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

Review: Robotics

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1. What is Robotics?

Robotics is a technology dealing with the design, construction, and operation of robots in automation.[1] Broadly speaking, robots are machines that are designed to operate independently of human control. That is, they can take in information about the environment around them, process this sensory information and respond accordingly without continued instruction from an operator. However, some robots are designed to operate under constant input from a controller (human or otherwise) e.g. remote-controlled vehicles. Components of a robot would typically comprise: the body/frame, control system, manipulators, and drivetrain.[2]

Robotics is a field where multiple technologies and disciplines overlap, namely, machine learning artificial intelligence, computer science and electromechanical engineering. Robots are typically designed to perform tasks that humans cannot do, or cannot do as well as a machine could. This can range from tasks that require immense power combined with precision e.g. high-pressure water cutting, to very dangerous tasks, e.g. bomb detection and deactivation.

2. Why is Robotics important now?

There are numerous reasons why robotics is more important now than it has ever been in the past and why it will continue to gain in relevance. The two key reasons are outlined below:

Exponential Growth in Computing Power

Moore's Law predicts exponential growth in the power of computing, which has been extended to other technologies such as storage capacity. The corollary is that the cost of obtaining computing power should fall proportionally. This is a theme which recurs throughout the technologies presented in this review.

With the power of computing growing exponentially, every year computers can process more information in a shorter space of time. These computers are also becoming smaller. For automated machines that rely on sensory information, this increased processing power means that more information can be taken into account, and more complicated and computationally intensive models and algorithms can be used. This results in robots with extremely accurate prediction and recognition systems. Previously, the computers that would have been required to process multi-video feeds, LIDAR, GPS and proximity sensors simultaneously, would have been either prohibitively large, expensive or non-existent. These machines are becoming increasingly accessible which enable more players to enter the market and develop robotics at reasonable costs. The robotics industry is growing rapidly

with market researchers at the International Data Corporation estimating a CAGR of 17% until 2019. This would mean the industry could nearly double in size by 2021.[3]

Advances in Artificial Intelligence

Artificial intelligence and machine learning have also been growing at an exponential rate, largely due to our ability to process large sets of data in reasonable times as described above. With machine learning systems now being trained off enormous sets of real data, robots are far better at predicting outcomes and recognising patterns than before. This advance toward near-human or even better-than-human pattern recognition has enabled robots to perform tasks that would previously have been too dangerous, or simply impossible for a machine to attempt. One such example is autonomous vehicles, which have been trained to recognise and predict traffic movements through machine learning.

Cloud Computing

The advent of cloud computing has a hugely positive influence on the field of robotics. When all robots are connected through real-time cloud computing, all of the learning experienced by one robot is immediately available to all other robots. For example, an autonomous vehicle learning from an anomaly on a farm in America, could broadcast that learning to a robot in South Africa in real time. South Africa's Theo Pistorius through his company IntegriSense, provides drones for mining and agricultural clients. One of his drones was attacked by an eagle whilst surveying a mine in Russia. Because that drone was uploading its experiences onto the cloud, a second drone flying in South Africa was able to avoid an eagle attack by sharing in the learning from the first drone. One can only imagine the rate of progress experienced when thousands of drones are all learning from collective experiences.

3. What are the applications of Robotics today?

Robotics is used in numerous fields and to varying degrees. A sample of use cases is broadly outlined below, before looking at robotics within agriculture specifically.

Industrial Robotics

These robots are used in the manufacture of products and other machines. They use very precise sensors and manipulators to craft items that would either not be possible by hand, or would be very inefficient without automation. An exciting area of development in manufacturing robots is 3D and 4D printing (or more technically correct, additive

manufacturing) where robots autonomously construct objects from raw materials in precise quantities and at an astonishing pace. See our report on 3D Printing.

Bionics

This area of robotics aims to replicate natural processes in non-living machinery. This field creates biologically inspired machines that aim to perform tasks that current vehicles and tools perform less well than natural systems. [4] Other applications of bionics relate to using robotics in an augmented way with a human body to enhance or restore functionality e.g. a bionic hand. Advances in robotics have also extended the human sensory experience, cognition, and physical abilities. An example of a cutting-edge application is direct nervous system control via a non-invasive robotic shell, which has offered disabled individuals a possibility to restore basic motor functions.[5]

Autonomous Vehicles

This area of automation is fast becoming the technology race to keep track of, with multiple large corporations pushing to be first to market with a viable product. Uber, Google (via Waymo) and several other businesses have developed self-driving vehicle prototypes that are currently on the road gathering test data.[6] Autonomous vehicles make use of advanced sensor technology, high precision positioning systems and artificial intelligence to create a robotic vehicle capable of successfully navigating city streets without a pilot. This an extraordinarily complex task but the implications of its success are enormous. The safety of roads, future of taxis, parking and even traffic will all be radically changed as the technology gains in acceptance and adoption.[7]

Agriculture

What does robotics look like in agriculture?

Agriculture is one of the areas where robotics and autonomous vehicles have clear and important use cases. Many agricultural tasks such as planting, harvesting, sorting, and packing, lend themselves to automation as they are repetitive, pre-planned and require the operation of heavy, slow-moving machinery.[8] Fleets of robots can be used to perform tasks on a farm, centrally controlled by a farmer, instead of many individuals performing many tasks in isolation. This can greatly enhance efficiency. Agricultural robots are not unlike industrial robots used in manufacturing, such as packing and sorting machines. However, if the robot needs to be mobile it can be thought of as comprising two integrated parts: the autonomous vehicle (e.g. tractor) and the autonomous implement (e.g. crop sprayer).[9]

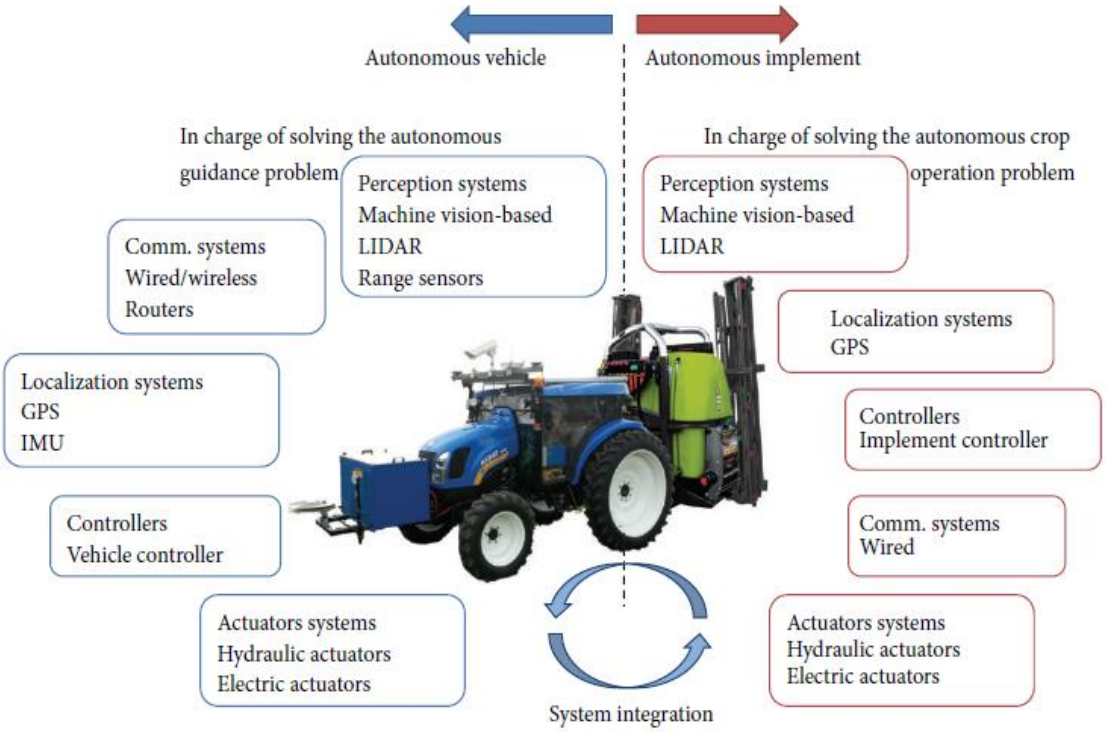

Figure 1: Components of Agricultural Robots

Autonomous Vehicles

Due to significant overlap of the systems used in both the vehicle component and the implement component (e.g. GPS, computing units) there are redundant systems in current agricultural robots, many of which are largely conversions and modifications from commercially available equipment.[10] Specially designed and integrated agricultural robots can reduce the number of systems and components to create a simpler and more reliable machine, which will result in greater adoption. There are several existing applications of autonomous agricultural machines.[11] An example of this is the Agrobot, a robot which identifies ripe berries and harvests them automatically at high speeds without damaging the crop.[12]

Figure 2: Agrobot. Source: www.agrobot.com

Many of the tasks that agricultural robots perform are operations which were previously performed by human labourers. While this advent has both pros and cons, it seems inevitable that as artificial intelligence becomes more powerful, human involvement in tasks such as recognising ripe fruit or manually operating a machine will become less valuable. As costs of robotics fall, opportunities for farm labourers seem likely to decline in frequency.

Drones

Another application of robotics in farming is the use of drones in pest control.[13] Drones are being used to identify and precisely apply pesticide to crops which minimises the need for pesticides through early detection, as well as the absolute quantity needed due to the extreme accuracy of the drone sprayer. Agribotix, an agriculture data-analysis company in Boulder, Colorado, supplies drones and software that use near-infrared images to map patches of unhealthy vegetation in large fields.[14]

Figure 3: Drone crop sprayer. Source: Anthony King - Future of Agriculture

Packing and Sorting

Consistent sorting of produce is extremely important for accurate packaging and sales. For example, higher prices can be attained by selling large blemish-free fruit to the high-end Chinese market. However, these markets require a high level of consistency per box of fruit if they are to buy fruit from a farmer. Limpopo Citrus has employed a large Greefa robotic sorting machine to sort fruit far more quickly, accurately and consistently than human sorters. The machine takes 120 pictures of each piece of fruit as it rapidly moves through a conveyor built. Using analytics software, the robot then sorts the fruit according to skin and size. The result is a 33% increase in bins of citrus packed per day. Because more bins are packed, the human sorters displaced by the machine are now employed in packing, thus illustrating how robotics also have the potential to create opportunities for employment even whilst displacing current jobs.

Figure 4: Greefe Robotic Sorting Machine. Source: Greefa.com

Why should farmers consider robotics?

Thomas Malthus predicted in his early 1798 economics essay, 'Principle of Population', that population growth would lead to our demise through food shortages and other scarcity. However, his dystopian vision has not come to pass and the population of the earth has grown from around 1 billion in 1800 to over 7 billion today.[15] One of the reasons for this was advances in agricultural technology. Robotics is now at the cutting edge of that, and is increasing yield and decreasing costs of farming rapidly. The berry picking machines mentioned above were found to decrease harvest times by 50% in the UK and the crop spraying drones pictured above improve the quality of crops as well as reduce expenditure on pesticides.[16] Fewer pesticides also have obvious environmental positives. Robotic cow milking machines have improved yields from cows by 28% and have improved the health of the livestock as they are more comfortable.[17] The point being that there are efficiencies to be reaped through the technology that result in farmers becoming more profitable and obtaining higher yields, ensuring food security

4. What is the Future of Robotics?

Robotics Everywhere

Automation is not a new concept and has been around for decades, however, the factor holding robotics back in the past was the limitation of artificial intelligence. With advances in machine learning and big data analytics enabling robots to learn from incredibly large

samples of data, robots seem likely to start to emulate human intelligence and usefulness more closely. More and more tasks previously reserved for the human operator who had to use discretion, will be performed by constantly working machines. The line between what humans can do well and what machines can do well is becoming increasingly blurry. Expect to see more autonomous vehicles and implements soon, specifically those which require advanced detection and recognition capabilities such as identifying fungal infestations only visible in the electromagnetic spectrum or dehydrated crops.[18]

Whilst robotics may well present new opportunities for human employment by uncovering new opportunities for economic growth and improvement, longer term, they are likely to have a devastating effect on employment for menial tasks in particular. Trying to prevent progress in robotics is futile. A country which outlaws robotics would quickly fall into ruin as they would not be able to compete with global economies embracing automation. Governments and companies need to begin radically upskilling the workforce so that they are empowered to perform tasks outside the purview of robots. Countries and companies that embrace robotics and use them to gain maximum economic benefit, will win in the race to become leaders in an increasingly globalised economy. It is vital that the fruits of those rewards are spent on upskilling the population.

5. Robotics Application Life Cycle

Robotics as a whole is quite mature in many applications such as vehicle manufacture. But in agriculture and in the context of the Western Cape, we are at an innovation or early adopter phase. Drone usage is increasing all across South Africa, particular for inspections. Autonomous tractors have not received widespread adoption as yet. Cost is a large factor which will probably mean that autonomous vehicle adoption in the Western Cape will only receive real attention in a few years' time. Robotics makes less sense in countries where labour is cheap like South Africa. Positives such as 24 hour operation with no breaks make robotics very compelling and improve the ROI on the fairly expensive machinery. Farmers in South Africa will certainly look to adopt robotics in all facets of farming should the price reduce enough to warrant investment.

6. Business Eco-System View

The South African ecosystem for robotics is in its infancy, with most major players based internationally. There is a strong focus locally on bots for automating clerical and customer service functions. From a purely agricultural standpoint, the main sources of ecosystem contributions come from universities and research facilities. This is typical of an early stage technology which is sure to explode as adoption takes off locally.

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

Robotics will have a colossal impact from an economic, social, ecological and political standpoint. Measuring the impact of robotics on the world is a field of study to which there are dedicated professionals. Thus, to try to accurately do so would be futile. The best we can achieve is an estimate of the future landscape for robotics in South Africa. From the economic view of farmers, the benefits of robotics are obvious. Having a few machines working around the clock, doing a job to perfection, would increase output and reduce costs. Farmers stand to benefit a great deal from robotics. Labourers would be the loser in this scenario long term. If the logical conclusion to robotics is that all labour is replaced by robots, then those labourers will have to find new vocations.

The key point is whether this scenario takes enough time to come to fruition so that wide scale upskilling can take place in time. The risks to society are huge. The farmers will incur the type of protests seen by mine workers, and taxi drivers, when threatened with job losses. Protests of this nature are seldom peaceful in South Africa. The policy on robot adoption would be a political nightmare, with politicians either siding with business or mass population. From a national economy perspective, robotics would enable many manufacturing businesses to flourish where few have remained competitive due to restrictive labour laws and an unskilled work force. Entrepreneurs would thrive in this environment which could add jobs from a new business perspective at least.

History has taught us that suppressing innovation seldom leads to prosperity. Whilst an era of robotics may be harmful in the short-term, the long term damage of non-adoption would manifest as being completely uncompetitive in the global market. One thing is for certain, if we do not adapt we will fail. Whether that means dramatically changing the skills of our workforce for the jobs of the future, or implementing universal basic income or income tax on robots, action must be taken because the relentless march of progress in robotics will not be slowed as long as companies can make money developing better robots.
Short term, we believe robotics means higher output and more jobs due to increased profitability of farms. Longer term, job losses are inevitable and will need to be planned for so as to minimise impact. It is recommended that a full investigation of the likely effects of robotics and AI be conducted purely on the human impact of the technology. Prior to this, we can say for certain that this impact will be severe.

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