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"IoT-Driven Fish Pond Automation: Feeding and Obstacle Avoidance"

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Abstract: This paper presents the design and implementation of a smart, IoT-enabled aquatic boat system equipped with four ultrasonic sensors, four directional motors, and an automated food dispenser for periodic fish feeding. The system is designed to autonomously avoid obstacles while navigating and also supports manual control and scheduling via the Arduino IoT Cloud. The periodic feeding process is synchronized with boat movement in a square pattern, ensuring uniform distribution across the waterbody.

***Index Terms* - Aquatic automation, obstacle avoidance, IoT, Arduino Cloud, fish feeding system, ultrasonic sensor, servo motor.**

I. INTRODUCTION

The increasing demand for automation in aquaculture has led to the development of systems that assist with daily fish feeding tasks. This paper proposes an intelligent, IoT-driven aquatic boat system designed to automate fish feeding while simultaneously addressing the challenges of obstacle detection and efficient navigation. The system is equipped with an array of ultrasonic sensors, strategically placed to detect pond boundaries or obstructions from all directions, ensuring collision-free movement within the aquatic environment.

To achieve uniform feed distribution, the boat follows a predefined square navigation pattern controlled by multiple directional motors. A servo motor-powered food dispensing unit is activated at scheduled intervals, ensuring timely and consistent feeding across the entire pond area. The heart of the system is an ESP32 microcontroller connected to the Arduino IoT Cloud, enabling both automated and manual control. Users can monitor system status and issue real-time commands via a cloud dashboard accessible on smartphones or PCs.

This dual-mode functionality not only increases user flexibility but also enhances operational reliability, especially in variable field conditions. The system's automation minimizes manual labor, ensures consistent feeding routines, reduces waste, and promotes balanced fish growth. Additionally, the cloud-based control mechanism allows remote supervision, making it ideal for large-scale or remotely located aquaculture setups. Overall, the proposed solution demonstrates how IoT integration can revolutionize traditional fish farming practices by improving efficiency, productivity, and sustainability.

II. System Overview

The system integrates four ultrasonic sensors, four directional motors (front, back, left, right), a food dispenser operated by a servo motor, and an ESP32 microcontroller connected to the Arduino IoT Cloud. As show in the below flow chat fig 1.

A. Obstacle Detection & Avoidance

Each ultrasonic sensor is strategically positioned to face a different direction—front, back, left, and right—allowing the boat to detect obstacles from all sides. These sensors continuously measure the distance between the boat and nearby objects or pond boundaries. When an obstacle is detected within a predefined threshold distance (e.g., 20 cm), the system identifies the direction of the obstacle and triggers the corresponding motor to respond. For instance, if the front sensor detects an object, the back motor is activated to move the boat in the opposite direction. This responsive mechanism enables the boat to steer away from pond walls or other obstructions automatically, preventing collisions. As a result, the boat remains well-centered and can continue its feeding route smoothly without manual intervention, enhancing safety and operational efficiency in the pond environment.

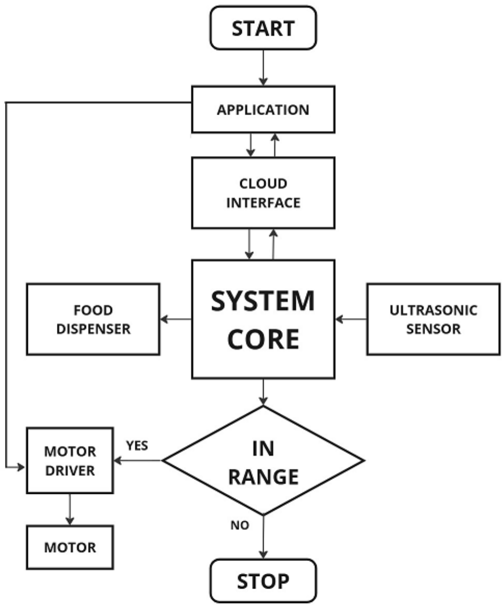

Fig. 1. Overall System Workflow

B. Manual Control

Users can manually control each motor through the Arduino IoT Cloud app interface, providing real-time remote maneuverability alongside the system's autonomous navigation features. This dual-mode operation allows users to intervene when necessary for example, to redirect the boat, pause movement, or perform targeted feeding. The intuitive app interface ensures seamless interaction, making the system flexible and user-friendly even from a distance.

C. Automated Feeding Mechanism

The food dispenser is operated by a servo motor, which is triggered based on a predefined time schedule configured through the Arduino IoT Cloud. At the scheduled time, the servo motor rotates to open the dispenser lid for a fixed duration, allowing a controlled quantity of fish feed to be released into the pond. After dispensing, the system automatically initiates a square-pattern movement of the boat using directional motors. This movement ensures that food is evenly spread across different areas of the pond, preventing overcrowding of fish in one location and promoting uniform growth. The entire process is automated, reducing manual effort and ensuring that feeding occurs consistently and efficiently at the optimal time.

III. IMPLEMENTATION

The implementation of the smart aquatic feeding boat involved a multi-phase process, including the integration of hardware components, development of control algorithms, design of a user-friendly application interface, and rigorous testing in a real pond environment measuring 20ft x 10ft. The ESP32 microcontroller served as the central unit, programmed using the Arduino IDE to manage all operations. It controlled the four directional motors responsible for navigation, the servo motor for operating the food dispenser, and established seamless communication with the Arduino IoT Cloud platform. This connectivity enabled both scheduled automation and real-time manual control via the cloud interface. The system was tested under various conditions to ensure reliable obstacle avoidance, accurate food dispensing, and stable performance in a natural aquatic setting. The system circuit diagram is shown in Fig. 2.

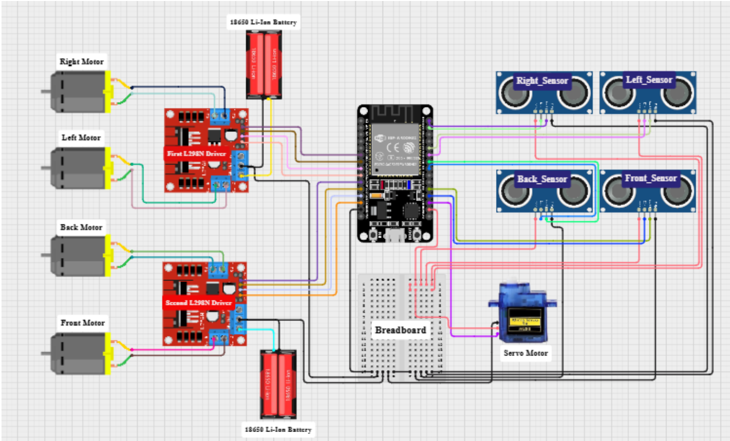

Fig.2. system Circuit diagram showing motor, sensor, and ESP32 connections

The obstacle avoidance system is implemented using four HC-SR04 ultrasonic sensors, each strategically positioned on the front, back, left, and right sides of the boat. These sensors continuously measure the distance between the boat and nearby objects or pond boundaries. When an obstacle is detected within a predefined range (e.g., 20 cm), the system identifies the direction of the obstruction and immediately activates the corresponding motor in the opposite direction to steer the boat away. This real-time reactive mechanism ensures smooth, uninterrupted navigation while preventing collisions with pond walls or floating debris. The obstacle avoidance logic is embedded into the ESP32 microcontroller, allowing for seamless integration with the boat's overall movement and feeding schedule. The functional prototype of the boat, including sensor placements and motor configuration, is illustrated in Fig. 3.

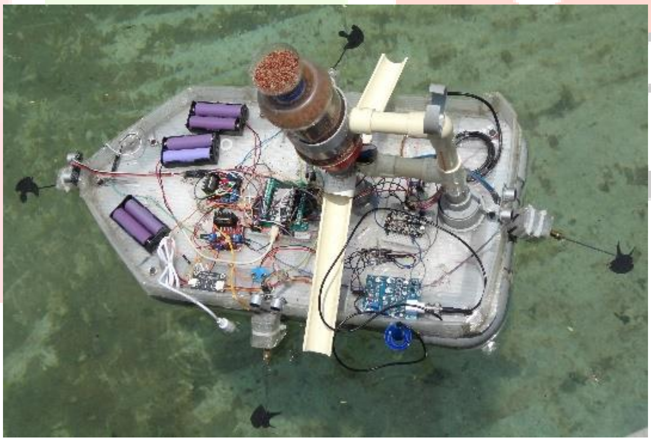

Fig.3. IoT-Driven Fish Pond Automation Boat prototype

The automated feeding process is governed by a predefined schedule configured within the Arduino IoT Cloud. When the scheduled feeding time arrives, the ESP32 microcontroller triggers the servo motor to rotate and open the food dispenser, releasing a measured quantity of fish feed into the pond. Following this, the boat executes a square-shaped movement pattern to ensure even distribution of the feed. This movement sequence involves activating the back motor for a specific duration, followed by the left, front, and right motors, each in turn, to cover all areas of the pond uniformly. This systematic navigation prevents overcrowding of fish in one location and ensures that feed reaches all corners of the pond.

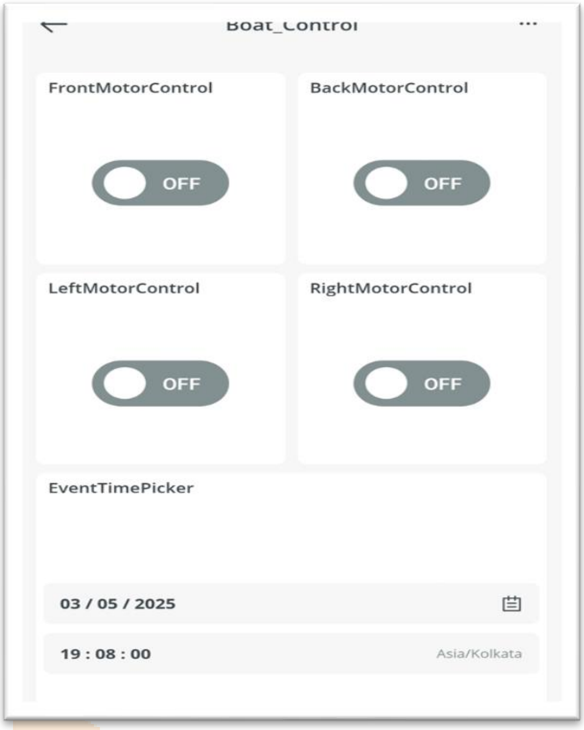

Fig.4. Application interface on Arduino IoT Cloud.

To enhance user experience and control, the system features a user-friendly graphical interface accessible via the Arduino IoT Cloud dashboard, as shown in Fig. 4. Through this intuitive interface, users can monitor real-time data such as motor status, feeding activity, water temperature (if sensors are integrated), and system connectivity metrics including Wi-Fi signal strength and battery levels. The dashboard provides visual alerts and notifications for critical events such as obstacle detection, motor faults, or missed feeding cycles, enabling proactive maintenance and rapid troubleshooting.

Users have the flexibility to adjust feeding schedules dynamically based on pond conditions or fish growth stages, allowing fine-tuning of feed quantities and intervals to optimize fish health and reduce feed wastage. The interface also supports manual override controls, enabling operators to initiate immediate feeding or remotely control individual motors to reposition the boat for maintenance, cleaning, or emergency interventions.

Furthermore, the cloud-based platform facilitates secure multi-user access with role-based permissions, making it easy for farm managers, technicians, and remote consultants to collaborate efficiently. Historical logs and data trends are stored in the cloud, supporting performance analysis and decision-making for long-term pond management.

This seamless integration of automation and manual control enhances operational reliability, ensuring timely feeding while simplifying system management. It makes the smart aquatic boat system adaptable to diverse aquaculture environments, from small-scale ponds to large commercial farms. Moreover, the real-time control capability provides operational flexibility, allowing users to intervene promptly if needed during the boat's operation such as in the event of unexpected obstacles, system errors, or changes in feeding requirements. This added layer of manual oversight significantly improves safety and adaptability, complementing the automated processes for a robust and responsive fish feeding solution.

IV. RESULTS

The system was tested extensively in a controlled pond environment to evaluate its performance, reliability, and responsiveness. The obstacle detection and avoidance mechanism, powered by four HC-SR04 ultrasonic sensors, functioned accurately and consistently. During multiple test runs, the boat successfully identified nearby obstacles and pond boundaries within the predefined detection range, activating the appropriate motors to change direction and avoid collisions. This ensured that the boat remained within safe operational limits and maintained a centralized path throughout the feeding routine. As shown in Fig. 5, the boat demonstrated effective real-time response to obstacles, confirming the robustness of the navigation algorithm and sensor integration. These results validate the system's capability to operate autonomously and safely in real-world aquaculture conditions.

Fig.5. Obstacle avoidance mechanism in action during pond testing.

The automated feeding function activated precisely according to the scheduled time set in the Arduino IoT Cloud. Upon activation, the servo-operated food dispenser released a consistent quantity of feed, followed by the execution of the programmed square movement pattern. This movement ensured that the feed was evenly distributed across all areas of the pond, preventing overcrowding of fish in a single location and promoting balanced feeding. Fig. 6 illustrates the boat in action, dispensing feed and navigating the pond in a structured path to achieve optimal coverage.

Fig.6. Automated fish feed distribution across the pond.

Manual control through the application interface was smooth, responsive, and user-friendly, allowing users to override automated functions when necessary. This feature proved particularly useful during system calibration, troubleshooting, and emergency scenarios where quick human intervention was required. As shown in Fig. 4, the mobile application interface provided intuitive buttons and real-time feedback, making it easy to control individual motors and manage feeding schedules directly from a smartphone or computer.

During the testing phase, the system maintained stable and consistent connectivity to the Arduino IoT Cloud, ensuring uninterrupted real-time updates, control commands, and system status monitoring. This reliable cloud integration allowed for remote management of the boat even from distant locations, enhancing the system’s flexibility and practicality.

A demonstration video of the working system is available at: **Video Link**:
showcasing the boat’s obstacle avoidance, scheduled feeding, and manual control capabilities in action.
Overall, the successful integration of hardware components, embedded control software, and cloud-based communication validated the design objectives. The system exhibited strong performance, efficient functionality, and real-world feasibility, confirming its potential for practical deployment in aquaculture environments.

V. CONCLUSION

The proposed IoT-Driven Fish Pond Automation system offers an effective and efficient way to automate fish feeding with integrated obstacle avoidance and cloud-based manual control. Future work may include integration with sensors for water quality monitoring and solar power for sustainable operation.

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