The Eight: Transforming Agriculture

Disruption is the word of the day. Disruption of taxis, hotels, movies and more have been evidenced by the arrival of Uber, Airbnb and Netflix, to name just a few. But who might transform agriculture? Since its advent about 10,000 years ago, farmers have cared for their animals in a more or less similar fashion. Little has changed except the farms have gotten bigger. As farm size increases, however, decisions are increasingly made on the averages: average feed consumption, average water intake, average milk or egg production. New technologies, such as digital technologies and nutrigenomics, allow us to imagine a more precise agriculture, with farmers no longer expected to farm just animals and crops but also farming data.

The Eight
Digital technologies are transforming all businesses and internet giants and agtech start-ups and investors are entering agriculture at an ever-increasing pace. The eight listed here were taken from a list proposed by PwC (Huff, 2016) and adapted to agriculture. The figure of eight diagram representing these technologies, hardware and software, includes a ninth, the internet of things to connect them all.

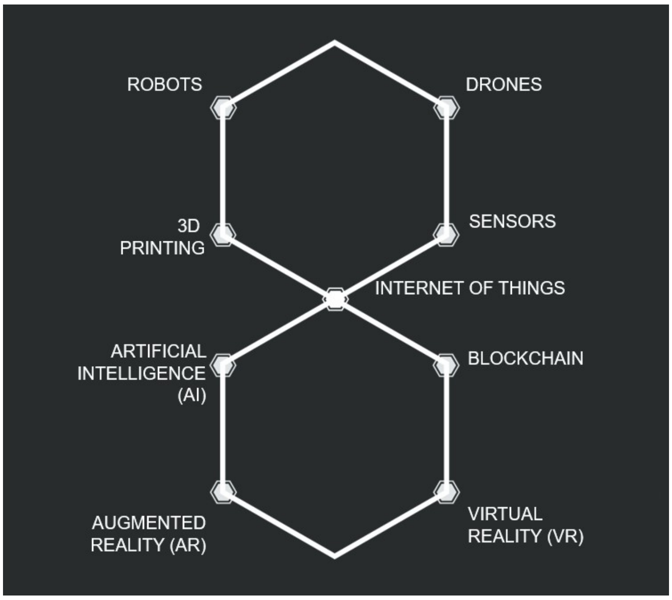


Figure 1. Eight technologies transforming agriculture

Robots
Certainly, robots have already established their role within different sectors of agriculture. Since 2012, robotic tractors have been helping farmers increase their efficiencies in row crop production. While most are still manned, autonomous vehicles are just around the corner.

The dairy industry has significantly benefited from robotic milking machines, which allow cows to determine their own milking schedule. The result is more milkings per day and decreases in labour costs. While being milked, a cow's health and other factors can be assessed, allowing dairy farmers to identify concerns and maintain a healthier herd.

The possible tasks that robots can offer in crop production seem endless, and are especially valued where labour is at a premium. They weed, fertilise and seed all manner of crops. Robots are detecting pH balance in the soil, moisture, nutrients, and the list goes on. They are picking strawberries in California, covering eight acres in 24 hours (Bouffard, 2018) and cutting shoots on grapevines in France while picking up 99% of the debris along the way (Ackerman, 2012).

Drones
Small aircraft, that are also referred to as UAVs (unmanned aerial vehicles), drones are exceedingly useful to many sectors of agriculture. From observing fields to checking cattle, drones can either be navigated or self-flying.

Drones can be used in crop production to spray fields with pesticide, fertiliser or water. Some drones can carry up to 10 kg of liquid and spray up to 7-10 acres an hour, 40-60 times faster than manual spraying (Byford, 2015). Equipped with cameras, they can measure pasture growth, which is useful to many areas in agriculture such as dairy, beef and crops (Tasmanian Institute of Agriculture, 2018).

Figure 2: Aerial image of crop fields in Zambia

In cattle production, farmers are using drones to check fence lines, spot holes or pockets that might need to be fixed or check water troughs and gates in remote locations through aerial images and video. Some models can run on their own after being flown through the route just one time (Carranza, 2015), and will follow the same path for routine checks without extra human intervention. Cameras on drones can gather visuals or allow farmers to zoom in for better viewing. Drones can alert farmers to calving or injured livestock in extensive models.

Underwater drones aid in aquaculture farming, offering opportunities for data collection, fish stock analysis, and environmental tracking, connecting to tablets or smartphones for analysis and interpretation of data (Hsiao, 2018). Drones can take on any number of tasks that are too dangerous for humans and supply information that is usable to create algorithms that further develop the technology or the applications available in the production of aquaculture and offshore fish farms.

Sensors

One of the most useful of the hardware technologies, sensors offer a myriad of opportunity for farmers and producers to know in real time what is happening on their farm. In crop production, sensors can detect water requirements, soil health, fertiliser needs, pesticide use, and the list goes on. Sensors range from the specific to the general, offering analytics including weather forecasts and then basing recommendations on this information. Algorithms can use this data to make future predictions of overall production levels or yields for the upcoming year.

The list of sensor options for animal production continues to grow. These allow farmers to generate individual animal observations and collect data to make real-time decisions. A sensor on the tail, for example, can alert farmers when a cow is going to calve (DeKay, 2017) offering the opportunity for time-saving in ways that dairy farmers have never had before. A farmer will receive a notification within an hour of birthing, allowing for continued productivity in other areas until the time is near. Sensors for cows now include rumen probes, ear tags, cow bells and ankle 'fitbits'. In poultry and pig farming, the focus on sensors tends to have been more on environmental measurements.

3D Printing

The opportunities for 3D printing in food and agriculture might not be immediately apparent. 3-D food printers are already available for home and their use is growing with their versatility and lower prices. They offer a new opportunity for home cooking: printing meals with the touch of a button. Nursing homes in Germany have incorporated 3D printers in over 1000 locations; residents say it is more appetising than pureed food and just as easy to chew (Locke, 2016). 3D printers often use lower value cuts of meat and so give another outlet for their consumption, increasing the value of each carcass.

3D printing offers opportunities for farmers to repair equipment, allowing tools and parts to be created immediately on the spot. For rural farmers, this is an option allowing continued productivity and lowered operational costs. Along these lines, rural farmers in remote areas can have the same advantages as those with better infrastructure, creating a level playing field, for example in Myanmar where Proximity Designs and MakerBot are working together to bring this technology to farmers (Harimoto, 2016).

Other prospects involve the opportunity to print parts for life-saving procedures, particularly for valuable breeding stock. Whether the veterinarian is there or not, having the technology available to sustain a life until appropriate action can be taken could very well be in the future. The opportunities are dizzying.

Artificial Intelligence

Artificial intelligence, or AI, is the technology often incorporated within the other eight technologies, allowing the interpretation of data by mimicking human cognitive functions. AI allows for the interpretation of data from sensors or machine vision, such as that from the company Cainthus, to determine the health of animals or crops using algorithms, recognising if they are eating and drinking as they should, or if something has changed in their behaviour to indicate illness, bullying, general discomfort, etc. Some use facial recognition to monitor cows

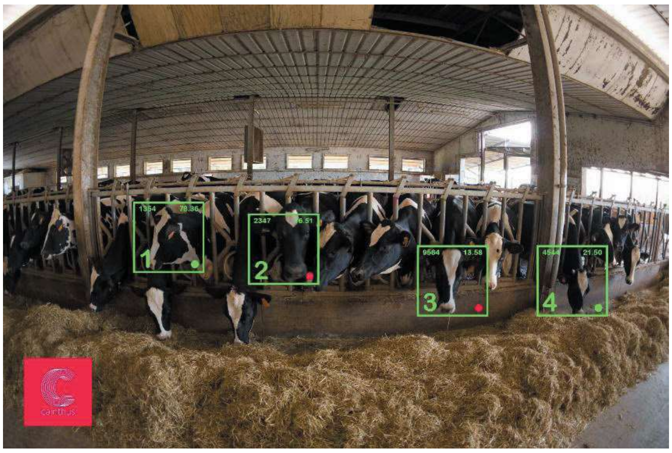


Figure 3: Cows observed through machine vision

on an individual basis (Taylor, 2018) or monitor cows' locations through geofencing and even keep cows from straying outside the designated area (Butler, 2015).

Virtual Reality

Virtual reality (VR) is a computer-generated simulation presented to our senses in which we can explore or navigate in some way (Virtual Reality Society, 2017). In agriculture, the most common opportunities for this technology are in the areas of teaching, training and education. Similar as they seem, each category represents a different stakeholder.

As a teaching tool, the primary application would be found in the field of veterinary science. Virtual reality allows students of veterinary medicine to experience almost exactly what the real-life setting would entail, but in a safe environment. Fibreglass models of the rear of a cow were created by former veterinarian Sarah Baillie and are a great example of combined technologies, including virtual reality and robotics (Baillie *et al*., 2016). The VR aspect is provided by a computer that allows future veterinary students to visualise an object within the cow — virtually enabling them to practice fertility examinations, such as pregnancy detection, or determine reproductive concerns without putting them in a situation that could be dangerous for both the cow and the student. Similar approaches are now being taken with horses and other animals.

From a company training standpoint, using virtual reality to instruct new employees on how machines work, the mechanics and what to do if a machine breaks down, all within the safety of the classroom. In the poultry industry, for example, VR has been used to teach line workers how to process meat (The Poultry Site, 2017).

It is no secret that consumers have lost the connection to their origins of their food, and this lack of knowledge has caused serious misunderstandings regarding the agriculture industry. Trying to reconnect consumers has been the goal of several organisations. VR technology is demonstrating to the public how beef cattle are raised, allowing consumers to virtually visit a farm (Wilson, 2017). A similar design is available for pig farms (National Hog Farmer, 2018).

Not only does this educate consumers and address common misconceptions, but it helps people relate to the farmer and see what life is like on the farm. There is much discussion about animal welfare, and giving consumers an opportunity to experience firsthand how a farm operates is an important component of influencing perception of the industry.

Augmented Reality
Augmented reality (AR) can be defined as the integration of digital information with the user's environment in real time, applying virtual visuals, but in the same physical world that the user inhabits. Through AR, information is added via computers or sensors; it is the middle ground between reality and virtual reality. It is believed that sales for augmented reality could rise from $2.4 billion in 2018 to $48.2 billion in 2025 (Seitz, 2018). Generally, most of the applications for virtual reality can be found with AR, but the ability to use the technology without additional hardware is what will make it more adoptable; many applications for AR can be used via apps with smartphones and iPads.

Augmented reality can allow people to see things the naked eye typically cannot, such as pathogenic bacteria. Giving those in food production the opportunity to actually see potential food safety threats can be incredibly valuable to an industry that is constantly striving to maintain consumer trust.

Transparency is becoming key for consumers and having the ability to know where and how their food is produced is seeing increased levels of importance. AR allows users to give detailed information on egg companies by scanning the egg carton and rating it on a scale, including information indicating how free-range the chickens were that produced it (Ibrahim, 2017).

From a commercial standpoint in crop production, AR can allow producers to lay out planting options in fields, make notes or take pictures of fields with the ability to recall that information in a way that allows immediate side-by-side comparison. The cloud system automatically collects the latest satellite observation data of the land and the images are then processed to show areas that need irrigation, pest control or disease management (Engler, 2017).

Blockchain
Blockchain technology is often considered the hardest technology by consumers to comprehend, but perhaps the most significant in its potential uses for agriculture. In its simplest form, blockchain is a digital ledger that records transactions for all participants at exactly the same time on millions of computers, and with the use of cryptology it is impossible to tamper with.

Figure 4: Sourcing our food through blockchain

The software can track and document all throughout the food supply chain. Having this data available to consumers and food retailers greatly increases trust and can prevent food fraud. Blockchain technology is similar to bitcoin, a system that allows for payment processing, so even payment security across national lines and around the globe is possible. Blockchain can also ensure regulatory compliance both nationally and internationally, and can provide safe access to markets for small and remote farmers.

The challenge of blockchain is getting all members of the food production supply chain on board. If the big food companies push it, however, it will happen.

IOT

These eight technologies can be connected together using the Internet of Things (IoT). IOT allows for cloud-based analytics or algorithmic interpretation of data from any individual item. Using the IoT, a food item, machine or agricultural produce and the data they gather can be sent to the cloud to combine a complete picture.

Putting them All Together

Together these eight (or nine!) technologies represent real opportunities within the agriculture industry for increased efficiencies, profitability and production with real-time precise information. They bring a new challenge to farmers and producers. No longer are they just farming food, they are farming data, and with that comes the need for understanding and comprehension to capitalise fully on the opportunities this data brings. Determining a clear return before investing in digital technologies helps to alleviate the purchasing pains once bought. Producers would be wise to learn which of these best suits their particular need in order to optimise the opportunities they present.

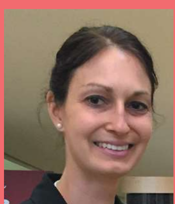
REFERENCES

1. Ackerman, E. (Sep 2012). Wall-Ye Robot Is In Your Vineyard, Prunin' Your Vines. https://spectrum.ieee.org/automaton/robotics/industrial-robots/wallye-robot-
2. Baillie, S., Kinnison, T. (2016). The Haptic Cow Simulator. https://norecopa.no/norina/the-haptic-cow-simulator
3. Bouffard, K. (Jan 2018). Local company advancing rapidly on robotic strawberry harvester
4. https://www.theledger.com/news/20180122/local-company-advancing-rapidly-on-robotic-strawberry-harvester
5. Butler, J. (Oct 2015). Farmers Use Satellites to Track Cattle, Watch Pastures
6. https://www.huffingtonpost.com.au/2015/10/24/farmers-use-satellites_n_8365926.html
7. Byford, S. (Nov 2015). DJI announces $15,000 agricultural drone designed to spray crops. https://www.theverge.com/2015/11/26/9805778/dji-agriculture-drone-agras-mg-1
8. Carranza, J. M. (May 2015). Scientist created drones that fly autonomously and learn new routes. https://phys.org/news/2015-05-scientist-drones-autonomously-routes.html
9. DeKay, W. (Feb 2017). Delivery time? Moocall knows tell-tale sign
10. https://www.producer.com/2017/02/delivery-time-moocall-knows-tell-tale-sign/
11. Engler, M. (Jun 2017). farmAR: Helping farmers making sustainable decisions based on satellite data. https://www.space-of-innovation.com/farmar-helping-farmers-making-sustainable-decisions-based-satellite-data/
12. Harimoto, T. (Sept 2016). Myanmar's Farmers are 3D Printing Their Own Tools. https://makezine.com/2016/09/15/myanmars-farmers-are-3d-printing-their-own-tools/
13. Huff Eckert, V. (Jul 2016). "What are the essential eight technologies?" http://usblogs.pwc.com emerging-technology/a-guide-to-the-essential-eight-emerging-technologies/
14. Ibrahim, T. (May 2017). CluckAR launches national hunt for true free-range eggs. https://www.choice.com.au/food-and-drink/meat-fish-and-eggs/eggs/articles/australiawide-hunt-for-free-range-eggs-with-new-cluckar-050417
15. Kharas, H. (Feb 2017). The unprecedented Expansion of the Global Middle Class. https://www.brookings.edu/research/the-unprecedented-expansion-of-the-global-middle-class-2/
16. Food and Agriculture Organization. (Oct 2009). How to Feed the World 2050: High-Level Expert Forum. http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf
17. Hsiao, J. (Aug 2018). Sailing Drones Collect Arctic Data. https://research.noaa.gov/article/ArtMID/587/ArticleID/2380/Sailing-drones-collect-Arctic-data
18. Locke, S. (Dec 2016). Meat products from 3D printer could be the new food for aged care homes and restaurants. http://www.abc.net.au/news/rural/2016-12-02/meat-ink-3d-printing/8086060
19. National Hog Farmer. (Jan 2018). Smithfield Foods unveils new virtual reality video of its group housing systems. https://www.nationalhogfarmer.com/business/smithfield-foods-unveils-new-virtual-reality-video-its-group-housing-systems
20. Seitz, P. (Jan 2018). Augmented Reality Glasses Still 2-3 Years From Consumer Market. https://www.investors.com/news/technology/click/augmented-reality-glasses-still-2-3-years-from-consumer-market/
21. Tasmanian Institute of Agriculture. (Sep 2018). Reality Check: measuring pasture with drones. http://www.utas.edu.au/tia/news-events/news-items/reality-check-measuring-pasture-with-drones
22. Taylor, C. (Jun 2018). Cow facial recognition brings agriculture into 21st century
23. https://www.irishtimes.com/business/innovation/cow-facial-recognition-brings-agriculture-into-21st-century-1.3536141
24. The Poultry Site. (Feb 2017). Are you ready for virtual reality poultry farming? http://www.thepoultrysite.com/poultrynews/38162/the-next-frontier-virtual-reality-for-the-poultry-industry/
25. Wilson, K. (Nov 2017). Saskatchewan Cattlemen's Association uses virtual reality to educate consumers. https://globalnews.ca/news/3876005/saskatchewan-cattlemens-association-uses-virtual-reality-to-educate-consumers/

Aidan Connolly

Aidan Connolly has been with Alltech for 28 years, initially in Ireland, and then based in France, Brazil and the United States, where he is currently based at Alltech's corporate headquarters near Lexington, Kentucky, USA.

Email: aconnolly@alltech.com



Alexa D. Potocki

Alltech, Inc.

Email: apotocki@alltech.com