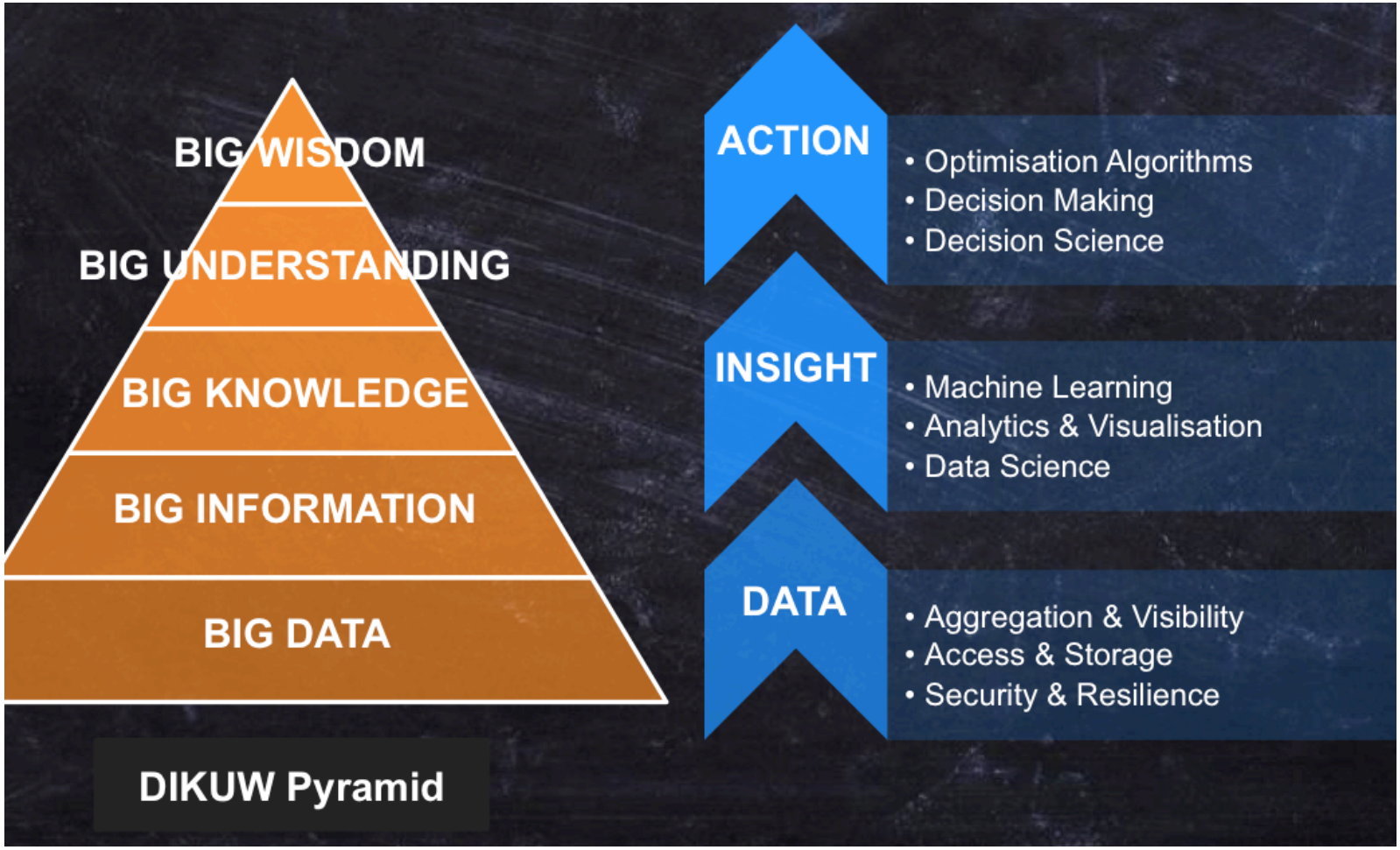
Actionable Answer

Source: Booz Allen Hamilton

Inductive and deductive reasoning

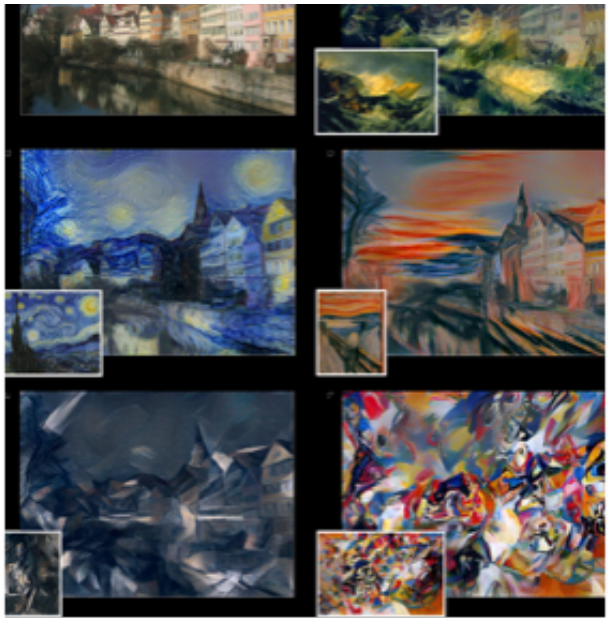
- Data Science supports and encourages shifting between deductive (hypothesis-based) and inductive (pattern-based) reasoning
- This is a fundamental change from traditional analysis approaches.
- Inductive reasoning and exploratory data analysis provide a means to form or refine hypotheses and discover new analytic paths.
- Models of reality no longer need to be static.
- They are constantly tested, updated and improved until better models are found.

From data to wisdom



Data Science principles

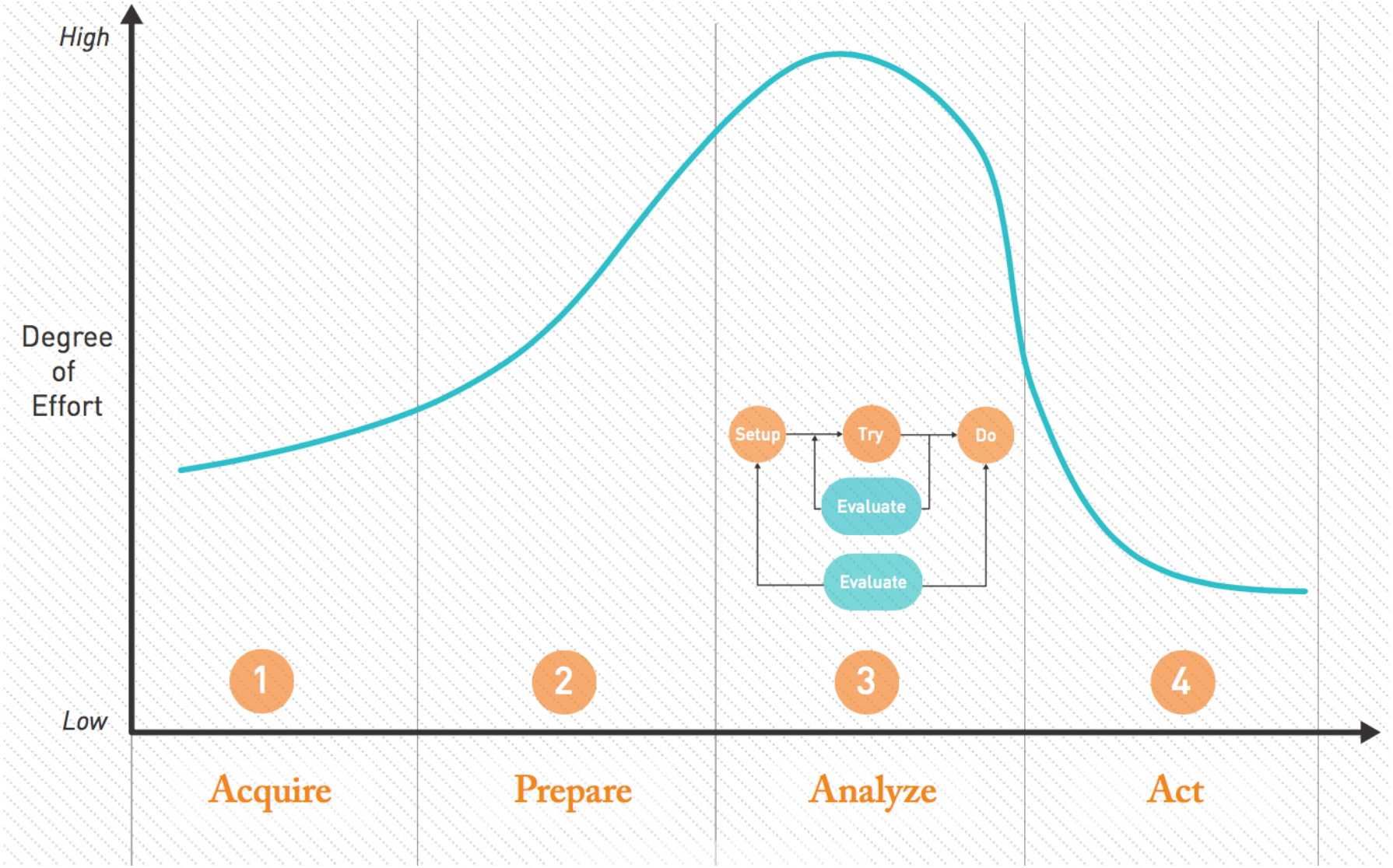
- Be willing to fail.
- Fail often and learn quickly.
- Keep the goal in mind.
- Dedication and focus lead to success.



- Leon A. Gatys, Alexander S. Ecker, Matthias Bethge. ``A Neural Algorithm of Artistic Style.'' arXiv:1508.06576. September 2015.
- Prisma and Convolutional Neural Networks: June 2016.

Practice of Data Science

Data science workflow



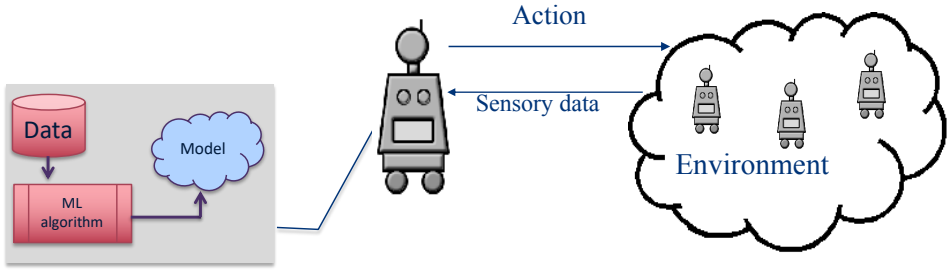
Data Science and AI

The (Third) Coming of AI

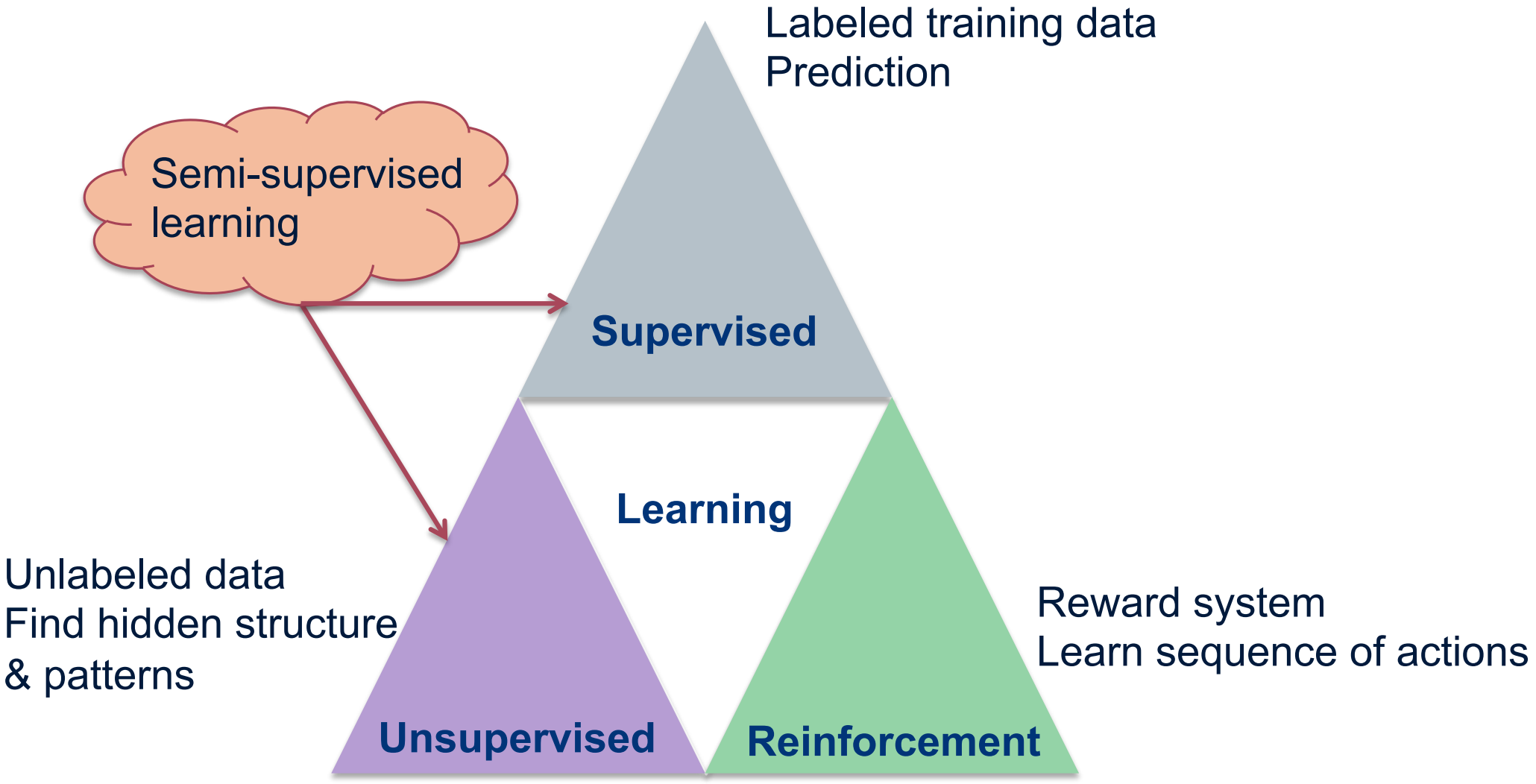
- Birth
- Early years & realisations
- Expert Systems
- AI Winter
- The (big) come back

An AI Perspective

- Truly intelligent systems need to adapt their behaviour
- Learning: the process of acquiring knowledge, skills, or attitudes through experience, imitation, or teaching, which then causes changes in behaviour
- Hence Machine Learning



Types of Learning

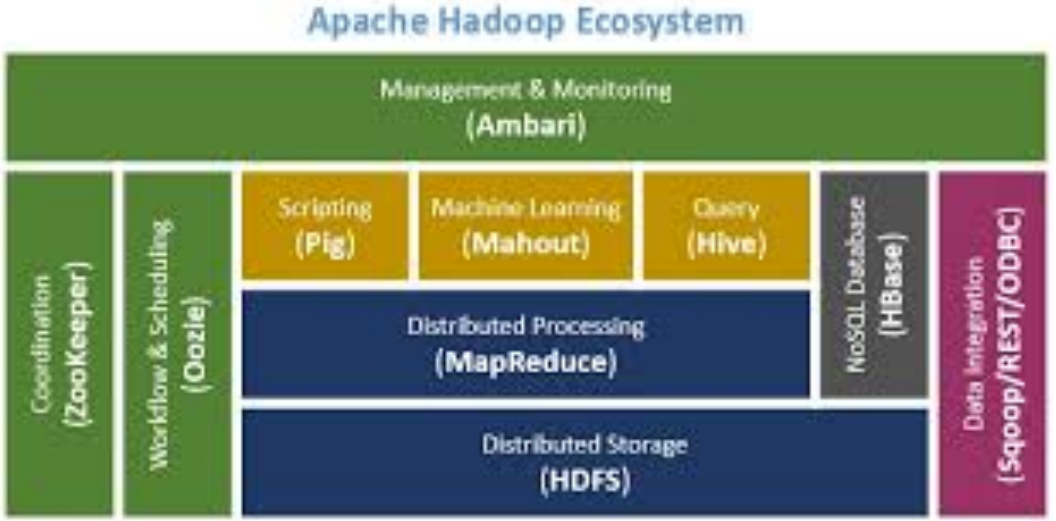


Why is Learning Important

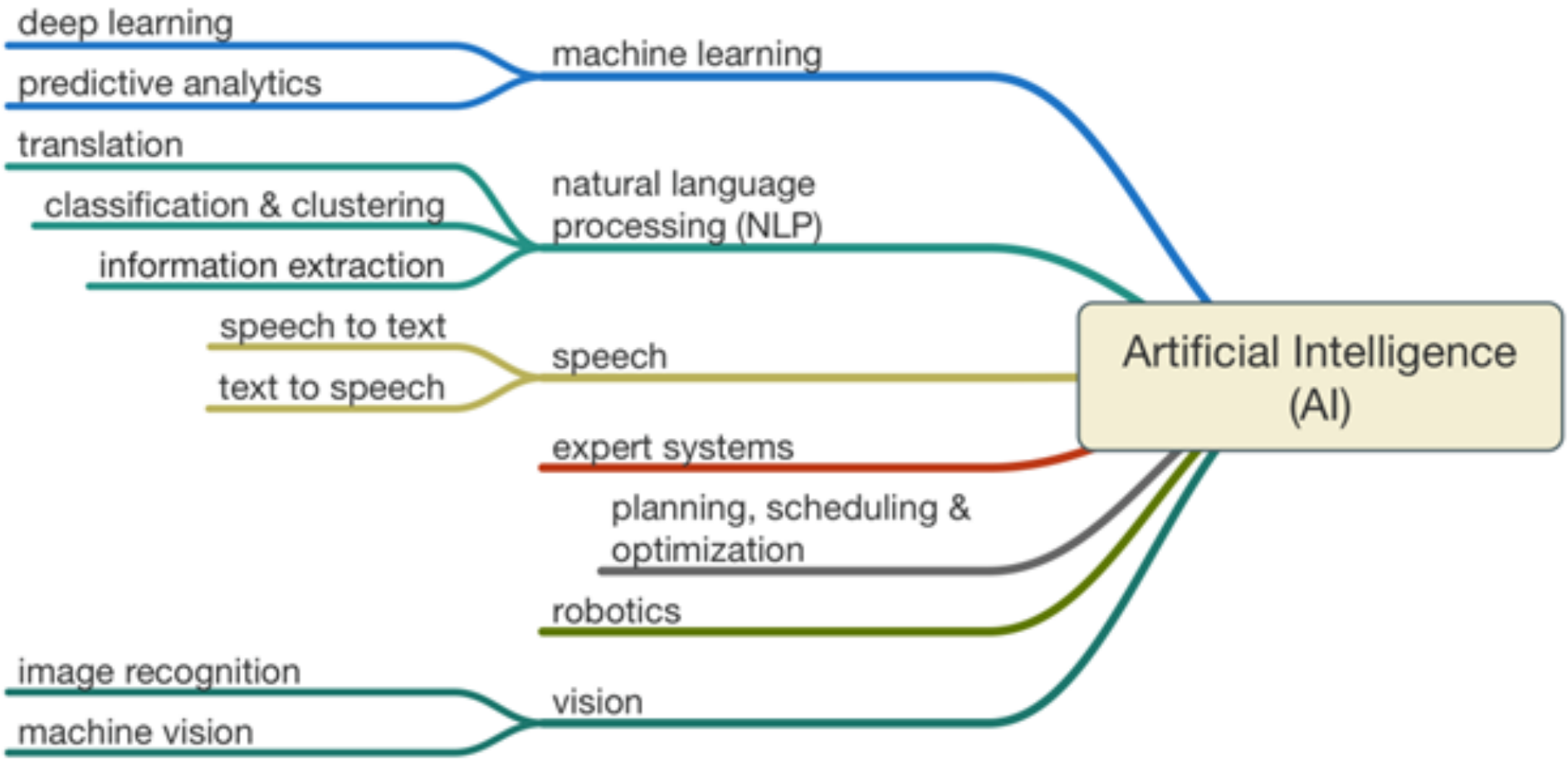
- Impractical/impossible to specify systems correctly and completely at the time of design/implementation
- Implemented systems may not work as well as desired or expected when put in operation
- Knowledge about certain tasks may simply be too large to be explicitly encoded by humans
- The environment may change and hence the system's goals need to be changed as well
- Hidden relationships and correlations among huge amounts of data

Why has ML become popular?

- Data explosion – Big Data!
  - Structured, unstructured, social media, labelled, unlabelled
  - Cost effective storage
- Computational power
- Faster processors, GPUs
- HPC, cloud computing, computing as a service
- Advances in algorithms and availability of toolkits



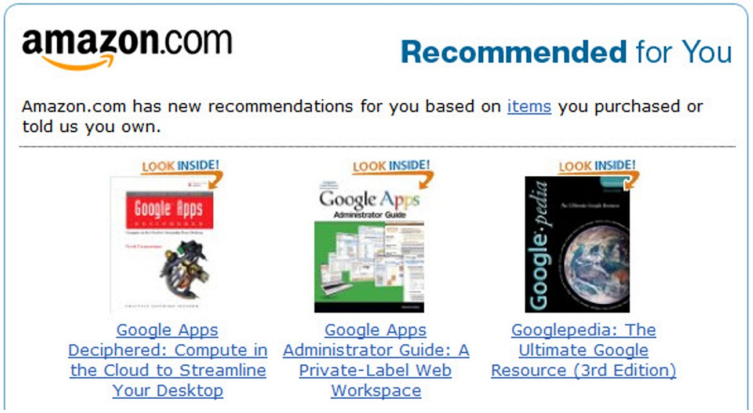
Main approaches in AI



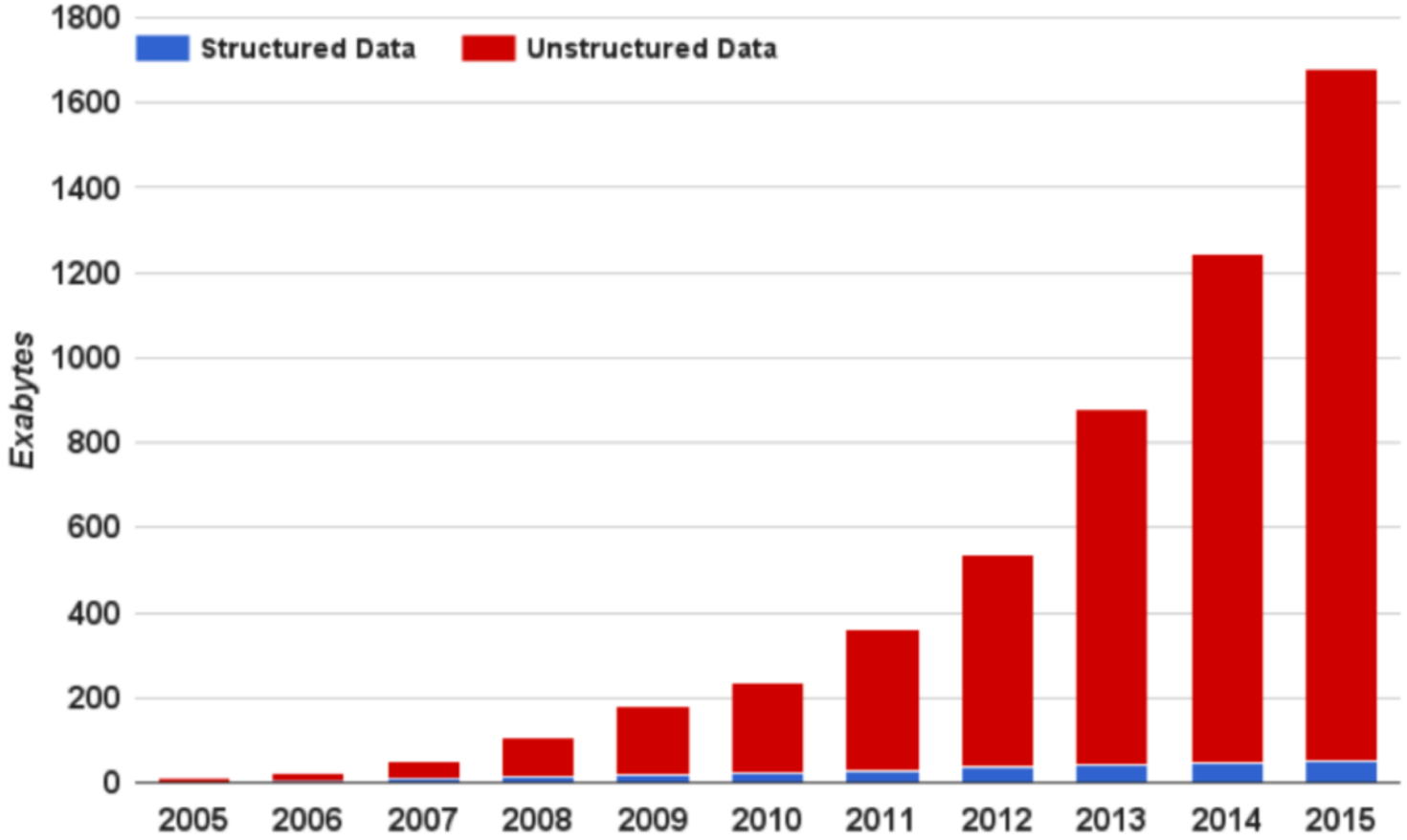
Data Science in the Wild

Personalisation

- What articles should be shown on the homepage of an online newspaper?
- What titles and images would attract the most clicks?
- Which product order would yield the highest profit?
- What is the best combination of drugs for patient?



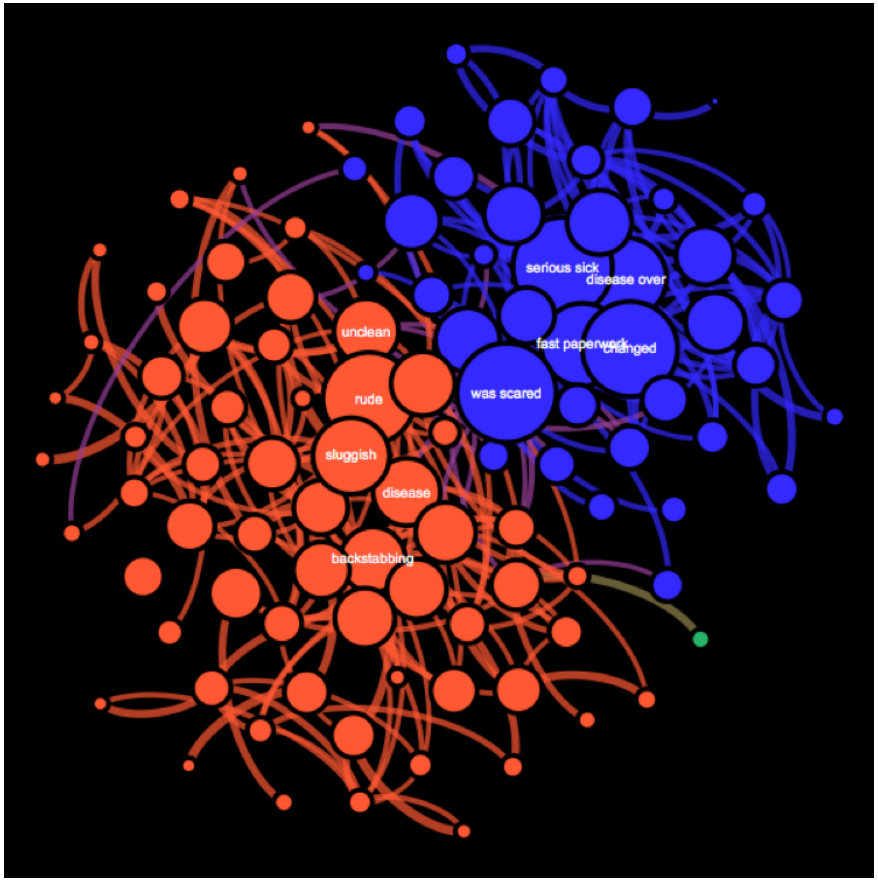
Unstructured Data



A.Nadkarni, N.Yezhkova, “Structured versus unstructured data: The balance of power continues to shift.” IDC (Industry Development and Models), March 2014.

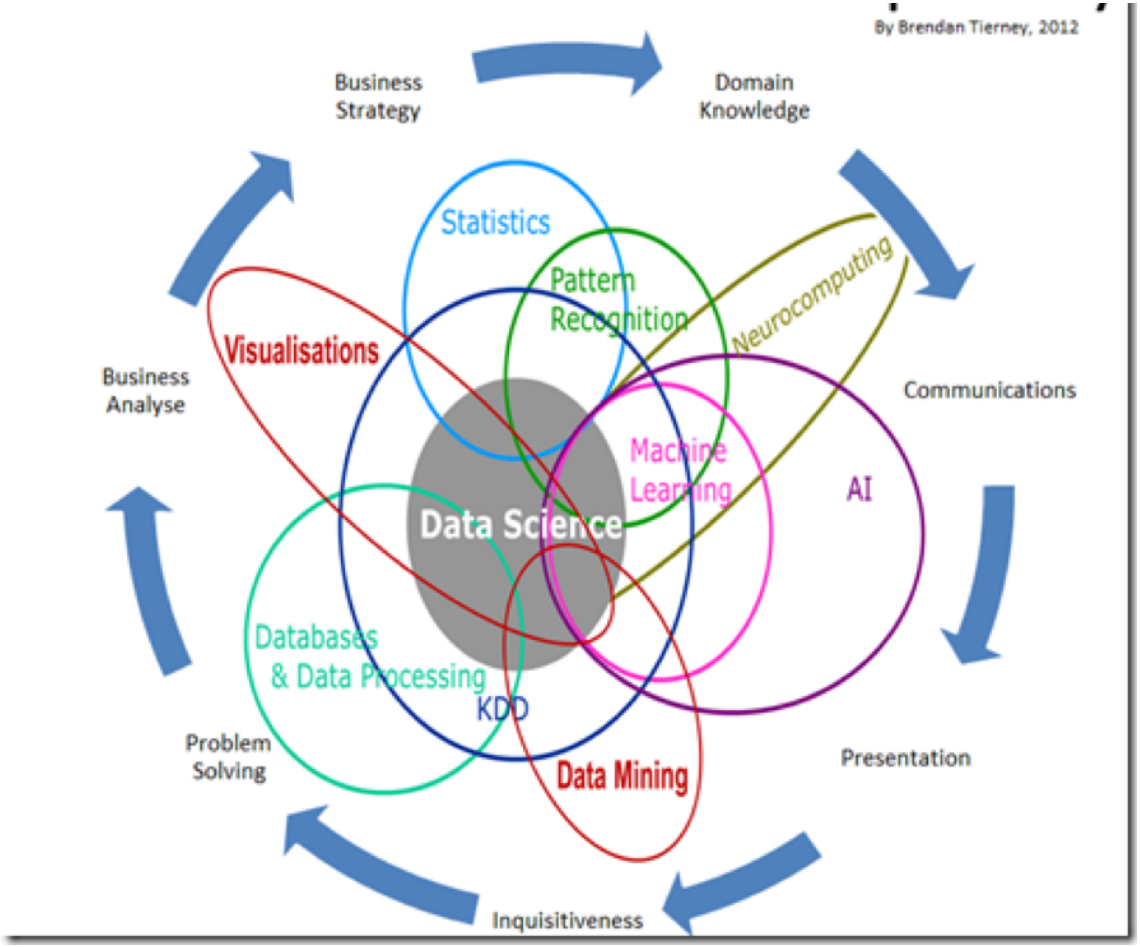
Understanding Patients

- Online reviews of primary care services (GPs) in England
- July 2013 - January 2017, 7.7K GP practices, 145K reviews
- ~ 3-5K reviews per month, 5-6 sentences long



Collaborate!

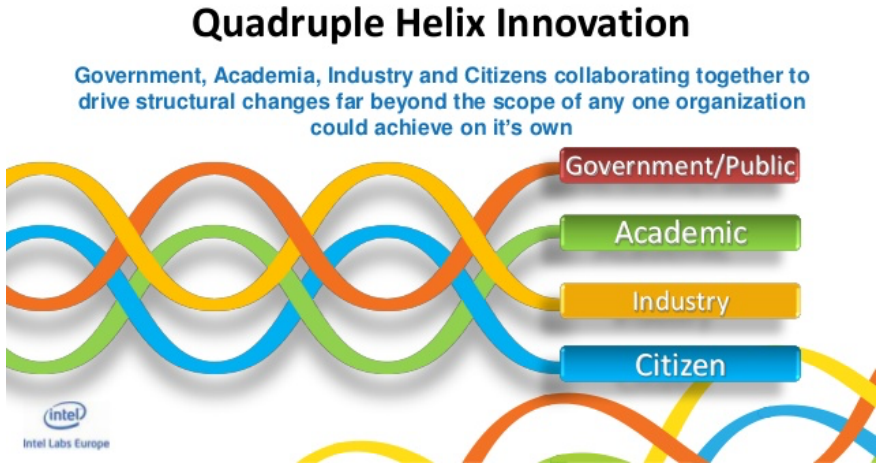
Ideal Data Scientist



http://www.kdnuggets.com/2014/06/data-science-skills-business-problems.html

Image from http://www.mysticwish.co.uk/product/anne-stokes-forest-unicorn-fridge-magnet/

Wicked Problems Require a System Approach



"Research in Big Data should be grounded in the quadruple helix model where civil society joins with business, academia, and government sectors to drive changes far beyond the scope of what any organization can do on their own."

Intel Corp policy position paper on Big Data

Benefits for Academia

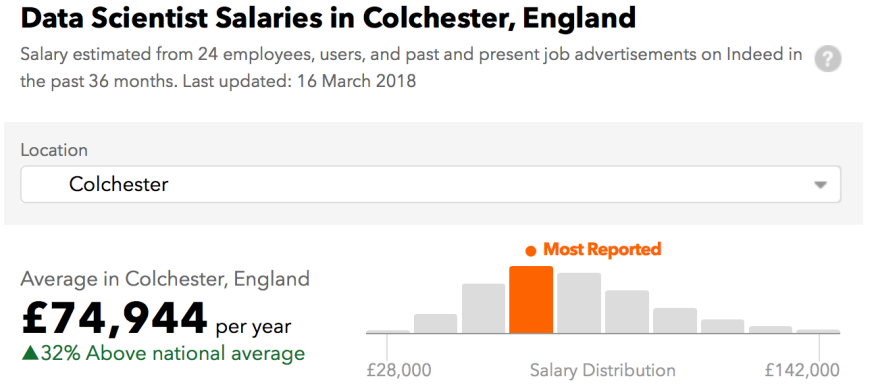
"In ML, where algorithms get published quickly and state-of-the-art frameworks are open-source, there isn't any first-mover advantage. Rather, competitive edge comes from data accumulation and infrastructure know-how. Which tends to benefit established large companies, rather than nimble upstarts with better tech."

François Chollet, Deep learning at Google, Author of Keras, @fchollet

Collaboration

- Cost-Benefit rather than technical issues
- Unclear benefits of sharing data: vague and conceptual rather than tangible and related to business outcomes
- Cost of sharing (perceived privacy, security risks, resource costs) outweigh unclear benefits.

- Knowledge Transfer Partnerships
- Embedding
- Secondments
- Joint appointments



By the time we are finished…

Using Data Science in Policy

A report by the Behavioural Insights Team

CabinetOffice
Behavioural Insights Team

- Children's social care
- Given the text of the initial referral and assessment, and structured data relating to the case, could we predict whether the case would be re-referred and escalated if it were closed?
- Machine learning and Natural Language Processing
- http://bit.ly/2FIL0H3

Figure 5: The inputs of the machine learning algorithm used to detect escalated closed cases.

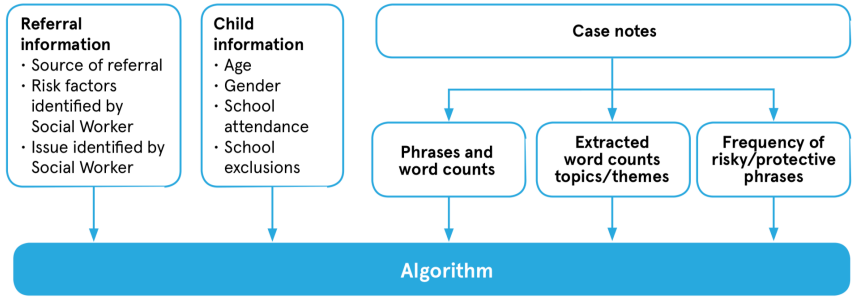
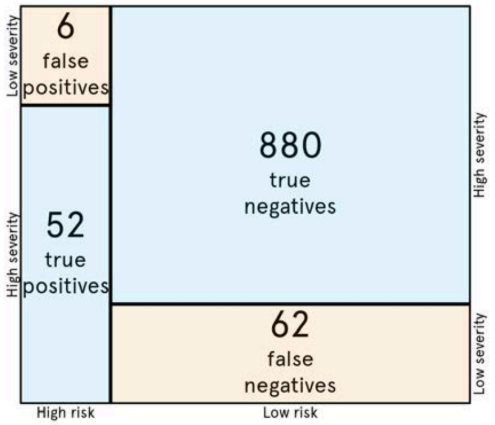


Figure 6: Expected distribution of true and false positives and negatives for 1,000 previously unclassified cases.



'Risk' refers to the model's prediction and 'severity' to the actual outcome. For example, a 'false negative' is a case that escalated but that the model categorised as 'low risk'.

EssexData: A risk profile for school readiness

- Can we predict whether children will be school ready on starting school?
- What factors are most likely to cause this early indicator of “best start in life”?
- 511 households at risk in the pilot area;
- Including 280 previously unknown to public services;
- 74% prediction accuracy rate.

Remarks

- We now have a reasonable machine learning armoury to draw from
- You can (semi-)automate the machine learning pipeline – business and problem dependent
- Lots of toolkits and software
- AI is advancing fast (chatbots/agents)
- Hunting for unicorns…
- Explainability and ethical considerations
- Collaborate!