sagentia

Agri-tech: heralding a new agricultural revolution

The basic economics of a rising global population (predicted to be 9 billion by 2050) and the potential for climate change to negatively impact farming conditions, puts agriculture in the unenviable position of having to produce more with less. Whilst on the one hand there could be cause for alarm, on the other there is an obvious spur for innovation in a market not traditionally associated with high-tech developments. From self-driving harvesters to laser-guided weeders, precision seeders to autonomous drones, it may not be long before farmers are managing their fields straight from a smartphone.

The financial markets seem to agree that agri-tech is hot. It's clear global financing of ag-tech deals have picked up considerably in recent years with deal activity more than doubling in 2014 and remaining high ever since.

With R&D investment in agri-tech at an all-time high and with significant market disruption on the horizon, the applications and possible approaches can seem overwhelming. We take a romp through the agricultural fields of the US, Asia and Europe to see what's driving this new agricultural revolution.

Higher yields

At a very basic level farmers need to produce more – they want higher yields. For farmers this means stronger crops – resistant to drought, pests and disease and healthier livestock. It means better soil and the ability to process larger quantities.

Cultivating innovations in crop care

As the need to improve the productivity of agricultural land intensifies and weather patterns continue to be unpredictable the market is doubling its efforts. Much of the work Sagentia is seeing in this area involves the gathering, processing and presentation of data. This has been enabled by modern communication infrastructure and the diminishing cost of sensors and electronics. Alongside this, seed breeders are under pressure to scale and automate their trait development processes, to deliver ever stronger and higher-yielding varieties.

Nature magazine argues for the need for new crop varieties that offer higher yields but use less water, fertilisers or other inputs. The American Seed Trade Association has as one of its goals the need to provide genetic resources to address the increasing demand for a wide range of nutritious and high quality products, but to do this while simultaneously supporting efficient and sustainable agricultural practices. As an example, many of Monsanto's publicly available patents are focused on applying genetic combinations to different popular crops to increase yields and make them resistant to certain pathogens. (CBInsights).

Chris Covey, VP Industrial at Sagentia expands: "Seed breeders are developing what we refer to as 'R&D enabling tools'. These are flexible tools and processes designed to accelerate and scale their seed breeding approaches. Our experience in automation and commercialisation of cell therapies in the medical sector can be utilised to great effect. We are able to analyse a client's process and design devices to reduce development times and process costs whilst improving throughput, quality and traceability."

Another answer to delivering more is to improve the quality of the land from which crops are harvested. Scientists are searching for new tools to build soil structures, maximise the efficient use of water and provide essential nitrogen and phosphorus to crops. Advances in plant, microbial and computational biology, materials science, electronics and optical sensing may provide new tools to improve soil productivity. Maximising soil health is one way to go with the application of nanomaterials and zeolites for use in soil to improve soil's water retention being just one area of focus. Developing disease suppressive soils by managing soil microbial communities is another.

The case of the connected cow

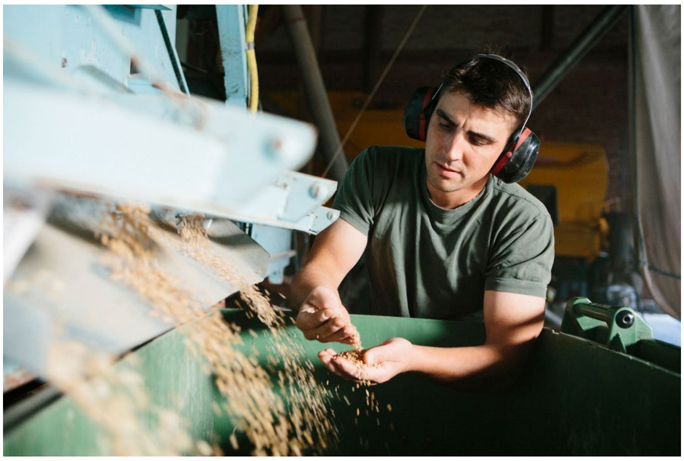
For livestock farmers, improving "yield" means managing the health and condition of their animals effectively and efficiently. Technology developments to help care for livestock are emerging to service this need. According to Sensors magazine, the market for wearable technology for animals is expected to grow from around $1 billion currently to $2.5 billion by 2025.

Key applications include the use of advanced biosensor technologies like microfluidics, image detection and sound analysers to provide a range of wearable applications. Just some examples include Silent Herdsman – a high-tech collar that monitors livestock activity and sends alerts to a farmer's mobile or tablet if there is a change. E-Shepherd is also a collar that uses a sheep's movements to detect when it is agitated by a predator and triggers an alarm and lights on the collar to drive them away.

Dr Mark Tuckwell, VP Product Development, Sagentia comments: "With the increased value achievable by instrumenting livestock there are exciting times ahead. Whilst a demonstration system can be quickly developed to prove value it is key to consider sensor modality, cost and reliability for any final product - this level of effort should not be underestimated. We also need to be thinking more deeply about sensing and tracking technologies for connected livestock; traditional methods (e.g. accelerometers, GPS) are often not good enough to achieve the desired outcome. This opens up a key area where companies can really innovate in sensing and tracking technology. "

High-throughput processing

As the year's harvest matures, a set of downstream applications which protect the yield and efficiently process the crop become key. Sorting and grading processes as well as packaging systems must be fit-for-purpose and be capable of handling higher and higher throughputs with speed and precision. Wider integration into the smart supply chain could also be a consideration.



Vision-based systems which combine imaging, intelligence and automation are able to drastically improve efficiencies in this area. One such example is the work Sagentia's scientists did with one of its clients who needed a high throughput system to sort and grade rice, beans and seeds and remove impurities at speed. Using hyperspectral imaging, Sagentia developed a light, robust, low-power device which could be integrated into farm machinery. The development included algorithms to trawl through the complex sets of data generated and provide simple graphics in easy to use dashboards.

Robotic practices

Part of this new agricultural revolution is in automating processes. Clearly agriculture is no stranger to mechanisation but a new breed of systems and technologies is taking automation to the next level.

The role of robotics and automation

Sophisticated visual monitoring systems are increasingly being used in robotic machinery and artificial intelligence systems to make simple agricultural decisions. Imaging is used to visually characterise each plant and this information is in turn used to spark an action – perhaps the deployment of chemicals or action to remove weeds. Visual monitoring combined with 4D phenotyping and machine learning is capable of providing banks of information which can fine-tune our approach to developing disease and drought resistant plants.

Bosch's BoniRob system uses sophisticated visual sensing technology to identify the leaf type of a plant and a stomping tool to remove the weed. This visual monitoring combined with 4D phenotyping allows the robot to identify healthy plants and their variety, recording critical genetic information in order to support modification. This technology can also provide feedback as to the quantity of plants and their relative size.

Whilst many farm machines already make the most of GPS technology to run repetitive operations like harvesting, allowing the driver to focus on other aspects of the process, the BoniRob makes us of Light

Detection & Ranging (LIDAR) imagery which uses a pulsed laser to measure ranges and make necessary adjustments. With LIDAR, the robot identifies obstacles and can 'see' exactly where the plant rows are. It is then able to adapt its track to fit.

Thorvald is just one of a new generation of farm robots bringing semi-automation to field operations. Thorvald carries trays of strawberries to workers or passes over plants with UV lights to kill mildew. Other robotic applications include skilled weeders which use a sensor to identify the plant and then hoe around them. Most robotic technology combined with intelligent sensors are focused on 'slaughter harvests' - that is crops which are harvested en masse. Picking soft fruits at speed and with dexterity is still difficult and there is still work to be done around automation of 'selective harvests' which must be harvested based on ripeness. In the case of strawberries and raspberries, novel low cost end-effectors will be needed to work with dexterous robotic arms.

Robots are growing lettuces in Japan. A company called Spread has created a highly controlled environment where the plants are mainly handled by machines and robots. Hydroponic water saving technology is used, along with LED lighting and pesticide-free cultivation. The company's business case is built on applying technology to create economies of scale.

Blue River Technologies is taking a 'see and spray' approach with the goal of providing plant care on an individual plant basis. The company's use of computer vision and machine learning algorithms has made it possible to spray individual plants selectively and reduce herbicide use by a factor of ten.

Agriculture uses 70% of the available water worldwide. Smart irrigation systems can clearly play a role and Sagentia's experience in intelligent metering and variable-rate flow control systems is proving useful.

¬ Smarter thinking

Producing more output with fewer resources is not just about stronger crops, healthy livestock and fewer manual processes, it is also about better decision-making. Decision making improves when it is data-driven and this requires reliable, accurate and multiple data points. The technology revolution that has brought sensors, drones, apps and GPS is providing agriculture with the tools to deliver the data points on which sophisticated decision support systems (AgriDSS) can be founded.

Automation & intelligence in the field

In a feature on technology in agriculture, The Times newspaper (April 29, 2017) describes a scenario where technology is deeply engrained into the heart of agricultural practices. Sagentia's experience supports this. In the new agricultural world, a device mounted on a tractor samples the soil at regular intervals and builds a detailed map of that farm's health. The data can then form the basis of a program that makes prescriptions for water, fertiliser, pesticide, seeds and soil microbes. Irrigators, planters and pesticide sprayers automatically adjust their work-rate for best economy. Crops are harvested either by robots or combine harvesters that can monitor quality in real-time and finally drones take high resolution images of fields for future analysis.

The Climate Fieldview system owned by the Climate Corporation, a division of Monsanto, is a digital agricultural platform, very similar to the above, which has been adopted by tens of thousands of farmers across the US and is now being tested in Europe. It works on the basis that every farm is different and every field is unique.

Agribotix has a complete solution including drone sensors, apps and complete integration with variable rate fertiliser and pesticide sprayers. The integrated approach allows current-condition data to be collected and provides at-a-glance, actionable insight. This method of interconnecting technology is revolutionizing the way farms are managed and can allow farms to optimise their workflow, reducing the costs whilst increasing their yield.

Again the patent market is a useful indicator here with publicly-available information signposting the future direction of technology and significant interest being shown around various methods for agronomic and agricultural monitoring using unmanned aerial systems.

One size does not fit all

Much of the next generation farming approaches emerging are about providing greater precision. Imaging and sensors are at the heart of providing this capability.

Remote sensing imaging systems usually take the form of hyperspectral and multispectral sensors which record very near infra-red (VNIR); short wave infra-red (SWIR) and thermal infra-red image data from within the electromagnetic spectrum. Not all visible to the human eye, these frequencies contain a huge wealth of information about the object from which they are being reflected.

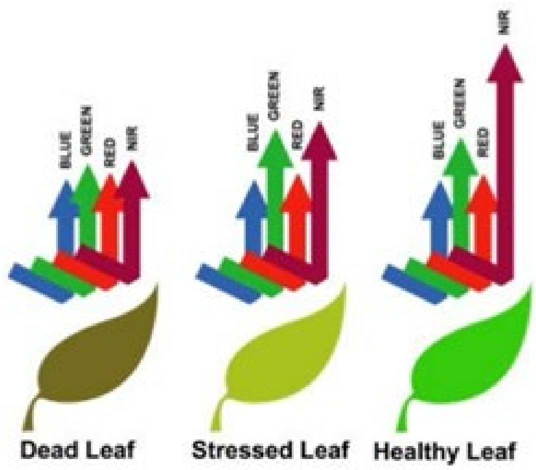


Figure 1 - Electromagnetic Reflectance VS Leaf Health, agribotix.com

Infra-red imaging can be teamed with panchromatic waves to cover the visible parts of the spectrum. Typically, the panchromatic band has an enhanced spatial resolution by a factor of four, compared to VNIR & SWIR, which is particularly useful when used with satellites to provide ground data.

In crop monitoring, for example, as the physiology of plants change they reflect light differently and enable the capture of detailed data. These data can be compared to a normalised difference vegetation index (NDVI). Hyper spectral and thermal imaging are capable of measuring moisture levels and in some cases the plant variety can be identified by the wavelengths they reflect.

When applied to agriculture, imaging technologies are able to provide immediate and continued feedback on a variety of parameters such as disease, nutrient and moisture levels. This level of detail, which would be unachievable with the naked eye, makes precision farming possible to the extent that, with the right intelligence, crop management could include tailor-made care programs for individual plants. Significant improvements in both environmental and economic costs have been seen.

Vision systems and sensors are enabling precision seeding systems which deliver higher yields from less seed. By planting seeds at the correct depth and proper distance every time, the resulting uniform growth rates and high germination levels deliver improved yields. Intelligent crop sensors could scan and fertilise on the go, avoiding over (and under) fertilisation and in turn creating additional savings and improved growth.

Collecting data from above

The commercial Earth observation satellite, WorldView 3, owned by DigitalGlobe operates at 617km above the earth, has a capacity of 680,000km^2 per day and creates images to an amazingly sharp resolution (31cm panchromatic resolution; 1.24 m multispectral resolution and 3.7m short-wave infra-red resolution).

Satellite does have its limitations however for the really granular data at the crop and soil level that is required for precision farming. The technology remains affected by atmospheric conditions and cloud belts. Satellite observation also relies on orbit times which may not be regular enough for actionable insights to be relayed to the agricultural industry.

Drones represent a more cost-effective solution for providing data mapping and images. With the ability to take high resolution pictures (down to a few cm per pixel), drones fly below the clouds and capture higher quality images in real time. Readily available commercial drones with low cost modified cameras are capable of providing NDVI values and produce on-demand results with relatively rapid deployment compared to manned aerial and satellite based imagery. These cameras can provide a clear geo-referenced image using the same type of sensors found on the satellites, however for lower cost applications NIR sensor are often used. Compared to the images gained from a satellite, drones only offer a short flight time which means a large fleet would be needed to provide the same amount of information. Development is rife in this area to enable drones to carry greater payloads.

¬ The dawn of digital farming

The agricultural revolution of the 18th and 19th centuries saw great changes, across Europe and North America, to the way people farmed. For the first time more scientific methods were used to improve crop yields and breed better livestock and mechanization made farming more efficient. In some respects this revolution is a continuation of the first – applying science to increase crop yields and technology to increase automation. But the first revolution was about standardising agriculture so that mechanization could work. Jethro Tull's seed drill allowed seeds to be planted in rows so that they could be easily hoed. This current revolution runs counter to that. It recognises that to extract maximum yield, the unique nature of each crop, animal, location or climatic condition needs to be understood and measured to allow the optimal environment to prevail. This intelligence based revolution treats animals, crops, fields and farms as individuals and allows them to be treated independently yet efficiently, at scale.

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