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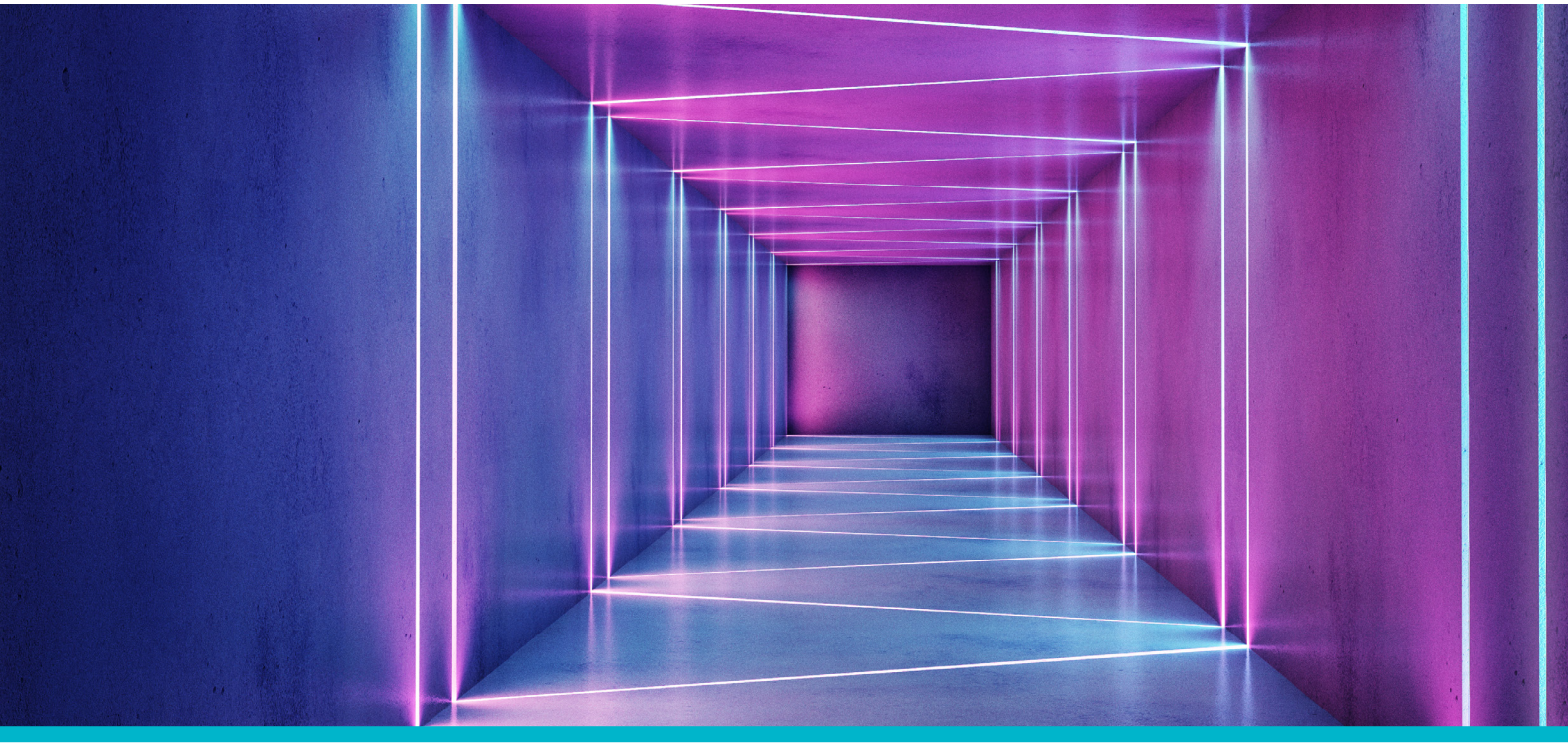

Thinking inside the box

Lifting the lid on the world of algorithms, machine learning and artificial intelligence

Better computing and artificial intelligence (AI) are driving improvements in many diverse areas, from optical sensing to motion actuators and touch/haptics. Such advances are set to take robots and automation to the next level, opening up new investment possibilities. Meanwhile, there are investment strategies that are themselves employing algorithmic and so-called 'deep learning' techniques. Their models have been described as a 'black box', owing to the lack of transparency with machine learning and its recondite inner workings. For active managers chasing returns, these models are not without risks. Yet, for investors to really understand the benefits of algorithms, artificial intelligence and machine learning techniques in investing, it is important that they learn to delve deeper inside the box.

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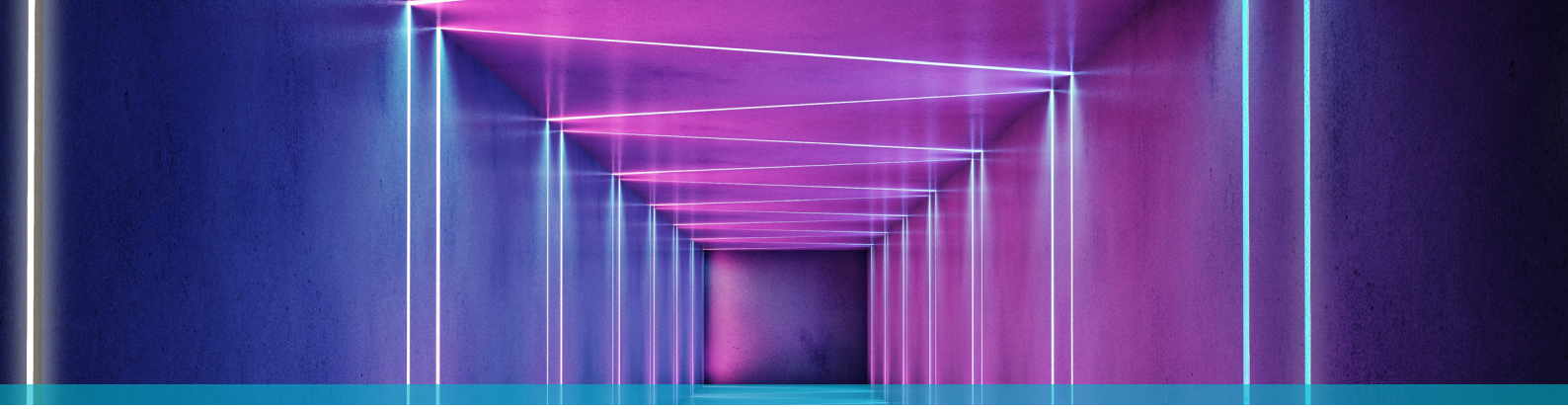


A (very) brief history of AI

'Artificial intelligence': Noun: the branch of computer science aiming to produce machines that can imitate intelligent human behaviour. Abbreviation: AI.

Every conversation about AI has its roots in the work of legendary mathematician Alan Turing. His 'Turing test' challenged a computer's ability to think, requiring that the covert substitution of the computer for one of the participants in a keyboard and screen dialogue should be undetectable by the remaining human participant.

Yet it was the American pioneer of computer science, John McCarthy, who actually coined the term 'artificial intelligence' in 1956. A year later, economist Herbert Simon predicted that computers would defeat humans at chess within the following decade. IBM's Deep Blue supercomputer did indeed beat then world chess champion Garry Kasparov – although not until 1997, some 40 years after McCarthy's foretelling. Incidentally, IBM computer scientist Arthur Samuel introduced the term 'machine learning' in 1959.

Problem solvers

Towards the end of the 1960s, the pioneering mathematician Marvin Minsky – who co-founded the Artificial Intelligence Lab with John McCarthy at MIT – predicted that the problem of creating AI would be solved within a generation. In contrast to alarmist warnings about the dangers of AI, he often took a philosophically positive view of a future in which machines might truly be capable of thought. He believed that AI might eventually offer a way to solve some of humanity's biggest problems.

By the early 1980s, Paul Benioff, Yuri Manin and Richard Feynman – the latter of whom won the 1965 Nobel Prize in Physics – were suggesting that 'quantum computing' had the potential to solve problems that 'classical computing' could not. Indeed, the blueprint for quantum computers that took shape in the 80s and 90s still guides companies like Google and others working on the technology.

It was during the 80s that the finance industry also started to take notice. In 1982, quantitative (quant) hedge fund industry pioneer James Simons founded Renaissance Technologies (the firm would go on to achieve its first $1 million one-day profit in 1990). And in 1988, former computer science professor David Shaw founded the hedge fund DE Shaw, which was an early adopter of AI techniques for trading.

But it's the introduction of the computer-aided investment strategies in the 1990s where, for the purpose of this paper, our journey into AI and machine learning begins in earnest...

The blueprint for quantum computers that took shape in the 80s and 90s still guides companies like Google and others working on the technology.

1956
Computer science pioneer John McCarthy coins the term 'artificial intelligence'

1959
IBM computer scientist Arthur Samuel introduces the term 'machine learning'

1980s
Finance industry begins to see the potential in 'quantum computing'

1988
Hedge fund DE Shaw becomes an early adopter of AI techniques for trading

1990s
'Quant funds' and sophisticated exchange-traded funds begin to take off

1998
Cliff Asness's hedge fund puts the theory of 'factor investing' into practice

2000
Robert Shiller's 'Irrational exuberance' finds flaws with many financial models

2008
Global Financial Crisis puts quants in the spotlight after high-profile funds fold

2011
Launch of Siri, the voice-controlled digital assistant

2014
Google's Ray Kurzweil says computers will be cleverer than humans by 2029

2018
Bengio, Hinton and LeCun win the Turing Award for their work on 'deep learning'

2020
'Robots don't catch coronavirus' remark sparks debate on the trend of automation

The rise of computer-aided investment strategies

In the 1990s, the digitalisation of both stock market trading and financial data, combined with an increase in computing power, made programmable investment strategies an attractive and explorative area of innovation. What started within the proprietary trading desks at investment banks and their associated hedge funds soon made its way into the broader financial community.

Quant funds and sophisticated exchange-traded funds (ETFs) began to take off. Many of these quants possessed algorithms that could scour market data, hunting for stocks with other appealing, human-chosen traits, known as 'factors' – an idea conceived by the economists Eugene Fama and Kenneth French.

Number crunching

One of the first true quants was Robert Merton, who started out as an applied mathematician at Caltech before switching to economics at MIT. In 1969, he tried to work out the pricing of stock options with the help of stochastic calculus – a branch of mathematics that studies dynamic random models and determines their properties (the most well-known of these models is the Brownian motion, which arises from physical phenomena such as the movement of particles in liquid). A high point for quants came when Merton and Myron Scholes won the 1997 Nobel Prize in Economics for their option-pricing model.

In 1998, Cliff Asness, a student of Fama's, founded a hedge fund that put the theory of factor investing into practice. Quants employed algorithms to choose stocks based on factors that were arrived at by economic theory and borne out by data analysis, such as value, size, momentum (recent price rises) or yield (paying high dividends). And back in the 90s, only a handful of money-managers had the technology to crunch the numbers.

Yet the collapse of Long-Term Capital Management – also in 1998 – was a reminder that even the most sophisticated computer-powered strategies can implode. Led by Salomon Brothers' former star trader John Meriwether and advised by the aforementioned Nobel laureates, Scholes and Merton, the hedge fund prided itself on its derivatives investing expertise.

In the late 90s, an algorithm might have simply tried to ride the momentum of a stock's price rise, buying at a certain price level and selling at a predetermined moment.

Its team generated above-average returns and attracted capital from all types of investors. It was famous for not only exploiting inefficiencies but also using easy access to capital to create enormous leveraged bets on market directions. But LTCM's highly leveraged investments began losing value after the Russian financial crisis and, by the end of August 1998, it had lost 50% of the value of its capital investments.

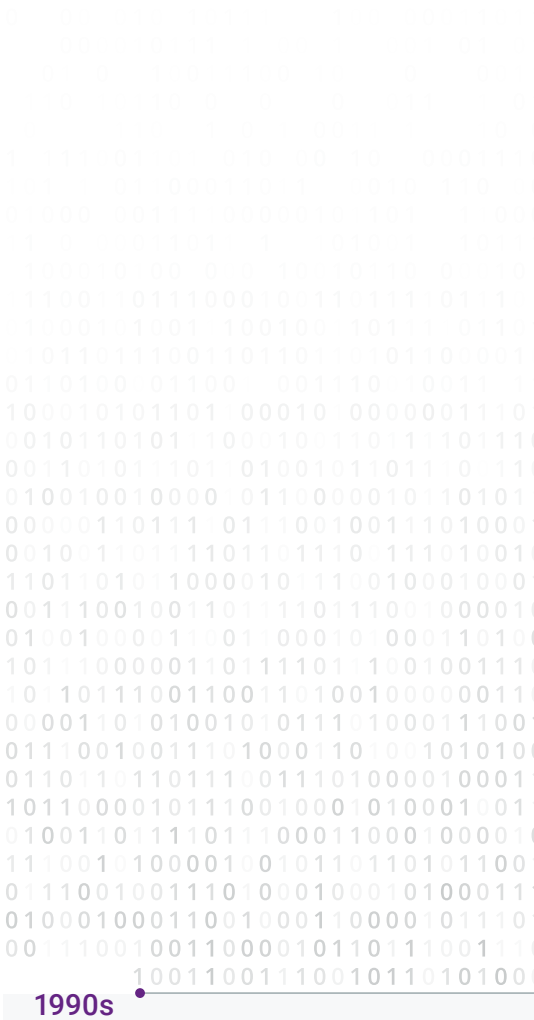
New wave

Today's algorithms can make continuous predictions based on analysis of past and present data while hundreds of real-time inputs bombard the computers with various signals. Yet, in the late 90s, an algorithm might have simply tried to ride the momentum of a stock's price rise, buying at a certain price level and selling at a predetermined moment.

A wave of financial innovation in the 2000s not only expanded the depth and breadth of tradeable securities but created new markets for these securities beyond the traditional exchanges. By the mid-noughties, quant funds were commonplace among global asset managers.

What was the attraction? Well, quants gave them the ability to develop systematic or targeted investment strategies for investors without the need for large teams to analyse and interpret the data. Instead, small teams of financial data scientists and computer programmers could run multiple investment strategies across one or several asset classes.

This meant that investors no longer had to choose between an active or index strategy for their US equity allocation, they could now access a variety of alternative strategies. These ranged from minimum volatility to mean reversion or systematic trading to managed futures, and all for a relatively cost effective price.



1990s

'Quant funds' and sophisticated exchange-traded funds begin to take off

Applying the Adaptive Markets Hypothesis

Quantum leaps

In 2004, MIT Professor Andrew Lo published his seminal 'adaptive markets hypothesis' (AMH), which attempts to combine the rational principles of the efficient market hypothesis (EMH) with the irrational principles of behavioural finance.

The EMH says that market prices incorporate all information rationally and instantaneously. However, the emerging discipline of 'behavioural economics' has challenged this hypothesis, arguing that markets are not rational, but are driven by fear and greed instead.

Economist and Nobel Prize winner Robert Shiller is one of original proponents of behavioural economics. In 2000, Shiller wrote the New York Times bestseller 'Irrational exuberance', in which he argues that many financial models are flawed because people don't always act in a rational way. Shiller posited that if you instead put conventional economics and financial theory together with scientific insights and cognitive reasoning, you factor in the systematic deviations – or behavioural biases – in investors' thinking.

Lo's theory of AMH is premised on the idea that markets are made up of people whose judgments are based on a broad set of factors that are not always easily measured and the relative importance of which can vary. As a result, the interplay between market risk and return is often based on investor perceptions rather than any objective measure of market risk.

This misalignment between investor perception and market reality, says Lo, can cause investor expectations and experience to deviate sharply at times. Yet it can also provide opportunities to create value for investors willing to actively manage portfolio risk by actively modulating market exposures.

In 1999, Lo founded AlphaSimplex Group, a quantitative investment management firm that offers alternative investment solutions designed to adapt to changing market dynamics. The firm draws from Lo's extensive research in financial economics, risk management and human behaviour, running trend-following managed futures, multi-alternative and alternative risk premia strategies.

> "The interplay between market risk and return is often based on investor perceptions rather than any objective measure of market risk.

Kathryn M. Kaminski, Ph.D., CAIA®
Chief Research Strategist, Portfolio Manager
AlphaSimplex Group

AlphaSimplex

AlphaSimplex Group is an investment management firm that strives to help our investors meet their long-term goals in ever-evolving markets by analyzing market behavior and risk. AlphaSimplex combines these insights and the expertise of their research team to create adaptive strategies that are attuned to changing market dynamics.

Black Swans and Black Boxes

In August 2007, a three-day period of dramatic losses occurred when fund managers had to sell similar positions in their quant books to cover margin calls from other portfolio losses. In a period commonly referred to as the 'quant quake', simultaneous selling caused losses at other firms – and further selling.

The US financial system went into meltdown and fingers were pointed at the physicists, mathematicians and engineers who had devised the computer programs, statistical tools and financial instruments supposed to help investors manage risks. As the rare, or 'black swan', event of the global financial crisis (GFC) slid into view, it was not necessarily the best time to be a quant.

Margin calls

Yet not everyone was against the quants. A 2010 paper by Mark Mueller and Andrew Lo – who conceived the 'adaptive markets hypothesis' – explores how the GFC re-invigorated the longstanding debate regarding the effectiveness of quant methods in economics and finance.

Appearing in the Journal of Investment Management, the paper 'Warning: Physics envy may be hazardous to your wealth' asks: 'Are markets and investors driven primarily by fear and greed that cannot be modelled, or is there a method to the market's madness that can be understood through mathematical means?' Those who railed against the quants and blamed them for the crisis believe that market behaviour cannot be quantified and financial decisions are best left to individuals with experience and discretion, the authors assert. Conversely, Mueller and Lo say, those who defend quants insist that markets are efficient.

At the time, critics said that it was the flawed assumptions of the financial models that brought banking to the brink of Armageddon. Lo and Mueller posit that, in the case of collateralised debt obligations (CDOs) during the GFC, a number of decision makers simply didn't have enough the technical expertise to properly evaluate the risk/reward trade-offs of these securities: "… the quants, who should have been more aware of the copula's weaknesses, weren't the ones making the big asset-allocation decisions. Their managers, who made the actual calls, lacked the math skills to understand what the models were doing or how they worked."

Opening the box

Lo and Mueller conclude their paper by calling for more transparency in the so-called 'black box' of quant strategies: "Faith in any person or organization claiming to have a deep and intuitive grasp of market opportunities and risks is no better or worse than putting the same faith and money behind a mysterious black-box strategy. What matters in each case is the transparency of the process, an opportunity to assess the plausibility and limitations of the ideas on which a strategy is based, clarity about expectations for risks as well as returns, an alignment of incentives between the investment manager and the investor, and proper accountability for successes and failures."

The global financial crisis dealt a blow to the popularity of quantitative investment strategies after a number of high profile funds folded.

In a nutshell, the GFC dealt a blow to the popularity of quantitative investment strategies after a number of high profile funds folded. Many of the computer models and algorithms that powered these quantitative strategies had been tried and tested under market conditions that failed to correctly assess the likelihood of such an event. Some were therefore unable to cope with the fluctuations that occurred between summer 2007 and winter 2009.

The events of the quant quake led some managers to develop more complex predictive rules that used a greater variety of signals. It led to a new era in which some quants didn't just tweak their computer models, but decided to rewire them altogether…

2008

Global Financial Crisis puts quants in the spotlight after high-profile funds fold

Two minutes with... Harish Sundaresh

On joining an investment bank in 2007...

Honestly, in a word, 'depressing'. When I joined in the summer of 2007, it followed a trading internship that I really enjoyed. At that time, there were about 400 traders on the mortgage desk.

As I'd had no real financial education, the bank sent me from New York to Stamford for two months of finance 101 training. By the time I returned, they had whittled the 400 traders down to about 60. So the mood was extremely depressing.

The cutback in traders increased my responsibilities quite significantly. Over the next nine months there, I learned some important lessons on tail risk and that it is more important to protect your downside than miss-out on a few basis points of upside.

It also taught me to model distributions as 'non-normal', which typically people avoid because first, they are much harder to generalize, and second, most algorithms are written for normal distributions. So, although it was a difficult period emotionally, just being there in New York during the global financial crisis played a huge role in shaping how I think about protecting downside risk.

On avoiding a black box-approach...

You cannot use an algorithm invented for human automation of mundane tasks. Think about the Roomba, the robotic vacuum cleaner, it knows exactly what to do over and over again without having to adjust its operation based on an unforeseen regime change.

With financial data, there's a regime change every week. Take the coronavirus, for example. It completely and suddenly changed the marketplace regime. Financial data is predominantly non-stationary. The use of structured algorithms on such datasets, doesn't help investors gain any relevant insight or perspective.

What we believe in, and what we have been doing for the last few years, is recreating the algorithm itself. For that, you need to have a theoretical understanding of the loss functions, how the algorithm works and the optimisers needed to produce results. This approach actually allows us to do things differently.

> "Just being there in New York during the global financial crisis played a huge role in shaping how I think about protecting downside risk.

Harish Sundaresh
Director of systematic investing strategies
Loomis, Sayles & Company

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Loomis, Sayles & Company helps fulfill the investment needs of institutional and mutual fund clients worldwide. The firm's performance-driven investors integrate deep proprietary research and integrated risk analysis to make informed, judicious decisions. Loomis Sayles looks for value across traditional asset classes and alternative investments to pursue attractive, sustainable returns.

Searching for the edge in a world of data

Since the GFC, the financial industry has seen a resurgence in interest and innovation when it comes to technology-driven investing. In 2014, Man Group began to use AI to manage client money; in 2017, Two Sigma hedge fund, which uses machine learning, surpassed $50 billion in assets under management. Research from Prequin found that the number of AI hedge funds launched in 2018 was up 77% on 2016.

The development of machine learning techniques is the result of greater availability of diversified databases, increased computational power and the success of companies such as Amazon and Google, which use machine learning to drive their business models. Pioneering firms now use AI and machine learning techniques to trawl through vast amounts of data to identify patterns.

These might link to the prices of securities, how weather patterns can affect the demand for certain commodities, or how filing irregularities might be a predictor of corporate mismanagement. Some hedge funds have even made money by tracking flights of CEOs, to see if CEO's have been in the same towns, and therefore the conclusion of a deal or merger can be expected. Others are applying the appetite for new data and techniques to environmental, social and governance (ESG) investments.

The big picture

A good story to illustrate how this has evolved is to look back at Neil Currie's analysis of parking spaces as a measure of company performance. In 2010, UBS analyst Currie analysed the satellite images of retailer Walmart's parking lots and published the results in a quarterly earnings preview. He posited, correctly, that the number of cars in the parking lots suggested that Walmart stock was undervalued.

As word spread that satellite images were a reliable predictor of corporate profits, a range of investment funds started buying retail traffic data from companies that specialised in satellite imagery and geospatial analytics. Indeed, when traders wanted to monitor the cars being produced at Tesla's California assembly plant a few years ago, those same specialist companies were employed to fly a plane overhead.

While quants, applied systematically, limit the human biases that skew our judgement in doubtful situations, algorithms themselves also have their own biases.

Of course, ten years ago Currie had to count the parking spaces manually from grainy satellite images. With the advances in satellite imagery and AI, there is now a way to automatically count the number of cars in a parking lot to predict how well the company is doing – indeed, a flourishing market has emerged for new forms of a range of alternative datasets.

Siri, tell us a joke

Yet machine learning is not without limitations and challenges. Asked recently about AI's progress since the launch of Siri in 2011, Dr Luc Julia, co-founder of the voice-controlled digital assistant, commented: "Siri had quite a tough start – it was only able to handle about 80% of requests. To fix this, we made the algorithm more human, giving it the feel of talking to a real person. If you like, we added a bit of artificial stupidity. So, when Siri didn't understand, it responded with a joke."

While quants, applied systematically, have the advantage of limiting the human biases that skew our judgement in doubtful situations, algorithms themselves also have their own biases, deriving from the choice of data they use to learn. "Microsoft's Tay chatbot, which was able to interact via Twitter, was taken offline less than 24 hours after launch, when it started tweeting sexist and racist comments," said Julia. "It turned out the algorithm had been primed with data from conversations happening in the southern states of the US during the 60s. It is hard to find high-quality annotated conversational data."

In 2014, Ray Kurzweil, Google's director of engineering, remarked that computers will be cleverer than humans by 2029. Yet, for all the great leaps forward in data availability and computational power, algorithms remain essentially a bit like children: they must be fed high-quality data if they are to 'learn' on their own…

2011

Launch of Siri, the voice-controlled digital assistant

Two minutes with... Bruno Poulin

On the limitations of machines…

Robots can do many things. But they cannot yet drive autonomously. We were supposed to have autonomous cars by 2017 according to Elon Musk, but as we approach the next decade, we're still not quite ready. Indeed, if anything, the industry appears to be stepping back.

We are starting to realise how complex tasks like driving a car can be, and the risks to human safety should we not get it right. It's much easier for computers to beat us at chess or Go, but not so easy to drive a car. A car should not confuse a real stop board and someone on the sidewalk carrying a stop sign.

Just think, you can show a picture of two cats to a toddler for the infant child to then recognise when they see a cat in the future. Machines need hundreds of thousands of cat images for the same outcome. So, there are some things that machines are not able to do in a smarter, safer or faster way than humans.

On combining machines with ESG investing…

ESG and machine learning is the perfect match. First, it's about familiarity. Amazon already suggests our next purchase based on the purchases we've made previously. It gets better every time because it learns. It is self-taught, so it is able to highlight evolutionary patterns without human intervention.

Then there is its processing power. We might be looking at 600 different ESG indicators – machines enable us to efficiently extract and analyse information from vast ESG databases. It's flexible too, so it quickly adapts to changes around a companies' ESG policies, or if there's a change of regulation.

On the issues with a black box model…

For algorithms to work effectively, you need to put the proper data in. But you must also explain what's coming out of the box and why. Just as you have a right to ask your bank why your bank loan application was rejected, so we, in the asset management industry, need to explain the outcomes of the machine learning tasks – especially when the results are counterintuitive or controversial. It's then up to us to sustain the responsible use of machines. If we don't, further regulation is likely to come in to make sure we do so.

> "For algorithms to work effectively, you need to put the proper data in. But you must also explain what's coming out of the box.

Bruno Poulin,
CEO, Ossiam Asset Management

ossiam

Ossiam is a specialist asset management company that develops and manages investment funds, including exchange-traded funds (ETFs), based on an active, systematic and nondiscretionary investment processes. Ossiam funds use alternatively weighted indexes – also known as alternative beta or smart beta – applied to a range of financial asset classes.

From programmable to self-teaching

Improved computing power and broader access to financial and non-financial information has helped investment managers refine and improve their models and techniques. The advent of AI and machine learning have also meant such strategies are becoming self-teaching.

Some investment managers rely on a form of machine leaning called 'Bayesian networks', which use a small group of machines to predict market movements and pinpoint particular trends. Others use AI that runs across hundreds of machines and include techniques like evolutionary computation and deep learning – the latter of which recognises images and spoken words, as well as performing tasks for the likes of Google and Microsoft.

There is also a class of AI pure play hedge funds to have emerged in recent years that are based entirely on machine learning and AI algorithms. Where fund strategies used to employ teams of human quants using machines to build large statistical models, new techniques can automatically recognise changes in the market and adapt in ways that quant models cannot.

Others firms, like DH Shaw – founded by the 80s quant pioneer of the same name – use a symbiosis of quant investing with traditional stockpicking strategies driven by humans, known as 'quantamental'. Whichever way AI, machine learning and deep learning are used, they are seen as the future of asset management. And many in the industry are now seeking computer scientists to help them implement these techniques into their strategies.

Beyond the deep

Look outside the world of finance and you see that improvements in processing power have been exponential. From IBM's success with Deep Blue at chess in 1997 to Google's joy with DeepMind in the International Go championship a decade later, the ability of machines to join the data dots has led to some remarkable results.

The IBM Watson system that played Jeopardy! used a machine learning based system that took a lot of existing data from sources like Wikipedia and national archives, then used that data to learn how to answer questions about the real world. Everything since, from speech recognition to machine vision, has led Watson to expand its suite of tasks and applications.

For the finance industry, there are plenty of lessons to learn from these experiences. The Deep Blue v Kasparov episode, for instance, showed a distinctive human way of looking a complex problem like chess, involving pattern recognition and intuition, while machines are search intensive and look through billions of possibilities. In the real world, the two different approaches can be complimentary – computers and humans together are better than either one alone.

In the real world, the two different approaches can be complimentary – computers and humans together are better than either one alone.

The latest thinking in AI takes highly advanced artificial neural network-based systems – the true 'black boxes' – and gives them the ability to explain themselves. Overcoming these enormously complex systems involves training them by feeding them examples of good explanations. How else can you really trust a recommendation coming out of a black box if the system itself can't explain it?

Indeed, overcoming the 'Why should I trust you?' scepticism about AI and machine learning is perhaps the biggest challenge that the industry and its players need to master. In many ways, this recalls the essence of Alan Turing's famous test.

2014

Google's Ray Kurzweil says computers will be cleverer than humans by 2029

Two minutes with... Ibrahima Kobar

On testing and learning…

We look to harness new technology not only to help improve investment performance, but also to build more efficient and robust operational business models and deliver better service to our clients. We have developed The Ostrum Labs, which is a means to identify, incubate and test these new technologies and techniques.

We are confident that new technologies and techniques will not only help transform client experience but also revolutionise the investment process. Furthermore, we do not believe that machines will replace humans, we believe that machines will help humans, and in many different ways.

On Blockchain…

At its heart, Blockchain offers a new way to complete transactions in financial services. Indeed, we believe that Blockchain will ultimately revolutionise the asset management industry and change the way asset managers build relationships with distributors. It will also help asset managers better understand the ultimate consumer of their investment products. In summer 2017, we were the first asset manager to complete a transaction into a mutual fund processed entirely through Blockchain, via our partner, FundsDLT.

On the use of AI…

We use AI to improve the efficiency of our operational processes. As an asset manager with a significant proportion of our assets in fixed income, each day our middle-office have to analyse and price over 4,500 bonds. There can often be significant variation in the available price information and therefore it is often difficult to establish an accurate price for some bonds. Typically, around 3% of these bonds, roughly 150 in total, would have to be manually analysed by a team of between four and five people armed with an unwieldly spreadsheet.

However, since deploying AI, we have been able to reduce the number of bonds that require manual intervention to fewer than five. And, thanks to the additional information provided by AI in the form of pricing clusters, we now only require one person to conduct the same analysis, allowing our teams to concentrate on adding value in our endeavours.

> “Blockchain will ultimately revolutionise the asset management industry and change the way asset managers build relationships with distributors.

Ibrahima Kobar,
Global CIO,
Ostrum Asset Management

Ostrum ASSET MANAGEMENT

Ostrum Asset Management has been committed to helping clients to provide for their future for more than 30 years. Ostrum Asset Management is a leading asset manager in Europe that provides a full range of high-quality fixed income, equity and insurance investment management strategies, with an active and fundamental approach.

A new theme emerges

Cutting-edge techniques developed in the 1990s and 2000s by Yoshua Bengio, Geoffrey Hinton and Yann LeCun underpin the current proliferation of AI technologies, from self-driving cars to automated medical diagnoses. The trio – often referred to as the 'godfathers of AI' – won the 2018 Turing Award, known as the 'Nobel Prize of computing', for their work developing the AI subfield of 'deep learning'.

As we move into a new decade, new opportunities now exist for investors to access many of the latest innovations as part of an investment portfolio. In the 2020s, thematic investments offer access to the companies that are leading the way in AI, machine learning and robotics.

Indeed, all technologies are becoming increasingly pervasive in the modern world. The same techniques that are used by investment teams to spot correlations across markets are today used by doctors to predict incidences of cancer in patients, by meteorologists to predict weather patterns and by energy companies to predict electricity demand.

Medical automation

The investable universe in medical automation alone is reported to be in the region of $80 billion. Through rehabilitation, diagnostics, exoskeletons and elderly care, using robotics and autonomous systems promises to drastically reduce costs, while improving quality of life.

In addition, robotics and automation can transcend cost-cutting by using robots for difficult surgeries and neurological treatments that were previously unfeasible. Advancements in AI, imaging and analytics and nano-medicine are enabling precision medicine that proposes the customization of healthcare, with medical decisions, treatments, practices, or products being tailored to the individual patient at a reasonable cost.

Robots have also joined the fight against Covid-19 in a number of ways. For instance, self-driving cleaning robots, which enter hospitals and kill microbes lurking on floor surfaces with a zap of ultraviolet light, have been in high demand in China, Italy and elsewhere. The machines have blue-glowing bulbs that emit concentrated UV-C light, which destroys bacteria, viruses and other harmful microbes by damaging their DNA and RNA, so they can't multiply.

The big challenge ahead, therefore, is to shift from the narrow AI we know today to the general AI, where the rules are not so well defined and the rewards are less certain.

Or take Temi, an AI-embedded, voice-activated device, which is able to enter coronavirus infected hospitals and give doctors a clearer picture of what their environment looks like. The robot can engage and interact with patients and provide doctors and other hospital staff with the information they need to make better-informed decisions about who to treat next – and all from a safe distance.

Exponential growth

The market for AI and robotics is estimated at over $500 billion. Yet growth in the AI industry is exponential, not linear. While we currently have AI that is able to perform single tasks or play games such as Go, it is still incapable of performing tasks beyond initial programming.

The big challenge ahead, therefore, is to shift from the narrow AI we know today to the general AI, where the rules are not so well defined and the rewards are less certain. This will be the human-level AI that can understand and reason, which will be able to innovate and come up with new ideas. It's a form of AI that is likely to exist within the next couple of decades.

2018

Bengio, Hinton and LeCun win the Turing Award for their work on 'deep learning'

Two minutes with... Karen Kharmandarian

Will robots steal all of our jobs in the future?

People tend to overestimate what robots can do over the short term – and they probably underestimate what they can do over the long term. Robots have been dramatically expanding the scope of physical tasks performed and have also started to do more and more cognitive ones. The pace of advancements is sustainable – and it will not be linear growth, it will be exponential.

There's a network effect, too. So, if you have one AI system learning a new task, it can be shared with and benefit all the other AI systems or robots through the cloud and connectivity. What one robot can achieve in eight hours can suddenly be performed in one hour by eight different robots.

I think the real question is what humans will do with all these devices. And it will very much depend on what we do as humans, collectively. Robots are very good at certain things; humans are very good at other things. For me, the future will not be about 'man versus machine' – rather, it will be defined by 'man with machine versus man without machine'.

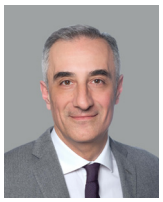
What's the appeal of investing in AI and robotics?

First, you have large data sets available thanks to ever-increasing connected devices, and the 'Moore's Law-powered' necessary computing power to deal with these data sets. In terms of AI techniques, especially neural network systems, you can uncover the insights based on the data.

There's also the fact that costs are coming down quite significantly for these technologies. And when you have this combination of technological advancements and costs coming down, you are at an inflection point – especially when this relates to a general-purpose technology that's applicable to a number of different industries and sectors.

We've seen more technologies being embedded into these robotic devices, be they sensors, machine vision systems, natural language understanding or generation, and contextual awareness systems, to name but a few. So, from basic mechatronic devices used for performing the very repetitive tasks on mass- manufacturing floors – what we call the four Ds: dull, demanding, dirty and dangerous – robots have suddenly become smaller, smarter, safer and cheaper. Moreover, they have made leaps forward in terms of versatility, adaptability, flexibility, user-friendliness and mobility, allowing them to become ubiquitous.

> "For me, the future will not be about 'man versus machine' – rather, it will be defined by 'man with machine versus man without machine'.



Karen Kharmandarian, Chairman, Thematics Asset Management

THEMATICS asset management

Thematics Asset Management is a dedicated equity investor in innovative thematic strategies, which include Water Safety, Artificial Intelligence & Robotics and the Subscription Economy. It invests in a collection of markets that have the potential to grow at a rate superior to that of the broader global economy due to the long-term secular growth drivers that underpin them. It integrates ESG principles in its portfolio construction process.

AI in a time of Covid-19

There was a throwaway remark in a Bloomberg interview in March 2020 that posited 'robots don't catch coronavirus'. It got people thinking that the Covid-19 pandemic crisis might add impetus to the trend of automation in areas of society that are less reliant on physical human exchanges with customers, such as in the investment management industry.

On the flip side, overestimating AI and robotics serves to underestimate the very people who can save us from these types of pandemic: the health workers who will likely never be replaced by machines outright. Take the horrendous triage decisions taken by overwhelmed hospital staff in Italy, forced to prioritise who to save as the virus raged out of control in the north of the country. This context makes a compelling argument in favour of humans remaining in charge when it comes to making the big decisions.

As we saw in the last chapter, robots can now go into hospitals and kill the vast majority of germs with powerful UV-C light. Yet just as with robotic vacuum cleaners like the Roomba, medical cleaning robots also have their limitations.

University College London's Dr Robert Elliott Smith, author of the 2019 book 'Rage Inside the Machine', said: "When you've a complicated human environment where complicated things are going on, I'd be too afraid that coronavirus might be hiding underneath the pillow and that a cleaning robot simply isn't going to address it. Are we really going to trust a robot to do well enough when it's a matter of life and death?

"Of course, I have great doubts about human beings too. But what I know about technology is that the way that it deals with certain complexities, like different surfaces and shapes, is less effective than an articulate human being can do. So, even though I have trust issues with both, I know that we can't build great portable robots with articulated hands yet, so I'd rather have an able and conscientious human doing a job like that."

The fear of the impact of AI and robotics on people's livelihoods could serve to dampen economic growth in the post-Covid-19 world.

Epidemiology versus economy

In some industries, machines will simply be better and more efficient than humans can ever be. Yet the fear of the impact of AI and robotics on people's livelihoods could serve to dampen economic growth in the post-Covid-19 world.

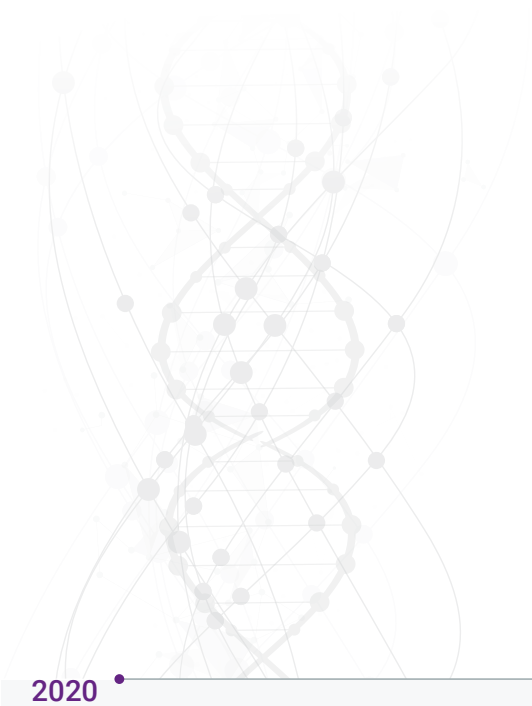
Professor Robert Shiller (who we met back in Chapter One) believes that as politicians have no way to prevent technology from replacing many people, they have decided to make immigration the scapegoat. "But if this becomes a period of high unemployment, people are going to start worrying technology is the cause of their problems," said Shiller. "During the 1930s, for instance, the dial telephone replaced the jobs of switchboard operators, making them redundant. This fear of machines replacing jobs was one of the narratives which meant the Great Depression lasted a decade."

Some worry that this could lead to something of a tech backlash, where the realities of what AI and robotics can actually do for us fails to live up to the hype. Yet, rather than succumbing to the more dystopian fears of one replacing the other, perhaps we should be able to look to a future where we can see a more cooperative relationship between humans and machines?

For that to happen, said Dr Smith, there also needs to be a greater understanding of the differences between human intelligence and its subtleties: "We have been told for a century or two that human thinking is best when it's purely rational, like a machine. That when we're doing our best at thinking, we're kind of logical engines like a machine – and that it is the perfectly rational agent in economics.

"In reality, human beings deal with an outstandingly uncertain world – uncertainty that cannot be quantified as a primary characteristic. We use our primitive feelings, or the feelings one has in one's gut, to invest emotion, so that we can make decisions in the face of high uncertainty."

The radical uncertainties created by an inherently complex world suggest that mechanised thinking is inadequate on its own. Robots won't steal all our jobs, but they won't catch coronavirus either. And in the aftermath of the Covid-19 pandemic crisis, humans may need to embrace machines like never before...



2020

'Robots don't catch coronavirus' remark sparks debate on the trend of automation

Two minutes with... Olivier Bouteille

What does AI hold for the future of financial data science?

Our traditional financial models are full of well-known assumptions and approximations. This is simply because, until recently, we did not have the computation power or numerical models to represent the 'real world' more accurately. The universe of data that was available to us was also pretty narrow.

The progress made by financial data science over the last ten years is vast and promises to add considerable value for investment managers. Kay-Fu Lee, one of AI's pre-eminent figures, compared the recent discoveries in data science to the harnessing of electricity a century ago. He said that 'once a fundamental breakthrough has been published, the centre of gravity quickly shifts from a handful of elite researchers to an army of tinkerers'. And this is where we are today.

Mobile phones, social media, satellites and the nascent 'Internet of Things' produce trillions of data points about our environment every day, which bring insights to investors. We are now developing models that not only adapt better to massive unexpected events such as Covid-19 but also aim to measure the environmental impacts of a portfolio. Even on the client-facing side, many people are engaged on building truly flexible and personalised advice that leverages the power of machine learning.

How is Natixis Investment Managers taking a lead in these areas?

Well, for one thing, we sponsored the first edition of *The Journal of Financial Data Science*, which gathers the views of both academics and financial institutions researchers, including from some of our affiliates. It focuses on state of the art use-cases-based research. These include remediating some inefficiencies of traditional factor models by taking into account non-linearity and interaction effects among variables, and correcting some of the biases included in classic mean-variance portfolio theory.

Ultimately, as investment managers, either we complement our investment decisions by integrating alternative sources of data or we correct the biases and limitations of traditional models, which we know are flawed.

Any words of caution on computer-aided investment strategies?

Well, the danger of misapplying these techniques is great, for multiple reasons. For example, taking the expression, 'to a man with a hammer, everything looks like a nail', there are multiple ways to analyse and use a single set of data – and every one of them will provide you with an answer.

Yet finding the most adequate models – be it linear regressions, machine learning or deep learning – and calibrating them appropriately, takes a lot of practice and skill. What's more, machine-learning applications often require far more data than is available in our field, which is of particular concern for investing over the longer term… we'll keep the data quality discussion for another day!

Finally, capital markets reflect the actions of people that may be influenced by a wide variety of fast changing and difficult-to-measure factors. This has been a longstanding challenge in quantitative finance. But investors need to pay even more attention to this problem in the field of machine learning as it can sometimes conceal the relationship between its inputs and the produced insight.

> "Either we complement our investment decisions by integrating alternative sources of data or we correct the biases and limitations of traditional models.

Olivier Bouteille, Chief Information Officer - Digital Transformation Lead, Natixis Investment Managers

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Natixis Investment Managers serves financial professionals with more insightful ways to construct portfolios.

Powered by the expertise of more than 20 specialized investment managers globally, we apply **Active Thinking®** to deliver proactive solutions that help clients pursue better outcomes in all markets.

Conclusion: Embracing an AI-powered future

The industries of financial services and technology have always been closely interlinked. Innovations have often been quick to diffuse from one industry to another, so too have the talented individuals that both technology and finance firms seek to attract.

Just as many engineers and computer scientists switched to finance after careers at Microsoft, IBM and Bell Laboratories in the 1990s, so analysts and investment bankers were among the entrepreneurs of the dotcom boom in the early 2000s. Common to both is the importance of innovation, continuous improvement and the endless quest for an edge over the competition.

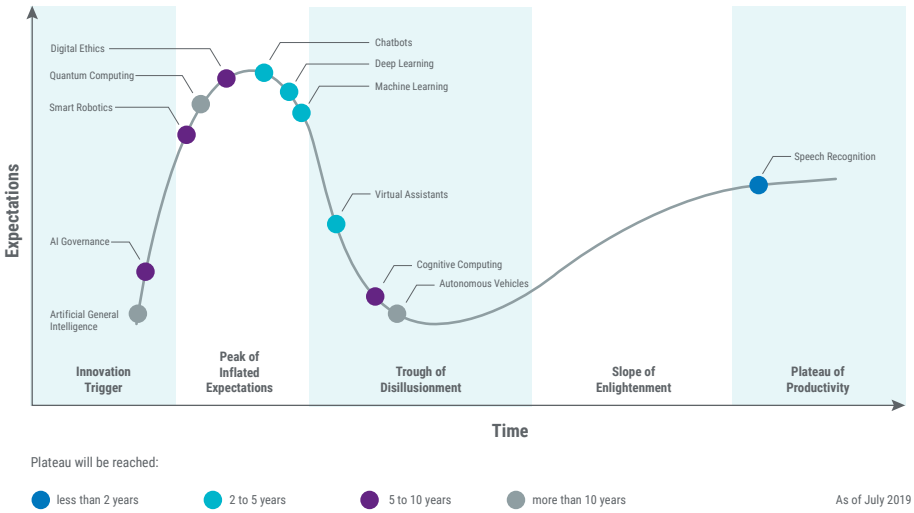
As we start to produce and use more and more data – from robotics applications to social networks to Internet of Things – machine learning and AI will help us to solve more and more societal challenges and improve our lives.

Seeing past the hype

As with investing, AI is a field well versed with cycles of boom and bust. When research fails to meet inflated expectations, it creates a freeze in funding and interest – like the so-called 'AI winter' of the late 1980s. Yet in its wake, the godfathers of AI began exchanging ideas and working on related problems. These included neural networks — computer programs made from connected digital neurons that have become a key building block for modern AI.

Technological advancements in investing have improved at a rapid pace over the last three decades. What started with the use of algorithms and computer programs to refine investment strategies has now evolved to include techniques such as artificial intelligence and machine learning which offer investors a whole new world of opportunities.

Gartner Hype Cycle for Artificial Intelligence, 2019



Probability to the fore

As we start to produce and use more and more data – from robotics applications to social networks to Internet of Things – machine learning and AI will help us to solve more and more societal challenges and improve our lives. Furthermore, people are starting to understand the limitations of the human brain to act and make decisions rationally in uncertain environments.

The mathematicians have always been at the heart of quant investing. Those who have been able to fuse probabilistic theory with real life applications have been able to branch into computer and social sciences, the economy and finance.

The possibilities of probability – which is central to not just machine learning and AI, but human decision-making too – will play a vital role in helping us to reshape and improve our society. The mathematicians would argue that there are a great many reasons to believe it will transform it for the better.

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