

AI-integrated Underwater Surveillance Robot for Aquatic Life Monitoring and Water Quality Assessment

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Abstract

The increasing number of fish farms worldwide faces many problems, such as labor shortage, high operational cost, difficulty in monitoring and maintenance, water contamination, high acidity levels, fish illness, and high population density. The main objective of this study is to design and implement a smart, real-time water quality monitoring and management system for aquaculture using Internet of Things (IoT) and Artificial Intelligence (AI) technologies. The system integrates pH, turbidity, underwater ultrasonic, and temperature sensors connected to an ESP32 microcontroller programmed using C++ and ESP-IDF. A design-build-test approach was adopted, where sensor calibration, data acquisition, and cloud-based analysis were performed at hourly interval to validate system performance. Data were transmitted via SIM800L and GPS modules to Google Sheets and Firebase for real-time visualization and storage, and the system was linked to both a webpage dashboard and mobile application for remote monitoring. Experimental evaluation demonstrated reliable wireless communication, accurate sensor readings within $\pm 2\%$ error, data uploading within 500 ms, and stable cloud synchronization. AI and ML algorithms were applied to analyze data, detect anomalies, predict water quality variations, and recommend corrective measures. This solution introduces a modular underwater monitoring platform with wireless and wired communication, enhancing automation, scalability, and sustainability in aquaculture management. Overall, the project effectively minimizes labor, cost, and time while ensuring maximum yield and a healthier aquatic environment.

Keywords: fish farm monitoring; underwater surveillance robot; real-time data; web-based application