Mini Project Report (Text-only)

Topic Name: “Semi-Automated Fish Farming using Embedded System and Blynk IoT”

# Introduction to the Project:

* We find fish to eat in the markets nowadays is getting more expensive with chances of animal-borne diseases getting spread faster than earlier. This is due to the low output of the fish industry mostly due to the fact that its completely based on fishing with nets; speaking about countries like India where technology is rising at a fast pace there is a need of integrating this tech with fish industry i.e., aquaculture.
* Aquaculture is the controlled cultivation (farming) of aquatic organisms such as fish, shrimps, seaweed and aquatic plants like lotus; which have immense value in the commercial markets. It involves cultivating fresh-water, brackish-water and salt-water populations under controlled or semi-natural conditions, and can be contrasted with commercial fishing.
* Aquaculture in sea-water habitats and lagoons is mariculture, opposite of fresh-water aquaculture; while pisciculture is aquaculture that consists of fish farming to obtain fish products as food. Overall, it can simply be defined as the breeding, growing and harvesting of fish and other aquatic plants; that can also be used to regenerate endangered aquatic species.
* Aquaculture can be conducted in completely artificial facilities built on land, like fish tanks, ponds or aquaponics, where the living conditions rely on human control such as water quality (oxygen), feed, temperature, etc. Alternatively, they can be conducted in shallow-waters nearshore of water bodies, where the species are subjected to relatively natural environments.
* Aquaponics is the combined culture of fish and plants in recirculating systems, which can significantly increase land productivity by 30% to 40%, since it’s a combination of aquaculture with hydroponics in one system to optimise water and space. The pH and total dissolved solids (TDS) in the hydroponics system affects the growth of existing fish and vegetables.
* The sector that uses the most water accounting to almost 70% of total consumption is agriculture; which can be reduced by aquaponics i.e., combination of hydroponics and aquaculture. Here, water is continually cycled back and forth between fish tank and plant bed. In simple words, aquaponics is aquaculture where aquatic animal waste is fed as nutrients to hydroponically growing plants, and water is recirculated between plants and fish.
* Aquaponics uses approximately one-sixth amount of water and produce 8 times as much food per acre with 5 times growth rate. The preservation of a healthy ecosystem that is conducive to the growth of fish and plants is made possible by automation of aquaponics with IoT; as it has the potential to transform the way sustainable food production is done in the future.
* Aquaculture faces operational challenges, related to manual labor, maintaining the quality of the seafood products, production and controlling the cost and the composition of feed. These issues can all be addressed with the help of automation as technology makes it possible to gather data for traceability and process optimization. Controlling parasites is also important here.
* The cost of feed makes up 50% of the operational costs and is crucial to improve profitability. So, an automation system can ensure that feed is used economically. Feed composition has impact on cost, fish growth and environment. The fish need different composition of feed at different stages of their lives, so automation helps operators produce the mix exactly and efficiently, on every occasion. Diet changes can be followed up and monitored, maximizing growth and yield.
* Improper water quality and high temperature during water shift can result in loss of yield. Hence, an automation system can analyse water quality all the time, ensuring maximum production by making suitable adjustments. Data analysis can help operators learn how various small changes at stage impact the development of the fish, improving their growth and health. Most of this is done manually in real-life; so, automation using IoT can be of great use.

# Related Works:

* [1] describes a system made to effectively monitor water quality parameters, feed consumption, and other environmental parameters with commonly used sensors for aquaculture purposes as specific IoT for the rearing of fish are not available. It involves measuring water quality parameters using sensors like temperature sensor, pH sensor, dissolved oxygen sensor, turbidity sensor, ammonia sensor, nitrate sensor, ultrasonic water level sensor, foul-smell sensor, etc.; then notifying users when the water quality parameter falls below or rises above the optimum value, maintains a historical data set of the water parameters; with some manual and conditional actuators.
* [2] describes a system that provides real-time monitoring on water quality of aquatic environments that includes a control feature that allow users to turn on or off the water pump through either the internet or physical switch. Also, this system can send notification to the user if the water quality is poor, so enable user to do a quick and timely action. It also has automation feature to turn the water pump on or off according to the dissolved oxygen level. The sensors used measure temperature, pH, TDS, dissolved oxygen and salinity.
* [3] talks about how small farmers who are not capable enough to hire workers to look at their farm or can’t contribute much capital wise can still monitor at their fish/shrimp farm growth with the help of some sensors and microprocessors, which will give them regular updates on their farms’ needs and it’s growth. The chief sensors used are pH sensor, ultrasonic sensor and DHT11; while the other things used are ESP32, cloud storage and Blynk application.
* [4] describes about their floating raft aquaponics system which consists of a plastic bottle, Styrofoam and an aquarium setup; the Styrofoam has four holes for storing plastic bottles and placed on top of the aquarium apparatus. It used 2 microcontrollers, the WeMos D1R1 microcontroller for fish feeding and the Arduino UNO as a data processor for pH and TDS sensors. The user inputs the fish feeding schedule through the Blynk-based app along with additional monitoring of pH and TDS in real-time.
* [5] speaks about an aquaponics system which uses common sensors for monitoring pH of water, water level, temperature and humidity of atmosphere; which is updated in cloud platform. Also, there’s a feeding mechanism for regular feeding when the farmer wants to; which works in such a way that it the Servo motor activates and rotates at predetermined angles after receiving signal from Node MCU which makes food fall into the fish tank as it rotates in desired quantities and timings.

# Data and methods:

Based on the related works, we had made the list of components initially, which changed later on due to monetary budget and/or unavailability of components.

## Project Components (Initial List):

* Arduino Uno and ESP8266 Node MCU (as the microcontrollers);
* Temperature Sensor DS18B20 (for measuring temperature of water);
* pH Sensor SEN0161 (for measuring pH of water);
* Analog Electrical Conductivity Sensor (for measuring water salinity);
* DHT22 Temperature and Humidity Sensor (for sensing atmospheric conditions);
* Analog Dissolved Oxygen Sensor (for measuring oxygen amount in water);
* SEN0244 Total Dissolved Solids sensor (for measuring water TDS);
* Ammonia/Nitrate Sensor MQ135 (for measuring ammonium and/or nitrates in water);
* Light Dependent Resistor (LDR) circuit (for measuring intensity of light on the water tank);
* Aquarium Heater/Cooler (for constantly maintaining water temperature);
* Aquarium Air Pump (for maintaining dissolved oxygen in water);
* Servo Motor SG90 (for feeding mechanism of the fish);
* Power Supply and Water Tank Enclosure;
* LCD with I2C module (for display unit); and
* Connecting Wires, Breadboard and some Electronic Components.

## Project Components (Final List):

* ESP8266 Node MCU (as the microcontroller);
* Temperature Sensor DS18B20 (for measuring temperature of water);
* pH Sensor SEN0161 (for measuring pH of water) [representation purpose];
* DHT22 Temperature and Humidity Sensor (for sensing atmospheric conditions);
* SEN0244 Total Dissolved Solids sensor (for measuring water TDS and assumed salinity);
* Servo Motor SG90 (for feeding mechanism of the fish);
* Arduino UNO as Power Supply and a plastic box for Water Tank Enclosure; and
* Connecting Wires, Breadboard and resistor of 4.7kOhm.

## Transition from Initial to Final Plan:

* The initial plan was to make this fully-automated with actuation mechanism as well, but had to be changed. Many of the sensors had to be removed; for instance the Dissolved Oxygen sensor and it’s actuation mechanism was removed due to the fact that the rare earth metal (like platinum) used in it makes it expensive. Similarly, we didn’t find an analog electrical conductivity sensor in our locality to measure salinity; and the Ammonia/Nitrate sensor described above was for measuring the quality of air, which might not work in water according to our studies from the internet.
* We had to remove the actuation mechanisms of all the parameters like pH and TDS (acid/base/salt was to be added in too small quantities i.e., of the order micrograms for the water tank we took); temperature (which intended to use an aquarium heater/cooler but wasn’t available in the locality); atmospheric humidity and temperature (which was intended to use humidifiers but were expensive), so the final system was semi-automated.
* We had finally stuck to using ESP8266 Node MCU as the chief microcontroller instead of Arduino UNO due to its Wi-Fi connectivity and also an idea of showing the sensor values in Blynk IoT application. The idea of using LCD with I2C module as a display unit was removed as neither the LCD worked well nor the other sensors worked due to the fact that it was drawing way high power from the supply unit. The final display unit comprised of the Blynk IoT app interface and the serial monitor as a secondary. Arduino UNO was used as the power supply unit because other conventional 5V power supply units were giving high current to the sensors except Arduino UNO.
* Light-Dependent Resistor (LDR) Circuit was also removed due to the fact that there was no actuation mechanism planned for that and it had a problem; if we block light only for the LDR circuit but not on the entire enclosure, the system might act in contradicting manner by taking the light intensity to be less than what actually is going on. Also the pH sensor had calibration issues due to the fact that there was no datasheet issued by the manufacturer which made us to use it for representation purposes only.

## Methodology of the Project:

* Firstly, we set up the entire model on a plastic airtight-container without it’s lid; At one of it’s sidewalls, we attached the breadboard comprising of the Node MCU along with TDS sensor, DHT22 sensor and the DS18B20 sensor such that the probes of theses sensors are into the container; its adjacent side wall has Arduino UNO attached to be used as power unit.
* The top of the container had a plastic water bottle fixed in a horizontal position, with SG90 servo motor attached to its bottom and small holes made at the side such that food falls from them; the pH sensor electrode was attached into the container with its module on the third side wall and correspondingly required 9v DC power supply was fixed beside. Two USB connections were to be given to a computer for providing power to the microcontrollers.
* The code for interfacing all the sensors (except the pH one which was used only for representation purposes) has been fed into the Arduino IDE with all required libraries and drivers installed. The same computer was used to provide power for the Arduino UNO and the Node MCU; while the Wi-Fi setup to the ESP8266 was given by a mobile hotspot. The Blynk IoT mobile interface represented all the sensor readings real-time.
* When the model runs, the data from each of the sensors attached will be shown on the serial monitor as well as the Blynk IoT application. The TDS and pH (well-calibrated) sensors provide analog outputs while all the others provide digital outputs; along with these the code orders the servo motor attached to the plastic bottle (which will hence be termed feeding mechanism) to rotate at specified degrees of angle for 3 times consecutively, keeping a time duration of 10 seconds for the next 3 rotations; there was no actuation part designed (as mentioned earlier). The flow chart gives a pictorial format of the above words, and the pictures of the model and the Blynk IoT interface are attached.

# Results and Discussions:

## Sensor Readings and their Accuracy/Precision:

* When we observed the DS18B20 temperature sensor readings in atmosphere, it was showing close values to that of the present temperature of the surroundings, with slight issues which could be further decreased with better resolutions; the same was observed when checking human body temperatures and water temperature vs. conventional thermometer; which indicated a precision of ±0.5°C based on our rough calculations.
* Similarly the DHT22 atmospheric temperature and humidity sensor also had good accuracy but there wasn’t an option to improve its resolution; the temperature readings of this sensor were always similar compared to the weather updates as well as the DS18B20 in air. The humidity was also accurate as well; it indicated accuracy of ±2% based on our calculations.
* The SEN0244 Analog Total Dissolved Solids (TDS) sensor also had proper readings as expected though the code worked entirely different when reference voltages transitioned from 5V (working with Arduino UNO) to 3.3V (Node MCU) and vice-versa; but it was able to differentiate drinking water and tap water every time. The difference might be due to the calibrations (the sensor supports 5V supply voltage which we provided, but the analog pin in Node MCU considers maximum value 3.3V); for instance we got the TDS of a drinking water sample to be 100ppm from the Node MCU, but 95ppm for the same sample from the Arduino UNO. This sensor has an accuracy of ±10% at temperature of 25oC.
* The SEN0161 pH sensor we acquired need 9V input voltage, whereas most of these kits in the market have 5V input voltage, resulting in many calibration issues; for instance the sensor was measuring a water sample of pH=7 as pH=3.7, which was the same with many codes from the internet and other sources; this is the sole reason being mentioned multiple times in the report making it just a representational object.
* The SG90 servo motor-based feeding mechanism worked perfectly alright as expected with precise rotations and perfect delays for multiple values applied. Finally, the Blynk IoT application also was getting updated regularly when checked with the serial monitor with 2 second delay (due to other delays in the code); provided a stable internet connectivity.

## Further Improvements possible:

* The project can become a fully automated version if the actuation mechanism is set up; like we can automate the maintenance of the model by just giving some commands. A water pump can be used to maintain freshness of the water in the model.
* With proper pH detection (well-calibrated sensor) and actuation mechanism (increase/decrease the pH levels of the model using acid/base/salt), the pH of the tank can be maintained, provided the range of pH by the user. The actuation mechanism could be implemented in this model but the problem is the weights are of too low order.
* The water salinity detecting and actuating mechanism could be implemented as well to support freshwater and/or seawater fish species; provided the range set by the user; similarly for the humidity we can use humidifiers as actuators so as to maintain atmospheric humidity similar to the coastal areas. The temperature of water can be also maintained by the water pump (to lower temperature) or aquarium heater (to higher temperature) as part of temperature actuation.

# Conclusions:

This project gives us an idea how aquaculture industry can be made labour-free thereby revolutionising it for the future’s increase in demand of fish consumption. It also ensures high productivity of healthy fish; the parameters of every fish leaving the aquaculture enclosure will be better than naturally-growing fish, thereby making it as an affordable yet nutritious food item. The growing usage of Internet of Things (IoT) and better sensing and actuating mechanisms will aid in making better versions of such models which will not only be limited to fish but also other animal dependent industries like milk, eggs, chicken, mutton and beef. The system of hydroponics nowadays is being implemented in many countries of the world including India successfully, which is a message to the animal-based industry that automation and technology is quite important for better and higher yields; and automated aquaculture/aquaponics will rise in a similar fashion.

## Future Scope of this Project:

* This project can be implemented in large fish tanks in the sea shore, with all the required sensors (as per the initial list along with other essential ones) attached such that they cover the whole region and the actuation mechanisms of all the sensors used (along with some other components) to fully automate aquaculture in coastal regions.
* This project can also be implemented in non-coastal areas by setting the required conditions for rearing fish in large wells and ponds with quality water and suitable weather; the conditions of weather most likely being temperature and sunlight intensity can be created artificially using heating mechanisms and light sources; humidity can instead be created by aquaponics-based system by growing plants above the fish tank.
* There can be startups created based on this idea that entirely design the system based on the customer requirement and either sell the design completely or rent it on a monthly basis; the startup can also rent out sensor and tank maintenance provided the customer acquire the components themselves. They can also provide nutrient-rich fish food.

# References:

* [1] The Internet of Things in the Rearing of Giant Freshwater Prawn: A Pilot Study; 2023 IEEE 6th International Conference on Applied Computational Intelligence in Information Systems (ACIIS).
* [2] Development of an IoT-based Fish Farm Monitoring System; 2023 IEEE 13th International Conference on Control System, Computing and Engineering (ICCSCE).
* [3] Smart Monitoring System for Pond Management and Automation in Aquaculture; 2020 IEEE International Conference on Communication and Signal Processing (ICCSP).
* [4] Fish Feeding Automation and Aquaponics Monitoring System Based on IoT; 2020 IEEE 6th International Conference on Wireless and Telematics (ICWT).
* [5] Automated Aquaponics Farming using Internet of Things (IoT); 2023 IEEE 2nd International Conference on Electronics and Renewable Systems (ICEARS).