Smart & connected agrifood: beyond precision agriculture

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Abstract

The digital revolution refers to changes sweeping the consumer goods and services sector made possible by advances in cheap, fast and reliable data acquisition and processing, sophisticated analytics, cloud computing services, wireless technologies, the Internet of Things and Artificial Intelligence. These offer the opportunity for a wide range of businesses to improve their operational effectiveness, and they have enabled the creation of a number of disruptive business models, e.g. Uber and Airbnb.

We asked: How might New Zealand's horticultural value chains be transformed or disrupted by the digital revolution? We then considered the technology platforms that would be necessary to enable this transformation. The technology platforms we identified are: sensor networks and connectivity; agri-food value chain informatics (including consumer insights); cloud computing service models; and cyberphysical systems (robotics). In addition, we need to consider social licence to operate.

The interdisciplinary development and integration of these platforms is an evolution of the precision farming concept (driving efficiency in largely agricultural commodity production systems), with added applicability to the whole value chain. We call this 'Smart & Connected AgriFood'.

Keywords: Smart & Connected, Horticulture, Industry 4.0, Food

Introduction

What are the transformational and disruptive forces of the 'digital revolution' and how are they relevant to horticulture and food production?

The digital revolution of cheap, fast and reliable data acquisition and processing, sophisticated analytics and the Internet of Things is transforming precision agriculture. Ongoing reductions in the cost to collect, store and analyse data have made it feasible to sense and analyse parameters important to crop production, in real time, at a spatial and temporal scale appropriate and useful to farmers in the day to day management of operations. Increased connectivity of sensors and farm machinery via the internet, along with improved processing power, have led to the creation of web-based platforms e.g. Connected Farm (https://www.connectedfarm.com).

Such platforms integrate information from sensor networks installed in the field and in farm machinery with decision support tools. With a smartphone and data connection, these types of platforms can be accessed from anywhere, at any time to collect, store, analyse and generate prescriptions of optimised input applications (amounts and timing) based on the individual requirements of predetermined crop management zones. The application of inputs is governed by controllers installed in farm machinery, such as auto-spreaders which vary the application rate of fertiliser and irrigation with geolocation. Responding appropriately to the inherent crop variability is resulting in large operational efficiency gains on-farm and translating to a reduction in the costs of meeting market and regulatory requirements such as food safety and environmental compliance.

However, if we look to the digital revolution in the consumer goods and services sector, we see that not only did existing businesses start to improve the operational efficiencies of their current operations, but completely new business models have also emerged, challenging and disrupting incumbents.

Airbnb and Uber are both connecting customers directly with providers through web-based platforms, uncovering previously unknown supplies of services and unmet customer needs. In the case of Airbnb, it is the supply of accommodation in the private homes of individuals which have space. Similarly, Uber puts drivers with spare space in their vehicles in touch with passengers looking to share that space. Both these businesses have successfully disrupted the incumbents in their respective industries, to the benefit of customers who are paying less for accommodation and transport.

We began to question how New Zealand's horticultural sectors might be transformed and/or disrupted by the intersection of the digital revolution and the precision agriculture philosophy. What operational efficiencies could we see becoming possible and what new business models could emerge? As we considered these questions, we identified that the philosophy at the heart of precision agriculture, that of variability management, when combined with the power of the digital tools and advances in powerful data processing techniques, added even more value - extending well beyond the farm gate, right along the value chain from paddock to plate or land to brand.

Products of the digital revolution and precision agriculture are the capacity and capability to embed throughout value chains sensors and/or computation technologies (smart elements) in the physical production systems and/or the products themselves to broadcast data regarding status either to coordinate with other production elements, or to a central hub for further analysis and subsequent action (connected elements). Smart and connected systems can integrate with others, to create smart and connected systems of systems, and thus increase operational efficiencies and value generation or retention along entire value chains.

Within the food production context, this means that multiple parties along a value chain can be highly interconnected (Bauer et al. 2015) and can form data and analytics arteries encompassing each organisation in the chain - from 'land to brand'. These arteries allow the players in the value chain to coordinate their interactions and to respond in collaborative and nimble ways - e.g. to changes in the market environment - not previously possible. This real-time monitoring, analysis and coordination of elements is poised to provide the next step change in improving operational effectiveness as well as align value chains with individual customer requirements more closely than ever before and is known as Industry 4.0 – or the fourth industrial revolution, after steam, electricity and automation (Bartevyan 2015; Bauer et al. 2015; Buhr 2015)

Connecting consumers and producers in new ways

Companies such as Amazon have completely disrupted the bricks-and-mortar retail model: online retailing has revolutionised the consumer market. To date, food categories driving the rise of online groceries are items such as fresh milk and chocolate. Fresh foods, however, continue to be a challenge, with low consumer trust of product selection by store-pickers and a preference for inspecting fresh items themselves (Anon. 2015; Richardson 2014). Smart and connected value chains will have new tools for consumers to select fruits and vegetables remotely, e.g. a haptic glove at a virtual supermarket, and increased food security with full traceability and visibility of the value chain available to the consumer with a simple scan by their smart phone.

An ecosystem of integrated technology platforms

By integrating the precision agriculture philosophy with the vision of Industry 4.0 and extending this along the value chain, a system of systems that optimally manages temporal and spatial variability at each point on the value chain could be developed. An equally smart and connected set of technology platforms in parallel with the social licence to deploy them needs to be developed. We suggest that these are:

Sensor networks & connectivity. Geo-spatially distributed autonomous sensors that monitor agri-food metrics, environmental conditions and the behaviours of customers, and which pass these data (often wirelessly) to a central repository. The sensors could be mobile, such as an autonomous vehicle moving within orchards or fields imaging the canopy and developing fruit at regular intervals; or static, such as sensors installed in the packaging to monitor the condition of fresh produce in a cool store.

AgriFood value chain informatics. Integration of analytics, machine learning and neural networks to build predictive models from the large data sets collected from the agri-food ecosystem, including, importantly, consumer insights. Interrogation of data collected about uniquely identified batches of fresh produce (or even individual produce items) from the orchard or field, through the packhouse, to the consumer would probably provide deep insights to enable optimisation of production, storage and transit.

Cloud computing service models. Business models which provision users via the internet with access to computing infrastructure such as virtual machines (Infrastructure as a Service or IaaS), computing platforms typically including an operating system, development environment, webserver and database (Platform as a Service or PaaS) and customised mobile applications and software (Software as a Service or SaaS). These services will supply participants in the value chain access to the predictive models outlined above in a readily accessible format and with sufficient compute power to turn 'big data' from the agri-food value chain into useful information in the form of hindsights, insights and foresight.

Cyberphysical systems. Autonomous physical elements in a production system embedded with sensors and computational capability such as control algorithms to manage and/or exploit variability; for example, automated robots that harvest fruit according to a digital fingerprint of quality prescribed by a web-based ordering management system which aggregates orders from customers into delivery lots.

In additional, we need to address the social licence to operate. Specifically, acceptance by consumers and producers that by sharing their data with other entities within and across agrifood value chains, sufficient value will be returned to them and that their data will be used as agreed.

Conclusion

The digital revolution has the potential to transform and/or disrupt New Zealand's horticultural sectors to create smart and connected agri-food businesses: smart in the use of resources and more intimately connected to consumers. To realise this, four related but distinct platforms need to be advanced and integrated along entire value chains. This is an evolution of concept of precision farming, a term that we consider unhelpfully focuses attention on the management of variability in agricultural (commodity) production systems. We suggest that 'Smart & Connected AgriFood' more accurately reflects the scope of scientific and technological innovation needed to position New Zealand's high value horticultural sectors for continued growth.

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