Precision Aquaculture using Underwater Sensor Network

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***Abstract* - It is noted that the growth is very rapid for IoT as well as Machine Learning and it is highly spreading throughout all the areas. Small processors like Arduino & Raspberry Pi make the modernized development in the ground level within its application in the field of Aqua Culture. The farmers dealing with aquaculture were feeling difficulty in the quality of water maintenance, Feeding the food, and identifying the diseases. This is the exertion of the implementation of the quality of water monitoring by employing Arduino, Raspberry Pi along with different sensors along with the machine learning algorithms applicable in the field of aquaculture. This arrangement will monitor the quality of water, feeding of food, recycling of water and the detection of diseases. The pH, Temperature and Electrical Conductivity is taken as the important parameters to maintain water quality for the better growth of fish. To ensure the survival fitness of aquatic life, the water quality is continuously monitored by the use of sensors. The acquisition of sensors is steered by Arduino and the data processing is carried out by Raspberry Pi. To ensure that the overfeeding or underfeeding is not happening, the automatic food dispenser is used here to supply constant food at certain periods. The Machine Learning algorithm techniques are being established to detect the diseases in the fish in the initial stage itself. The water pump is integrated with this process to make water recycle in a regular time gap. Hence, the projected smart arrangement is assumed to be the gainful and fully automated aquafarming process that can reduce the efforts and loss of large scale and small-scale investors.**

Keywords – Aqua Farming; Internet of Things; Detection of Fish Disease; Machine Learning Techniques; Water Quality; Raspberry Pi; Arduino.

I. INTRODUCTION

Aquaculture is also known as aquafarming, are the farming of fish, algae, and other organisms for rearing, breeding, and harvesting in all type of water environment. Under controlled conditions, freshwater and saltwater populations are cultivated. As the demand for fish is intensifying day by day, aquaculture is one of the booming areas in many countries in the world.

The average consumption of fish products average has increased from 9kg in 1960 to 20 kg in 2020 per person. Aquaculture is facing plentiful issues because of sudden climatic uncertainty because of which water quality parameters are changing and the spreading of disease occurs. Traditional manual testing is followed by aqua farmers for knowing the condition of the water parameters and also for the identification of disease which is time-consuming. It may also give inappropriate results. So, it is better to have automatic monitoring of the aquafarm. These problems can be eradicated by incorporating several modern technologies. Technologies have to support many key application areas of aqua farming such as living quality, identification of disease in its early stages, safety, fish feeder, water quality monitoring, changes in the environment etc. Hence, for this kind of advancement, it is required to be more careful in choosing the appropriate technologies. For data processing and storing, an IC Raspberry Pi is used that has an inbuilt Wi-Fi module. Underwater sensors are implanted to collect various water parameters. Underwater cameras are also fixed in various locations to take the photo of the fishes in various intervals. Early diseases attack can be detected by inputting these images into the Machine Learning algorithm. This work will be helpful to the farmers to maintain water quality parameters and to identify the diseases in the early stage itself. The implementation of this project makes the aquaculture fully automatic, thereby the huge loss due to the fish death will be avoided.

II. REVIEW OF LITERATURE

The effect of water quality parameters and their impact on aquatic life describes the few papers in the literature. It also mentioned how IoT devices usage will makeover the impact caused due to the water quality. A lot of research is carried out with IoT on this issue. IoT is making positive use of things in the field of agriculture.

The papers with the study of pH, DO and turbidity and a solution for these is mentioned. The biological, chemical and physical properties of water are very important for the fish to live and to improve productivity. Thus, water quality plays an important role in the fish living environment such as pond or bio-flog. The parameters such as TDS, Dissolved oxygen, transparency, colour, Temperature, pH, conductivity defines the quality of water.

The research on water quality parameters makes us understand that not all parameters are necessary for fish growth. So, it is not necessary to monitor all the parameters because most of the parameters are related to each other. So, we are considering three parameters in our work. The temperature comes first, pH comes second and Electrical Conductivity comes to the third parameter in our study. pH will let us know that the water is acidic or not. The salinity can be determined by quantifying the conductivity of the water.

Table 1 – Parameter Ranges

SN	Parameter	Acceptable range	Desirable range
i.	Value of Temperature	>15 & <35	>20 & <33
ii.	Value of pH	>7 & <9.5	>6.5 & <9
iii.	Value of Conductivity	>30 & <5000	>60 & <2000

III. SYSTEM ARRANGEMENTS

A. *Software and Hardware Descriptions*

Sensing Unit: It consists of a pH sensor to measure the pH level of water. The sensor that can be connected with Arduino is to be used for the pH sensing unit. The terminal of the dfrobot is connected with an Electrical Conductivity meter to measure the conductivity of the water. The sensor and the meter should be provided with a waterproof system. Also, dfrobot temperature sensor is connected to Arduino to measure the temperature of the water. All the sensors should be compatible with Arduino. Fig 1(a), 1 (b), 1 (c) shows the pictorial representation of the pH sensor, EC Sensor and Temperature Sensor. This makes us understand how the sensors look like and we can identify them easily.

Fig 1 – Sensing Units

Arduino and Raspberry Pi: We are using Arduino for the acquisition of sensors. All the sensors we use in this work are compatible with Arduino. The Raspberry Pi 3 is using in this work as a Processing Unit. All the data processing work will be carried out with Raspberry Pi associated with our work.

Camera: Here we are using a high-quality underwater camera to capture the images of fish in a particular interval. This is given as input for the Machine Learning Algorithms to identify the fish diseases. This method will help us identify the diseases at their starting.

B. *System Arrangements*

In this session, we are providing the detailed arrangements of our system. Fig 2 describes the overall architecture of the system.

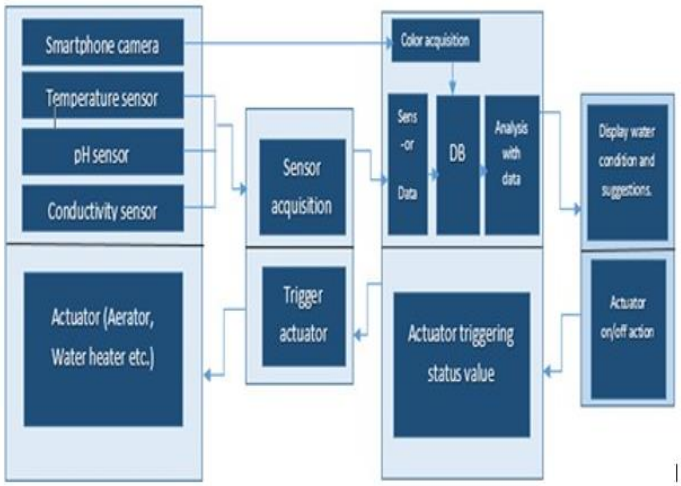

Fig 2 – System Architecture

IV. PROPOSED METHODS

A. *System for Quality of Water Monitoring*

The quality improvement, progress in environmental control reducing the cost as well as the production cost can be achieved through the aquaculture atomization. The growth rate, utilization of food feed, rate of growth, Salinity, Temperature and pH are the most important parameters to be controlled and monitored in the system specialized for aquaculture. The fish growth and the pattern of feeding are caused by the temperature change. The increase in temperature may cause diseases and stress in fish. Cool water has more Dissolved Oxygen (D)) than warm water. The temperature, Activity level, feed rate and fish size are proportional to the oxygen usage. The increase in temperature causes the reduction in dissolved oxygen and vice versa. The cause of stress, poor appetite, disease attack and slow growth is due to the reduction in dissolved oxygen.

B. *Food Feeding System*

The overfeeding of fish causes the wastage of food and also makes the water polluted and also the growth of the fish is reduced due to underfeeding. So, feeding plays an important role in the field of aquafarming. The farmers along with other farming cannot get time to feed the fish properly, hence may cause overfeeding or underfeeding in their aqua farm. For automatic food feeding, we introduce a food feeder and this will avoid manual feeding and the effects of overfeeding and underfeeding. The fish feeder will provide the food according to the measurements and time. This feeder unit with a proper feed plan will aid the reduction in terms of time and labour cost hence the overall cost of feeding can be reduced. The design of a food feeder is based on the land size, type of fish and fish size. This unit will dispense the fixed amount of food in a particular interval of time. This will be happening with the help of a motor and timer associated with the food dispenser. Fig 4 shows the architecture of the Automatic food feeder.

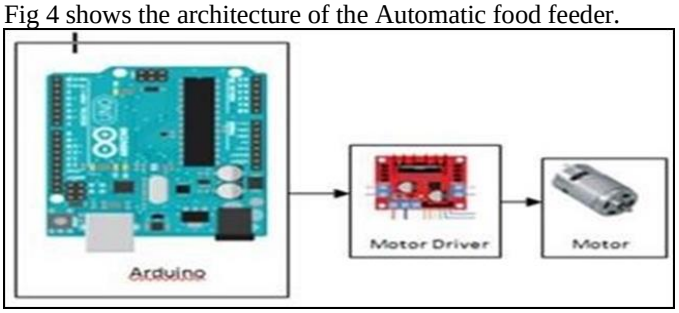

Fig 3. Food feeding system architecture

C. *Water Recirculating System*

Recirculation in aquaculture is an essential technology for aquafarming Here we use the recirculating system, which pumps water from the fish tank and is allowed to pass it through growing bags especially for filtration. As well as biochips are used for nitrification. The water which is passed through the plants is fed back to the tank so that it reduces the excess nitrate content as well as the impurities present in the water. The most environmentally friendly way of producing fish at good levels is the recirculating fish farm. The nutrients from the fish farm are being utilized for the production of biogas or they can be used as the natural fertilizer for the agriculture

D. Disease Detection Method

Aquaculture production is a great loss due to disease in fish. Increasing mortality in fish farms is due to fish diseases. Production cost increased as a result of loss in treatment cost, dead cultured species and reduced quantity and quality of yield. The focus of this work is on the main causes, importance, and control of fish diseases in aquaculture production. It creates consciousness on the management of cultured fisheries and practices by offering hands-on information on diseases and management of health in aquaculture production. Factors such as Low resistance of the fish, pathogens existence, unfavorable water environment etc. are the causes of active diseases in the fish.

In this system, the image is acquired and morphological operations like conversion of the image into grey, noise removal, image segmentation are applied. Features from accelerated segment test (FAST) are feature extractor used which helps to extract feature points. Dimensionality reduction by Principal Component Analysis (PCA) is done after the features are extracted using FAST. A Neural Network classifier is applied to train for detecting the fish disease. Comparing the Training dataset with the testing dataset, it gives better accuracy. This method automates the process of aquaculture and reduces the time of diagnosing fish disease.

The Steps involved in this methodology are:

1. Image Acquisition - It is the process by which we collect the image and translate it to the preferred output format according to the system.

2. Image Pre-Processing - Acquired images are then pre-processed. Some preprocessing steps include increasing contrast, converting the image into grayscale, noise removal and image segmentation.

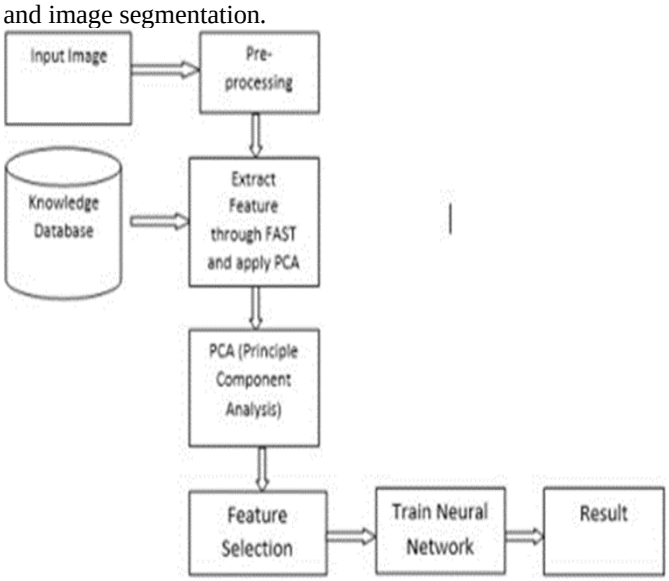

Fig 4. Methodology for the detection of diseases

3. Feature Extraction and Recognition

The symptoms of the disease are detected using this step. Once the acquired image is pre-processed, The FAST (Features from Accelerated Segment Test) algorithm is used to extracts the features. Infected images are loaded into the database to diagnose EUS. PCA (Principal Component Analysis) is to reduce the dimensionality for better accuracy.

4. Classification

Classification of the diseased fish and non -diseased fish is done by the classifier after feature selection. The dataset will be divided into training validation set and testing validation set. It is then fed into the Neural Network for classification. It is a fast and accurate method for the detection and classification of fish disease images. It is the simplest and easy way to detect the EUS disease, after applying the PCA.

V. CONCLUSION

IoT plays an important role in the implementation of automatic aquaculture system design in a unique way. This implementation is very cost-effective and it will give us a better result for the farmers while comparing with other systems that are available in markets. By the implementation of our new system, the farmers time can be saved and also it will help farmers to meet the demand of the fish in the market by producing a greater number of fish. This system will automatically maintain the quality of water by sensing the values using the sensors associated with this system. It gives an accurate measurement of water quality parameters. Food feeding is an important part of the growth and production of fishes in aquaculture and its management. The system provides a good solution for this problem since it dispatches a fixed quantity of food at regular time intervals. A water recycling system for water purification is also included in this system. It is simple which works without a pump and motor. It may not be possible to identify the fish diseases with naked eyes which is another challenge faced in aquaculture. By using machine learning applications and algorithms, it is possible to identify the disease in the fish easily. This system can be used to reduce the operation cost and also it will lessen the loss owed by the cause of fish diseases.

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