AquaGuard: Enhancing Fish Farming Efficiency with SmartFishBot

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***Abstract*—Our project introduces an innovative solution to automate water quality monitor and management and improve fish farming practices. The pond in our country frequently gathers a variety of dirt. These wastes pollute the pond. The ponds consequently lose their suitability for fish farming. As a result, the fish farmers do not achieve the desired outcomes. There are various more parameter that must be known in order to effectively farm fish, such as pond's pH level, temperature, turbidity. And the values of these parameters are irrelevant to the village fish farmers in Bangladesh's remote areas. And all we know is that fish feeding is an important thing in fish firming. To solve this problem we designed a robot to clean dust in the pond and utilizes pH, temperature, and turbidity sensors to measure water quality parameters. The collected data is then analyzed using a machine learning model to predict the most effective fish species for farming in the specific pond. A camera module is added to our robot for security purpose resulting in surveillance with object detection. This project uses modern technology to increase productivity, improve fish health, and support environmentally friendly fish farming methods. A feasible approach for simplifying operations and boosting production in the aquaculture sector is the combination of the cleaning mechanism, sensors, and predictive algorithms.**

Keywords:Smart fish firming, Water monitoring, Prediction.

I. INTRODUCTION

The "Water Monitoring and Cleaning Robot for Smart Fish Farming" project introduces an innovative solution to maintain optimal water quality in fish farming ponds. It focuses on the development of a remotely operated robot equipped with pH, temperature, and turbidity sensors to monitor the water quality and collect real-time data on water quality parameters that is used for prediction using a machine learning model. It also designs an infrastructure to clean floating dust.

Aquaculture, another name for fish farming, is important for supplying the rising global demand. Fish health and growth depend on healthy water conditions, yet manual cleaning techniques are time- and labor-intensive.

The primary objective of this project is to create a water monitoring and cleaning robot that can remotely clean pond dust that is floating while also taking important measurements of water quality. The robot has a pH sensor to determine the acidity or alkalinity of the water, a temperature sensor to keep track of the water's temperature, and a turbidity sensor to gauge the amount of suspended particles. By gathering these data points, we manually input the data into a machine learning model that recommends the best fish species for productive fish farming in the particular pond.

There are a number of important benefits to remotely controlling water cleaning and monitoring procedures in fish farming with a specialized robot. Firstly, it increases cleaning operations' accuracy and effectiveness while reducing their dependency on manual labor. Second, real-time monitoring of water quality metrics offers useful insights into the conditions required for the best possible growth and health of fish. By incorporating predictive algorithms, fish farmers are better able to choose fish species that grow in the particular water conditions of their ponds. In the end, this promotes successful and sustainable fish farming methods.

II. LITERATURE REVIEW

Water quality data collection moved from written notes to digital displays through sophisticated digital electronics with the real time data. Examining limit has progressed from a couple of hand estimations every day, one parameter at any given moment, to steady surges of information transmitted by multi parameter instruments sent for couple months on end. The accuracy has developed a lot in between the development of this technology [2][1].

Several developments in IoT based monitoring for aquaculture are currently underway with applications in various aspects of the monitoring system. In line with tremendous research efforts in this area, European Commission in 2017 H2020 innovation action call coined a term "Aquaculture 4.0" to refer to smart aquaculture integrated with IoT system with active research projects [5]. The projects focus on 1) Development of high performance and low-cost sensors: PROTEUS project is developing carbon nanotubes based chemical sensors 2) Affordable and easy-to-deploy technology: WAZIUP project in Ghana 3) Smart and friendly environmental systems for aquaculture: IMPAQT project [3][4].

The authors in [6] have designed and implemented a prototype of a distributed monitoring system based on wireless sensor network (WSN) and on IoT to monitoring water quality in ponds. The proposed system is claimed to be low cost, low power consumption, portable, versatile, and accurate. In [10], an IoT based automated system comprises of pond controller with various sensors for monitoring equipped with an integrated CCTV that can record activities around the pond. Moreover, authors in [13] have proposed the utilization of Wivity modem into the IoT monitoring system that supports various connectivity through WiFi, GSM, satellite communication, or LoRaWAN, allowing real-time monitoring in a remote area with limited cellular connection or a certain type of internet connections. On the other hand, several papers [18][16][11] detailed more specific IoT monitoring systems for various aquatic organisms such as shrimp, catfish, crab.

Various studies related to Water Quality Monitoring can be found. For example, a study by Guerrero and Fernandez [8] discussed the main problems and alarms in the aquaculture and water sector in the country. Water quality is one of the critical criteria for the growth and survival of freshwater and marine life but is often set aside by the aquaculture farmers due to the lack of resources for water quality testing. The Real-time Water Monitoring and Automation developed by Harun et al. [9] focused on different parameters such as temperature, pH and DO levels and interfaced with aerating and water supply pumps utilizing Arduino. The data were later sent to the preferred communication or gadget at a certain period of time through Internet. Simbeye and Yang [17] concentrated their study on temperature, dissolved oxygen, pH, ammonia, nitrates, salinity, and alkalinity that are the vital parameters needed to be monitored and regulated, since they directly affect animal's wellbeing, feed usage, growth rates and carrying abilities. A wireless sensor network (WSN) monitoring and control system was designed for this study. The studies in [19][7] used ISFET and glass electrode as water pH measurement devices for their aquaponics (a hybrid of aquaculture and hydroponics) setups.

In the course of recent decades, water quality observing technology has quickly advanced to address the issues of the inhabitants. Firstly, the work started with survival, scan for predators look for source of movements under water or beside the watering hole. The understanding of health and science regarding this issue has ascended due to the need of clean water. This action was started in mainly Egypt through the Hippocratic sleeve system. It was basically a filtering system [14].

The scope of water pollution changed drastically after the World War 2. Lots of industries exploded during the war, chemicals and byproducts entered the wasted streams during this period. So, the focus back then was to support the water issues [14].

In 1948, the first advanced water monitoring system was tested. That was mainly done to check whether the water was contaminated or not though no sensor were not used. In 1956, the system was a little more advanced for the usage of different chemicals with turbidity sensors, but it was not permanent. After that, in 1970, after the production of first portable pH sensors, people started measuring the pH levels of water. After a short period of time, the oxygen sensors were introduced in the monitoring system. It was mounted to monitor the proportion of oxygen [14][12][15].

III. Material Description

For this project, we need several hardware and software tools.

Hardware:

A) Arduino Uno: As the main controller of the robot, the Arduino Uno microcontroller board is in charge of collecting and analyzing sensor data, managing motor actions, and enabling communication.

B) ESP32-CAM: Wireless connectivity, the ability to broadcast videos and object detection are provided via the ESP32-CAM module. It permits the robot's operations to be observed and managed remotely.

Fig. 1: ESP32-CAM

C) pH Sensor: To determine how acidic or alkaline the pond water is, a pH sensor is used. It offers pH measurements in real time, making it possible to examine the water quality with precision.

D) Water Temperature Sensor: The pond's water temperature is measured using a temperature sensor. This sensor aids in maintaining the ideal temperature range for fish aquaculture.

E) Turbidity Sensor: The turbidity sensor is utilized to measure the water's clarity or turbidity. It provides important information about the water quality by detecting suspended particles, silt, or contaminants.

F) Motor Shield: An interface board called the motor shield makes it simple to control multiple motors. It is used to manage how the cleaning mechanism and other motorized parts operate.

G) Servo Motor: Here, a servo motor is utilized to distribute fish feeding items in the pond.

H)Gear Motor:The robot's locomotion and movement are propelled by gear motors. They offer the power and torque

Fig. 2: pH Sensor

Fig. 3: Water Temperature Sensor

required to move about on the pond's surface and carry out cleaning and maintenance tasks.

I) Speaker: Here we connect a speaker is used to be talking ability to our robot.

The Arduino Uno, ESP32-CAM, pH, temperature, turbidity, motor shield, servo motor, and gear motor are among the hardware elements that combine to form an integrated system for water monitoring, cleaning, and fish species prediction. They improve the effectiveness and sustainability of fish farming techniques by enabling efficient data collecting, control, and automation.

IV. METHODOLOGY

The following can be used to summarize the technique for the "Water Monitoring and Cleaning Robot for Smart Fish Farming" project:

Robot Design and Construction:

• Define the specifications and needs for the robot that will monitor and clean the water, taking consideration of things like size, weight, and mobility.

• To build the robot, select the right materials and components, making sure they are durable and waterproof.

• Design the cleaning mechanism of robot, make a infrastructure that capabilities to efficiently remove floating dust from the pond's surface.

• Implement the robot's floating skills to make sure it stays stable while operating.

Hardware Integration:

Fig. 4: Turbidity Sensor

Fig. 5: Gear Motor

• Select suitable pH, temperature, and turbidity sensors based on their accuracy, reliability, with the robot's design.

• Calibrate the sensors to provide precise measurements while adjusting for any environmental elements that can have an impact on their performance.

• Here we have connected ESP32-CAM as a camera module to enable robot to real-time survivability and object detection.

• Make sure the sensors are properly positioned and securely connected to the microcontroller by integrating them into the robot's body.

• To fish feeding process we have to connect a servo motor with a mini bottle with the robot.

• Here we have connected a speaker which makes the robot able to speak.

Data Acquisition and Storage:

• Connect the sensors to a microcontroller to capture real-time data on pH, temperature, and turbidity.

• After connecting all the equipment properly, we will upload a suitable sketch on the Arduino IDE.

• After the sketch is uploaded, we can get and collect the values from the sensors attached with the robot.

• From these values of PH, temperature and turbidity sensor we can monitor or measure the quality of the pond's water.

Data Analysis and Fish Species Prediction:

• Develop a machine learning algorithm that depends on the temperature, turbidity and PH values of the pond to specify which fish are suitable for firming in a specific pond.

• After developing an ML model, we input the sensor's value to the model, which analyzes these values and makes a prediction about which fish are suitable for firming in that pond.

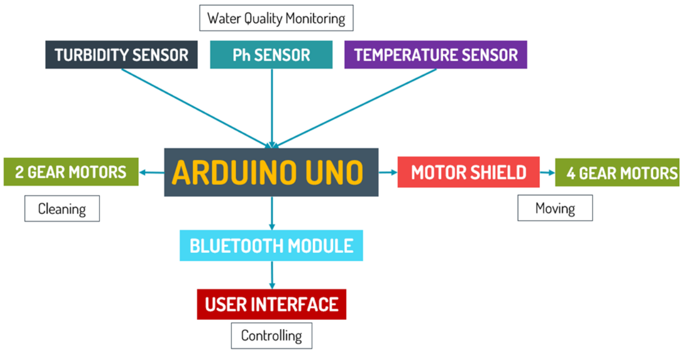

Fig. 6: Block Diagram

• Three classifier algorithms that are Random Fo have been utilized in this machine learning model. We have found that the random forest classifier algorithm is the most dependable, appropriate, and provides the highest level of accuracy for our model.

Fig. 7: AquaGuard

Machine Learning Model Description: We took a number of steps to develop this machine learning model. The steps are data collection, data processing, algorithm training, recommendation generation, evaluation, user interface. We have collected data on many types of fish in data collection phase. In data data pre-processing step, data cleaning and normalization tasks are completed. Here, five different classification algorithms have been applied. These include Random Forest, Naive Bayes, SVM, Decision Tree, and Logistic Regression. Finally, we evaluated each algorithm's accuracy. Users may easily input numbers and get their results through using user interface.

A) Random Forest: Random Forest is an ensemble learning method that combines multiple decision trees to make predictions. It creates a "forest" of decision trees, where each tree is trained on a random subset of the data and features. The final prediction is determined by aggregating the predictions of individual trees. Random Forests are versatile, robust against overfitting, and can handle both classification and regression tasks.

B) Naive Bayes: Naive Bayes is a probabilistic classifier based on Bayes' theorem with an assumption of independence between features. It calculates the probability of a particular class given the input features and selects the class with the highest probability. Despite its "naive" assumption, Naive Bayes can perform well in practice and is particularly useful for text classification and spam filtering tasks.

C) Support Vector Machines (SVM): SVM is a supervised learning algorithm that is used for classification and regression tasks. It finds a hyperplane in a high-dimensional feature space that best separates the data into different classes. SVM aims to maximize the margin between the decision boundary and the closest data points of different classes. It can handle both linear and non-linear classification problems through the use of kernel functions.

D) Decision Tree: Decision Tree is a simple yet powerful supervised learning algorithm that is used for classification and regression tasks. It creates a tree-like model of decisions and their possible consequences based on the input features. Each internal node represents a feature, each branch represents a decision rule, and each leaf node represents the outcome or prediction. Decision Trees are interpretable, can handle both categorical and numerical data, and can capture non-linear relationships.

E) Logistic Regression: Logistic Regression is a popular statistical model used for binary classification problems. It estimates the probability of a binary outcome based on input features using a logistic function. Despite its name, logistic regression is a linear model and works by finding the best coefficients that minimize the error between the predicted probabilities and the actual labels. It can be extended to handle multi-class classification as well.

Testing and Evaluation:

• Test the water monitoring and cleaning robot carefully to determine how well it functions and performs.

• By comparing the sensor data to the values from the standard calibration, we can evaluate the sensor's accuracy and dependability.

• To test the robot's performance and movement, it should be placed into the pond's water and checked for functions, mobility, movement etc.

The design, implementation, and testing of the water monitoring and cleaning robot for smart fish farming can be done using the technique described above. Following this methodology guarantees the proper integration of cleaning capabilities, water quality monitoring sensors, data processing methodologies, and user interface development, resulting in an efficient and effective solution for sustainable fish farming practices.

V. Result and Discussion

Since this robot performs multiple tasks, some parameters should be kept in mind in the results and discussion phase, such as cleaning effectiveness, water quality measurements, and fish species prediction.

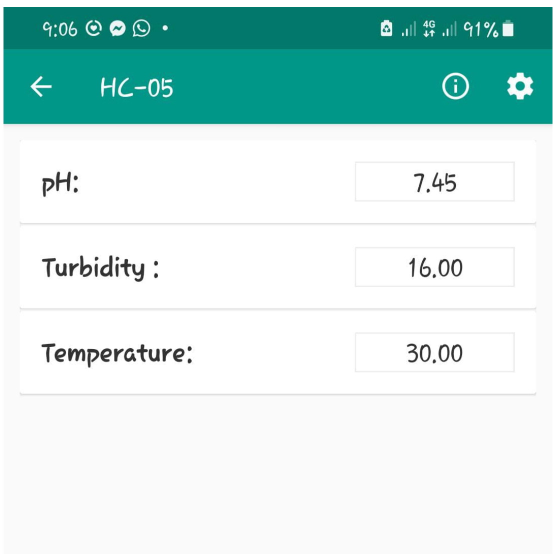

Fig. 8: Water Quality Monitoring

Cleaning Effectiveness: Evaluate the performance of the water monitoring and cleaning robot in removing floating dust from the pond's surface. We measured the robot's efficiency in reducing floating dust in comparison to manual cleaning techniques. Discuss the advantages of using the robot, such as increased efficiency, time savings, and reduced labor costs. Lastly point out the difficulties or restrictions discovered during the cleaning procedure and highlights suggest any changes.

Water Quality Measurements: In this section we collect the data that was gathered in real time by the pH, temperature, and turbidity sensors. Examine the patterns and changes in turbidity, temperature, and pH values over time. Find any unusual patterns or variations that might point to environmental or water quality issues.

Real time surveillance with object detection: In this phase we can monitor the real time video with object detection. So this robot ensure the security of the pond.

Fish Species Prediction:

In the machine learning model, we have used five different types of classifier algorithms and measure accuracy. Among them, we can see that the Random Forest classifier gives us much more accuracy than others and for our model Random Forest classifier algorithm is much more reliable and accurate than other algorithms.

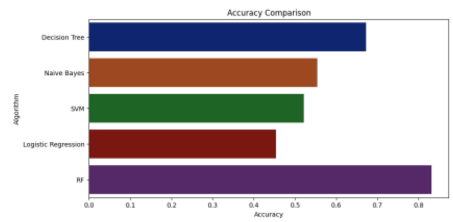

Fig. 7. Accuracy in Different Algorithm

Fig. 9: Accuracy in different algorithms

In this phase we manually input the sensor value into the machine learning model and it will predict which fish are suitable for firming in the specific pond.

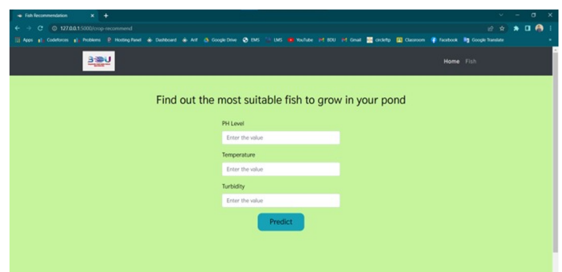

Fig. 10: Water Quality Parameter

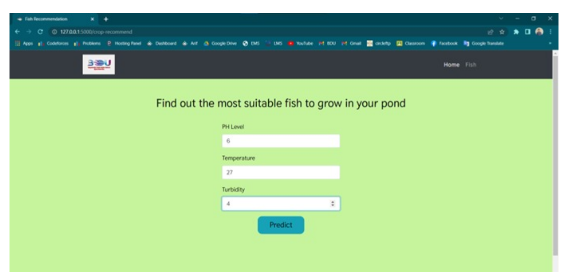

Fig. 11: Value Insert

VI. FUTURE ENHANCEMENT

The project "Water Monitoring and Cleaning Robot for Smart Fish Farming" provides the basis for advances in fish farming's automated water quality management. While the robot's current deployment shows its efficacy in removing dust and manually we can predict fish species based on pH,

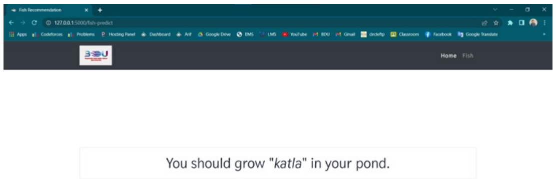

Fig. 12: Fish Species Prediction

temperature, and turbidity readings, there are a number of opportunities for further growth and improvement:

Integration of Additional Sensors: In future we can integrate many more types of sensors that will play a role as a parameter in measuring pond's water quality Combining the information from many sensors might help us better understand the condition of the pond as a whole and spot any issues or imbalances that might be having an impact on the health and growth of the fish.

Advanced Data Analysis Techniques: Investigate the utilization of advanced machine learning algorithms or artificial intelligence techniques to improve the accuracy and reliability of fish species predictions. Train predictive models using historical data on fish growth, behavior, and water quality parameters to enhance the prediction capabilities of the system.

Autonomous Navigation and Operation: Increase the robot's capabilities by including autonomous navigation and obstacle detection algorithms to allow it to move across the pond with ease. Implement algorithms that enable the robot to independently determine regions that require cleaning based on real-time data analysis and prioritize its cleaning activities accordingly.

Remote Monitoring and Control: Create a mobile application or web interface that enables fish farmers to remotely observe the robot's operations, view real-time water quality data, and get alerts or notifications about any anomalies or maintenance needs.

Scalability and Integration: Explore increasing the system's capacity to handle larger fish farming areas operations, possibly using several robots to cover more pond space. Integrate other smart technologies in fish farming, such as automated feeding systems, environmental control systems, or data analytics platforms.

The project's scope will continue to grow as its capabilities for water monitoring and cleaning are improved and expanded. The initiative can help to improve fish farming methods that are more sustainable, effective, and profitable by including more sensors, utilizing innovative data processing techniques, enabling autonomous operation, and supporting collaboration.

VII. Conclusion

The "Water Monitoring and Cleaning Robot for Smart Fish Farming" project has successfully designed and deployed an innovative approach to automate water cleaning, monitor water quality indicators, and provide manually made predictions on the most productive fish species for farming in a particular pond. To improve productivity, accuracy, and sustainability in fish farming operations, the robot combines a pH sensor, temperature sensor, turbidity sensor, and predictive algorithms. Automated water quality management is essential for fish farming, with a water monitoring and cleaning robot removing dust, reducing labor requirements, and improving cleaning efficiency. Sensors enable real-time monitoring and data collection, enabling proactive decision-making.

The predictions on fish species suitability based on the water quality data have proven valuable in optimizing fish farming practices. By analyzing the collected data, the robot provides insights into the most effective fish species for firming in the specific pond, ensuring optimal conditions for fish health, growth, and productivity. This feature enables fish farmers to make informed decisions about fish species selection, leading to improved profitability and environmental sustainability.

The developed user interface provides a user-friendly platform for monitoring the robot's activities, accessing real-time water quality information, and remotely controlling the robot. The interface facilitates informed decision-making, enabling fish farmers to stay updated on the pond's condition and take necessary actions to maintain optimal water quality.

The "Water Monitoring and Cleaning Robot for Smart Fish Farming" project has contributed to sustainable fish farming practices by integrating sensors, predictive algorithms, and advanced data analysis techniques. The future scope of the project lies in the integration of additional sensors, advanced data analysis techniques, autonomous navigation, and collaboration with fish farmers and experts.

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