THE FUTURE OF THE WESTERN CAPE AGRICULTURAL SECTOR IN THE CONTEXT OF THE 4TH INDUSTRIAL REVOLUTION

Review: Artificial Intelligence(AI) and Machine Learning

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USB
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Table of Contents

1. What is Artificial Intelligence?

Introduction

Artificial intelligence (AI) is a branch of computer science dealing with the simulation of intelligent behavior in computers[1]. It is a term which describes a machine which exhibits human intelligence by performing acts such as language recognition, learning, reasoning, perception, planning and problem solving. AI is an area of study that has existed since the 1950s[2]. The field has enormous potential for change at almost every level of human activity.

Types

There are broadly two types of AI: weak and strong. This type of categorisation divides artificial intelligence systems by how generalised (or human like) the intelligence is.

Weak AI: also called narrow AI, is a system designed and trained for a particular task. Virtual personal assistants, such as Apple's Siri, are a form of weak AI[3]. Narrow AI is an area where artificial intelligence vastly outstrips human intelligence. This is due to the speed at which computers can process large volumes of information and calculate accurate outputs from given inputs. However, outside of the task that the AI is trained for, the narrow AI tends to perform poorly. There are some examples of narrow AIs that are described in the sections below.

Strong AI, also known as artificial general intelligence, is an AI system with generalized human cognitive abilities, so that when presented with an unfamiliar task, it has enough intelligence to find a solution[4]. This is perhaps the most interesting and promising area of AI. The idea of a general purpose artificial mind that can emulate human intellectual ability, but with the ability to search for and process information millions of times faster than humans, is both exciting and frightening. While general AIs are not a reality to the extent depicted in many films and books, the advent of deep learning (subset of machine learning) is allowing computers much higher levels of predictive capacity which will feed into the development of stronger AI. The extreme form of strong AI would be when a machine gains self-awareness. In this category, AI systems have a sense of self and consciousness. Machines with self-awareness understand their current state and can use the information to infer what others are feeling. This kind of AI does not, at this stage, exist[5].

Examples of Artificial Intelligence

Machine Vision is the technology which, in machines, automates the capture of images and the analysis thereof [6]. Machine vision is able to perform image analysis at high speed and in combination with other sensory information. Machines are also not bound by the visible spectrum of light and can utilise x-ray and other imaging technology.

Figure 1: South African Machine Vision software, DeepAlert, uses a computer to automatically categories a security image. Source: deepdata.works

Natural language processing (NLP) is the processing of human language in various forms e.g. text or speech. One of the older and best known examples of NLP is spam detection, which looks at the subject line and the text of an email and decides if it's junk. Current approaches to NLP are based on machine learning. NLP tasks include text translation, sentiment analysis and speech recognition[7].

2. Machine Learning

Introduction

Machine learning is a method of data analysis that automates analytical model building. Using algorithms that iteratively learn from data, machine learning allows computers to find hidden insights without being explicitly programmed where to look[8]. Machine learning is essentially a predictive computer program that becomes better over time as it learns from success and failure. It is an iterative process where a model is updated continuously. For example, voice recognition that improves as it is used, would be the result of AI having a larger sample of

ways that certain instructions are given by the user, thus increasing the chances that it recognises the next one.

The concept of machine learning has been around for some time, but with advances in technology allowing enormous quantities of data to be processed in less time, we have been able to apply machine learning to extract the most out of our data. Machine learning automatically builds models. This is the key to understanding why it is important. Imagine building your own model from a set of 10 million rows of data. This would take a lot of time and you would need to update your model each time the data changed. You may be able to do this 2 times a week and at great opportunity cost of your time and resources. With machine learning, the model is continuously updated and the data is analysed automatically. The result of this is high-value predictions that can guide better decisions and smart actions in real time without human intervention.[9]

Some common uses of machine learning are listed below:

- Fraud detection which improves over time. PayPal uses a homegrown artificial intelligence engine built with open-source tools.
- Web search results providing the most relevant results based on previous user selection of pages. Google does this with every search.
- Real-time ads on web pages and mobile devices based on user activity and interests. The ads that you see on Facebook are an example of this.
- Text-based sentiment analysis used in customer service (see applications of AI below).
- Credit scoring uses ML to decide whether an applicant qualifies for credit. This is the reason your bank can offer you a credit card with a certain limit before you have even applied. The bank runs your bank statements through its AI. Most modern banks will make use of some kind of machine learning in its credit granting.
- New pricing models based on current demand and customer behaviour. Insurance companies, such as Irish AXA, are using machine learning to identify high risk customers based on claim action, and adjust future pricing for similar customers[10].
- Network intrusion detection and anti-malware. Blue Vector is a company offering machine learning network protection[11].
- Pattern and image recognition used in manufacturing (SAB uses this at all its production lines to reject defective bottles), signature verification (Parascript is a company offering this kind of product[12]).
- Email spam filtering that improves as users self-categorize emails which slip through the filter. Gmail is an email provider using machine learning to eliminate spam.

Methods of Machine Learning

Two of the most widely adopted machine learning methods are supervised learning and unsupervised learning. Most machine learning is supervised. Semi-supervised and reinforcement learning are two other technologies that are sometimes used[13].

Supervised Learning

This type of machine learning uses pre-labelled data sets with “correct” and “incorrect” tags. The machine is trained to learn by processing the data and building a model based on the historic information. This kind of learning is useful for applications where future outcomes are very likely to be predicted by previous outcomes. For example credit card fraud would likely be predicted by patterns of previous fraud. Weather prediction can improve by analysing historic meteorological data.

Unsupervised Learning

Unsupervised learning is used against data that has no historical labels. The system is not told the "right answer." The algorithm must figure out what is being shown. The goal is to explore the data and find some structure within. Unsupervised learning works well on transactional data. For example, it can identify segments of customers with similar attributes who can then be treated similarly in marketing campaigns. Or it can find the main attributes that separate customer segments from each other[14]. Unsupervised learning is most useful for pattern recognition in large unstructured datasets.

Semi-supervised Learning

Semi-supervised learning is used for the same applications as supervised learning. However, it uses both labeled and unlabeled data for training – typically a small amount of labeled data with a large amount of unlabeled data (because unlabeled data is less expensive and takes less effort to acquire). This type of learning can be used with methods such as classification, regression and prediction. Semi-supervised learning is useful when the cost associated with labeling is too high to allow for a fully labeled training process. Early examples of this include identifying a person's face on a webcam[15]. Google has made use of semi-supervised learning to train its autocaption system for Youtube. The developers used the same deep neural network that Google voice recognition uses, to automatically caption videos when they are uploaded. The algorithm was recently trained to detect sounds like “applause”[16].

Reinforcement Learning

Reinforcement learning is often used for robotics, gaming and navigation. With reinforcement learning, the algorithm discovers through trial and error which actions yield the greatest rewards. This type of learning has three primary components: the agent (the learner or decision maker), the environment (everything the agent interacts with) and actions (what the agent can do). The objective is for the agent to choose actions that maximize the expected reward over a given amount of time. The agent will reach the goal much faster by following a good policy. So the goal in reinforcement learning is to learn the best policy[17].

Deep Learning

Deep learning is a machine learning method which is loosely based on how we understand the brain. Artificial neural networks (ANN) are the basis for this type of machine learning.

Artificial Neural Networks:

The job of an ANN, in simple terms, is to output a guess about what something is or what the best output is, given a set of inputs. Image recognition is a common use case whereby parts of the image are analysed to decide what it is.

ANNs use layers of artificial neurons which assign weightings to inputs depending on how important the input is to predicting the final output. The output will be a function of the weights of the inputs and the input values. These neurons exist in layers and each layer passes its outputs on the next layer which then has inputs at a higher level of abstraction. While this sounds complex, the diagram below shows how this might look. The outputs are passed up the layers of neurons each time and the outputs of the one layer are given weightings in the next layer and so on.

So, how does this result in machine learning? The answer lies in how we can fine tune the weightings to find more accurate predictions. If we find that input 1 is more important in predicting the output then we might increase the weighting of input 1. Likewise, if we find that if both input 1 and 2 have high values then there is a very low chance that the output is what we are looking for. So we might then assign a lower weighting to the results of output 1 and output 2. The machine learning comes in when we program the software to automatically adjust these weightings to achieve higher levels of accuracy.

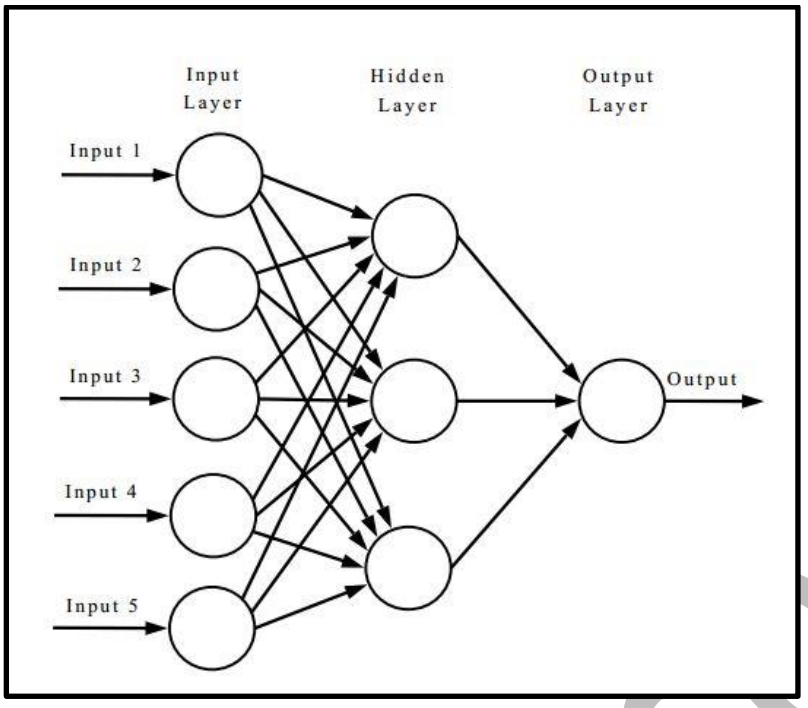

Figure 2: An artificial neural network
Source: http://www.astroml.org.

Deep Learning, describes the use of millions of layers of neurons instead of just a few, and much larger sets of training data to refine the weighting[18]. Deep learning combines advances in computing power and special types of neural networks to learn complicated patterns in large amounts of data. Deep learning techniques are currently state-of-the-art for identifying objects in images and words in sounds. Researchers are now looking to apply these successes in pattern recognition to more complex tasks such as automatic language translation, medical diagnoses and numerous other important social and business problems[19].

3. Why is Artificial Intelligence important now?

Consistent with other growth industries in the world today, the driving force behind AI is the growth in computing power, cloud infrastructure and falling costs of these technologies. With the computing power per unit of space increasing rapidly, more potent AI can be built into a given set of hardware each year. Essentially, the better computers become, the better AI becomes.

As machine learning, specifically deep learning, improves, AI technology will advance rapidly. At a high level, this means that software and AI systems will improve over time through repeated use. These systems can become extremely powerful, especially when used through the cloud en masse.

With cloud technology improving, the ability to host AI systems in the cloud has emerged. AI "as a service" (a version of SaaS) is now possible, which allows firms and individuals access to an extremely well trained AI from any internet connected device. This leads to immense productivity increases at substantially lower costs than purchasing a proprietary AI system, as the development costs could be split amongst the subscriber base. Access to AI technology does not need to be prohibitively expensive through cloud computing. IBM Watson is an example of an AI system sold as a service[20].

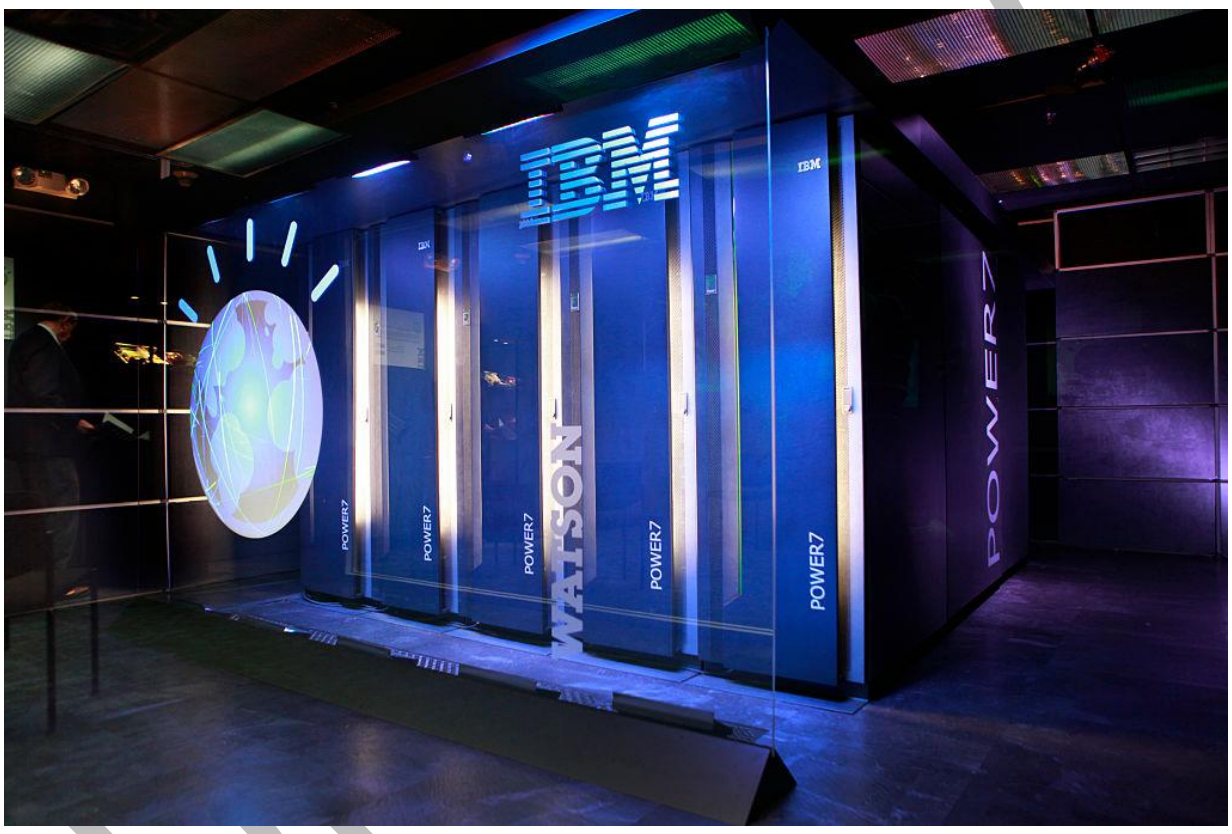

Figure 3: IBM's supercomputer, Watson. Source: IBM

Artificial intelligence is important to anyone doing business. AI technology has the potential to free up thousands of work hours from a firm's key employees allowing them to focus on the tasks that really add value. Imagine reclaiming the 20+ hours a week which are spent on repetitive and low value add tasks, and putting those to use on client development or planning.

Big data has become more valuable as our ability to process it has improved. With powerful AI we are able to sift through masses of data in structured or unstructured forms, and identify trends and potential problems before they occur. AI can extract insights from live data feeds

and assist people in obtaining valuable information from enormous sets of data. AI has incredible potential and some of the use cases so far can be seen below.

4. What are the applications of AI today?

Customer Service

AI has significant application in business, especially in customer relations management (CRM). IBM Watson is an example of a service offered which applies cognitive systems to CRM to improve the way businesses understand and service their customers.

One area where AI has revolutionised customer interactions is in customer care departments. A prominent example is chatbots, which speak to customers through an instant message or email and respond to queries intelligently. They also improve through machine learning. This enables more rapid customer interaction and allows customers to solve problems without waiting for days in a backwards and forwards email conversation or being put on hold at a call centre for hours.

Some systems, such as Watson, are able to recognise tone and emotion in customer text and voices[21]. This helps call agents by recommending best practices based on the customer's mood and what they are talking about in real time. Watson can also analyse all customer interactions which are recorded to improve CRM in the future. BusinessOptics, a South African AI platform, analyses customer interaction data in order to prescribe the best time to call customers based on their behaviour, and which products are best suited to their individual needs. BusinessOptics has achieved incredible results in the field of AI and Machine Learning.

Education, Law and Medicine

AI could become the new industry standard for tutoring children. A teacher AI interacts with a student and adapts to their learning style by analysing performance and how the student reacts to different forms of instruction. Many of the large online learning platforms such as edX, The Khan Academy and locally based GetSmarter are experimenting with AI to improve teaching. This of course can extend to education on agriculture, where smaller farmers can learn from AI tutors on how best to farm their land.

Within law, AI is already being used to help draft legal letters for people to appeal fines and other routine legal tasks. Do Not Pay, an AI created to appeal traffic fines, successfully overturned 160,000 fines in the UK[22]. Some companies have also developed AIs to give legal

advice based on input given from a client through natural language processing, Ross Intelligence is a company offering this service[23]. This AI makes use of vast legal databases and case law. Overall the technology provides cheaper legal services as well as freeing up time for lawyers who perform legal research.

Medical advice can be given in a similar fashion, with the added advantage of being able to analyze x-rays and even blood samples. By learning through successful and unsuccessful diagnosis, the AI doctor could improve over time and help medical practitioners assist patients better. AI can already read mammograms more accurately than human beings and up to 30 times faster.[24] In the near future, it may well be illegal for human beings to read mammograms as their underperformance in comparison to AI would be viewed as gross negligence.

Manufacturing

Robotics and other automated manufacturing can be greatly enhanced through AI. An example is in a brewery, where the production line can use machine vision to identify defects in bottles and actively remove those bottles from the production line without input from an operator. This kind of AI can increase production speed and reduce manufacturing defaults significantly.

Agriculture

AI has many uses in smart and automated agriculture. A key area of its use is in the analysis of farm data. Data is collected through a system of sensors around the farm in an IoT (internet of things) network. For more information, see our report on the Internet of Things.

Sensors around the farm give real time updates to the AI, which can be trained to send the correct response to that area. For instance, if the soil moisture sensors indicate that a certain field is dry, the AI would be able to recognise this and irrigate that specific area until it is at the required moisture content. Furthermore, AI could be used to determine optimal soil conditions for crops based on access to soil science databases, yield data, and machine learning. Weather predictions (which are a product of AI themselves) are built into the AI system such that crops are irrigated only when rain is not expected. The AI could also offer farmers advice in terms of optimal planting or harvest times based on weather predictions and crop ripeness. AI can also assist in caring for livestock by analysing vitals of the animals and diagnosing any problems[25]. This can guide a farmer toward 'perfect' farming, and when used at scale would create huge efficiencies.

An actual example of a system that uses an AI to determine optimal growing conditions and actively monitor crops using machine vision is Huxely[26]. This system can even be combined with augmented reality (AR) to overlay farming information to the user of the AR device and offer recommended actions based on what the user is looking at. This tool could give farmers, particularly hydroponic farmers, a huge productivity boost, by effectively giving the farmer access to machine-learned farming expertise.

Within farm robotics, an AI system could coordinate many robots to work harmoniously so that the farm runs more efficiently and reacts to changes more quickly and effectively. This would reduce labour and costs associated with slow reaction to problems. In summary, AI enhances other technology on farms, particularly where there are automated systems with live sensor feeds. Robots, drones, software systems, IoT systems, automated vehicles, 3D printers and many many more will all benefit from powerful AI. AI will become the brain that runs all of these moving pieces, and ensure they work perfectly together.

5. What is the Future of AI?

Artificial intelligence is moving toward becoming more general. As we perfect AI software we will be able to create systems that emulate human cognitive ability more closely, which will allow a powerful general AI to emerge. This could become a virtual person on the internet, performing any computerised task that a person can do. With the aid of robotics, this AI could even take physical form and perform physical tasks. While this kind of AI may not be on the near term horizon, it is not unreasonable to predict that in a few years it will be possible to replace a general purpose office employee, such as an administrator, with an AI. Already, there are AI personal assistants which help people schedule meetings such as Kono AI[27].

Other areas where AI is advancing is through big data analytics and prescriptive modelling. As the adoption of autonomous vehicles and IoT grows, our cities and their infrastructure could be actively managed by a powerful artificial intelligence. Traffic, lighting, power and emergency services could all be intelligently coordinated by an AI that recognises and predicts demand for infrastructure such as road space or energy and plans the supply accordingly for optimal efficiency. For example it could clear a path for emergency services when a disaster occurs[28].

In conclusion, AI will continue to develop rapidly, and repetitive and routine tasks, especially those that are computerised will almost certainly be the domain of AI. Even areas requiring high qualifications such as analytics and statistics will be dominated by AIs. While this has obvious implications for many people's skills becoming redundant, the economic growth potential is huge. Governments and businesses, including farms, need to deeply understand

the impact of AI on employment, in order to put measures in place to upskill populations into areas that are least affected by AI, or new areas that emerge as a consequence of AI.

6. AI Application Life Cycle

Weak AI is well into its adoption and will start becoming a majority technology in the next year or two, particularly with big corporates. This narrow form of AI is a huge cost saver and efficiency driver in a world where efficiency is becoming more and more difficult to find. Of course, the main benefit of AI is that it continues to learn and improve and this drives rapid adoption as the technology becomes better and cheaper. Strong AI or artificial general intelligence is very much in the innovation phase. The computing power necessary for this form of AI is yet to become available, however, as computers continue to learn and get faster, we continue to strive towards artificial general intelligence. For the purposes of agriculture in the Western Cape, AI is very much ripe for adoption at affordable pricing.

7. Business Eco-System View

The business ecosystem for AI and machine learning in South Africa is growing fast. There are numerous software developers who can build custom applications for businesses and many off-the-shelf software products available through resellers. The biggest constraint in AI are the data scientists required to implement and advise on the technology. Such expertise is not widely found but is increasingly in demand. Companies such as BusinessOptics, based in Johannesburg and Cape Town, aim to solve this problem by offering platform solutions. It is our opinion that the demand for AI will become so great, that the ecosystem will struggle to keep pace with demand.

8. Potential Economic, Social, Ecological and Political Developments and Impacts

In much the same way robotics will replace the labourer, AI will replace many office workers. Already we are seeing applications like Kono.ai replacing the personal assistant. AI, when fully adopted for big data analytics will also replace highly skilled resources such as data analysts. People likely to be displaced by AI will need to develop alternate skills in order to find employment in a world dominated by AI. If the world is completely connected through AI, even politicians and policy makers would be replaced by AI, that would be able to make optimal decisions on resource allocations. AI would have huge benefits for society in terms of resource usage, as it would essentially eradicate all waste in any given system. It remains to be seen whether these benefits will outweigh the displacement of jobs caused. As per our

review on robotics, we believe a deeper understanding of these consequences should be researched in order to thoroughly plan for the eventuality of ubiquitous AI.

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