Int.J.HIT.TRANSC:ECCN.Vol.10: Special Issue (2025) Page 54-57 ISSN: 0973-6875

Available Online at www.hithaldia.in/locate/ECCN

ORIGINAL CONTRIBUTION

IoT-Based Smart Fishery: Revolutionizing Aquaculture Management

[1]Jinat Kaderi, Joydev Jana, K. Sukriti, Koustav Nayak, Rishav Panda, [2]Banibrata Bag

[1]*UG student, Dept. of Electronics& Communication Engineering, Haldia Institute of Technology, Haldia, Purba Medinipur, West Bengal*

[2]*Dept. of Electronics& Communication Engineering, Haldia Institute of Technology, Haldia, Purba Medinipur, West Bengal*

ABSTRACT

This paper presents an IoT-enabled smart fishery automation system that employs a combination of ESP32 and Arduino Nano microcontrollers to monitor and manage a fish pond autonomously. The system is designed to feed the fish regularly, monitor water quality, and maintain the pond environment, enhancing fish growth and reducing labor. A line-follower bot, equipped with a food dispenser, navigates the pond along a predefined black tape path controlled by an Arduino Nano. The ESP32 serves as the master control unit, overseeing water parameters such as temperature and levels and managing pumps for draining excess water and supplying oxygen. This implementation leverages real-time data analytics and predictive capabilities to improve productivity, ensure sustainability, and address the challenges faced in traditional aquaculture. Furthermore, the final product is designed to balance functionality and cost-effectiveness, making it both competitive and affordable, ensuring it is accessible to a wide range of families.

KEYWORDS: *Smart Fishery, fishery automation, Water bodies monitoring, IoT, Fish health monitoring*

1. INTRODUCTION

As global seafood demand continues to rise due to an increasing population and changing dietary preferences, implementing IoT-driven solutions will be crucial for ensuring sustainable practices in aquaculture. By embracing these advanced technologies, the fishing industry can contribute to food security while minimizing its ecological footprint, positioning smart fisheries as essential components of a responsible and future-focused seafood supply chain.

The Internet of Things (IoT) is revolutionizing traditional aquaculture, paving the way for a cutting-edge fishery system that significantly enhances the way fish farming is conducted. By incorporating IoT technologies, fish farmers can achieve real-time monitoring of aquatic environments, leading to improved productivity and sustainable practices in fish farming. This paper delves into the comprehensive design and implementation of an IoT-based smart fishery, detailing its numerous advantages. It highlights the integration of automated environmental monitoring systems that continuously track water quality parameters such as temperature, pH levels, and dissolved oxygen, ensuring optimal conditions for fish health. Additionally, it explores intelligent feeding systems that utilize data-driven algorithms to dispense the right amount of feed at the right times, effectively reducing waste and boosting maturation. Furthermore, the paper emphasizes the role of predictive analytics in forecasting potential challenges and making informed decisions, ultimately enhancing operational efficiency. Through these innovations, an IoT-driven approach to aquaculture maximizes yield and promotes ecological sustainability in the fishing industry.

2. Literature Review

Implementing the Internet of Things (IoT) in aquaculture has garnered significant attention in recent years, with various studies showing its potential to address critical challenges in fish farming. Li et al. (2020) demonstrated the effectiveness of IoT-based water quality monitoring systems in maintaining optimal

*Corresponding Address: banibrata.ecehit@gmail.com

DOI: 10.5281/zenodo.14591595

environmental conditions for aquaculture [1]. Their study emphasized the importance of monitoring dissolved oxygen, pH, and ammonia levels using various sensors integrated with IoT platforms to provide real-time alerts and analytics. Ahmed et al. (2019) explored the integration of LoRaWAN in remote fish farms, ensuring reliable data transmission even in areas with limited connectivity [2]. Additionally, Sharma and Gupta (2021) highlighted the role of AI-driven feeding mechanisms in minimizing feed wastage [3]. Their system utilized underwater cameras and machine learning algorithms to analyze fish behavior, allowing for adjustments in feeding schedules. Zainuddin et al. (2018) conducted a comparative analysis between automated feeders and manual feeding methods, revealing a 20% improvement in feed efficiency with IoT-enabled systems [4]. Zhou et al. (2022) implemented computer vision-based fish health monitoring using IoT cameras, achieving early detection of common fish diseases and reducing mortality rates by 30% [5]. Kumar et al. (2020) focused on using predictive analytics to forecast potential disease outbreaks, leveraging historical data and AI for risk assessment. Singh et al. (2019) introduced a line-following robot equipped with environmental sensors for routine maintenance tasks on aquaculture farms, simplifying remote monitoring and control through its integration with IoT platforms [6]. Furthermore, a review by Patel and Rao (2021) and Singh A. et al. (2019) have discussed the scalability of self-sufficient robotic systems, highlighting their cost-effectiveness and efficiency [7, 8]. These studies collectively underscore the potential of IoT in aquaculture, paving the way for more innovative and sustainable fishing systems.

System Design and Components

An Internet of Things (IoT)-based smart fishery operates through three essential components:

A. **ESP32 (Master Controller)**:

- Receives user input for the feeding schedule and various parameters.
- Monitors sensors for water temperature and level.
- Controls two pumps through a relay module.

B. **Sensors and Actuators**:

These devices monitor critical parameters, including temperature, pH levels, dissolved oxygen, and ammonia concentrations, ensuring optimal conditions for aquatic life.

- Temperature Sensor (e.g., DS18B20) for water temperature.
- Ultrasonic Sensor to measure water level.
- Water Drain Pump to remove excess water.
- Oxygen Pump to maintain oxygen levels.
- Servo Motor on the bot to control food dispensing.

Automated Feeding Mechanisms:

Feeder systems are intelligently controlled based on fish activity levels and real-time water quality data, optimizing feeding efficiency.

Line Follower Bot:

- Follows a black tape path around the pond.
- Dispenses food via servo motor at specific intervals.

Underwater Imaging Systems:

High-resolution cameras facilitate observing fish behavior, enabling the detection of early stress or disease indicators.

C. **Connectivity: Wireless Communication Protocols**

The system utilizes protocols such as Wi-Fi, ZigBee, or LoRaWAN for efficient data transmission among devices.

Cloud Integration: The data collected is securely stored and processed in the cloud, allowing remote access to facilitate analysis and informed decision-making.

Data Processing and Analytics: Advanced artificial intelligence (AI) and machine learning algorithms are employed for predictive analytics, particularly in anticipating disease outbreaks within fish populations. The system generates actionable insights and real-time alerts based on analyzed data, supporting dynamic management strategies.

Functional Modules:

Environmental Monitoring: Continuous tracking of water quality parameters ensures that conditions remain within optimal thresholds for fish health. The system can send alerts for any critical deviations in these parameters, thus mitigating mortality risk.

Smart Feeding Systems: The application of AI in developing feeding schedules reduces feed wastage while promoting optimal growth rates. Sensor integration aligns feeding behavior with water quality conditions and fish activity. **Disease Detection**: By leveraging underwater imaging and AI-based diagnostic models, the system identifies anomalies in fish movement and physical appearance. This capability facilitates early intervention, minimizing financial losses and preventing disease outbreaks.

Line-Follower Robot for Maintenance and Surveillance:

Autonomous robotic units equipped with line-following technology navigate predetermined pathways within aquaculture environments. These robots, integrated with IoT capabilities, efficiently collect environmental data and execute essential maintenance tasks.

Fig.1. Line-Follower Robot designed for the proposed system.

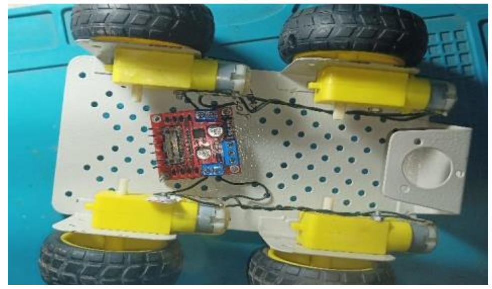

Fig.2. Circuitry of the Line-Follower Robot designed for the proposed system.

3. Algorithm and Pseudo-code

Master Control Algorithm:

Step 1*: Initialize Wi-Fi, sensors, and relay outputs.*
Step 2*: Start an infinite loop:*

- *Read water temperature and water level.*
- *If the temperature or water level exceeds the set thresholds, activate the corresponding pump.*
- *If feeding time appears, send a signal to the Arduino Nano to start feeding.*
- *Send real-time data to the IoT dashboard.*

Arduino Nano - Bot Controller Algorithm*:*

Step 1*: Initialize IR sensors, motor drivers, and servo.*
Step 2*: Start an infinite loop:*

- *Wait for the feeding command from ESP32.*
- *Start moving along the black line using IR sensors.*
- *At each predefined stop, activate the servo to release food.*
- *Stop once the feeding cycle is complete.*

Pseudo-code:

```
Initialize sensors and motors
While True:
    Read left, center, and right sensor values
    If the center sensor detects the line:
        Move forward
    Else If the left sensor detects the line:
        Turn left
```

Else If the right sensor detects the line:
  Turn right
Else:
  Stop
Send environmental data to the cloud

4. Conclusion

Integrating sensors, data analytics, and connectivity allows fishery operators to monitor water quality, fish health, and environmental conditions in real-time. The system significantly enhances Productivity by optimizing conditions and feeding schedules, boosting fish growth and yield. Reducing feed wastage and energy consumption lowers operational costs. Moreover, using resources efficiently minimizes environmental impact. Smart fisheries utilize predictive analytics to optimize feeding schedules, reduce waste, and improve stock management, leading to healthier fish populations and higher yields. However, the initial costs can be high, hindering small-scale farmers' adoption. Remote fish farms might face challenges with stable internet access. Therefore, developing scalable and modular systems is crucial for broader adoption. Insights gained from analytics enhance long-term management strategies. The functionality and cost-effectiveness of this solution make it accessible and appealing to a wide range of farmers.

Finally, there is a crucial need for further research into the long-term use and maintenance of smart fishery and aquaculture. Understanding the durability and reliability of these systems over time is essential, along with the resources and necessary support for their sustenance.

REFERENCES

[1] Li, J., et al. (2020). "IoT-based water quality monitoring for sustainable aquaculture." Sensors and Actuators B: Chemical, 321, 128679.

[2] Ahmed, M., et al. (2019). "LoRaWAN-enabled IoT systems for remote aquaculture monitoring." Journal of Aquatic Technology, 45(3), 215-229.

[3] Sharma, P., & Gupta, N. (2021). "AI-driven feeding systems in smart fisheries." Artificial Intelligence in Aquaculture, 6(1), 1-12.

[4] Zainuddin, M., et al. (2018). "Efficiency analysis of automated feeding systems in aquaculture." Aquatic Economics Journal, 29(4), 300-317.

[5] Zhou, T., et al. (2022). "Computer vision-based disease detection in aquaculture." Computers and Electronics in Agriculture, 190, 106468.

[6] Kumar, R., et al. (2020). "Predictive analytics in IoT-based aquaculture systems." International Journal of Smart Agriculture, 12(2), 88-95.

[7] Patel, D., & Rao, S. (2021). "Autonomous robotic systems in large-scale aquaculture: A review." Aquaculture Engineering, 55, 32-45.

[8] Singh, A., et al. (2019). "Line-following robots for aquaculture maintenance." Robotics and Automation in Aquaculture, 10(4), 44-51.