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IoT Aquaculture System Prototype

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Abstract: Aquaculture is a major factor in securing the world's food supply and a source of environmentally friendly protein at the same time. Nonetheless, the traditional aquaculture installations have suffered from problems like in-depth supervision, irregular feeding, and changing environmental conditions. The fast coming up of IoT, AI, and ML has turned the aquaculture industry around by making possible the real-time data acquisition, predictive analytics, and automated processes. The present Paper provides an extensive review of the research about the combination of IoT and AI in the aquaculture, especially in the context of water quality. Monitoring, automatic feeding, and the creation of a smart management framework are the main areas of concern. The review also mentions the attempts made in the experimental setups incorporating ESP32 and Arduino, where the cloud systems have been utilized for inland-based aquaculture. The aquatic health monitoring and controlling parameters were pH, temperature, turbidity, and ammonia. With the help of IoT, the environmental parameters within which the aquatic turnovers are kept have been controlled with a very high level of precision. Hence, the decrease of turnover lowers the requirement for manual interventions that in turn support sustainability. Thus, the review presents the evolution of smart aquaculture, assesses the current installations in terms of their merits and demerits, and paves the next step in aquaculture as the continuation of the journey.
Keywords Aquaculture, IoT, AI, ESP32, pH, temperature, turbidity, ML, Remote Monitoring, Automation.

INTRODUCTION

The fish farming industry, referred to as aquaculture, is one of the sectors that has shown more rapid growth than other sectors in the global food production ecosystem. Moreover, protein production with less impact on the environment is one of the main benefits of the aquaculture industry. thus, providing a solution to the problem of protein deficiency caused by declining natural fish populations and the increasing demand for fish and seafood. In addition, the true success of aquaculture today relies on the perfect combination of three water parameters: Temperature, PH, and clarity. There are still traditional methods for monitoring and controlling these parameters, but these methods are often very labour-intensive, time-consuming, and the process is also prone to many of the human-handling errors that happen along the way. The agriculture sector has been transformed with this combination of IoT and AI technologies with monitoring and control systems being IoT system based on sensors and automated. Microcontrollers, and the cloud connection can provide not only real-time data collection but also, automated decision-making. AI and ML then algorithms are employed with the purpose of augmenting these systems work much better if they are combined with personnel in a meaningful way to spot data trends. Anticipating anomalies, and making best use of resources. To reduce the cost and power Consumption, researchers have been using ESP32 and Arduino microcontrollers to create systems that can monitor and control an area continuously. Firebase cloud platforms allow for remote access, visualization, and Automation. This paper presents the results of a literature survey on the current IoT-based smart aquaculture research. The literature review includes ten of the most important studies on the development of the ESP32 prototype. The integration of IoT and sensor technology is the main topic of the review while the rest of the approaches that achieve efficient and sustainable ecosystems through tech and decisions are also discussed.

LITERATURE REVIEW

The IoT technologies have now reached the stage where they can completely replace the traditional aquaculture management and monitoring systems.

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The manual monitoring system is the backbone of traditional fish farming practices, and it often leads to problems like irregular feeding, incorrect monitoring, and poor water quality, which eventually affect the growth and survival of fish. However, these drawbacks are addressed by the different IoT solutions that researchers propose. This includes smart sensors and microcontrollers, automation units, and cloud platforms working together. The work in [1] presents an IoT-based Smart Aquaculture System using the ESP32 integrated pH microcontroller sensors, DS18B20 temperature sensors, turbidity modules, and ultrasonic sensors. The automatic feeding is done by a servo motor system, and the authors claim that the following has been achieved: 95% accuracy for sensors and 98% accuracy in total. Thus, the operational efficiency is established and the reliability of real-time monitoring and automatic control is proven. In a like manner, in [4] It delves into cloud-based monitoring. The architecture constantly evaluates parameters such as pH, turbidity, and temperature of water and subsequently transmits them to Adafruit for real-time rendering, alerting, notifying, and controlling the environment. This case depicts the growing reliance on cloud services in the aquaculture industry as they offer remote access to the aquaculture tanks. The quality of water is one of the most important factors affecting the health of fish. This is pointed out in [3], which indicates dissolved oxygen, Temperature, ammonia, and pH as three major factors in fish growth and, if not properly controlled, Death. Their IoT-based architecture facilitates the integration of many sensors, cloud storage, and mobile access to enable farmers to act promptly. [2] goes beyond basic IoT monitoring by incorporating machine learning and its (ML) methods for improvement in This leads to prediction accuracy. The authors argue that the ML models can "detect abnormal situations before they become critical," which implies that water quality fluctuations can be detected earlier. Moreover, the paper states: that regression calibration has the potential to elevate the low-cost sensors to high performance and precision standards to a large extent. As in [6], a low-cost and straightforward method is suggested in which the proposed fish monitor system is custom-made for small and rural fish farms. The authors claim that the system is "affordable, easy to apply and suitable for small 'farmers,'" implying that IoT technology is accessible to resources-limited areas. The ESP32 microcontroller is the one that has been preferred in all the studies mentioned above due to its very low power consumption, Wi-Fi availability, and the capability to handle different kinds of sensors [1], [4]. The shared features noticed in the application of multi-parameter sensing: pH, temperature, and turbidity, referenced literature. DOI), cloud dashboards for remote access, and the whole process using motors, aerators, and relays automation. These systems are integrated that constantly monitor environmental conditions together with the reduction of human power requirement, and at the same time, the eco-friendly practice of Aquaculture is supported. The articles reviewed were those that showed the IoT-based aquaculture systems as being reliable, flexible, and even economical solutions that could greatly improve the health of fish and the productivity of farms.

PROPOSED SYSTEM METHODOLOGY

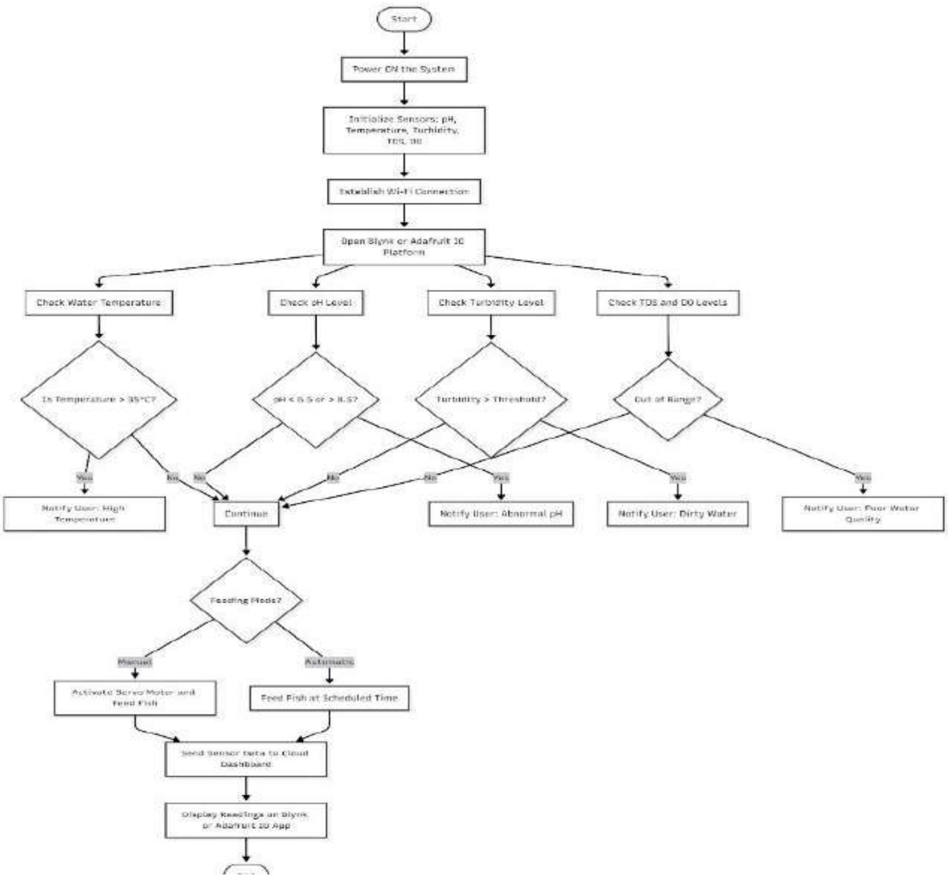

Fig:1 System model

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IoT-enabled aquaculture fish farming plan should be automated and optimized with the application of intelligent systems. Sensors and controls. The system introduces a network of sensors that will keep on monitoring very thoroughly and accurately water quality parameters like pH, temperature, turbidity, and total dissolved solids, so the condition is not always good for fish. An ESP32microcontroller acts as the core of the operation, and it is in charge of collecting and processing sensor data and forwarding it to the cloud for real-time monitoring and decision making. The setup also includes actuators or devices like aerators and feeding machines that will work automatically following environmental conditions and predefined limits. The data through the cloud can also be seen and controlled from a distance by means of a web and mobile app that enables the farmer to supervise and modify the operations at his convenience.The combination of hardware, software, and IoT analytics leads to healthier fish, improved feeding cycles, and less human intervention, among others.

EXPERIMENT RESULTS

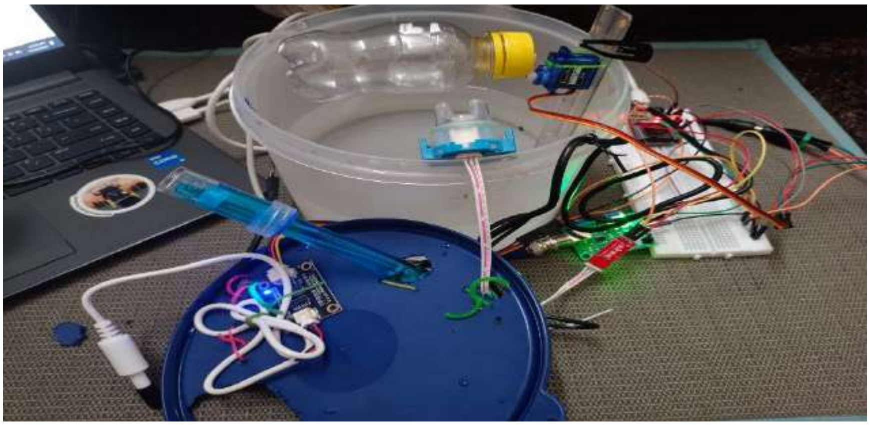

Fig2: IOT aquaculture prototype

In this picture, IoT aquaculture prototyping can be seen. Various sensors like pH, temperature, TDS, and turbidity were fixed in the prototype along with the actuators. The servo feeder and water pump are included in this list. The ESP32 is on a breadboard, which is the interconnection for all components for live water monitoring and control two ways. Monitoring and control.

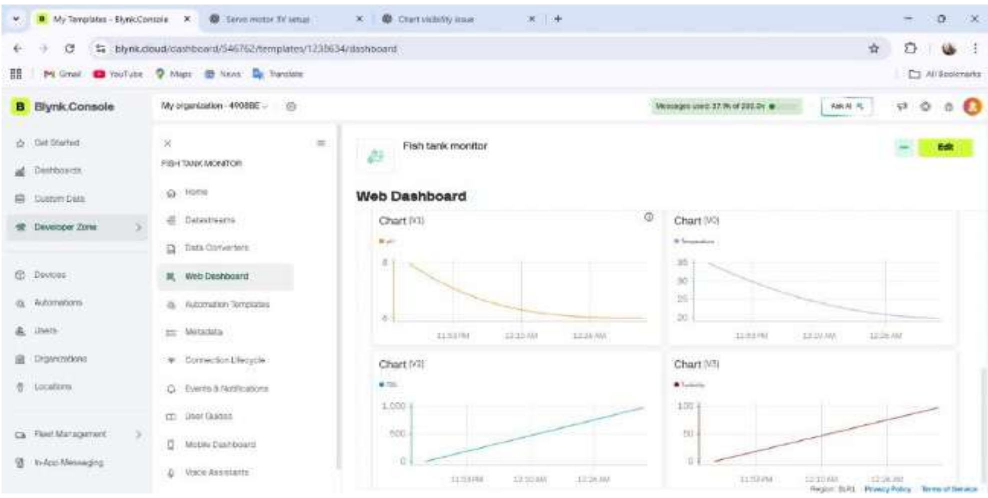

Fig3

This shows the whole wise device Fish Tank Monitor is connected to the Blynk cloud and is online. The pH and temperature graphs are displayed, which is the indication that the system is sending sensor data actively at the same time.

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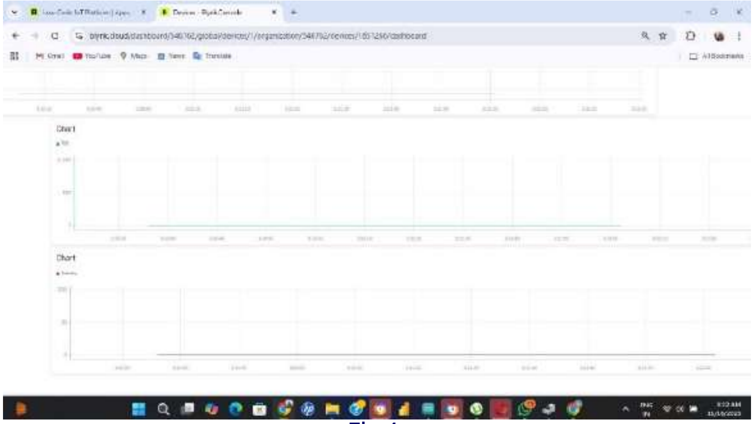

Fig 4

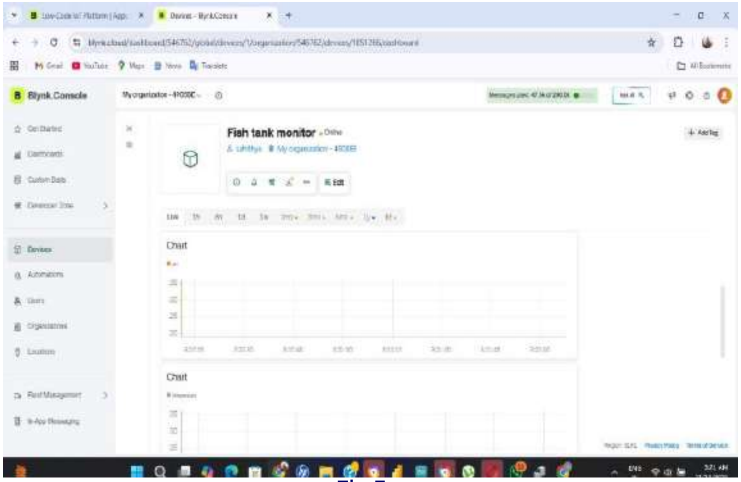

Fig 5

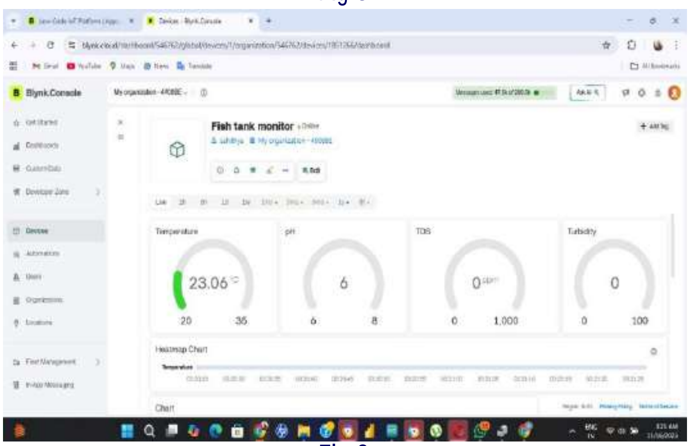

Fig 6

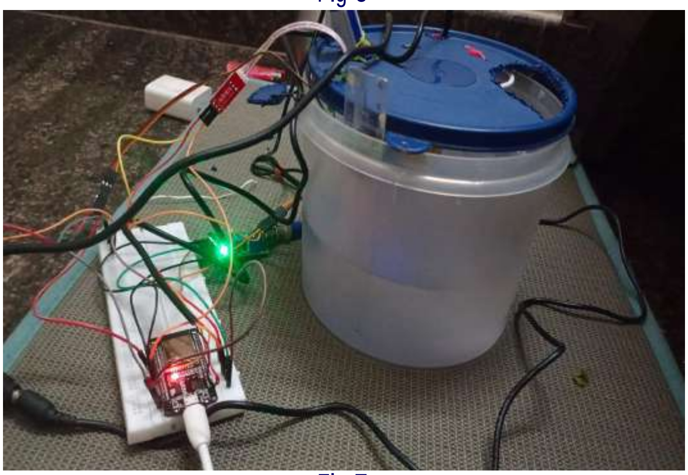

Fig 7

The above image shows the water quality when it is totally clean, that no dissolved solvents are in it. The dashboard presents the water-quality readings of the fish tank in real time, such as Temperature, pH, TDS, and turbidity. The sensors in the IoT-based aquaculture system continuously keep track of these readings. Their precise readings on the gauge confirm that indeed the ESP32 is sending all sensor data to the Blynk platform for monitoring purposes. The IoT aquaculture system is capable of: real-time efficient monitoring of important water parameters through sensors connected to the ESP32. Blynk dashboard, it offers real-time data that makes water management easier thus resulting in fish tanks with better quality and healthier conditions.

CONCLUSION

The suggested IoT-enabled aquaculture system is a modern and environmentally friendly solution to the many problems traditional fish farming has to face. The use of technology like sensors, microcontrollers, actuators, and cloud allow the system to constantly control the monitoring of pH, temperature, turbidity, and TDS. The ESP32 microcontroller takes care of the sensor data very well and makes real-time decision making possible. Automated feeders and aerators are working in the background, keeping the environment ideal for fish without any human intervention. Furthermore, cloud connectivity broader than previously opens up access to the system. Therefore, farmers can control and watch operations. The aquaculture operations can be controlled remotely with the help of various web or mobile applications. This automation would lead to less feeding and manual work inconsistencies, while the latter would promote the growth of healthier fish. Thus, the system not only improves productivity and operational efficiency, but at the same time, it allows sustainable aquaculture techniques by optimizing the use of resources and stabilizing the environment. Among the machine learning model for predictive control, energy-efficient designs powered by renewable sources, and advanced data analytics for smart aquaculture ecosystems, the former is the area that is more likely to receive through improvements.

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