Old MacDonald Had a Farm AI, AI, O!

by Cyr Couturier

ISTOCKPHOTO.COM/HIGYOU

A slightly reduced version of this essay is published in the Newfoundland and Labrador Aquaculture Industry Association's Cold Harvester magazine, summer edition 2023.

Artificial Intelligence and the Farming World
The concept of artificial intelligence, or AI, was first described in the mid-20th century in a now famous article titled *Computing Machinery and Intelligence* (Turing, 1950). At the time it was thought that computers could enable humans and eventually machines to perform certain tasks to address production needs. However, it was expensive to use computers with limited computing capacity that were the size of a standard bungalow, and it often took hours, if not days, to do large computations. It was also difficult for computers to connect machines by any other means than a phone line, as cellular phones and the internet had not yet been widely invented (1960s for cells, 1990s for the internet, and 2000s for cloud computing). Fast forward to the present day with cloud computing, the internet, wireless communications (cell or satellite), even our handheld smartphones, are much more powerful and faster (almost real time) and allow humans to activate or enable certain tasks to be done on the farm remotely by machines. The definition of AI from the Oxford Dictionary is "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." It has taken a while to get to this point since AI was first recognized almost 75 years ago.

When combined with machinery that serves a purpose, AI algorithms are capable of machine learning, whereby input data from a variety of sensors (visual, auditory, or other) are used repeatedly and, if offered by the farmer, decision-making on a course of action. AI systems do result in the recognition of individual animals and can take on a task suitable for that animal's welfare. One only has to think about milking robots used in the dairy industry today, all powered by AI and "learned" machine technology. In this case, the computer develops an algorithm (a mathematical model) that is constantly being updated millions of times over, which tells the robot which cow is entering the milking area, the size and shape of her udder and teats, her daily production of milk, and whether she is developing mastitis, among other health attributes. In other words, the machine (i.e., the robot) has learned to take care of the individual dairy cow, and relays that information to the farmer (on wireless or other communications) so they can take appropriate management action for the animal's welfare.

These AI powered machine learning agriculture and agrifood operations are referred to nowadays as precision farming or smart farming. It has also been employed in terrestrial agriculture for well over a decade, from the dairy milking robots mentioned earlier, to spreading fertilizer and monitoring plant growth in field crops by using real-time indicators of water and nutrient levels in the soil. An additional benefit of these systems is that they allow farmers to lower greenhouse gas emissions to reduce costs of production and enhance yield and productivity in their crops. Some robots can even identify weeds and pests, and remove these mechanically or chemically, all using AI-powered algorithms.

Machine learning, of course, is only as good as the sensors, the input data they generate, the algorithms behind it all, and the communications available for decision-making. Communications in real time, via satellite, mobile phone, or other internet connection, is crucial for effective decision-making, and so are infrastructure needs in order for this to be of benefit to all farm producers, whether on land or sea.

AI, Machine Learning, and Aquaculture
AI is currently being used in aquaculture settings on land and at sea for a variety of purposes, including environmental monitoring, tracking from egg to plate, early disease and

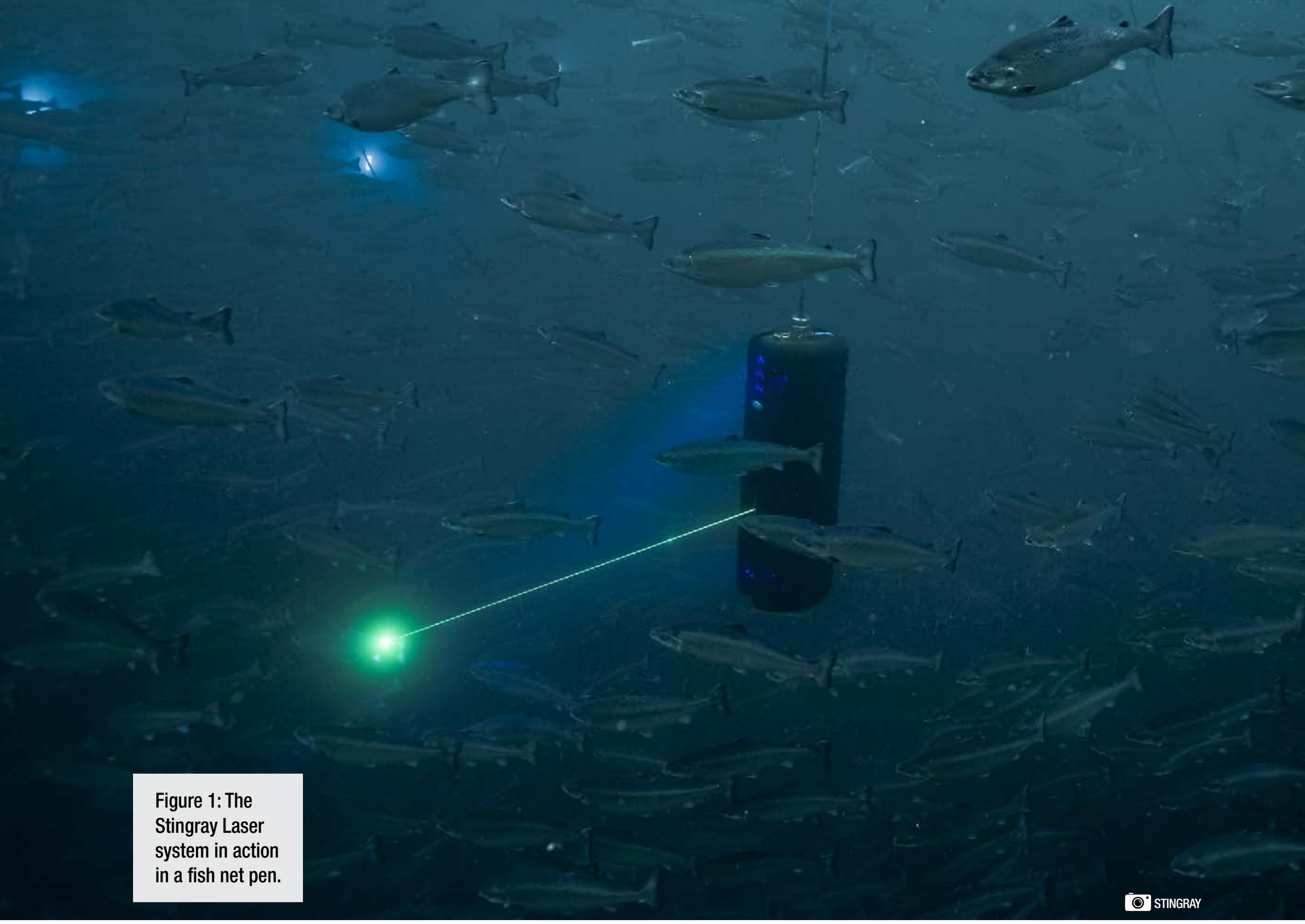


Figure 1: The Stingray Laser system in action in a fish net pen.

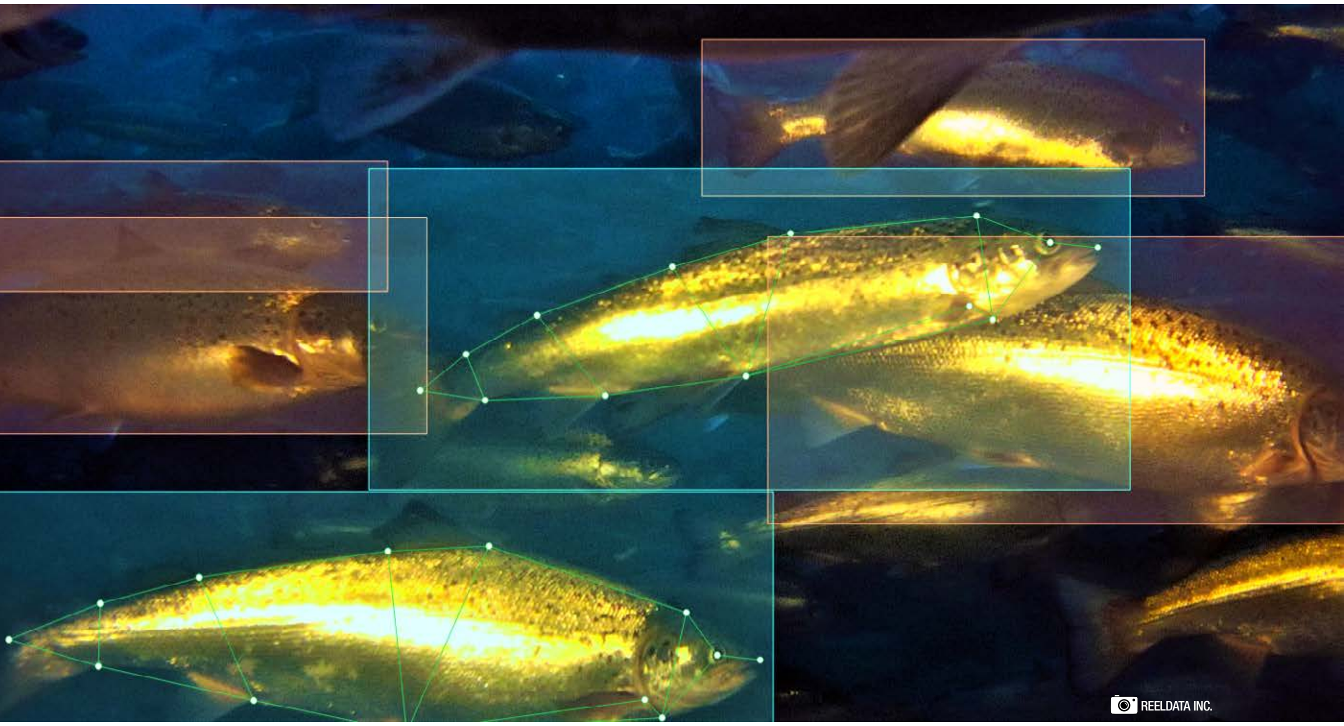
parasite detection and animal health, growth and biomass estimation, processing, and feeding, among others. Some aquaculture machinery that is AI powered even serves to treat animals for health conditions.

One example of a fish health application, fit for purpose, is the Stingray delousing system, developed over a decade or so (Figure 1). The devices can count and size sea lice stages, determine infection rates, and destroy the parasites with the use of underwater lasers. This laser system has been trained to delouse a couple of salmon and cod parasites – all of this without further human intervention or decision-making. The system also uses biometric data to estimate biomass and growth in a given net pen of salmon. After years of development, the system appears to work well with over 800 units in operation in Norwegian and Nordic salmon farms at present, with a huge order backlog. Continuous development of both hardware and software over the years has improved the system several times. All nodes are online and in a virtual neural network that secures over-the-air updates and frequent training of each detector. The overall system is now referred to as the Fish Health Hub from Stingray.

New upstart companies are also developing even smarter AI systems for fish health management, providing treatment options depending on the environmental conditions in which the farms are located. For example, AquaByte (Figure 2) highlights the following on its site: "Healthy fish at lower cost. Automatic lice counting, welfare scoring, and biomass control. Information for data-driven decision making to increase revenue." One of the different attributes in this system is that real-time environmental data can be incorporated into the algorithm for more rapid development of patterns and treatment options. This has captured the attention of several large fish farming corporations in Europe, North America, and South America.

Figure 2 (left): Aquabyte fish health display showing fish welfare indices over time.

Figure 3 (below): Optical imaging and biometric measures employed for fish biomass estimates in near real time in land-based tanks.



Another startup has planted its feet firmly on land-based fish farming systems. ReelData uses optical and water quality data in real time to optimize feeding of salmonids autonomously, while measuring growth, biomass, and stress in fish in real time in recirculating aquaculture systems (Figure 3). A number of these systems are in operation in North America, Europe, and South America.

Innovasea is an ocean technology leader using the best in-situ communications and environmental monitoring for fish growth, biomass, autonomous and remote feeding, and oxygenation in ocean pens, using specialized acoustic receivers to transmit data via satellite or cellular. All of this is in real time so rapid decisions can be made by the farmer on a course of action. The CageEye system from

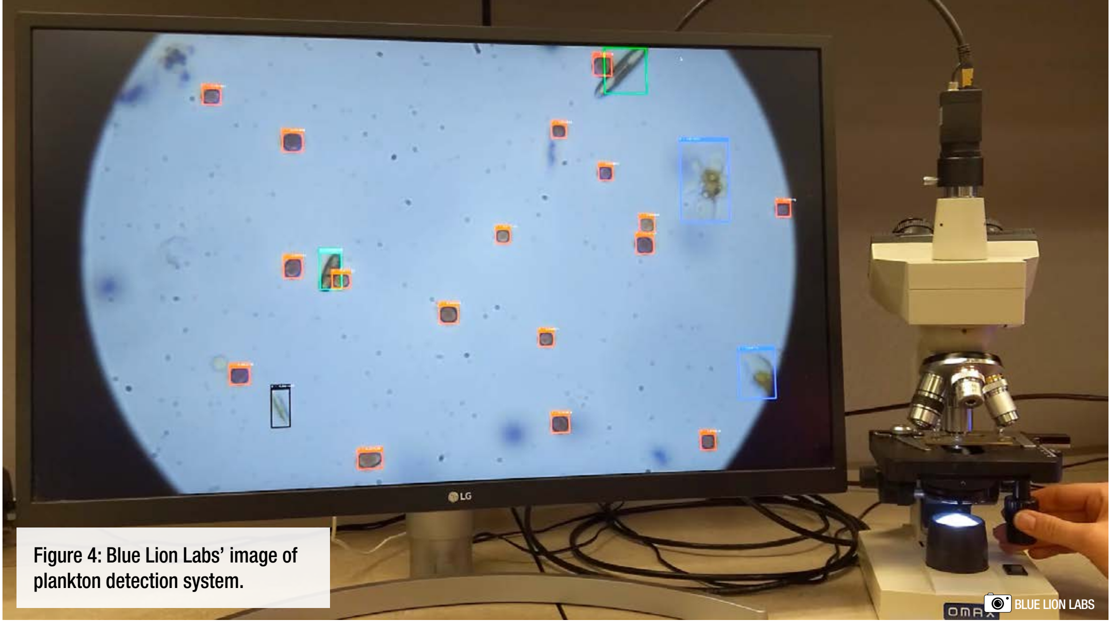


Figure 4: Blue Lion Labs' image of plankton detection system.

Norway aims to accomplish the same in automated feeding for salmonids in particular.

On the plankton monitoring front, there are AI systems emerging to detect plankton that may provide much better predictive capacity and decision support for mitigating impacts on these types of concerns. The leader in this space is Blue Lion Labs, which uses machine learning to automatically identify and count plankton for dealing with toxic or harmful plankton concerns for aquaculture farms (Figure 4).

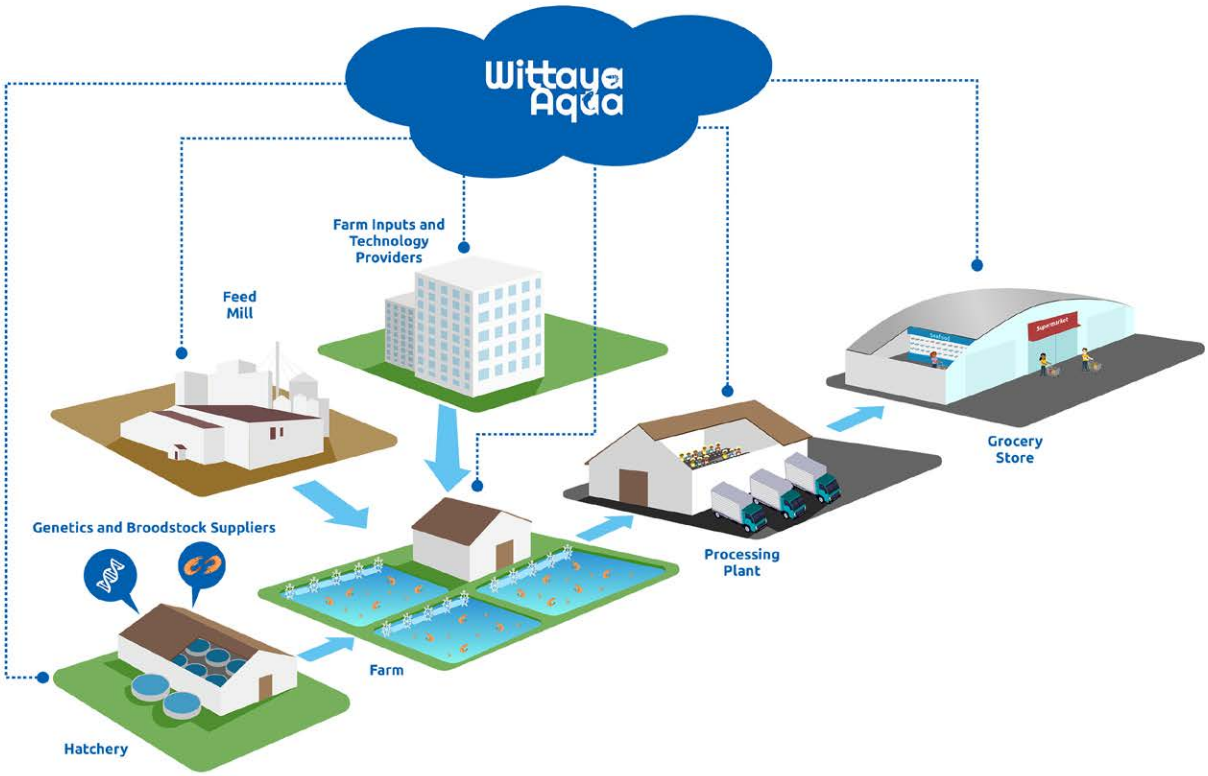
Wittaya Aqua has developed a digital ecosystem for aquaculture producers, feed manufacturers, and feed ingredient suppliers (Figure 5). Its AquaOp Farm and AquaOp Feed platforms allow companies to optimize aquafeed nutrition and improve farm production practices through the power of data. Wittaya's software has been developed for most farmed species and is based on decades of cutting-edge research. The software is cloud-based and accessible anywhere in the world by subscription.

Optoscale and iFARM are yet other versions of smart fish farming in development at the moment, showing promise for real-time fish welfare and health tracking and management. These systems, as with others, are meant to operate in both net pens in the ocean and/or semi-enclosed containment systems for fish rearing.

Fish are not the only animals being used in aquaculture smart farming operations. The most valuable aquaculture output globally (in U.S. dollars) is the shrimp farming sector, ranging from small-scale "mom and pop" operations to intensive and hyperintensive systems operating on land. With increasing needs to monitor inputs and outputs of these farms for production, some operations are resorting to AI and machine learning for controlling the growout cycle. Similar to approaches used in finfish AI systems, various sensors, cameras, and probes are employed to monitor in real time the shrimps' health and performance, and to control environmental parameters for optimal production.

Xpertsea is a fairly new startup from Canada for semi-intensive shrimp farms and touts itself as the future of sustainable shrimp farming globally. It is currently developing its machine learning and algorithms in southeast Asia and soon in central America.

Vertical Oceans is a commercial land-based vertically integrated shrimp farming company in Singapore whose claim to fame is full-cycle production efficiencies (zero-waste, 100% recirculating aquaculture system) using AI, machine learning, and various in-situ sensors to manage production. In fact, shrimp harvests are distributed daily within



WITTAYA AQUA

Figure 5: The Wittaya Aqua ecosystem.

hours from its smart farm modular system, based on customer demand, so it is the freshest possible. The interesting part of this system is the broodstock, post-larvae, and growout systems in tanks as well as customer demands are integrated into the algorithms vertically so there is little wastage.

Last, but not least, autonomous delivery of feed by vessels to remote salmon farms has taken place in Norway recently, powered by AI and machine learning to deliver the food safely in open ocean conditions. These are but a sampling of a few types of AI-machine learning applications in aquaculture. Future endeavours in farm AI at sea and on land in aquaculture will almost certainly include robot mitigation of unfavourable environmental conditions such as plankton blooms, low oxygen levels, temperature anomalies, and other health and welfare challenges. At some point, entire farms will be autonomous production facilities, requiring only oversight by humans on the technical side of things.

Issues, Constraints, and Future Trends in AI

Communications and sensor performance are essential for good AI solutions for fish farming. If reliable data cannot be transmitted in real time to the operator, they may not be able to manage or instruct robots on performing a stock-saving operation or an environmental mitigation instruction for the fish. These communication tools need to be rapid, precise, and use reliable sensors for a well-run operation, with animal welfare always first. This is often a constraint in many parts of the world where cell or internet services are unreliable, but perhaps satellite high-speed internet might be option at relatively low cost (e.g., Starlink).

Another possible constraint is that farmers will need access to data scientists or employ these folks to develop and understand their AI systems. These positions are increasingly in demand across economies of the world using large data inputs and analytics tools. Farmers will always want to own the data from their own farms, so they need to be careful as to the terms of service and security provided by AI-machine learning specialists and providers. Security of data and who uses it and for what purpose is always something a farmer will be concerned about.

One exciting trend in the AI-machine learning sphere is the use of real-time eDNA monitoring for pests, parasites, diseases, even fish presence and absence. Readers may be familiar with detection of infection loads from the COVID-19 virus and its variants in municipal wastewater, but systems are now available to detect organism presence or absence in aquatic systems in real time. Why not use them for predicting plankton, disease organisms, or pests like sea lice larvae, and other interactions among farmed and wild organisms in real time? There is plenty to be done on this in the near future.

The race is on now for optimizing food production both on land and at sea in the agriculture and agrifoods business. Improvements will be made at rapid pace, each year bringing new solutions for reducing environmental impacts of farming, improving animal health and welfare, and connecting with customers in real time. It is an exciting time to be in the seafood farming business with all of these innovations.

Cyr Couturier is marine biologist, aquaculture scientist, and chair of the M.Sc. Sustainable Aquaculture program at the Fisheries and Marine Institute of Memorial University. He has 35+ years of experience in applied research and development, training, and education in aquaculture and fisheries. He is a board and executive member of several farming and development associations, including Canadian Aquaculture Industry Alliance (CAIA), Canadian Federation of Agriculture, Canadian Agricultural Human Resource Council, HORIZON TNL; and is a past president of Aquaculture Association of Canada, CAIA, and Newfoundland and Labrador Aquaculture Industry Association. He has worked in aquaculture and fisheries development in over 18 countries. The views expressed herein are his own. cyr@mi.mun.ca | Twitter @aquacanada