TECH TRENDS IN PRACTICE

THE 25 TECHNOLOGIES THAT ARE DRIVING THE 4TH INDUSTRIAL REVOLUTION

BERNARD MARR

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To my wife Claire, and my children Sophia, James, and Oliver;
and everyone who will use these amazing technologies
to make the world a better place.

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INTRODUCTION

We have never lived in a time of faster and more transformative technological innovation. Incredible technologies like artificial intelligence, blockchains, smart robots, self-driving cars, 3D printing, and advanced genomics, together with the other tech trends covered in this book, have ushered in a new industrial revolution. Similarly to how steam, electricity, and computers have respectively been the driving forces of the first three industrial revolutions, this fourth industrial revolution is driven by the 25 technologies featured in this book. And as with the previous industrial revolutions, this fourth industrial revolution will change businesses, reshape business models, and transform entire industries. These technologies will change how we run our businesses, what jobs we will do, and many other aspects of how we function as a society.

For most leaders it can be very challenging to keep up with the speed at which many of these new technologies are emerging. As a futurist and strategic advisor to many of the most innovative companies and governments in the world, it is my job to help leadership teams understand and prepare for the impact of these technologies. With this book, I want to provide an easy-to-understand, state-of-the-art overview of the key technologies underpinning this fourth industrial revolution and outline how they are practically used by businesses today, as well as provide some tips on how to best prepare yourself and your organization for the transformation they bring.

I have chosen these 25 technology trends because I believe that they are the key ones every business leader needs to be aware of today. There are some technologies in this book that are more foundational – like big data, 5G, and artificial intelligence – and then there are others that overlap with or use technologies like big data, 5G, and artificial intelligence – like self-driving cars, chatbots, or computer vision. My aim is to discuss the key technologies and applications that are having the biggest impact on businesses today and the medium-term future.

Before you dive into the various future tech trends, I just want to say that the fourth industrial revolution offers us huge opportunities to make our world a better place and use these technologies to address some of the world's biggest challenges – from climate change, to inequality, and from hunger to healthcare. We shouldn't waste them.

As with any new technologies, there is also huge scope to exploit them for evil and we have to put in place safeguards to ensure that doesn't happen. What is sure is that all these technologies will change businesses, reshape business models, and transform entire industries.

With many of the technologies featured in this book the rate of innovation and development is simply mind-boggling. Every week there are new breakthroughs and new applications even I didn't think possible just a few years ago. It is my job to keep a close eye on all this and I share my insights in my *Forbes* articles, YouTube videos, and across my social media channels. I would like to invite you to connect with me on LinkedIn, YouTube, Instagram, Twitter, and Facebook. I also have a weekly newsletter in which I share all the latest developments. If you would like to keep up to date then you can sign up to the newsletter on my website www.bernardmarr.com, where you can also find many more articles, videos, and reports on future tech trends.

TREND 1
ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

The One-Sentence Definition

Artificial intelligence (AI) and machine learning refers to the ability of machines to learn and act intelligently – meaning they can make decisions, carry out tasks, and even predict future outcomes based on what they learn from data.

What Is Artificial Intelligence and Machine Learning?

Speaking in 2016, Stephen Hawking said, "Success in creating AI would be the biggest event in human history." Now, it's no secret that technology trends often create a lot of hype. But in the case of AI, the hype is warranted. Like Hawking, I believe AI will transform our world and how we live in it.

AI and machine learning already plays a bigger role in everyday life than you might imagine. Alexa, Siri, Amazon's product recommendations, Netflix's and Spotify's personalized recommendations, every Google search you make, security checks for fraudulent credit card purchases, dating apps, fitness trackers … all are driven by AI.

AI and machine learning is the foundation on which many other technology trends in this book are built. For instance, without AI, we wouldn't have achieved the amazing advances in the Internet of Things (IoT, Trend 2), virtual reality (Trend 8), chatbots (Trend 11), facial recognition (Trend 12), robotics and automation (Trend 13), or self-driving cars (Trend 14) – to name just a few.

But what exactly is AI and machine learning, and how does it work? In very simple terms, AI involves applying an algorithm (a rule or calculation) to data in order to solve problems, identify patterns, decide what to do next, and maybe even predict future outcomes. Crucial to this process is an ability to learn from data and get better at interpreting data over time. And this is where the machine learning part comes in. Machine learning is a subdiscipline of AI, and it involves creating machines that can learn. ("Machines," by the way, may include computers, smart phones, software, industrial equipment, robots, vehicles, etc.)

The human brain learns from data, not a preprogrammed set of rules. We humans are continually interpreting and learning from the world around us. We generally get better at this process over time, learning from our successes and failures. And we make decisions or take action based on what we've learned. AI – or, more specifically, machine learning – replicates this process, but in machines. So, rather than just giving a machine a set of rules to follow, machines can now "learn" from data. Deep learning is another AI-related term that you might have heard. If machine learning is a subset of AI, deep learning is a subset of machine learning – it's essentially a more cutting-edge form of machine learning, involving more complex layers of data processing. (For the purposes of this chapter, both machine learning and deep learning will be wrapped up in the umbrella term AI.)

Like humans, the more data a machine has to learn from, the smarter it becomes. That explains why AI has made such dramatic advances in the last few years – advances that we might not have thought

possible 10 or even five years ago. Modern AI needs data to function. And we're now creating more data than ever before (see Big Data, Trend 4). This continual expansion in data, along with advances in computing power, is fueling a rapid acceleration of AI capabilities.

AI isn't just infiltrating our everyday lives; it's going to transform our industries and businesses. According to one survey, 73% of senior executives see AI, machine learning, and automation as important areas to maintain or increase investment in.[1] (Governments, too, are prioritizing AI investment. In 2019, the White House launched a National AI Initiative directing government agencies to commit to advancing AI.[2])

As well as transforming entire businesses and industries, AI is also going to transform many human jobs. IBM predicts that more than 120 million workers globally will need to be retrained in the next three years due to AI.[3] AI-enabled automation (see Trend 22) will have a particularly significant impact and may lead to the displacement of many jobs. But rather than subscribe to a vision of a dystopian future where all human jobs are given over to robots, I believe AI will make our working lives better. Yes, jobs will be impacted by automation and AI, and many current human jobs will no longer exist in 10 or 20 years' time. But AI will enhance the work of humans, and new jobs will arise to replace displaced jobs. (Just think how computing and the internet led to the demise of some jobs but created many more new roles.) What's more, as machines become more intelligent and capable of carrying out more human tasks, I believe that our uniquely human capabilities – things like creativity, empathy, and critical thinking – will become all the more precious and valuable in the workplaces of the future.

How Is Artificial Intelligence and Machine Learning Used in Practice?

AI gives machines the ability to carry out a wide range of human-like processes, such as seeing (think facial recognition), writing (think

chatbots), and speaking (think Alexa). And as machines' ability to act intelligently gets better and better, AI will infiltrate even more of our lives.

Because AI underpins so many other technology trends, throughout this book you'll find lots of specific examples of how AI is used across different businesses and industries. Here, I want to briefly whet your appetite and set out just a few of the amazing things AI can already do.

Thanks to AI, Machines Can Beat Humans at Games

Machines battling man is the theme of many a sci-fi movie. In real life, AI research and development has seen intelligent machines beat their human opponents in some significant (but thankfully less harmful) ways.

- In 1997, IBM's **Deep Blue** chess-playing machine beat world champion Garry Kasparov.[4] Many hailed this as the start of machine intelligence catching up to human intelligence, but the reality is perhaps a little less compelling. Deep Blue used brute force computing power to consider every possible chess move, and that's how it beat Kasparov. (Discover how machines learned to get a lot more creative at game-playing in Chapter 17.)
- In 2011, **IBM's Watson** AI system beat two human contestants at the game show *Jeopardy!*.[5] And not just any contestants – two of the most successful contestants the show had ever seen, who had won $5 million between them.
- In 2018, **DeepMind's AlphaStar** AI beat one of the world's most successful professional players of the real-time strategy game StarCraft II, in an impressive 5–0 victory.[6]
- In 2019, Microsoft revealed its **Suphx** AI can now beat top players at the complex Chinese tile game Mahjong. After 5,000 games, the AI was able to compete at 10th dan ranking

(basically, super-expert level) – a feat that only 180 humans have ever been able to manage.[7]

- Also in 2019, we learned that AI can now solve a Rubik's Cube in 1.2 seconds – that's two seconds faster than the current world record holder (and about 20 years faster than the average human).[8] The **DeepCubeA** system was created by researchers at the University of California, Irvine.

AI Is Driving Advances in Healthcare

In August 2019 the UK government announced it would dedicate £250 million to funding AI in the National Health Service.[9] Here are just a few examples of how AI is beginning to transform healthcare.

- A study published in *The Lancet* in 2019 found that AI is as good as human experts when it comes to **diagnosing disease** from medical images.[10] Deep learning is showing enormous promise in diagnosing a range of diseases, including cancer and eye conditions.
- **MIT** researchers have developed an AI model that can predict the development of breast cancer up to five years in advance.[11] Crucially, the system works as well for black and white patients, whereas similar projects in the past have often been based overwhelmingly on white patients.
- **Infervision's** image recognition technology uses AI to look for signs of lung cancer in patient scans. The technology is already in use in healthcare settings across China.[12]

Books, Music, and Food: How AI Is Transforming Some of Our Favorite Pastimes

Content platforms like Netflix and Spotify are built on AI – they use AI to understand what viewers most want to watch or listen to,

make personalized recommendations, and (in Netflix's case) create new content based on what it knows users enjoy. Here are a few other examples of AI infiltrating our hobbies and downtime.

- Chinese search engine **Sogou** has confirmed it's creating an AI that can read novels aloud, simulating the voice of their authors[13] (in a similar way to how deepfakes can create realistic audio and video content of people in the public eye). This could revolutionize audiobooks, particularly for self-published authors who perhaps don't have the means to create their own audiobooks.
- **Sony** has created an AI that can produce drumbeats for songs. Called AI DrumNet, the system was trained using hundreds of songs, and can now produce its own basic drumbeats to match other instruments on a track.[14]
- **MIT** researchers have taught AI how to reverse engineer pizza. After looking at a picture of a pizza, the AI can identify its toppings, and then tell you how to make it.[15] Why do this, you might be wondering? In theory, this technology could be used to analyze any photo of food and produce a suitable recipe. So if you want to recreate an amazing restaurant meal at home, in a few years' time there might be an app for that!

The Future of AI?

In 2019, Microsoft announced it was plowing $1 billion into AI research lab **OpenAI** – which was founded by, among others, Elon Musk.[16] What's behind such a big investment? OpenAI is dedicated to creating something called artificial general intelligence (AGI), widely considered to be the "holy grail" of AI.

While AI can do some incredible things when it comes to "general intelligence," AI lags way behind the human brain. In other words, AI is great at learning to do specific things, but AI systems can't just

apply that knowledge to other tasks in the way humans can. This is the goal of AGI – to create an AI system that's as generally intelligent and flexible as the human brain. It's not been done yet – in fact, we don't know if AGI is even possible – but Microsoft's investment shows it's certainly a serious goal.

Key Challenges

I opened this chapter with a Stephen Hawking quote, "Success in creating AI would be the biggest event in human history." Hawking immediately followed that up with, "Unfortunately, it might also be the last, unless we learn how to avoid the risks."

AI isn't without its challenges and risks. For one thing, there are potentially huge risks for society and human life as we know it (particularly when you consider some countries are racing to develop AI-enabled autonomous weapons). But let's focus on the key challenges that everyday businesses will have to overcome if they're to deploy AI successfully.

Regulation

There will no doubt be regulatory hurdles to negotiate as regulators begin (quite rightly and belatedly) to take a greater interest in the application of AI. Until now, some of the early adopters of AI have played a bit fast and loose with the technology (Facebook, for example, is facing legal action over its use of facial recognition technology for auto-tagging photos, without gaining user consent).[17] That sort of behavior can't continue, and business leaders will have to take an ethical, responsible approach to AI.

Privacy Concerns

Part of using AI ethically means making sure you respect individuals' privacy, gain consent to use their data for AI applications, and make

it clear how you are using their data. Again, this is where some big players have fallen short in the past. Amazon, for example, faced consumer outrage over the news that contractors were listening to people's Alexa requests. Individuals could not be identified by their audio, and Amazon stressed the practice was necessary to help develop Alexa's capabilities, but the fact remains that most users had no idea that anyone would ever hear their private audio. Amazon has since introduced a "no human review" option to its Alexa settings, which allows users to opt out of their audio being manually reviewed.[18]

Lack of Explainability

Remember I said that AI can now solve a Rubik's Cube in just 1.2 seconds? Interestingly, the researchers who built the puzzle-solving AI can't quite tell how the system did it. This is known as the "blackbox problem" – which means, to put it bluntly, we can't always tell how very complex AI systems arrive at their decisions.

This raises some serious questions around accountability and trust. For example, if a doctor alters a patient's treatment plan based on an AI prediction – when he or she has no idea how the system arrived at that prediction – then who is responsible if the AI turns out to be wrong? What's more, under GDPR (the General Data Protection Regulation legislation brought in by the European Union), individuals have the right to obtain an explanation of how automated systems make decisions that affect them.[19] But, with many AIs, we simply *can't* explain how the system makes decisions.

New approaches and tools are currently being developed that help to better understand how AIs make decisions but many of these are still in their infancy.

Data Issues

Put simply, AI is only as good as the data it's trained with. If that data is biased or unreliable, then the results will be biased or unreliable.

For example, facial recognition technology was found to be generally better at identifying white males than women and people of color, because a leading data set used to train facial recognition systems was estimated to be more than 75% male and 80% white – something that programmers were able to correct by adding a more diverse range of faces to the training dataset.[20] This means companies will need to ensure their data is as unbiased, inclusive, and representative as possible if they're to get the best results from AI.

The AI Skills Gap

Finally, one area in which many companies will struggle is finding the right AI talent. There's a shortage of people who can develop these complex AI systems – and what talent there is tends to be scooped up by the Googles and IBMs of this world. AI-as-a-service (AIaaS) could be part of the solution. AIaaS offerings from companies like IBM and Amazon allow companies to make use of AI tools, without having to invest in expensive infrastructure or new hires, which makes AI much more accessible to businesses of all shapes and sizes.

How to Prepare for This Trend

AI is going to revolutionize almost every facet of modern life, including business. Therefore, despite the challenges involved, businesses cannot afford to overlook the potential of AI. So how might you use AI in your business? Broadly speaking, companies are using AI to improve their business in three ways:

- Developing smarter products (see Trends 2 and 3 for great examples of this).
- Delivering smarter services (check out Trends 18 and 23 as examples of AI-driven services).
- Making business process more intelligent (Trends 12, 13, and 17 for just a few examples of AI-enhanced business processes).

Every business should consider whether they can use AI to improve their business in one or, ideally, all of these ways. But you'll need a robust AI strategy in order to get the most out of AI – and a good AI strategy should always be linked to your overarching business strategy. To put it another way, you need to look at what the business is trying to achieve and then see how AI can help you deliver those strategic goals.

Notes

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TREND 2
INTERNET OF THINGS AND THE RISE OF SMART DEVICES

The One-Sentence Definition

The Internet of Things (IoT) refers to the increasing number of everyday devices and objects that are connected to the internet and are capable of gathering and transmitting data.

What Is the Internet of Things?

The rise of smart devices has played a key role in the massive explosion of data (see Big Data, Trend 4) – and is rapidly changing our world and the way we live in it. But, in the IoT, data is created by things, not people, which has given rise to the term "machine-generated data." How exactly are machines generating data? Typically, it's when smart devices, gadgets, or machines gather information and communicate that data via the internet – an example being your fitness tracker automatically sending activity data to an app on your phone. (However, as we'll see later in this section, in the future, devices will increasingly process the data themselves, without having to transmit it for analysis.)

This is all possible because, these days, pretty much everything is getting smarter. It all started with the iPhone, and has since snowballed to include smart TVs, smart watches, and fitness trackers (see wearables,

Trend 3), smart home thermostats, smart fridges, smart industrial machinery…even smart nappies that alert you when your baby has, well, done what babies do best. A huge range of devices, machines, and equipment are now fitted with sensors and have the ability to constantly gather and transmit data. Today, even the smallest devices can effectively function as a computer. (However, it's important to note that an actual computer wouldn't count as part of the IoT, since the IoT generally refers to everyday objects that we wouldn't traditionally expect to be able to connect to the internet – like fridges and TVs.)

An IoT device could be as small as a light bulb – smaller, in some cases – or as large as a streetlamp – see intelligent spaces and smart places, Trend 5 – and may be found at home, on our city streets, in our offices, in healthcare settings, in industrial settings, and more. I delve into some of the practical applications of the IoT later in the chapter.

The ability of machines to connect to and share information with each other is a key part of the IoT. These machine-to-machine conversations mean that devices can talk to each other and potentially decide on a course of action without human intervention. For example, manufacturing equipment fitted with sensors could transmit performance data to the cloud for analysis, and based on that data, the system could automatically schedule the equipment for repair and maintenance. (The use of the IoT in industrial and manufacturing settings is often referred to as "Industry 4.0" – smart industry, in other words.)

How big is the IoT? Pretty darn big. The IoT has experienced enormous growth in recent years and the popularity of smart devices shows no sign of slowing down. IHS predicts that 75 billion devices will be connected to the internet by 2025.[1] If that number seems hard to fathom, consider this: as of January 2019, Amazon had sold more than 100 million smart devices with Alexa installed.[2] That's just Amazon Echo smart speakers and other Alexa-enabled devices! (Interestingly, many IoT devices are catching on to the power of voice interfaces like Alexa – see Trend 11.)

As well as becoming more ubiquitous, these smart devices are also becoming more powerful, which means that more of the computing can be done on them, rather than having to upload data to the cloud for analysis. This is what's known as "edge computing" (see Trend 7). With edge computing, data is processed closer to the source of the data and away from the cloud – in theory meaning that your smart fridge could process data itself. It's relatively early days for edge computing, but it's predicted to bring big benefits. If you think about it, IoT devices create masses of data – not all of it critical – which can slow down processing and decision-making (fine if you're just asking Alexa for the weather report, but definitely not fine in, say, a self-driving vehicle). With edge computing (see also Trend 7), networks are less clogged because more processing is happening closer to the data source, which means critical data can be handled much more quickly.

Edge computing is just one of the advances we can look forward to in the IoT, but it's by no means the only one. As businesses quickly cotton on to the power of the IoT, expect many more exciting IoT-related developments in the coming years.

How Is the Internet of Things Used in Practice?

The IoT is set to become even more deeply embedded in our everyday lives: at home, at work, and when we're on the move. In fact, you might be surprised how deeply entrenched it is already. Let's look at some of my favorite real-life examples of the IoT in action.

Making Our Homes and Everyday Lives Smarter Through Intelligent Consumer Goods

Unlocking your front door with a boring old key? No need, if you have a smart front door lock. Turning light switches on and off with your actual hands? What are you, a cave dweller? The idea behind many smart consumer goods is to simplify (and even automate) those

mundane, everyday tasks. What's more, the best of today's smart products get to know your preferences and behavior, so that they can anticipate your needs and respond to your behavior. For example:

- Google-owned **Nest's** learning thermostat tracks how you use your home so that it can regulate your home's temperature accordingly.
- The **Orro** intelligent light switch can tell when you're in the room and switch the lights on and off without you having to do anything. It'll also adjust the lighting based on the time of day.
- The **August Smart Lock Pro** allows you to lock and unlock your home from anywhere, without a key. It automatically locks the house when you leave and unlocks it when you come home and can integrate with voice assistants like Alexa and Siri.
- **LG's smart wine fridge** can tell you what food to pair with your tipple, and recommend which wine to buy next, based on what it learns about your tastes.
- **LINKA's** smart bike lock recognizes you as you approach and automatically unlocks your bike, without a key. You can also grant remote access to your bike to family and friends.
- You can even get smart toilets these days. No really. The **Kohler Numi 2.0 Intelligent Toilet** comes with built-in Amazon Alexa – a snip at $8,000.

Wearable devices such as smart watches, fitness trackers, and even smart clothes make up a critical part of the IoT. Read more about the wearables trend in Chapter 3.

Making People Healthier with the Internet of Medical Things (IoMT)

The IoT is poised to transform the healthcare industry, giving rise to its own name: the IoMT. These IoMT devices can be used to help

monitor patients, inform caregivers in the event of an emergency, and provide healthcare professionals with data that could inform diagnosis and ensure patients follow doctors' orders. For example, IoMT devices can track vitals and heart performance, monitor glucose and other body systems, and track activity and sleep levels. Think about the impact of this for a second – instead of doctors relying on what the patient tells them, the IoMT gives healthcare providers an incredible insight into what's really going on with the patient's health and lifestyle. As you can probably imagine, the IoMT is closely linked to the rise of wearable technology (see also Trend 3).

Transforming the Way We Do Business

The IoT offers huge benefits to businesses. There are some great examples of this.

- For companies that make and sell products, making those products smart can deliver unprecedented insights into how those products are used. Thanks to these insights, companies can deliver a better service and improved products. **Rolls-Royce**, for example, installs sensors in the jet engines it manufactures, so it can better understand how airlines use those engines.
- The IoT also gives businesses the chance to deliver new customer value propositions. For instance, tractor and farm equipment manufacturer **John Deere** has developed intelligent farming solutions where sensors continuously monitor soil health and other factors, and give farmers advice on what crops to plant where, and so on.
- Companies are also generating new income streams, thanks to the IoT. **Google's Nest** smart thermostats are one example of this. The thermostats collect real-time energy usage data from customers – data that's incredibly valuable to utility companies

and other interested parties. In this way, data generated from IoT devices can become a key business asset, and potentially bolster the company's value.

- For many companies, the biggest IoT opportunities lie in the ability to improve and optimize operations. Data generated from smart machines – for example, manufacturing equipment – can be used to improve the way the company is run, potentially automate various processes, drive efficiencies, improve reliability, reduce costs, and so on. It's no surprise, then, that manufacturing and industrial companies have been leading adopters of IoT technology, which brings me to…

Introducing the Industrial Internet of Things (IIoT)

Companies are increasingly seeing the value in connected machinery that is capable of reporting every detail of operations – and this network of connected industrial devices is known as the IIoT. Examples include:

- Robotics and automation company **ABB** used connected IIoT sensors to monitor its robots' maintenance needs, so it can carry out repairs and maintenance before parts break.
- Automobile parts manufacturer **Hirotec** used IIoT technology to monitor the reliability and performance of machinery at one of its tool-building operations. The data was used to make machines more productive. The company is now focusing on connecting a whole production line at one of its manufacturing plants in Japan. This means the production of a complete auto component – in this case, a car door – will all happen in a smart, connected way.[3]
- The IIoT is even helping trains run on time. **Siemens AG** gathers data from sensors on trains and rail infrastructure to, among other things, carry out predictive maintenance and increase