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The Role of Artificial Intelligence (AI) in Aquaculture: Improving Efficiency, Sustainability, and Profitability

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Smart fish farming aims to maximize resource efficiency and advance aquaculture's sustainable growth. Artificial intelligence (AI) is being used to monitor and manage fish populations to boost productivity in fish farming. The use of AI has greatly improved the accuracy of data monitoring. Feed wastage is one of the major issues in aquaculture that can be minimized by using AI tools. Additionally, AI tools keep track of issues like disease outbreaks that are difficult for humans to identify. While artificial intelligence may eliminate some jobs, it will create new ones, and human labor will be more considerate, satisfying, and rewarding.

Keywords
Artificial intelligence, aquaculture, smart feeder, Internet of Things, Fish

Introduction

Fish is a highly nutritious food that offers many health benefits for consumers. However, the increasing demand for fish has put pressure on natural resources and the environment, requiring more sustainable and efficient ways of fish production. Aquaculture refers to farming aquatic organisms, including fish, molluscs, aquatic plants, and other organisms. Aquaculture is the controlled breeding of freshwater and saltwater fish populations.

The traditional aquaculture system has the following limitations:

- More human labor is required. The cost of labor is rising by the day.
- It is not easy to maintain water resources and the environment.
- Farmers' failure to respond promptly has caused problems.
- Machines and tools are operated by hand.

"Smart fish farming" refers to a new scientific discipline aiming to maximize resource efficiency and advance aquaculture's sustainable growth. A significant amount of information is gathered in smart fish farming from various sources, including the Internet of Things, machinery, processes, people, and the environment.

Artificial intelligence (AI) is one of the technologies applied in aquaculture (Fearn, 2018). It refers to the intelligence exhibited by machines, unlike the natural intelligence shown by humans and animals. In aquaculture, AI is being utilized to monitor and manage fish populations. Farmers use AI to keep track of the fish being cultured. Aquaculture has long relied on farmers' wisdom and knowledge in areas like feeding and disease forecasting. Some businesses are using artificial intelligence (AI) to boost productivity. Artificial intelligence has a plethora of applications. The technology can be applied to a wide range of sectors and industries. AI is being tested and used in the healthcare, agriculture, financial, and aquaculture industries (Copeland, 2023).

A potential solution is to apply Artificial Intelligence (AI) to enhance different aspects of aquaculture, such as managing feed, detecting diseases, monitoring water quality, and analyzing market trends. Prapti et al. (2022) state that AI can help improve fish growth, reduce costs, enhance welfare, and mitigate the environmental impacts of fish farming. To address this challenge, the application of innovative technologies, including Artificial Intelligence (AI), holds great potential for sustainable fish production (Prapti et al., 2022). Artificial intelligence will assist in overcoming these limitations because it involves automatic operations of various tasks, such as controlling machines and tools without human resources. Meaningful data exploration is made possible by using AI in aquaculture farms, which provides continuous analytical and objective evidence of how fish growth responds to farmer input under various circumstances.

Internet of Things

IoT is a computing and communications revolution that enables robots to carry out tasks when given instructions from a distance or sends data from sensors to manufacturers for analysis on mobile devices. Aquaculture and IoT are not new ideas. Fish farms already use sensors and cameras integrated into new aquaculture machinery for creative projects. The type of data sensors can gather information on everything from water parameters to the state of the nets (Ashton, 2009).

IoT in aquaculture:

- Data and information can be analyzed even if the farm is located away from the land.
- Water physical and chemical parameters are being monitored. Inform the farmer about the status of these values via SMS.
- Based on the response, the farmer turns the pumps, motors, aerators, or diffusers on or off (Niswar, et al., 2018).

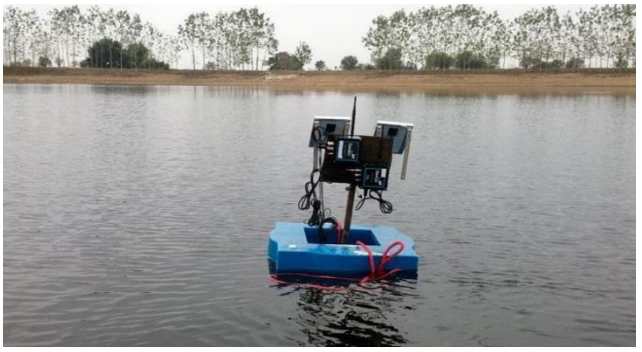

Figure 1: IoT Device in pond (Source: Niswar et al., 2018)

Feed Monitoring AI Tools Used in Aquaculture

AKVA observe: AKVA Global Aquaculture Company and British artificial intelligence (AI) specialist Observe Technologies have developed AKVA Observe, a new software that uses AI to help feed fish more efficiently. When used together, the software helps the operator optimize feeding by counting visible pellets and thoroughly analyzing fish behaviour. The AI feeding assistant supports the most crucial and price-sensitive step in fish farming decision-making here and now. The results from the operational sites are compiled and reported back via a separate web-based management tool, making it simple to monitor and benchmark sites and learn on a larger scale how different factors interact (AKVA, 2021, Minapoli (2021).

Figure 3: uneaten feed detected by AKVA observe system (Minapoli, 2021).

eFishery smart feeder: eFishery has developed a system that uses sensors to detect hunger levels in shrimp and fish, controlling dispensers that release the right amounts of food; the company claims this can reduce feed costs by up to 21 per cent (van Beijnen, J. (2021). This device can automatically feed fish, detect the fish's hunger, and modify the amount of feed based on the fish's appetite. It is also internet-connected. Monitoring in real-time Real-time internet updates from eFishery include the feeding's time and volume. It is accessible from a personal dashboard, via a smartphone, tablet, or PC, whenever and wherever.

Figure 2 eFishery smart feeder (Source: online)

Diseases Tracking AI Tools

FarmMOJO: FarmMOJO is an application provided by Indian aquaculture technology startup Aquaconnect. FarmMojo, a mobile app from Aquaconnect, uses big data and artificial intelligence (AI) to give farmers recommendations on how to operate their ponds based on ongoing monitoring of the water quality, feed intake, disease outbreak indicators, and biomass conversion, which shows how effectively a farm feeding strategy is working. The application also uses the IoT or smart farm management tool data. Shrimp farmers receive daily assistance from FarmMojo in feeding optimization, disease prevention and control, and water management. It ensures that feed is used effectively and that biomass is converted in prawn farming. Suppose FarmMOJO ever notices a low Feed Conversion Ratio (FCR). In that case, it will advise the farmer to take the appropriate actions and use the appropriate products to restore the pond's natural environment. Shrimp farmers have benefited from this strategy by seeing improved disease detection rates and accuracy, increased production effectiveness, higher-quality shrimp production, higher profits, and less reliance on outside resources for day-to-day operations (FarmMojo, 2019).

AquaCloud: The Seafood Innovation Cluster introduced AquaCloud, a brand-new innovation platform that will combine the knowledge of fish health managers, researchers, and data scientists to provide fresh insights from the vast amounts of data generated daily by the sector. AquaCloud offers municipalities and commercial aquaculture a platform for cloud-based monitoring. With the help of this innovation, sea lice, a natural parasite, can be tracked. By combining experience-based intuition with fact-based analyses, the

farmer will be better able to take preventative action in response to signs of an escalating biological situation with increased focus and knowledge of data-supported analyses (Yang et al., 2021).

Other Ai Tools Used in Aquaculture

Drones: Land-based businesses are being transformed by flying drones, with realtors taking aerial photos of for-sale homes and retailers investigating drone-based delivery systems. A similar revolution may be on the horizon for aquaculture, with underwater drones providing fish farmers with eyes beneath the waves, allowing them to monitor water conditions and fix equipment problems on the cheap. According to the drone builders (Orlowski, 2017), these underwater drones will measure dissolved oxygen levels and other physical and chemical information, and they will be equipped with cameras to detect tears in nets before they become too severe. The underwater drone can withstand adverse weather conditions; such inspections can be hazardous to divers. Fish farmers can use the drone's information about fish movements and environmental conditions to improve feed accuracy, decrease waste and boost growth. Additionally, the data can be used to lower disease outbreaks and mortality by analyzing fish stress levels. On the other hand, analyzing light conditions can aid in regulating maturity and enhancing harvest quality (Ding & Ma, 2012). The first commercial remotely operated underwater drone in India, EyeROV TUNA, can transmit real-time video of ships and other underwater structures to aid in maintenance and repair. The use of more expensive and dangerous manual inspection by divers has been avoided thanks to the drone's ability to navigate to a depth of 50 metres and capture real-time HD video images for underwater analysis. One of the most cutting-edge systems, fishSHOAL, uses robot fish to find sources of underwater pollution near fish farms and other facilities (EyeROV TUNA, n.d.).

Figure 4: EyeROV TUNA (Source: Online)

Robotic cages: For use in the open ocean, robotic cages are complete cages equipped with cameras, sensors, feeding and recirculation systems. A cage that fishermen can place their fish in before setting it adrift in the ocean. Brass mesh creates a cage, which prevents biofouling or the growth of algae and barnacles on submerged objects. By doing this, drag, and the requirement to clean the cages are reduced. Aquapods (Small Amphibious Robots with Sampling Capabilities) are a common name for robotic cages. These monitoring tools can be applied to aquaculture and exploration (The Fish Site, 2009; Mackowiak, 2019).

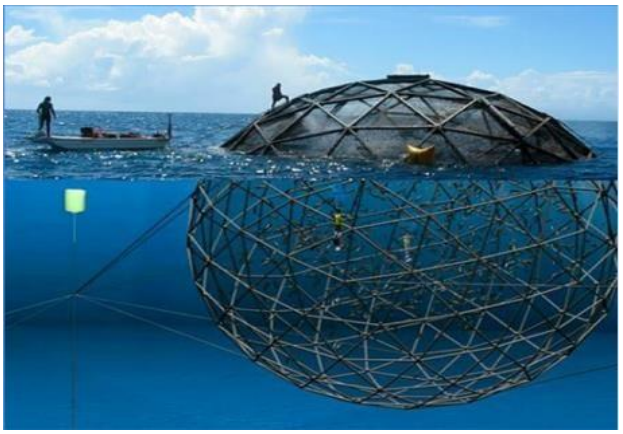

Figure 5 Robotic Cages (Sources: Mackowiak, 2019)

Aquaculture AI has much potential, but its value will significantly influence the species and farming practices used. Data and AI will be necessary for commodity seafood markets, such as those for prawns and salmon, where international competition determines the price. Investing in AI for lower-value species that are typically consumed locally might not be financially advantageous. Significant changes to aquaculture have been brought about by artificial intelligence. Smart feeders, which use sensors to detect fish hunger levels, have reduced feed waste. By interpreting collected data, showcasing it, and implementing preventive measures, programmes can predict disease outbreaks before they occur. AI and automation can help increase seafood production sustainably and cost-effectively to meet the growing demand for food. However, AI in aquaculture also poses some challenges for human workers who may lose their jobs to machines. AI tools can perform tasks such as feeding, cleaning, harvesting, and monitoring more efficiently and accurately than humans. However, they also threaten the livelihoods of small fishing communities that rely on manual labour. For example, divers who used to explore deep water have been replaced by AI tools that can collect data more

precisely. AI tools can also reduce feed waste and detect diseases humans may miss. Although AI may eliminate some jobs, it may also create new opportunities for human workers who can focus on more creative and meaningful tasks.

Conclusion

The role of artificial intelligence in aquaculture is instrumental in improving efficiency, sustainability, and profitability. AI technologies enable precise monitoring, optimized feeding strategies, disease prevention, and real-time data analysis, empowering farmers to make informed decisions and maximize resource utilization. With continued advancements and responsible implementation, AI has the potential to drive the future of aquaculture, addressing global food security challenges while minimizing environmental impacts.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

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