White Paper

March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow
Introduction

Automated technologies are transforming the industrial landscape. Whether it’s the spread of robots across factory floors, or new levels of hyper-connectivity enabled by the Internet of Things (IoT), the unstoppable drive towards digitalisation is having a profound effect on the ways that products are made and services are delivered.

But that’s just the half of it. There’s a much less tangible form of automation that promises to make an even bigger impact on our daily lives. Step forward artificial intelligence (AI), an enigmatic concept that would appear to hold the key to dozens of innovations. AI could, for instance, take us into a new era of cognitive manufacturing, where machine learning underpins efforts to deliver leaner working and improved productivity. Or it could deliver smarter buildings, where self-regulating heating and ventilation systems respond to changing factors such as the number of people in a room, therefore increasing comfort and maximising energy efficiency.

“This whitepaper attempts to demystify AI as a concept, tracing the man-machine continuum and determining its potential impact on the economies of developed nations.”

It could even be applied across a wider network of intelligent infrastructure – such as traffic systems, energy, health services and law enforcement – delivering the truly smart cities of the future. But AI, by its very nature, can be an impenetrable subject. This whitepaper attempts to demystify AI as a concept, tracing the man-machine continuum and determining its potential impact on the economies of developed nations. It also highlights several real-world applications across key industrial sectors, looking at how these advances are delivering a host of exciting new technologies and are transforming traditional business models.
March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow

Tracing the development of AI

So, what is artificial intelligence? And why has it suddenly started to come to such prominence? Let’s start with a definition: broadly speaking, AI is about simulating intelligent behaviour in machines of all kinds, even to a point where they can imitate intelligent human behaviour. Colloquially, the term ‘artificial intelligence’ is applied when a machine mimics ‘cognitive’ functions that humans associate with other human minds, such as ‘learning’ and ‘problem solving’.

AI, as a concept, has actually been around since the development of the electronic computer. It was first coined as a term in the 1950s, and led to the development of computer programs deliberately engineered to mimic the problem-solving skills of a human being. However, despite a flurry of research activity in the 1960s and 1970s, hardware and software limitations meant these early computer programs could only perform a narrow set of tasks, often with human intervention. Funding dried up over time, and many projects were shelved.

More recently though, advances in computational power have re-ignited interest in AI, and most of the world’s biggest companies now have specific research departments devoted to furthering the concept. Google, for instance, is spending billions of dollars on AI as a means of pushing forward its pursuit of driverless cars, while Skype has launched real-time voice translation services. Apple and Amazon, meanwhile, have developed voice-activated intelligent assistants that incorporate AI, while Amazon employs transactional AI to predict our online buying behaviour. But AI is also starting to impact B2B markets. Indeed, according to a comprehensive report on AI published by PwC, companies across a wide range of industrial sectors are being forced to face up to the disruptive capability of AI. Today, smart machines are beginning to advance from an ability to handle traditional applications of repetitive tasks to the capability to adapt to continuously changing tasks. This evolution is seeing AI applications move from assisted intelligence to augmented intelligence, and ultimately to autonomous intelligence, with each stage building on the one before, and bringing to bear its own specific capabilities. That progression, suggests PwC, will present both opportunity and threat to industrial organisations.

“AI’s progression presents both opportunity and threat.”

PwC states that “AI’s progression is being fuelled by a range of drivers, including the levelling-off of the technology cost curve and the maturing of underlying technologies, including mobile connectivity, cloud infrastructure, the proliferation of sensors, advances in processing power, machine-learning software and storage”.

“In addition, other major trends contributing to the growth in AI are the rise of the open-source software movement and the ongoing democratisation of AI. As it continues to evolve and machines become smarter, significant opportunities will emerge across the complexity spectrum. First, repetitive and routine manual and cognitive tasks will be automated to provide assisted intelligence; next, in situations where the complexity of decisions is greater, AI will augment human decision making; and finally, when machines are able to learn enough about the situation and make predictable recommendations that humans trust, they will become autonomous,” says the PwC report.
AI – the size of the prize

The enormous potential of AI means that most developed nations are doing all they can to grow their AI capability, primarily by coordinating and investing in their research activities. In the UK, for example, a recent independent review entitled Growing the artificial intelligence industry in the UK which was produced on behalf of the Department for Digital, Culture Media & Sport and the Department for Business, Energy and Industrial Strategy, gave an upbeat assessment of the potential of AI, suggesting that it could bring massive social and economic benefits. The report estimated that AI could add an additional £630bn to the UK economy by 2035, increasing the annual growth rate of GVA from 2.5 to 3.9%.

Indeed, according to Made Smarter, an industry-led review exploring the adoption of digital technology within manufacturing, the UK holds a comparative advantage in developing AI technologies with a thriving ecosystem of researchers, developers and investors. UK AI companies such as Deep Mind, VocalIQ and Swiftkey have all been acquired by global technology companies on the basis of the technologies they offer. There are at least 226 AI software companies in the UK, with more than 60% founded in the last three years, making the UK a recognised global hotspot of AI research and development.

But it’s not all plain sailing. The Made Smarter report found that many UK businesses – as in many other developed countries - were confused by a combination of hype and a lack of information on how AI could help solve specific business problems. Those who overcome these challenges then found it difficult to build a business case to invest, making ROI predictions impossible, it said.
March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow

“There is a gap between those who have started and those who have not, but even the leaders appear to be implementing point solutions rather than making AI investment part of an overall strategy,” stated the report. “In addition, businesses raised concerns about the predictability of outcome from machine learning. Also highlighted was the need to navigate a complex ecosystem of suppliers, customers, academia, government, regulators and other stakeholders. The complexity of this ecosystem acts as a disincentive to adoption of AI technologies,” it concluded.

The way forward, said the Made Smarter review, was for government, industry and academia to work together to develop a programme to encourage the adoption of AI technologies and to develop the necessary skills to achieve successful deployment.

Application of AI in key sectors

So where might AI have the biggest impact on the industrial base? Let’s start with manufacturing, where the integration of intelligent machines could lead to some remarkable advances in predictive maintenance. Here, the convergence of AI and the Internet of Things (IoT) is creating some real opportunities, particularly when it comes to flagging up performance issues with equipment on the shop-floor, and then dealing with them before expensive downtime occurs.

In recent years, many manufacturing firms have embarked on a journey of digital transformation and the era of the smart factory is now very much upon us. Cheaper and more reliable connectivity is enabling manufacturers to embrace IoT-enabled architectures, giving them far better visibility of their factory assets than ever before.

In an industrial context, the connected ‘things’ can be a long list of systems and machines that can be fitted with sensors which record data around pressure, level, flow, temperature, vibration and acoustics. This data, combined with analytics, can be used to reveal patterns within factories, or even with equipment out in the field.

Healthcare advances: Machine learning inspires Wi-Fi-based health monitor that works through walls

There are some tremendously innovative examples of AI-inspired technologies being developed in the health sector, where real-time data collection and monitoring has the potential to change the way that social care is administered.

At the University of Coventry in the UK, for instance, engineering researchers have developed a passive Wi-Fi sensing system with machine learning that can detect body movements and vital signs of a subject through walls and without any physical contact. The detailed analysis of the Wi-Fi signals that reflect off a patient reveals particular patterns, which can be served up to gesture recognition libraries and machine learning systems for classification of activities and model lifestyle behaviour for healthcare applications.

The widely-adopted detection methods currently used within care homes include wearable devices, camera-based vision systems and ambient sensors. However, these established technology options have major drawbacks – they cause physical discomfort, introduce privacy concerns, and have limited detection accuracy.

The researchers in Coventry, led by Dr. Bo Tan, lecturer at the school of computing, electronics and mathematics, believes there is an urgent requirement to develop novel monitoring solutions, which are contactless, accurate and minimally invasive. This was the inspiration behind the passive Wi-Fi sensing systems, which has been developed using National Instruments LabVIEW.

“Compared to the established monitoring techniques, the technology has some obvious advantages,” says Tan. “Firstly, it’s contactless and pervasive, with the ability to identify activities anywhere Wi-Fi connectivity is available, without the need for any for subjects to carry devices. Also, it can provide diverse and accurate information, allowing the detection of many activities from respiration to body gesture, from casual day-to-day operations to severe events.”
March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow

But there’s a problem. As companies rush to adopt IoT, they fit more sensors and create more data. Soon, it becomes difficult to manage, analyse and create meaningful insight from the information produced. In time, these data flows can become overwhelming.

That’s where AI comes in. By enabling truly smart machines, which can simulate intelligent behaviour and make well-informed decisions with little or no human intervention, it becomes possible to unlock the value from large volumes of digital data. For some, this combination of IoT with AI is the holy grail for industry: it’s the only way of improving the speed and accuracy of big data analysis, providing true insight into what’s working well or what’s not. According to IBM, AI and IoT are shaping up to be a symbiotic pairing, as AI doesn’t just depend upon large data inputs; it thrives upon them. “AI systems can rapidly consume vast quantities of structured and unstructured data, and give it meaning by creating models of entities and concepts, and the relationships among them,” says Susanne Hupfer, a senior consultant and lead analyst at IBM. “They generate hypotheses, formulate possible answers to questions, and provide predictions and recommendations, which can be used to augment human intelligence and decision making.”

Furthermore, given new data and scenarios, AI-based systems evolve over time, inferring new knowledge without being explicitly programmed to do so. As Hupfer notes: “Got vast volumes of data from IoT? Feed it to AI systems and let them make sense of it.”

**AI role in managing big data**

The ability to make meaning from vast flows of data means that AI is being touted as a key enabler of smart factories and products, and is causing much excitement within the research and development divisions of the big industrial players. One company that sees huge potential in AI transforming its business is Siemens. The German giant has more than 200 experts working on data analytics and neural networks, identifying a variety of applications in areas such as energy distribution, electric motors, and rail technology. For Siemens, AI will transform the way that companies make products, and change the way that equipment is used out in the field.

Siemens says that the potential impact of AI within industry cannot be over-stated. In a recent presentation, Roland Busch, Siemens’ chief technology officer, explained how the company was already using AI to improve the operation of gas turbines. By learning from operating conditions and other data, Busch said AI could help achieve a significant reduction in the emission of toxic nitrogen oxides without affecting the performance of the turbine or shortening its service life.
Busch also added that the application of AI was not restricted to new products. Siemens is also looking at how it can be retrofitted to existing equipment such as motors and transmissions, bringing them into the digital age. Here, smart boxes containing sensors and a communications interface can be used to analyse data, with AI systems then drawing conclusions regarding a machine’s condition. This information can be used to underpin predictive maintenance.

Siemens is not alone. Arch-rival GE is also throwing millions of dollars at AI research and development, looking for ways to apply AI to jet engines, medical scanners and other machines. There’s particular scope for such technologies within the smart factories of the future, predicts GE. AI systems could, for example, provide workers with the intelligence they need to make informed decisions around whether to scrap or repair a turbine blade. The data used to underpin such decision making could also be simultaneously collected in a closed loop to make the system smarter and smarter, so next time around it provides even better insights.

What this means for manufacturers

Given the scale and range of potential benefits on offer, it’s hardly surprising that companies in many industries are beginning to take steps to seize the opportunities presented by combining IoT and AI. According to the PwC report, IoT/AI will make an impact across manufacturing – in markets as diverse as domestic appliances, aircraft, automobiles, ships and mining. PwC believes the combined disruption from AI and IoT will reshape business life in a dramatic manner that is not at present fully imaginable or comprehensible. The PwC report said ‘at one end of the scale, it will displace routine, monotonous human jobs with machines. At the other, it will radically disrupt the competitive landscape, by giving the early adopters of artificial intelligence tremendous advantages in terms of lower costs and a head-start in pursuing new business opportunities.’

While the full impact of this disruption will not arise overnight, it will come a lot faster and sooner than most businesses and individuals are currently expecting, PwC insists. Thus, switched-on manufacturers are not waiting for the tsunami of disruption to reach their shores before they react. Instead, they are moving now to start the strategic dialogue needed to fully understand and prepare for the disruptions before they arrive. “Companies that take this proactive, far-sighted approach can turn the upcoming disruptions from an irresistible force that could sweep them away, into a massive opportunity that they’re well-placed to realise. Put simply, the AI revolution is here — and now is the time to get ready for it,” the report adds.
March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow

How will analytics make life easier?

So how do companies prepare for the arrival of AI? If each ‘thing’ connected by industrial organisations in IoT generates millions of data points every day, and the number of devices grows exponentially year-on-year, surely traditional approaches to analytics will start to become obsolete? New means of tackling the volume, velocity and variety of data will therefore be required to deliver the real value of IoT to end users. And that’s where specific software platforms combining AI with IoT come into their own.

One of the leaders in the field is PTC, the US-based technology provider. Two years ago, PTC bought ColdLight Neuron, a big data machine learning and predictive analytics company, for $105 million. Since then, ColdLight’s technology has been integrated into PTC’s ThingWorx IoT platform, and now serves as the company’s core data analytics technology, automating the analysis of data from things to address a range of important challenges. These challenges include detecting failure patterns from data, modelling correlations, predicting failures, prescribing remedies and prioritising recommendations against cost constraints.

ColdLight’s Neuron platform addresses these challenges by using artificial intelligence and machine learning technology to learn automatically and continuously from data, discover patterns, build validated predictive models and send information to virtually any type of application or technology. The ability to predict outcomes has incredible value, especially in the context of ensuring product performance and preventing product failure and downtime.

PTC believes it will be particularly useful for improving after-sales service, which PTC believes is a major industrial application that drives business value in the IoT. Companies today have an overwhelming need to gain insights from massive amounts of data. To meet that demand, companies are competing for a scarce new resource – data scientists. ColdLight’s Neuron platform automates deep data discovery and predictive modelling, speeding time to market and reducing the dependency on expert data scientists.

“It’s been said that data is the new oil – but it needs to be refined for it to be of value,” says Rob Patterson, vice president of strategic marketing at PTC. “That’s what our AI-inspired machine learning does. It democratises the data. It enables pretty much every developer to perform some advanced analytics in the apps they build on top of our platform, and it translates data into something that’s contextual and meaningful for people on the shop-floor.”
March of the machines: the use of artificial intelligence (AI) in the smarter factories and buildings of tomorrow

The combination of ColdLight’s Neuron into the ThingWorx IoT platform will enable rapid development of more advanced IoT applications that employ machine learning capabilities. The technology simplifies how predictive models are defined and maintained, removing the largest hurdle to a quick and broad adoption of advanced and predictive analytics for IoT. By combining Neuron with ThingWorx, results and corrective actions will be able to be delivered to people or directly to machines and devices. “This is the means by which manufacturers can handle the volume, velocity and variety of data IoT collects,” adds Patterson. “You cannot investigate such data streams by clicking around on a dashboard or by trying to build a manual model. The data is so great that you need to augment the human mind to investigate all the inter-connections of the data in order to deliver actionable insight. And that’s what our AI-inspired analytics can now deliver.”

AI-powered smart buildings

Manufacturing isn’t the only area where AI is starting to have a significant impact. It also has the potential to make buildings much smarter. In recent years, micro-electrical-mechanical-systems (MEMS) have dramatically increased the intelligence of sensor-based technologies used to gather information around temperature, humidity, air quality and vibration. In each case, these datasets are used to underpin the control of modern heating, ventilation and air conditioning (HVAC) systems, which can be regulated for optimum comfort. Already, IoT-enabled HVAC systems can be programmed to be relatively adaptable, turning on before workers arrive in the building and saving energy by automatically switching off when a room is not used. Now, though, by combining local sensors with AI, it becomes possible to envisage truly smart HVAC technologies, where computers can learn to recognise patterns ranging from the number of people in the room, through to changes in the ambient weather conditions outside, and make operating decisions accordingly.

How AI will power the intelligent cities of the future

Smart buildings are just one component of what, in the near future, could be a vastly expanded network of intelligent infrastructure designed to make life simpler, safer and more environmentally efficient.

This vision of a so-called smart city would be enabled by the use of a comprehensive network of sensors used for the collation of huge amounts of data from numerous heterogeneous subsystems. It might sound fanciful, but some major technology organisations are applying significant resources to enable such an ambitious vision to come to life.

Nvidia, for instance, has developed a complete cloud-to-edge video analytics platform for the building of smart cities. The Metropolis platform comprises a range of tools and technologies that are designed to help build smarter and quicker AI-powered applications.

The underpinning enabler is the rapidly expanding network of connected cameras that are being applied across modern cities. Nvidia believes that by 2020, this network will number 1 billion connected cameras, capturing as many as 30 billion images a second. Human beings would find it impossible to sift through the flood of moving images to gain insight, storing the majority of it on hard drives for later viewing.

But what Metropolis enables is the use of deep-learning inspired intelligent video analytics, in the cloud and at the edge, for real-time actions in applications like multi-object classification, facial recognition, and behaviour analysis. Applied across cities, that could result in video-based, automated control of key urban infrastructure.

That could mean smarter use of traffic lights and signalling to ease rush-house congestion and to allow first responders to get to incidents in the shortest amount of time. Or it might be applied to track down missing persons, or to alert the police to crimes in progress. New applications are being imagined on a daily basis, all of which are based on transforming pixels into meaningful insight.

“Manufacturers can handle the volume, velocity and variety of data that IoT collects.”
Indeed, air conditioning firm Kaer is bringing such technology to life. Over the past two years, the Singapore-based company has been quietly developing a system that it says will unleash the power of machine learning to optimise the next generation of air-conditioning. Its briQs technology automatically extracts data from a building management system, and uploads it in real-time into an AI-based software platform. The data is then run through neural networks to get a deep understanding of how the air-conditioning can operate more efficiently. The briQs system then updates the air-conditioning control variables and set points of the building management system to optimise system performance and efficiency. As well as taking care of day-to-day operations, the software can also produce customised diagnostic reports which can support system upgrade planning and encourage the use of preventative maintenance.

“We believe that buildings should think for themselves so we can spend our time thinking about other things,” says Benjamin Lai, general manager at Kaer. “The unlocking of information within building automation systems represents a significant opportunity to move towards a greener, more sustainable future. By feeding the data into the machine learning software, we are beginning to demonstrate how we can control air-conditioning systems, improving their performance and making occupants more comfortable.”

At present, Kaer manages around 40 large-scale commercial air-conditioning systems across south-east Asia. In each case, performance data is sent back in real-time to Kaer’s headquarters in Singapore, where it is continuously monitored by a team of engineers assessing plant operations. Traditionally, this has been a relatively manual process carried out with ‘eyes on screens’.

“As we have added more air conditioning plants, analysis of the data has become more taxing on our engineers,” says Lai. “So, we started to look at how machines could help by spotting patterns and recognising anomalies. By using machine learning, we believed we could perform some analytics, and optimise the plants.”

“The unlocking of information within building automation systems represents a significant opportunity to move towards a greener, more sustainable future.”

A two-year research project, carried out in tandem with the A*Star scientific research institute in Singapore, has resulted in a set of algorithms that can drive autonomous optimisation of air-conditioning plants, driven by variables including changes in the weather through to the number of people inside the building. The software can also be used to analyse patterns of data over time, providing early-warning of maintenance problems and pinpointing areas where improvements in energy-efficiency can be made. Indeed, a recent trial of the system at the Insead Business School in Singapore reduced chiller plant energy consumption while also delivering a 90% reduction in manpower.

“There’s no doubt that machines can handle more variables than a human at any one time,” says Lai. “But this is not about AI and automation taking away people’s jobs. It’s about freeing up highly-skilled engineers so that they spend less time watching screens and more time overseeing higher level analytics and performing design activities. We feel AI technologies will help us retain our engineers because, ultimately, they will make their jobs more interesting.”
Conclusion - next steps for AI

It’s clear, then, that AI is moving swiftly from concept to reality. From manufacturing to healthcare, building services to smart cities, the development of augmented and autonomous intelligence is starting to deliver a new generation of products and services that have the potential to touch upon every facet of work and life. The pace of innovation is particularly keen in certain countries, where an established community of AI start-ups has begun to emerge.

The challenge now comes with increasing the uptake of AI, which requires a better understanding of what it can do and where it could be applied. This would be best provided at national levels through coordinated approaches to providing guidance on how to explain decisions and processes enabled by AI. It could also be extended to include support for export and inward AI-related investments and through national programmes to support public sector use of AI.

There’s also the challenge of how to monetise AI inside existing businesses and organisations. In many respects, the adoption of AI requires asking the same sorts of questions as any other new technology. What business need would it address? How would it fit in alongside legacy systems? What are the cost implications? How would ROI be measured? How can performance be assessed? These are all crucial considerations at an early stage. And then there are people issues. Any mass adoption programme requires a fundamental evaluation of company culture and skills to ensure that it is a success. That’s particularly true of AI, a concept which has been subject to an enormous amount of hyperbole.

The potential of AI is, however, there for all to see. AI has emerged as the hot technology topic of the modern age, and any enterprise ignoring its continued advancement does so at its own peril.
Glossary

The author would like to thank the following companies and organisations for providing information in support of the writing of this whitepaper.

**Department for Digital, Culture Media & Sport and Department for Business**
Growing the artificial intelligence industry in the UK

**IBM**
AI is the future of IoT

**GE**
I Machine, You Human: How AI Is Helping GE Build
A Powerhouse Of Knowledge

**Kaer**
Briqs

**Made Smarter review**
Made Smarter Review 2017

**National Instruments**
Combining Passive WiFi Sensing and Machine Learning Systems to Monitor Health, Activity, and Well-Being Within Nursing Homes

**Nvidia**
Deep Learning for Smart Cities

**PTC**
IoT and AI: Made for Each Other

**PWC**
Leveraging the upcoming disruptions from AI and IoT

**Siemens**
Artificial Intelligence: Optimizing Industrial Operations

**Author**
Lee Hibbert
Industry analyst & Content Director, Publitek

Publitek has been a pure tech B2B marketing agency for more than 20 years. We really understand technology buyers: what they value, where they look for information, the content that appeals to them, and how they make decisions. As a result, we’re able to create effective tech B2B marketing campaigns, including deeply technical content that enhances your valuable strategic, product and engineering resources. Please contact us to find out more.

www.publitek.com