LA TROBE UNIVERSITY

Building AI – Module 1

AI in Context
17 May 2022

Optus U

The course in brief

- Welcome!
- LMS (show)
- Teams and email
- Six modules across 6 weeks (17 May to 21 Jun)
- Two hours face-to-face online (Tuesdays 10 – 12 pm) and a 3-5 hours self-study/hands-on
- Two quizzes and one assignment
- Assessment outcome is binary
- Q&A

Six modules

- Pre-work?
- Module 1 – AI in Context
- Module 2 – Python for AI
- Module 3 – AI Lifecycle
- Module 4 – Data and Stats Refresh
- Module 5 – Predictive Models
- Module 6 – Classification Models (Ethics and Containers)

Agenda

1. Defining AI
2. AI taxonomy
3. AI capabilities
4. Progression of AI
5. AI and Automation

What is AI? …from the textbooks

- Artificial Intelligence (AI)
  - The science of making machines do things that would require intelligence if done by humans - Marvin Minsky, 1968.
  - *Viewed narrowly, there seem to be almost as many definitions of intelligence as there were experts asked to define it (Massaro and Gregory, 2006)*
  - The entire discipline - an umbrella term
- Machine learning (ML)
  - The study of computer algorithms that improve automatically through experience – Tom Mitchell, 1997.
  - A machine is said to learn from experience *E* with respect to some class of tasks *T* and performance measure *P* if its performance at tasks in *T*, as measured by *P*, improves with experience *E*
  - ML functional subset of AI that has proven to be more effective than the others.

And there's more…

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Thinking rationally

- Laws of thought approach – logic vs intuition vs emotion
- Recall premises and conclusions?
- A formal representation of information/knowledge about the world so that a machine can solve complex tasks.
- Knowledge based systems, expert systems
- Fuzzy logic
- Bayesian inference
- Is it plausible to encode all of the world's knowledge?

Thinking humanly

- Need to understand the human thought process:
  - through introspection of own thoughts - Psychoanalysis
  - through experiments and observations of a person in action - Psychology
  - by imaging the brain in action - Neuroscience
- Cognitive science: the scientific study of the mind and its processes
  - Hebbian theory: “Neurons(or cells) that fire together wire together”
  - Neuroplasticity: The brain's ability to reorganize itself by forming new neural connections over time.
  - Neocortex: as a hierarchy of layered filters in which each layer processes information from a prior layer.

Acting rationally

- A rational agent approach.
- A machine that acts to achieve the best outcome or the best expected outcome, given the circumstances (current reality)
- Treats correct inference (thinking rationally) only as one of several possible mechanisms for achieving rationality (others are intuitive logic, fuzzy logic).
- More general than the laws of thought approach but also more specific than the human thought process.
- Standards of rationality are mathematically/logically well defined and generalizable.

Thinking humanly

- Alan Turing proposed the Turing Test to provide a satisfactory operational definition of AI.
- Turing Test (Imitation game) - A machine passes the test if a human interrogator, after posing some written questions, cannot tell whether the written responses were generated by a machine or a human.
- Such an algorithm/machine would need to demonstrate:
  - natural language processing
  - knowledge representation
  - automated reasoning
  - machine learning
- Although 70 years old, it is still valid today.
- But artificial flight did not arise from imitating the flight of birds?

An example

- Thinking rationally

- Thinking humanly

- Acting rationally

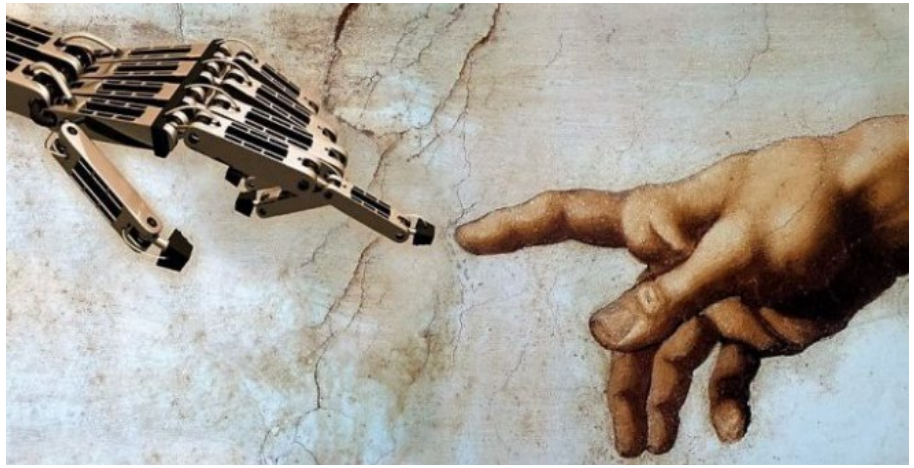
- Acting humanly

Online shopping/online search	**Smart factory/ Industry 4.0**
PageRank	Supply chain optimisation
Collaborative filtering	User-centric design generation
Neural machine translation	Internet of Things manufacturing line
Conversational agent	Value chain automation

An AI taxonomy

- A taxonomy: a structure or classification of knowledge
- Also known as ontology, ‘body of knowledge’, classification
- What is epistemology?

Human Intelligence	Artificial Intelligence
Memory	Knowledge engineering
Learning	Machine learning
Reasoning	Machine reasoning
Evolution	Evolutionary computation (metaheuristics)
Awareness	Generative modelling (basic)



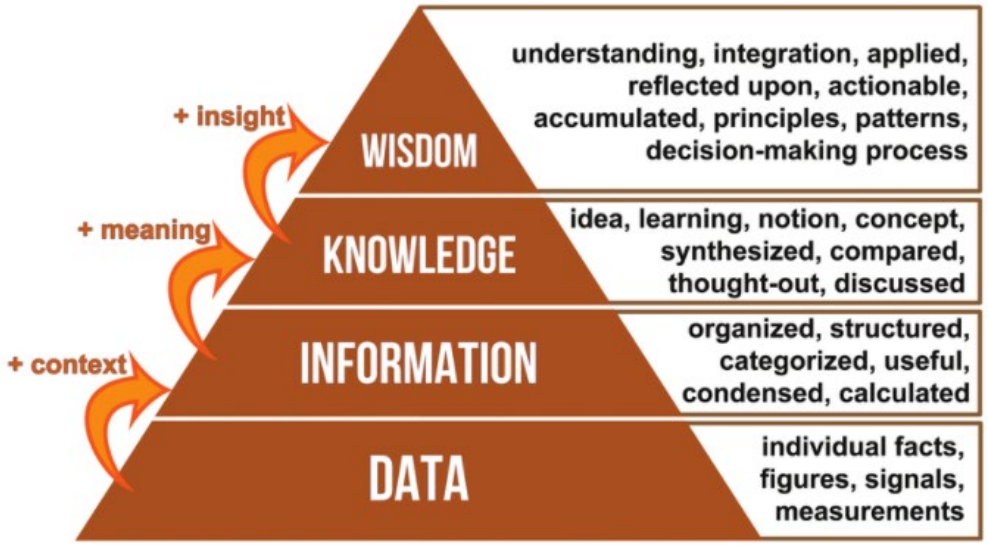
abc.net.au

In comparison to human intelligence:

- Artificial Narrow Intelligence
- Artificial General Intelligence
- Artificial Super Intelligence

A further taxonomy

- Top-down (model-based) approach
  - Knowledge representations
  - Bayesian reasoning
  - Evolutionary computation
- Bottom-up (data-driven) approach
  - Machine learning
  - Generative modelling

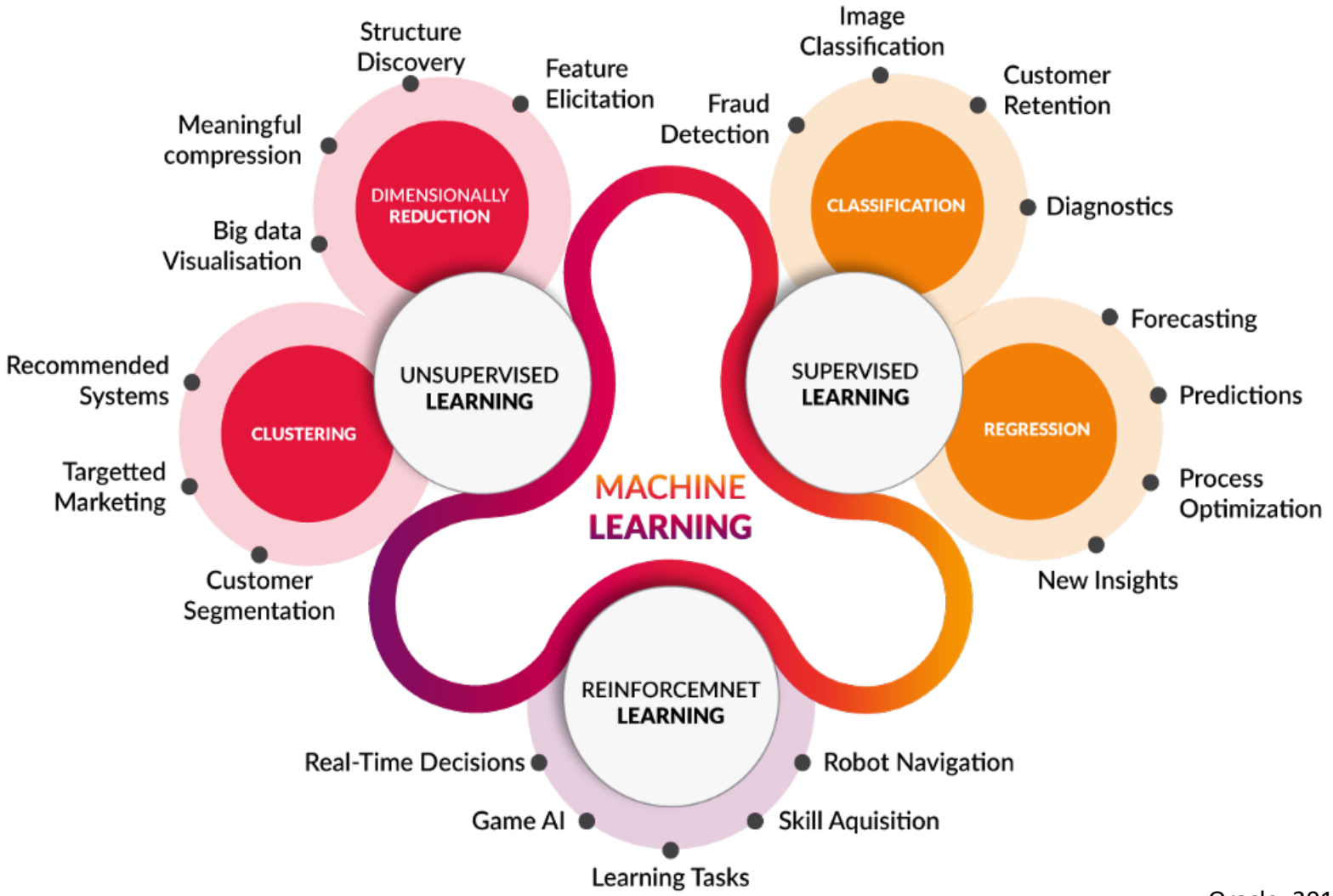


- Which approach is proving to be more effective?

More practically…

- Machine learning is used to create an "artificial intelligence" (several other methods to intelligence)
- Deep learning is a sophisticated type of machine learning (ML)
- Predictive Analytics is the application of ML for predictions/forecasting
- Data Analytics/Data Science is the broad application of ML for insights generation
- Big Data is an enabler of all of the above
- Data mining is what used to be called artificial intelligence
- Automation is when ML learns and applies that knowledge to take decisions/actions
- Autonomy is… when it all gets out of hand…

A machine learning taxonomy

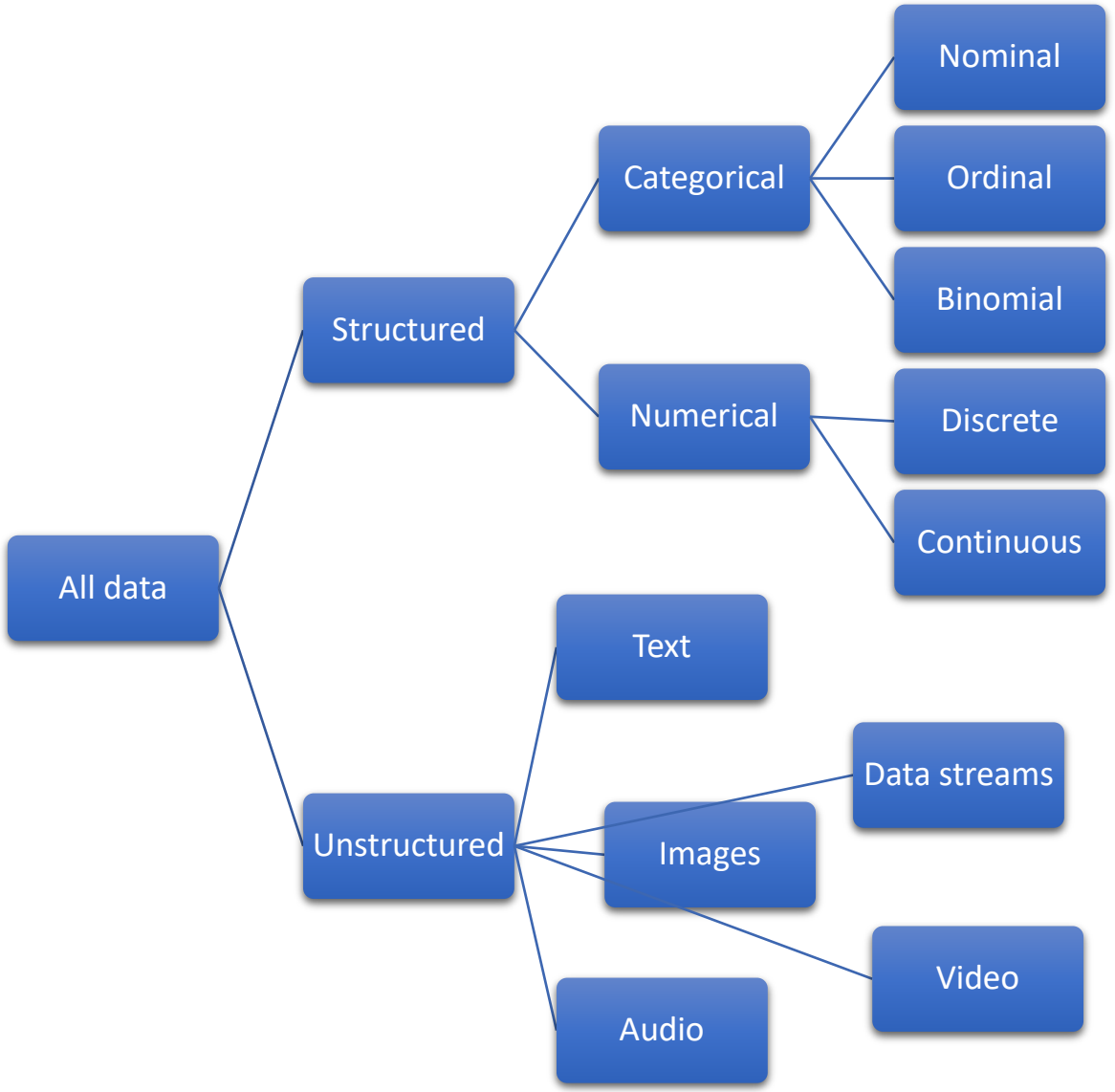


Oracle, 2018

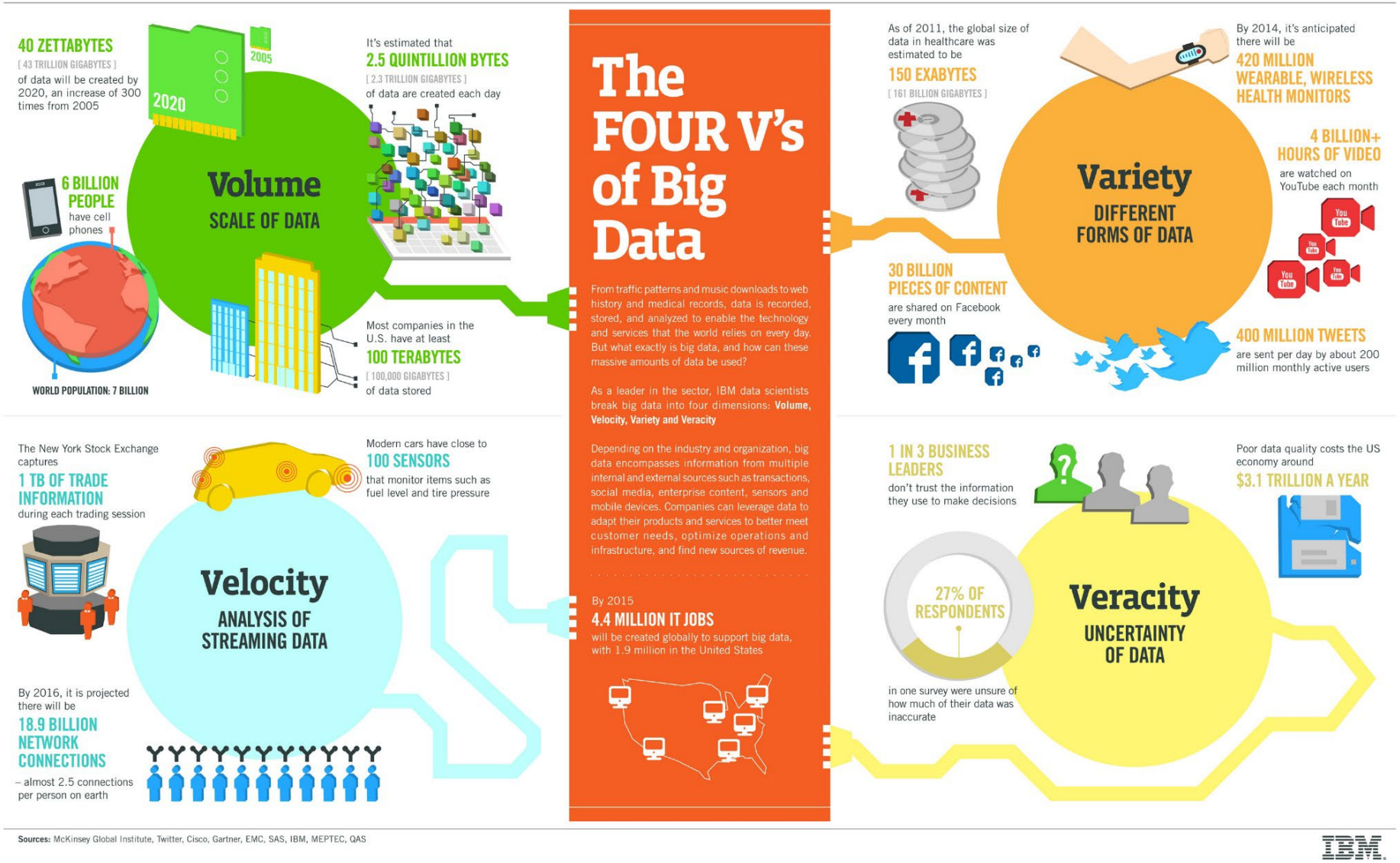
Decision-making capabilities

- “Algorithms that generate intelligence to inform decision-making”
  - How about algorithms that do not generate intelligence?
- The decision-making capabilities are,
  - A prediction – regression, classification, time series, sequence
    - Classification is also detection – object, anomaly, concept
  - An association – clustering, feature selection, dimensionality reduction
  - An optimisation – scheduling, planning, control, generation, simulation
- And these capabilities work across different modalities of data
  - Text – natural language processing/understanding (NLP/U)
  - Image, audio, video – computer vision, speech recognition

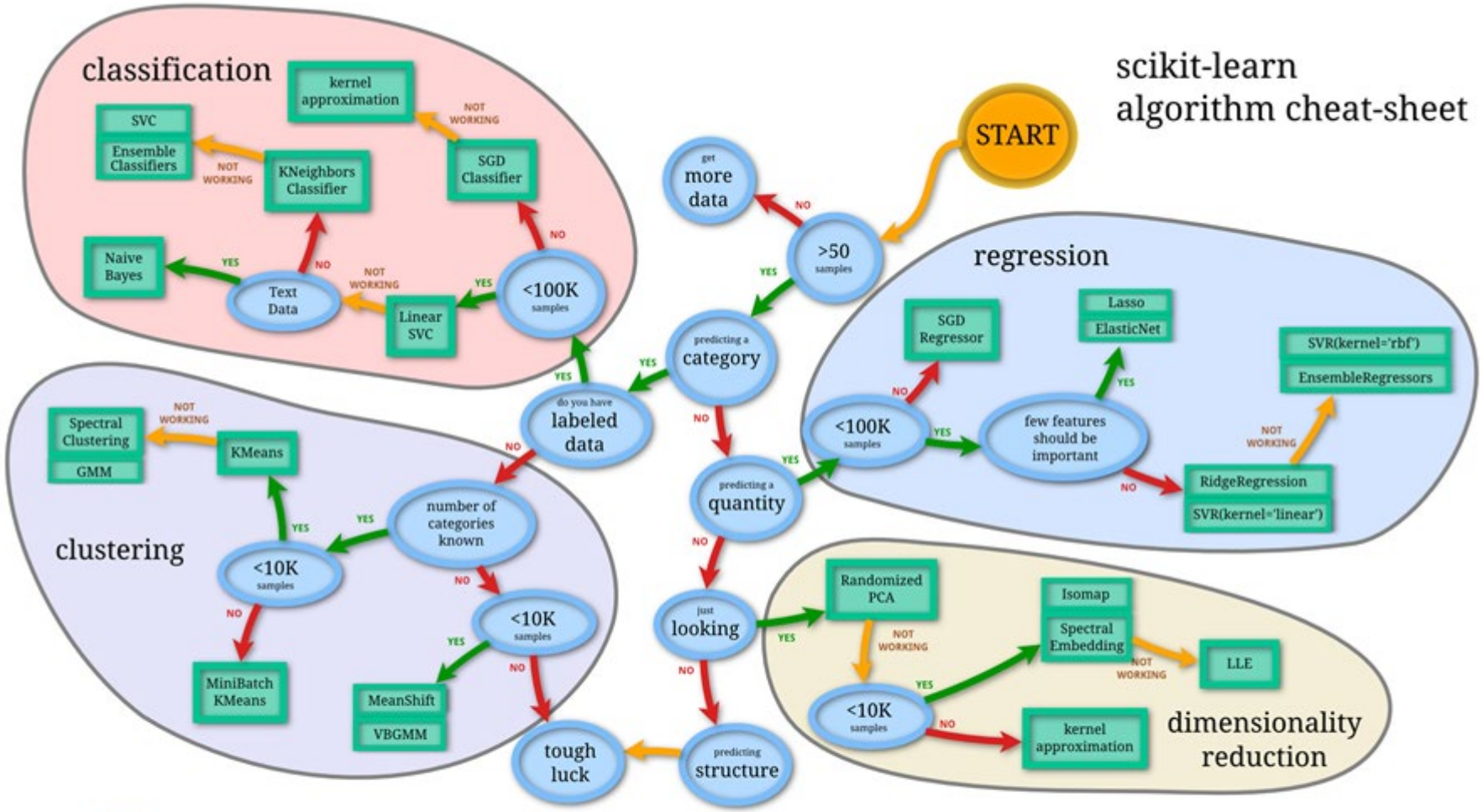
A taxonomy of data types



Big Data


40 ZETTABYTES
[43 TRILLION GIGABYTES]
of data will be created by 2020, an increase of 300 times from 2005
2005
2020
It's estimated that
2.5 QUINTILLION BYTES
[2.3 TRILLION GIGABYTES]
of data are created each day
6 BILLION PEOPLE
have cell phones
WORLD POPULATION: 7 BILLION
Volume
SCALE OF DATA
Most companies in the U.S. have at least
100 TERABYTES
[100,000 GIGABYTES]
of data stored
The Four V's of Big Data
From traffic patterns and music downloads to web history and medical records, data is recorded, stored, and analyzed to enable the technology and services that the world relies on every day. But what exactly is big data, and how can these massive amounts of data be used?
As a leader in the sector, IBM data scientists break big data into four dimensions: Volume, Velocity, Variety and Veracity
Depending on the industry and organization, big data encompasses information from multiple internal and external sources such as transactions, social media, enterprise content, sensors and mobile devices. Companies can leverage data to adapt their products and services to better meet customer needs, optimize operations and infrastructure, and find new sources of revenue.
By 2015
4.4 MILLION IT JOBS
will be created globally to support big data, with 1.9 million in the United States
As of 2011, the global size of data in healthcare was estimated to be
150 EXABYTES
[161 BILLION GIGABYTES]
By 2014, it's anticipated there will be
420 MILLION WEARABLE, WIRELESS HEALTH MONITORS
4 BILLION+ HOURS OF VIDEO
are watched on YouTube each month
30 BILLION PIECES OF CONTENT
are shared on Facebook every month
400 MILLION TWEETS
are sent per day by about 200 million monthly active users
Variety
DIFFERENT FORMS OF DATA
The New York Stock Exchange captures
1 TB OF TRADE INFORMATION
during each trading session
Modern cars have close to
100 SENSORS
that monitor items such as fuel level and tire pressure
Velocity
ANALYSIS OF STREAMING DATA
By 2016, it is projected there will be
18.9 BILLION NETWORK CONNECTIONS
– almost 2.5 connections per person on earth
1 IN 3 BUSINESS LEADERS
don't trust the information they use to make decisions
Poor data quality costs the US economy around
$3.1 TRILLION A YEAR
27% OF RESPONDENTS
in one survey were unsure of how much of their data was inaccurate
Veracity
UNCERTAINTY OF DATA
Sources: McKinsey Global Institute, Twitter, Cisco, Gartner, EMC, SAS, IBM, MEPTEC, QAS
IBM

Capabilities to algorithms

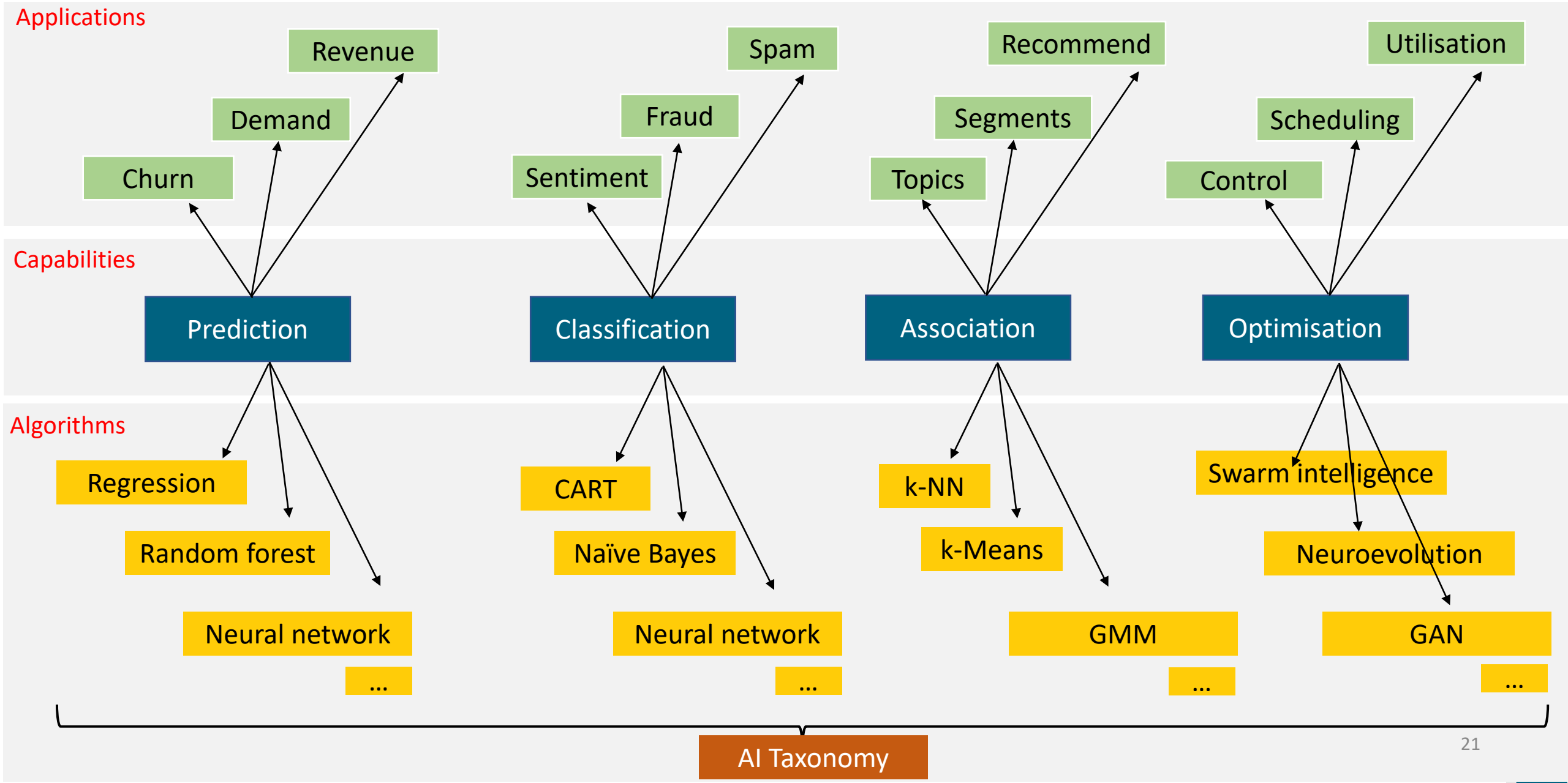


From capabilities to applications

- Prediction – demand, revenue, churn, weather, stock price, protein folding
- Classification – face recognition, spam detection, credit card fraud, sentiment
- Association – recommendation, behaviour profiling, customer segments, topics, machine translation
- Optimisation – resource utilisation (CPU, storage, networks, energy), digital twins, control, robotics

- Complex applications requiring multiple capabilities:
  - Algorithmic trading
  - Conversational chatbots
  - Self-driving vehicles

Algorithms → Capabilities → Applications



Capabilities → Action

Capability	Application	Data	Algorithms	Output	Action
Prediction	Sales prediction	Past sales, channels, demographics	Regression, CART, RF	Dollar sales, unit sales	Market/sales strategy, new products
Prediction	Revenue forecasting	Past revenue	LSTM	Future revenue	Budgeting
Classification	Sentiment/emotion analysis	Feedback, reviews, demographics	XGBoost	Positive, neutral, negative or 8 emotions	CRM, service strategy
Classification	Network anomalies	Time series activity, audit logs, events	ANN/DNN	Anomalous readings and properties	Maintenance, security, BPM
Association	Customer profiling	All customer data	KNN, SOM	Customer segments	Markets and products
Association	Complaints handling	Complaints, timeline	LDA, BERT	Themes and topics	Resolutions, planning
Optimisation	EV dis/charging	Capacities, availability	Swarm, RL	Charging schedule	Grid management
Optimisation	Network/road/air traffic	Trips, stops, roads, intersections, lanes	GAN, Auto ML	Route plans, scenario models	Traffic management, fleet management

Taxonomy – Machine learning

- Supervised -
  - k-nearest neighbour, linear regression, logistic regression, naive bayes, decision trees, CART (Classification and Regression Trees), gradient boosting (XGBoost, Light GBM), neural networks (perceptron, backpropagation), support vector machines
- Unsupervised -
  - k-Means clustering, mixture models, PCA, self-organising maps, autoencoders
- Reinforcement -
  - Monte Carlo, SARSA, Q-learning
- Deep learning -
  - CNN, RNN, LSTM, DBN, Stacked autoencoders
- Fine-tuning (domain adaptation) -
  - Transfer learning, active learning, ZSL, OSL, FSL

Taxonomy – Others

- Knowledge engineering/representation -
  - Decision trees, CART (Classification and Regression Trees), knowledge graphs, ontology engineering
- Machine reasoning -
  - Decision trees, Fuzzy logic, Bayesian networks, Markov models
- Evolutionary computation (metaheuristics)
  - Genetic algorithms, swarm intelligence (PSO, ACO, ABC)
- Generative modelling
  - GANs, latent spaces, representation learning

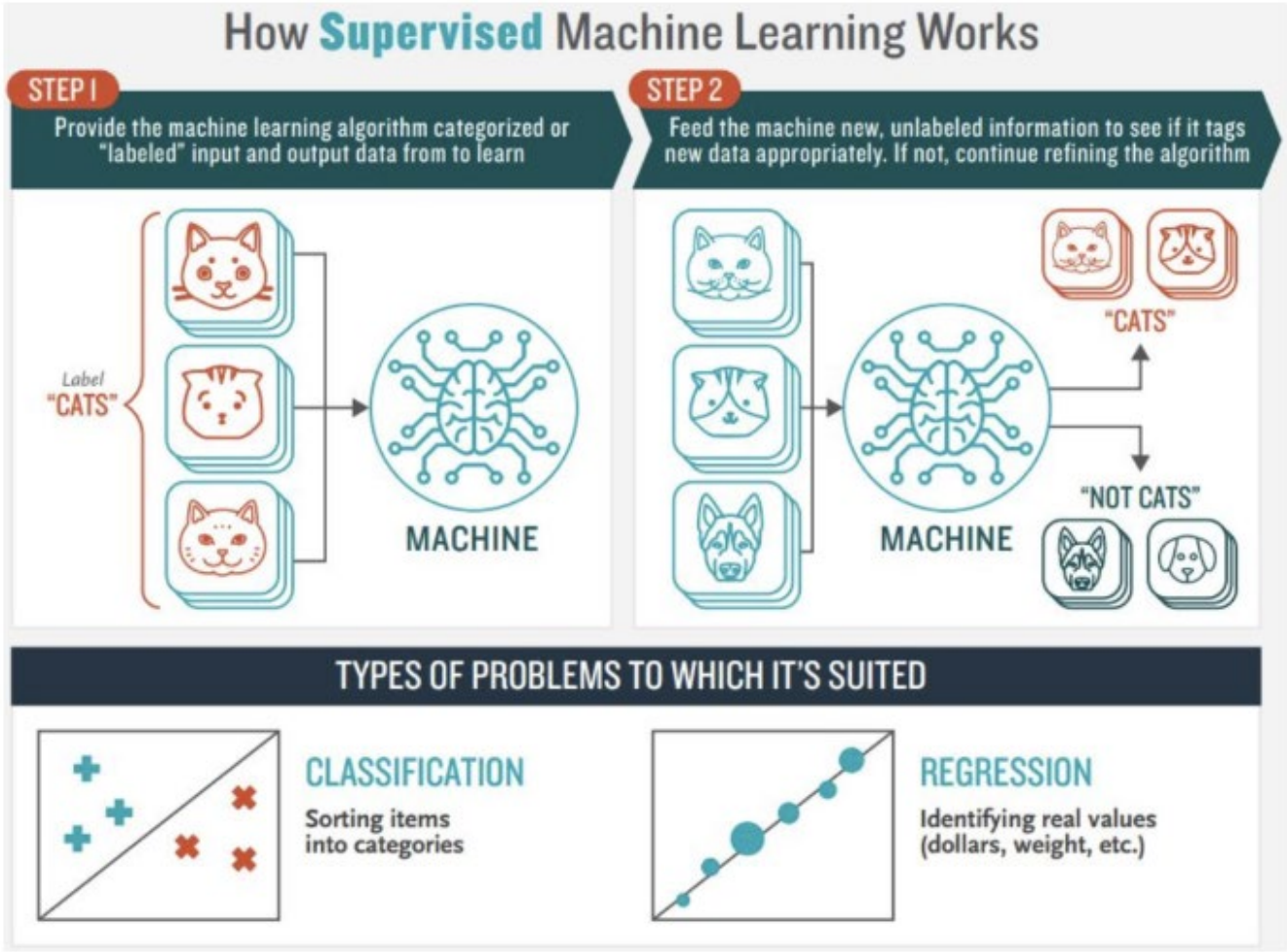
Common AI/ML terminology

- Algorithm - a set of instructions - on how to learn from data
  - Examples
- Architecture (or model architecture) – a predefined structure that enables the learning algorithm
  - Such as, nodes, node types, layers/branches, learning rule, loss function, meta-learning techniques
- Data – how the algorithm learns - training, testing, validation datasets (labelled/unlabelled)
- Model (or learned model) – the architecture adapted by the algorithm to learn/fit the data (algorithm+architecture+data)
- Parameters (or hyper-parameters) – variables in the model (algorithm+architecture+data) that can be tuned to improve performance metrics
- Output – prediction (regression, classification), clustering

Statistical models vs Machine learning

- Isn’t regression a statistical model? - fairly dated debate, but you may still come across this.
  - “When we raise money it’s AI, when we hire it's machine learning, and when we do the work it's logistic regression” (by a statistician of course)
  - Short answer – just get the job done
- Model-based vs data-driven
  - In ML, training a linear regressor to predict = In SM, best fit line to minimise the squared error
  - SM starts with a hypothesis test and a set of rules (assumptions), ML is less rigid
  - SM takes all the data, ML separates training and test datasets – validation vs rigidity of modelling
  - But SM will also remove outliers or look for known distributions whereas ML doesn’t
  - SM focuses on causality through linearity, ML focuses on correlation through non-linearity
  - ML is more technology-ready (big data, cloud, pipelines)

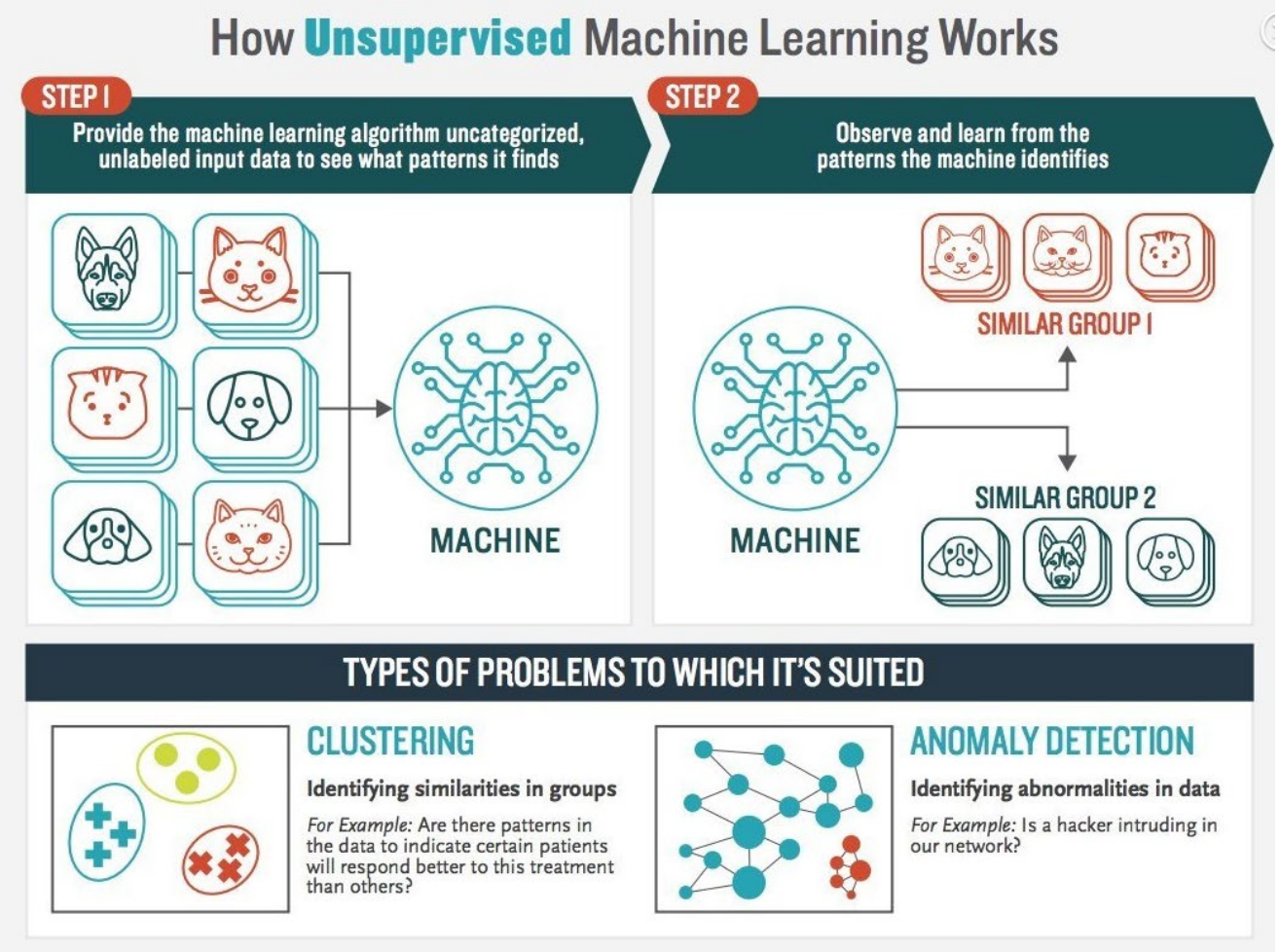
Supervised machine learning



- Feature based – #limbs, coat, diet, sound, gait, affinity -> label (cat, not cat)
- Image based – shape, contours, positioning, texture -> label (cat, not cat)

Medium.com

Unsupervised machine learning

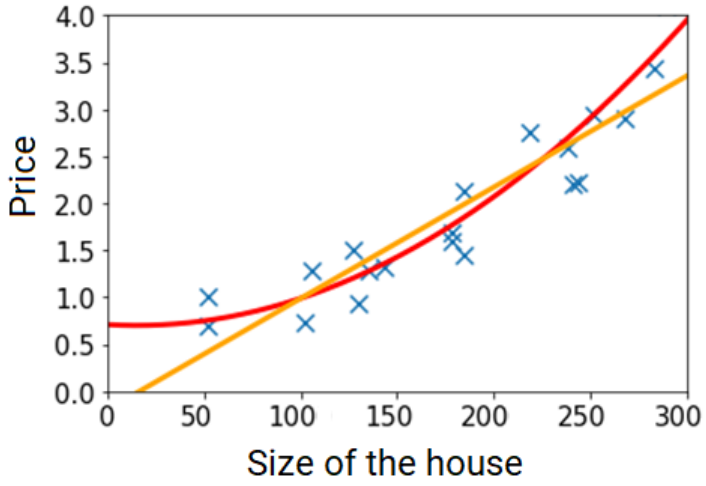


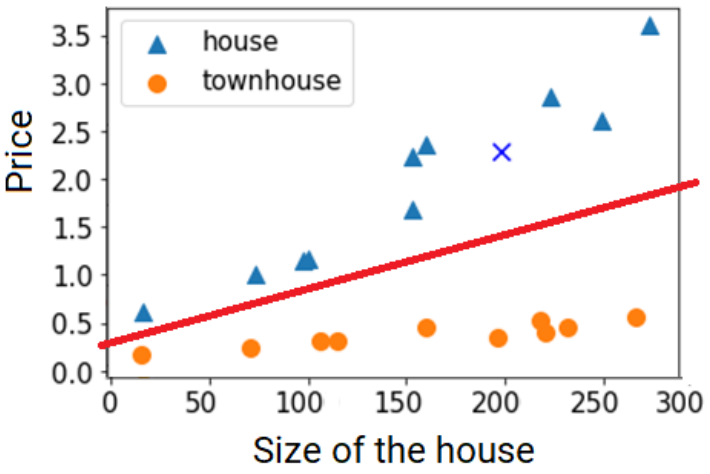
- Feature based – #limbs, coat, diet, sound, gait, affinity -> no label
- Image based – shape, contours, positioning, texture -> no label

Medium.com

A prediction using supervised learning

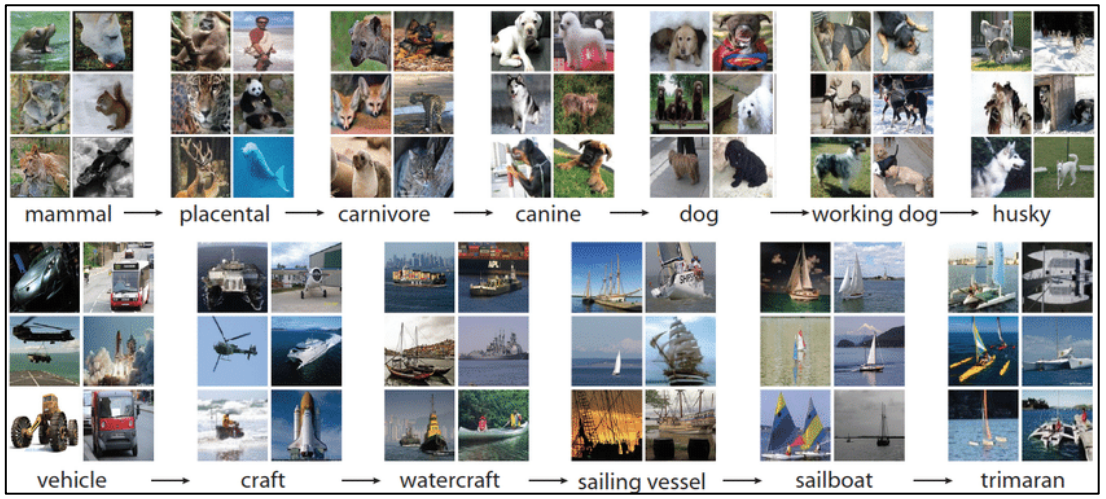
- A labelled dataset of many records (rows), each record containing many input variables and one output variable
- House prices - can we predict price (y) given (x) square meters?
- How about y given many x
  - Size, type, year built, postcode, features etc.
- Now how about predicting type (y) given (x) square meters
  - How is predicting price different to predicting size?
- Regression vs Classification – two main types of predictions
  - Regression – predicts a numerical variable (continuous or discrete)
  - Classification – predicts a categorical variable (a class label)



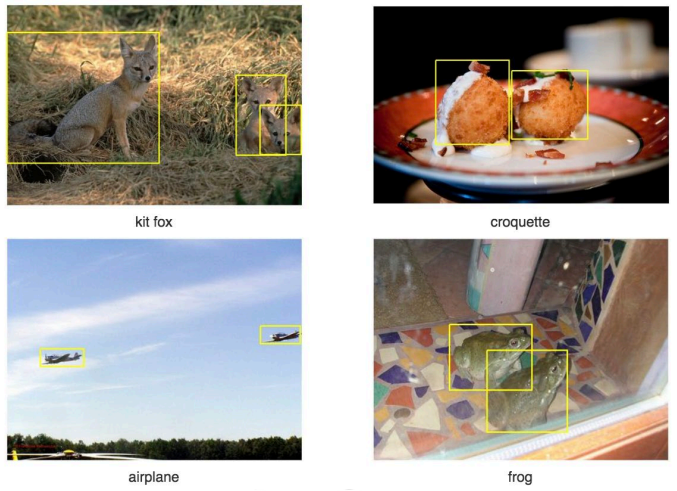


More examples

- Input (x) – pixels, output (y) – object name



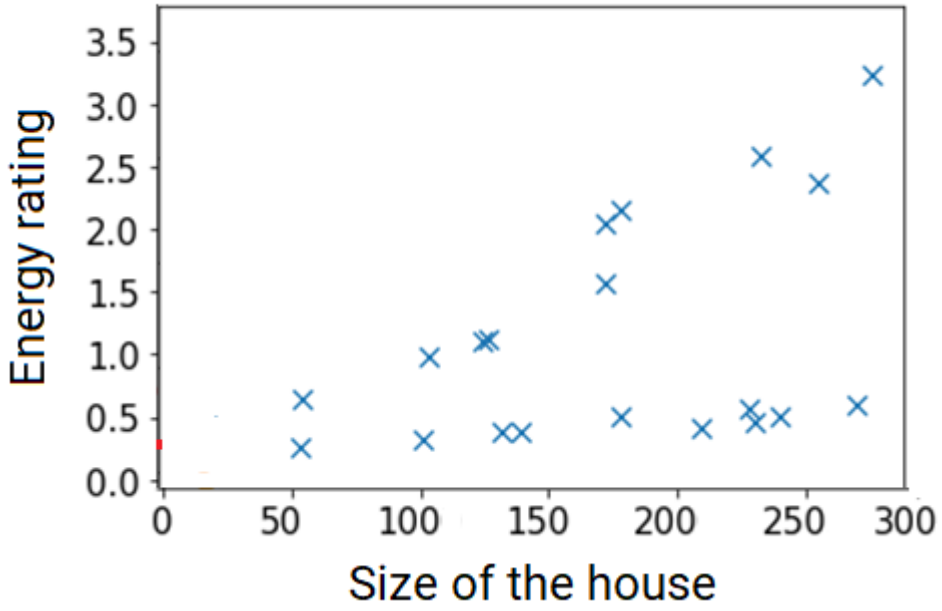
- What is different here?

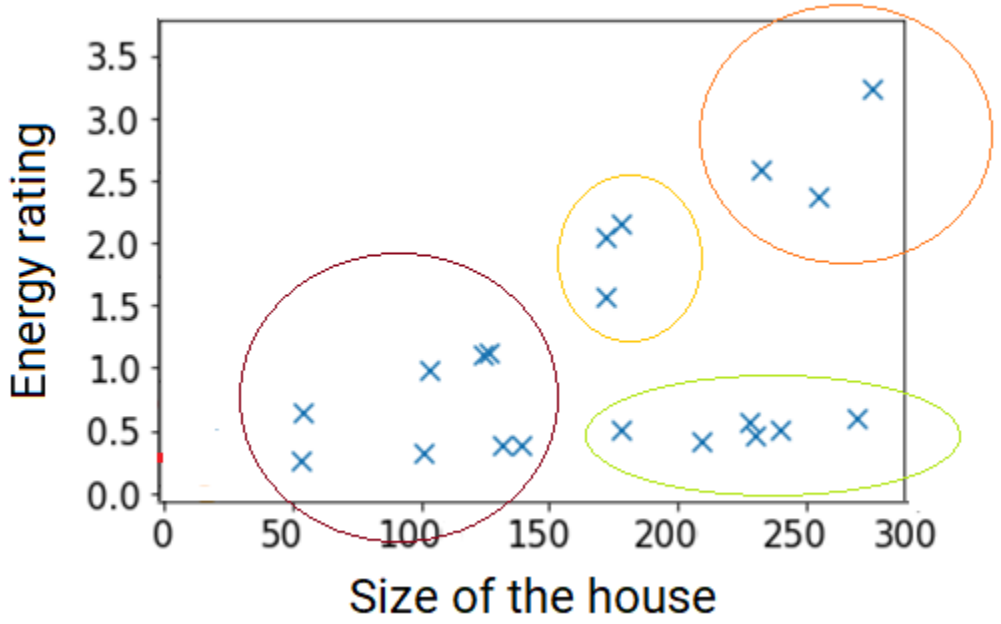


INPUT X	OUTPUT Y	APPLICATION
Voice recording	Transcript	Speech recognition
Historical market data	Future market data	Trading bots
Photograph	Caption	Image tagging
Drug chemical properties	Treatment efficacy	Pharma R&D
Store transaction details	Is the transaction fraudulent?	Fraud detection
Recipe ingredients	Customer reviews	Food recommendations
Purchase histories	Future purchase behavior	Customer retention
Car locations and speed	Traffic flow	Traffic lights
Faces	Names	Face recognition

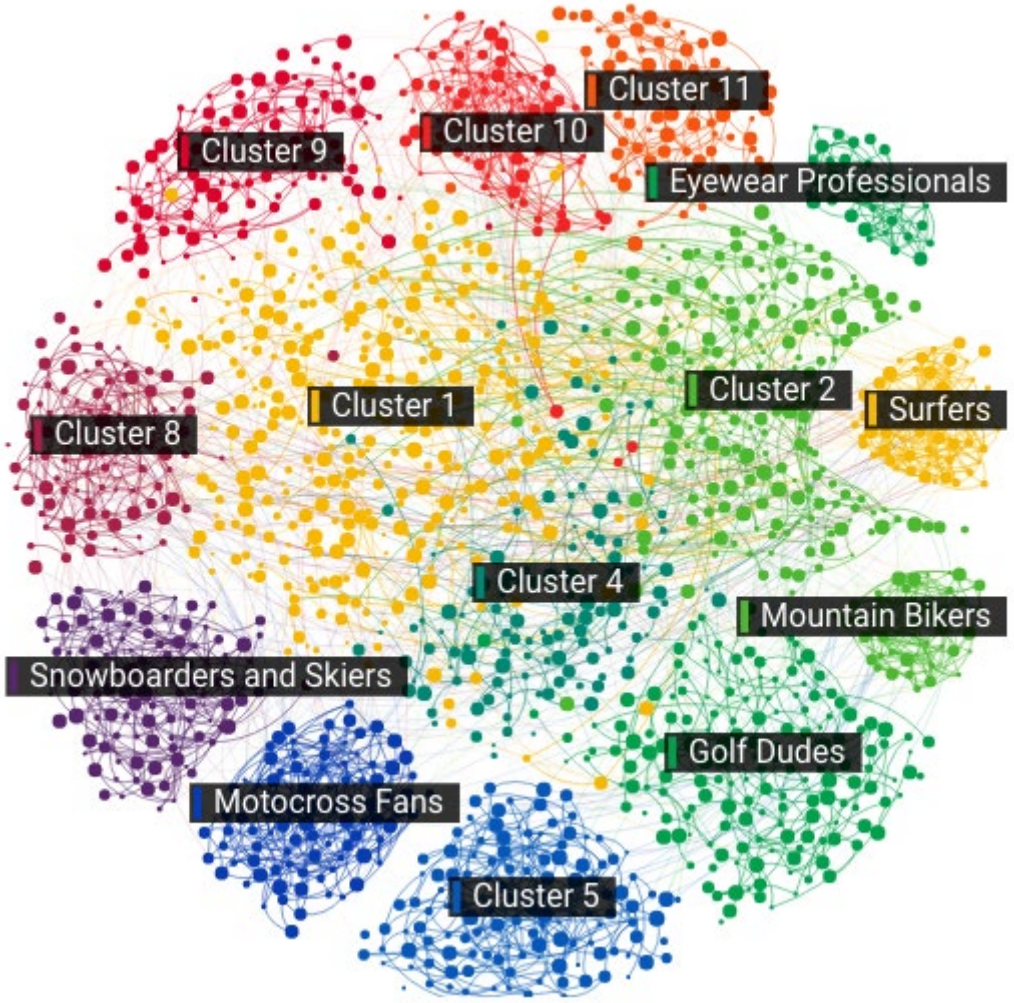
Clustering using unsupervised learning

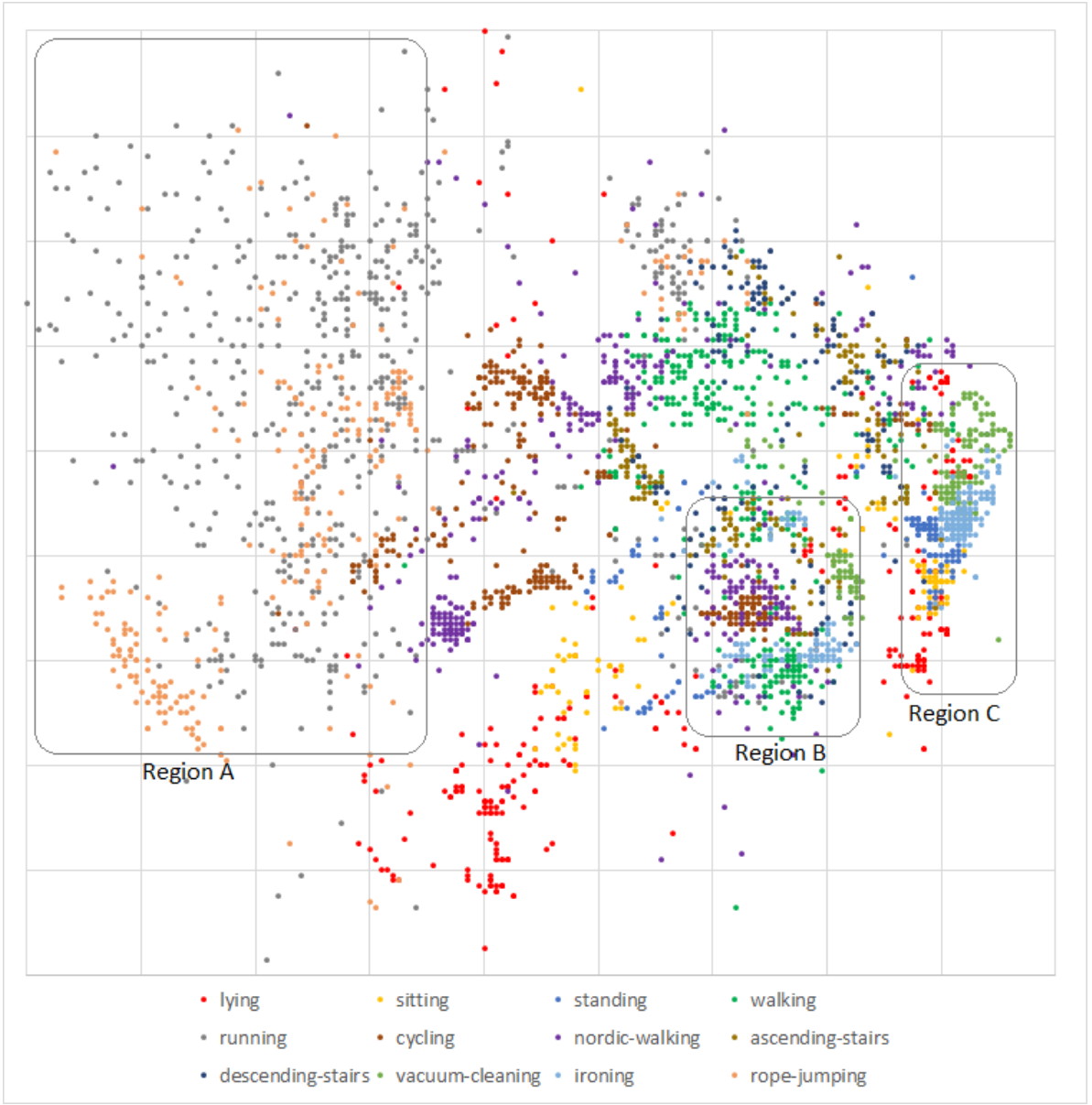
- Unlabelled, unstructured data (more than 80% of Big Data) – all inputs, no output
- Clustering is a feature of human intelligence, often the first step of infantile brain development.
- A cluster is a set of similar entities, or at a minimum, a set of entities that are more similar to each other than to members of other clusters.



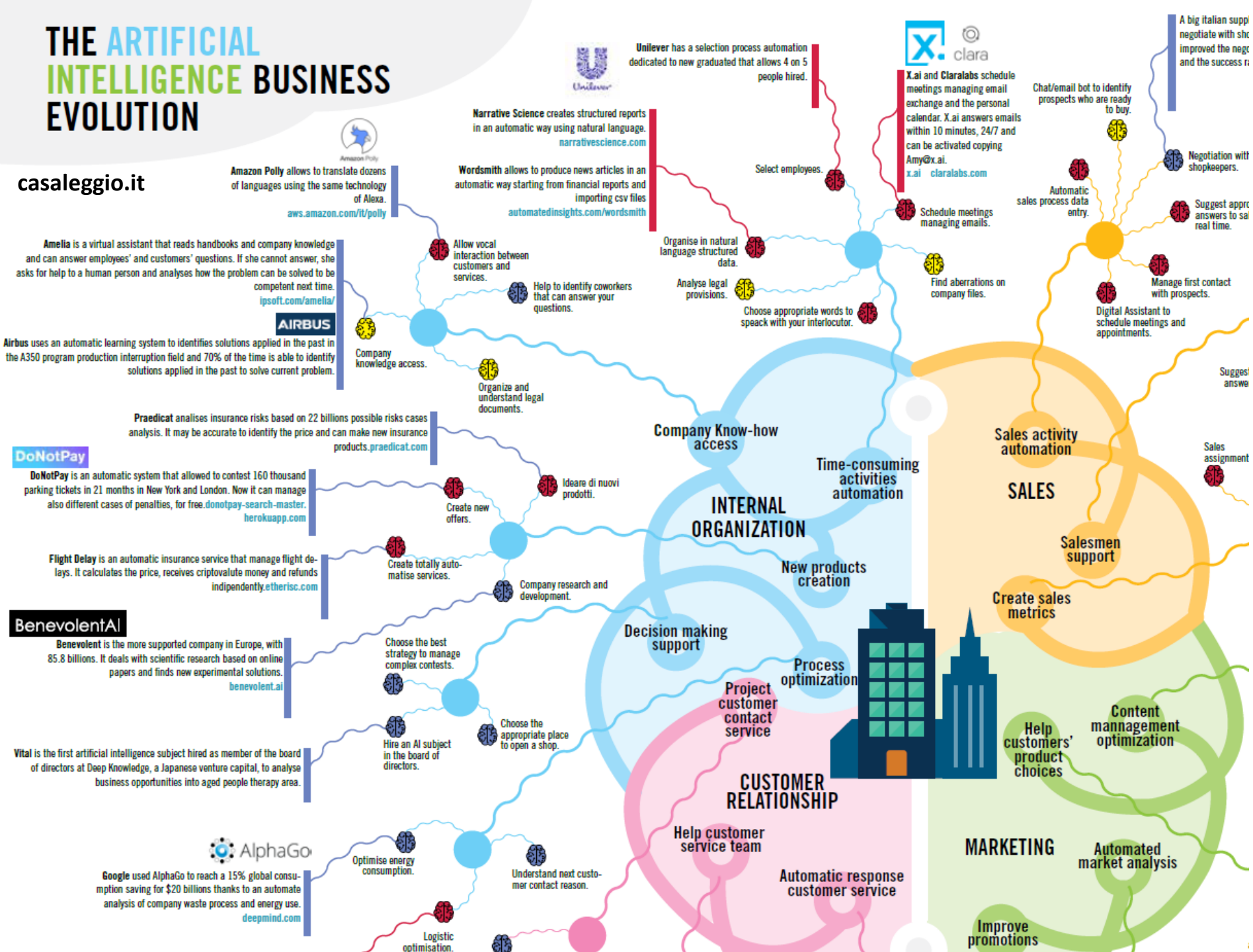


More examples





More!


THE ARTIFICIAL INTELLIGENCE BUSINESS EVOLUTION
casaleggio.it
Unilever has a selection process automation dedicated to new graduated that allows 4 on 5 people hired.
Narrative Science creates structured reports in an automatic way using natural language. narrativescience.com
Wordsmith allows to produce news articles in an automatic way starting from financial reports and importing csv files automatedinsights.com/wordsmith
Amazon Polly allows to translate dozens of languages using the same technology of Alexa. aws.amazon.com/it/polly
Select employees.
Organise in natural language structured data.
Analyse legal provisions.
Choose appropriate words to speack with your interlocutor.
X.ai and Claralabs schedule meetings managing email exchange and the personal calendar. X.ai answers emails within 10 minutes, 24/7 and can be activated copying Amy@x.ai. x.ai claralabs.com
Schedule meetings managing emails.
Find aberrations on company files.
Chat/email bot to identify prospects who are ready to buy.
Automatic sales process data entry.
Digital Assistant to schedule meetings and appointments.
Manage first contact with prospects.
Negotiation with shopkeepers.
Suggest appropriate answers to sales in real time.
A big italian supp negotiate with sho improved the nego and the success r
Amelia is a virtual assistant that reads handbooks and company knowledge and can answer employees' and customers' questions. If she cannot answer, she asks for help to a human person and analyses how the problem can be solved to be competent next time. ipsoft.com/amelia/
Allow vocal interaction between customers and services.
Help to identify coworkers that can answer your questions.
Company knowledge access.
Organize and understand legal documents.
AIRBUS
Airbus uses an automatic learning system to identifies solutions applied in the past in the A350 program production interruption field and 70% of the time is able to identify solutions applied in the past to solve current problem.
Praedicat analises insurance risks based on 22 billions possible risks cases analysis. It may be accurate to identify the price and can make new insurance products. praedicat.com
DoNotPay
DoNotPay is an automatic system that allowed to contest 160 thousand parking tickets in 21 months in New York and London. Now it can manage also different cases of penalties, for free. donotpay-search-master.herokuapp.com
Ideare di nuovi prodotti.
Create new offers.
Flight Delay is an automatic insurance service that manage flight delays. It calculates the price, receives criptovalute money and refunds indipendently. etherisc.com
Create totally automatise services.
Company research and development.
BenevolentAI
Benevolent is the more supported company in Europe, with 85.8 billions. It deals with scientific research based on online papers and finds new experimental solutions. benevolent.ai
Choose the best strategy to manage complex contests.
Vital is the first artificial intelligence subject hired as member of the board of directors at Deep Knowledge, a Japanese venture capital, to analyse business opportunities into aged people therapy area.
Hire an AI subject in the board of directors.
Choose the appropriate place to open a shop.
AlphaGo
Google used AlphaGo to reach a 15% global consumption saving for $20 billions thanks to an automate analysis of company waste process and energy use. deepmind.com
Optimise energy consumption.
Understand next customer contact reason.
Logistic optimisation.
Company Know-how access
Time-consuming activities automation
INTERNAL ORGANIZATION
New products creation
Decision making support
Process optimization
Project customer contact service
CUSTOMER RELATIONSHIP
Help customer service team
Automatic response customer service
Sales activity automation
SALES
Salesmen support
Create sales metrics
Sales assignment
Suggest answe
Content mannagement optimization
Help customers' product choices
MARKETING
Automated market analysis
Improve promotions

Automation

- “The use of technology in tasks and functions that are generally repetitive to achieve an equal or better performance than the human experts and operators who perform the same” – Parasuraman, 1997
- An automation that gradually becomes stable and permanent is recast as ‘machine operation’ (vs human operators)
- Human civilisation boasts a rich history of automation
  - mechanical clocks (Antikythera) of ancient Greece and Arabia, steam engines, boilers, regulators during the industrial revolution
  - relay logic and controllers following electrification in the 20th century, digital controllers and computers of the 21st
  - lights-out factories of Industry 4.0, algorithmic trading, fake news bots

Automation at work

- ‘Business automation, ICT automation, home automation, workflow automation, DevOps, CI/CD, orchestration’
- Business process automation (BPA) - automates **workflows** (across processes), new systems, APIs, integration
- Robotic process automation (RPA) - automates **tasks** (within the process), UI-based low/no code, single system
- Vendors – MS Power Automate, UiPath, Automation Edge, Blue Prism, TruBot, Automation 360

Automation in practice

- Successes
  - BMS process control systems and PID controllers – regulate flow, temperature, pressure, level
  - ATM – basic bank transactions
  - Code automation – CI/CD
  - Voice/ virtual assistant – Siri, Alexa, Cortana, Google
  - Amazon warehouses – debatable but most effective human-machine interactions
  - Personalised/targeted advertising on social media (also debatable)
- Failures
  - Transformation of jobs, not elimination
  - Boeing 737 Max
  - RoboDebt

Process Automation

- **First wave - standardised processes**
  - Henry Ford’s assembly line for the automobile industry
  - Mainly in manufacturing
  - Each steps in the overall process was measured, optimized, and standardized for efficiency gains
- **Second wave - automated processes**
  - Business process reengineering and office automation, ATMs in banking
  - "Reengineering Work: Don't Automate, Obliterate“
  - Also, process improvement with Six Sigma (DMAIC), Jack Welch and GE
- **Third wave (current) – adaptive (hyper-automated) processes**
  - RPA – pre-defined business logic, GUI vs API-based
  - AI – emergent and dynamic, complement and augment automated processes

AI and Automation

- How can AI improve automation?

  "The use of technology to achieve an equal or better performance than humans"

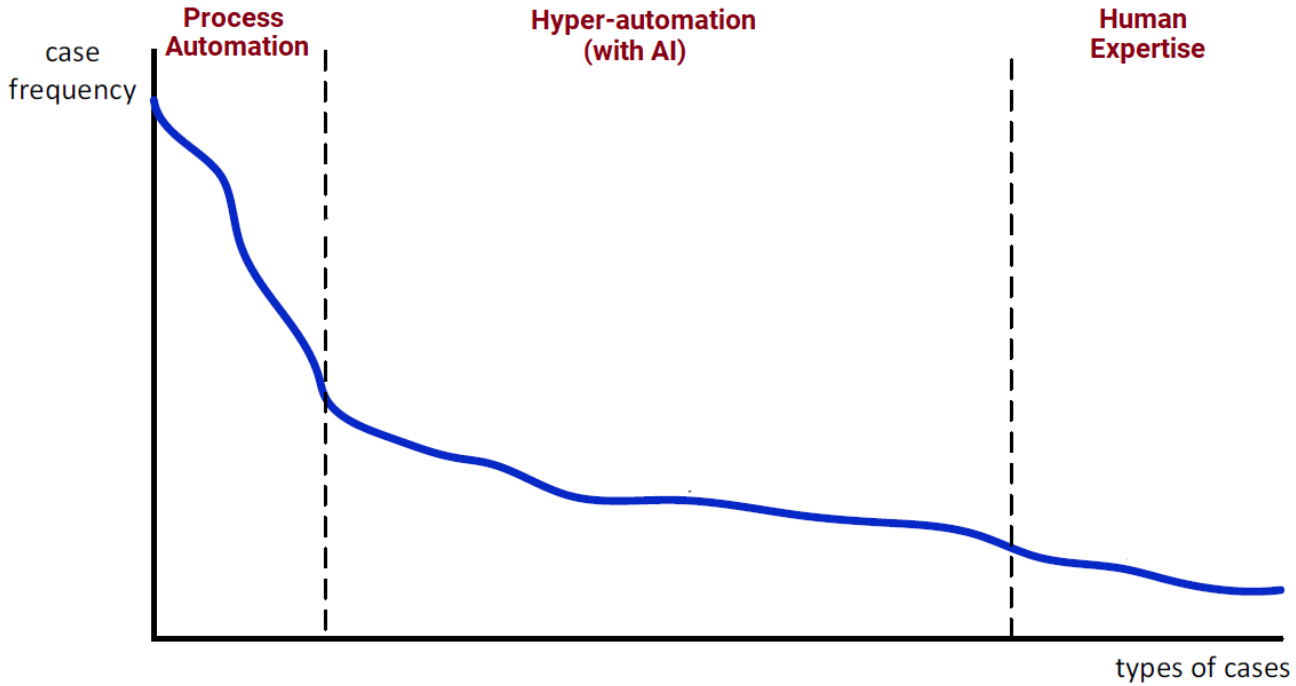
  "The science of making machines do things that would require intelligence if done by humans"

  Consider layers of functionality – performance and intelligence

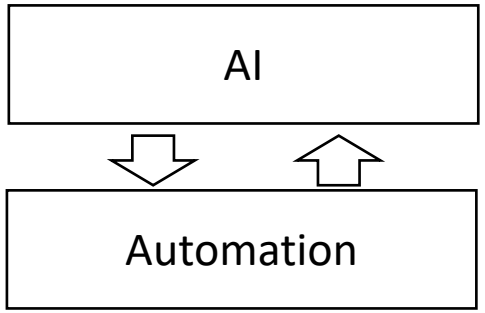
- Hyper-automation
  - Gartner in Top Strategic Technology Trends for 2021
  - Digital acceleration of decision process and task automation tools
  - Expedited by the pandemic and remote work requirements
  - In other words, the use of AI in Automation

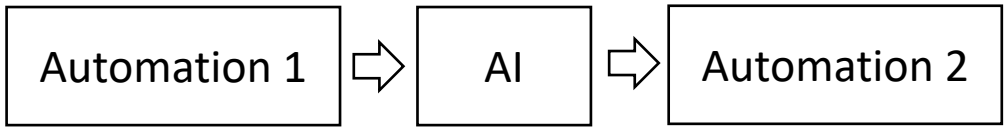
Hyper-automation

- Sequential – order processing
- Repetitive – order provision
- Interactive – service desk
- Decision – recommendation
- Optimise – lead generation



Adapted from Alast et al 2018



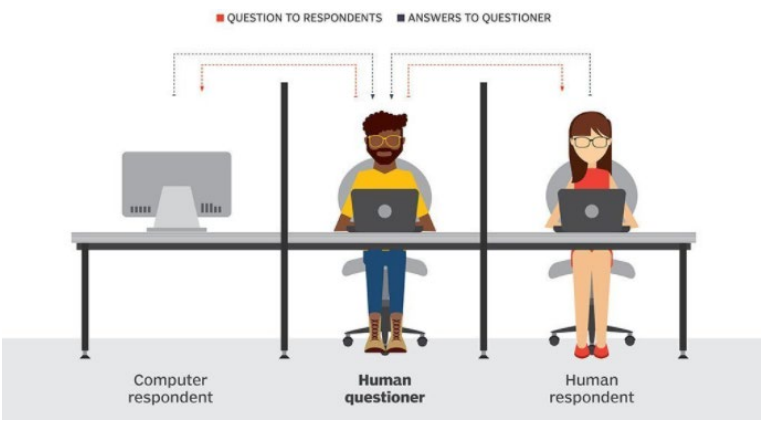


From action to hyper-automation

Capability	Application	Output	Action	Hyper-automation
Prediction	Sales prediction	Dollar sales, unit sales	Market/sales strategy, new products	Direct predictions for supply chain automation
Prediction	Revenue forecasting	Future revenue	Budgeting	Algorithmic trading
Classification	Sentiment/emotion analysis	Positive, neutral, negative or 8 emotions	CRM, service strategy	Service prioritisation, discounts, VAS
Classification	Network anomalies	Anomalous readings and properties	Maintenance, security, BPM	Predictive maintenance, personnel scheduling
Association	Customer profiling	Customer segments	Markets and products	Micro-targeting clickstream
Association	Complaints handling	Themes and topics	Resolutions, planning	Employee performance review
Optimisation	EV dis/charging	Charging schedule	Grid management	Storage networking
Optimisation	Network/road/air traffic	Route plans, scenario models	Traffic management, fleet management	Detour incentivisation through navigation apps

Evaluating intelligence

- Alan Turing - Can machines think? Too vague to consider “thought”
- Based on the imitation game:
- A human questioner, a human respondent and a computer respondent. The questioner tries to distinguish the human from the computer by asking questions from both. A computer that is indistinguishable from the human is deemed intelligent.
- Descartes 1641, Mind-body dualism, “I think, therefore I am… robot”
- A chatbot named Eugene Goostman passed the test in 2014 (simulates a 13-year old Ukrainian boy)
- And many other breakthroughs – Chess, Robocup, Roomba, Watson, AlphaGo, Tesla, deep fakes, duplex, GPT3… and mainstream apps



Visual Turing and a few negatives..

1. Q: Is there a person in the blue region? A: yes
2. Q: Is there a unique person in the blue region? A: yes
   (Label this person 1)
3. Q: Is person 1 carrying something? A: yes
4. Q: Is person 1 female? A: yes
5. Q: Is person 1 walking on a sidewalk? A: yes
6. Q: Is person 1 interacting with any other object? A: no

⋮

9. Q: Is there a unique vehicle in the yellow region? A: yes
   (Label this vehicle 1)
10. Q: Is vehicle 1 light-colored? A: yes
11. Q: Is vehicle 1 moving? A: no
12. Q: Is vehicle 1 parked and a car? A: yes

⋮

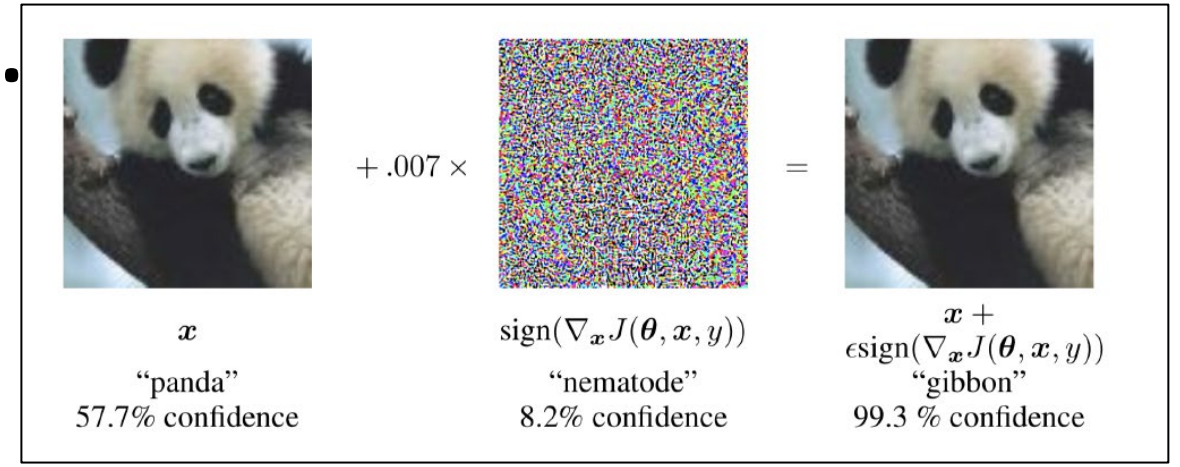
14. Q: Does vehicle 1 have exactly one visible tire? A: no
15. Q: Is vehicle 1 interacting with any other object? A: no
17. Q: Is there a unique person in the red region? A: no
18. Q: Is there a unique person that is female in the red region? A: no
19. Q: Is there a person that is standing still in the red region? A: yes
20. Q: Is there a unique person standing still in the red region? A: yes
    (Label this person 2)

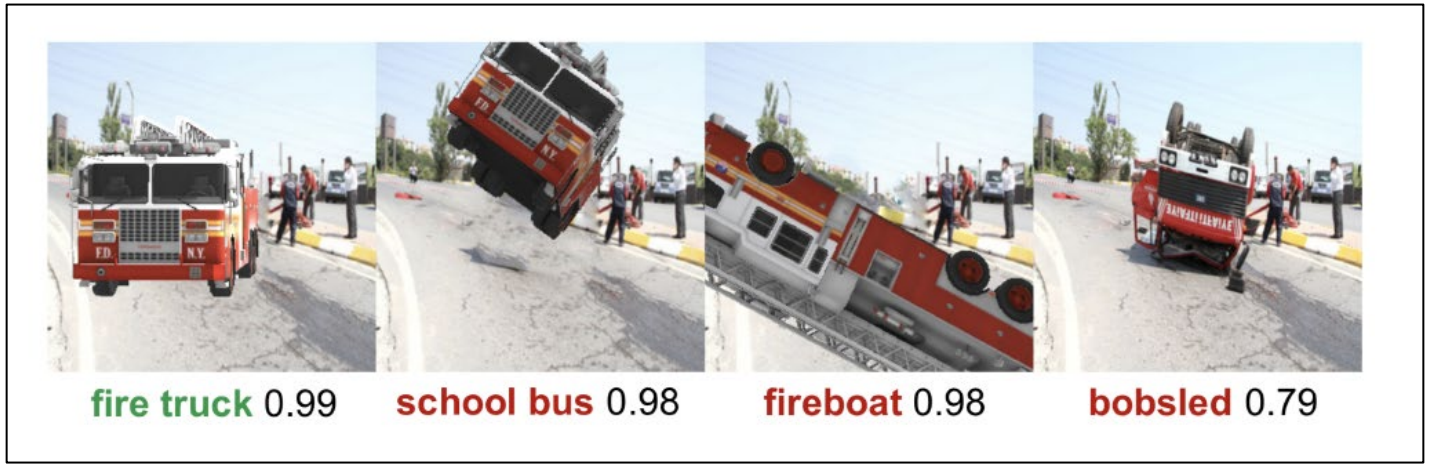
⋮

23. Q: Is person 2 interacting with any other object? A: yes
24. Q: Is person 1 taller than person 2? A: amb.
25. Q: Is person 1 closer (to the camera) than person 2? A: no
26. Q: Is there a person in the red region? A: yes
27. Q: Is there a unique person in the red region? A: yes
    (Label this person 3)

⋮

36. Q: Is there an interaction between person 2 and person 3? A: yes
37. Q: Are person 2 and person 3 talking? A: yes





The beginnings

- The birth of AI is generally attributed to the Dartmouth Conference, a two-month workshop at Dartmouth in 1956
  - Ten attended, Claude Shannon, the father of information theory, Marvin Minsky, father of modern AI, Nathaniel Rochester, the lead designer of the IBM 701 (first mass produced computer); and John McCarthy, creator of the Lisp programming language
  - The term itself “artificial intelligence” was coined by John McCarthy at this conference
  - Newell and Simon demonstrated the "Logic Theorist" which simulate human reasoning.
  - It proved 38 of the first 52 theorems in Principia Mathematica.

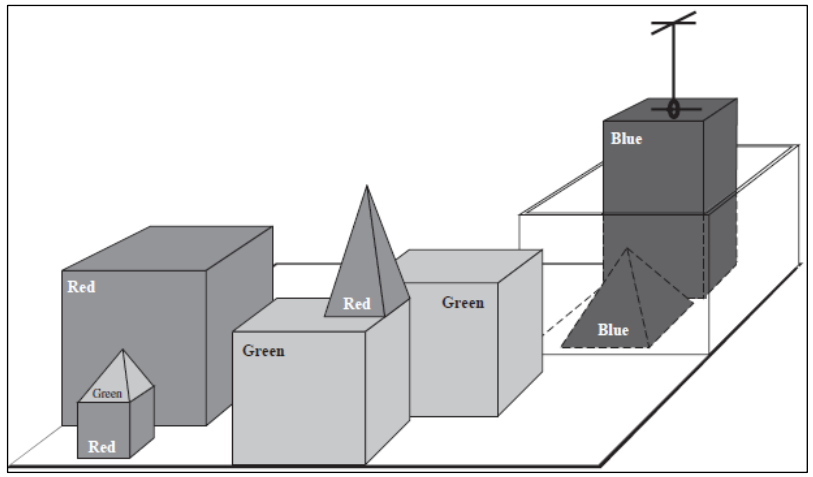
- Opening paragraph:

> We propose that a 2 month, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The golden years 1956 – 1974

- The General Problem Solver, the Geometry Theorem Prover, LISP, the world of blocks and Huffman's vision project, the Perceptron.

- Blocks world - “Find a block which is taller than the one you are holding and put it in the box.”



- Marvin Minsky in 1970, "In from three to eight years we will have a machine with the general intelligence of an average human being”

- The first AI winter (1974 – 1980) - due to exaggerated claims (Moravec's paradox) and lack of value/progress.

Boom… and bust 1980 - 1987

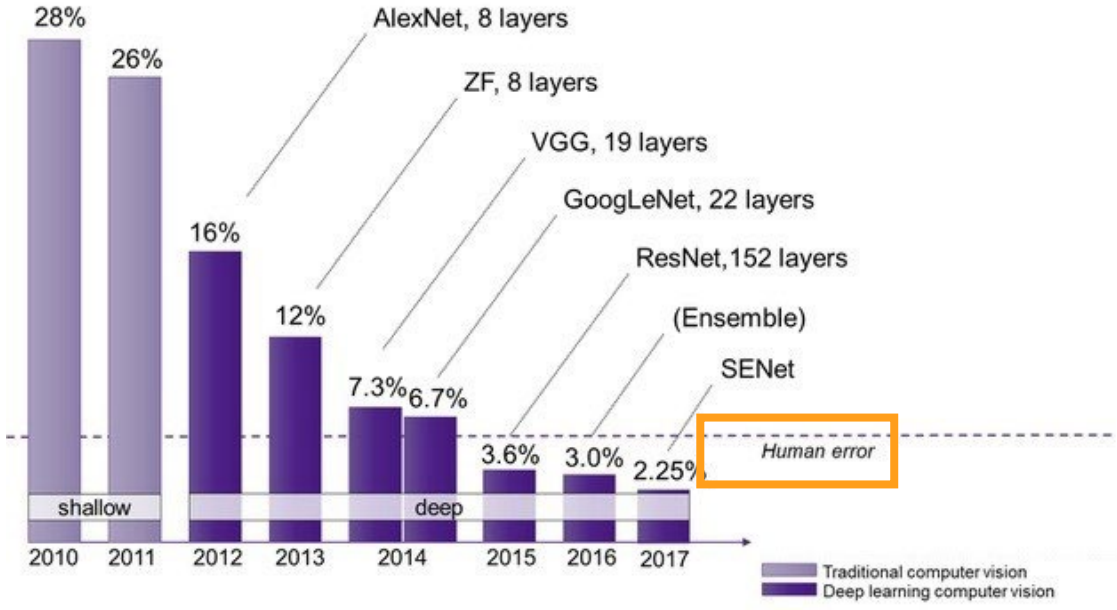
- A resurgence in the 1980s led by strong methods of reasoning, in contrast to the weak methods of the 70s that generated commercial value.
- Expert systems
  - Dendral project that inferred molecular structure from the information provided by a mass spectrometer
  - MYCIN to diagnose blood infections from about 450 rules.
- Connectionism (early days of machine learning)
  - back-propagation – the backward propagation of errors across neuronal layers
  - Hopfield nets – associative memory in time, recall a ‘whole’ from a single ‘part’
  - Parallel distributed processing – network of nodes, learning rule, activation etc.
- The second AI winter 1987 – 1993, due to the desktop computer, funding cuts, receding interest from government and industry funding bodies.

Recent developments

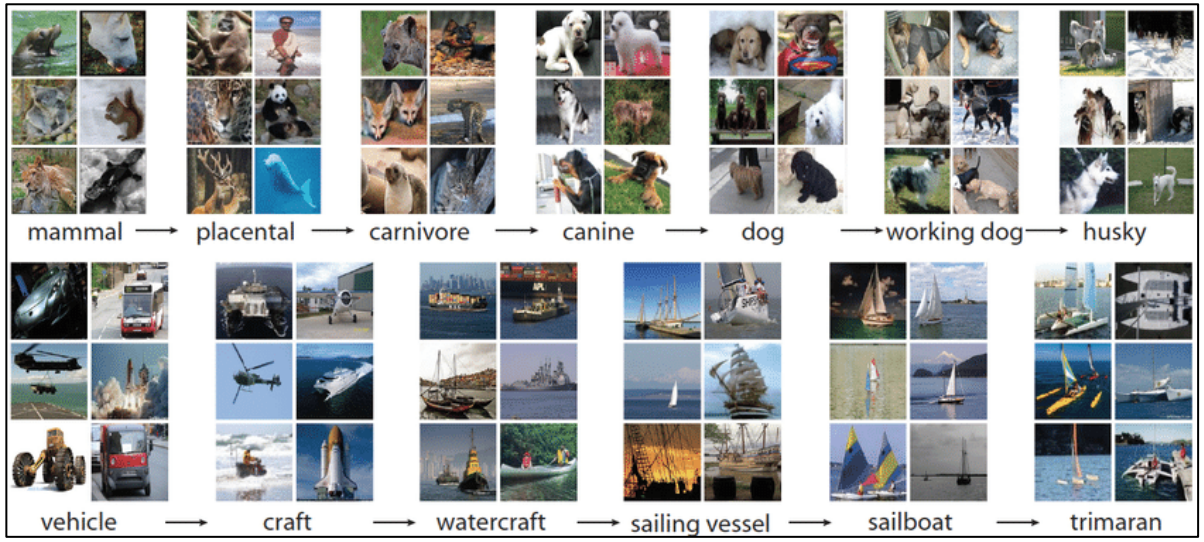
- A more cautious approach based on the scientific method (experimentation and mathematical formulation) was adopted in the 1990s (1997-2011).
  - Victory of the neats (neats vs scruffy)
  - Deep Blue vs Kasparov
- Enabled by more powerful computers (Moore's law)
- First applications in optical character recognition, speech recognition and computer vision.
- Although not commonly referred to as AI due to obvious reasons, this wave of interest has persevered through to the present date.
  - Intelligent agents, data mining, industrial robotics, intelligent search, neurocomputing, machine learning.
- In 2011 - data (Big Data), algorithms (deep learning) and processing (cloud computing)
- And now - towards AGI, ASI and the singularity..

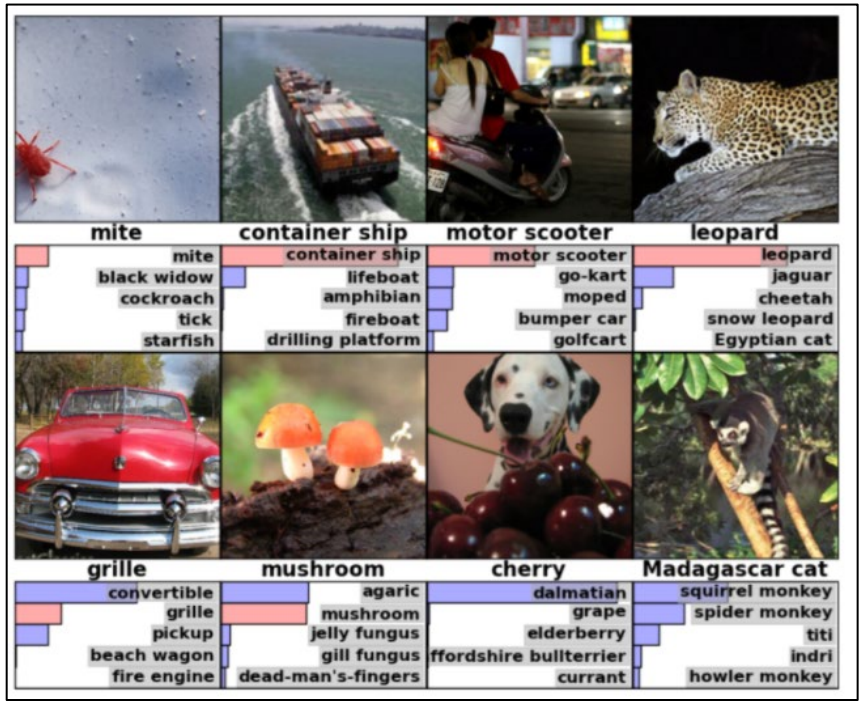
The rise of deep learning

- Better data instead of better algorithms
- In 2009, Prof Li worked closely with a co-inventor of the WordNet database (1985) Prof Fellbaum to create a dataset called ImageNet.
  - A database of ‘URLs’ to over 14 million images - hand-annotated, crowdsourced, localised objects
  - Multiple images for more than 20,000 categories (like a hundred images of bananas)
- ImageNet Large Scale Visual Recognition Challenge (ILSVRC)
  - Image classification, + localisation, + detection
  - Up until 2011, one of four wrong ~25% error
  - AlexNet – Prof Hinton’s work in 2012
  - 60 million parameters, 650,000 neurons
  - Prof Ng’s GPU computations from 2009



ImageNet





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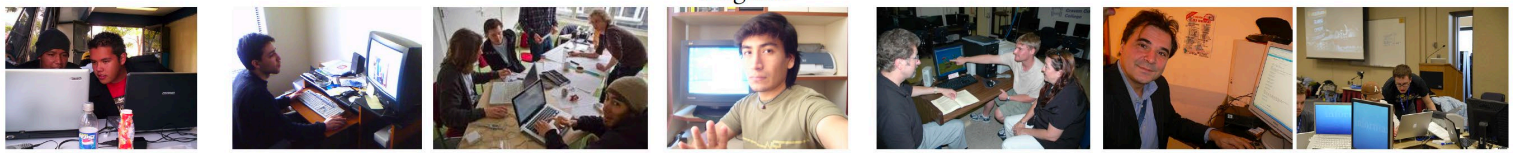
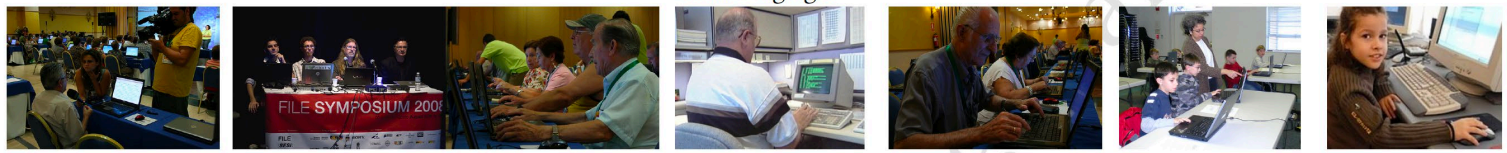


Balancing gender:

Balancing skin color:

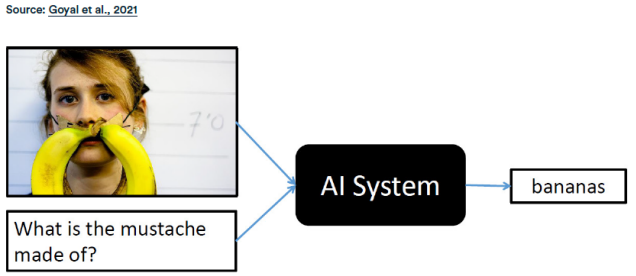
Balancing age:



Ethical refresh:
http://image-net.org/update-sep-17-2019

Stanford AI Index Report 2022 - Vision

- AI is more affordable and high performing: Since 2018, the cost of training image classification has decreased by 63.6%, while training times have improved by 94.4%, driven by commercial adoption
- Image classification: in 2021, an average 10% error on “Top-1” accuracy compared to 40% in 2012 (Top-5 is 99%)
- Facial recognition: 100%, in 2017% error rates of 50%, in 2021, none over 3%. Only 5-16% worse with masks on
- Image segmentation: colonoscopy polyps on CVC-ClinicDB, accuracy of 94% in 2020, 83% in 2015
- Image generation: generating images that are indistinguishable from real ones, measured by the FID score which was 37 in 2018 and 7.7 in 2021
- Deepfake detection: based on the FaceForensics++ dataset, accuracy of 70% in 2012, 97% in 2021
- Human pose estimation: Leeds dataset of 2000 images from Flickr of athletes playing a sport, 99.5% in 2021, 82% in 2015



Stanford AI Index Report 2022 - Language

- Sentiment: SemEval 2014 Task 4 Sub Task 2, classify sentiment of a phrase, instead of an entire sentence or paragraph, accuracy of 89% in 2021, compared to 72% in 2015.
- Speech recognition: 100%, one of the first for AI (0-9), LibriSpeech, error rate of 1.4% not exceeded in 2021.
- Speaker recognition: VoxCeleb, error rate of 7% in 2017 to 1% in 2022
- Machine translation: 100%, commercial and open-source applications 9 in 2017, 46 in 2021
- Inference: SNLI dataset of 600,000 sentence pairs labelled as entailment, contradiction, or neutral: accuracy of 93% in 2021, 83% in 2015
- Abductive Inference: drawing the most plausible conclusion from a context of limited information and uncertain premises (e.g. left a window open, returns from work to find valuables missing, infer: break in), an accuracy increase of 7.7% since 2019, but lower than a standard human effort

If you can dream it, you can achieve it—unless you're a goose trying to play a very human game of rugby. In the video above, one bold bird took a chance when it ran onto a rugby field mid-play. Things got dicey when it got into a tussle with another player, but it shook it off and kept right on running. After the play ended, the players escorted the feisty goose off the pitch. It was a risky move, but the crowd chanting its name was well worth it.	The crowd believed they knew the name of the goose running on the field.	Because the crowd was chanting its name, the crowd must have believed they knew the goose's name. The word "believe" may have made the system think this was an ambiguous statement.	A3 (News)	E	N	E E	Reasoning (Facts), Reference (Coreference)

Premise: An adult dressed in black holds a stick.
Hypothesis: An adult is walking away, empty-handed.
Label: contradiction
Explanation: Holds a stick implies using hands so it is not empty-handed.

Premise: A child in a yellow plastic safety swing is laughing as a dark-haired woman in pink and coral pants stands behind her.
Hypothesis: A young mother is playing with her daughter in a swing.
Label: neutral
Explanation: Child does not imply daughter and woman does not imply mother.

Premise: A man in an orange vest leans over a pickup truck.
Hypothesis: A man is touching a truck.
Label: entailment
Explanation: Man leans over a pickup truck implies that he is touching it.

Stanford AI Index Report 2022 - Other Highlights

- AI is more affordable and high performing: cost of image classification has decreased by 63.6%, while training times have improved by 94.4%
- More advanced language models and multimodal models but they also learn multimodal biases
- Private investment in 2021 ~$93.5 billion, more than double the total private investment in 2020
- In 25 countries, number of bills containing “artificial intelligence” that were passed into law grew from just 1 in 2016 to 18 in 2021
- Increasing importance of AI ethics - since 2014, fivefold increase in AI ethics publications, where researchers with industry affiliations contributed 71% more each year
- A McKinsey survey reveals ~41% respondents recognise “equity and fairness” and “explainability” as AI risks, but only ~27% are taking steps to address these
- Robotic arms are cheaper: median price decreased by 46.2% in the past five years

Summary

- Defining AI
- AI Capabilities
- AI Taxonomy
- Progression of AI
- AI and Automation