Asset Allocation, Machine Learning and High-Performance Computing

Ian McWilliam

Macro Systematic Strategies, Aberdeen Standard Investments

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Contents

Introduction to Machine Learning

Machine Learning for Asset Allocation

ASI Machine Learning with MATLAB®
Introduction to Machine Learning

What is Machine Learning?

- Subfield of Artificial Intelligence focussed on the study of methods for autonomously inferring relationships from data.
Introduction to Machine Learning

What is Supervised Learning?

- Study of methods for mapping a set of inputs to a set of targets.

- There are a variety of supervised learning algorithms, from linear regression to complex, deep neural networks.
Introduction to Machine Learning

Supervised Learning Example – Image Recognition

<table>
<thead>
<tr>
<th>What we see:</th>
<th>What the computer sees:</th>
<th>Machine learning algorithm:</th>
<th>Algorithm Predictions:</th>
</tr>
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Source: Aberdeen Standard Investments, 27/09/2018
**Introduction to Machine Learning**

**Why Machine Learning Now?**

- A number of factors have developed over the past few years to catalyse the current AI/machine learning renaissance:

<table>
<thead>
<tr>
<th>Big Data</th>
<th>High Performance Computing (HPC)</th>
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<tbody>
<tr>
<td>• Data is the <strong>fuel</strong> of machine learning.</td>
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<td>• We are producing data at an unprecedented rate.</td>
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<td>• Big data + machine learning =&gt; <strong>HPC</strong>.</td>
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<tr>
<td>• Cloud Computing, GPUs, FPGAs, Database Solutions.</td>
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<table>
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<th>Theoretical Innovations</th>
<th>Proliferation of Software and Expertise</th>
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<tr>
<td>• Landmark theoretical breakthroughs.</td>
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<td>• Backpropogation, <strong>Deep Learning</strong>, CNNs, RNNs.</td>
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- **MATLAB®, Python, Scikit-learn, TensorFlow, Keras, R.**
- **Academic Data Science, Coursera, Codecademy, Kaggle.**

Source: Aberdeen Standard Investments, 27/09/2018
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Machine Learning for Asset Allocation

Machine Learning at ASI using MATLAB®
Goal of Asset Allocation

- **Understand** the key drivers of market behaviour.
- **Predict** future asset performance.
- **Construct** portfolios based on expected behaviour to **deliver** desired investment outcomes.

Challenge

- Market behaviour is **complex**.
- Driven by **multi-dimensional, non-linear** relationships.
Machine Learning for Asset Allocation

Why Machine Learning In Investment?

• Asset prices are driven by a multitude of factors, from macroeconomic conditions and investor sentiment, to the whims of day traders or unpredictable geopolitical events.

• The result is that relationships in financial markets are highly multi-dimensional and non-linear, requiring suitably complex modelling approaches to understand such dynamics.

Data is hypothetical and for illustration purposes only.

Source: Aberdeen Standard Investments, 27/09/2018
Machine Learning for Asset Allocation

Multi-Dimensionality

- Relationships may also be non-linear and multi-dimensional, for example a typical XNOR type relationship between asset price performance and two hypothetical factors ‘Momentum’ and ‘Value’.

- Again, we may be able to model such dynamics with traditional models using interaction terms, however this is a manual process and very difficult in higher dimensions.

Data is hypothetical and for illustration purposes only.

Source: Aberdeen Standard Investments, 27/09/2018
Machine Learning for Asset Allocation

How does it work? – Support Vector Machines

- Non-linearly separable classes are separated by automatic space transformations.

Data is hypothetical and for illustration purposes only.
Machine Learning for Asset Allocation

Key Advantages

- State of the art learning methods
- Can be tailored to individual investment needs
- Scalable to new asset classes or strategies
- Uncorrelated with other investment approaches

Intelligence

Flexibility

Scalability

Diversification
Machine Learning for Asset Allocation

Market factors definition

- Macroeconomic
- Liquidity
- Value
- Sentiment

Leveraging industry and academic research for factor pre-selection

Machine learning input

Data cleansing, signal processing and transformation in order to define the input to the Machine Learning algorithms

Data transformation for interpretability

Question to the machine

- **Tactical Asset Allocation**: underweight Credit to overweight Equities
- **Absolute Return**: Short FTSE 100 vs Long S&P 500
- Ability to accommodate different risk and target return client profiles

Defining the problem
Machine Learning for Asset Allocation

Supervised Learning for Asset Allocation

Input/Predictive Variables
Macroeconomic factors, valuation metrics, technical indicators

Targets (what we want to predict)
Subsequent asset performance – e.g. % appreciation of asset, binary variable indicating outperformance

Learning Process
Algorithms learn the relationships between Inputs & Targets

New Inputs Variables
Current market factors

Machine Learning Model
Quantitative model of market behaviour

Model Outputs
Asset return forecasts
Machine Learning for Asset Allocation

Model Outputs used for Portfolio Construction

**New Inputs Variables**
Current market factors

**Machine Learning Model**
Quantitative model of market behaviour

**Model Outputs**
Asset return forecasts

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Machine Learning for Asset Allocation

ASI Machine Learning with MATLAB®
HPC - Distributed Computing Cluster with MATLAB®

- Academic collaborations have produced various papers on accelerating our investment process with HPC.

- 2018 paper “Parallelising a Machine Learning Application in Computational Finance” explored using the MATLAB® Distributed Computing Cluster.

- The study achieved near-linear speed improvements using the distributed cluster, enhancing the scope of our research and testing capabilities.

Source: Aberdeen Standard Investments, 27/09/2018
Key Points:-

- The Head and Worker Node Virtual Machines (VMs) are started when the cluster is required and stopped once no longer needed. This is done by the users using bespoke, in-house built Powershell scripts. The MDCS Windows Service (mdce) is auto-started on each VM and the cluster comes up in a handful of minutes.
- Fixed IP addressing used for VMs to ensure cluster comes up cleanly every time.
- No data is stored in Azure. Data passes from the Client Node to the Worker Nodes via the Head Node.

Source: Aberdeen Standard Investments, 27/09/2018
Macro Machine Learning with MATLAB®

Deep integration with other key systems

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MATLAB® App Designer

• Purpose built apps for regular tasks ensure the process is scalable and robust –
  • Strategy backtesting
  • Portfolio Management
  • Trade Execution
  • Live Performance Monitoring
  • Auto-Generated Reports

Performance numbers are hypothetical and for illustration purposes only.

Source: Aberdeen Standard Investments, 27/09/2018
Model Interpretation and Visualisation – Feature Sensitivity Analysis

- Model interpretability is a key problem in machine learning.
- Looking under the hood of an algorithm is key to understanding whether a model is behaving properly.

- Our purpose built Feature Sensitivity Analysis capability uses MATLAB® visualisation tools to improve model explainability.

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Source: Aberdeen Standard Investments, 27/09/2018
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