DEVELOPMENT OF SENSOR BASED INDIGENOUS SYSTEM FOR PREDICTING A SUITABLE WATER FOR A FISH POND CREATION AND MANAGEMENT

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Abstract- Fish farmers need to confirm that the water in the area of land aimed for fish pond creation is suitable for an adequate growth fish. Currently, most local fish farmers do not have automated systems for ensuring that the water content of a farm land is viable for the healthy growth and production of fish. This may be due to high cost of those systems, transportation risks, inaccessibility, etc. Most farmers choose farm lands at random and eventually discover that the water is not favorable for fish pond. This normally led to the sudden death of fish in the pond, poor fish yield, and reduction in its economic values. Effort, energy and resources are also wasted. Sensor based technologies has been used to predict the quality of water and determine its viability for a fish pond. However, not all of them are affordable for the local fish farmers. Those that are affordable are not easily accessible due to distance. A local and cost effective microcontroller (ATMEGA 328P) based Fish Pond System was developed, which is programmed to work with smart sensors to determine a suitable water for fish in a pond. It uses water PH sensor to determine the PH level of the water; the water turbidity sensor to determine the turbidity level of the water; the Ultrasonic sensor to determine the water level of the pond; and the temperature sensor to determine the temperature of the water. The Liquid Crystal Display (LCD) screen is used to display the values of the quantities measured above in real time. The system makes use of a very simple object – detection algorithm to help the fish farmer learn how to use it easily. This system is relatively less costly, and gives accurate results. The system ensures reduced fish mortality rate and increased fish production rate.

Index Terms- Microcontroller, Sensor, Predicting, Suitable water, Creation, Management, Fishery, Food Security, Pond.

I. INTRODUCTION

Population is increasing all over the globe amidst decreasing food production. So, trying to fill food shortages by producing more food on less land is a necessity. A large part of the food comes from the fish. So many steps are being taken to increase the production of fish. But due to the poor quality of the pond, the production is being interrupted. Currently, fishery farming in Nigeria is a booming and productive process. It contributes a lot to the National Gross Domestic Product (GDP). It becomes very important at the present digital age to modernize the fishery process for optimum gains. The sensor based fish pond system is a system that connects objects to the LCD screen and can either be automated or manually controlled. The system collects data from the surrounding through some sensors and displays it on the LCD screen in real time.

The work is consistent with some of the work done locally by fish farmers. Fishermen in Nigeria are not properly trained to increase fish production as expected. Farmers incur many losses in sudden death of fish in the pond. Raising or lowering the temperature, PH and water level at appropriate time is of utmost important for the overall wellbeing of the fish in the pond. This kind of change is not naturally easy for the farmers to realize. These losses are avoidable. There are no available devices for local farmers to use in maintaining the environmental factors for healthy sustainability of the fishes in the pond in order to reduce the mortality rate of fish. To reduce this death rate of fish, a microcontroller and sensor based smart device has been developed, which will get some information from the surrounding to guide the fish farmer properly. Hence, the fish mortality rate will be decreased and fish production rate can be increased.

An indigenous sensor based system has been introduced which can detect temperature level, PH, Turbidity and water level from water floating point at every moment. The device can determine the condition of the pond for the specific fish which is needed. It helps fishermen with some useful information which supports them to produce more fish such as the Dissolve Oxygen and PH for fish farming which are the most important things. Farmers will know about the Oxygen level in the water and PH from the devices and can take necessary steps. Besides, fish farmers will also be able to know about temperature in the water through this device and protect their fish from harmful substances inception of ideas till their publications.

II. OVERVIEW OF FISH DEMANDS IN NIGERIA

The demand for fish in Nigeria mostly outstrips the local production. Nigeria is the largest fish consumer in Africa and among the largest fish consumers in the world with over 1.5 million of tons of fish consumed annually. Yet, Nigeria imports over 900,000 metric tons of fish while its domestic catch is estimated at 450,000 metric tons per year [1]. According to [2] as shown in Table 1 below the projected human population figures, the fish demand and supply in Nigeria from year 2000 – 2015. The statistic available indicates that the growth in fish production is due to increased activities of aquaculture, and the need for aquaculture arose from the decrease in supply from ocean fisheries as a result of over-fishing, habitat destruction and pollutions [3]. Unlike capture fisheries, aquaculture requires deliberate human intervention in the organisms' productivity which results in yields that exceed those of natural environment alone. Such interventions are stocking water with seed (fingerlings), fertilizing the water, feeding the organisms, and maintaining water quality.

Table 1: Projected Human Population, Fish Demand and Supply in Nigeria (year 2000 - 2015).

Year	Projected Population (Million)	Projected Fish Demand (Tonnes)	Projected Domestic Fish Supply (Tonnes)	Deficit (Tonnes)
2000	114.4	1,430.00	467.098	962.902
2001	117.6	1,470.00	480.163	984.836
2002	121.0	1,412.50	507.928	1,004.572
2003	124.4	1,555.00	522.627	1,063.082
2004	128.0	1,600.00	536.917	1,063.072
2005	131.5	1,643.75	552.433	1,091.317
2006	135.3	1,691.25	567.948	1,023.301
2007	139.1	1,732.75	583.872	1,154.873
2008	143.0	1,782.30	600.612	1,186.887
2009	147.1	1,838.75	617.353	1,221.397
2010	151.2	1,810.00	634.500	1,225.440
2011	155.5	1,943.75	652.606	1,291.143
2012	160.0	2,000.00	689.958	1,328.508
2013	164.0	2,113.75	709.683	1,365.042
2014	169.1	2,175.00	730.248	1,404.067
2015	174.0	2,055.00	671.492	1,444.752

Source: [2] (FDF, 2008) (Tonnes x 1000)

Although aquaculture activities in Nigeria started about 50 years ago [4], yet Nigeria has not been able to meet domestic production demand for the populace. According to [5] statistics indicate that Nigeria is the largest African aquaculture producer, with population output of over 15,489 tonnes per annum. This is closely followed by Egypt with output of about 5,645 tonnes. Only five other countries; Zambia, Madagascar, Togo, Kenya and Sudan produce more than 1,000 tonnes each. This result shows that Africa in general is far behind in aquaculture production. Only in recent years has aquaculture been viewed as an activity likely to meet national shortfalls in fish supplies, thereby reducing fish imports.

A. Aquaculture Farm Systems and Techniques

There are different systems and techniques used in aquaculture for fish production. We have three major systems based on feeding methods; extensive, intensive and semi-intensive.

In extensive system, the fish feeding is based on natural foods like phytoplanktons and zooplankton. That is, no supplementary feeding is required.

Intensive system is the one in which the fish are fed with external food supply; whereas, in semi-intensive, the fish are fed with supplementary feed in support of natural food supply. They various techniques used are as follows: Flow through system, Ponds, Cages, Tanks and re-circulating systems.

1. **A Flow –through system,** also known as a raceway, is an artificial channel used in aquaculture to culture aquatic organisms. Raceway systems are among the earliest methods used for inland aquaculture. A raceway usually consists of rectangular basins or canals constructed of concrete and equipped with inlet and outlet. A continuous water flow – through is maintained to provide the required level of water quality, which allow fish to be cultured at higher densities within the raceway.[6]. Fresh water species such as catfish and tilapia are commonly captured in raceways. According to [7].
2. **Fish Cage aquaculture** refers to rearing of aquatic species within enclosures in natural waterways. The fish

cages are placed in lakes, ponds, rivers or oceans to contain and protect fish until they can be harvested according to [8]. The method is also called "off-shore cultivation" when the cages are placed in the sea. Fish are stocked in cages, artificially fed, and harvested when they reach market size.

3. **Fish Tanks:** Fish farming can also be carried out in outdoor or indoor concrete or plastic tanks. Tanks can be informed of small aquaria (glass or plastic) or large fiber glasses. Production tanks varies in size and shape, however, round tanks between 5,000 to 10,000 litres are most commonly used according to [9]. Tanks need to be non-corrosive, therefore, plastic or fiberglass is recommended. Smooth round tanks with a conical shaped bottom are considered advantageous as this will assist waste solids disposals during draining.
4. **A Fish Pond** is a controlled pond, artificial lake or reservoir that is stocked with fish and is used in aquaculture for fish farming, or is used for recreational fishing or for ornamental purposes. Mostly earthen ponds are used for culture of carps, tilapia, catfishes and sea bass.
5. **A Re-circulating Aquaculture System (RAS)** is essentially a closed system and involves fish tanks and filtration and water treatment systems. The fish are housed within tanks and the water is exchanged continuously to guarantee optimum growing conditions. Water is pumping into the tanks through biological and mechanical filtration systems and then returned into the tanks. Not all water is 100% exchanged however as it is difficult to ensure that all waste product are converted or removed by the treatment process. Most culture recommend at least 5% to 10% water exchange rate per day depending on stocking and feeding rates (ALSS), (2013). RAS occupy a very small area and allow the grower to stock fish at high densities and produce high yields per unit area. These systems are very intensive and then require a high level in management of stock, equipment and water quality. They provide a predictable and constant environment for growing fish. RAS can be expensive to purchase and operate. For this reason, it is usually very economically viable to farm high value species in these systems.

B. The Problems of Aquaculture

[10] found out that a number of problems confront the production of catfish; being a major species in Nigeria. Prominent among these are poor management skills, inadequate supply of good quality seed, lack of capital, high cost of feed, faulty data collection, lack of environment impact consideration and marketing of products. If the associated problems of production, especially the twin issue of feed production and fingerling supply are tackled, Nigeria will soon become a world exporter of catfish. According to Oota cited in [11], high cost of input, lack of credit facilities to fish farmers at low interest rate, lack of skilled manpower and lack of aquaculture in the country. However, [12] stated that the major problem hindering the promotion and development of the aquaculture industry in Nigeria has been the scarcity of fish fingerlings and that the major factors militating against the production of high quality of fish seed are energy and water quality related problems arising from skills gap in the industry.

C. Fish Pond Preparation

Before a pond can be stocked with new fish, the excessive wastes, which accumulate in the pond during the previous farming, must be removed and the soil and water conditioned or upon a newly constructed pond, the following preparations have to be taken into consideration: cleaning and liming.

1. Cleaning

There are two methods of cleaning; the drying method and wet method. The drying method occurs where the ponds can be completely dried like a concrete pond. Whereas, the wet method takes place in ponds like earthen ponds in which the water in the pond cannot be completely dried.

2. Liming

Once the pond is cleaned, it is filled with water and left overnight before flushing out to remove debris and elevate the PH. This process should be repeated until the PH of the water remain above

7, and only then the lime is applied. The types of lime to be used depend on the water PH. It is recommended that agricultural limes ($CaCO_3$) or dolomite [$CaMg(CO_3)_2$] should be used in pond with water PH below 5 according to [13]. The amount of lime to be used should be carefully calculated to avoid inducing an excessively high water PH, which may increase ammonia toxicity and result in the mortality of the fish stocked. When the pond is properly limed and filled with water, the average water PH should be between 7.5 to 8.5 with daily fluctuation of less than 0.5.

D. Fish Stocking Density

Stocking marks the beginning of production cycle. Stocking density of any aquaculture pond has to be first and foremost considered in management principles. This is because if a pond exceeds its carrying capacity, fish stress is bound to occur which can eventually lead to fish mortalities. The process of stocking referred to here, starts with the collection of fingerlings from the hatchery, transporting to the farm and, finally putting them into the pond. Poor stocking procedures, are among the major causes of low survival in grow-out ponds. [14]. They result in stress, diseases and reduced growth and eventually lead to mortality and financial losses. Also, quality fingerlings are another important factor to note while stocking. Poor quality stock will give poor production performance regardless of other factors. The most important practical criteria for assessing the quality of fingerlings are source, physical appearance and how they swim. A pond's carrying capacity is influenced by the following: A size of the fish in the pond (because this influences the feeding rate); the species of fish being raised because fish like Clarias spp become air breathers and do not need to rely on dissolved oxygen in the pond, therefore the carrying capacity is higher for Clariasspp compared to Tilapia.

E. Fish Pond Parameters

1. Temperature

Unlike man that is warm blooded, fish are cold blooded. The metabolism which occurs in their bodies is greatly influenced by the water temperature. For the African Catfish, an acceptable temperature range is between 26ºC to 32ºC. When water temperature in the ponds consistently stays between 16ºC and 26ºC, feed intake reduces and fish growth rate also drags tremendously. A farmer will be stressed. Prolonged stress can open up the fish to opportunistic infections. When fish are consistently exposed to temperatures below 15ºC, fish growth will ultimately stop and death is just around the corner.

Low temperature negatively affects rates at which wastes are converted in the water. However, when water temperature is above 32ºC, the resultant effect on the African Catfish in not good at all. This is because of the fact that Oxygen is not readily soluble in very warm water. High temperature in ponds will stress the fish and eventually lead to death.

2 pH

pH is the level of the Hydrogen ion present in the water. For the fish in the pond, acceptable pH value is between 6.5 to 7.5. When it is below 4, fish will die due to water acidity.

When pH is constantly between 4 to 6, fish will be alive, but, due to stress, will experience slow growth. Feed intake will be highly staggered and reduced. In fact, for the observant fish farmer, low pH in pond water is an indication of high CO2, (carbon dioxide) in the water.

High pH values of between 9 to 11 in pond water will also retard fish growth. Fish will ultimately die when pH levels rise above 11. Low pH aids higher proportions of ionized ammonia which is less toxic to fish. The reverse is the case with high pH in water.

[15] Fish culture in earthen ponds is an important source of income for farmers in northern Thailand. Water quality in ponds has strong impacts on fish production farmers' return and is sensitive to weather and climate. Low levels of dissolved oxygen in fish ponds are major cause of mass mortality. Stratification with depth in ponds followed by rapid turnover or exchange of surface and bottom water can expose fish to dangerously low dissolved oxygen levels.

F. Appraisal of Reviewed Work

Catfish among others is major species of fish in Nigeria. Among the prominent challenges in Nigeria on fish production are poor management skills, inadequate supply of good quality seed, lack of capital, high cost of feed, faulty data collection, lack of environment impact consideration and marketing of products. If the associated problems of production, especially the twin issue of feed production and fingerling supply are tackled, Nigeria will soon become a world exporter of catfish. Also, the major factors militating against the production of high quality of fish seed are energy and water quality related problems arising from skills gap in the industry. Hence, there is a need to implement an automated system for ensuring that a fish pond will be suitable for effective fish production

III. HOW THE SENSOR BASED FISH POND WORKS

Unified Process Modelling Approach was adopted in this work. As expected, Object Oriented Paradigm (OOP) styles was followed to ensure essential component of the System are treated independently as an object. This also ensured data security and abstraction.

Different data gathering techniques including interview, internet, brainstorming, observation and study of related materials was utilized for the successfully completion of this research. Documented materials on local fish ponds in Nigeria and worldwide were studied. There were also direct observation of existing automated systems for firsthand information. A set Fish Pond Famers were interviewed from Ettagha Agro-Ventures Fish Farm whose responses gave more insight into the project work.

A. Analysis of Existing system

Ettagha Agro-Ventures Fish farm was examined. These are two different types of fish ponds examined. They are concrete and earthen fish ponds. The concrete pond is 4ft deep with water level of about 3ft to avoid the fish jumping out of the pond. The water quality is always affected by their feed as shown in Figure 1a below. On the earthen pond there's an inlet and outlet in which water flows in and out of the pond. While, there's an overflow pipe which checkmate water level in the pond as shown in Figure 1b

Figure 1a: Earthen fish pond

Figure 1b Concrete fish pond

B. High Level Model/Block Diagram of the New System

Design and Construction of a Microcontroller Based System for predicting the most suitable water for fish pond farming and management is divided into four (4) units as shown in figure 2.

The detection unit is made up of the four sensors namely: Ultrasonic Sensor, Liquid Ph Sensor, Turbidity sensor and Temperature sensor. These are used to read the various fish pond data like water level, water ph, water turbidity, and water temperature respectively. The data collected from the intended fish pond area is being received by the Control Unit (Atmega328 MCU), which is programmed to do all the processing and sequencing functions. The control unit also determines the actual components of the feedback unit to trigger. The feedback unit is made up of the LCD Screen which is used to display the real time data collected from the sensors. The other part of this unit is the Indicator LEDs. They are used to indicate when certain sensors have gone below or above threshold values.

The last part is the power unit. This unit consists of the Dc-Dc bulk converter which is used to step down 9v from the battery to usable and stable 5v for powering the entire circuit.

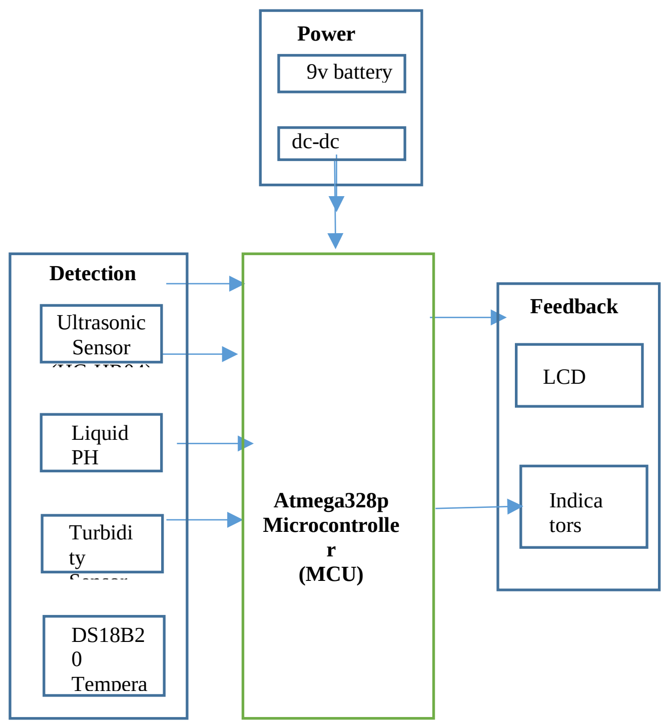

Figure 2: The Block Diagram of the New System

C. Use Case Diagram of the System

Use Cases was used to specify the functional requirements of the system. Figure 3 below shows that the system itself is an actor. It is capable of detecting water ph, water turbidity, water level and water temperature of the intended pond water. The system is also able to display the sensors' data on the screen in real time. Finally, it is able to indicate when the sensor data go above or below threshold. The farmer is also seen as part of the use case diagram because he collects information from the output units.

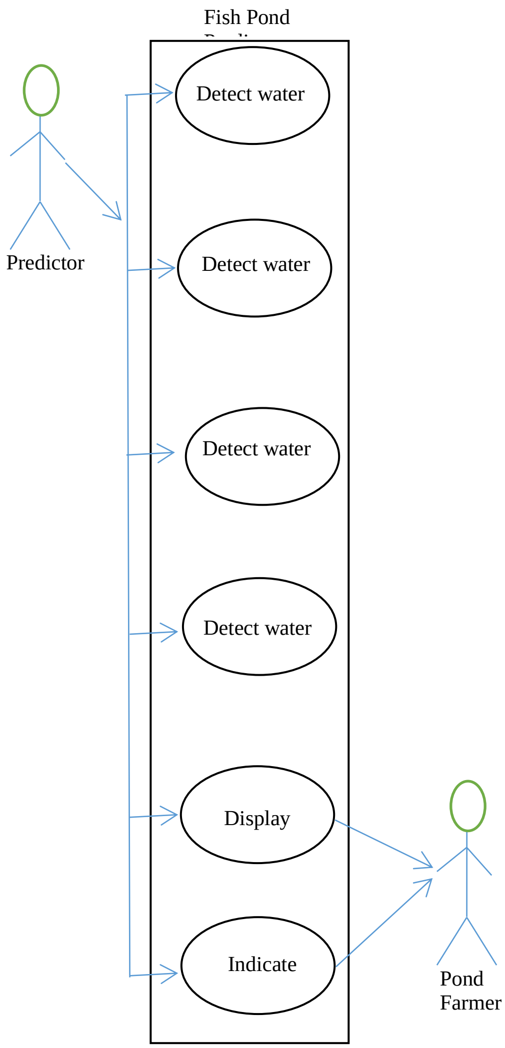

Figure 3: The Use case diagram of the New System

D. The Communication Diagrams of the System

The communication diagram is used to show how classes of the system interact to produce overall results. We have considered the communication diagrams of the various use cases as in figure 4

The communication diagram shows how the various sensors which are triggered by different pond water factors pass messages from one object to another. When a sensor reads values from the outside world, it transmits the value in form of signal to the object of the Fish Pond Predictor class. This object then passes the processed signal to the object of the detection class in order to determine the sensor value range. If the sensor value is confirmed to be within expected range, the object of the detection class passes the confirmation message back to the object of the Fish Pond Predictor class for further decision and action. From the diagram, this object decides which actuator to trigger. In our case, the LEDs are triggered to indicate to current state of the sensor and the LCD class is used to display the current readings from the sensors

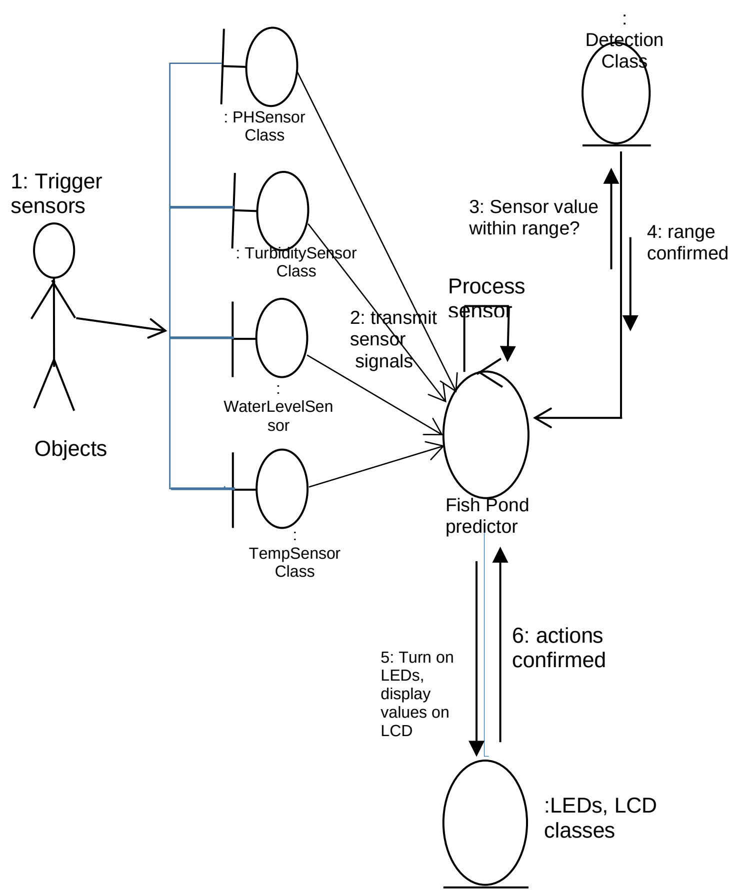

Figure 4: Communication Diagram for the Use Cases

IV . *SYSTEM COMPONENTS AND RESULTS*

The New system was made up of three major sub units namely: detection unit, control unit and notification unit.

A. Control Unit

The control unit of the system is made up of Arduino Uno which is a microcontroller board developed by Arduino.cc and based on Atmega328. Arduino Uno consists of USB interface, 14 digital

I/O pins, 6 analog pins, and Atmega328 microcontroller. It also supports serial communication using Tx and Rx pins. The Atmega328 microcontroller is a system of 40 pin chip that comes with a built-in microprocessor. It is the main chip that is programmed to carry out all the input signal processing. It is housed in the Uno board for easy programming and debugging. Each of the sensors' data is fed into the controller, which then processes the inputs based on the stored logics and hence trigger the necessary output devices. The controller was programmed in C language using Arduino IDE (Integrated Development Environment).

B. Detection units

This represents the input units of the system. They are merely sensors which take readings from the pond and transmit them to the microcontroller for processing.

1. PH Sensor E-201-C: PH stands for the Power of Hydrogen and pH sensor is used to measure the hydrogen ion concentration in the body or liquids. 1 to 14 is the scale range of the total pH and 7 is the neutral value of pH. If there is less than 7 then the liquid will be acidic; and if the solution contains greater than 7 then the liquid will be basic or alkaline. This PH meter is low cost and effective. This pH meter is convenient and practical and it is specially designed for Arduino controllers to contain a "Gravity" connector and a bunch of features. The meter's probe is connected to Arduino to get measurements at +- 0.1pH (25 degrees centigrade).

   This meter has a great accuracy range. It also has an LED that is working as the Power indicator. It also contains a BNC connector and PH2.0 sensor interface. To use this meter, connect this device to the BND connector and plug the PH2.0 interface into the analog input port by any Arduino controller. With the help of pH Meter and Arduino, other pH meter gadgets could be made.

2. Turbidity sensor: this sensor works on the simple principle of light being blocked by particles suspending in the liquid. The turbidity can be measured by detecting the amount of light going through the liquid sample. The turbidity unit is measured in NTU "Nephelometric Turbidity Units" which is global standard.

   The larger the turbidity is, the cloudy the sample is. Turbidity sensor connects to the microcontroller through an analog to digital converter through this A to D converter. The output signal can be switched between analog and digital. Under analog mode the signal wire from A to D converter goes to the analog input pin on the microcontroller. The turbidity is represented by the voltage of the output pin.

3. Ultrasonic Sensor: The HC-SR04 Ultrasonic distance sensor consists of two ultrasonic transducers. The one acts as a transmitter which converts electrical signal into 40 KHz ultrasonic sound pulses. The receiver listens for the transmitted pulses. If it receives them, it produces an output pulse whose width can be used to determine the distance the pulse travelled.

   The sensor is small, easy to use in any robotics project and offers excellent non-contact range detection between 2 cm to 400 cm (that's about an inch to 13 feet) with an accuracy of 3mm. Since it operates on 5 volts, it can be hooked directly to an Arduino or any other 5V logic microcontrollers.

   Ultrasonic Sensor has been used in this research work to monitor the water level of the fish pond. The water level should not be too low or high but moderate.

4. DS18B20 Temperature Sensor: DS18B20 is 1-Wire digital temperature sensor from Maxim IC. It reports degrees in Celsius with 9 to 12-bit precision, from -55 to 125 (+/-0.5). Each sensor has a unique 64-Bit Serial number etched into it - allows for a huge number of sensors to be used on one data bus.

   This sensor has been used in this project to detect and monitor the temperature changes in the fish pond. Fishes require moderate temperature to survive in the pond.

C. The output unit:

This unit can also be called the actuators. They are used by the system to either give feedback or control real life situations. LCD screen and LEDs have been used in this research work to display the sensor values and indicate some changes respectively. They are further discussed as below:

1. LCD Screen:

   LCD (liquid Crystal Display) is an electronic display module and find a wide range of applications. A 16*2 display is used in devices and circuits. The 16*2 module is preferred over a seven segments. The 16*2 LCD means it can display 16 characters per line and there are 2 such lines. The LCD has two registers namely command and data.

   It is used in the proposed system to display all the sensor values in real time. From the readings on this display, the fish pond farmer can take quality decisions.

2. LEDs: they are used as indicators. They indicate both system booting and various states of the sensors.

V. DISCUSSION AND DEPLOYMENT

The LCD Screen has been mounted at the front side of the casing for real time monitoring of the various sensor outputs. The sensors are seen connected to the microcontroller through holes perforated on the body of the casing. All the indicator LEDs are shown in red, yellow and green at the bottom front of the casing as shown in Figure 5.

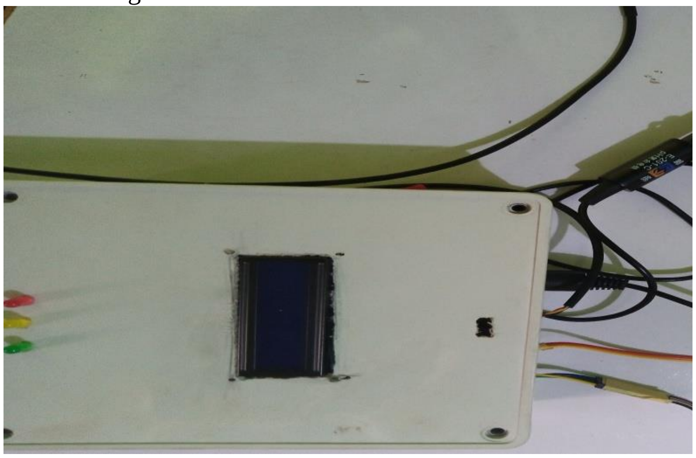

Figure 5: Sensor Based Fish Pond System Outer view

A. Software for the system

Software was used to model the interfacing of various component parts of the system. It was used to access components like Arduino Uno Board, Ultrasonic sensor, jumper cables and colorations. The Procedure started Loading the Fritzen Application. Choose Breadboard, Schematic, PCB, or Code tab depending on what you want to do. Breadboard has been selected as we need to interface components only. Search and select any component models you want from the Part panel by the right of the window. This is done by dragging it out to the workspace. You can position it anywhere on the workspace by dragging method. When all the required components have been gathered, you can begin to connect them together by dragging out a jumper wire from one component terminal to another component terminal. You can determine the color of the jumpers too. When you are done, you can save the overall model and export to any other application for use. The parts of the system are connected using Fritzen Software as shown in figure 6

The implementation of this Smart system was done in C Programming language. The main component of the system that is programmed is the ATMEGA328P Microcontroller.

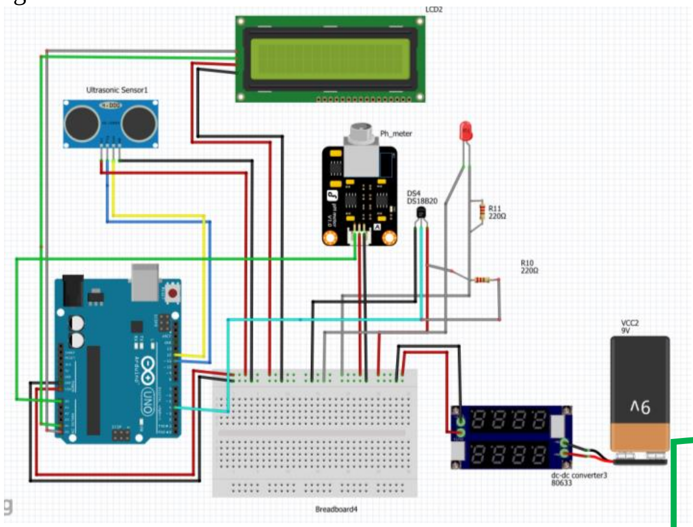

Figure 6: The connection of parts of the New System Using Fritzen IDE

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B. Input Data Discussion

The system acquires data from the pond through the detection unit. The ph sensor is used to measure the ph of the water. The turbidity sensor is used to measure how turbid the water is. The ultrasonic sensor is used to measure the water level of the pond. The temperature sensor is used to detect the temperature of the fish pond. The outputs of all the aforementioned sensors become input to the microcontroller. The microcontroller processes the input data based on stored program and triggers the output units. The information gathered by the sensors are also displayed on the LCD screen in real time. The LEDs are used to indicate the levels of the quantifiers after reading.

C. System Testing

The Smart system was tested and the outcome or results are as discussed :

1. Power on Test

The system was powered on by pressing the red ON/OFF switch at the right side of the casing. Once the switch was pressed, the 9v battery in the casing supplied the required voltages (5v) to all the components of the system through the lm 2596 buck converter. The three LEDs attached to the front of the casing blinked to indicate that the system was booting.

2. Operational Test

After booting, all the sensors were activated and began to monitor the water in the pond for water level, temperature level, pH level and turbidity level changes. The system detected the levels of expected quantities and displayed their levels on the LCD and indicated whether the levels were abnormal (above or below threshold) or normal using the red and green LEDs.

VI CONCLUSION

The research work,for predicting suitable water for the creation and management of fish pond, was designed, implemented and tested. It was confirmed to be working in line with the objectives stated. Sensor Based Fish Pond System can assist Fish Farmers to increase their productivity. This will definitely contribute in solving the problem of Food Insecurity not only in Nigeria but other countries especially in Africa.

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