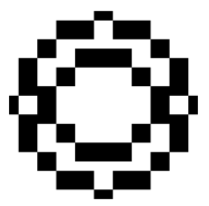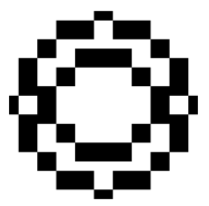# Machine Learning Tribes

Master in Data Science and Advanced Analytics
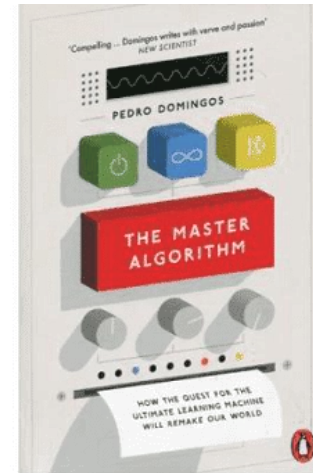BA and DS

Roberto Henriques

How do computers get new knowledge?

- Fill in gaps in existing knowledge

- Emulate the brain

- Simulate evolution

- Reduce uncertainty

- Check for similarities between old and new
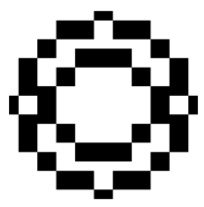
Tribes of Machine Learning

- Associated to each of these ways, we have Machine Learning areas

    - Symbolism

    - Connectionism

    - Evolutionary Computation

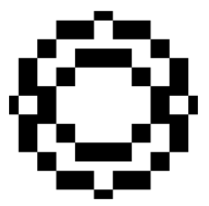   - Statistical Learning

    - Analogy Modelling

The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World
- Pedro Domingos, 2015
- ISBN:978-0465065707

Tribes of Machine Learning

Tribe	Origins	Master Algorithm
Symbolists	Logic, philosophy	Inverse deduction
Connectioninsts	Neuroscience	Backpropagation
Evolutionaries	Evolutionary biology	Genetic programming
Bayesians	Statistics	Probabilistic inference
Analogizers	Psycology	Kernel Machines (SVM)

Symbolists

- As in mathematical operations

Addition $\qquad 2 + 2 = ?$

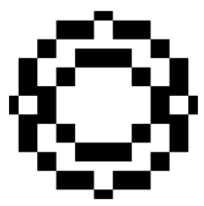Subtraction $\qquad 2 + ? = 4$

- Inverse deduction (induction)

Deduction

Socrates is human
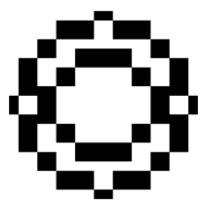+ Humans are mortal
= ?

Induction

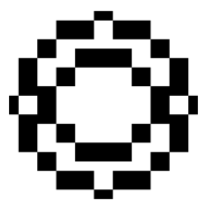Socrates is human
+ ??
= Socrates is mortal

Symbolists

- Logic programming

  - Prolog

  - Inductive and Abductive logic programming

- Expert systems

  - Knowledge bases, Inference Engines,

- Decision Trees

  - C4.5 the most popular, but has many variants, including regression trees and random forests

- Functional programming – Lisp …
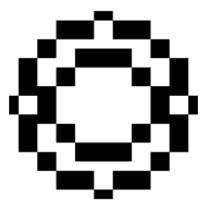
Connectionists

- World is not logic!

- Draws on Biology, more specificially Biological Neurons
  - Model neural cells, McCullor and Pitts (1943)

- Milestones
  - 1957: Perceptron invented by Frank Rosenblatt.
  - 1968: Minsky and Papert publish the book Perceptrons, criticizing single-layer perceptrons.
  - 1986: Backpropagation (re)invented, and connectionist research restarts
  - 2006: Hinton *et al.* publish A fast learning algorithm for deep belief nets, which rejuvinates interest in Deep Learning. Important points of Deep Learning success and transfer learning
  - 2017: AlphaGo defeats reigning Go world champion, using DL
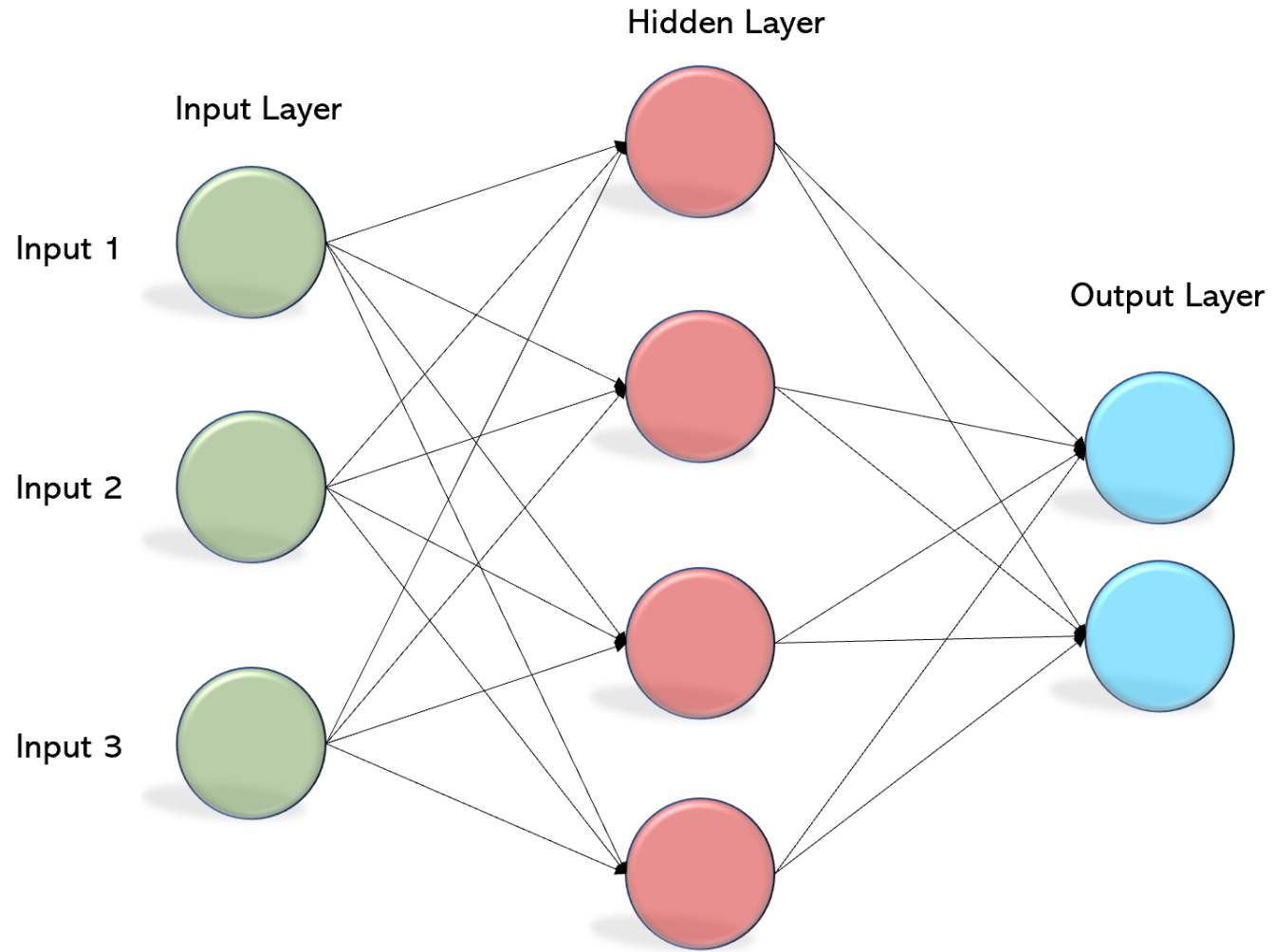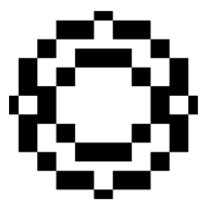
Connectionists

- Main algorithms

  - Perceptron (simple perceptron)

  - Multilayer Perceptron (MLP)

    - Varying structures, including feedback and time-delay

  - DeepLearning Networks

    - Convolutional Neural Networks

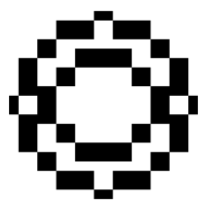 - Hopfield Networks

  - Boltzman Networks
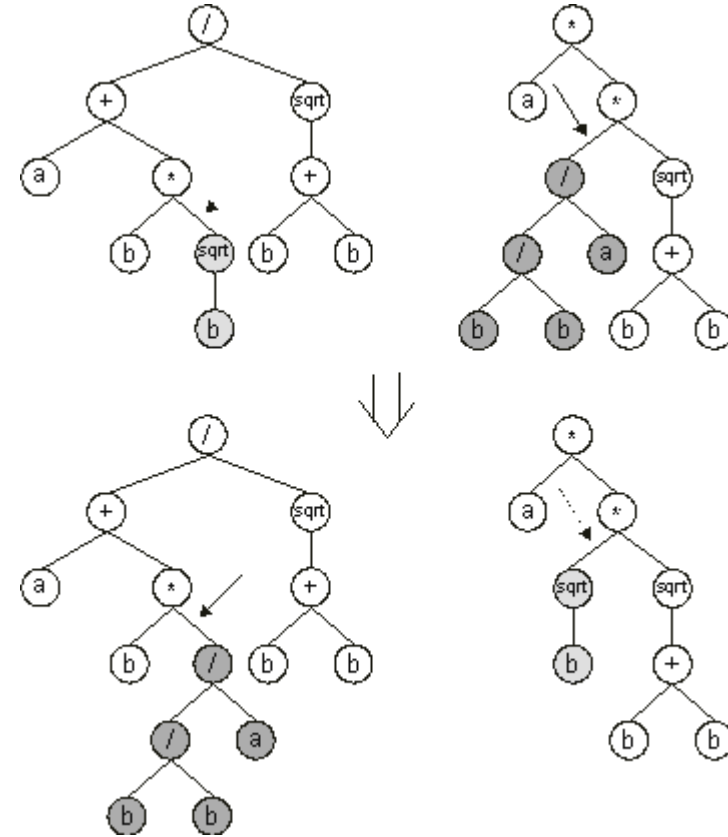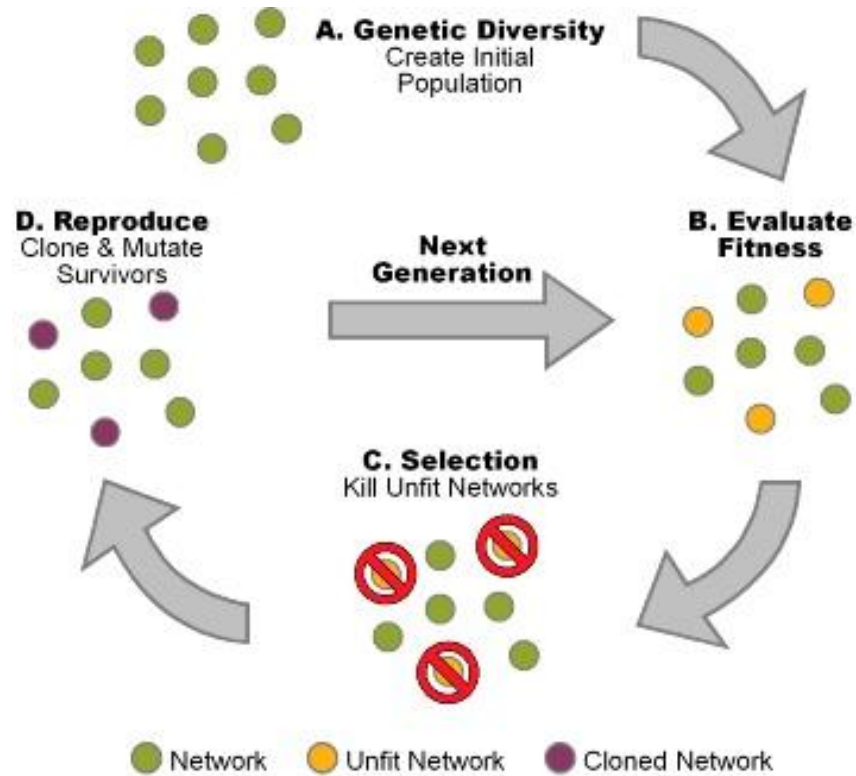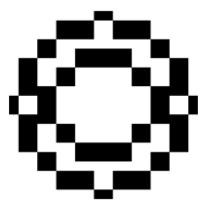
Connectionists: MLP

Evolutionary

- Draws on Biology, the Theory of Evolution and Natural Selection

  - Models natural selection, crossover, mutations

- Milestones:

  - 1964: Lawrence Fogel published on *evolutionary programming*

  - 1975: John Holland invents *genetic algorithms*.

  - 1981: Richard Forsyth coins *genetic programming* and demonstrates it using trees of actions.

  - 1991: Dorigo writes a thesis on *Ant Colony Optimization*

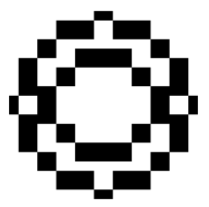 - 1995: Kennedy & Eberhart invent *Particle Swarm Optimization*

Evolutionaries: GA and GP

Bayesians

- Draws on Statistics

  - Bayes Theorem, and evidence

- Everything is uncertainty, so compute probabilities

- Milestones:

  - 1953: Monte Carlo Markov Chain (MCMC) invented. Bayesian inference finally becomes tractable on real problems.

  - 1968: Hidden Markov Model (HMM) invented.

  - 1988: Judea Pearl authors Probabilistic Reasoning in Intelligent Systems, and creates the discipline of probabilistic graphical models (PGMs).

  - 2000: Pearl authors Causality: Models, Reasoning, and Inference, and creates the discipline of causal inference on PGMs
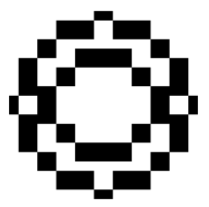
Bayesians: algorithms

- Bayesian Classifiers
  - NB, MAP, ML

- Bayesian Belief Networks

- Variants of Markov Models

https://luminousmen.com/media/data-science-bayes-theorem-2.jpg
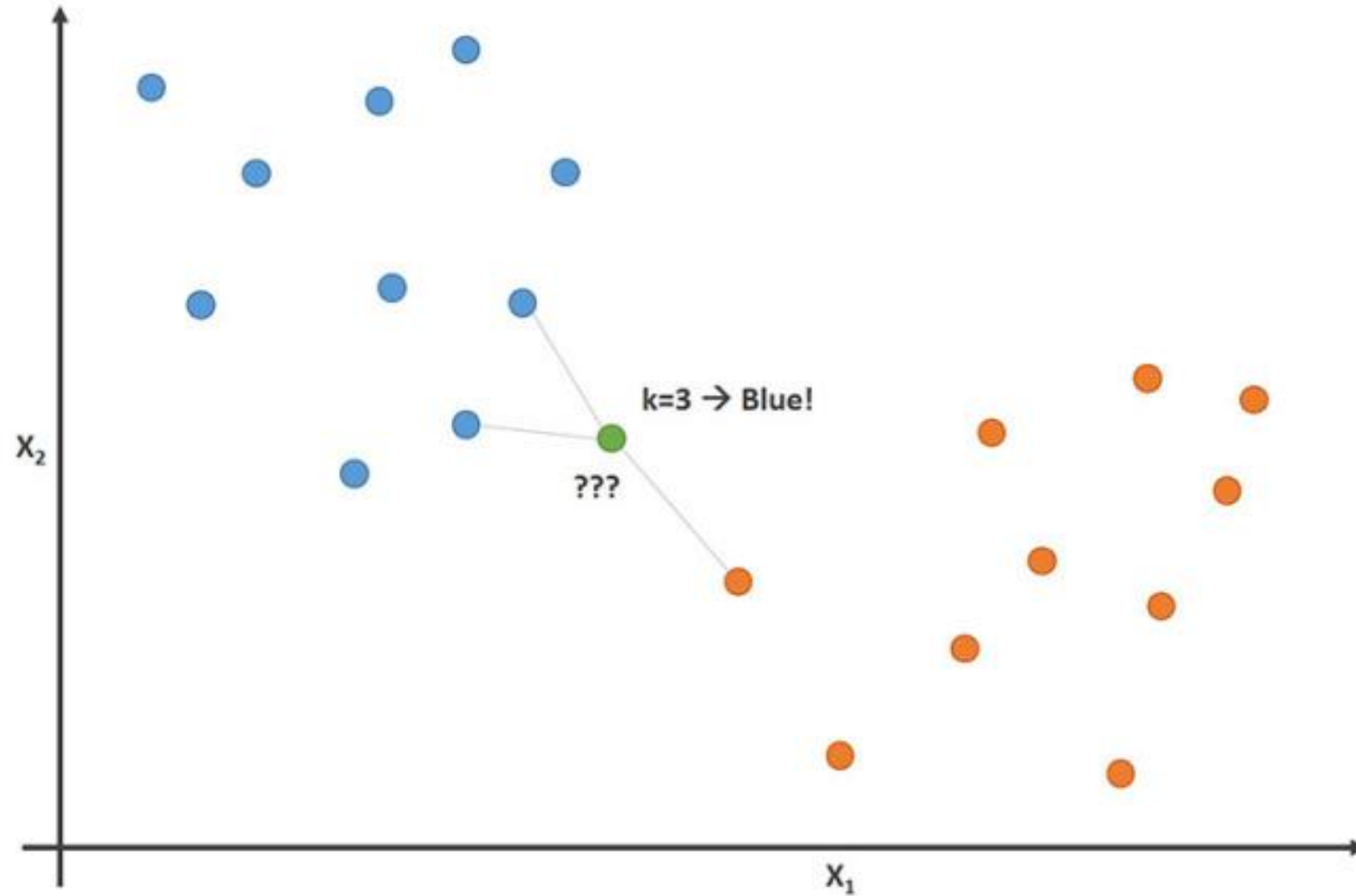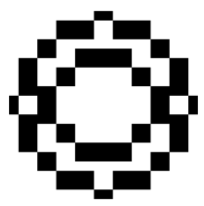
Analogizers

- Everything we learn is reasoning by analogy

- Draws on Human behaviour and Statistics

- Milestones:

  - 1968: k-nearest neighbor algorithm increases in popularity.

  - 1979: Douglas Hofstadter publishes Godel, Escher, Bach.

  - 1982. Kohonen's book on Self-Organization and Associative Memory

  - 1992: Support Vector Machines (SVMs) invented
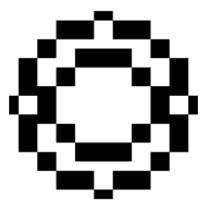
Analogizers: kNN and SVM

Can we unify all tribes?

Tribe	Origins	Master Algorithm
Symbolists	Logic, philosophy	Inverse deduction
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Components of ML

- Representation

  - Probabilistic logic (Markov logic Networks)

  - Each rule has a weight

- Evaluation

  - Posterior probability

  - User-defined objective function

- Optimization

  - Formula discovery: Genetic programming

  - Weight learning: Backprop

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Questions?