WATER MONITORING IOT SYSTEM FOR FISH FARMING PONDS

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Abstract: *Fish like many living organisms have specific tolerant range of various environmental parameters, thus fish farming of specific types of fish species requires certain conditions that have to be reached. Moreover, the people that work in the fish farming ponds have to be engaged in all day activities to maintain the living fish habitat. Therefore, monitoring and taking actions to maintain the habitat's sustainable environment for certain fish species inside of fishing ponds over distributed machine to machine communication, which will shorten the time needed for some basic actions, is the main motivation for this paper. In this paper we present an upgrade on a functional Internet of Things (IoT) system for monitoring fish farming ponds. The IoT system consists of various sensors that measure important factors of the water quality like temperature, light intensity or water level, as well as small board computer that processes the data and sends sound and visual notifications to the fish farming manager. The current system lacks the ability to process the data to the end-user via web or mobile platform. Due to remote distance of the fish farming ponds and their location dependence of clean fresh water, one solution of this problem is using expansion module like Wivity modem to enable the end users in real time to monitor and control certain aspects of the fish farming pond IoT system. Wivity modem allows user to communicate to the IoT system via WiFi connection, cellular, LoRaWAN or satellite communication; all in one product. Later on, this module can be integrated with IoT platforms including Japser, Microsoft Azure or Amazon Web Services. For future work, we plan to expand not only the applicable services on different platforms, but also add more control modules and sensors to the existing IoT system for specific fish species.*

KEYWORDS: *FISH FARMING PONDS, MONITORING, WIVITY, TEMPERATURE, PH, AUTONOMOUS*

1. INTRODUCTION

In the recent years with advancement in monitoring and automation technology, research in aquaculture resulted in development of production technologies that improved the quality of the fish farming ponds, thus leading to improvement and increasing of fish production. Fish farming pond is an artificial man-made eco-system and on the most basic level we can differentiate two types of ponds, ponds that breed tropical fish that are used as pets commonly known as aquariums in stead of ponds, and ponds that breed fish for food. Our focus in this paper are the ponds that bread fish for food, typically build and maintained in remote eco-clean areas, near to water springs, and any outside environmental stress will negatively impact on the fish production. This is due to the fact that fish are cold-blooded animals that regulate their temperature directly by the surrounding environment. Consequently on this, temperature is one of the many key parameters that is needed to be monitored, combined with other important factors like light intensity, water level in the pond and etc. Therefore, the monitoring of this eco-system is a problem combined of some multiple sub problems that are linked between each other, and they are in constant interactions. Their interaction is a complex process that needs a lot of time, dedications and knowledge by humans to be controlled and maintained.

In the past decade we have witnessed an enormous progress in the exploitation of the power that is offered to us by the computing machines into almost every field of production process. The machines are usually used to automate the processes and lower the human interactions steps to reduce the risk of an error. The idea of such a system that automates the fish farming industry, came from a couple of problems that this technological process faces. One of the problems is the time consuming process of manually checking and measuring every parameter and every part in a fish farming pond. Second problem is the lack of possibility to put them in sort of remote location which you can check once a day, not multiple times in very remote areas, most of the time without any internet connection. Furthermore, we have to include the problem of running the fish farm sometimes without human presens even for a couple of days.

In this direction, the paper aims to present a smart IoT system that is used to automate the monitoring and maintenance of a fish farming pond in remote locations, with a goal to bring it closer to its natural form by the most effective means using remote monitoring via wireless communication technologies like cellular, LoRaWAN, WiFi or Satellite communication. This smart system aims to reduction of the environmental stress that affects the fish population in the fish farming pond. This is a very active research area and researchers have developed similar systems, that try to automate the monitoring of the fish farm environment. Authors in [1], have provided an automated IoT system for automated fish farming where they monitor the water temperature, pH and water level, using Wi-Fi remote connection, which could be a problem for systems that are placed far from areas where cellular or any type of internet connection is available. In order to address this problem, the authors in [2], proposed a GSM type of notification by sending SMS messages to the end-user. One disadvantage of this proposed system, is the process of notification to the end-user after specific time intervals or after a certain parameter value is reached, and not in real-time. To overcome this in one sense of real-time monitoring, the authors in [3], proposed combination of IoT system in [2] with CCTV cameras, which constantly monitors the fish farming pond. Other authors investigate the possibility of using power out of the standard power grid [4], which is typical for remote places. This raises other important problem for fish farming ponds remotely located in a forest or in mountains terrain, and that is the availability of internet connection. One possible solution is to use LoRaWAN or satellite networks that can be used to cover large areas, and especially satellite communication where we can reach areas that are typically not covered by mobile cellular networks. Wivity [5] works with all these types of networks worldwide, across different networks - without requiring different designs for every region, supporting various connections (Wi-Fi, 3G, 4G, LTE, SIGFOX, LoRaWAN and satellite connections). Another positive impact of this module is the elimination of expensive truck rolls and skilled techniques, this modem can be easily hot-swapped on the small board computer directly on the site to the required type of connection. With this modem, IoT devices can support new form of connectivity and the proposed water monitoring fish pond farming IoT system can be used in very remote areas, typical for eco-tourist sites where fish farming ponds are usually placed.

The rest of the paper is organized as follows; in Section 1 we will present the current state of the monitoring system for fish farming ponds and detail description of the sensors used for the monitoring system. Section 2 presents the current state of the water monitoring IoT system for fish farming ponds, followed by section 3, which discusses the benefits from the implementation of the Wivity module for remote communication and potentially new sensors that will increase the the fish quality and their production. The conclusion of the paper is given in Section 4.

2. CURRENT STATE OF MONITORING SYSTEM FOR FISH FARMING PONDS

The current system includes the Arduino Mega2560 [6] board one of the many small board computers, that consumes very low power and it is widely available. Connected to this control unit are various sensors for monitoring some of the parameters which can be

labeled as input units, actuators such as relays that can be labeled as output units, executive units that affect some parameters, such as the heater and some interactive elements such as LEDs, buzzer, LCD display presented on Fig. 1

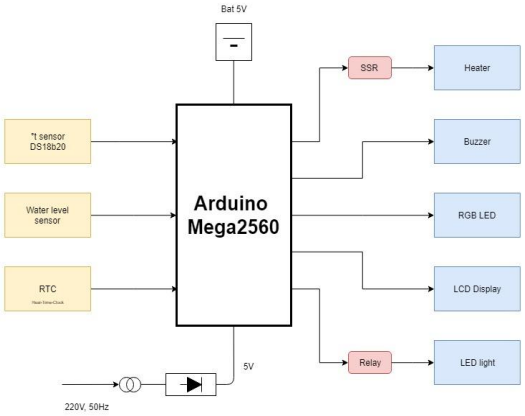

Fig. 1. *System schematic of the water monitoring IoT system for fish farming ponds.*

The IoT smart monitoring system includes several sensors to sense the environment and based on the readings from these sensors, the fish pond manager can make important decisions for improving the quality and quantity of the fish production. We give detail explanation of the sensors and the actuators used in the current IoT system (see Fig. 2)

The temperature is the driving factor of all processes that happen in the fish pond. It's not only affecting the development and growth of the plants and other animals in the pond, but also regulates the oxygen level in the water. The optimal temperature for tropical fish is 25°C with allowed deviations of 2°C and for fish that live in rivers like the trout that temperature is too hot so the optimal temperature for it is around 14°C. Therefore is a need to monitor and regulate this parameter through additional equipment. The monitoring is done by a waterproof DS18b20 [7] digital temperature sensor with accuracy of ±0.5°C (See Fig. 2 - Box 1). Data is read from the sensor and depending on the values the board sends control values to the heating equipment. The regulation or heating of the water is done by an Omron GL3 205p1c Solid-State-Relay (see Fig. 2 - Box 2), which receives the control signal from the board and then turns off or on the heater. This kind of relay is used because it has a fast reaction time, it is electronic (there are no mechanical contacts as in standard relay) and it's more durable of the harassment done by the PID heating algorithm. Also in this parameter there is a heater element. All of the standard heaters for fish pond or aquariums have a thermostat built in, but in this system with the control of the heater from the board the risk from malfunction of this element is lowered multiple times.

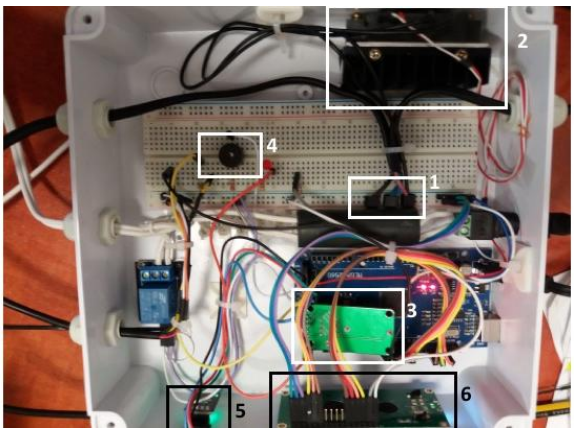

Fig. 2. *Implementation of the IoT water monitoring and control system for fish farming ponds.*

The role of the light intensity in the fish breeding process is very important because only with fully securing the proper lighting, natural or artificial, you are allowing the fish and the plants to have a normal life cycle. If you are breeding a fish type that is a natural occupant in that area where the pond is, the needs of light are automatically satisfied, but if you are breeding other types of fish you need to control it. It is important to determine what type if light is most suitable, in which intensity and the time interval. Basically you need to determine the day/night cycle. The lightning parameter affects the fish color, feeding habits, mating drive, orientation and territory placement, and also affects photosynthesis of the plants and the oxygen levels in the water. The most suitable "day" period in the ponds is between 10 and 12 hours, it can be longer but it can't be lower in any case. In our system we regulate the day-night cycle using RTC module (DS1302 RTC [8] - (see Fig. 2 - Box 3)) which indicates the time and depend on it we switch on or off the light. We use LED for lightning and with a little more complex solution you can even control the LED intensity depending on the clock, you can have less bright light in the morning and evening and highest brightness during mid-day.

Every change in the water level, either raising or lowering, it affects in a great manner the finishes in the pond and causes suitable reaction from them. The fish occupy some area of movement, feeding and relaxing, either at the bottom or at the top of the pond, and by lowering the water level that area shrinks and causes inadequate living conditions and may cause battle for survival among the fish. This is why we need to keep the amount of water at some constant level. The IoT monitoring and control system measures the water level in the pond using a simple magnetic float sensor, Water level sensors float switch P45 [9], which notifies the end-user when the water drops below our desired limit. Using a float sensor instead of the conventional electric sensor such as droplet depth detection sensor is much more friendlier to the occupants of the pond because there is no water-electricity contact.

The IoT system at this stage communicates to the end-user to a set of sound and light (visual) notification that are placed in the control room of the fish farming pond. The sound notifications are produced using buzzer (see Fig. 2 - Box 4), which sends sound signals whenever some of the measured parameters goes out of the desired range. This is very important in many monitoring systems, not just to notify the fish farm manager when he decides to change some important monitoring factor(s), but also for the alerting when some of the critical factors are mismanaged. Another important aspect of the IoT monitoring system is the light notification, which in our system we achieved by using RGB LED diode (see Fig. 2 - Box 5) [10]. This diode presents the current temperature state using different voltage levels (blue, green and red color) thus representing the temperature degree of the fish farm water (cold, normal and hot). If the measured temperature is out of the predefined range, or out of the defined min and max range, the RGB diode together with the sound buzzer will notify the fish manager with applicable color (blue for cold, red for hot). And finally, we implemented an LCD notification screen (see Fig. 2 - Box 6), that displays the current state of the monitored parameters and controlled using from the IoT sensors for the fish farming ponds. If something goes out of hand it displays text message with the problem that is detected.

3. *REMOTE MONITORING AND OTHER SENSORS*

Current IoT system lacks the ability to process the data to the fish farming manager via any remote platform: web or mobile platform. However thanks to the great robustness of the Arduino platform, by using various expandable modules, the current system can be expanded using different types of modems. In our case in this paper work, we decided to use Wivity module [5], which can provide internet connectivity through GSM, Wi-Fi, LoRaWAN or satellite communication. This is very important in our case of fish farming ponds, since the location of the fish farming pond can be very remotely and in many cases no mobile and thus no internet communication is available.

The Wivity module is a interchangeable modem that offers a modular approach to the IoT connectivity part (see Fig. 3). By using the plug-and-play technology in a form of USB pluggable module, it can be easily installed and maintained. This doesn't requires any technical knowledge for the fish farming managers and more important it can interconnect several fish ponds in different areas, so you can easily use the modem that suits the most for that location and without code changes. Another aspect of this device is power flexibility, beside the main power is drawn from the Arduino Mega 256, the device has additionally micro-USB connector that supply more power. The next feature that allows better and faster connection is the possibility of interchange between fixed and movable antenas. The device also supports Java execution on board, and have built in SIM module. From the connection perspective, it has an built in protocol stack, that offers transparent and non-transparent TCP/UDP client and server, as well as SMPT/ FTP/HTTP/DNS and Ping client. Another great aspect of this device is the support of the TLS for all previous mentioned protocols, thus providing better security for IoT devices. A typical communication between two IoT devices with this module is initiated with HTTP request which is passed to the Wivity modem using the usb or serial port. This HTTP server resides on the Wivity modem, and this server pushes data to the backend cloud server no matter what communication network is used. For all this is to work, we can use development kits like SIGFOX [11], in order to make more functions available to the end-user. On top of this layer for remote monitoring and control, an application interface for a web or mobile application which will indicate the status of the pond and it will give possibility to set some new values to the parameters of the system like new min/max temperature, working light hours etc, should enable the end-user more pleasant experience. Since the Wivity modem can be expanded not by other hardware, but also with other software modules, we can can use to further ease the enchant the notification panel for the fish farming manager. One such option will be sending SMS messages for the most vital events that can jeopardize the fish environment.

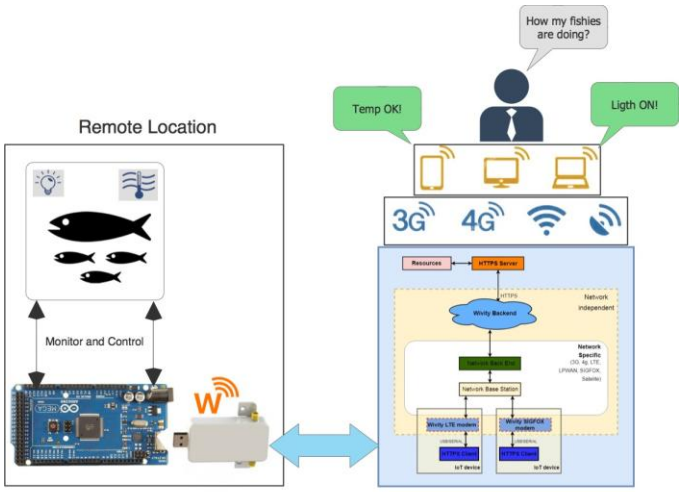

Fig. 3. *Water monitoring IoT system for fish farming ponds with Wivity module.*

Another important factor is further development of the system in terms of adding new sensors that will improve the fish production and quality. Sensors that measure the pH or Dissolved Oxygen have priority in our plans for improving the IoT system. PH sensor, like the sensor presented in [12], play an important role, because this sensor measure the level of acidity in the water, which should be maintained between 6 and 8. If pH goes below, 5 the water becomes to acid for the fish and they will suffer from several diseases like tissue coagulation necrosis, acid erosion of the gill [14] tissue etc, and will eventually die. Aeration or measuring dissolved oxygen is another factor that is vital for fish farming ponds. This parameter describes the level of dissolved oxygen in the water. It is affected by the temperature, pressure and salinity. It's utilized in aerobic decomposition of organic matter, respiration of the fish, and chemical oxidation of minerals. Low dissolved oxygen levels will slow or stop the fish growth. If it drops below the level of endurance of the fish it will cause death. There are several sensors for measuring dissolved oxygen, but there is already a pre-built one for arduino from DFRobot[13]. Another idea is to use this sensors to connect to an air pump and automatically control the level of oxygen in the water. Depending on the dissolved oxygen level you can add or lower the power to the pump.

4. CONCLUSION

In this paper we have presented water monitoring IoT smart system for managing and improve the fish productions in fish farming ponds. The current implemented system consists from the most vital sensors that are needed to monitor the water quality and notify the fish pond manager on-site. We upgraded this system by adding a hardware module that will allow the end-user to monitor and in the future to control vital parameters in the most remotely fish pond locations. The Wivity module can be easily installed and configured, without the need of any high level of technical knowledge. Additionally to this, if the end-user requests, the Arduino platform can be remotely configured as remote server or client with ease, as well as other hardware settings. Further on, module for mobile and web interface should be developed for more easy user interaction. In future we plan to expand the IoT water monitoring system by adding a variety of other sensors, like sensors that will measure pH or dissolved oxygen vital for the fish life cycle.

5. LITERATURE

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