CLOUD-CONNECTED IOT BASED REAL TIME AQUACULTURE SYSTEM

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ABSTRACT

The **"Cloud-Connected IoT-Based Real-Time Aquaculture System"** aims to transformaquaculture managementbyintegratingIoTandautomationtechnologies to monitor and optimize water quality, temperature, humidity, and turbidity in real time. Using an ESP-32 microcontroller, the system gathers data from various sensors,includingtemperature,humidity,andturbiditysensors,anRTC(Real-Time Clock) module, and displays it on an LCD for easy monitoring. It also automates processes such as feeding and water circulation through actuators, ensuring a healthier environment for aquatic life. With Bluetooth communication for local monitoring and IoT connectivity for remote control, the system reduces manual intervention, increases operational efficiency, and improves sustainability in aquaculture practices.

1. INTRODUCTION

Aquaculture is an essential component of modern food production, providing a sustainable source of fish and seafood to meet the growing global demand, which can negatively impact aquatic life and overall productivity. The advancement of technology, particularly the Internet of Things (IoT) and automation, presents an opportunity to revolutionize fish farming by introducing smart systems that can optimize water conditions, automate feeding, and provide real-time monitoring. This project aims to develop a Smart Aquaculture System using the ESP-32 microcontroller, which serves as the core processing unit for integrating various sensors and actuators. The system is designed to automate key aspects of fish farming, including monitoring environmental parameters such as temperature, humidity, and turbidity, controlling feeding mechanisms, and managing water quality through automated pumps. By incorporating real-time data analysis, remote access via IoT, and local controlthrough Bluetooth, the system offers a modernized solution to traditional aquaculture challenges.

The ESP-32 microcontroller is an ideal choice for this application due to its low power consumption, built-in Wi-Fi and Bluetooth capabilities, and compatibility with multiple sensors and actuators. The project includes a temperature and humidity sensor to monitor environmentalconditionsaffectingaquatic life, aturbiditysensor to assesswater clarity, a real-time clock (RTC) module to maintain accurate feeding schedules, and a Bluetooth module to enable local control and communication. Additionally, an LCD display is integrated to provide real-time system updates, and a feed motor is used to automate the fishfeedingprocess.Thesystemalsocontrolsinletandoutletwaterpumpstoregulatewater quality by maintaining proper circulation and filtration. The Smart Aquaculture System is powered by a regulated power supply to ensure stable operation. The ESP-32 processes data collected from various sensors and actuates the necessarycomponentstomaintainanoptimalaquaticenvironment.Withtheintegrationof IoT technology, fish farmers can remotely access system data, adjust parameters, and receive alerts regarding water quality, feeding schedules, or other critical factors. This remotemonitoringcapabilitysignificantlyenhancestheefficiencyandeffectivenessoffish farming operations. One of the key motivations for developing this system is to reduce the dependency on manual labor and human intervention in aquaculture. Traditional methods of fish farming often require constant supervision, leading to increased labor costs and inefficiencies. By automating the monitoring and maintenance of water quality, the Smart Aquaculture System minimizes human error and ensures that optimal conditions are consistently maintained.

2. LITERATURE SURVEY

Aquaculture, the controlled farming of aquatic species, plays a crucial role in global food production. Ensuring optimal water quality, proper nutrition, efficient breeding, and protection from diseases and predators are fundamental aspects of successful aquaculture practices **[1]**. The industry has experienced significant growth, with aquaculture production increasing at an annual rate of at least three percent between 2011 and 2019 **[2]**. This expansion is largely driven by the rising global population and the depletion of wild aquatic resources. However, numerous challenges persist in aquaculture, such as resource inefficiency, environmental concerns, and disease management, which must be addressed to ensure sustainable production **[3]**.

One of the most pressing challenges is maximizing yield while optimizing resource utilization. This issue can be mitigated through **precision aquaculture**, whichincorporatesadvancedtechnologiessuchasArtificialIntelligence(AI)andthe Internet of Things (IoT) to enhance efficiency, sustainability, and environmental conservation **[4, 5]**. Unlike traditional aquaculture, which relies on manual experienceandobservation, precisionaquacultureleveragesdata-drivenapproaches to improve decision-making and automate key processes **[6]**.

Asubsetofprecisionaquaculture,**smartaquaculture**,alsoknownas**intelligent aquaculture** or **digitalaquaculture**, integratesmoderntechnologiessuchassensors, computer vision, and AI to enhance productivity and sustainability **[7, 8]**. These technologies allow for real-time monitoring and automated decision-making, reducing labor costs and increasing operational efficiency **[9]**. Among these innovations, IoT plays a criticalrole by enabling seamless communication between various sensors and devices within aquaculture systems **[10, 11]**. IoT-based aquaculturesystems facilitateremotemonitoringofwater quality, automatefeeding schedules, and provide predictive analytics to enhance farm management **[12, 13]**Water quality monitoring is one of the most critical components of smart aquaculture. Wireless sensor networks (WSNs) have been widely adopted to continuouslytrackkeyparameterssuchastemperature,pHlevels,dissolvedoxygen, turbidity,andammoniaconcentration**[14,15]**.Real-timedatacollectionthroughIoT platforms helps detect anomalies early, reducing fish mortalityrates and optimizing farmproductivity**[16, 17]**.Inaddition, IoT-based systemsenableremoteaccessand control, allowing aquaculture farmers to monitor conditions and make informed decisions from any location **[18, 19]**.

Automation in aquaculture extends beyond water quality monitoring to feeding systems, which play a crucial role in reducing food waste and ensuring proper fish nutrition.Automatedfeedersequippedwithreal-timeclocksandIoTintegrationhave been developed to dispense precise amountsoffeed at scheduled intervals **[20, 21]**. These intelligent feeding mechanismsprevent overfeeding, whichcan lead to water contamination and increased operational costs **[22, 23]**. Similarly, AI-driven predictive models help optimize feeding patterns based on fish behavior and environmental conditions **[24, 25]**. The integration of machine learning (ML) and AI in aquaculture has also advanced significantly. AI-based systemsanalyze historicaldata and detect patterns topredict waterqualityfluctuations,fishhealthissues,andoptimalharvestingtimes **[26, 27]**. Blockchain technology has further enhanced aquaculture operations by providing secure, tamper-proofrecordsofwater quality parameters and fish growth metrics **[28]**. These innovations contribute to a more transparent and efficient aquaculturesupplychain.Environmental sustainability is another major focus of smart aquaculture. Traditional fish farming methods often lead to excessive water usage and pollution. However, modern technologies, including automated water recycling systems and aeration control mechanisms, help conserve resources while maintaining optimal aquatic conditions **[29, 30]**.

3. PROPOSED SYSTEM

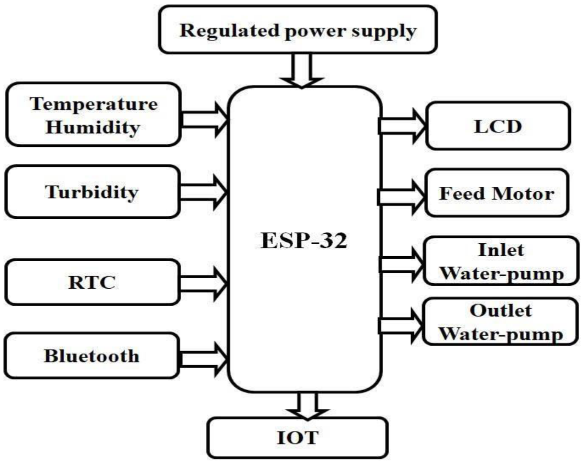

Fig1:BLOCK DIAGRAM

The proposed system enhances the automation and monitoring of the fish farm using an advanced ESP-32 microcontroller, which is powered by a regulated power supply. This system integrates various sensors and actuators to ensure optimal fish farm management. Temperature and humidity sensors provide real-time environmental data, while a turbidity sensor monitors water quality. A real-time clock (RTC) maintains accurate scheduling for operations, and Bluetooth connectivity allows for wireless communication. IoT technology is incorporated for remote access and control, enabling farmers to monitor and manage the system from anywhere. The system includes an LCD display for real-time data visualization, a feed motor for automated fish feeding, and inlet and outlet water pumps to regulate water circulation efficiently. This advanced setup ensures improved environmental conditions, reduces manual labor, enhances fish growth, and optimizes resource usage, leading to better productivity and cost efficiency in fish farming.

The **"Cloud-Connected IoT-Based Real-Time Aquaculture System"** utilizes various sensors and automation techniques to monitor and optimize the aquaculture environment. To track and regulate environmental factors such as water temperature, humidity, and turbidity, the system collects data through sensors integrated with the ESP-32 microcontroller. The data is processed and displayed in real-time on an LCD screen, providing continuous feedback. For automated feeding, the system utilizes a feed motor, and water quality is managed using inlet and outlet pumps. The system's IoT connectivity allows for remote monitoring and control through a cloud platform.

The setup requires initial configuration, where sensor data is collected, and the system is trained to recognize optimal environmental conditions. Once initialized, the system will continuously track water quality, temperature, and other factors, sending alerts when adjustments are needed. These readings are logged for analysis, ensuring that the aquaculture environment remains within the desired parameters for the well-being of the aquatic life.

The system continuously monitors key environmental factors in aquaculture, including temperature, humidity, and turbidity, using various sensors connected to an ESP-32 microcontroller. Real-time data is displayed on an LCD screen, allowing immediate feedback for operators. Automated feeding is controlled via a feed motor, and water quality is regulated through inlet and outlet pumps. The system leverages IoT connectivity for remote monitoring and control, enabling operators to manage the environment from anywhere. This integration reduces manual intervention, enhances operational efficiency, and ensures a healthier aquatic ecosystem by maintaining optimal conditions for aquatic life. Alerts are sent when adjustments are needed, helping operators maintain stability in the system.

CircuitDiagram:

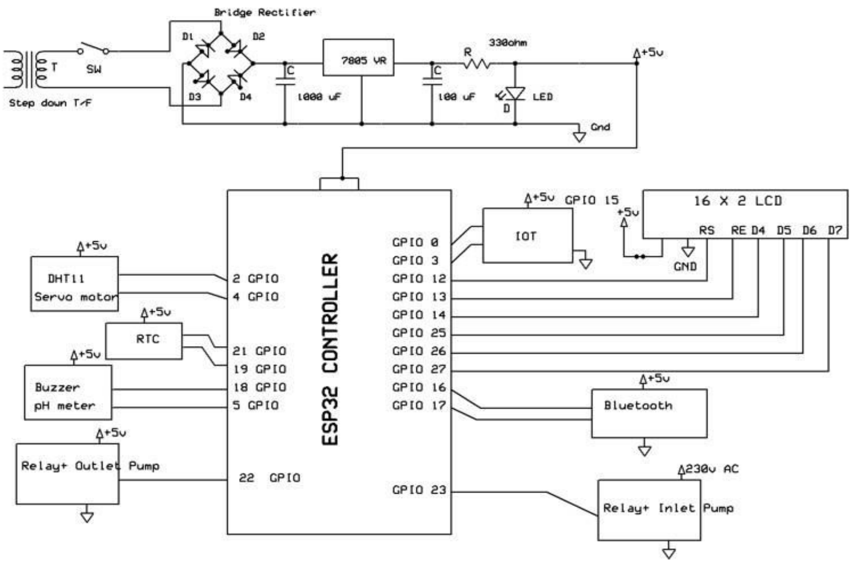

Fig2:Circuit Diagram

The givencircuit diagramrepresents anautomated fish farmmonitoring and control systemusingtheESP32microcontroller.Thesystemincorporatesvarioussensors,actuators, andcommunicationmodulestoensureefficientoperation.Belowisthedetailedexplanation of the circuit along with the pin configurations:

PowerSupply Section:

- Astep-downtransformerreducestheACvoltage.
- Abridgerectifier (D1-D4) convertsACto DC.
- A7805voltageregulatorprovidesastable5VDC output.
- Capacitors(1000µF, 100µF)filteroutripples.
- Aresistor(330Ω)and LED act asapowerindicator.

4. RESULTS

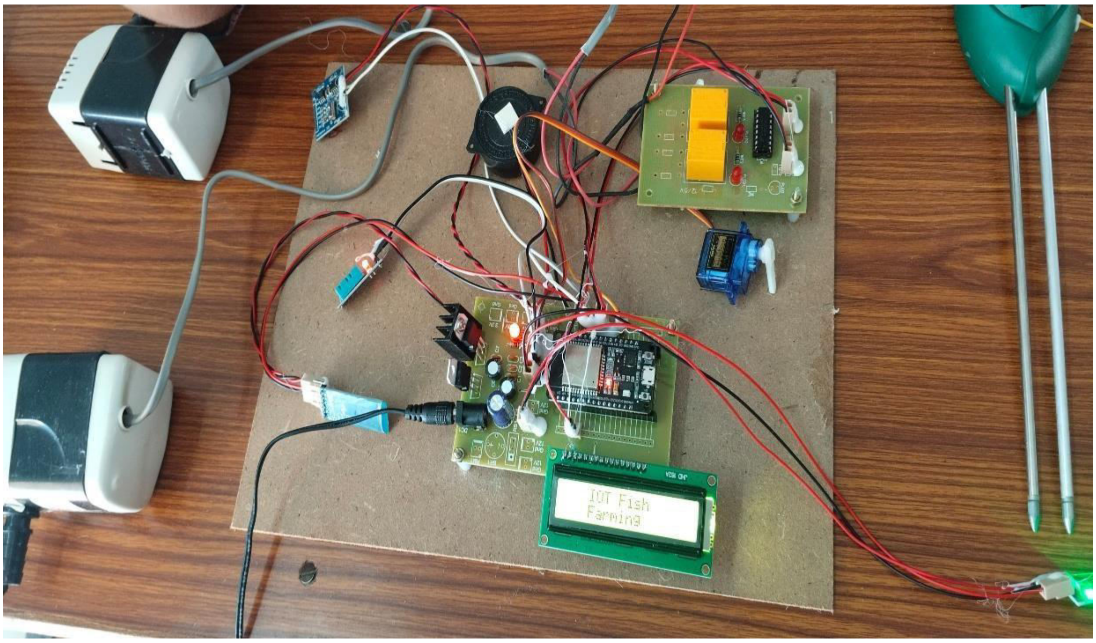

Fig3:HardwareCircuit

Title of Project in LCD Display:

Fig4:TitleDisplay

INLETON:

Fig5:Pump On

OUTLETON:

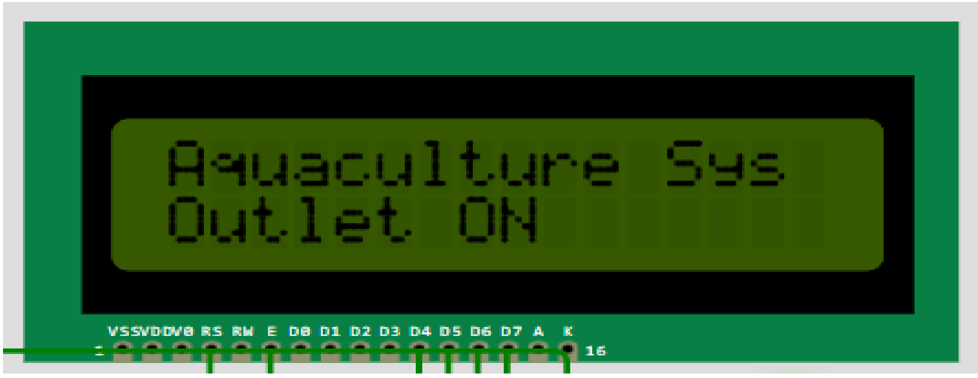

Fig6:Pump Off

Howitisworking

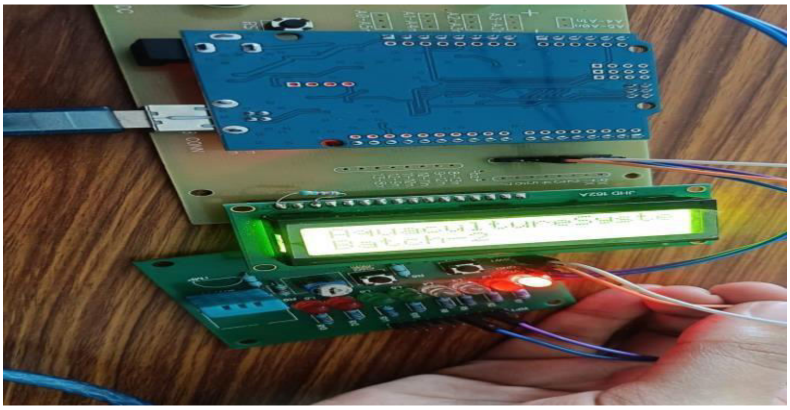

Fig 7: Working

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S.No	Ph	Temperature	Humidity	Status	Date
1	0	32.00	60.00	-	2025-03-22 11:44:15
2	0	32.10	60.00	-	2025-03-22 11:42:41
3	0	32.00	61.00	-	2025-03-22 11:41:31
4	0	32.00	60.00	-	2025-03-22 11:39:22
5	0	31.80	60.00	-	2025-03-22 11:37:46
6	0	31.80	61.00	-	2025-03-22 11:36:10
7	0	31.80	61.00	-	2025-03-22 11:34:35
8	0	31.80	61.00	-	2025-03-22 11:33:01
9	0	31.80	62.00	-	2025-03-22 11:31:26
10	0	31.70	63.00	-	2025-03-22 11:29:50
11	2	30.30	90.00	-	2025-02-06 11:06:16
12	2	29.60	61.00	Pump2-ON	2025-02-06 11:06:00
13	2	29.60	61.00	Pump2-ON	2025-02-06 11:05:54
14	2	29.60	62.00	Pump1-OFF	2025-02-06 11:04:55
15	2	29.60	62.00	-	2025-02-06 11:04:45
16	2	29.60	64.00	-	2025-02-06 11:03:10
17	2	29.60	64.00	Pump1-ON	2025-02-06 11:03:01
18	2	29.60	64.00	Pump1-ON	2025-02-06 11:02:54
19	3	29.50	67.00	-	2025-02-06 11:01:29
20	4	29.40	66.00	Feeding-ON	2025-02-06 11:01:00

Fig8:Web Page

CONCLUSION

The project successfully implements an automated fish farming system using an ESP32 microcontroller.Varioussensorsmonitorenvironmentalparameterssuchastemperature,humidity, and water turbidity, ensuring optimal conditions for fish growth. The system automates feeding and water management througha feed motorand waterpumps, reducing manuallabor. Real-time monitoring isachieved viaanLCDdisplay,Bluetooth,andIoTintegrationforremoteaccess.The RTC module ensures accurate scheduling of feeding and water changes. The Bluetooth module enhances local connectivity, allowing users to control the system wirelessly. IoT connectivity enablesremotemonitoringandcontrol, improving systemefficiency.Theregulatedpowersupply ensuresstable operationofallcomponents. Automated controlenhancesproductivityand reduces human intervention. The system provides a cost-effective and efficient solution for modern fish farming

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