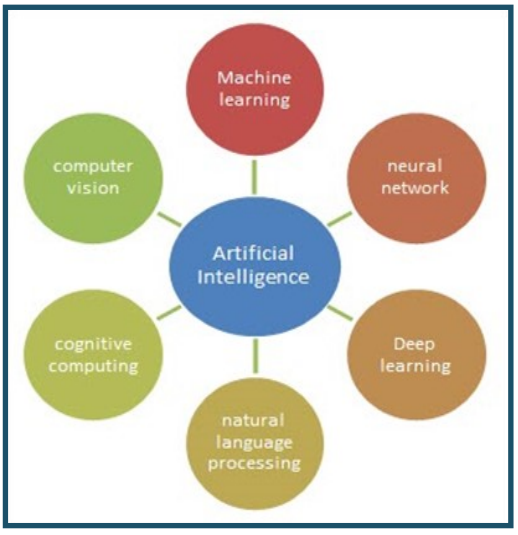
INFORMATION PROCESSING: ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND BIG DATA

Artificial intelligence (AI) can be described as the ability of digital systems to acquire and apply knowledge, and to autonomously execute tasks associated with intelligent beings. This includes a variety of cognitive tasks such as sensing, processing, language, reasoning, learning or even making decisions or self-correcting. AI combines sophisticated hardware and software with elaborate datasets and knowledge-based processing models to demonstrate characteristics of effective human decision-making.

It would be a mistake to think of AI as a technology of the future, because it is already used in our smartphones, on websites, in aircraft, for traffic navigation, in the finance sector, and increasingly in manufacturing.

TECHNOLOGICAL NOVELTY OR MERIT

AI is considered to be narrow (or weak) if it is designed to perform a specific task such as playing chess or doing facial recognition. However, strong AI that can be likened to human cognitive capacity is not yet available, despite the hype in the media and the excitement created by techno-enthusiasts.



Some of the sub-fields of AI include machine learning, neural networks, deep learning, computer vision, cognitive computing, natural language processing and robotics. In some advanced applications of AI, such as autonomous driving, many AI sub-fields are combined with different forms of processing and control. However, for many manufacturers, narrower applications such as machine learning in assembly functions, big data analytics for predictive maintenance or visual quality control are probably the most relevant in the short term.

Most of the research and development of more powerful computing processing and advanced algorithms are concentrated in only a few places in the world. However, the application of AI has become more ubiquitous in our everyday lives in the form of speech recognition, language editing and image processing.

Many applications of AI are now available through software as a service (SaaS) via the cloud or through off-the-shelf solutions. It is this easy access to these solutions that poses a threat to many incumbents and industries because it provides opportunities for new entrants, new specialised service providers, and innovative new ways to design and manage manufacturing processes.

TECHNOLOGICAL CHANGE AND INNOVATION SYSTEM OBSERVATORY

The aim of the Technological Change and Innovation System Observatory project is to support the Department of Trade, Industry and Competition (the dtic) and industry sectors to develop an integrated, strategic response to discontinuous technological change and disruptive innovation. It aims to equip public and private organisations to become more sensitive to global technological shifts, and the changing demands placed on the innovation system, the manufacturing sector and its stakeholders.

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Even though artificial intelligence has been around since the 1950s, recent advances in processing power, a reduction in processing costs, and easier access to cloud computing technology have resulted in rapid advances. These advances are most visible in artificial intelligence applications related to natural language processing, vision and speech recognition and the use of real-time data to make decisions (autonomous vehicles, robots).

NEW COMPETENCE REQUIREMENTS

In the financial and service sector, AI is already in use behind many websites, call centres and risk management systems. Many companies that employ data scientists are already using AI.

In the manufacturing sector, the uptake has been much lower. However, some manufacturing solutions might include narrow AI capabilities without it being explicit, so the effects might be underreported. Examples of solutions for which AI could be underreported could include assembly robots using machine learning, sorting and packaging solutions, and quality control solutions using visual computing.

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In short, South Africa is lacking imagination about the possibilities of how AI can be applied in manufacturing and business.

Skills and knowledge

Behind the sophistication of AI are known elements such as information system design and management, data science, software development, the development of large data libraries, and microelectronics design.

For instance, for a manufacturer to use an AI system to scan for mechanical defects, it would have to procure and commission a scanning system consisting of different cameras along with a powerful computer. The second critical aspect would be to either license a visual library (dataset), or to develop an own visual library through machine learning.

Organisational arrangements

As the costs of AI solutions go down, AI might be employed in more processes and functions in a manufacturing or business environment. This means that functions, such as quality control, that are often further downstream might be applied throughout the manufacturing process. Design, which is typically upstream, might move closer to customer engagement in order to tap into rich streams of user data.

For AI to work, more data is needed. In many places, production systems data is available that is not used to inform decision-making, and these are the places where AI solutions could make a difference to improve efficiency, reducing waste and co-ordinating manufacturing functions. Companies that are able to leverage the value of the data inherent in their processes will have a distinct advantage over companies that are not able to reimagine key processes.

Value chain or business network effects

In some manufacturing sectors, it might be too expensive for each manufacturer to develop its own visual library. When different companies work together to develop visual libraries, the costs of using AI will go down. Alternatively, service providers that specialise in building libraries might become valuable solution providers.

It can be expected that the number of solution providers, developers of libraries and specialised solution/equipment providers will increase. At present, larger companies can often procure solutions through their international networks, leaving local firms at a disadvantage. Most of the focus of supporting institutions is focused on information and communications technology (ICT) and corporate services, and it is much harder to find public organisations that can assist smaller manufacturers, such as with new solutions and technology demonstrations.

MARKET NOVELTY AND NEW FUNCTIONS

The development of AI libraries and data sets related to manufacturing might lead to the emergence of new industry standards and skills training. When AI is combined with automation, dangerous and mundane tasks in manufacturing can be replaced by technology, with humans supervising the process.

STRATEGIC IMPACT ON FIRMS

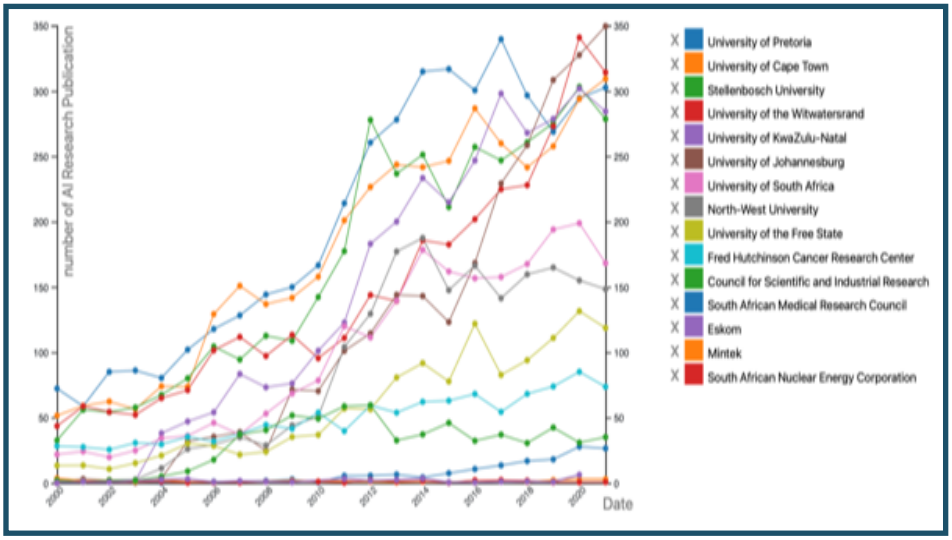
Companies that have sufficient scale to justify early investments in AI applications will be able to outperform competitors and develop capabilities in technologies that will most likely become more widespread in the future.

REGULATORY REQUIREMENTS

In South Africa, there is already a strong momentum building around the ethics of AI. AI and related technologies are important ways to improve workplace safety and complement the abilities of humans in various assembly and labour intensive tasks. In addition, capability is being developed for standards and governance around implementing AI technology.

TECHNOLOGICAL CAPABILITY IN SOUTH AFRICA

The OECD AI Policy Observatory (OECD.AI) is tracking research outputs related to AI in South Africa. Most of the patents granted for AI in South Africa were submitted by publicly funded research programmes at universities, research councils, Eskom, Mintek and the South African Medical Research Council. However, the total number of patents is still low. The graph below shows the increase in publications by the leading universities and research centres in South Africa in the past 10 years.



Note: This chart shows the number of AI publications by institution for a given time range. Data downloads provide a snapshot in time. Caution is advised when comparing different versions of the data, as the AI-related concepts identified by the machine learning algorithm may evolve in time. Data source: Microsoft Academic Graph. OECD.AI (2022), visualisations powered by JSI using data from MAG, version of 31/12/2021, accessed on 11/8/2022, www.oecd.ai.

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The Centre for Artificial Intelligence Research (CAIR) is a distributed South African research network with nine established and two emerging research groups across eight universities funded primarily by the Department of Science and Innovation. It is virtually hosted and co-ordinated by the Council for Scientific and Industrial Research (CSIR).

CAIR is structured as a hub-and-spoke model with established groups at six universities: the University of Cape Town, the University of KwaZulu-Natal, North-West University, the University of Pretoria, Stellenbosch University and the University of the Western Cape. CAIR also has emerging groups at Sol Plaatje University and the University of Limpopo. See https://www.cair.org.za

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At this point, it is possible to identify the following starting points for manufacturers:

- The CSIR Learning Factory can demonstrate AI applied to manufacturing processes and can develop customised solutions for manufacturers involving hardware, software and manufacturing process design. The CSIR is also establishing a Smart Factory where Fourth Industrial Revolution (4IR) and AI application technology for batch/discrete assembly can be evaluated and derisked for specific industrial applications. The Smart Factory is planned for completion in the last quarter of 2022.
- Many of the engineering faculties at universities such as the University of Cape Town, North-West University, University of Johannesburg, University of Pretoria and Stellenbosch University have laboratories where graduate and postgraduate students work with machine learning and other AI technologies.
- Almost all of the information systems and data sciences programmes at the leading universities are working with different forms of AI, data processing and information management. A starting point would be the CAIR research network at https://www.cair.org.za.

Additional reading

Naudé, W. 2020. Artificial intelligence: neither Utopian nor apocalyptic impacts soon. In *Economics of Innovation and New Technology,* 1-23. Available at: https://www.tandfonline.com/doi/full/10.1080/10438599.2020.1839173

The Technological Change and Innovation System Observatory project aims to track and create awareness of disruptive innovation and discontinuous technological change by organisations in the public, private and not-for-profit sectors of technological change to enhance their service delivery to the public. Trade & Industrial Policy Strategies (TIPS) implements the project in co-operation with the economic development consultancy Mesopartner. The project lead is Dr Shawn Cunningham from Mesopartner.

Visit the Observatory

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