Machine Learning for Macroeconomics

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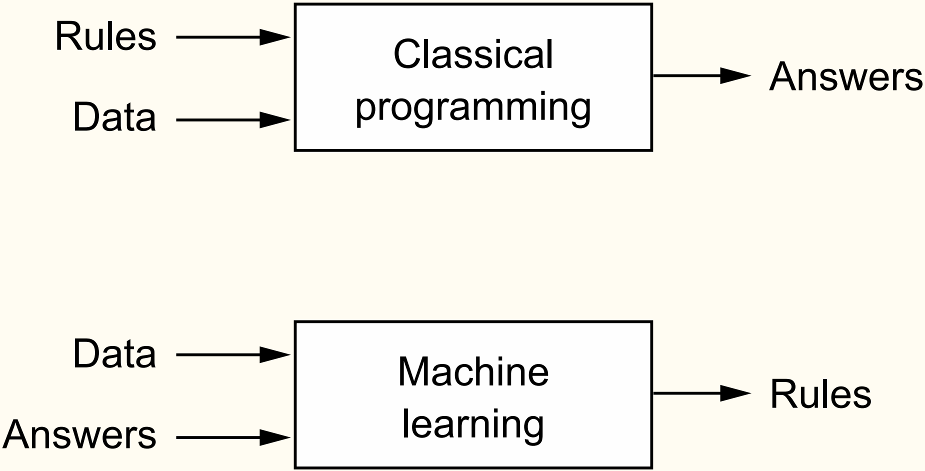
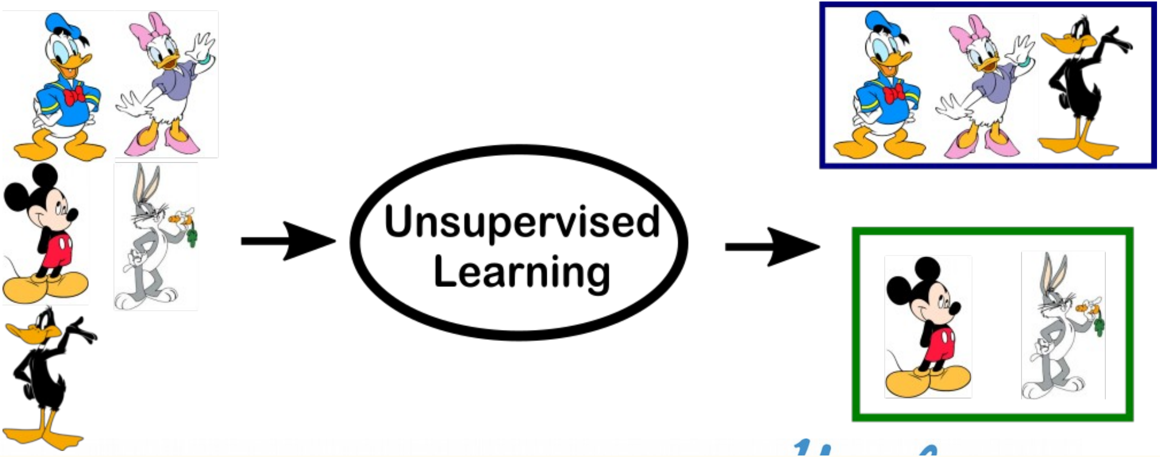
What is machine learning?, I

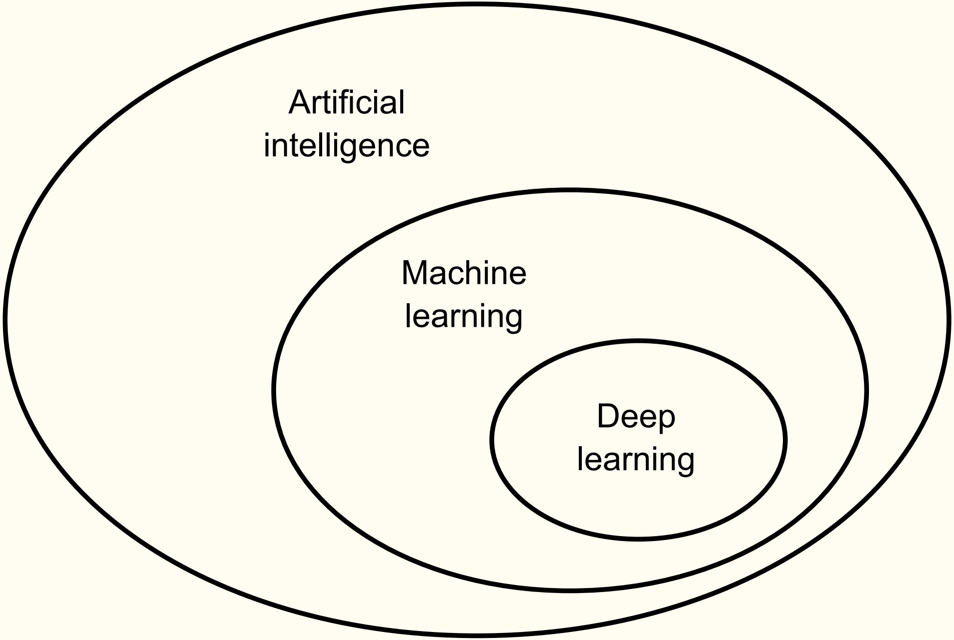
- Wide set of algorithms to detect and learn from patterns in the data and use them for decision making or to forecast future realizations of random variables.
- Focus on recursive processing of information to improve performance over time.
- In fact, this is clearer to see in its name in other languages: Apprentissage automatique or aprendizaje automático.
- Even in English: Statistical learning.
- More formally: we use rich data to select appropriate functions in a dense functional space.

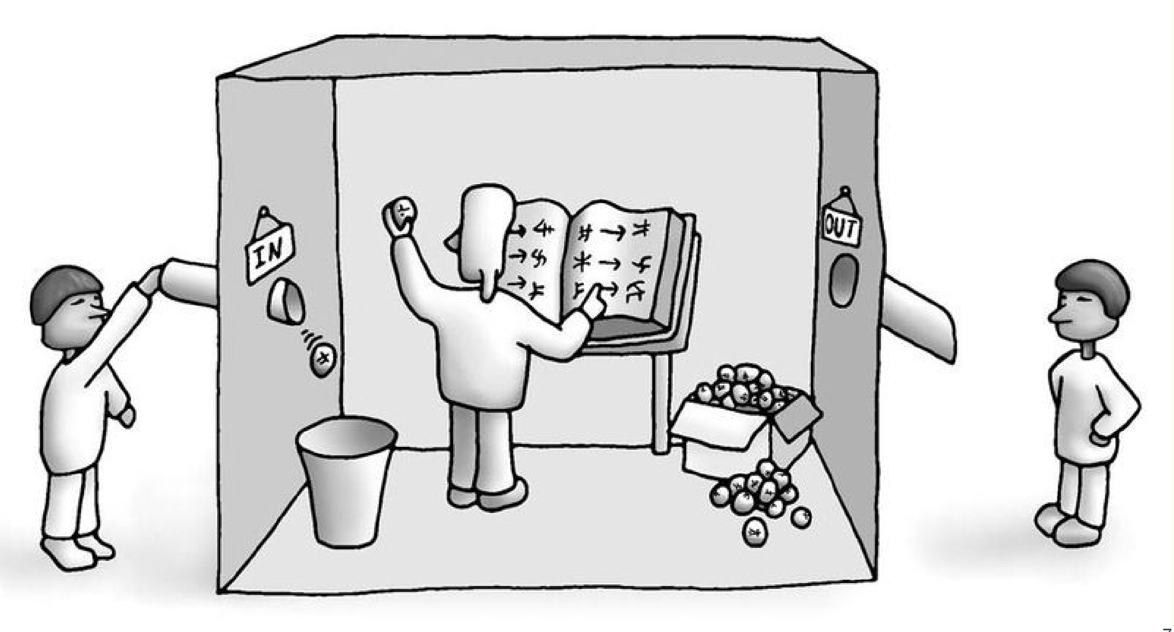

Rules
Data
Classical programming
Answers
Data
Answers
Machine learning
Rules


Unsupervised
Learning

What is machine learning?, II

- Opposition with traditional scientific computation (both standard numerical analysis and Monte Carlos).
- Opposition with symbolic reasoning, expert systems, and cognitive model approaches in artificial intelligence.
- Think about the example of how to program a computer to play chess.
- Operational definition of learning (i.e., Turing test and Chinese room).

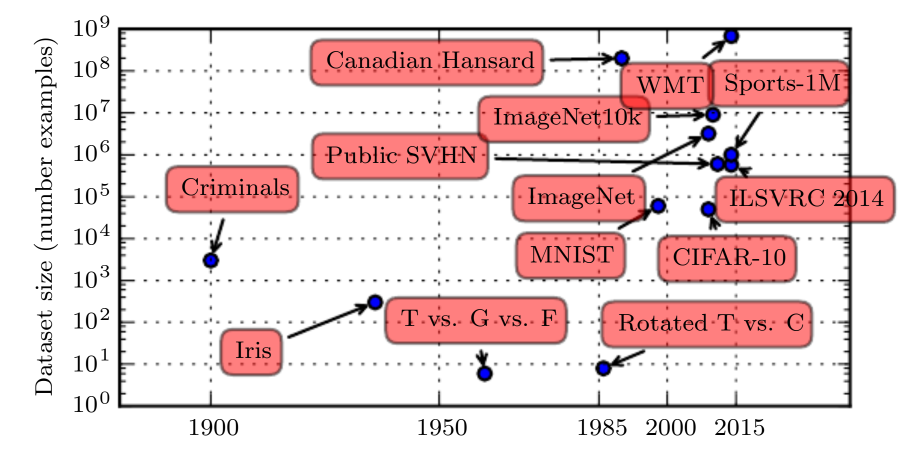

Artificial intelligence
Machine learning
Deep learning


IN
OUT

Why now?

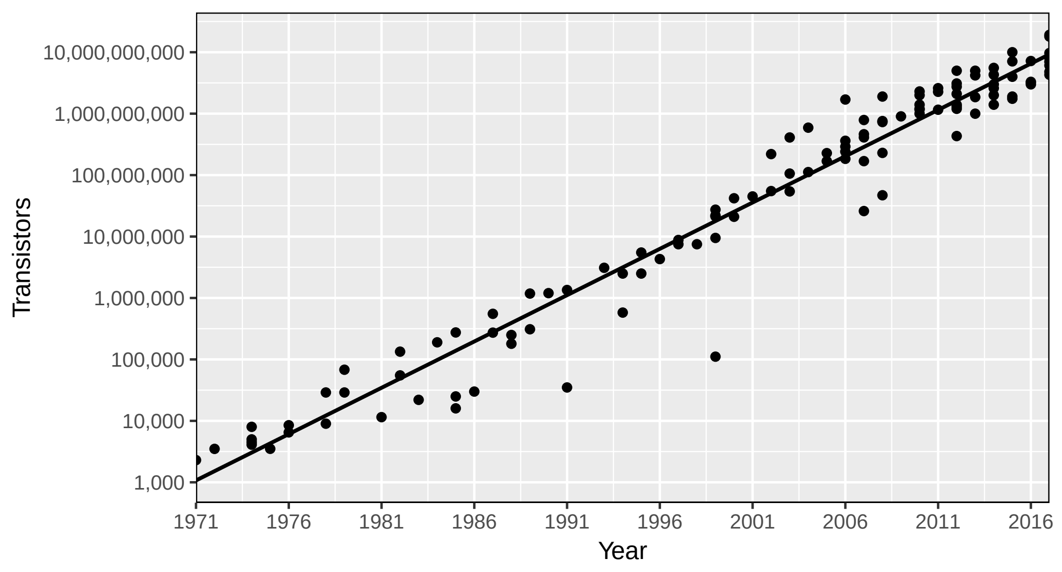
- Many of the ideas of machine learning (e.g., basic neural network by McCulloch and Pitts, 1943, and perceptron by Rosenblatt, 1958) are decades old.
- Previous waves of excitement: late 1980s and early 1990s. Those decades were followed by a backlash.
- Four forces behind the revival:
  1. Big data.
  2. Long tails.
  3. Cheap computational power.
  4. Algorithmic advances.
- Likely that these four forces will become stronger over time.
- Exponential growth in industry $\Rightarrow$ plenty of packages for `Python`, `R`, and other languages.

Data sizes

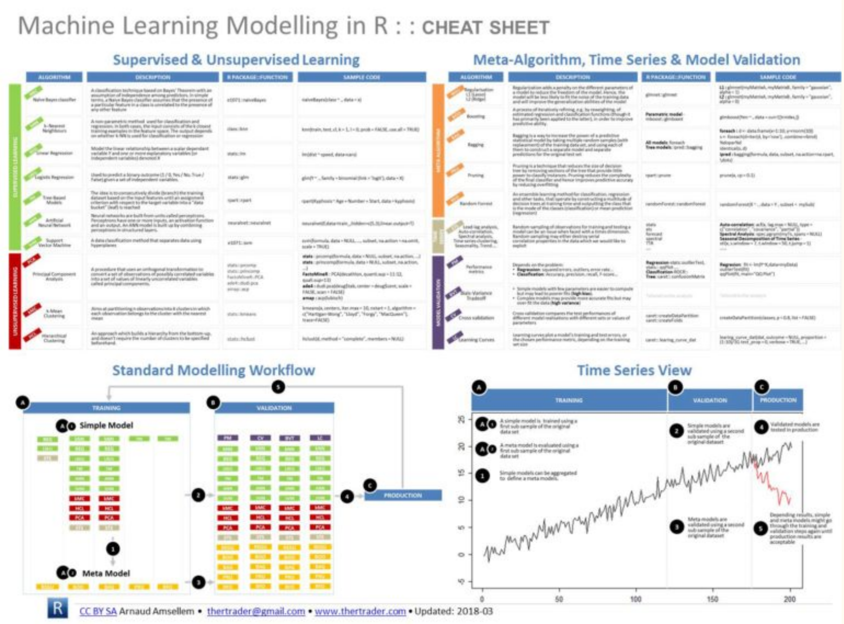


Dataset size (number examples)
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
1900
1950
1985
2000
2015
Canadian Hansard
WMT
Sports-1M
ImageNet10k
Public SVHN
Criminals
ImageNet
ILSVRC 2014
MNIST
CIFAR-10
T vs. G vs. F
Rotated T vs. C
Iris

Number of transistors



scikit learn


Machine Learning Modelling in R : : CHEAT SHEET
Supervised & Unsupervised Learning
Meta-Algorithm, Time Series & Model Validation
ALGORITHM
DESCRIPTION
R PACKAGE::FUNCTION
SAMPLE CODE
Standard Modelling Workflow
TRAINING
VALIDATION
PRODUCTION
Simple Model
Meta Model
Time Series View
TRAINING
VALIDATION
PRODUCTION
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Relation with other fields

- Link with computer science, statistical learning, data science, data mining, predictive analytics, and optimization: frontiers are often fuzzy.

- Many similarities with econometrics and statistical learning, but emphasis is somewhat different:

    1. No unified approach.
    2. Practical algorithms vs. theoretical properties (scalability vs. asymptotic properties).
    3. Traditional statistical inference is de-emphasized.
    4. More interest in forecasting than in causality assertions (cross-validation, regularization).

The many uses of machine learning in macroeconomics

The many uses of machine learning in macroeconomics

- Recent boom in economics:

    1. New solution methods for economic models: my own work on deep learning.

    2. Alternative to older bounded rationality models: reinforcement learning.

    3. Data processing: Blumenstock *et al.* (2017).

    4. Alternative empirical models: deep IVs by Hartford *et al.* (2017) and text analysis.

    5. Large language models: Korinek (2023).

- However, important to distinguish signal from noise.

- Machine learning is a catch-all name for a large family of methods.

- Some of them are old-fashioned methods in statistics and econometrics presented under alternative names.

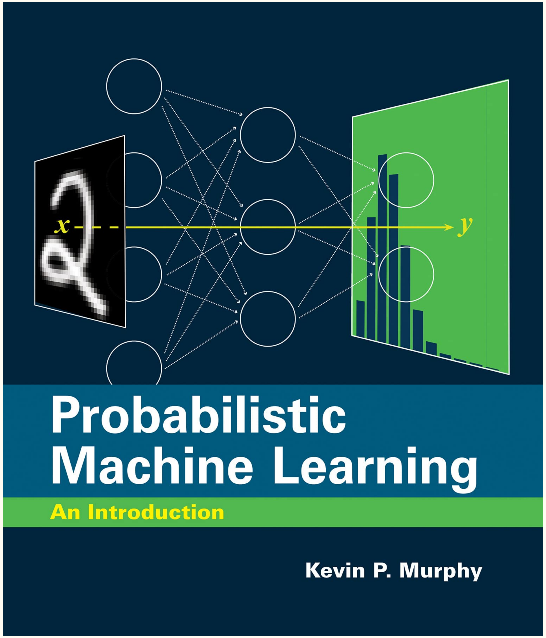
Course outline, I

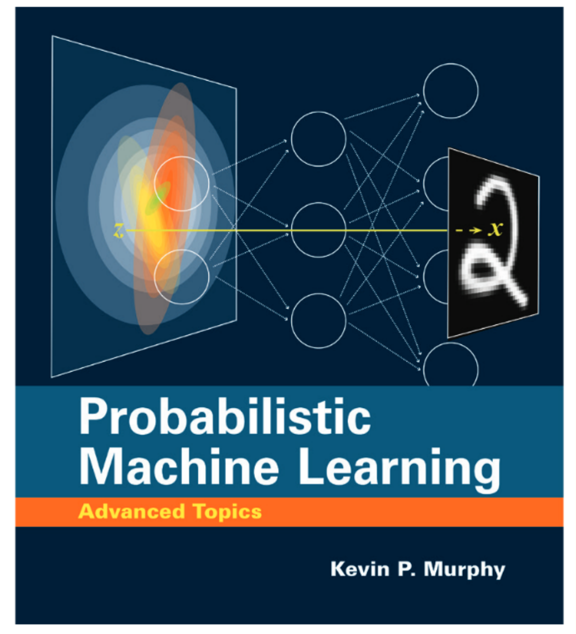
- Block 1: Coding Machine Learning Algorithms.
- Block 2: Challenges Solving Economic Models.
- Block 3: Introduction to Deep Learning.
- Block 4: Optimization in Deep Learning.
- Block 5: Deep Learning for Solving Economic Models.
- Block 6: Advanced Topics in Deep Learning.
- Block 7: Symmetry in Dynamic Programming (if time allows).
- Block 8: Transversality and Stationarity with Deep Learning (if time allows).

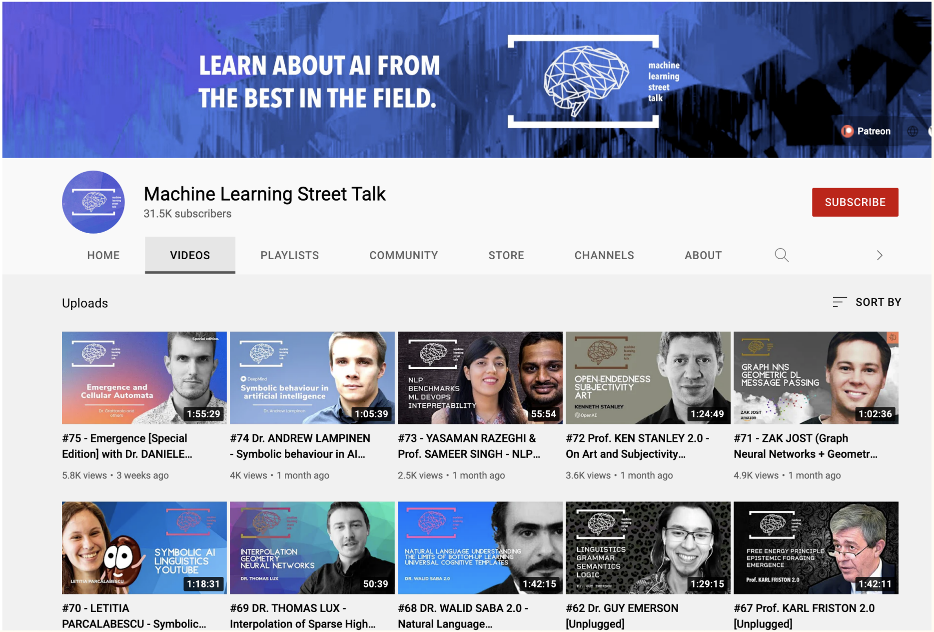
Course outline, II

- Block 9: Reinforcement Learning.
- Block 10: Machine Learning for Data Analysis (if time allows).
- Block 11: Text Analysis (if time allows).
- Block 12: Structural Estimation with Unstructured Data (if time allows).

References


x
y
Probabilistic
Machine Learning
An Introduction
Kevin P. Murphy


z
x
Probabilistic
Machine Learning
Advanced Topics
Kevin P. Murphy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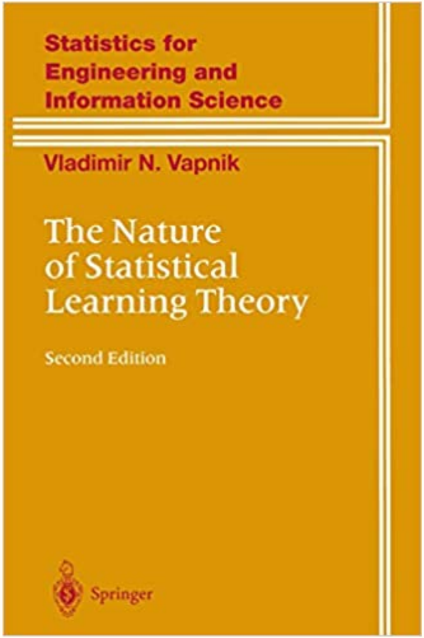
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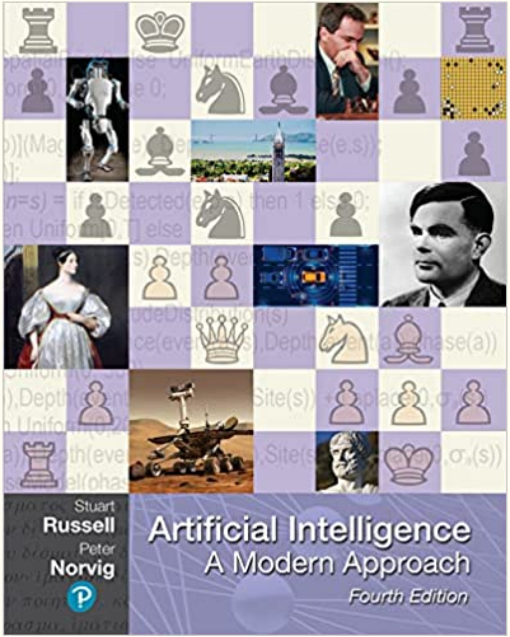
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