

Role of machine learning and artificial intelligence

in transforming aquaculture and fisheries sector

Satyamvada Maurya¹, Murali S Kumar¹, Ravindra Kumar^{1*} and Basdeo Kushwaha¹

¹ICAR-National Bureau of Fish Genetic Resources, Lucknow, Uttar Pradesh 226 002

The rapid growth in the area of computer science has focused on creating machines that can perform tasks, such as visual perception, speech recognition, decision-making, and language translation, like human does. The two closely related fields of the computer science, viz. machine learning (ML) and artificial intelligence (AI), are revolutionizing the way we interact with the technologies. These technologies have ushered in a new era of technological possibilities for various industries, including fisheries and aquaculture. The future of ML and AI in aquaculture and fisheries holds promising advancements that will reshape the industry's landscape. This article focuses on the diverse applications of ML and AI in the fisheries sector, particularly for environmental monitoring, stock assessment and disease detection for enhancing the efficiency, sustainability and management of fisheries and aquaculture operations along with its limitations and the way forward. AI can help in better price discovery for fishermen and provide incentives for maintaining traceability, help policy makers to obtain the trend of aquaculture activities across the country and in identifying and resolving farmer issues more quickly.

Keywords: Artificial intelligence, Aquaculture, Fisheries, ICAR-NBFGR, Machine learning

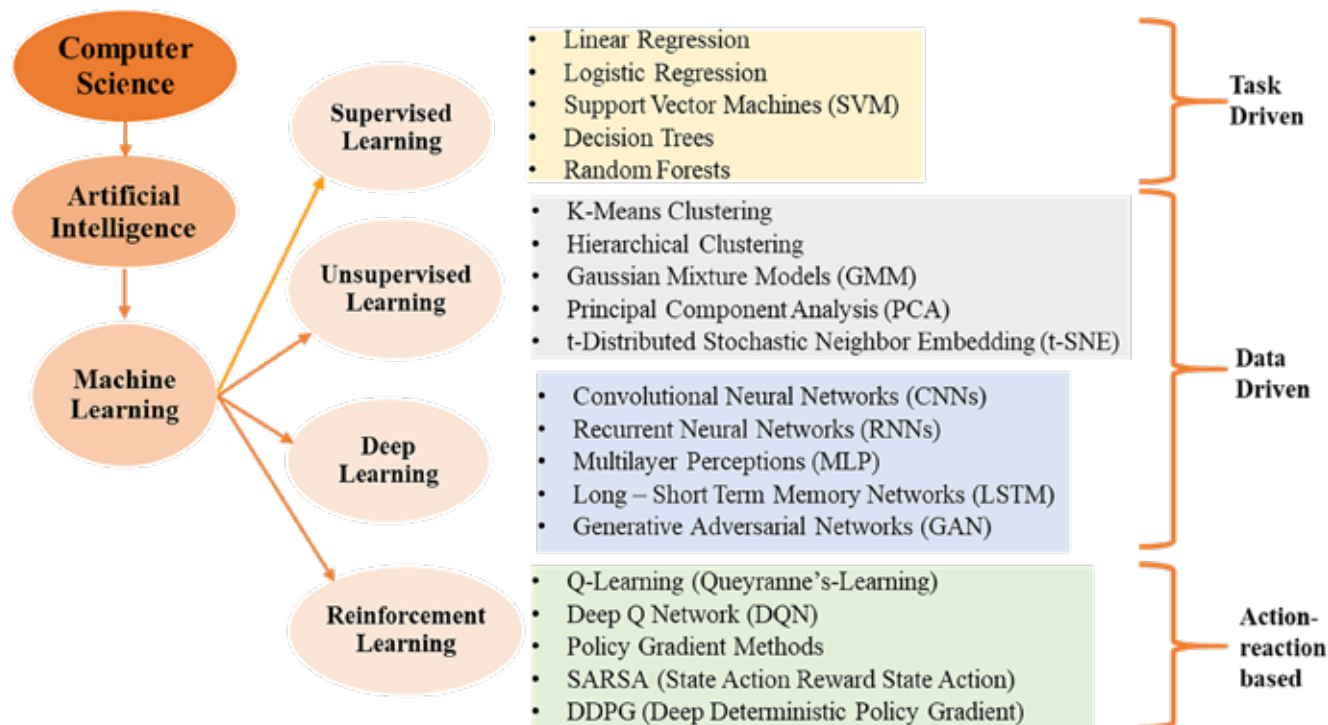
In recent years, the pace of technological advancement, especially in computational power and machine learning algorithms, has grown in leaps and bounds, profoundly contributing in the development of novel fields. One such area is artificial intelligence (AI), which is the intelligence of machines or software that was initially conceived as a technology to mimic the simple human intelligence. It has now been used in different manners by researchers based on their interpretations and applications. Now-a-days, it is generally agreed upon that the AI has the ability to perform at least some of the cognitive tasks, such as thinking, perceiving, learning, problem-solving and decision making. Further, different sets of learning, like machine and symbolic, have been evolved under the AI. Machine Learning (ML) usually focuses on enabling the computers to learn from data and improve their

performance over the time without being explicitly programmed, while the Symbolic Learning (SL) attempts to explain how imagery works and develop a coding system to create a mental blueprint of how to complete a deed. The AI simulates human intelligence, aiding in tasks such as decision-making and pattern recognition, while ML involves training algorithms to decipher patterns in data, facilitating predictions and informed decisions.

Fisheries and aquaculture sector play a very significant role in nutrition, livelihood and global food security. Total fisheries and aquaculture production reached an all-time record of 214 million tonnes in 2020. Around 58.5 million people were employed in the primary fisheries and aquaculture sector, and 600 million people rely on the sector for their livelihoods (<https://www.fao.org/state-of-fisheries-aquaculture>). The global aquatic food production is increasing with

an annual growth of 3-5%, but numerous challenges abound such as overfishing, disease outbreaks, large-scale fish mortality, water pollution, the need for conservation strategies etc., which need novel and innovative solutions. To overcome such challenges and meet the increasing demand, the blue transformation of the sector is required to be achieved through sustainable aquaculture intensification and expansion, effective management and upgraded food chains.

Today, AI is being extensively used for a wide variety of applications in robotics, e-commerce, finance, social media, healthcare, gaming, agriculture etc. As the AI's capabilities are increasing, it is being progressively used in many other sectors, and aquaculture and fisheries is one where it has many usages. The integration of AI and ML technologies has far-reaching implications for market



AI and ML components and their integrations

demand prediction and supply chain optimization in fisheries and aquaculture sector. Analyzing market trends, consumer preferences and external factors allow farmers to make informed decisions about production levels, marketing strategies, reducing waste and enhancing profitability. Meanwhile, ML algorithms streamline logistics and supply chain operations, ensuring the timely delivery of high-quality seafood products to consumers, while minimizing the costs. In this article, we discuss some of the major applications of AI and ML in fisheries and aquaculture sector, their limitations and future directions.

Applications in fisheries and aquaculture

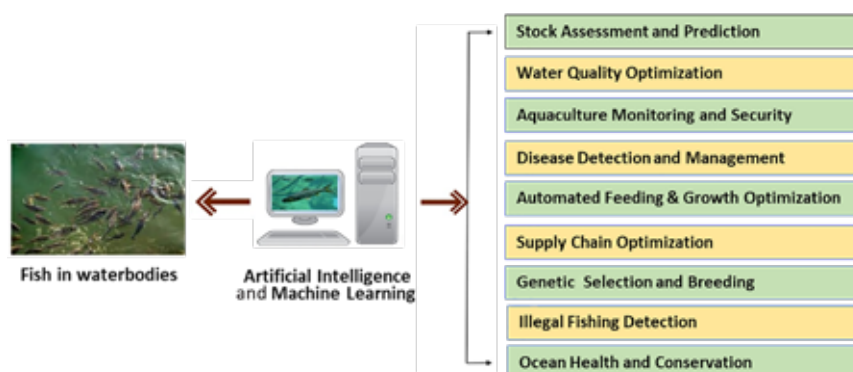
The AI and ML are being harnessed through diverse ways in the fisheries and aquaculture industry, ushering in transformative changes and enhancing various aspects of operations and management. Some of the applications of both the algorithms in fisheries and aquaculture sector are as follows:

- **Water quality management** is a critical aspect of successful aquaculture operations and the integration of ML and AI

is playing an essential role in continuously monitoring the essential water parameters, *viz.* temperature, pH, dissolved oxygen, ammonia levels etc. AI can also optimize water quality management by processing data via different sensors & probes, and gives real-time insights. ML and AI models can discern patterns, trends and anomalies in water quality parameters and furnish timely alerts for potential deviations from the ideal conditions, enabling swift corrective actions. It can be extremely useful when major water parameters, like dissolved oxygen (DO) levels dip below a specified threshold, the AI-enabled system can trigger interventions like switching

on aerators or initiating water exchange and prevent fish mortality or stress.

- **Feed optimization:** Feed forms a significant proportion of management costs and the success of the fish farm majorly depends on the cost incurred towards fish feeding. ML and AI optimize feeding schedules using sensors, cameras and historical data to establish ideal feeding times, where adaptive algorithms adjust schedules based on the real-time factors. For feed composition, the ML algorithms take into consideration, both the nutritional requirement of the target species and the local feed ingredient availability. They create balanced diets that



Application of artificial intelligence in aquaculture and fisheries

boost growth and health, while reducing the waste. ML and AI can analyse fish feeding behaviour, growth rates and environmental conditions to optimize feed composition and feeding schedules to prevent over- or under-feeding. This has resulted in optimal feeding control, accelerated growth, cost reduction, improved economic efficiency and reduced environmental impact. Environmentally efficient feeding generally minimizes waste, reduces the risk of water pollution & eutrophication and subsequently poor water quality-associated risks. Thus, through ML and AI, we can tailor diets and feeding schedules to species needs and promote sustainable aquaculture industry.

- **Fish species classification and stock assessment:** Automatic fish detection through image processing and pattern recognition has been tried by different researchers with varying levels of success. ML and AI techniques, involving the adaptive predictive models and employing the neural networks or support vector machines, are being employed for fish detection and classification to enhance efficiency in monitoring and managing diverse fish populations in various ecosystems, ranging from farms to oceans. By employing both the historical data and the environmental variables encompassing water temperature, algal availability, current information and ecological conditions, the ML and AI have revolutionized our ability to predict fish stock abundance, distribution and migration patterns. Predictive models have been successful in predicting fish migration patterns and spawning locations that can be useful to promote strategies for fishing quotas in closed areas and closed seasons, thereby, enhancing the conservation and sustainability of the fishery germplasm.

- **Disease detection and management** is a crucial aspect for successful aquaculture, where early signs of disease outbreak enable timely intervention and help to reduce disease spread. The AI, using neural network models, has been proved to be an effective tool in analysing the fish behaviour for any abnormal conditions/actions. ML and AI tools may significantly improve early disease detection in aquaculture by analysing large datasets, like water quality parameters, fish behaviour, feeding pattern, swimming style, biological markers etc., in real-time and predict as well as enhance the overall fish health.

- **Decision support systems (DSS)** is a computerized program that analyses massive amounts of data and compile comprehensive information to solve problems and support in decision-making process. DSS also assists in optimizing resource allocation. Integrating real-time data with AI tools in aquaculture, the DSS system can be modelled to empower farmers with actionable insights in relation to environmental conditions, water quality, stock levels and market trends. By processing real-time data, they offer insights into feed optimization, disease management, environmental control and aid in better decision-making. This can lead to enhanced operational efficiency, reduced costs and improved productivity, while minimizing the risks.

Global scenario

Artificial intelligence has widely been used for high value aquaculture species where intensive culture is being practised. Use of sensors, drones and robots are being avidly used for data collection and then fed to sophisticated algorithms for improved decision making. Since feed is the major cost component of culture, most of the AI is focussed on understanding various

feeding strategies to reduce feed wastage through smart analytics or demand driven automated feeding systems. An example is the Akvasmart CCS Feed System (<https://www.akvagroup.com/>) from AKVA group, Norway, where fish feeding is automated, making it possible for feeding to be adjusted based on the water quality or fish behaviour. Culture conditions, like water quality and health management, are another area, where most of the AI is functional. An IoT (Internet of Things) device OxyForcis, manufactured by Smalle Technologies, Spain, employs AI to measure water temperature and DO levels, where an optical sensor is placed inside the pond and the readings are obtained on App. Nippon Steel Engineering Co. Ltd., Japan, is testing an automated underwater camera system which uses AI to determine the fry size and weight for automated feeding, leading to 70% lower production costs. Automated disease prediction and identification has been made possible for salmon louse, flounder parasites, crab and shrimp diseases etc. The AI has enabled live and dead rainbow trout fish eggs separation and size sorting of sea bream fries. Culture of flounder, tilapia, salmon, crabs and trout in countries, like Norway, Japan and Israel, has benefitted from such initiatives.

Capture fishery has also been making use of AI through data collection systems for increasing seafood traceability, promoting sustainable fishery and significantly reducing overfishing and bring accountability in fishing practices. Japan is using AI to advise fishermen to adjust catch according to fish prices to reduce both the working hours of fishermen and the fuel costs associated with fishing to stabilize their income, while protecting natural resources. Illegal, unregulated and unreported (IUU) fishing is valued to be at least 10-20 US\$ annually. AI tries to address these issues by lowering the monitoring cost of fishing operation with use of automatic review of video footage, analysing vessel movement, automated catch

identification and estimation etc. Countries with long coastlines, like Japan, Australia, Canada, Indonesia, Taiwan etc., use cameras with AI and ML tools to monitor number of fishing vessels at sea and to estimate catch species. An independent organization, Global Fishing Watch Platform by Google, has combined AI with satellite data to understand global fishing activity. Fisheries information and marketing is another area where AI systems deployed over cloud infrastructures are used to provide real-time analysis to the farmers, enabling price discovery and harvesting timeline. Expert systems, like STRATEX, APPFSS and CBR, have been used by fish farmers in Norway, China and Danish, respectively, to obtain global forecast of aquatic products for exports and local trade. The AI could also aid fishery conservation efforts by employing drones and transmitters to track endangered species. Australia is employing AI to identify species, predict extinction possibilities for understanding and conservation of coral reefs. Scientists at UC Berkeley, USA, utilized AI and robotics to assess population re-growth in fisheries to make better resource management decisions.

Indian Scenario

In India, the application of AI in agricultural and fisheries activities across various stages of value chain, like precision agriculture, weather, yield estimation and price forecasting, though at a very nascent stage, is progressing rapidly. The *mKRISHI® AQUA App*, an android application developed by Marine Produce Export Development Authority (MPEDA) in collaboration with Tata Consultancy Services– Innovation Lab Mumbai's Digital Farming Initiative, provides operational guidance to shrimp farmers on complete weather updates, stocking information, pond management,

feed and water management, book-keeping functionality etc. *mKRISHI Fisheries* is another mobile App, developed by TCS in collaboration with ICAR-CMFRI, Kochi, and INCOIS, Hyderabad, to help fishermen in planning their fishing trips by providing information on availability of fish shoals based on remote sensing data, sea surface temperature and presence of phytoplankton. *Sagar Vani* is an Integrated Information Dissemination System, developed by the ESSO-INCOIS under Ministry of Earth Science, GoI, through the Industry M/s. Gaian Solutions Pvt. Ltd., that provides timely information of Ocean Information and Advisory Services that includes Potential Fishing Zone (PFZ) advisories, Ocean State Forecast (OSF), High Wave Alerts and Tsunami early warnings and to coastal fishermen on weather conditions using advanced AI and ML capabilities. Another mobile app *Aquaconnect* (earlier called as FarmMojo), developed by Chennai based Startup Aquaconnect company, provides traceability and advisory services to optimise feeding, monitor water quality, improve disease prediction and decide inventory levels and gate-prices to shrimp farmers of Andhra Pradesh, Gujarat and Tamil Nadu using AI.

Challenges and limitations

Although AI and ML have lots of advantages, but still there are certain drawbacks too. These technologies are expensive at present for small-scale fish farmers and have a longer learning curve too. Accurate and reliable data is essential for training ML and AI models, which can be challenging in the fisheries sector due to variability in aquatic environments, sensor inaccuracies and other data gaps. Privacy is another concern where sensitive information related to

farm operations, fish health, and environmental conditions must be safeguarded against unauthorized access and potential breach. People employed in aquaculture farms may be worried that automation of tasks normally performed by them, like feeding, water quality monitoring, fish size sorting etc., may take away their employment. Hence, it is necessary to ensure participation of all stakeholders in taking the technology forward. Collaboration and careful consideration are essential in overcoming these challenges.

CONCLUSION

The future of ML and AI in aquaculture involves the integration of IoT, early warning systems, autonomous underwater vehicles and personalized aquaculture approaches. These tools can contribute significantly in farm management by ensuring optimal conditions, while minimizing waste and optimizing feed. It will become instrumental in optimizing stock assessment and predictive modelling, enabling more accurate estimations of fish populations and migration patterns. AI will revolutionize the way the aquaculture and fishing activities are carried out, especially with respect to safety, productivity and sustainability. Deployment of AI will help in better price discovery for fishermen and provide incentives for maintaining traceability. It will help policymakers to obtain the trend of aquaculture activities across the country and help in identifying and resolving farmer issues more quickly and effectively. Collaboration between AI experts and fisheries professionals, along with ease of regulatory frameworks can contribute to widespread adoption of these technologies.

*Corresponding author e-mail:
Ravindra.Kumar@icar.gov.in

! Attention !

Want to try your hands at the ICAR textbooks released recently! No Worries! We got you covered. Now shop the latest textbook collection of ICAR online from the convenience of your home.

SCAN QR Code to
Purchase Online

