High impact innovations transforming Australian agriculture

Agriculture is being transformed by technologies that have the capacity to make the entire agricultural supply chain more precise, more profitable and more sustainable.

With a strong track record of technology integration, the speed of technology innovation means that industries need to proactively seek out alternative sources of technology and sift out those with the potential to be game changers.

This is the second report in a series of scans looking for high impact technologies overseas and in other sectors of the Australian economy that will likely disrupt the agricultural supply chain.

The five technologies identified through the research will support industries to be better positioned to maintain a strong competitive advantage and ensure the sector is well placed into the future.

Report contributors

Dr Grant Hamilton, Dr Levi Swann, Dr Sangeetha Kutty, Prof Greg Hearn, Assoc Prof Richi Nayak, Dr Markus Rittenbruch, Prof Roger Hellens, Dr Debra Polson, and Dr Jared Donovan.

Full report

DIGITAL TWIN

A digital twin is a dynamic software model of a physical thing or process. Digital twins are based on sensors that are installed in the physical thing or process that is being represented. With assets in the real world represented by digital twins, it is possible for a user to monitor and control assets remotely. Over time, and with extensive data, digital twins can be used to predict asset failure or to simulate changes to a process before implementing them in the real world. With an expanding number of smart things in the world driven by the Internet of Things, it will be possible for digital twins to represent highly complex operations and processes. Given this, digital twin technology has the potential to be transformative in nearly all industries.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of digital twin technology on a 5-point scale. On average, responses show that the capabilities offered by digital twin technology were perceived to have high impact for Australian rural industries. Particularly highly rated were the capabilities to view real-time data on the working condition of equipment, and to predict and monitor the conditions under which equipment might fail.

INNOVATION TRENDS

Digital twin technology is driven by General Electric and Siemens. With the growth of the Internet of Things, digital twin technology is likely to experience significant growth.

APPLICATION

In agricultural contexts, digital twin technology can be used to monitor equipment status, such as part wear, run-time, and power input and output. With all components of a system represented by digital twins, it is possible to facilitate optimal system performance. In the case of upgrading to new equipment, a digital twin could be used to test the benefits before making the investment.
LoRaWAN

LoRaWAN is a type of low power wide area network that provides low bandwidth communication between sensors and smart devices. Communication between devices is enabled by LoRaWAN gateways, which relay messages between devices and a central network server. Gateways have a range of up to 15km, and several gateways can be used to cover a larger area. As a low power and low bandwidth networking solution, LoRaWAN can support thousands of devices for several years on a single battery. One of the key benefits of LoRaWAN technology is that it utilises unlicensed radio bands, rather than relying on commercial wireless or broadband networks. Private Internet of Things networks can be set up independent of a network operator.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of LoRaWAN technology on a 5-point scale. On average, responses show that there is a strong interest in smart things, and the Internet of Things in Australian rural industries. Low power and inexpensive networks that are not reliant on complex local infrastructure were perceived to have high impact by participants.

INNOVATION TRENDS

LoRaWAN technology is popular in Europe, with large networks accessible in the Netherlands and Switzerland. Smaller networks are in use in parts of the USA and Australia.

APPLICATION

The low bandwidth communication enabled by LoRaWAN make it ideal for applications that receive and send a reduced number of regular and irregular messages. This includes agriculture applications such as cattle management or monitoring growing conditions for crops. Able to be setup as private networks independent of network carriers, LoRaWAN is suited to remote locations.
HUMAN-MACHINE INTERFACES

Human-machine interfaces provide the means for humans and machines to communicate. With the development of increasingly advanced technology, and the growth of artificial intelligence, new and advanced human-machine interfaces are emerging.

**Natural Language Interfaces** utilise both sensory and non-sensory inputs such as touch, sight, and radar to facilitate communication between humans and machines.

**Conversational Interfaces** enable communication through spoken or written language, where a human is able to give commands or make enquiries directly to machines.

**Wearable User Interfaces** collect input from a user or the environment, such as level of fatigue or location in 3D space, and then use this to communicate to a machine, and inform how it functions.

Innovative human-machine interfaces have the potential to remove complexity from interactions with machines, allowing unskilled workers with poor computer literacy to perform complex tasks.

**EXPERT OPINION**

Experts were surveyed and asked to rate the impact of human-machine interface technologies on a 5-point scale. On average, responses show that human-machine interfaces have potential impact for addressing skill shortages in rural workers, allowing unskilled workers to operate complex equipment. Interfaces that allow verbal communication between humans and machines were perceived to have higher impact than communication via electronic wearable devices.

**INNOVATION TRENDS**

Analysis of number of patents published by country identifies the USA as the main innovator for human-machine interfaces. Innovation has occurred to a lesser extent in the Asia-Pacific region. Innovation has predominantly occurred for natural language interfaces and conversational interfaces.

Analysis of number of patents published per year shows that innovation of natural language interfaces and conversational interfaces has occurred for several years, with peaks in 2014 and 2016. Innovation of wearable user interfaces has been less extensive, but more recent between 2014-2017. This is likely due to the increasing prominence of consumer wearable devices.
SOLAR RETRANSMISSION

The use of satellites and the imagery they capture is an important asset for precision agriculture. Extending upon these capabilities, solar retransmission proposes the use of satellites to capture solar energy and then retransmit it to Earth. The technology specifies that the frequency of sunlight retransmitted to Earth can be controlled to that which is optimal for photosynthesis (450nm-650nm). Although ahead of its time, the notion of using satellites to capture solar energy and retransmit it to Earth represents an iteration of a persistent interest in utilising space-based resources for applications on Earth. This proposed innovation sits in the context of active work in the areas of lunar-based mining and solar energy.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of satellite imagery and solar retransmission technology on a 5-point scale. On average, responses demonstrate the value of satellite imagery for agricultural applications. Although perceived to have lesser impact, the capabilities of proposed solar retransmission satellites were of interest to survey participants. The ability to control and optimise sunlight exposure and growing conditions for crops was perceived to have particular impact.

INNOVATION TRENDS

The below diagram provides a visual representation of the proposed solar retransmission system in the patent, a system for capturing and retransmitting solar energy for reinforcing photosynthesis (Laine & Parrot, 2015).

APPLICATION

The technology comprises of a satellite with two optical assemblies; the first for collecting sunlight, and the second for retransmitting sunlight. The optical assembly for retransmission has a controllable orientation, meaning that it can be positioned to retransmit sunlight to specific locations on the surface of the Earth. By transferring light through the optical assemblies, only light in frequency bands that are optimal for photosynthesis is retransmitted.
PERSONAL ANALYTICS

Personal analytics technologies monitor personal activity and behaviour. Although popular in consumer products (FitBit and the Apple Watch), personal analytics technologies have received great interest for tracking workers to improve worker safety and increase operations efficiency. **Labour Tracking** technologies can measure biometric inputs such as fatigue and heart rate, and then cross reference this to environmental data such as location. This information can then be relayed back to work site supervisors to ensure the safety of workers. **Smart Contact Lenses** are like regular contact lenses, but embedded with nano-scale sensors and electronics. They are being developed to measure biometric inputs such as blood-glucose levels. Smart contact lenses with augmented reality functionality to enhance vision are also in development. Personal analytics technologies will offer advantages to industries where workers perform jobs alone or under hazardous conditions. It is expected that 50% of employees in isolated and hazardous working conditions will be monitored by personal analytics technologies by 2020.

EXPERT OPINION

Experts were surveyed and asked to rate the impact of personal analytics technologies on a 5-point scale. On average, personal analytics technologies are perceived to have greatest impact for the purpose of monitoring workers. The ability to track worker location to increase productivity and safety, and to monitor stress and fatigue were highly rated. Comparatively, communication of this data to health professionals was perceived to have less impact.

INNOVATION TRENDS

Analysis of patents published by country identifies the USA as the main innovator of labour tracking and smart contact lens technology. However, innovation has also occurred in Europe and Asia.

Analysis of number of patents published per year shows that innovation of labour tracking technology has steadily increased over the last several years. Innovation of smart contact lenses emerged in 2014 and has increased in 2016 and 2017. This increase is in parallel to the increasing interest in the use of nanosensors in unobtrusive wearable devices.