



*Artificial intelligence  
and the future of accountancy*

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# Summary

## AI - A LONG-TERM VISION

In the coming decades, intelligent systems will take over more and more decision-making tasks from humans. While accountants have been using technology for many years to improve what they do and deliver more value to businesses, this is an opportunity to reimagine and radically improve the quality of business and investment decisions - which is the ultimate purpose of the profession. In order to realise this potential, the profession needs to focus on the fundamental business problems it aims to solve, and imagine how new technologies can transform its approach to them.

## AI TECHNOLOGY

Artificial intelligence (AI) systems can be very powerful and are improving quickly. They provide outputs that can be extremely accurate, replacing and, in some cases, far superseding human efforts. However, they do not replicate human intelligence. We need to recognise the strengths and limits of this different form of intelligence, and build understanding of the best ways for humans and computers to work together.

## AI AND ACCOUNTANCY

Although AI techniques such as machine learning are not new, and the pace of change is fast, widespread adoption in business and accounting is still in early stages. In order to build a positive vision of the future, we need to develop a deep understanding of how AI can solve accounting and business problems, the practical challenges and the skills accountants need to work alongside intelligent systems.

## AI AND ICAEW: NEXT STEPS

ICAEW has a unique place as an independent, professional body with long-standing expertise in technology-related issues, and which draws on experience across many aspects of business, finance and accounting. Our future work on AI will focus on building understanding of the practical use of AI across business and accounting activities today and in the near future. In addition, it will lead and encourage wider debate about the long-term opportunities and challenges for the profession.

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# Introduction

Accountants have embraced waves of automation over many years to improve the efficiency and effectiveness of their work. But to date technology has not been able to replace the need for expert knowledge and decision-making. Indeed, previous generations of 'intelligent' systems have generally demonstrated the continuing power of human expertise and the limits of machines.

Artificial intelligence (AI) has been an aspiration of computer scientists since the 1950s, and it has seen tremendous progress in recent years. Examples of AI are already an integral part of many of our online activities, and will become increasingly embedded in everything we touch and do.

These systems do not replicate human intelligence. Indeed, some experts would dispute the use of the term 'AI' at all to describe current machine learning systems. However, on a task-by-task basis, systems increasingly produce outputs that far exceed the accuracy and consistency of those produced by humans.

In the short to medium term, AI brings many opportunities for accountants to improve their efficiency, provide more insight and deliver more value to businesses. In the longer term, AI raises opportunities for much more radical change, as systems increasingly take over decision-making tasks currently done by humans. This report outlines a framework for embracing the opportunities created by increasingly intelligent systems, based on three questions.

## 1 WHAT IS THE LONG-TERM VISION FOR AI AND ACCOUNTANCY?

We need to envision how intelligent systems can enable better decisions in business, and understand how accountants can help this process.

## 2 HOW DO ARTIFICIAL AND HUMAN INTELLIGENCE WORK TOGETHER?

We need to develop an understanding of what is new about the technology, how it can 'turbo charge' the capabilities of humans, and its limits.

## 3 HOW ARE ACCOUNTANTS USING AI CAPABILITIES?

We need to explore real-world examples of accountants using AI systems, including the specific benefits and limitations, to help us develop the longer-term vision.

This reflects the framework laid out in our report *Providing leadership in a digital world*, and is shown below.

POSITION FOR THE FUTURE	UNDERSTAND TECHNOLOGY	APPLY TO ACCOUNTING
<b>What is the long-term vision for AI and the profession?</b>	<b>How do artificial and human intelligence work together?</b>	<b>How are accountants using AI capabilities?</b>
<ul style="list-style-type: none"><li>• Focus on purpose</li><li>• Exploit powerful technologies</li><li>• Think radically</li><li>• Be adaptable</li></ul>	<ul style="list-style-type: none"><li>• Human decision-making</li><li>• Approaches to AI</li><li>• Strengths of machine learning</li><li>• Limits of machine learning</li></ul>	<ul style="list-style-type: none"><li>• Accounting problems</li><li>• Practical challenges</li><li>• Roles and skills</li><li>• Institutional issues</li></ul>

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# What is the long-term vision for AI and the profession?

In the coming decades, intelligent systems will take over more and more decision-making tasks from humans. While accountants have been using technology for many years to improve what they do and deliver more value to businesses, this is an opportunity to reimagine and radically improve the quality of business and investment decisions - which is the ultimate purpose of the profession.

In order to realise this potential, the profession needs to focus on the fundamental business problems it aims to solve, and imagine how new technologies can transform its approach to them.

## FOCUS ON PURPOSE

Accountants want to help organisations and economies work better by giving good advice and making good decisions. After all, accounting is not an end in itself. All the activities associated with accounting ultimately aim to help people make good decisions about the allocation of resources, and hold others to account for their decisions. This underpins investment, growth and confidence in all organisations and economies.

More intelligent systems enable radically different approaches to this ultimate objective and the kinds of fundamental business problems the profession aims to solve. Investors need to gain confidence and trust in the financial results of companies; companies and governments need to ensure the correct levels of tax are paid; management needs to decide how to spend organisational resources, and be held accountable for those decisions. Solving these kinds of fundamental problems is essential for companies and economies to succeed and are at the heart of the accountancy profession.

There may also be new problems that can be transformed with new data and more intelligent systems. As an example, the UN Global Goals represent a broad consensus of what we, as humans, want the world and society to look like in the coming decades. In all cases, there is an enormous amount of work to do to achieve those goals. At the very least, we need effective measurement to enable informed decisions on the allocation of financial and other resources to achieve the goals. We also need accountability for those decisions.

The starting point for creating a longer-term vision is therefore to focus on the profession's ultimate purpose of better decisions, and identify the fundamental business problems that better decisions will solve.

## EXPLOIT POWERFUL TECHNOLOGIES

It is then important to recognise and exploit the power of new technologies effectively. This report highlights the strength of machine learning approaches to AI, and deep learning methods in particular, which are regularly leading to major advancements in many areas of research. But it is a complex and ever changing technological context. Other areas of technology will interact with AI and have a significant impact on business in the future, like blockchain or quantum computing. In addition, the pace of change in capabilities can be very fast, and the nature of learning-based and data-driven systems enable continual improvement.

To fully exploit powerful new technologies, we need to be clear about their unique characteristics and how they can help to solve real problems. There is typically a long time from building a working technology to getting the maximum value from it. Often, technology can be a solution looking for a problem to solve, or simply enables us to replicate how we do things using different tools.

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Instead, we need to encourage debate, interaction and learning between technology experts, business and the profession to reimagine the way that we solve fundamental business problems with the help of new technologies.

### **THINK RADICALLY**

In doing this, the profession also needs to be open to more profound change and avoid just defending or incrementally improving the status quo. Where AI enables greater insight from data, it helps human experts make better decisions and provide better advice. Indeed, evidence suggests that humans and computers working together in areas as diverse as chess and medicine produce better results than human or computers in isolation.

However, as systems continue to get more powerful, they will be able to move further into complex decision areas, potentially replacing humans altogether in many cases and enabling entirely different solutions, services and models. When looking at the longer term, therefore, the profession must think beyond incremental improvements to existing processes. Furthermore, it needs to reflect on the specific skills and qualities that accountants bring to businesses. This goes beyond technical knowledge to incorporate qualities such as professional scepticism, gaining and applying insight from numbers, and ensuring that numbers can be trusted.

This also means engaging positively in debates on, for example, the role of human judgement in more complex business areas. There may well be uniquely human characteristics, such as leadership, empathy and creativity, which will never be replaced by computers. And we should not underestimate the adaptability and ingenuity of humans. However, 'human judgement' is often just a substitute for lack of data - powerful computers with access to new sources of data may well supersede the need for human judgement in the vast majority of cases. Attempts to deny the potential of computers to surpass many human capabilities, and simply to protect current models and ways of doing things, are likely to end in failure.

### **BE ADAPTABLE**

It is impossible to predict the extent to which computers will replace human decision-making over the next 20 to 30 years. There is much broader context and the long-term future of accountancy will ultimately reflect how we, as humans, see and shape our relationship with powerful systems. This will be influenced by a range of economic, social and political factors. The technology of the future will also be very different to what we see today. As a result, a flexible approach is essential when thinking about the future.

The skills and learning agenda for the future accounting professional in particular has been subject to a lot of debate between professional bodies, including ICAEW, employers and educators. Most would agree that accountants will need more hard skills in areas such as technology and data, as well as a greater emphasis on things like soft skills, critical thinking and adaptability. There also needs to be greater emphasis on life-long learning. However, there are competing longer-term visions of the future accountant - from highly qualified hybrid professionals, to lower-skilled workers, who use technology to access expert knowledge.

When business needs change, and all the relevant stakeholders agree, the profession is able to adapt. Professional bodies change their qualifications as market demands evolve. Accountancy organisations in business and practice innovate all the time to provide more value. This quality will become increasingly important for all stakeholders involved in the profession.

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# How do artificial and human intelligence work together?

AI systems today can be very powerful and are improving quickly. They provide outputs that can be extremely accurate, replacing and, in some cases, far superseding human efforts. However, they do not replicate human intelligence. We need to recognise the strengths and limits of this different form of intelligence, and build understanding of the best ways for humans and computers to work together.

## HUMAN DECISION-MAKING

Humans make decisions in two different ways.

INTUITION	REASONING
Much of our thought process is instinctive and unconscious, taking place very quickly and with little effort. This type of thinking is rooted in recognising patterns based on what has happened before, and is often described as intuitive.	We also use logic and reason in order to answer questions and make decisions. This conscious process uses our knowledge and typically takes over when intuition has not produced a satisfactory answer. This process takes time and effort.

Accountants, as expert decision makers, use both ways of thinking – they apply their knowledge to specific situations to make reasoned decisions, but also make quick intuitive decisions based on extensive experience in their field.

Our intuitive thinking is particularly powerful, reflecting quick learning and high levels of flexibility. It provides the foundation for our language, vision, sensing, understanding of the everyday world and ways of interacting with others. However, it is not perfect. It is subject to many biases and inconsistencies, explored in detail by psychologists such as Daniel Kahneman.

- Availability bias – more recent or common examples tend to come to mind, which can skew our decision-making processes.
- Confirmation bias – we tend to see only things that are consistent with our existing views.
- Anchoring – we are strongly influenced by prior suggestions.

## APPROACHES TO AI

Research in AI focused for many years on replicating human reasoning capabilities, for example, representing knowledge and encoding logic-based rules and decision trees. This was the approach taken in expert systems, which became popular in the 1980s and 1990s. These systems attempted to capture the explicit knowledge of experts, and build it into rules engines that would make decisions or recommendations.

This approach had some success but it rarely produced results that could be seen as akin to human intelligence. While there were a variety of technical issues with such systems, they were ultimately defeated by the complexity of the real world, and the extent to which we rely on intuitive thinking. We were unable to articulate our knowledge and decision-making rules clearly enough. This meant that systems could not cope with complex or ambiguous circumstances, or where things changed.

Recent successes in AI take a very different approach. Rather than trying to impose a top-down model of rules, they take a bottom-up approach and learn rules based on observation of what happened previously. This uses pattern recognition and is known as machine learning. While there are many fields of research into AI, improvements in machine learning are the main drivers behind the hype around AI today and the focus of this report.

By combining approaches in machine learning with developments in other areas of AI, such as knowledge representation and reasoning, computers can be used to complement and increasingly improve on both ways of human thinking.

## STRENGTHS OF MACHINE LEARNING

In many ways, these developments in AI are quite profound. Machine learning techniques tap into our own cognitive strengths - pattern recognition and learning - rather than attempting to define complex rules. The most sophisticated techniques in this area - based on artificial neural nets and deep learning - are enabling major breakthroughs in areas such as natural language processing, translation, machine vision and game playing.

This approach could also enable computers to move far further into decision-making processes than was previously possible, when they were defeated by the complexity and ambiguity of pre-defined rules. Indeed, research in areas such as medical imaging and diagnosis increasingly shows machines producing far more accurate results than humans do. While there is nothing new about algorithms performing better and more consistently than many experts, AI systems 'turbo charge' this capability and potentially lead to much more powerful decision tools than have previously been possible. This reflects three features about models and the algorithms they contain.

LARGE DATA VOLUMES	COMPLEX AND CHANGING PATTERNS	CONSISTENCY
They can process huge amounts of data (structured and unstructured) - much more than humans ever could; for example, the results of every piece of medical research carried out on a topic, or every piece of financial regulation. This provides a stronger and more powerful basis for learning.	They can pick up weaker or more complex patterns in data than we can. Therefore, machines may be better in environments that we find less predictable. Where feedback loops can be built into the models, they can also be highly adaptive and learn from errors or new cases.	They can be far more consistent decision-makers. They do not suffer from tiredness or boredom. They also do not exhibit human biases and therefore provide opportunities to eliminate cognitive biases - such as availability or confirmation bias - as well as socially-based biases, such as racism.

These capabilities are particularly important for organisations aiming to exploit the increasing amount of big data that is available to them. Humans alone simply cannot analyse and extract insight from the volumes of data being created today. It is essential to work with machine learning techniques to gain meaning from, and make best use of, big data.



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## LIMITS OF MACHINE LEARNING

While these models can be very powerful, there are still limits to their abilities. Machine learning is not a general AI and models are not particularly flexible. Models learn to carry out very specific tasks based on a given set of data.

Data quantity and quality is fundamental, and not all problems have the right data to enable the machine to learn. Many models require substantial amounts of data. The big breakthroughs in areas such as computer vision and speech recognition rely on very large training data sets - millions of data points. Although that is not the case with all areas of machine learning, success depends on having sufficient data of the right quality.

Data often reflects existing bias and prejudice in society. Consequently, while models can potentially eliminate human biases, they can also entrench societal biases that already exist.

Furthermore, not every problem will be suitable for a machine learning approach. For example, there needs to be a degree of repeatability about the problem so that the model can generalise its learning and apply it to other cases. For unique or novel questions, the output may be far less useful.

The outputs of machine learning models are predictions or suggestions based on mathematical calculations, and not all problems can be resolved in this way. Other considerations may need to be factored into decisions, such as ethical questions, or the problem may require deeper root cause analysis.

Different levels of predictive accuracy will also be appropriate in different circumstances. It does not particularly matter if recommendation engines, for example, produce inaccurate recommendations. In contrast, high degrees of confidence are required with medical diagnosis or compliance tasks. Providing explicit confidence levels alongside the output of models can be useful decision aids in themselves. But they emphasise the limits of models, the dangers of inappropriate reliance on them and the need to retain the involvement of humans in many decision processes.

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# How are accountants using AI capabilities?

Although AI techniques such as machine learning are not new, and the pace of change is fast, widespread adoption in business and accounting is still in early stages. In order to build a positive vision of the future, we need to develop deep understanding of how AI can solve accounting and business problems, the practical challenges and the skills accountants need to work alongside intelligent systems.

## ACCOUNTING PROBLEMS

Accountants apply their technical knowledge about accounting and finance to help businesses and stakeholders make better decisions. To support their decision-making and advice, accountants need high quality financial and non-financial information and analysis. This is reflected in a wide range of accountancy roles across business and practice to capture, prepare, check and communicate information, to undertake analysis, and to make a wide variety of decisions.

Accountants have been deploying technology for many years to help them provide better advice and make better decisions. Technology can help them do this by solving three broad problems:

- providing better and cheaper data to support decision-making;
- generating new insights from the analysis of data; and
- freeing up time to focus on more valuable tasks such as decision-making, problem solving, advising, strategy development, relationship building and leadership.

The very nature of machine learning techniques lend themselves to substantial improvements across all areas of accounting, and can equip accountants with powerful new capabilities, as well as automate many tasks and decisions.

Therefore, it is important to identify accounting and business problems where machine learning is likely to be particularly fruitful and where problems may be less suitable for these techniques. This will ensure that adoption efforts are driven by business need, rather than simply technology capabilities. To date, there has been limited use in real-world accounting but early research and implementation projects include:

- using machine learning to code accounting entries and improve on the accuracy of rules-based approaches, enabling greater automation of processes;
- improving fraud detection through more sophisticated, machine learning models of 'normal' activities and better prediction of fraudulent activities;
- using machine learning-based predictive models to forecast revenues; and
- improving access to, and analysis of, unstructured data, such as contracts and emails, through deep learning models.

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## PRACTICAL CHALLENGES

Data volumes and quality are crucial to the success of AI systems. Without enough good data, models will simply not be able to learn.

Transactional accounting data is well-structured and high quality, and therefore should be a promising starting point for developing models. However, given long-standing issues around data in many organisations, especially those with complex and unintegrated legacy systems, this is still likely to be a major challenge in practice. Smaller organisations may not have enough data to enable accurate results. Similarly, there may not be enough data about very specific problems to support good models. Powerful models may need external sources of data, which may not always be possible to access at an appropriate cost.

Furthermore, it is difficult to know in advance how successful machine learning will be. Models learn on the basis of a specific dataset. Therefore, building experience of both successful and less successful cases will help to inform future adoption.

Another more principled limit will be privacy and ethics, especially where AI systems are drawing on personal data. Fraud detection, for example, may draw on the text of emails sent by employees, which will encounter legal and ethical limits.

Adoption will also be ultimately driven by the economics and business case around AI. This will reflect two different ways that organisations will adopt machine learning capabilities.

First, machine learning is increasingly becoming integrated into business and accounting software. As a result, many accountants will encounter machine learning without realising it, similar to how we use these capabilities in our online searching or shopping activities. This is how smaller organisations in particular are most likely to adopt AI tools.

Second, conscious adoption of AI capabilities to solve specific business or accounting problems will often require substantial investment. While there is a lot of free and open source software in this area, the use of established software suppliers may be required for legal or regulatory reasons. Given the data volumes involved, substantial hardware and processing power may be needed, even if it is accessed on a cloud basis. As a result, AI investments will likely focus on areas that will have the biggest financial impact, especially cost reduction opportunities, or those that are crucial for competitive positioning or customer service. Other areas, while potentially beneficial, may lack a strong investment case. Likewise, using machine learning to develop more intelligent products in specialist accounting areas may lack the market potential to justify investment from software developers.

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## **ROLES AND SKILLS**

Organisations will also need access to the right skills. Clearly, this starts with technical expertise in machine learning. But, as with data analytics, these technical skills need to be complemented by deep understanding of the business context that surrounds the data and the insight required.

Accounting roles are already changing in response to new capabilities in data analytics. Indeed, accountants are well placed to work effectively with data analytics, as they combine high levels of numeracy with strong business awareness. These trends will accelerate with AI. Some roles will continue to emphasise technical accounting expertise and human judgement to deal with difficult and novel cases. Other roles may expand to increase collaboration and partnering with other parts of the organisation to help them derive the right meaning from data and models. There will also be new jobs. For example, accountants will need to be involved in training or testing models, or auditing algorithms. They may need to get involved in projects to help frame the problems and integrate results into business processes. Other accountants may be more directly involved in managing the inputs or outputs, such as exception-handling or preparing data.

This evolution will be reflected in the skills required of accountants. Some roles, such as training models, may require deep knowledge of machine learning techniques. In other areas, accountants may just need a more superficial knowledge of machine learning to be able to have informed conversations with experts and other parts of the business. Critical thinking and communication skills are likely to become increasingly important.

In addition to skills, accountants may need to adopt new ways of thinking and acting in order to make the most of machine learning tools. For example, spending more time on predictive and proactive activity - eg, putting predictions in context, or building capabilities to change course quickly - will need different ways of thinking.

## **INSTITUTIONAL ISSUES**

Accounting has a wider institutional context, and regulators and standard setters also need to build their understanding of the application of AI and be comfortable with any associated risks. Without this institutional support, it is not possible to achieve change in areas such as audit or financial reporting. Therefore, the active involvement of standard setters and regulators in these areas is essential.

For example, standard setters in audit will want to examine where auditors are using these techniques to gain evidence, and understand how reliable the techniques are. Such bodies are already debating the impact of data analytics capabilities on audit standards, and consideration of machine learning should build on those discussions.

There are particular issues in this context concerning the transparency of models. We do not fully understand how the most complex models - such as deep learning models - derive their outputs. If organisations and audit firms increasingly rely on black box models in their operations, more thinking will be required about how we gain comfort in their correct operation.

Regulators can also actively encourage and even push adoption where it is aligned to their work. Much of the investment in this area, for example, is coming from financial services organisations to support regulatory compliance and pressure from regulators.

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## Next steps

ICAEW's future work on AI will focus on building understanding of the practical use of AI across business and accounting activities today and in the near future. In addition, it will lead and encourage wider debate about the long-term opportunities and challenges.

### **TRUSTED INFORMATION SOURCE**

ICAEW has a unique place as an independent, professional body with long-standing expertise in technology-related issues, and which draws on experience across many aspects of business, finance and accounting. This enables it to provide information to many stakeholders that gets beyond the hype typical of many technologies, and grounds discussion in a deep understanding of the business and accounting environment.

This provides a strong platform to build and share understanding of the specific application of machine learning technologies. We also support other stakeholders in the profession who need to understand the capabilities and issues here, including:

- educators and training providers, who are considering the future skills of accountants;
- regulators, who are considering the risks attached to new technologies; and
- governments and policymakers.

### **INSTITUTIONAL PARTNER**

Working across disciplines is an essential part of building learning and capabilities in this area. ICAEW is keen to work with other organisations in many other disciplines to support thinking about the short and longer-term impacts of AI technologies. This includes:

- accountants working in business and practice and in small and large organisations, who can reflect the diverse range of experience across the profession;
- computer scientists and machine learning experts, who understand the strengths and limits of techniques;
- software providers who are developing solutions for accounting problems using AI; and
- other experts and professions who are facing similar opportunities and threats from AI.

This approach was demonstrated in a multi-disciplinary workshop held in early 2017 on AI in audit and forensic accounting, as outlined below.

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## ANOMALY DETECTION IN FLIGHT PATHS AND AUDIT

In January 2017, ICAEW held a joint workshop with Portsmouth University that brought together accounting academics, researchers into machine learning and practitioners from audit and forensic accounting. The multi-disciplinary approach encouraged sharing of different perspectives from machine learning and accounting to identify relevant accounting problems and discuss the kinds of capabilities offered by machine learning techniques.

Discussions drew on experience of modelling 'normal' flight paths, which demonstrated the benefits of building a model of 'normal' based on machine learning, as well as the practical challenges and limits. Such models could have potential application in areas of audit or forensic accounting, where there is a need to identify fraudulent behaviour or errors.

### HUB FOR INNOVATIVE THINKING

It is also essential to encourage innovation to exploit capabilities and develop new ways of adding value to clients and businesses. While individual firms and businesses will innovate based on their specific needs, there may be opportunities for collaboration to encourage broader innovation.

- In areas where the business case for investment may be weaker, there may be opportunities to share some of the effort and resource.
- There may be significant benefits from sharing data to build better models or models which reflect shared goals.

ICAEW will actively explore ways in which it can help the profession to think more radically about a future working with AI, and translate innovative ideas into practice.

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## FURTHER READING

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Training, developing and supporting accountants throughout their career, we ensure that they have the expertise and values to meet the needs of tomorrow's businesses.

Our profession is right at the heart of the decisions that will define the future, and we contribute by sharing our knowledge, insight and capabilities with others. That way, we can be sure that we are building robust, accountable and fair economies across the globe.

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