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AI in Africa

Realities, challenges and solutions

Artificial Intelligence (AI) is increasingly becoming a part of our lives. While AI is an exciting technology which is already transforming how we do many different things, it also has huge potential to solve some of South Africa's – and Africa's – biggest problems.

What is AI?

There are many different perspectives of AI, but generally we are referring to the idea of intelligent machines. However, modern computers are usually linked with other computers or devices, such as a file storage in the cloud, or your mobile phone or smartwatch, so it makes sense to refer to an intelligent system rather than just a machine. An *AI system* is a computer system that uses one or more AI techniques for a substantial part of its functionality.

This brings us to the notion of intelligence. This is difficult to pin down, but traditionally we viewed machines that can perform complex cognitive tasks that humans do as being intelligent. Initially, AI systems focused on recognition, analysis, search, optimisation and planning tasks. For example, computer vision systems identify people or objects in an image; like face recognition or number plate recognition systems; speech systems, like Siri and Alexa interpret voice commands; and natural language processing systems perform tasks on text, like checking your spelling and grammar. Google, a good example of search, finds relevant web pages given some search terms. Similarly, a navigation system such as Google Maps, is a good example of an optimisation and planning task. You supply a destination, it considers different routes, the current traffic in the area, and provides the fastest route to get to your destination. More recently, AI language systems like ChatGPT can perform creative or generative

tasks, like creating new images and art, writing poems or essays, or creating music.

What is machine learning?

Machine learning AI techniques are a suite of powerful pattern recognition techniques that can learn to identify patterns in large quantities of historical data. For example, let's consider the development of a simple face recognition system in a company with, let's say 100 employees. We first need a data set of face images, let's say 1000 face images of each employee at different times, which gives a total of 100 000 images. We must also supply the name of the employee that appears in each image. Now, when an image of an employee is fed into the system it must correctly identify the employee by name. We first have to "train" the system. An algorithm (program) is used to iteratively go through the data set, usually a few hundred times, to find unique identifying patterns across the images, until it is able to distinguish between the faces that appear in the data set. Each time the data set is fed into the system, it makes slight adjustments to do better. Once the developer is happy with the performance, she stops the training, and the system can be considered for deployment.

Deep learning algorithms are the dominant techniques in modern machine learning systems. These are based on artificial neural networks or just neural networks. Like the human brain a neural network consists of a network of neurons or nodes, which are connected to each other. A node has incoming connections to its input nodes, and outgoing connections to its output nodes. Like a neuron in the brain, it fires (turns on) when the incoming signals from its input nodes are strong. A node in a simple neural network is made up of two mathematical functions. The first averages out the incoming signals from its input neurons based on the strength of its connection to each input node. The second takes this average and determines whether to fire, output 1, or not, in which case it outputs 0 to all its output neurons. The power of a simple neuron comes into play when it is connected with thousands of other neurons in complex layered structures, which is the basis for deep neural networks or deep learning techniques.

Deep neural networks were initially trained for pattern recognition like recognising faces in a computer vision system. Large Language Models or LLMs were initially developed to predict the next words in a text sequence, but they have progressed substantially since then. They can now generate or create new text when given an input text task or prompt. OpenAI's Generative Pre-trained Transformer (GPT), is a deep neural network trained using internet data to generate text. The third-generation of GPT, GPT3, has over 175 billion parameters or connections. ChatGPT builds on GPT's language model to interact with humans in a conversational way.

What do we mean by knowledge-based AI?

The knowledge-based approach to AI takes a different, but complementary perspective to machine learning. It deals with explicit, symbolic representations of concepts or information along with reasoning procedures for deriving further implicit information. The case for a knowledge-based approach was made early on in the history of AI, motivated by how humans represent and reason about concepts and information in everyday life. A simple example is when you see a bird perched on a tree, you would infer that it is an entity that has wings and that it has the ability to fly. Typically, these symbolic representations encode information on some domain. This collection of symbolic expressions is called a knowledge base (KB). In the example above, the observation of the bird is explicit information and the reasoning procedures allow us to infer the implicit information, in this case, that it has wings and consequently that it can fly.

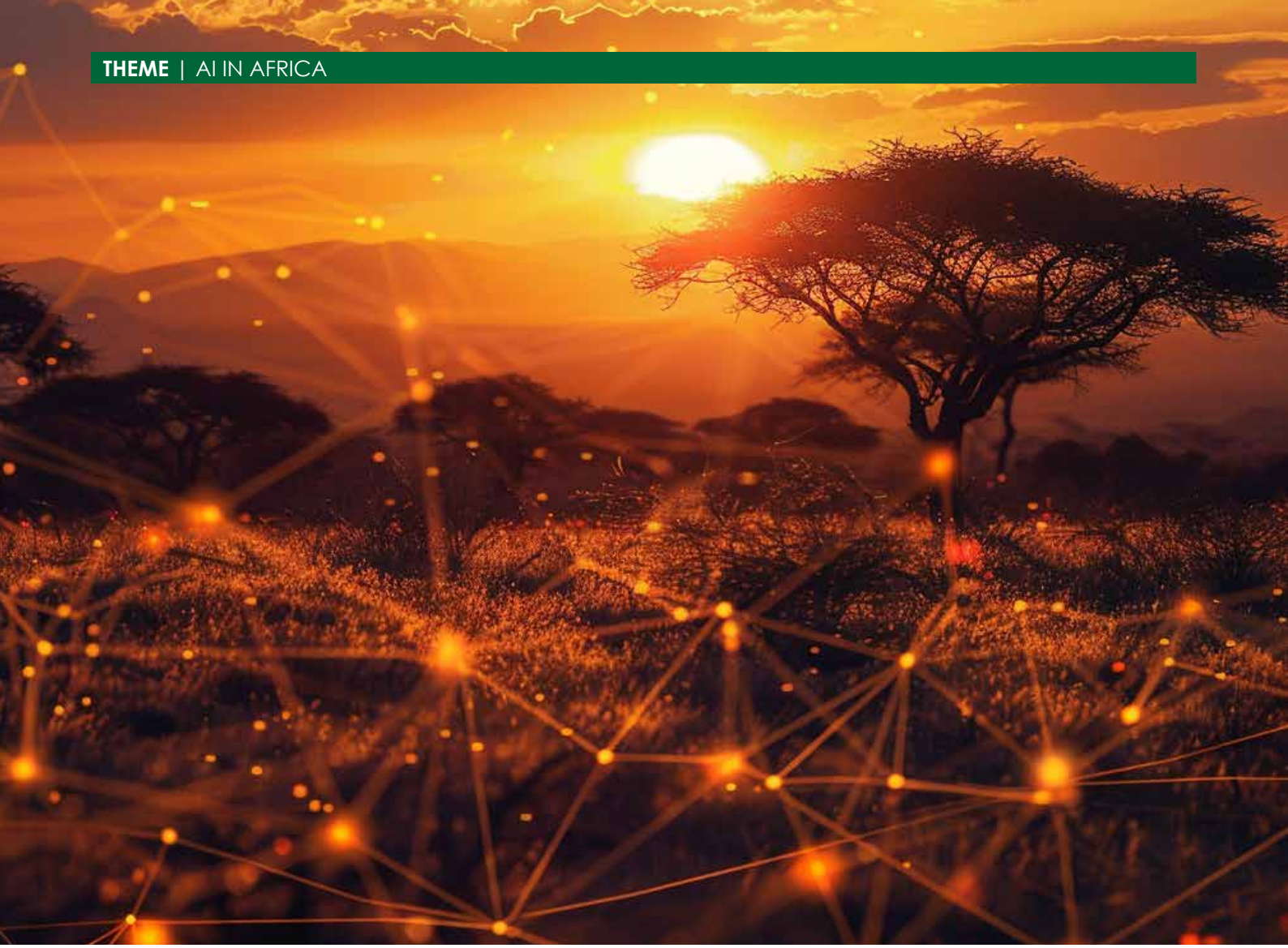
The recent success in the use of deep neural networks have brought about a new general trend in research on combining machine learning with knowledge-based approaches. On the one hand, researchers expect knowledge-based methods to help tackle machine learning problems. On the other hand, they expect machine learning to help address some of the challenges of knowledge-based systems. For example, despite the success of deep learning, the ability of neural networks to reason and to generalise in systematic ways has often been called into question. This view has led to the development of neuro-symbolic methods, which integrate deep learning architectures with knowledge-based reasoning processes.

Explainability and interpretability have also become important topics within machine learning. Given that transparency is one of the key strengths of knowledge-based systems, it should come as no surprise that ideas from the knowledge-based approach often play a central role in this context.

Leveraging AI in South Africa

AI is already widely used across different industry sectors in South Africa. In the automotive industry, BMW has established an AI and data science expert team in their IT hub in South Africa which provides service to BWM globally, while VW is actively building local capability in AI. One of South Africa's largest AI startup companies, Aerobotics, uses AI to analyse drone images for proactive and remote monitoring in agriculture. South Africa's big banks, financial and investment companies are also increasingly incorporating AI in their processes and for real-time decision making. In the longer term smart logistics and next generation e-market places are two other emerging application areas to watch.

Government agencies and state-owned enterprises are not far behind. SARS has built a world-class AI team.



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SARS is using AI for instant analysis of tax returns and for identifying tax dodgers. Eskom is exploring AI for predicting electricity consumption patterns and predicting and detecting faults at power stations to help solve the energy crisis.

There is also potential for AI to bring about a radical change in our approach to public health care in South Africa. Generally, technology is under-utilised in the public health system in South Africa so there's an opportunity for us to reimagine the ways we approach health and wellbeing. There are already AI tools available to assist doctors with diagnoses and treatment options. However, our current health system focuses on curative care, i.e. treating an ailment or condition after it has developed. In a low-resource setting, you cannot afford to put all your eggs into the curative basket – it's too costly and we don't have the facilities and staff. With smart phones, computers and digital technology giving us the ability to maintain our own health and well-being there's a shift to empower individuals with the knowledge and tools for proactive monitoring to track their physiological and mental health and decide, in consultation with their doctor, to continuously improve their health and wellbeing. This has the potential to slash healthcare budgets by half over the long term.

How should we regulate AI?

While AI has huge benefits, there are many risks and challenges with its development and deployment. Many international bodies like the United Nations (UNESCO) have produced guidelines for the responsible development and use of AI. The European Union also recently developed the AI Act, the world's first comprehensive AI law, to regulate the use of AI. These documents can help guide other countries in formulating their own AI policies and regulations.

How do I become an AI systems developer?

At the heart of an AI system are computer algorithms or software, the programs that run AI systems. Most AI system developers are software developers who have specialised in AI. Many universities have incorporated AI into their undergraduate Computer Science curriculum. So, studying Computer Science and taking AI courses is probably one of the easiest routes to becoming an AI systems developer. What is clear, is that AI has a bright and burgeoning future in Africa.

Article written by A/Prof. Deshen Moodley, Prof. Tommie Meyer and Zoë Boshoff of the Artificial Intelligence Research Unit (AIRU) at the University of Cape Town. Moodley also holds the DSI/NRF-UCT SARChI Chair in Artificial Intelligence (AI) Systems and Meyer and Moodley are CoDirectors of of the Centre for Artificial Intelligence Research (CAIR).