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Short Communication

Edge Intelligence for Smarter Aquaculture Operations: Improving Farm Performance

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DESCRIPTION

Aquaculture has become one of the fastest-growing food production sectors, supplying fish, shellfish, and other aquatic products to millions of people across the world. As production expands, farmers face increasing pressure to maintain healthy stock, reduce operational expenses, improve environmental performance, and meet consumer expectations for quality and safety. Traditional monitoring methods often depend on manual inspections and delayed data analysis, making it difficult to react quickly when conditions change. The introduction of edge Artificial Intelligence (AI) has created new opportunities for fish farmers by allowing data processing to occur directly where information is collected instead of sending every measurement to distant cloud servers.

Edge Artificial Intelligence (AI) combines intelligent software with nearby computing devices installed at fish ponds, raceways, cages, hatcheries, and recirculating aquaculture facilities. Cameras, dissolved oxygen sensors, temperature probes, pH meters, ammonia detectors, and water flow instruments continuously collect information about farm conditions. Rather than transmitting all collected data across networks, compact computing units analyze the information immediately. This local analysis enables automatic recognition of unusual conditions, allowing farmers to respond within seconds instead of waiting for remote processing. Such rapid evaluation helps reduce losses that may occur because of declining water quality or equipment failure.

Feeding management also benefits from local artificial intelligence. Feed represents one of the largest operating expenses in commercial aquaculture, and excessive feeding leads to financial waste while reducing water quality. Edge Artificial Intelligence (AI) systems examine underwater video during feeding sessions to estimate appetite and detect leftover pellets. When fish lose interest in feed, automatic feeders reduce or stop feed delivery. If activity remains high, feeding continues according to programmed limits. This approach decreases unnecessary feed consumption while supporting healthy growth. Better feed management also lowers nutrient accumulation in ponds and tanks, reducing pressure on filtration systems and surrounding ecosystems.

Water quality changes can occur rapidly because of weather variation, biological activity, stocking density, or equipment malfunction. Edge Artificial Intelligence (AI) continuously evaluates sensor readings for oxygen concentration, temperature, salinity, turbidity, pH, and nitrogen compounds. Instead of relying only on fixed threshold alarms, artificial intelligence recognizes combinations of measurements that suggest developing problems. Aerators, pumps, oxygen injection equipment, or water exchange systems can then be activated automatically without waiting for human intervention. Immediate action helps maintain stable production conditions and reduces stress experienced by cultured animals.

Remote aquaculture sites frequently experience unstable internet service. Offshore cages, rural ponds, and isolated hatcheries may lose communication for hours because of weather or infrastructure limitations. Since Edge Artificial Intelligence (AI) performs analysis locally, essential farm activities continue without interruption. Cameras, sensors, and automated equipment remain operational while storing collected information until network access returns. Farmers continue receiving local alerts through nearby communication systems, allowing daily operations to proceed despite external connectivity challenges.

Edge Artificial Intelligence (AI) also contributes to stock counting and biomass estimation. Underwater imaging systems combined with local processing estimate fish numbers, average body size, and weight distribution. Farm managers receive updated production estimates without repeated manual sampling, which often stresses fish and requires additional labor. More accurate biomass information supports feed planning, harvest scheduling, inventory management, and market preparation. Continuous observation also identifies uneven

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growth among production groups, allowing management practices to be adjusted accordingly.

Environmental protection has become an important objective for aquaculture businesses operating near rivers, lakes, estuaries, and coastal waters. Local artificial intelligence assists by monitoring discharge quality, sediment accumulation, oxygen demand, and nutrient release. Automated responses can reduce water exchange during unfavorable conditions or activate treatment equipment before discharge standards are exceeded. Such monitoring supports environmentally responsible production while helping producers comply with regulatory requirements and community expectations.

Small-scale aquaculture operations can also benefit from edge Artificial Intelligence (AI) because modern computing hardware has become more affordable and energy efficient. Compact processors installed in waterproof enclosures consume relatively little electricity while supporting advanced image recognition and sensor analysis.

CONCLUSION

As computing technology continues to become smaller, faster, and more affordable, local artificial intelligence is likely to become a standard component of modern aquaculture facilities across both developing and developed regions. Its ability to support continuous monitoring while reducing delays offers farmers an effective method for improving productivity, protecting aquatic animal welfare, and maintaining sustainable food production for a growing global population. Farmers who previously lacked access to sophisticated monitoring technology may now implement intelligent systems without investing in expensive computing infrastructure. User-friendly software interfaces further simplify daily operation by presenting recommendations through mobile devices or local display panels

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