PREFACE

The SIG CS@e-Learning committee sincerely appreciates the dedication and contributions of the educators from Jabatan Sains Komputer & Matematik (JSKM), UiTM Penang Branch, in bringing the 9th edition to fruition. This edition received 30 scholarly articles, all of which met the required criteria and were accepted. Authors are encouraged to further refine their research with additional insights and discussions for potential publication in high-impact journals indexed by SCOPUS, WOS, or ERA.

The theme for the ninth volume, "Beyond Boundaries: The Multidimensional Horizons of E-Learning," reflects the continuous evolution of digital learning. Over the past few decades, e-learning has proven to be a transformative force in education, demonstrating exceptional adaptability and effectiveness. The widespread use of mobile technology has expanded its reach, making e-learning an essential component not only in higher education and vocational training but also in primary and secondary education. Emerging trends such as artificial intelligence (AI), micro-credentials, big data, virtual and augmented reality, blended learning, cloud-based platforms, gamification, mobile learning, the Internet of Things (IoT), and online video are reshaping the digital learning landscape.

SIG CS@e-Learning remains dedicated to fostering academic excellence through impactful publications. With continuous commitment and innovation, we aspire for JSKM to attain recognition in esteemed academic journals, further advancing the frontiers of e-learning.

Ts. Jamal Othman
Chief Editor
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ADVANCING AQUACULTURE AUTOMATION: THE ROLE OF AI AND IOT IN SUSTAINABLE SEAFOOD PRODUCTION AND ENVIRONMENT QUALITY

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ABSTRACT

Aquaculture automation is one of the effective solutions to meet the growing global demand for seafood by improving efficiency and sustainability in the aquaculture industry. In this study, it can explore the abilities of advanced technologies such as robotics, artificial intelligence (AI) and the Internet of Things (IoT) to optimize operations in the field of aquaculture to be more advanced. Key innovations include robotic fish feeders, which can improve feeding accuracy based on fish behavior and environmental conditions, and automatic cleaning systems that maintain optimal water quality, reducing labor consumption and fish health will be more assured. These technologies collectively reduce operating costs, minimize indirect waste and can reduce environmental pollution. Despite challenges such as high start-up costs and technical complexity, aquaculture automation provides great opportunities in the production of a product. This research highlights how automation can revolutionize aquaculture practices, ensuring economic stability, increasing product quality and environmental balance that can guarantee global sustainability.

Keywords: Aquaculture Automation, Robotic Fish Feeders, Automated Cleaning Systems, Artificial Intelligence, Sustainable Aquaculture

Introduction of aquaculture automation

Overview of aquaculture automation

Nowadays, the number of fish farmers is increasing day by day, whether for business or as a hobby. In 2019, Malaysia's fisheries industry accounted for 1.1 percent of the global total, with 0.4 percent coming from aquaculture. This increased the national agricultural Gross Domestic Product (GDP) by 8.9 percent and generated 1.75 million jobs for Malaysians, (Chong, 2023).

Aquaculture has become one of the sources of income for some people. Aquaculture is the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments, (National Oceanic and Atmospheric Administration, 2019).

Aquaculture is now considered one of the largest sources of food today. The popularity of aquaculture is increasing, leading to a rise in demand for seafood. The rancher's economy becomes more stable with the advancement of technology. Assisting local residents in upgrading their lives by providing them with high-demand job opportunities is crucial. Furthermore, aquaculture can reduce operational costs, produce more product, and, most importantly, be environmentally sustainable.

Importance of automation in aquaculture

Automation is the use of machines or technology to perform tasks without much human intervention. The approach tries to streamline processes, enhance efficiency, and reduce human error. Learn more about automation from this article, (Kanade, 2024).

Due to rising demand for seafood, the aquaculture industry is increasingly turning to automation technologies to improve the efficiency of productivity. Therefore, opportunity to explore artificial intelligence in aquaculture. Artificial intelligence can be practiced in aquaculture. This is because using artificial intelligence can detect any changes in the disease suffered by the fish and can identify the disease suffered by the fish. This method can assist aquaculturists in identifying fish infections sooner, which can enhance treatment results and lessen the disease's ability to spread to other fish populations, (Rather et. al, 2024).

Robotic fish feeders

Functionality and features

A robotic fish feeder offers numerous benefits, making it a valuable tool for both casual fish owners and professional aquarists. One of its primary advantages is the ability to provide a consistent feeding schedule, which is essential for the health and well-being of fish. Regular feeding routines reduce stress and promote healthy growth, ensuring fish receive the nutrients they need. Additionally, robotic feeders prevent common issues like overfeeding or underfeeding by dispensing precise portions of food. Overfeeding can lead to poor water quality, obesity, and harmful ammonia spikes from uneaten food, while underfeeding weakens fish and makes them more susceptible to disease. By automating the feeding process, these devices maintain a balanced environment in the tank, reducing waste and preserving water quality.

For fish owners, robotic feeders offer unparalleled convenience, saving time and effort, especially for those with busy schedules or during vacations. They eliminate the need for manual feeding or reliance on pet sitters, ensuring fish are cared for even when the owner is away. Many models are versatile, capable of handling various food types such as flakes, pellets, and granules, making them suitable for a wide range of fish species. Advanced feeders also allow customizable feeding schedules and remote control via apps, providing flexibility and precision.

In addition to being user-friendly, robotic feeders contribute to the overall health of the aquarium ecosystem. They minimize the risk of water contamination caused by uneaten food and reduce the frequency of water changes, ultimately saving costs in the long run. For professional and commercial use, such as in aquaculture, these feeders automate large-scale feeding, ensuring uniform distribution and reducing labor costs. By integrating seamlessly with other automated systems, robotic fish feeders enhance the efficiency and sustainability of aquarium management, making them an indispensable tool for maintaining a thriving aquatic environment.

Automate feeding schedules based on fish behaviour

The automatic fish feeder technology was developed to improve fish feed selection so that the fish receive a higher food intake and increased growth compared to the manual fish feeder. Most automatic fish feeders had the problem of controlling the amount of fish feed released. The right portion of fish feed supposedly based on the total weight of fish. Fish feed given to fish that are not hungry will be wasted. By monitoring specific behaviors and environmental cues, these systems aim to enhance fish health, improve growth rates and reduce feed wasted (Fish Farm Feeder, 2022) .

First example, computer vision and machine learning that have a system equipped with cameras and deep learning algorithms analyse fish movements and behaviours to determine the optimal feeding time. Next, a sensor integration that detects the environmental changes such as the water ripples caused by fish activity to infer the hungry levels of fishes. A proposed method combines counting the nutrients and estimating ripples behaviour to control the feeding machines effectively.

Environmental conditions

The robotic fish feeder is an advanced solution that can automate the feeding process in aquariums by dynamically adjusting to the environmental conditions, optimizing feeding schedules and portions. These are sensor-enabled systems that monitor critical parameters such as a water temperature, pH and quality. On the change of these conditions, the operation of the feeder changes, which may delay or reduce the food dispensation to avoid stress on the fish and maintain a healthy aquatic environment.

In addition to environmental monitoring, robotic feeders monitor general activity of fish, change behavior or increased activity and regulate the quantity of food dispensed. The feeders are interfaced with automatic portion control thereby delivering food in very accurate amounts required by the species of fish maintained in the tank. Most of them interface with the natural light and day night cycles for feeding at times when fish naturally feed.

Advanced feeding robots can also be integrated with other aquarium automation, including filtration and lighting systems, for even further optimization of the overall health of the aquarium.

Besides that, adaptive algorithms enable the feeder to learn from the conditions in the tank over time, refining its operation for maximum efficiency. In summary, robotic fish feeders offer an efficient, adaptive solution that ensures proper nutrition for fish while maintaining a stable and healthy aquarium ecosystem.

Types and advantages of robotic fish feeders

Figure 1: Single fish feeders (Fish Farm Feeder, 2022)

There are six types of fish feeders. The first type of fish feeders as shown in figure 1 is the single fish feeder for aquaculture. Single fish feeders are individual feeders that are connected to a control panel. The advantage for single fish feeders is low-cost investment. They allow continuous dosing, (Fish Farm Feeder, 2022).

Figure 2: Moving feeders for fish farming (Fish Farm Feeder, 2022)

Figure 2 shows the second type of fish feeders named moving feeders for fish farming. Moving fish feeders is a moving truck with a complete feeding system. The advantage for moving feeders for fish farming is having the ideal feeding capacity for large areas with large tanks, (Fish Farm Feeder, 2022).

Figure 3: Rails feeders for aquaculture farms (Fish Farm Feeder, 2022)

Figure 3 is the rails feeders which are the third type of fish feeders for aquaculture farms. This type of feeders has silos and dispensers that circulate on a rail previously installed over the tanks at a fish farm. The advantage for these feeders is it contributes to labour savings. It has centralized software for feeder and feeding management, (Fish Farm Feeder, 2022).

Figure 4: Drag chain feeding system (Fish Farm Feeder, 2022)

Figure 4 shows the drag chain feeding system. These feeding systems work through pipes with a drag system. The advantage for this feeding system is it has a single feeding line for transporting feed, (Fish Farm Feeder, 2022).

Figure 5: Central feeders (Fish Farm Feeder, 2022)

Next, the figure 5 is the central feeders. These feeders are located in the centre of the farm, with pipes connected to each tank. The advantage for these feeders is it allows them to mix feeding pellets. It permits centralizing pellet storage as well as creating random feeding with multiple doses, (Fish Farm Feeder, 2022).

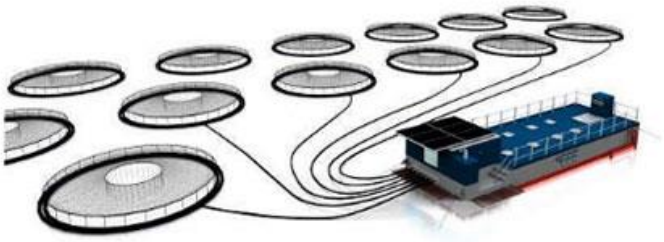

Figure 6: Barges for fish feeding in lakes and sea (Fish Farm Feeder, 2022)

The sixth type as shown in figure 6 is the barges for fish feeding in lakes and sea. In order to be able to feed fish in large areas located far from land, centralized feeders are integrated into a barge. They are usually used for feeding cages in sea or lakes, (Fish Farm Feeder, 2022). The advantage of these feeders is that they can be used for large quantities of cage and in a larger area.

Benefits of robotic fish feeders

There are a lot of robotic fish feeders benefits. First of all, it can optimize the food usage and reduce food waste. This is because robotic fish feeders can feed farmed fish at the right time that has been set in the system on the control panel. In fact, this can ease the use of excessive human labor to feed fish if the large livestock area will again make it difficult to feed at the same time. Furthermore, with the use of robotic fish feeders, the food given to farmed fish is in the same quantity. This will cause no excessive feeding in the fish cage as well as prevent the waste of fish food (Ratiwy & Haetami, 2023).

Second, robotic fish feeders can further improve the efficiency of fish growth and health. This is because with robotic fish feeders, the amount of fish food distributed is exactly according to the needs of each fish cage. The nutrients distributed will also be given according to the needs of farmed fish. This allows each farmed fish to get the proper nutrition as well as increase the growth of farmed fish. Indirectly, the health of farmed fish is also guaranteed because they get adequate nutrition and reduce stress in farmed fish, reducing the risk of getting diseases that will lead to the continued stability of farmed fish health.

Other than that, maintain water quality and be environmentally friendly. An excess of food that is not consumed by fish will be decomposed underwater, thus leading to water pollution. This can be

proven because robotic fish feeders will only distribute food supplies to fish according to the prescribed needs.

Automated cleaning systems

A robot cleaning fish tank and net is an intelligent cleaning device used for cleaning fish tanks and maintaining devices such as fish net's tools. Primarily, robotic cleaners for fish tanks remove algae, wash glasses, vacuum, and purify the water. Devices such as magnetic algae scrubbers or automatic gravel cleaners assist in cleaning by relieving manpower and sharing the workload. For home aquariums, and even commercial aquaculture, systems to automatically clean fish nets have become common. These systems improve water flow and help prevent diseases by cleaning the nets of algae, debris, and biofouling. By automating such tasks, robot cleaners save a considerable amount of time while reducing stress on the fish, hence enhancing the aquatic environment

Functionality and features

RoboSnail is an intelligent robotic cleaning solution designed to make aquarium glass maintenance quick and easy, for the best clarity and a much healthier aquatic environment. Engineered for autonomous operation, it comes pre-programmed to perform daily cleaning cycles, with the added effect of preventing algae build up while keeping the glass surfaces pristine. Utilizing strong magnetic adhesion, the RoboSnail is securely attached to the glass of the aquarium and glides around with ease due to its sleek and low-profile design (Fpsbackuptest, 2012).

Equipped with a programmable timer, this novelty gadget will enable users to plan cleaning according to their schedule. Made from durable, nontoxic materials, the RoboSnail is energy-efficient and safe for the aquatic ecosystem. Quiet operation minimizes disturbance to aquarium inhabitants, while advanced safety mechanisms include edge detection and obstacle avoidance sensors that allow precise navigation around decorations and uneven surfaces.

The RoboSnail can be used with different thicknesses of glass and different tank sizes, hence being versatile on various aquariums. Once it finishes its cycle of cleaning, the device automatically returns to its resting position for ease of access. The RoboSnail reduces manual cleaning drastically, improves water quality, and is a professional solution in maintaining an aquarium.

Robots clean fish tanks and nets

Figure 7: RoboSnail an aquarium Roombas is a small robot that functions as a vacuum (Fpsbackuptest, 2012) .

The fish tank and net cleaning robot refers to an innovative solution that automates aquarium maintenance and the cleaning of important tools such as fishing nets. In the case of fish tanks, robotic devices are designed to perform tasks such as removing algae, cleaning glass or acrylic surfaces, vacuuming debris from substrates, and even monitoring and maintaining water quality. These robots, which can include magnetic algae scrubbers, automatic gravel vacuums, or more advanced underwater cleaning robots, significantly reduce the time and effort required for manual cleaning. They ensure a consistent level of cleanliness, which is important for the health of the aquatic environment and the well-being of the fish and plants in the tank (Fpsbackuptest, 2012).

When it comes to cleaning fish nets, robotic or automated systems are often used in both home aquariums and large-scale aquaculture setups. The system is designed to remove algae, biofouling and other debris that can accumulate on fishing nets over time. In home aquariums, smaller automated devices can clean and sanitize hand nets, ensuring they remain free of contaminants that may harm fish. In commercial fish farming, robotic net cleaners are used to clean large nets that enclose fish in open. water environments, maintaining proper water flow and preventing the accumulation of harmful substances that can lead to disease outbreaks

The use of robotic cleaners for fish tanks and nets offers many benefits, including saving time, reducing manual work and minimizing the risk of spreading contaminants. This device also helps maintain a healthier and more stable aquatic environment by ensuring that cleaning tasks are done regularly and thoroughly. Whether for hobbyists maintaining small home aquariums or professionals managing large-scale aquaculture operations, robotic cleaning technology represents a valuable tool to facilitate maintenance and improve the overall health of aquatic ecosystems.

Enhanced water quality and fish health

The Robotic Aquarium and Net Cleaning System will remain the transformative tools needed in solving the best water quality to maintain aquatic life. Advanced technologies now perform key maintenance of consistent care of the aquarium environment. Such systems contribute to a generally healthier ecosystem by preventing some of the most prevalent problems with freshwater aquariums, such as algae growth and accumulation of organic wastes due to poor circulation of water (Fpsbackuptest, 2012).

One of the most valued advantages of robotic cleaners is preventing algae formation on the glass of an aquarium. If allowed to grow, algae will block the penetration of light, which is necessary for the photosynthesis of water plants and disruption of the balance in the tank. Continuous removal of algae provides for good visibility and maintains the natural processes of keeping the water clean. Organic debris, such as food that is not consumed and waste from fish, along with decaying plant material, is effectively removed by robotic net cleaners. These substances, if left to accumulate, would degrade into harmful compounds such as ammonia, nitrites, and nitrates, which deteriorate water quality and may lead to stress, disease, or even mortality in fish.

Robotic systems provide the perfect precision and continuity with no chances of overcleaning, thus reducing the risks of perturbing beneficial bacterial colonies that attach themselves to gravel surfaces and other filter media. This bacterium is an important aspect in the process of biological filtration by degrading substances into much less harmful components to preserve the water's chemical balance. Moreover, these robots act in such a quiet manner that they do not disturb the fish at all, which is one of the most critical factors for their immune system and good health in general.

By automating routine maintenance tasks, robotic cleaning systems save time for the aquarium owner and create favourable, stable conditions for the aquatic life. These systems are especially helpful for larger or more complicated aquariums, where manual cleaning is time-consuming and less efficient. Conclusion Robotic aquarium and net cleaning systems enhance the quality and health of the water for the fish by sustaining regular maintenance, preventing waste build up that could be harmful, and preserving the ecological balance within the tank. This leads to an aesthetically pleasing, biologically stable, safe environment for aquatic life.

Benefits of automated cleaning system

An automated tank and net cleaning system present a large degree of advantage to aquarium owners by enhancing operational efficiency and, in turn, the health aspect of the aquatic environment (Fpsbackuptest, 2012). This system reduces time and effort by making regular maintenance easy without involving much in keeping the tank at its best. Automated cleaning prevents algae, debris, and waste from building up, allowing superior water quality and a healthier ecosystem for fish and other aquatic organisms. These systems can be programmed to operate at specific intervals, providing

consistent and comprehensive cleaning without the risk of missing spots or over-scrubbing areas. This will result in clearer water, more stable conditions in the tank, and an aesthetically pleasing environment. The automated systems are very discreet and efficient in operation, minimizing agitation among the creatures of the tank, which is usually present during manual cleaning. By preventing the build-up of these pernicious compounds, they promote long-term health for both life and plants that live in the water. Over time, automated cleaning systems bring economies through minimizing the need for cleaning supplies and reducing the risk of damage to tank surfaces. In conclusion, automated cleaning solutions provide a more efficient, effective, and sustainable way of maintaining aquariums, ensuring the aesthetic and ecological well-being of the tank.

Conclusion

In conclusion, aquaculture automation represents a transformative approach to addressing the challenges faced by the aquaculture industry. By integrating advanced technologies such as IoT, AI, robotics and machine learning, automation has the potential to enhance productivity, optimize resource utilization and ensure sustainability. These technologies allowed for efficient feeding systems, precise monitoring of water quality and real time health assessment of aquatic species, thereby reducing the waste and improving overall yield.

Moreover, this shift toward automation not only addresses the growing global demand for seafood but also ensures that aquaculture practices align with sustainable development goals. However, the adoption of these technologies also presents challenges, including high initial costs, technical complexity and the need for skilled labour.

As we move forward, aquaculture automation has the potential to set a new standard for the efficient and sustainable food production. By embracing innovation, aquaculture can become a cornerstone in ensuring global food security while preserving marine ecosystems for the future generations.

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