Horizon Scanning Series

The Effective and Ethical Development of Artificial Intelligence: An Opportunity to Improve Our Wellbeing

AI and Agriculture

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1. Summary overview of this sector and the role artificial intelligence may have;

It is anticipated that by 2050 there will be close to 10billion people on our planet, requiring a significant increase in food production. Most of this population growth will occur in Africa and Asia where there will be an increase in demand for higher quality and quantity of food. On the one hand we will see an increase in the desire for more protein as well as more fruit and vegetables with an increasing vegetarian/vegan market; and on the other hand a desire to reduce environmental footprint including chemical use, soil compaction and deterioration, on-farm waste, and bettering animal welfare.

These growing demands and desires affect those that work on the farms the most but they are under significant constraints. The average age of growers around the world is increasing beyond 50years, farm succession planning is weak, and most people do not want to work on the land especially in harsh conditions. The impact of climate change is having short term effects on the impact of crop quality and variability, and the increase of new pest/diseases; as well as long term affects in the form of global shifts in what is grown and where. Consumer demands for quality at low cost drives the margins of growers down, further exacerbating the issues at hand.

Thus, growers around the world are seeking new technologies that can assist them with their daily tasks on-farm, as well provide them with a competitive economic edge.

Artificial Intelligence, both as a stand-alone technology as well as its embodiment into mobile machines (robotics), will probably have the most explosive effect on farm production of crops and animals. The ability to collect vast amounts of information across large spatial-temporal scales down to the individual flower, fruit, nut, plant and animal; to analyse that data in real time; to make informed decisions in real-time; as well as the ability to act out that decision; will completely transform how we grow our food now; inform what farms of the future may look like; and cause great social challenges and changes.

2. Current and recent advancements in this area both locally and internationally;

Precision agriculture is a term that has been used for many decades to define the use of sensors, data and software to make informed farm management decisions on small scales. The hypothesis is that with decisions on a small scale, the potential is there to increase land and labour productivity. The science and engineering of precision agriculture has focussed on delivering very specific solutions to very specific problems – for example the amount of nitrogen to place in a given area for grains; or what new location to move cattle to given pasture yield estimates from satellite data. Most of precision agriculture research and implementation comes from the agriculture community.

What we have been seeing over the last 5 years however has been a significant interest turn towards more general approaches that utilise the power of AI, especially machine learning techniques and robotics, that can go beyond classic precision agriculture approaches. Spurred on the by the development of low cost, high bandwidth sensors; 3D printing; and greater memory and computational resources; there are now more computer scientists and engineers than agriculture scientists working in this area, solving problems that both currently exist as well as driving ideas and visions that capture concepts of fully automated farms.

Most of this research and development work is applied – that is, the focus is on taking advances in AI technologies and applying them to the context of food production. The key areas of advancement include:

- Greater use of stochastic machine learning techniques that can capture and learn from semi-structured data, and that need to deal with very noisy and inconsistent data. For example, changing light conditions, moving animals, plant variability, and effects of different pests and diseases on the data collected of the plants and animals.
- Developments in semi-supervised and unsupervised learning techniques in order to easily capture the great variety of food produced without the need for experts to train the algorithms for each type.
- Machine learning techniques for decision making, especially in automated crop and animal growth models, to assist in yield and quality prediction of each individual plant and animal.
- Automated decision support tools that can identify what physical action needs to be undertaken in real time to support the use of continuous on-farm robotic solutions. This includes automated mechanical weeding, targeted fertiliser applications, foreign object detection and removal, and eventually automated harvesting.

3. What are the gaps in Australia/New Zealand (e.g. around skills, training, infrastructure, regulation) as it relates to AI (and how this may compare internationally);

The Australian Agriculture market's relationship to technology is unique. There are many advances in agriculture technology that either have been developed here, or were initially tested in Australia before going international. The predominant reason has been the drive by local growers to maintain international competitiveness within very demanding environmental and social constraints.

AI will take on the same pathway. It is expected that there will be significant impacts made by AI and they will be developed here, or will be tested completely here. However for this to be realized there a couple of gaps identified:

- The technical digital divide: a lack of synergy between computer scientists and automation engineers with agricultural experts including scientists and agronomists. Computer scientists and automation engineers lack practical knowledge in the agriculture space and agricultural experts generally have little (or no) understanding of the complexities of technologies such as machine learning and robotics. This is a common problem internationally, although in some countries where there has been a greater emphasis on digital technologies in food production (for example urban food production and large scale greenhouses), we are seeing either multi-disciplinary teams formed or the re-training of engineers/computer scientists in agronomy or vice versa.
- The spatial digital divide: Most AI courses, training programs, startups, and AI communities in general are found within the city areas where there are large financial and engineering hubs. This generally means that any activity in AI for agriculture will naturally gravitate to these areas where there is a surplus of knowledge in AI, at the expense of the rural areas where this knowledge is needed. The ability for example to collect large amounts of data, the key to any machine learning techniques, or the

ability to undertake automatic tasks on a farm, the key to validating robotics, is hampered by the tyranny of distance. This is probably the most significant gap that Australia will face as compared to the internationally where the distance between where the knowledge is and where it needs to be applied is much shorter.

Policies are still in their infancy with regards to AI and agriculture in Australia.

- A more complex gap is in predicting what impact AI will have on agriculture communities. If we are to believe that AI will have a positive impact on food production this may come at the expense of social quality in rural areas. Thus, policies and regulations may need to be considered that look how this technology is introduced, or at least frameworks need to be developed to help understand what this impact maybe. This would have a significant impact on Australian agriculture compared to the international scene again because of the tyranny of distance that would isolate the rural communities.
- Who owns the data collected is also something that needs to be addressed. There is great benefit in the collection and ownership of data by those who write the algorithms that could benefit all users. There is also great benefit in sharing of that information for supporting biosecurity concerns. However the growers in this case are giving up a significant asset that could draw them financial returns (if done properly) or could give up significant freedom of operation if the data is used improperly, for example what if the banks or supermarkets who partly "own" the assets have control of the data and are not comfortable with the operation. This is of international concern and is being discussed, but not yet addressed, by many parties.

Telecommunication infrastructure is also another gap in Australia. Many developing countries have greater connectivity than Australia. This will impact how much data can be transferred, and with AI being a data hungry technology, will hamper the progress of AI in agriculture.

4. What will the next 10 years bring for Australia/New Zealand (i.e. where do you see the field heading and what opportunities or risks will this provide to AI)

If one looks at AI as a disruptive technology than the greatest impact AI will have is in digitising agronomy services. Currently agronomy services help farmers with operational decisions such as what to spray and when, information about pests/diseases and how to deal with them etc. However this service happens infrequently because of the distance to be travelled by a small number of knowledgeable agronomists, or because of the cost of the service. Continuous agronomy service in Australia only happens with very large commercial farms that can afford their own agronomist.
AI will remove this barrier by providing agronomy services to all farmers when and where they want, however it is a complex area to digitise which in turn means great opportunities for AI research and technology development.
Specific areas of importance in research and development include

- Fast learning unsupervised probabilistic algorithms that can develop growth models for different crop and animal varieties
- Query based machine learning algorithms that assist farmers in answering agronomy questions

- Human-Machine interfaces that can provide vast amounts of data to the farmer based on what is important to display or what query is being asked
- Machine learning algorithms that can learn from other automated platforms, share information, and undertake joint tasks on-farm.
- Machine learning algorithms that can retrieve information from the broader agriculture science community – ie publications.
- Decision support algorithms that can capture the economic risk function of a grower
- Decision support algorithms that can assist farmers in undertaking on-farm experimentation (automated hypothesis testing and validation), thus shortening the almost decade long transition it takes between knowledge gained on a University farm to on-farm practice.

5. What resources and actions will be required to realise this potential (e.g. by government, industry, the education sector, and by individuals).

Government

- To take a multi-decade look at agriculture and the impact AI will have on what the social and technological aspects on the future of farming, coupled with the loss of growers and the impact of climate change.
- Initially to target the development of greater communication infrastructure in rural areas identified to speed up the development and trials of AI in agriculture, with expansion to other areas in a staged manner.
- Encouragement of the Rural Development Corporations to come up with unified plans by providing funding to specified areas that will encourage the development and appropriate introduction of AI into agriculture.
- Targeted funding mechanisms for AI in Agriculture startups.

Industry

- Greater acceptance, and quicker acceptance, of AI into operations.
- Greater activation of the innovation pipeline with particular focus on local startups to foster new solutions.
- Have the various rural development corporations come together with a unified plan that is broad enough to deal with the various issues that AI can solve for the whole industry, whilst at the same time deal with the specific problems a commodity is facing.
- Joint funding schemes from the rural development corporations and commercial partners so as to maximise the leverage from the funding.

Education Sector

- Secondary – greater ICT knowledge/challenges in a food production problem based learning paradigm, especially for rural schools.
- Tertiary – bringing greater synergy between the agricultural and biological sciences with those in the engineering and computer sciences. In particular combined degrees or specific new degrees, and multi-disciplinary research and problem-based learning projects.
- Scholarly – developing transdisciplinary approaches to understanding the impact that AI will have on the social fabric of agriculture communities, as well as the food and nutrition security for Australia and its ability to support the food and nutrition security of other countries.