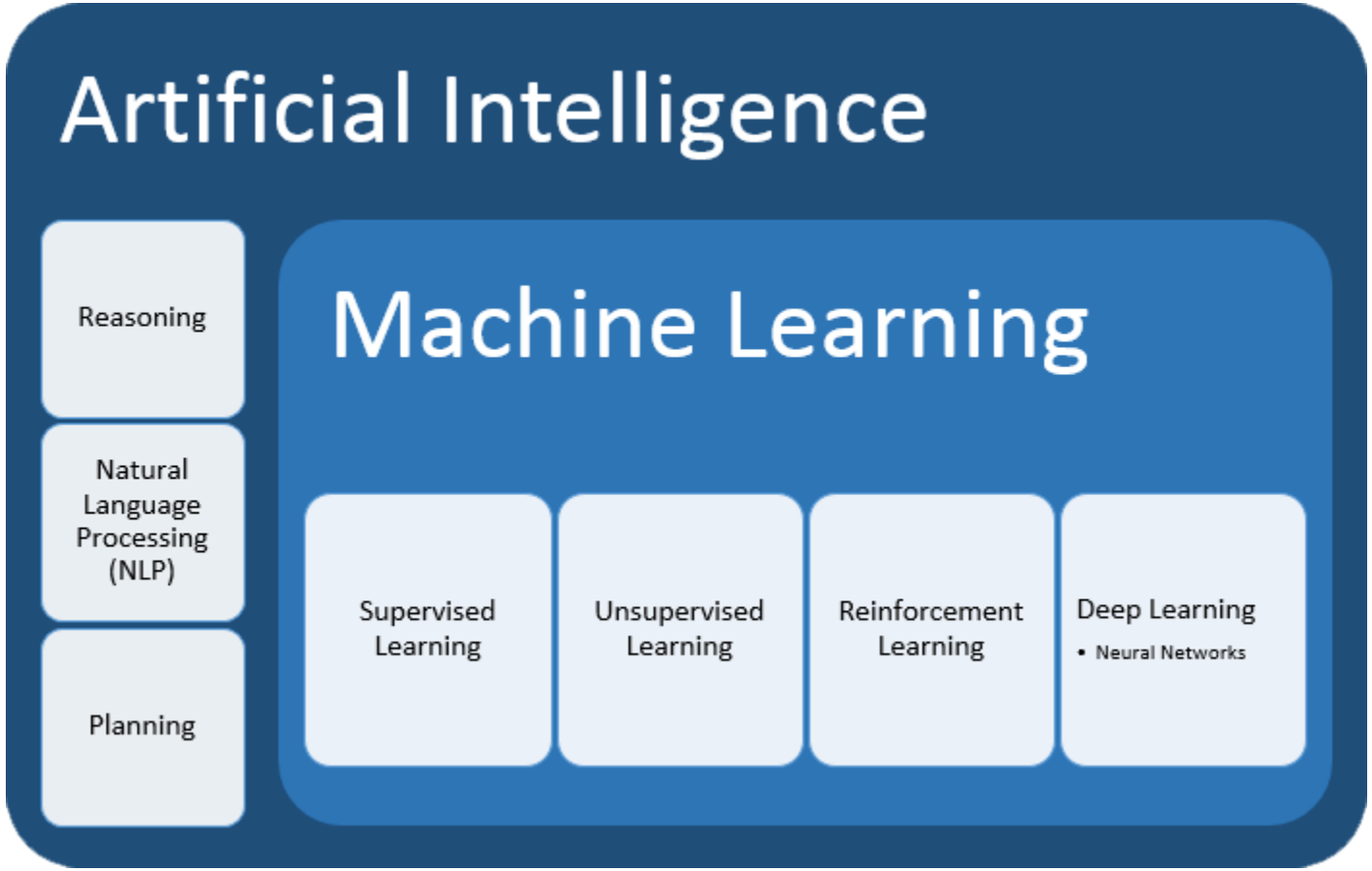
Machine Learning

Arturo Aguilar, Diego Hernandez & Mariano Herrera

Finamex®
Casa de Bolsa

Pynance+ Workshops

Artificial Intelligence & Machine Learning



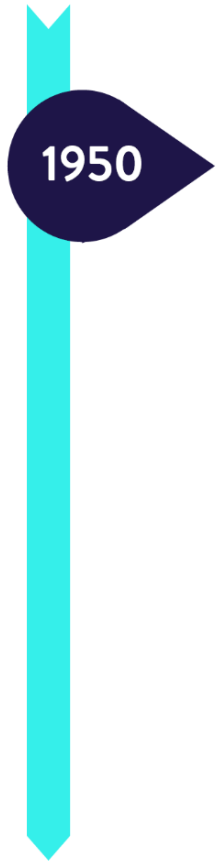
Source: https://www.ibm.com/analytics/machine-learning

Artificial Intelligence

Think of artificial intelligence as the entire universe of computing technology that exhibits anything remotely resembling human intelligence. AI systems can include anything from an expert system—a problem-solving application that makes decisions based on complex rules or if/then logic—to something like the equivalent of the fictional Pixar character Wall-E, a computer that develops the intelligence, free will, and emotions of a human being.

Source: https://www.ibm.com/cloud/learn/what-is-artificial-intelligence

It started more than 70 years ago…



Alan Turing publishes the landmark paper "Computing Machinery and Intelligence", in which he:

- Speculates on the possibility of Thinking Machines.
- Defines the "Turing Test / Imitation Game" that determines when a machine can be considered as "thinking".
- Concludes that thinking machines are at least plausible.

It is the first serious proposal in the philosophy of artificial intelligence (AI). For a good counter-argument read John Searle's paper, "Minds, Brains and Programs" (1980), in which he put forward his famous Chinese room thought experiment.

Source: https://wqu.org/

First Checkers & Dartmouth Conference

Christopher Strachey creates the first checkers program:

This establishes game AI as one of the primary metrics for progress within the wider field of AI.

The Dartmouth conference establishes artificial intelligence as a scientific field:

- This enthusiastically sparks off the golden era of artificial intelligence.
- The conference boldly makes the assertion: "Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it". – McCarthy et al. (1955)

This is the philosophy of functionalism, which is the dominant theory in the philosophy of the mind. Functionalism introduces the idea of mental states being functional states and how these functional states could then be instantiated into a machine – that "we would be able to do psychology by doing robotics". Despite all the strengths of functionalism, it faces the major problem of phenomenal consciousness. For more on the philosophy of mind, refer to the following MIT course: Minds and Machines

Source: https://wqu.org/

Golden Years

The golden years of artificial intelligence

This was an era of intensive research, discovery and optimism, when it is relatively easy to secure funding for practically anything related to AI.

- 1958: "Within ten years a digital computer will be the world's chess champion."
  – H. A. Simon and Allen Newell
- 1965: "Machines will be capable, within twenty years, of doing any work a man can do."
  – H.A. Simon
- 1967: "Within a generation … the problem of creating 'artificial intelligence' will substantially be solved." – Marvin Minsky
- 1970: "In from three to eight years we will have a machine with the general intelligence of an average human being."
  – Marvin Minsky

Source: https://wqu.org/

First Winter & Second Boom

The first 'AI winter' strikes

This term later coined to describe a period of dramatic stagnation owing to:

- Limited computing power.
- The curse of dimensionality.
- Moravec's paradox: High-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources.

Funding draws to a halt and the earlier optimism is replaced with a culture of critique and pessimism.

The second AI boom

- Expert systems restricted to very specific problems, allowing domain knowledge to be applied.
- New architectures are introduced – e.g. Hopfield neural networks.

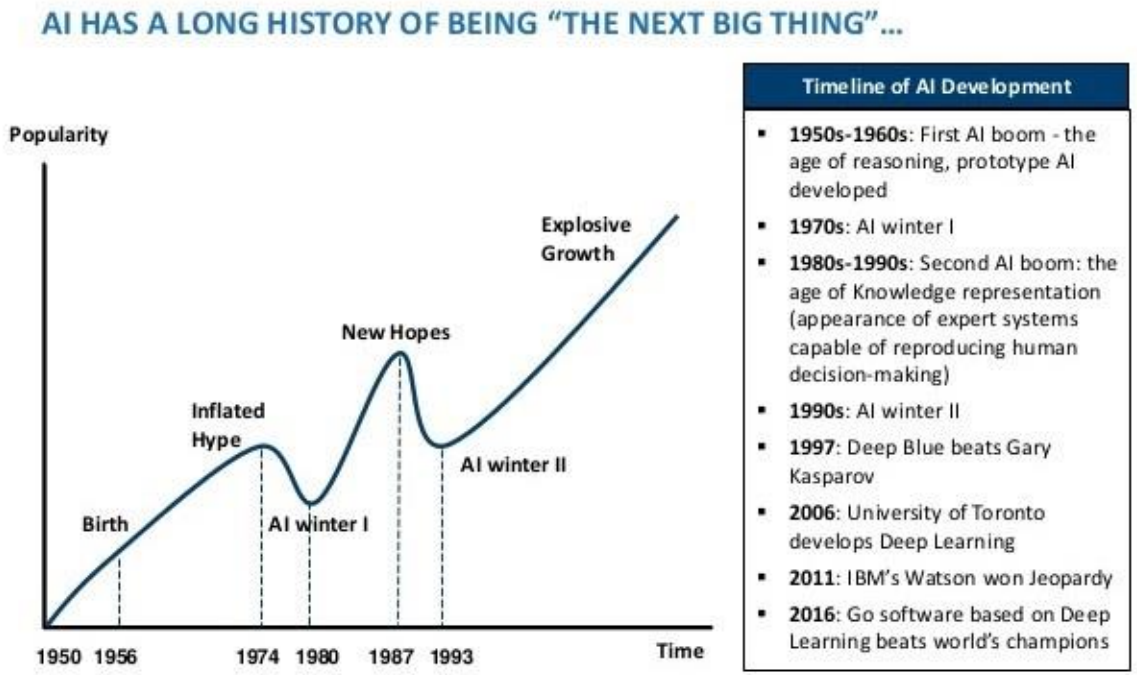
Source: https://wqu.org/

Second Winter

1987 – 1993

The second AI winter

- Enthusiasm dies down, mirroring a classic economic bubble.
- The term 'AI winter' is coined.



Source: https://wqu.org/ & https://www.actuaries.digital/2018/09/05/history-of-ai-winters/

From Invisibility to Deep Learning

The era of invisibility, a period defined by:

- Waiting for computation times to speed up. In 1965 Gordon Moore noticed that the number of transistors per square inch on integrated circuits had doubled every year since their invention. Moore's law predicts that this trend will continue into the foreseeable future – that computational speed will double approximately every 18 months.
- Algorithms being applied as parts of greater systems.
- AI systems receiving little to no credit.

The era of deep learning

- Big data and cloud computing.
- Deep learning:
  - Convolutional neural networks.
  - Recurrent neural networks.
  - Adversarial learning.
  - Machines regularly rival or exceed human performance.

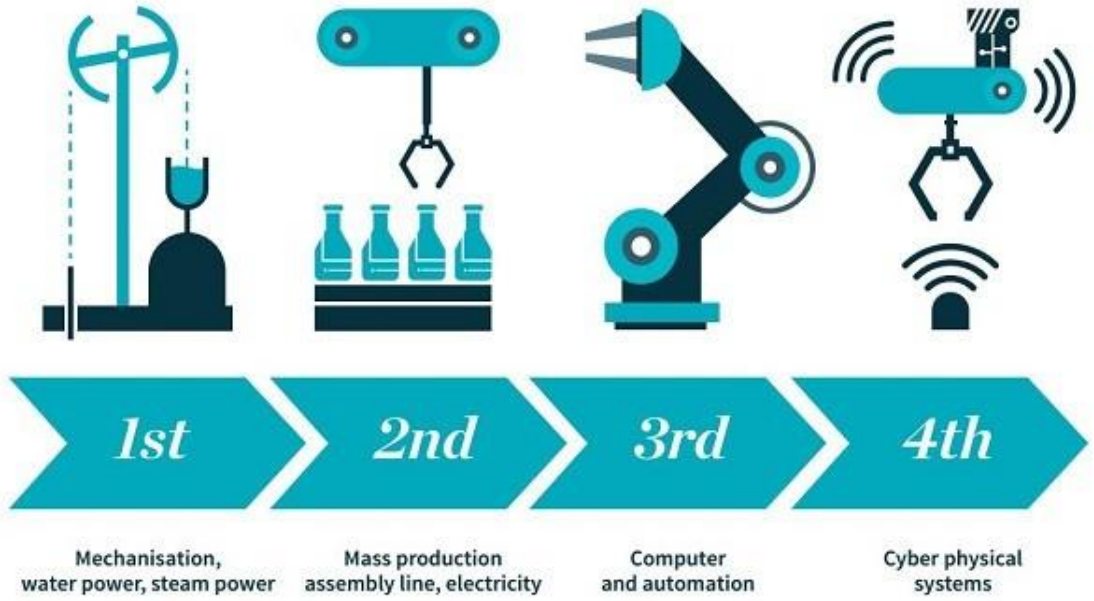
Source: https://wqu.org/

Future…

Today – Future

A subject for debate and speculation – many believe we are entering the fourth industrial revolution:

The end of Moore's law – molecular and quantum computers.



Source: https://wqu.org/ & https://qswownews.com/academia-can-important-vanguard-fourth-industrial-revolution/

Machine Learning

- Machine learning is an area of artificial intelligence (AI) with a concept that a computer program can learn and adapt to new data without human intervention.
- A complex algorithm or source code is built into a computer that allows for the machine to identify data and build predictions around the data that it identifies.
- Machine learning is useful in parsing the immense amount of information that is consistently and readily available in the world to assist in decision making.
- Machine learning can be applied in a variety of areas, such as in investing, advertising, lending, organizing news, fraud detection, and more.

Source: https://www.investopedia.com/terms/m/machine-learning.asp

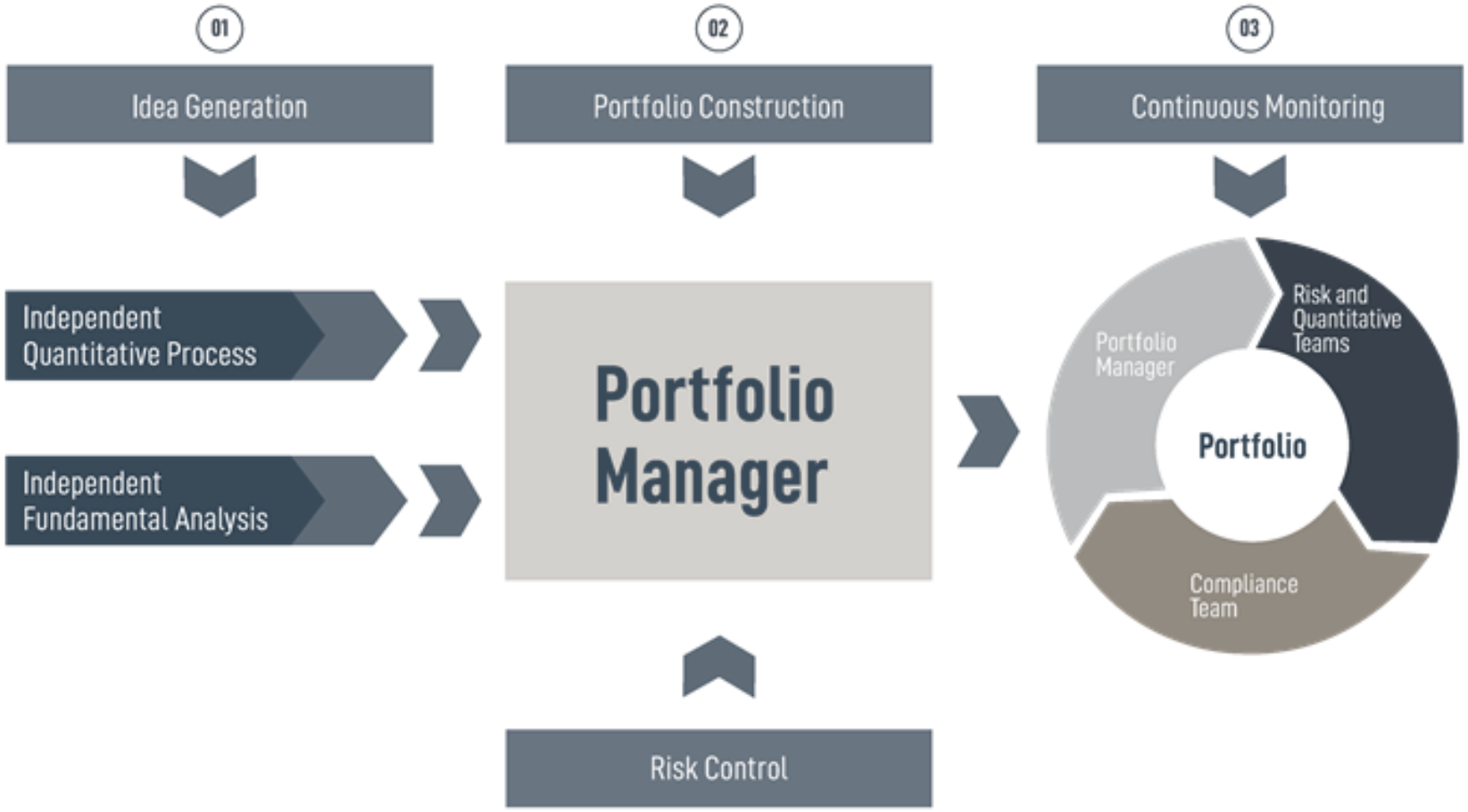
Ten Financial Applications of Machine Learning

https://www.youtube.com/watch?v=3gxx0QBuznI

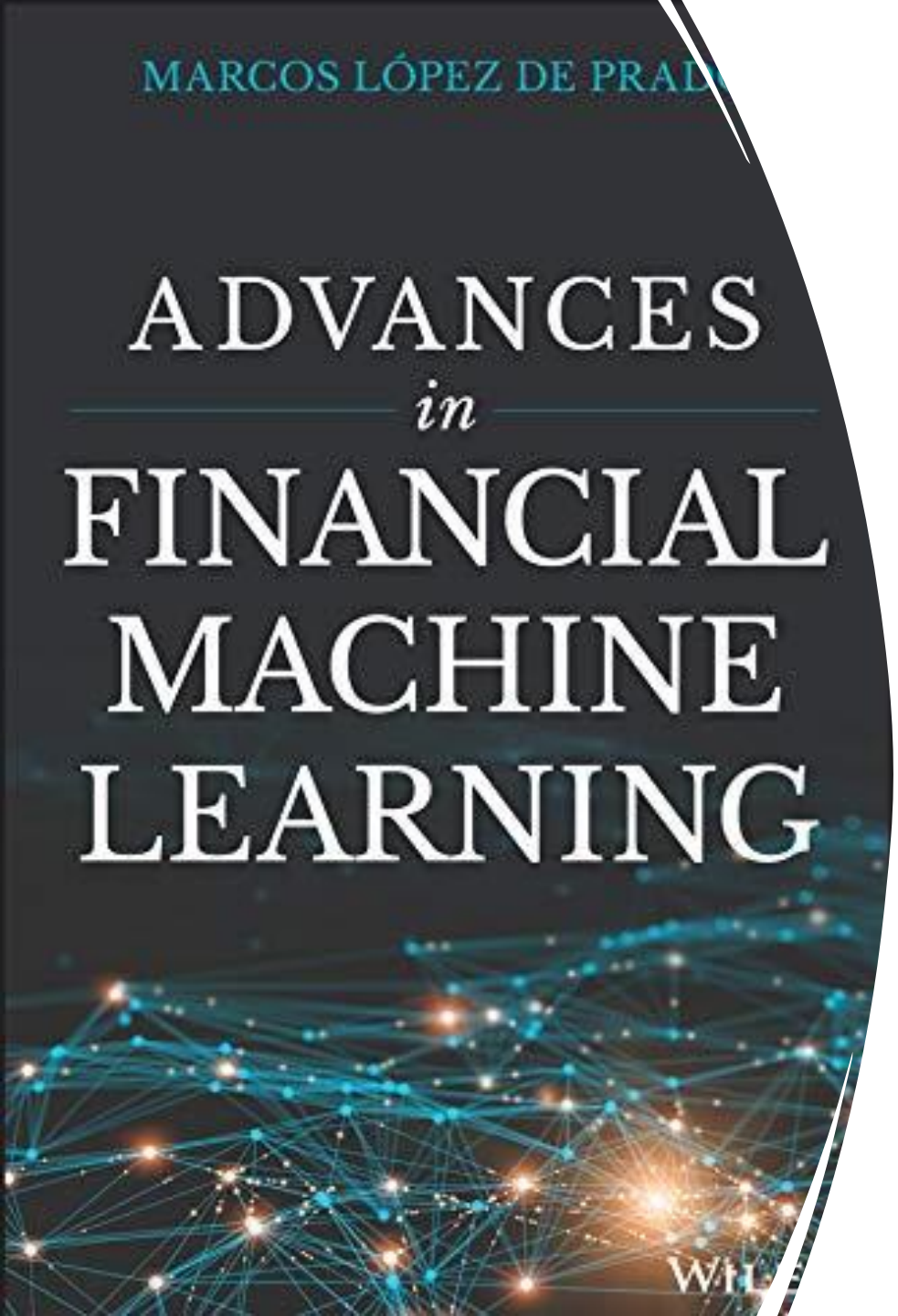
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3197726

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3365271

The Investment Process

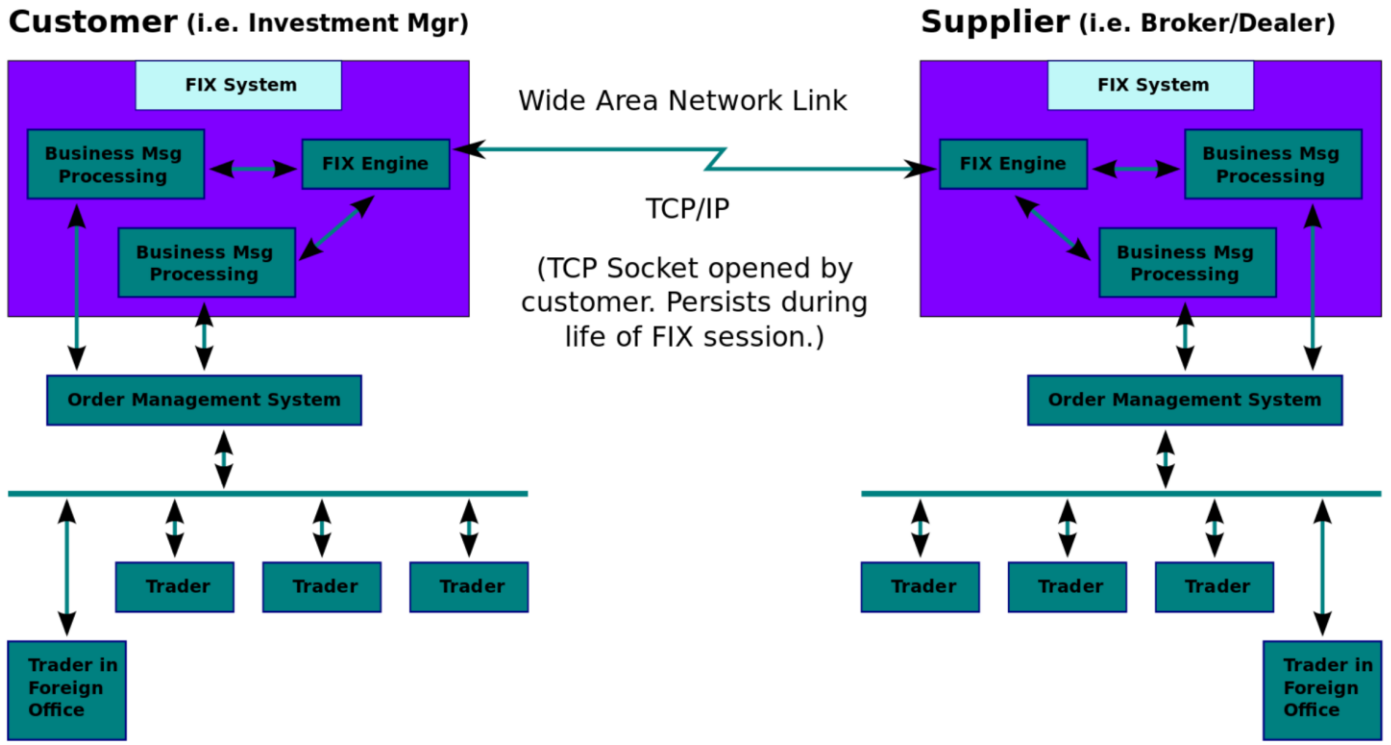


Source: https://www.pictonmahoney.com/About-Us/Our-Process.aspx



According to Marcos Lopez de Prado we can structure the investment process as a chain of production…

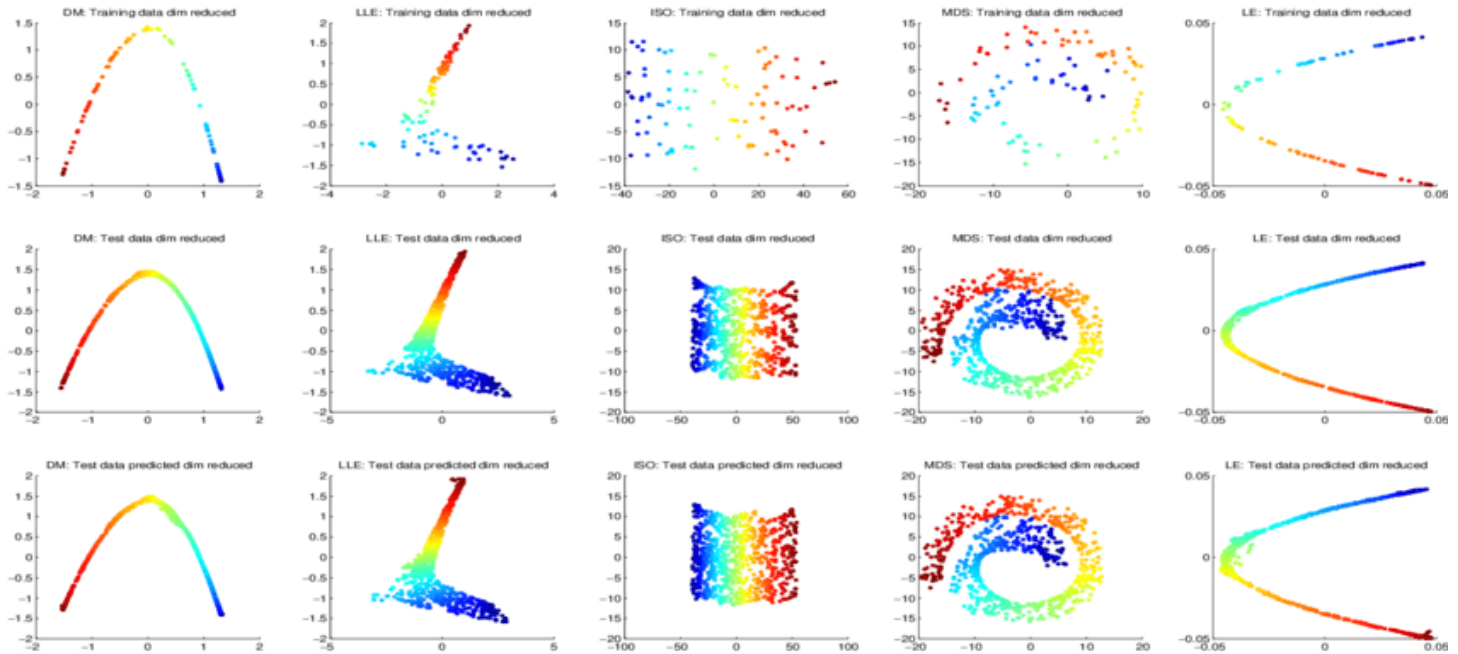
Data Curators



This is the station responsible for collecting, cleaning, indexing, storing, adjusting and delivering all data to the production chain.

Team members are experts in market microstructure and data protocols such as FIX. [1]

Feature Analysts



This is the station responsible for transforming raw data into informative signals.

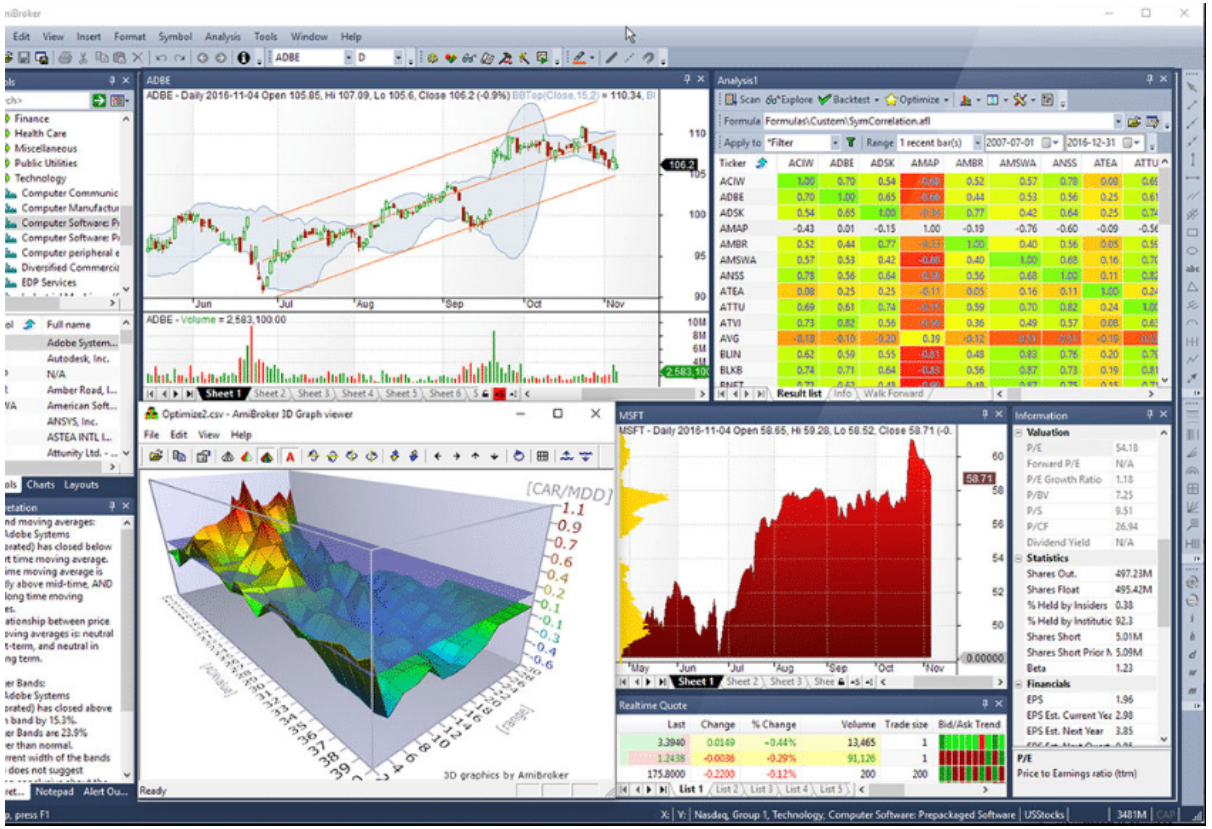
Team members are experts in information theory, signal extraction and processing, visualization, labeling, weighting, classifiers and feature importance technics. [1]

Strategists

In this station, informative features are transformed into actual investment algorithms.

Team members are data scientists with a deep knowledge of financial markets and the economy. [1]

Backtesters



This station assesses the profitability of an investment strategy under various scenarios.

Team members are data scientists with a deep understanding of empirical and experimental techniques. [1]

Deployment Team

The deployment team is tasked with integrating the strategy code into the production line.

Team members are algorithm specialists and hardcore mathematical programmers. [1]

Portfolio Oversight

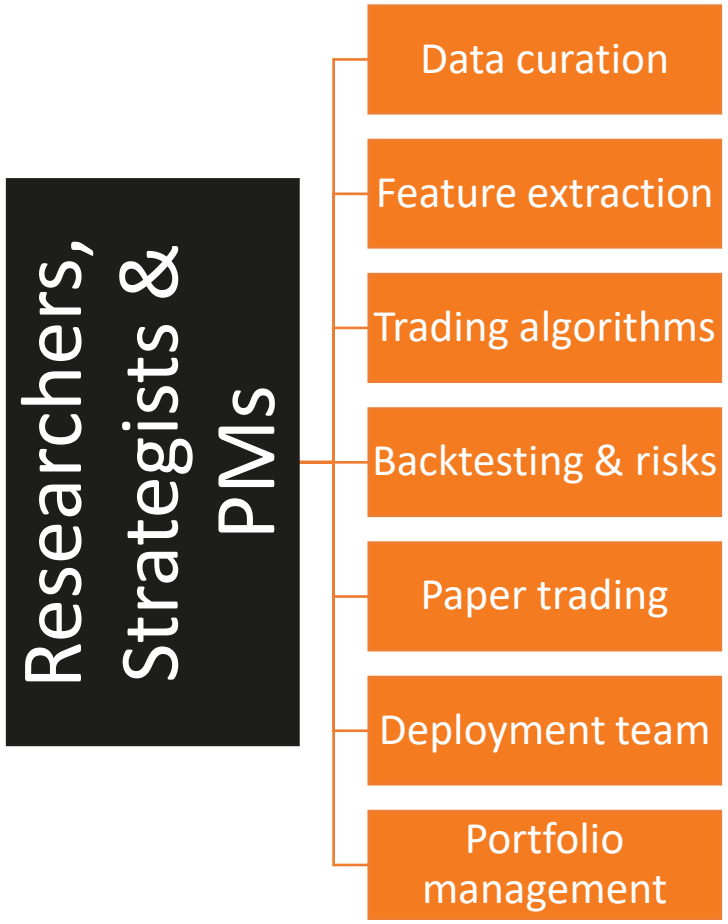
Once a strategy is deployed, it follows a *cursus honorum*, which entails the following stages or lifecycle [1]:

- Embargo
- Paper trading
- Graduation
- Re-allocation
- Decommission

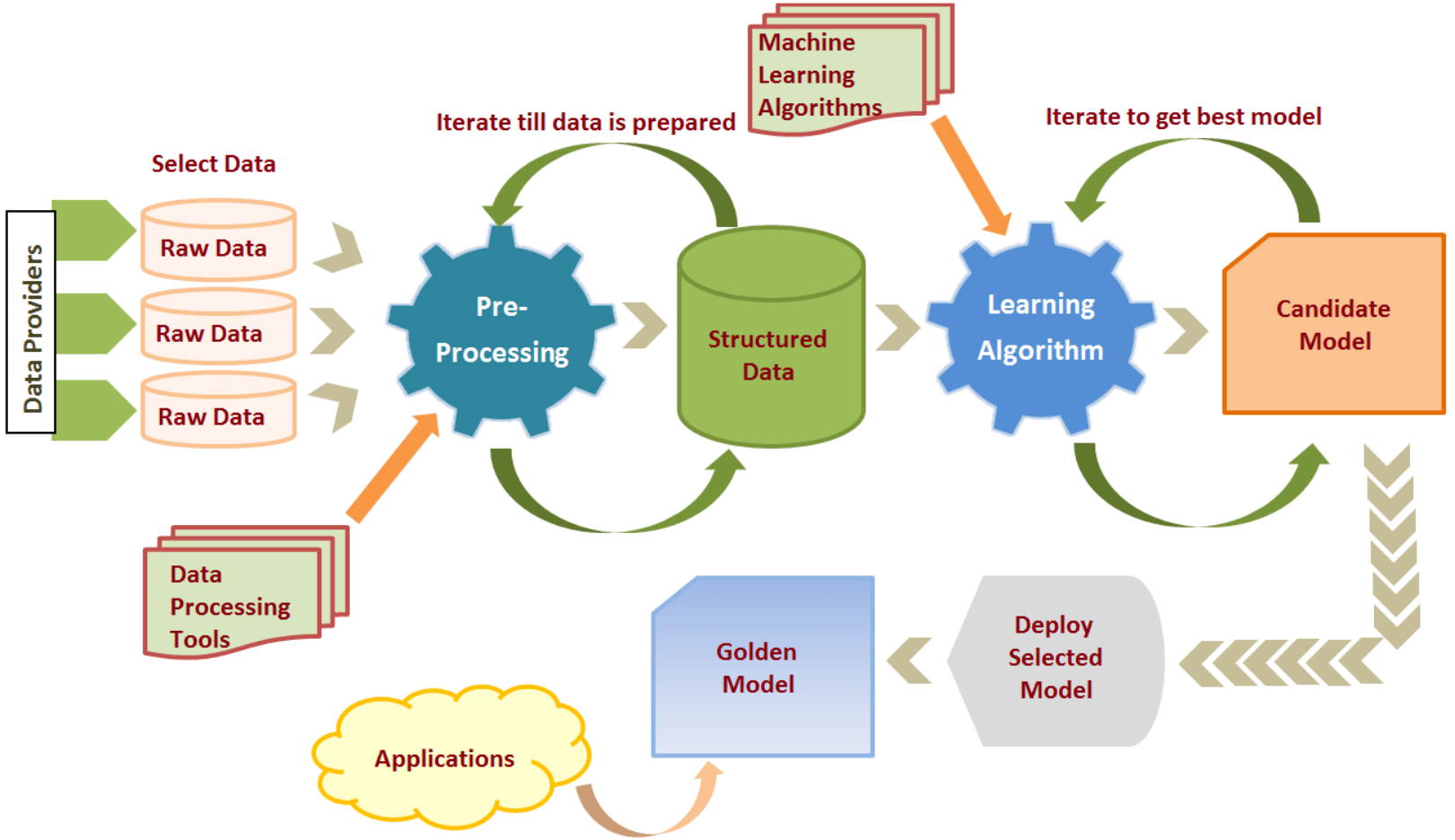
“Just like in The Wizard of Oz, someone is behind the curtain driving the process. As with any model, it's only as good as the human who develops the program.”

Source: https://www.investopedia.com/articles/trading/09/quant-strategies.asp

Quant Team Structure Idea & Process



Machine Learning Process



Source: https://www.pictonmahoney.com/About-Us/Our-Process.aspx

ML Python Libraries

- ✓NumPy
- ✓SciPy
- ✓Scikit-learn
- ✓Theano
- ✓TensorFlow - https://www.tensorflow.org/resources/learn-ml
- ✓Keras
- ✓PyTorch

Fundamental Preprocessing Techniques

Scaling datasets

Normalization

Whitening

Training, validation, and test sets

Cross-validation [2]

Characteristics of a ML Model

Learnability

Capacity of a model

Bias of an estimator

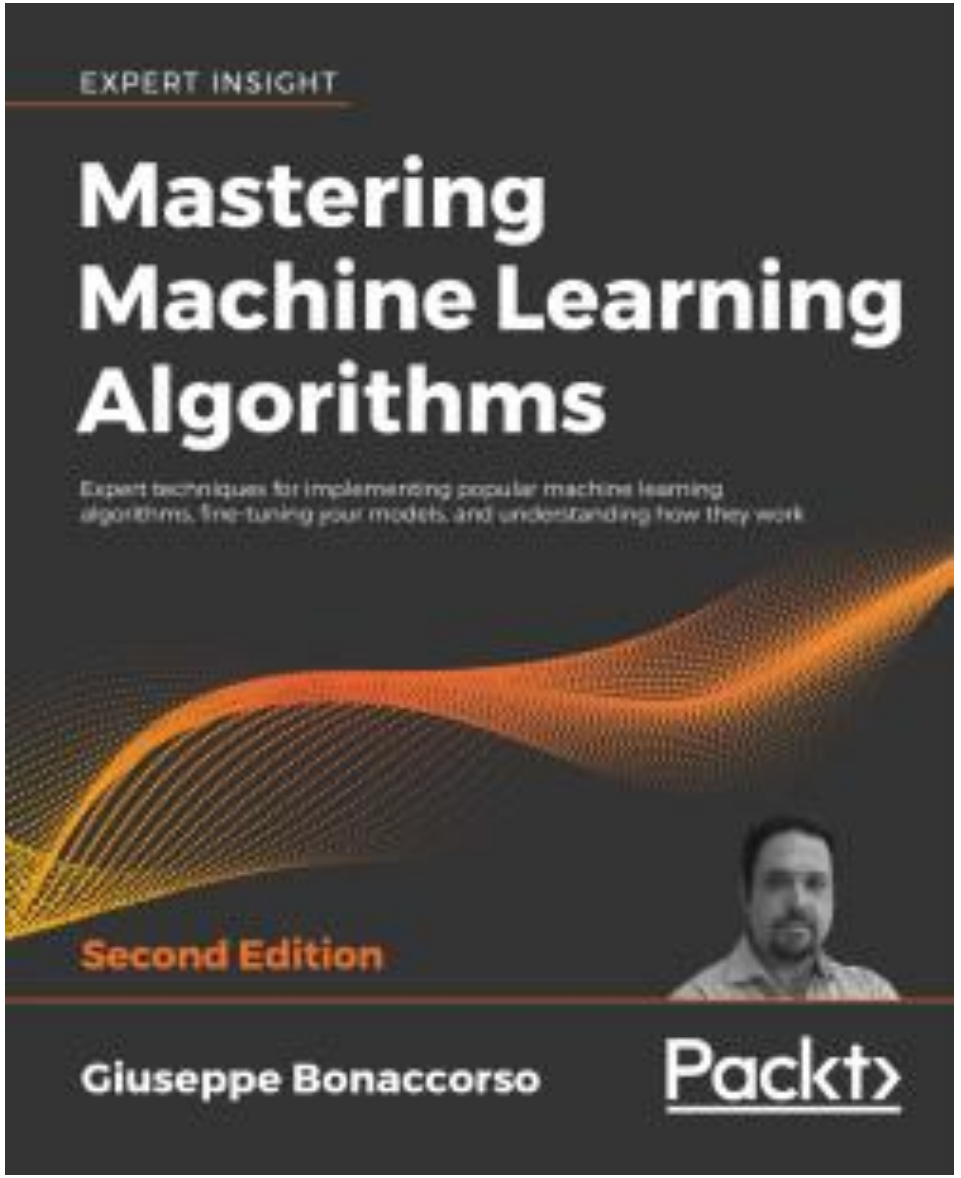
Underfitting

Variance of an estimator

Overfitting [2]

Codes

https://www.packtpub.com/product/mastering-machine-learning-algorithms-second-edition/9781838820299



Cost Functions

Mean squared error

Huber cost function

Hinge cost function

Categorical cross-entropy[2]

Regularization

L1 or Lasso regularization

L2 or Ridge regularization

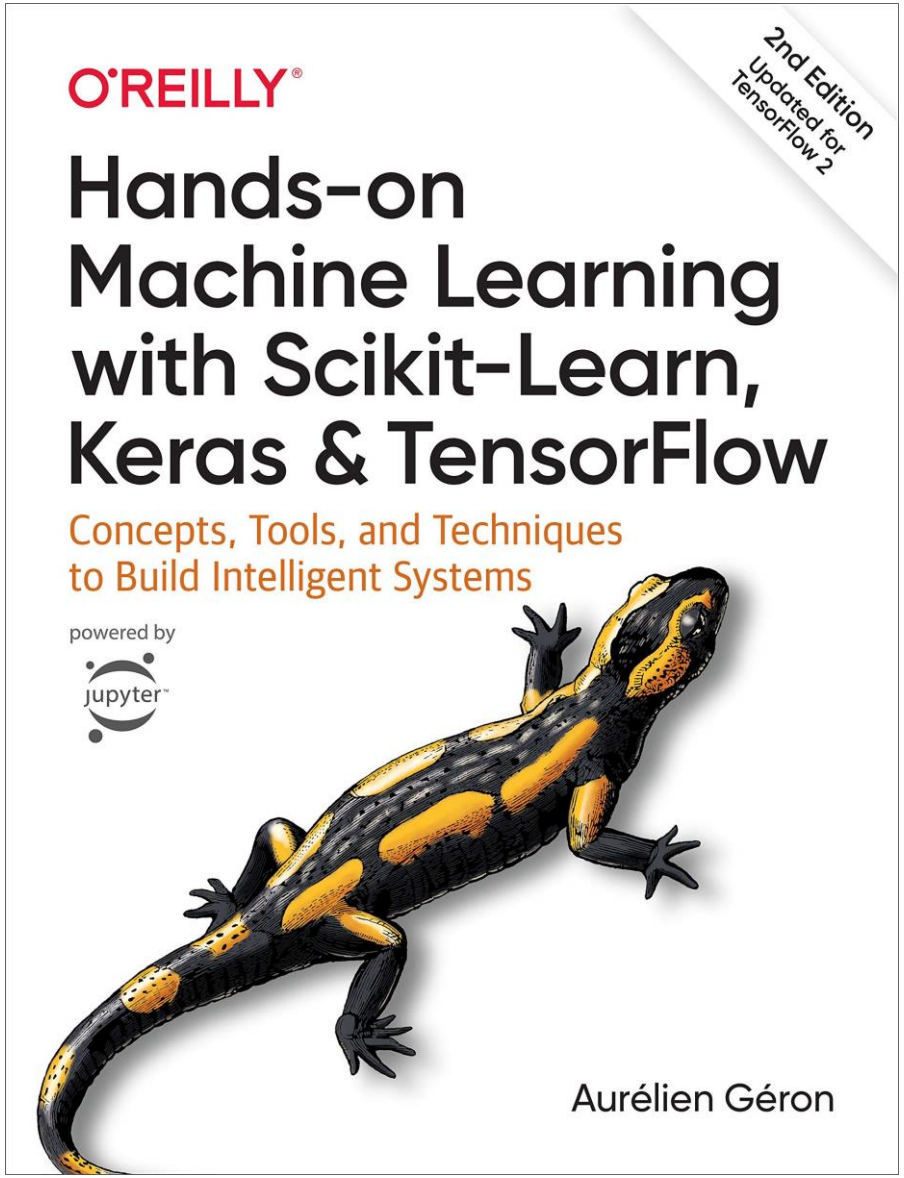
ElasticNet

Early stopping[2]

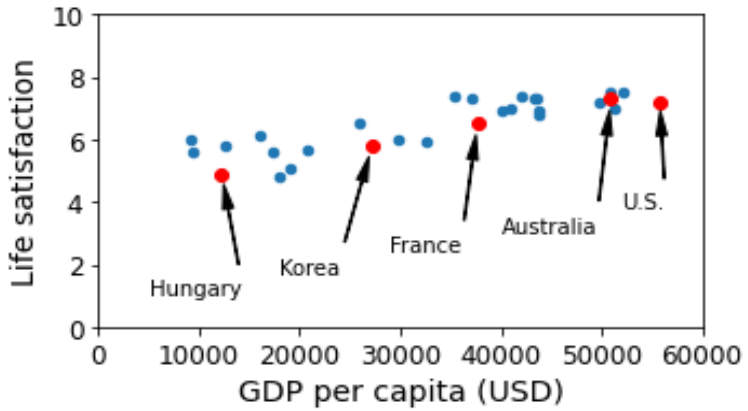
https://icml.cc/Conferences/2004/proceedings/papers/354.pdf

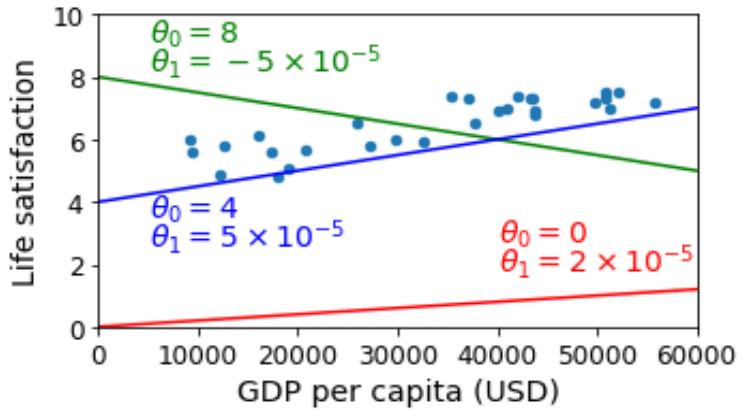
Codes

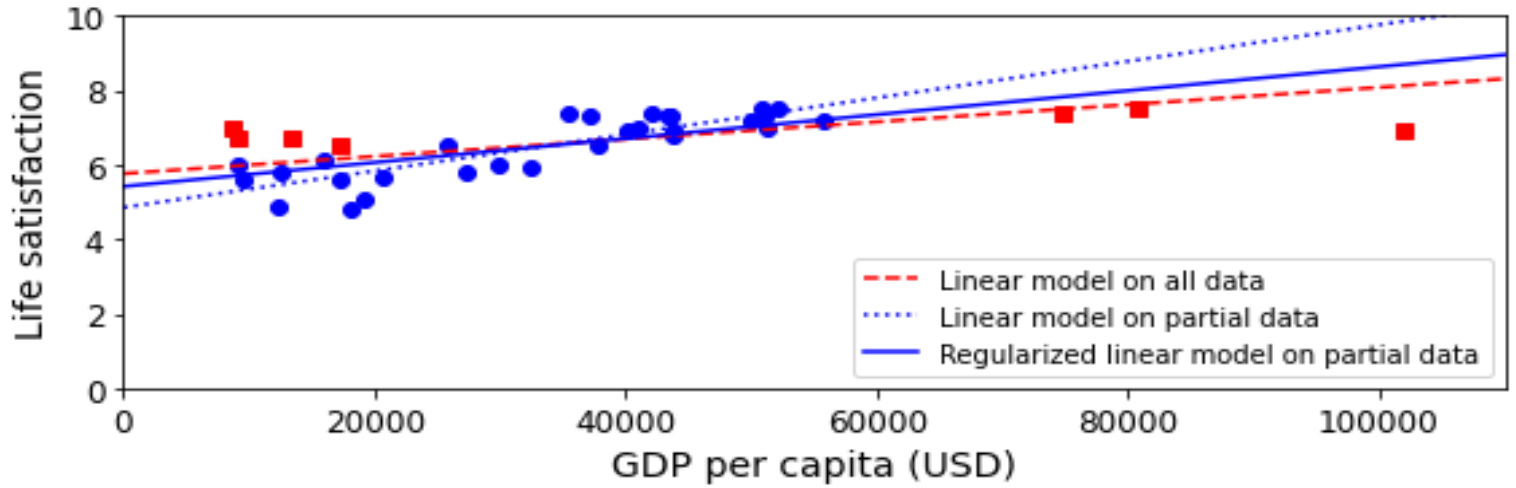
https://github.com/ageron/handson-ml2



01_the_machine_
learning_landscape







Additional References

[1] Marcos Lopez de Prado (2018). Advances in Financial Machine Learning.

[2] Guiseppe Bonaccorso (2020). Mastering Machine Learning Algorithms.

[3] Aurélien Géron (2019). Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.

Disclaimer

The opinions expressed in this presentation and on the previous slides are solely those of the presenter.