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Smart Feeding Technologies used in Aquaculture

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Global aquaculture production has been steadily increasing, now exceeding three times the total live weight, with key species groups such as catfish, seaweeds, carps, bivalves, and tilapia accounting for 75% of total production. Additionally, marine species, including fish and crustaceans, have seen significant growth during this period. The variety of species in aquaculture continues to expand, with around 40% of these species comprising fish, shellfish, and algae, which are cultivated in diverse aquatic environments like marine, brackish, and freshwater across the globe. Traditional aquaculture presents several environmental challenges, limited production capacity, and high labor demands. As a result, smart aquaculture has emerged as a concept aimed at developing the industry in a more sustainable manner, increasing production, and promoting environmentally friendly practices. Modern aquaculture has evolved into a global industry that spans from extensive farming, where the surrounding environment, influences the majority of production to intensive farming, where humans carefully manage factors like nutrition and other key elements of the production environment. Today, aquaculture encompasses over 100 species of animals and plants, raised in various production systems, ranging from indoor tanks and semi-natural ponds to marine sea-cages, across freshwater, brackish, and seawater environments. Digital tools in fish farming, particularly in the realm of smart fish nutrition, refer to any type of device, sensor system, equipment, or vehicle created to assist humans in monitoring and performing tasks that would traditionally be done manually. Additionally, we include computer systems, mathematical models, and

other theoretical frameworks designed to either replace or assist human analysis of specific situations. As the term suggests, the shared characteristic of the tools, systems, and methods discussed is that they are grounded in highly technical and digitized fields of science, such as computer science, embedded systems, control engineering, and artificial intelligence.

What are smart feeding system?

Feeding plays a crucial role in aquaculture, influencing both the healthy growth of fish and the overall cost and economic returns of the industry. Currently, feeding is typically managed through mechanical systems that regulate timing and quantity, relying on a set amount of feed determined by the breeder. However, this approach does not account for the fish's changing feeding requirements, which can result in underfeeding or overfeeding, potentially hindering fish growth and polluting the water. Machine vision, a highly efficient, cost-effective, non-destructive, and objective technology, offers significant potential for advancing the automation and intelligence of aquaculture. Integrating machine vision with fish feeding needs can enhance efficiency and foster intelligent aquaculture systems. Feed provides essential nutrients and energy for fish survival, playing a vital role in aquaculture. This includes plant-based feeds, animal-derived fresh feeds such as earthworms, commercial compound feeds, and homemade pellet feeds (Hao, 2016). Research indicates that feed costs constitute over 60% of the total aquaculture expenses. As a result, minimizing feed costs can significantly enhance the economic returns of aquaculture. Feed expenses are influenced by both the type and quantity of feed used. The type of feed is typically determined by the fish species being farmed, while effectively managing the feed quantity has become a key strategy for reducing costs and maximizing profits (Føre et al., 2016).

Technologies that use sensors

Sensors play a crucial role in fish growth monitoring by providing real-time data on various environmental and physiological parameters. Sensors are regarded as devices that detect and process physical data such as temperature, power, light, electricity, and sound. These sensors enable fish farmers, researchers, and aquaculture professionals to track and optimise the growth and health of fish populations.

Ph Sensor: The pH sensor is essential for assessing water quality. The pH scale, ranging from 0 to 14, measures a solution's acidity or alkalinity, based on the concentration of hydrogen ions. A pH level between 0 and 7 indicates acidity, 7 is neutral, and levels above 7 up to 14 indicate alkalinity. The optimal pH range for aquaculture is between 6.5 and 9.5.

Temperature Sensor: This sensor is used to monitor and control the temperature of the water, typically measured in Celsius (°C). A waterproof liquid temperature sensor is often employed for this purpose, with an optimal temperature range for aquatic environments between 6.5 and 9.5°C.

TDS Sensor: The Total Dissolved Solids (TDS) sensor measures the total quantity of dissolved solids in water, including minerals, salts, organic matter, and some gases. It works by passing a current through the water to assess its electrical conductivity, which is inversely related to the TDS level. TDS is usually reported in parts per million (ppm).

EC Sensor: The Electrical Conductivity (EC) sensor is used to measure the electrical conductivity of water, which helps evaluate water quality in aquaculture. It plays a crucial role in assessing the ionic content of water to ensure optimal conditions for aquatic life.

Salinity Sensor: A salinity sensor measures the amount of dissolved salt in water, typically expressed in parts per million (ppm). It uses electrical conductivity properties to determine the salinity, which is essential for maintaining proper conditions in marine and brackish water environments.

Feeding Management: Sensors can monitor feeding patterns and food intake. For instance, underwater cameras and acoustic sensors can track the frequency and amount of food fish are consuming. This information enables adjustments to feeding times and portions to enhance growth.

Fish Health Monitoring: Sensors can help identify early signs of disease or stress in fish. For example, certain sensors can measure cortisol levels in fish, which can signal stress. Early detection enables timely intervention to prevent health problems that may affect growth.

Types of smart feeding

- Smart automation system for fish feeders
- Sensor-based feeders
- Computer vision and AI

What are the Benefits of smart feeding

Smart Aquaculture combines cutting-edge technologies and creative methods to enhance productivity, efficiency, and resource management in the aquaculture industry. From precision farming to automation and AI, it offers the potential to make the industry more resilient, eco-friendly, and economically sustainable. The main objectives include reducing effluents, lowering input and labor costs, while enhancing human health and environmental benefits. These smart systems can manage various aspects such as breeding, nursery operations, grow-out, water quality, feeding, effluent control, growth and health monitoring, size-based sorting, and counting. By utilizing digital and electronic technologies such as computer vision, machine learning, information and communication technologies (ICT), the Internet of Things (IoT), cloud computing, and automation, Smart Aquaculture holds great promise for sustainable management and increased production. This article reviews the latest advancements and investigates opportunities for smart mariculture. Key elements of smart aquaculture systems include Artificial Intelligence, Machine Learning, Virtual Reality, and Augmented Reality.

- Improved feed efficiency
- Cost Reduction
- Environment sustainbility
- Enhanced fish health

Major Challenges in implementing smart feeding technologies

Implementing smart feeding technologies in aquaculture presents several challenges. While these systems help optimize conditions by monitoring variables like temperature, oxygen, and feeding, they require significant upfront investment, which can be a barrier for smaller farms. Their integration and maintenance demand specialized expertise, and managing the vast data they generate necessitates efficient storage and analysis. Environmental factors like water quality and fish behavior impact system performance, requiring continuous calibration. Additionally, technical issues such as hardware failures and software glitches can disrupt feeding schedules. Many traditional farmers may resist adoption due to limited awareness or trust, and scaling these technologies to different farm sizes and species remains a challenge.

Conclusion

In overall conclusion, the rapid expansion of global aquaculture has increased production and species diversity but also introduced environmental and operational challenges. The adoption of smart aquaculture leveraging digital tools, automation, and artificial intelligence offers a sustainable solution to enhance efficiency, optimize nutrition, and reduce labor demands. Among these advancements, machine vision technology plays a crucial role in improving feeding efficiency, minimizing waste, and lowering costs. As technology continues to evolve, smart aquaculture will drive sustainable growth, ensuring the industry's long-term profitability and environmental responsibility.

References

1. K. Komeyama, M. Kadota, S. Torisawa, K. Suzuki, Y. Tsuda, and T. Takagi, “Measuring the swimming behaviour of a reared pacific bluefin tuna in a submerged aquaculture net cage,” Aquat. Living Resour., vol. 24, no. 2, pp. 99–105, 2011.