IOT- INTEGRATED IMAGE PROCESSING FOR ENHANCED FISH FARM MONITORING AND MANAGEMENT IN AQUACULTURE

Arun Prasad H L[a], Chandra Bose R[b], Manoj S[c], Mohammed Nafiz A R[d], Dr.D. Magesh Babu[e]

a, b, c, d - B.E Mechatronics Engineering, Velammal Institute of Technology,panchetti, ponneri, Tiruvallur dist, Tamil Nadu- 204

e – Dr.D.Magesh Babu,M.E.,Ph.D., Professor, Department of Mechatronics Engineering,Velammal Institute of Technology, panchetti, ponneri, Tiruvallur dist, Tamil Nadu- 204

ABSTRACT:
Aquaculture, the farming of aquatic organisms, plays a crucial role in meeting the growing global demand for seafood. However, effective management of aquaculture facilities, particularly in monitoring the health, lifespan, and breeding conditions of fishes, remains a challenging task. This paper proposes a novel approach utilizing Internet of Things (IoT) technology integrated with image processing [1] techniques to enhance fish farm monitoring and management. By employing IoT sensors and cameras strategically placed within aquaculturefacilities, real-time data on water parameters, environmental conditions, and fish behavior can be collected. [2] Additionally, image processing algorithms are applied to analyze fish behavior, assess their health status, determine lifespan, and identify breeding conditions. This integrated system offers aqua culturists valuable insights, enabling proactive management strategies and optimizing production efficiency.

KEYWORDS: Aquaculture, Internet of Things (IoT), Image Processing, Fish Monitoring, Fish Health, Lifespan, Breeding Conditions.

1. **INTRODUCTION:** Aquaculture has emerged as asignificant contributor to global foodsecurity, providing sustainable source of sea food to meet the nutritional needs of a growing population. However, ensuring thehealth and welfare of farmed fishes while maximizing production efficiency remains a complex task. Traditional methods of monitoring fish farms often rely on manual observation and periodic sampling,which can be labor-intensive, time- consuming, and prone to errors.

In recent years, the integration of IoT technology has revolutionized various

Industries by enabling real-time monitoring and data collection. By deploying a network of sensors and connected devices, IoT offers unprecedented insights into environmental conditions and process parameters. Leveraging IoT in aquaculture presents immense opportunities to enhance farm management practices.

2. LITERATURE SURVEY:

The most recent study by Chen j et al. (2021) provides a comprehensive survey of IoT applications in smart aquaculture, offering insights into various aspects such as water quality monitoring, feeding automation, and environmental control. shareef et al. (2019) propose a system for monitoring fish behavior using computer vision, focusing on analyzing swimming patterns and social interactions to assess fish well- being and stress levels. Bhawiyuga and yahya (2018) demonstrate the effectiveness of convolutional neural networks (CNNs) in fish detection and counting, showcasing the potential of advanced image processing algorithms. kabir et al. (2018) present automated fish recognition and counting system using image processing techniques, highlighting its ability to reduce manual labor and improve accuracy. Finally, curiel et al. (2017) propose an IoT-based monitoring system for aquaculture, laying the groundwork

For incorporating image processing for fish monitoring while focusing on water quality parameters. Together, these studies demonstrate the evolving landscape of IoT-integrated image processing in enhancing fish farm monitoring and management, offering opportunities to improve efficiency, productivity, and sustainability in aquaculture.

3. SYSTEM ARCHITECTURE:

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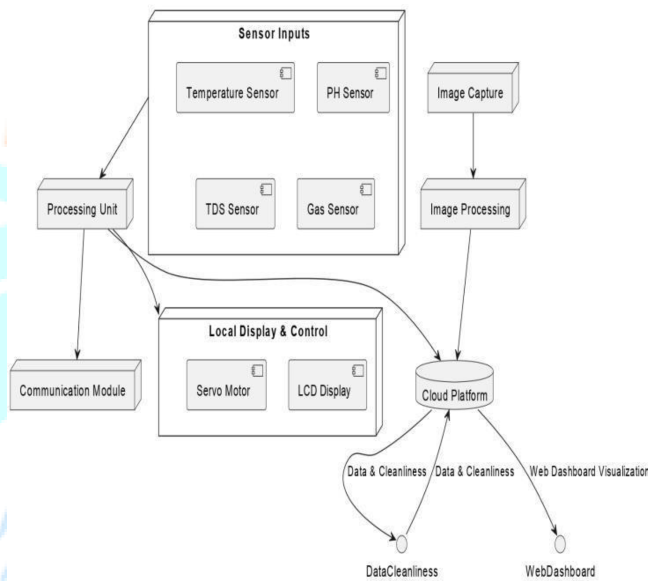


Temperature Sensor: The temperature sensor measures the temperature of the environment. This data can be used to control the temperature of the environment, or to monitor the temperature of a process.

PH Sensor: The pH sensor measures the pH level of a solution. This data can be used to control the pH level of a solution, or to monitor the pH level of a process.

Image Capture: The image capture sensor captures images of the environment. This data can be used to monitor the environment, or to identify objects in the environment.

TDS Sensor: The TDS sensor measures the total dissolved solids ina solution. This data can be used to monitor the quality of water, or to control the concentration of solids in a solution.

Gas Sensor: The gas sensor measures the concentration of gases in the environment. This data can be used to monitor the air quality, or to detect the presence of hazardous gases.

Image Processing: The image processing module processes theimages captured by the image capture sensor. This data can be used to identify objects in the environment, or to track the movement of objects in the environment.

Processing Unit: The processing unit is the central processing unit of the system. It is responsible forprocessing the data from the sensors, and for controlling the actuators.

Communication Module: The communication module is responsible for communicating with the cloud platform. This data can be used to monitor the system, or to control the system remotely.

Local Display & Control: The local display and control module is responsible for displaying the data from the sensors, and for controlling the actuators. This data can be used to monitor the system, or to control the system locally.

Servo Motor: The servo motor is responsible for controlling the position of the actuators. This data can be used to control the position of the actuators, or to monitor the position ofthe actuators.

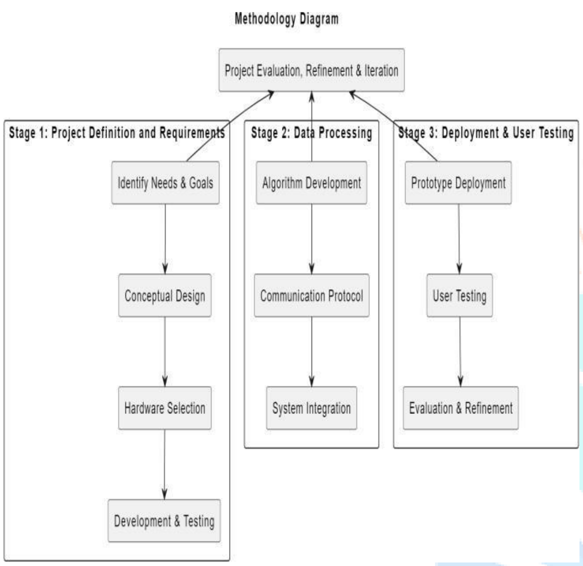
LCD Display: The LCD display is responsible for displaying the data from the sensors, and for controlling the actuators. This data can be used tomonitor the system, or to control the system locally.

Cloud Platform: The cloud platform is responsible for storing the data from the sensors and for providing access to the data from the remote devices. This data can be used to monitor the system, or to control the system remotely.

Data & Cleanliness: The data and cleanliness module is responsible for cleaning the data from the sensors, and for ensuring that the data is accurate and reliable. This data can be used to monitor the system, or to control the system remotely.

Web Dashboard Visualization: The web dashboard visualization module is responsible for visualizing the data from the sensors, and for providing access to the data from the remote devices. This data can be used to monitor the system, or to control the system remotely.

4. METHODOLOGY

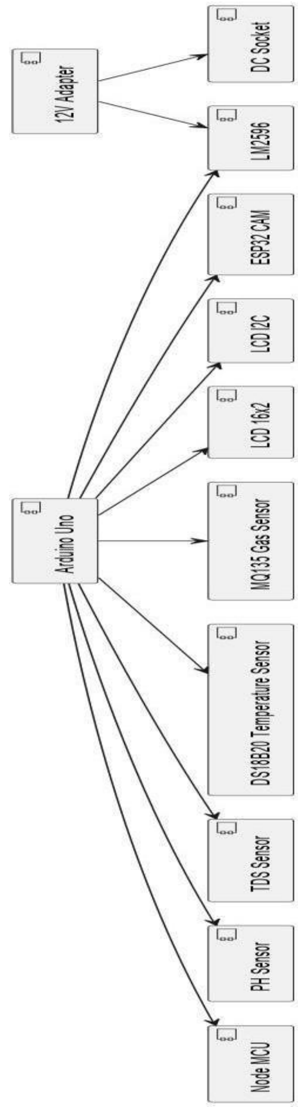


Stage 1: Project Definition and Requirements Identify Needs &Goals Conceptual Design Hardware Selection Development & Testing

Stage 2: Data Processing Algorithm Development Communication Protocol System Integration

Stage 3: Deployment & User Testing Prototype Deployment User Testing Evaluation & Refinement The projectwill be evaluated, refined, and iteratedupon throughout the process.

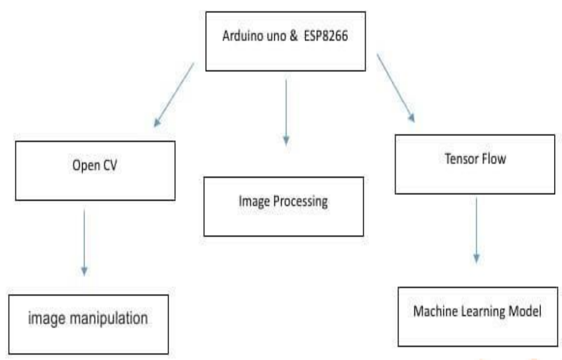
5. HARDWARE DESCRIPTION



The image shows a block diagram of a project. The project is based on Arduino Uno. It has 12 components. They are connected to the Arduino Uno. The components are: Node MCU, PH Sensor, TDS Sensor, DS18B20 Temperature Sensor, MQ135 Gas

Sensor, LCD 16x2, LCD 12C, ESP32 CAM, LM2596, DC Socket and a 12V Adapter

6. SOFTWARE DESCRIPTION



Software Setup:

- Install the Arduino IDE software and ensure it's updated.
- Install necessary libraries for Image processing and machine learning: Open CV (for image manipulation) Tensor Flow (for machine learning model)
- Download a pre-trained machine learning model for Fish Monitoring System. Alternatively, train your own model using a dataset of labeled Fish tank's clean and dirty images.

Image Preprocessing and FeatureExtraction:

- Develop Python scripts to capture images from the webcam at regular intervals.
- Implement image preprocessing techniques like noise reduction, color space conversion (e.g., RGB to HSV), resizing, and normalization to prepare theimage for analysis.
- Design algorithms to extract relevant features from the preprocessed image that can be used for classification. This could involve: Color analysis: Identify dominant colors for clean tank and dirty tank differentiation. Texture analysis: Extract texture features to distinguish between clean tank and dirty tanktextures

7. ALGORITHM:

System Initialization:

- **Arduino Startup:** Initialize serial communication for LCD display and ESP8266 module. Initialize pins for sensor readings (analog/digital), servo motor control and potential LED indicators.

- **Sensor Calibration (Optional):** If applicable, perform sensor calibration procedures based on sensor manuals.

- **ESP8266 Setup:** Configure Wi-Fi connection details for connecting to your network. Establish connection with Adafruit IO dashboard (or chosen platform).

Main Loop:

- **Sensor Data Acquisition:** Read sensor data (temperature, pH, TDS, gas) at regular intervals (e.g., every 10 seconds). Apply calibration factors if performed earlier.

- **Data Processing & Alarms:** Analyze sensor readings forpotential issues (e.g., temperature out of range). If critical values are detected, trigger alerts (e.g., display on LCD, send email/SMS notification).

- **LCD Display Update:** Display current sensor readings (Temperature, pH, TDS, gas) on the LCD for on-site monitoring.

- **Food Dispenser Control:** Based on a pre-programmed timer or potential sensor readings (e.g., time of day, temperature), activate the servo motor for a set duration to open and close the food feeder valve.

- **Image Capture & Processing:** At a defined interval (e.g., every hour), capture an image from the webcam. Apply image processing algorithm (your development) to analyze the image and classify water cleanliness (clean vs. dirty).

- **Data Transmission:** Prepare data packet containing sensor readings (or potentially raw data) and water cleanliness information. Transmit data packet to Adafruit IO web dashboard (or chosen platform) using ESP8266 Wi-Ficonnection.

Additional Considerations:

- **Error Handling:** Implement error handling routines to address potential sensor malfunctions or communication issues.
- **Data Logging:** Consider storing sensor data on an SD card for later analysis or troubleshooting.
- **Advanced Features:** You can expand the functionality by incorporating Machine learning for fish health prediction based on sensor data and image analysis. User-configurable thresholds for triggering alerts. Remote control functionalities via the web dashboard (e.g., adjusting feeding schedule).

8. RESULTS & DISCUSSIONS

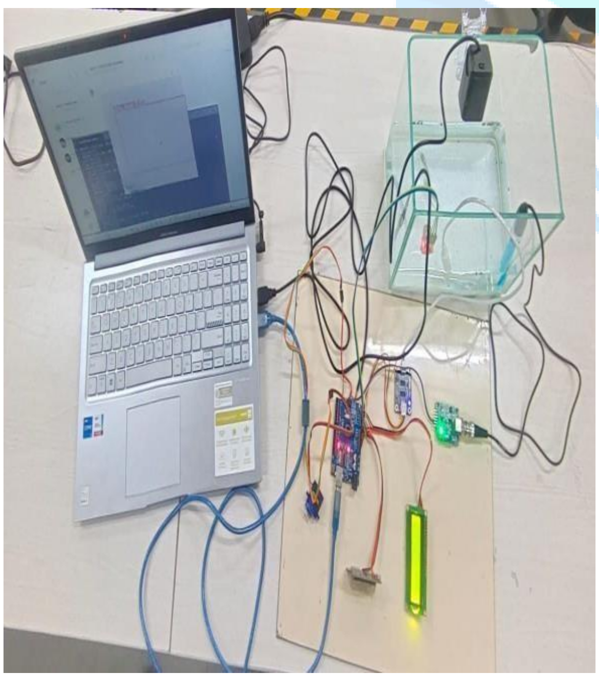


FIGURE – 1

In Fig – 1 the prototype was shown. In this the laptop is running a program that is monitoring the water quality in the aquarium. The Arduino Uno is connected to the breadboard, which is connected to the sensors that are monitoring the water quality. The sensors are sending data to the Arduino Uno, which is then sending the data to the laptop. The laptop is displaying the data on the screen.

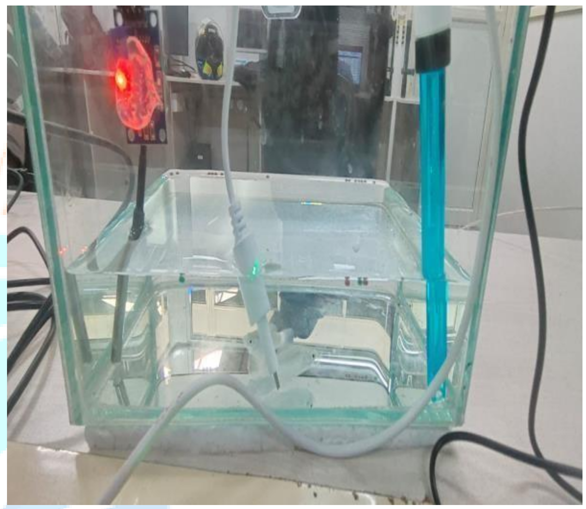


FIGURE – 2

In Fig-2 the sensors like temperature sensor, Ph sensor, TDS sensor all were integrated into the tank to determine the temperature of the water, to determine the Ph value of the water, to determine the gas molecules present in water. All this data were showcased in micro controller

FIGURE – 3

In fig – 3 Temperature, Ph, Gas values were displayed.

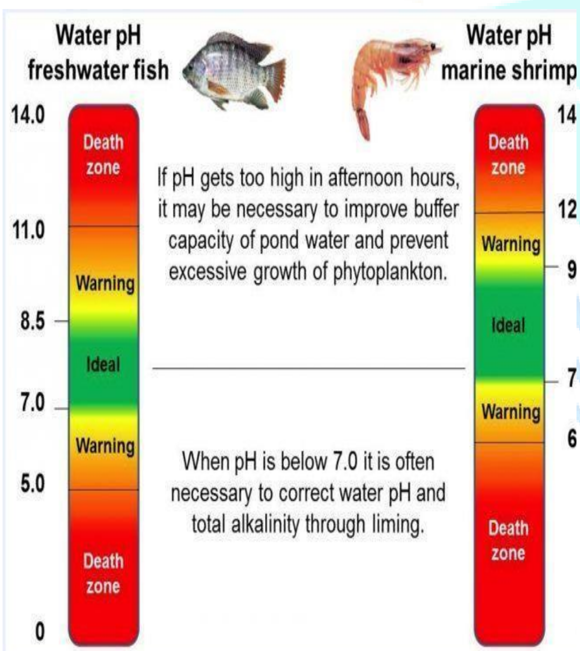


FIGURE – 4

From fig – 4 we had been comparing our results of Ph we got 8 as Ph Value which mean it is in idle conditions. So, in this condition we can grow fishes. The fishes won't get affected

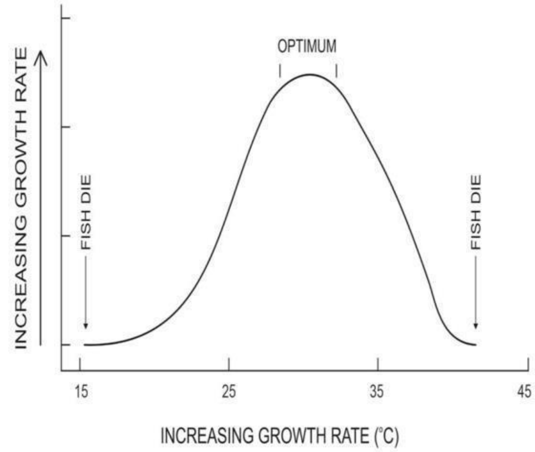


FIGURE – 5

With reference to fig – 5 the optimum temperature is 25-35c. In our results we got temperature as 26 c so we are havingan optimum zone for fish cultivation.

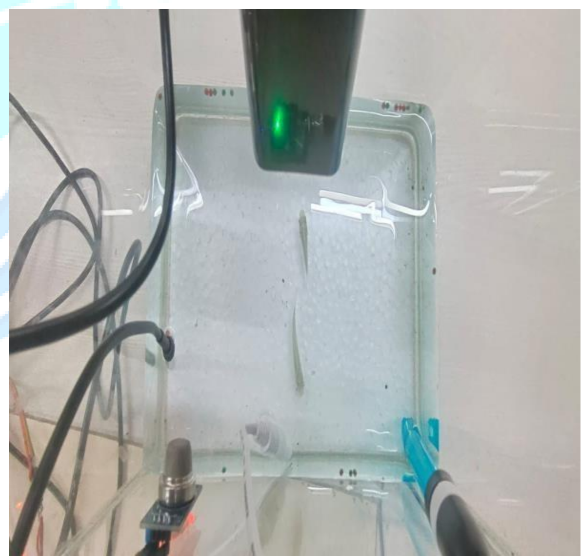


FIGURE – 6

In fig – 6 A webcam is placed to send the live images of the fishes inthe tank. It sends the signals to the receiver. Through image processing techniques we get the results of required things

FIGURE – 7

In fig – 7 we observed that themovement of fishes is normal. So still, it's possible to live & expand its lifespan

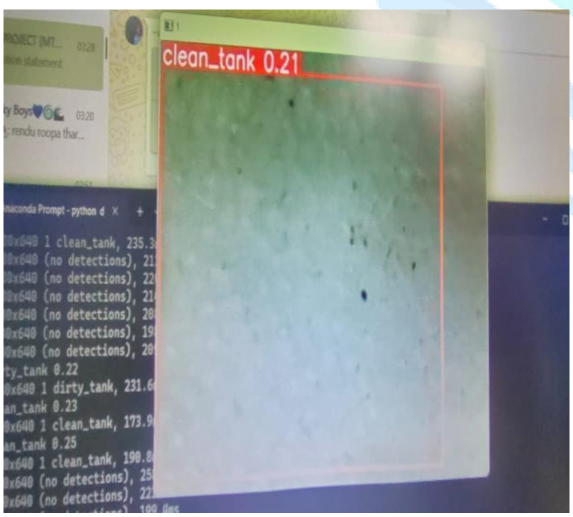


FIGURE – 8

Fig – 8 shows that the tank is clean it doesn't contain any dust particles. In the clean tank we can cultivate thefishes

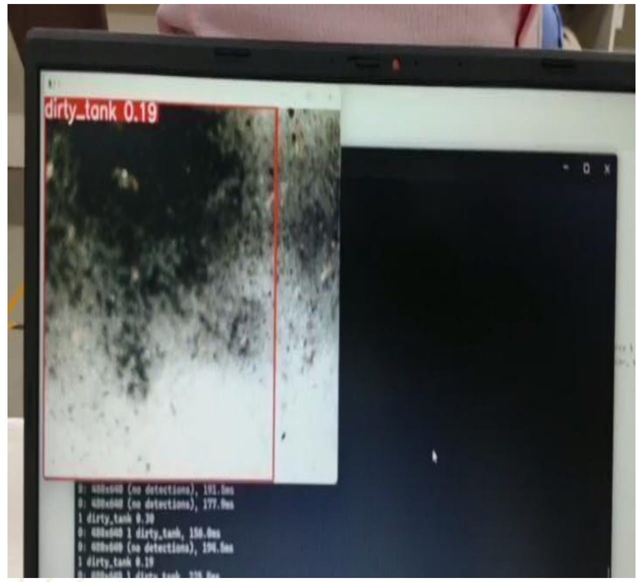


FIGURE – 9

In fig – 9 the system shows the tank isdirty. This is not suitable for the growth of fishes.

These were the required results we got & constant monitoring will lead to achieve the desired target.

9. CONCLUSION

In conclusion, the integration of IoT and image processing technologies offers significant advancements in the monitoring and management of fish farms in aquaculture. By leveraging real-time data collection and analysis, this system provides valuable insights into breeding conditions and fish lifespan, ultimately enhancing productivity and sustainability in the industry. The ability to monitor parameters such as water quality, temperature, and fish behavior allows for proactive management practices, leading to

Improved fish health and overall farm efficiency. Moreover, the early detection of abnormalities or diseases through image processing algorithms enables prompt intervention, minimizing losses and optimizing production. Overall, this project underscores the potential of technological innovation to revolutionize aquaculture practices and meet the growing demand for seafood in a sustainable manner.

10. LIMITATIONS

The integration of IoT and image processing for fish farm monitoring inaquaculture faces several limitations. Firstly, the high upfront costs associated with implementing comprehensive IoT systems may deter adoption, particularly for small-scale fish farmers or those in resource- constrained regions. Additionally, reliable internet connectivity isessential for transmitting real-time databut may be lacking in remote areas, hindering the effectiveness of thesystem.

11. FUTURE WORKS

In the future, integrating robots into the project could enhance efficiency and scalability. Robots could be used for tasks such as automated feeding, water quality monitoring, and even fishhealth inspections. Additionally, robotic systems equipped with cameras and sensors could Autonomously navigate through fish farms, collecting data and images for continuous monitoring and analysis. This could significantly reduce the need for manual labor and allow for more frequent and precise data collection, leading to improved decision-making processes in aquaculture management. Moreover, the use of robots could also facilitate the implementation of interventions in response to detected issues, further enhancing the overall effectiveness of fish farm monitoring and management systems.

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