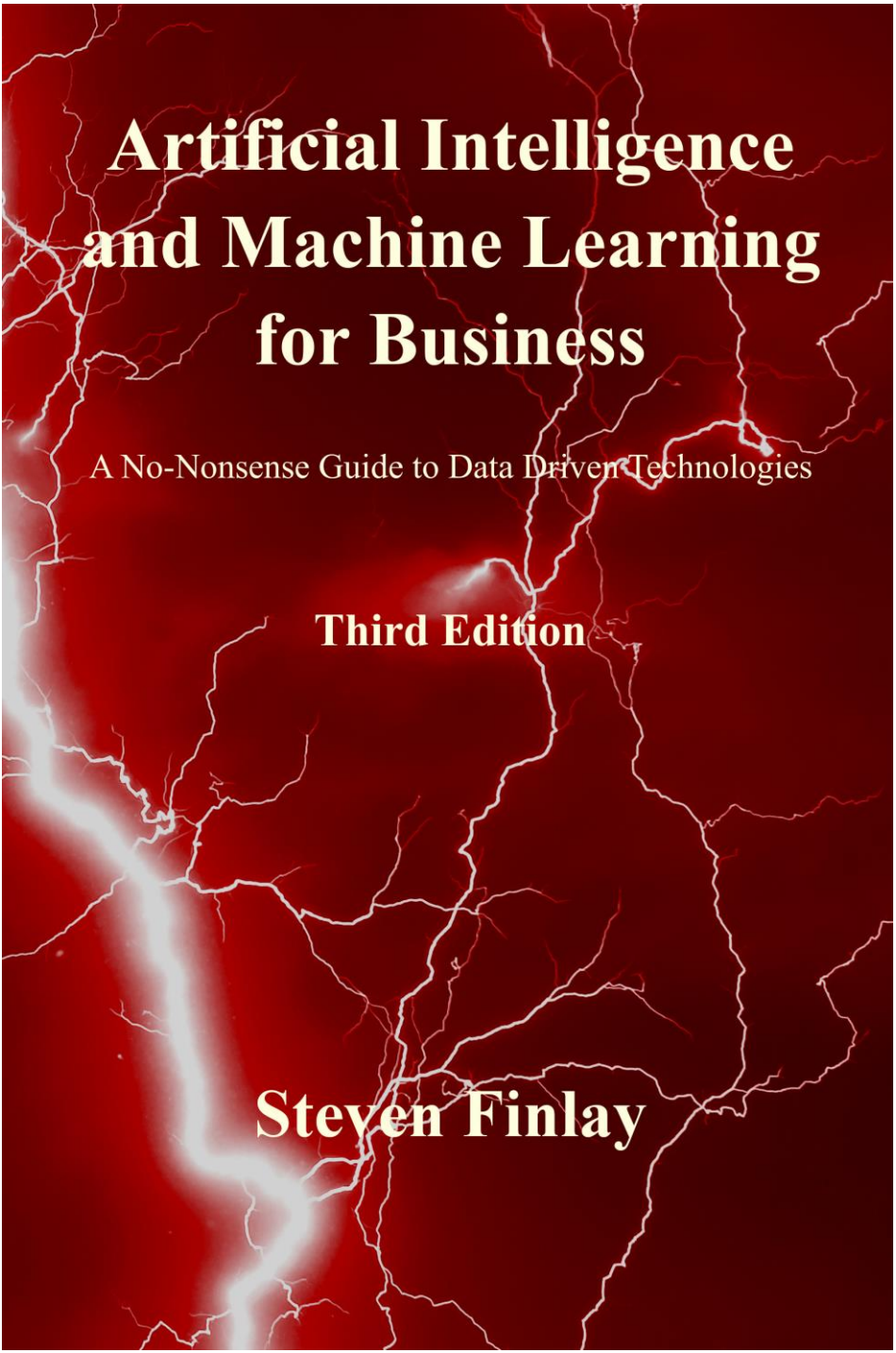
Artificial Intelligence and Machine Learning for Business
A No-Nonsense Guide to Data Driven Technologies
Third Edition
Steven Finlay

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No plants or animals were mistreated in the writing of this book.

Cover image: "Fire in the blood." Thanks to Pixabay.

To Sam and Ruby

Contents

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I would like to thank my family, and my wife Samantha in particular, for their support in writing this book. I would also like to extend my gratitude to all those readers of the previous edition who contacted me with suggestions, corrections, thoughts and ideas. I have incorporated the majority of these into this edition. I am particularly grateful to the reader who told me where I could buy an orange washing machine.

Foreword

56 minutes one way. 112 minutes for the round trip. That's the time it takes my commuter train to travel from my home town of Preston to the great British city of Manchester and back. I find this is an ideal time to catch up on a bit of reading. Therefore, I thought that a concise book about artificial intelligence and machine learning, which could be read in about this time, would be useful to people with not much free time on their hands.

An understanding of machine learning is important because it's having a huge impact across many aspects of our lives. In particular, it's driving the explosion in "Artificial intelligence" applications in many areas such as language translation, autonomous robots and medical diagnosis.

Artificial intelligence and machine learning are also having a direct impact on many everyday business functions. Automated systems, based on machine learning, are replacing numerous tasks that were once undertaken by people. This is giving organizations which embrace these technologies a competitive advantage over their rivals because of the efficiency savings and improved customer service that such systems can deliver.

This new and updated edition of the book is considerably longer than the previous one. In particular, there are several new chapters covering a broader set of topics than before. However, I have striven to retain the "concise no-nonsense" style of the original. Not least, because this was a key feature that readers said they liked about it. Therefore, the book may now take a little longer than 112 minutes to read (maybe two round trips to Manchester rather than one), but I hope you find the time well spent.

1. Introduction

Do you have a smartphone or a credit card? Do you buy stuff from supermarkets or play computer games? Are you employed or use health care? If the answer to any of these questions is yes, then artificial intelligence and machine learning will be having an impact on your life in one way or another. This is because they are the primary tools organizations use to leverage the data they hold about you in order to decide how they are going to deal with you. They are used to inform organizations about how you are likely to behave under different circumstances, and hence the way that they should treat you in order to maximize their (and sometimes your) objectives.

These technologies are now being used in almost every walk of life to improve processes and enhance peoples' everyday experiences via "artificially intelligent" machines and computer interfaces. Amazon's Echo, Apple's Siri and Google Translate are just three well known software products that demonstrate the benefits that these technologies can deliver.

These days, many products and services are also adaptive. They tailor their responses to the behavior of individual users. TV and music streaming services learn to identify the content you like, and present you with recommendations that you'll no doubt be interested in. Change the type of music you listen to and their recommendations will change too. Likewise, you can buy heating systems which learn to anticipate when it's the best time to turn the heating on so that you don't have to bother, while at the same time optimizing energy usage to reduce your bills. These are further examples of artificial intelligence in action.

This concise text provides a managerial (i.e. non-technical and no

complex formulas) overview of artificial intelligence and machine learning, what they are and how they are used. No prior knowledge is assumed. To put it another way, if you can read and write and do basic arithmetic (there is a bit of arithmetic, but not that much) then you should be OK with the material in this book.

A good question to ask at this point is: why do I need to know about these things? One reason is personal. Intelligent decision-making systems, based on machine learning, are widely used by organizations to decide how to treat you, your friends and your family. They use these tools to decide if you will receive a great offer or a poor one, if you should be placed at the front or the back of the queue, if you will be subject to a tax audit or treated as a suspect in a criminal case. Therefore, it's not a bad idea to know something about these things so that you can understand why an organization may have treated you in one way and not in another.

The other reason to learn about artificial intelligence, and the one that is the main focus of this book, is that it is now a mainstream business tool. Not that long ago, artificial intelligence was the domain of a few nerdy specialists working mainly in academia, financial services or large marketing departments. These days, regardless of what business you are in, applications of artificial intelligence, based on machine learning, can be found across the full range of business activities. This covers everything from employee vetting, answering customer queries and target marketing through to robots on the production line, warehouse management and customer deliveries. As a consequence, artificial intelligence is supporting or supplanting human expertise in many domains. Some examples include: replacing underwriters when setting insurance premiums, helping HR professionals decide who to hire/fire, automatically identifying customers as they walk into your store and supporting doctors when diagnosing illnesses such as cancer and heart disease.

Artificial intelligence has arrived big time. It's no fad and it's here to stay. Those organizations which can use it to solve business problems, improve efficiency and cut costs will benefit at the expense of their rivals.

This doesn't mean that you need to learn all the things that a

technical specialist (a data scientist) needs to know. However, having a working knowledge of what artificial intelligence and machine learning are, and knowing how they can be used to help your organization deliver better products and services, will be beneficial. Not least, because in order to make effective use of these tools they need to be focused on business objectives to address specific problems that organizations face.

If on the other hand you happen to be an equation quoting, formula juggling, bad ass mathematical genius who thinks they know all there is to know about artificial intelligence, then this book may also have some value for you too. Possibly even more than those who know nothing at all. Why? Because if all you care about are the theoretical aspects of the subject then you face a real risk of hitting a brick wall when it comes to delivering useful solutions in the minefield that is the real world; a world populated with social, ethical and political issues. This, together with a growing raft of privacy and data protection legislation, could derail your solutions no matter how good they are mathematically. Without consideration of these "soft issues" the best case is that the solutions you develop don't get to be deployed. The worst-case scenario is that you design an artificial intelligence based system that lands you in court because it unfairly discriminates against minorities, women or some other group of people. Maybe you can skip a few of the earlier chapters, but you should certainly read the later ones.

To get the most out of artificial intelligence, data scientists need to engage with business users to understand their problems. Data scientists also need to understand an organization's culture and its approach to the adoption of new ideas, technologies and working practices. Legal and regulatory issues in the region(s) in which their clients operate also require due consideration. It doesn't matter how good a solution is in terms of cutting edge hardware and software, if it's not aligned with an organization's business objectives and operational processes, then it's all just a waste of time and money.

Lots of solution suppliers can bamboozle you with their fancy tech and the latest terminology, which is often just a rebranding of last year's tech with a new twist. However, the suppliers who add value will be those who spend time understanding how you and your

organization work. They will then determine if and how their solutions can be used to improve what you do and explain this to you in simple language which you can understand without needing to reach for Wikipedia.

Successful artificial intelligence is a two-way thing. Data scientists need to know something about your organization and what it does, and you need to understand a little bit about artificial intelligence and machine learning. Without this joint understanding it's unlikely that you or your organization will be able to realize the full benefits that artificial intelligence has to offer.

OK. So, what will you learn from reading this book? The key topics that we are going to cover in the following chapters are:

- What machine learning and artificial intelligence are.
- The sort of things organizations use artificial intelligence for.
- What a predictive model looks like.
- The relationship between artificial intelligence, machine learning and "Big Data."
- The people and tools needed to apply artificial intelligence.
- How to use artificial intelligence to improve business processes and the bottom line.
- The legal and ethical issues that need to be considered when developing artificial intelligence based solutions that are going to be used to make decisions about people.
- How advanced forms of machine learning are applied to drive artificial intelligence applications such as object recognition and language translation.
- The current limitations of machine learning and artificial intelligence.

Recommended further reading and a glossary of common machine learning/artificial intelligence terms are provided in Appendices B and C respectively.

2. What are Machine Learning and Artificial Intelligence (AI)?

Machine learning is the use of mathematical procedures (**algorithms**) to analyze data. The aim is to discover useful patterns (relationships or correlations) between different items of data. Once the relationships have been identified, these can be used to make inferences about the behavior of new cases when they present themselves. In essence, this is analogous to the way people learn. We observe what goes on around us and draw conclusions from our experiences about how the world works. We then apply what we have learnt to help us deal with new situations that we find ourselves in. The more we experience and learn, the better our ability to make decisions becomes.

One application of machine learning is object recognition. The goal is to develop systems that can identify everyday objects from images the system is presented with. The data used to develop an object recognition system consists of pictures of different objects such as chairs, umbrellas, washing machines and so on. Each picture presented to the machine learning algorithm is labeled to identify which type of object it contains. For each type of object there may be hundreds or thousands of different images, representing alternative forms of that object from different perspectives (you'd be surprised at just how many variants of an umbrella there are!)

By analyzing the different images, machine learning algorithms recognize that certain objects are associated with certain features (patterns). Chairs tend to have protuberances (legs) coming from a flat, often squarish base (the seat). They are also differentiated from

stools by having a back rest. Washing machines tend to be cube shaped with knobs on and are almost never pink or orange (please, do let me know if you ever come across somewhere where I can buy a pink washing machine!) Similarly, umbrellas are long and thin (when closed), are often, but not always, black and so on.

One of the most common, and arguably the first, application of machine learning is prediction. It's about using machine learning to determine something that you don't currently know, based on the information that you currently have available. The patterns that one finds relate to the relationships between behaviors and outcomes. Very often this relates to people's past behavior and what they subsequently went on to do. Having identified the relationships that exist, it is then possible to make predictions about someone's future behavior based on their current state of being. If you give me a sample of peoples' previous purchasing history, I can utilize machine learning to identify patterns in their purchase behavior. I can then use these patterns to predict what goods someone is likely to buy next; i.e. future purchases are the outcome that I want to predict. This allows me to target them with tailored promotional offers for those specific products.

Using machine learning for prediction is sometimes referred to as predictive modelling or **Predictive Analytics** (PA). In fact, predictive analytics is such a common application of machine learning that many people (rightly or wrongly) often use the two terms interchangeably.

Predicting the future behavior of individuals is what people usually associate with machine learning, but there are other situations and problems to which machine learning can be applied. All you need is some unknown event or thing that you want to determine (predict), and this could be in the past, present or future. Doctors examine their patients, carry out tests and question them about their symptoms in order to gather evidence (data). They then use this data to come to a view as to what they think is wrong with the patient. They are not making a prediction about the patient's future health but trying to work out what's wrong with them today. Doctors can do this with a high degree of accuracy because they cross reference the patient information that they have obtained against what they

have learnt from years of training and practice. In other words, they are looking for how the patient's symptoms correlate with their knowledge of known illnesses. Machine learning can be applied in the same way. Given a host of detailed information about the symptoms of different illnesses, machine learning can be used to estimate the probability that someone has a certain condition, based on the symptoms that they present.

Another way to think about machine learning/predictive analytics is as a method of reducing uncertainty. There are a whole host of possible outcomes that could occur in any given situation. Machine learning won't tell you with absolute certainty which outcome will occur, but it can provide some insight into the likelihood, or odds, of each outcome.

You may know that when someone goes grocery shopping they often buy bread, wine and chicken, but with machine learning you can determine that there is say, an 80% chance that the next product they buy is bread, a 15% chance that they buy wine and a 5% chance that they buy chicken. Therefore, if you want to encourage them to make their next purchase in your store, you are far more likely to win their custom with a bread offer rather than a wine or chicken offer.

A **predictive model** (or just model going forward) is the output generated by the machine learning process. The model captures the relationships (patterns) that have been uncovered by the analytics process. Once a model has been created, it can be used to generate new predictions. Organizations then use the model's predictions to decide what to do or how to treat people. So, machine learning is a process and a predictive model is the end product of that process.

There are lots of different types of predictive model, and there are dozens, if not hundreds, of machine learning techniques and algorithms that can be used to generate a model. However, regardless of the type of model or the mathematics used to create it, a model's predictions are almost always represented by a number - a **score**. The higher the score the more likely someone is to behave in the way the model predicts, the lower the score the less likely they are to behave in that way.

Machine learning can be applied in all sorts of situations and to many types of problem. However, the most common business

applications of machine learning, and the ones that are the main focus of this book, relate to what people are going to do or how they will behave in the future, based on what you know about them today[1].

One very well-known application of machine learning is credit scoring. When someone wants a loan, credit card or mortgage the lender asks the individual questions about themselves and their lifestyle. They then combine this with information from a credit report containing details about the individual's previous borrowing history, provided by a credit reference agency such as Experian or Equifax[2]. The information is then fed into a predictive model to generate a credit score.

If you live in the USA you will probably be familiar with FICO and/or Vantage scores. A high score (>750) is a prediction that someone is very likely to repay any money they borrow; i.e. that they are creditworthy. A low score (<500) indicates that someone is very uncreditworthy. Banks and finance companies the world over use similar credit scoring methods.

Another common application of machine learning is target marketing. Given information about someone's age, gender, income, web-browsing, purchase history, location and so on, a marketing department can predict if the person is interested in a particular product or not. They then use that prediction to decide whether or not to target them with promotional offers. Likewise, predictive models can also be used to infer how much people are willing to pay for products like insurance. This information is then used to tailor a personalized pricing strategy to each person's individual circumstances.

A further example of machine learning in action is preventative health care. Traditional health care systems are reactive. People seek medical assistance when they feel ill. Doctors then do their best to treat the illnesses they are presented with – treatments that can be very costly and time consuming. These days, advanced health care systems are increasingly focusing their attention on prevention rather than cure. This vastly reduces costs and improves patient outcomes. Machine learning is used to assess people's medical records and predict the likelihood of them developing specific

conditions such as heart disease or diabetes, often years in advance. Individuals who come at the top of the pile; i.e. those that the model predicts are most likely to get the disease, are contacted with a view of initiating preventative action. For example, making lifestyle changes or taking preventative medication.

A final example of machine learning in action is determining what type of news (and other) articles to recommend to people. Social media providers use machine learning to analyze what articles you've read in the past and the type of topics you discuss with friends. This then drives the content that they promote to you.

That's just a few ways in which machine learning is being used. Today, machine learning supports a huge range of applications. In fact, almost any aspect of life that involves decision-making in one form or another. The algorithms that match people on dating sites, the technology used to detect credit card fraud and systems for identifying terrorist suspects all utilize predictive models derived using machine learning. If you want a more comprehensive list of applications then see the book by Eric Siegel[3], which details more than 120 different applications of predictive models in use today – and that's not a comprehensive list!

That brings us on to the question as to what one means by **Artificial Intelligence** or AI. There are many and varied definitions of what AI is, and as with predictive analytics, many people use the terms AI and machine learning interchangeably. In terms of the overall scope of AI research, machine learning is a key field of study, but there are many others. True artificial intelligence is about much much more than just pattern recognition and prediction. Some experts also question if true AI can ever be achieved by just following a "Brute force" approach of developing ever more complex algorithms using ever more powerful computer hardware. Is there some additional (as yet unknown) element required for human-like intelligence and self-awareness which can't be replicated via computation alone[4]?

So, in one sense it's incorrect to say that machine learning and artificial intelligence are the same thing. However, in practice almost every AI system in use today relies heavily on machine learning. Therefore, for the purposes of this book a simple working definition

of AI that we shall adhere to is:

- **Artificial Intelligence (AI) is the replication of human analytical and/or decision-making capabilities.**

A good AI application is one that can perform as well or better than the average person when faced with everyday tasks. For example, the ability to identify people from their Facebook photos, being able to assess someone's creditworthiness more accurately than an experienced underwriter, the ability to beat the best Go and chess players or being better able to spot the signs of cancer on a medical scan than an expert radiologist.

At one level, AI applications can seem almost magical to the layperson. However, like most things, once you get under the bonnet the mystique evaporates. In practice, all of the news stories one hears about the amazing applications of "AI" are really just very sophisticated applications of machine leaning.

A key mistake to avoid is thinking that current AI applications are in any way intelligent in a human conscious way. Sure, they are very complex, exceedingly clever and can be creepily lifelike at times, but it's all just math at the end of the day. Most experts agree, we are years away from being able to create a machine with a human-like sense of self, or which could pass itself off as human day in, day out. That's not to say there aren't some very good chatbots out there!

All of the AI applications in use today are what the industry refers to as **Narrow AI**. They are very good at behaving intelligently when applied to one well defined area of expertise. However, these systems are miles away from **General AI.** General AI is a system that can learn and act intelligently across a wide range of environments and problems in a similar way to a person. An AI application that is used to detect tax avoidance for example, is useless at detecting the signs of cancer from medical scans. However, a person could learn to do both these tasks if they were given suitable training. In a similar vein, a system such as Google Translate is great at understanding the spoken word but wouldn't be much use when it comes to assessing if someone on a dating site might be compatible

with you.

The core components that drive most AI/machine learning applications are:

- **Data input.** This can be sensory inputs from cameras (eyes), microphones (ears) or other sources. It also includes pre-processed data such as the information captured when someone fills in a form online, details of what someone has bought using their credit card or an individual's credit history provided by a credit reference agency.

- **Data (pre)processing.** The raw data input needs to be processed into a standard "computer friendly" format before it is ready to be used.

- **Predictive models.** These are generated by the machine learning process using past experiences; i.e. large amounts of historic data. Pre-processed data for new cases is fed into the models in order to generate fresh predictions going forward.

- **Decision rules (rule sets**). A prediction on its own is useless. You have to decide how to use it. Decision rules are used in conjunction with data inputs and the scores from predictive models to decide what to do. Sometimes these rules are derived automatically by the machine learning algorithm, but often they will include additional rules defined by human experts/business users.

- **Response/output.** Action needs to be taken based upon the decision(s) that have been made. If the decision is that someone is creditworthy, then a credit card needs to be issued. If the decision is that someone should be hired, then they need to be sent an offer letter, given a contract to sign and so on.

It's the combination of these individual components that give us the "AI."

What makes some AI applications appear so clever is the sheer complexity of the algorithms that underpin them, combined with a slick user interface to gather data and deliver the required responses in a human friendly way. Combine these components with the latest generation of industrial machinery, or integrate them into cars and other vehicles, and one has robots that can interact with their environment and engage with us in a very human like way.

Let's begin by considering a marketing AI application for a drinks company. The application takes information gathered about individuals from social networks and feeds it into a predictive model to determine how likely they are to buy a particular brand of whisky. The system then applies a number of rules to decide if an individual should be marketed to. The rules that might exist are:

1. If the predictive model estimates that the chance of them buying whisky is more than 90% then do nothing. They will probably buy the whisky anyway.

2. If the predictive model estimates that the chance of them buying whisky is between 1% and 90% then send them a $5 discount coupon to try and make the whisky a more attractive offering; i.e. influence the customer's behavior to increase the chance of them buying.

3. If the predictive model estimates the chance of them buying whisky to be less than 1% then don't do anything. They probably won't buy the whisky whatever you offer them. Therefore, it's not worth the effort trying to persuade them.

So, these rules would be derived based on some type of cost-benefit analysis, where the 1% and 90% cut-offs are deemed to be the optimal level at which to trigger marketing activity. However, other business rules would also come into play, such as:

1. NEVER make an offer to sell whisky to children, no matter what their propensity to buy it!

2. DO NOT send offers to people with a history of alcohol dependency.

Both groups referred to by these rules will contain lots of people who would like to buy whisky; i.e. >1% chance, but from an ethical perspective targeting children or people with alcohol problems is difficult to argue for. From a purely profit-orientated perspective, marketing to children is likely to be illegal and targeting such individuals could result in a significant amount of negative publicity. These two rules are a great example of why human expertise is required to support automated machine learning based systems, especially where systems are being used to make risky or controversial decisions about people.

One highly publicized example of the algorithms running wild is the case of YouTube and its ad placement policy. In 2017, many large organizations withdrew their advertising from YouTube. This was because YouTube were found to be placing some of their adverts alongside material from terrorists and other unsavory sources. It was YouTube's machine learning algorithms which decided which ads to place where that had caused the problem. Consequently, YouTube had to undertake a major review of its ad placement process[5]. As a result, many months later in 2018, they decided to revert to a manual vetting process. Every video clip had to be reviewed and approved by a real person before it was included in YouTube's service which paired advertisers with popular content[6].

A reasonable question to ask is why it took almost a year for YouTube to figure out a solution? One can't be certain as to the reason, but a very plausible answer is that they spent a lot of time trying to solve the problem using a solely automated (machine learning/AI) approach, before realizing that they needed to maintain a human element in the assessment process.

Notes

1 Predicting consumer behavior is a very common application of machine learning, but there many are others. For example, the same techniques are used to predict stock prices, when complex machines are likely to break down and which organizations are likely to become bankrupt.

2 The original role of credit reference agencies (also known as credit reporting agencies or credit bureaus) was as a central repository for data about debts and loan repayments. This is still at the core of what they do, but these days credit reference agencies also hold all sorts of other personal information. Consequently, a credit report can contain a wide variety of personal data in addition to information about a person's credit history. Credit reference agencies were arguably the first "Big Data" companies, decades before the term began to be applied to the likes of Google, Amazon, Facebook, et al.

3 Siegel, E. (2016). 'Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die.' 2nd Edition. Wiley.

4 See, for example, the arguments made by Roger Penrose in his books: 'The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics' and 'Shadows Of The Mind: A Search for the Missing Science of Consciousness.'

5 Cellan-Jones, R. (2017). 'Can Google police YouTube?' BBC http://www.bbc.co.uk/news/technology-39338009, accessed 12/05/2018.

6 Kelion, L. (2018). 'YouTube toughens advert payment rules'. BBC http://www.bbc.co.uk/news/technology-42716393, accessed 12/05/2018.