

Algorithms in decision-making

A response to the House of Commons Science and Technology Committee inquiry into the use of algorithms in decision-making

April 2017



Key messages

- Artificial intelligence will become pervasive in most, if not all, aspects of decision-making in the foreseeable future. The Royal Academy of Engineering would welcome continued support by government to ensure the ethical and accountable use of algorithms in decision-making.
- There are many different types of algorithms, with differing functions, and associated issues of bias and transparency. Ongoing dialogue with the public by government, supported by businesses and public bodies, will be essential for public acceptance and trust of the use of algorithms in decision-making.
- Algorithms are not inherently biased, algorithmic decisions depend on a number of factors, including how the software is deployed, and the quality and representativeness of the underlying data. It will be important to ensure that data transparency, review and remediation is taken into account throughout algorithmic engineering processes.
- Government, businesses and public bodies will need to consider their use of algorithms in decision-making, consulting widely, and ensuring that mechanisms are in place to detect and address any mistakes or unintended consequences of decisions made.

Introduction

1. The Royal Academy of Engineering welcomes the opportunity to respond to this inquiry into the use of algorithms in public and business decision-making. As the UK's national academy for engineering, the Academy brings together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering. The Academy's response has been informed by the expertise of its Fellowship, which represents the nation's best engineering researchers, innovators, entrepreneurs, and business and industry leaders.
2. Algorithms have been in use for many years. An algorithm is simply a set of instructions that can be understood by a computer to solve a problem or complete a task. However, the increasing availability of data, and accessibility of computers with significant processing power, has influenced the development of new algorithms to help predict behaviour and automate decisions. This has opened up many novel applications with the aim of increasing productivity, and enabling more efficient and informed decision-making in government, businesses and public bodies.
3. Nevertheless, the increasing use of algorithms in decision-making also brings to light important issues about governance, accountability and ethics; and the Academy welcomes the committee's recognition of this.

The extent of current and future use of algorithms in decision-making in government and public bodies, businesses and others, and the corresponding risks and opportunities

4. Artificial intelligence will become prevalent in most, if not all, aspects of decision-making in the future. The use of algorithms is rapidly growing as large amounts of data are being created, captured and analysed by government, businesses and public bodies. Recognising this, the Academy has concerns about the general lack of understanding of the different types of algorithms, and the way that they are used. The opportunities and risks associated with the use of algorithms in decision-making depend on the type of algorithm; and understanding of the context in which an algorithm functions will be essential for public acceptance and trust. Similarly, whether an artificial intelligence system acts as a primary decision maker, or as an important aid and support to a human decision maker, will imply different regulatory approaches.
5. Algorithmic decisions can be based on handcrafted systems that use simple scoring mechanisms, or the identification of keywords, or natural language extraction. Rules may be articulated directly by programmers, or be dynamic and flexible based on machine learning of contextual data.
6. In recent years, debates have centred around the opportunities and implications of the use of machine learning algorithms in decision-making. Machine learning is a type of artificial intelligence that provides computers with the ability to automatically draw inferences when exposed to new data, without being explicitly programmed.
7. There are numerous examples of the current and future use of machine learning algorithms in decision-making, including:
 - in financial industries, machine learning is being used to automate trading decisions and detect investment opportunities for clients
 - in legal sectors, machine learning is being used to provide legal advice to individuals and small businesses. In the future, machine learning could allow for more informed decision-making by creating new insights from legal data and facilitating better interaction with clients through new services
 - in criminal justice systems in the US, machine learning has been used to determine bail and prison sentences. In the future, machine learning could allow for crime pattern detection, and for predictive policing
 - in the education sector, machine learning is being used to rate teaching performance in schools. In the future, machine learning could be used to enhance learning efficiency by selecting assessments and other learning resources for each student individually
 - in healthcare, machine learning is being used to improve the accuracy of diagnostics through pattern detection. In the future, machine learning could be used to predict responses to particular treatment pathways, enabling more informed decision-making around tailored treatment options
 - government is currently using machine learning to provide insights into a wide range of data, which could be used in the future to inform decisions on existing services – such as health, social care, or emergency services¹. Machine learning could also be used to inform the development of public policy in the future. For

¹ Government Office for Science (2016), *Artificial intelligence: opportunities and implications for the future of decision making*, www.gov.uk/government/uploads/system/uploads/attachment_data/file/566075/gs-16-19-artificial-intelligence-ai-report.pdf

example, the Department of Health had been trialling a learning algorithm tool to help analyse public consultation responses ².

8. It has been noted that, as more data is generated, an increase in the use of machine learning algorithms will allow organisations to consider a much broader range of datasets or inputs than was previously possible. This provides an opportunity for better decision-making – by combining human and machine intelligence in a smart way.
9. While the extent of the future use of algorithms in decision-making will differ by sector, the Academy believes that an underlying risk is the assumption that algorithms are near-perfect, or will replace humans entirely in all decision-making processes.
10. While this might be the case in some sectors, there is a risk that new applications of artificial intelligence are not being introduced properly and are introduced at the behest of people who do not fully understand how artificial intelligence works, its limitations, or its potential impact on society. The Academy believes that it is important for government to have an authoritative voice on these matters.

Whether ‘good practice’ in algorithmic decision-making can be identified and spread, including in terms of:

– the scope for algorithmic decision-making to eliminate, introduce or amplify biases or discrimination, and how any such bias can be detected and overcome.

11. Algorithmic decision-making has the potential to eliminate, introduce or amplify biases or discrimination. However, this depends on how the software is deployed, and the quality and representativeness of the underlying data used by the algorithm. As highlighted in the Academy’s and the IET’s 2015 report, *Connecting Data*,³ data quality is influenced by a number of factors that include timeliness, granularity, the quality of metadata and the possibility of calibration error. There are added concerns about social exclusion and unconscious bias being embedded in these systems; and the threat of ‘spoofing’, whereby data is falsified intentionally without the knowledge of the data recipient. Any uncertainties may be amplified by the combination of various datasets.
12. The quality of data therefore influences the value of the analytics and the confidence to make decisions based on the outputs. The software engineering and computer science community acknowledges that this is a significant challenge, especially for machine learning, and recognises its role in the design of robust systems.
13. The increasing use of ‘intelligence’ in machines is shifting the responsibility for safe operation from the operator to the designer, with consequent legal and ethical implications. It will be important to ensure that data transparency, review and remediation are taken into account throughout algorithmic design processes. Additional research is needed as different types of algorithmic models and data types may demand different technical approaches.

² www.publictechnology.net/articles/news/dh-trials-algorithm-tool-analyse-consultation-responses-effort-handle-%E2%80%98click-democracy

³ Royal Academy of Engineering and the Institution of Engineering and Technology (November 2015), *Connecting data: driving productivity and innovation*, www.raeng.org.uk/connectingdata

14. The Academy advises careful monitoring by government, businesses and public bodies where the use of algorithms has a greater scope to introduce or amplify biases or discrimination. This has been noted as a particular concern in financial, recruitment, legal, criminal and education sectors where algorithms may focus on specific metrics, such as age, gender or ethnicity. While this is a significant concern, it also creates the opportunity to remove existing biases by designing systems that are independent of these variables.

— whether and how algorithmic decision-making can be conducted in a 'transparent' or 'accountable' way, and the scope for decisions made by an algorithm to be fully understood and challenged.

15. Ensuring transparency of algorithmic decision-making is a challenge, particularly for machine learning and self-adaptive systems. Issues of governance and accountability will need to be considered in the design and development of these systems so that incorrect assumptions about the behaviour of users – or designers – are avoided.
16. There are many human influences in algorithmic decision-making, including setting criteria choices and optimisation functions. Software engineering of algorithms will need to consider ways that support feedback and logging mechanisms, to allow for greater accountability.
17. Government, businesses and public bodies will also need to consider their use of algorithms in decision-making, consulting widely, and ensuring that mechanisms are in place to detect and address any mistakes or unintended consequences of decisions made.
18. As discussed, the efficiency of algorithms depends on data. As organisations increase their use of data, the transparency of the data on which the algorithmic decisions are being made is critical to ensure accountability.
19. There are many opportunities for organisations to be transparent about the data used by algorithms. One mechanism is to communicate the context in which the data is being used, the quality of the data, its representativeness, and possible limitations. It will also be important to document how data has been collected and analysed. For example, metadata should include information on how data is processed and interpreted: communicating the assumptions behind aggregation, abstraction, knowledge and hypothesis makes it possible to revisit data to discover things that were not originally noticed⁴.
20. Documenting the type of data and how it has been used to inform decision-making can help to reduce any uncertainty on how decisions are made, and to allow for decisions to be challenged.

— the implications of increased transparency in terms of copyright and commercial sensitivity, and protection of an individual's data.

21. The Academy recognises that there are significant implications for government, businesses and public bodies in requiring increased transparency. Regulatory issues, commercial constraints, cultural attitudes and the need to protect personal data affect the willingness and ability of organisations to share information.

⁴ Royal Academy of Engineering and the Institution of Engineering and Technology (November 2015), *Connecting data: driving productivity and innovation*, www.raeng.org.uk/connectingdata

22. It will be important for data protection safeguards to be built into software and services from the earliest stages of development. There will be requirements for systems with properties that can be checked by regulators or the public without compromising data protection. Mechanisms could include the disclosure of certain key pieces of information, including aggregate results and benchmarks, when communicating algorithmic performance to the public. Further research into effective mechanisms and strong leadership is required to address the evolving intellectual property and legal constraints.
23. Part of a balanced debate is appropriately engaging the public. Ongoing dialogue with the public by government, businesses and public bodies will be essential to gain public trust, and to ensure that concerns about ethics, transparency and the governance of personal data are addressed in a timely way.

Methods for providing regulatory oversight of algorithmic decision-making, such as the rights described in the [EU General Data Protection Regulation 2016](#).

24. How algorithms are used by government, business and public bodies will ultimately determine the level of regulation required for this technology. Future regulations will need to be flexible enough to accommodate different requirements, data types and possible new uses of algorithms in the future, yet ensure protection and consistency in approaches.
25. While the regulatory landscape is developing, government should lead by example by applying standards to its own use of algorithms, to ensure accountability and help build public trust in use of algorithms. It will be important to consider the protection of personal data, auditability, and liability for harm caused by the use of algorithms.
26. It is important to ensure that regulatory guidance and criteria are developed with sufficient expert input. The Academy stands ready to advise government on regulatory issues, as appropriate.