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Development of IoT-based non-cleaning water quality measuring equipment

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Abstract It takes lots of time and labor if a worker have to measure the water quality at a certain but designated time every day in an un-automated aqua farm. In addition, if the equipment is soaked in the sea water consistently, it will be contaminated by diverse floating matters and barnacles, and it often becomes mal-functional within 2~3 months. Therefore, we need to develop a system with which the sensed data could be checked in real time and operated automatically, while preventing the contamination of the sensor, a crucial component for water quality measuring equipment, as much as possible, and increasing the replacement cycle.
We have developed a non-cleaning water quality measuring equipment and its software which are used in the fishery household of offshore aqua farms. By providing the workers with a mobile application which has a function of monitoring the water quality in real time, they can check the situation directly without going to the fishery household.

Keywords IoT, Sensor, aqua farm, non-cleaning

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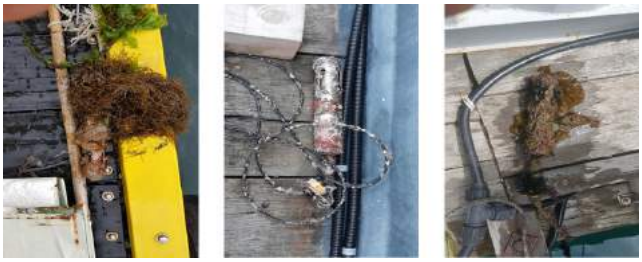
1 Introduction

Aqua farm fishing culture has been steadily growing since its first introduction to the coastal area of Tongyeong in 1975. In the 2000s, as the "Fish Farming Development Act" was enacted and "Fish farming development plan' is established accordingly. As the government policy was beginning to be concentrated on the fish farming development project, the production of shallow sea fish farming has grown drastically. However, as the offshore aqua farms in Korea are concentrated in the semi-closing costal area and back bay which have less sea water circulation and is hydraulically stable, they are vulnerable to natural disasters such as high water temperature and red tide. At present, workers measure the water quality with a portable measuring device or a fixed-type one to prevent these, however, it is hard to manage the water quality information as the floating matters and barnacles are attached as shown in [Picture 1]. To solve this problem, a number of domestic sensor production companies developed an ultrasonic sensor and its cleaning brush, however, it does not help solving the problem.
To solve this problem, diverse fish-farming technologies are becoming high-tech around the world. Moreover, as the international standard of fish farming is strengthened, there is a growing demand for new farming technologies, and as the customers' demand for seafood is diversified, farming technologies should be developed to cope with the consumption environment.
We have developed a non-cleaning water quality measuring equipment to solve the raised problem, and upgrade the technology, thus in this paper, we are suggesting an IoT-based technology with which farmers can monitor the situation inside and outside of aqua farm.
This paper is composed as follows. We will explain about IoT and water quality measuring equipment in chapter 2, and the proposed water quality measuring system in chapter 3. And it will be finalized with a conclusion and suggestion for further researches.



Picture 1 Sensors are contaminated by floating matters, etc.

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2 IoT and Water Quality Measuring Equipment

IoT(Internet of Things)

IoT (Internet of Things) is a technology which connects diverse things to internet with a built-in sensor and communication function. The things, in this case, are diverse embedded systems such as home appliances, mobile equipments and wearable computers. All the things connected through IoT should have on IP address, which can discriminate themselves, and be connected to internet, and they may have a built-in sensor to receive data from the external environment.

As all the things can be the target for hacking, both IoT and security should be developed at the same time. If lots of things are connected to internet like this, a large-scale data, which cannot be analyzed in a short period of time, will be accumulated, and we call it 'Big Data.'

IoT is known that it upgraded the existing human-based communication paradigm by making things participate in the activities such as production (collection), exchange and analysis of data, and active interactions between them. Speaking of the existing IoP (Internet of People), such as wire communication and mobile internet, data has been produced through the connection between the specific things such as PC and smart phone, and there should be a human who plays a role of the medium. On the other hand, through IoT, things have intelligent relationships with one another without a human intervention as they cooperatively execute sensing (production of data), networking, and exchanging and processing data. Especially, as they are possible to react or interact with the changes of environment automatically, it is considered to have upgraded the prospect of automation.

Water Quality Measuring System of the Existing Offshore Aqua Farm

A lot of offshore aqua farms sea are not automated. In most of the farms, workers are measuring the water quality at a certain time every day using a simple or portable water quality measuring device, and spending much time and labor for it.

Picture 2 Water quality measurement using a portable device

In addition, as the workers of offshore aqua farms are not well trained since most of them are from foreign countries, the measured data of water quality is not properly recorded, or simply written by hand. Therefore, its informational value is relatively low, and the recorded data is not shared, or used as a database.

IoT-based Non-cleaning Water Quality Measuring Equipment

As the offshore aqua farms are located away from the land by maximum of 1.5KM, they used to have relatively a poor infrastructure, however, they have electricity due to a support from local government or the government recently, and also have LTE wireless internet service. Therefore, for the internal area, we have established an IoT device based on the ethernet using the hub inside, and made it possible to communicate through LTE service in the external area.

The developed equipment is an IoT-based non-cleaning water quality measurer with a highly durable sensor driving mechanism which minimizes the contamination from floating matters even for a long-term use, and it can be applied to almost every aqua farm. This equipment is composed of an integrated status indicator where the information on water quality can be checked regardless of time and place, and an integrated monitoring system which makes possible to strengthen the competitiveness of price and quality by reducing the mortality rate and farming cost through increasing the efficiency of fish management. It can also provide a basis of IoT-based smart aqua farm system through an alarm system and monitoring facility which makes possible to cope with an emergency at the early stage.

3 Proposed Water Quality Measuring System

IoT-based water quality measuring device is composed of a hardware device that measures the water quality, a frame which is made by considering the marine environment, a home display for monitoring, and a smart phone application which indicates an emergency and water quality condition, as shown in [Picture 3].

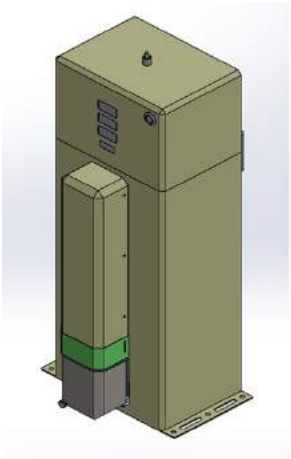
picture 3 System diagram of IoT-based non-cleaning water quality measuring equipment

3.1 Hardware Composition

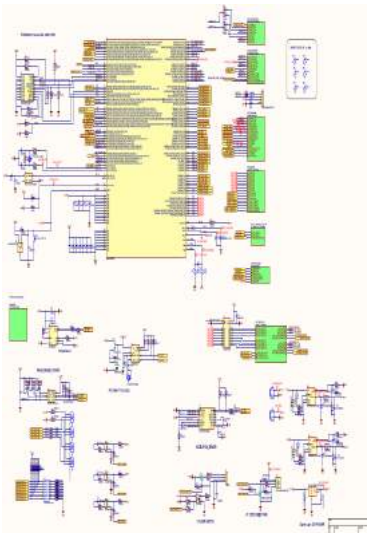
3.1.1 A frame made by considering the marine environment

As shown in [Picture 4], the upper part of waterproof frame, which is designed to be used stably in the ocean, indicates data values of the sensor, and data values of the water quality is indicated depending on the depth of water by using a pulley. It can be installed in both rivers and the sea.

The interior and exterior of the frame are waterproofed based on IP67 standard so that the module core should not be exposed to water, and H/W can be installed through the upper part of waterproof frame. Speaking of the lower part of the frame, it is designed to measure the water quality depending on the depth of water through a combination of a pulley and a sensor.



Block diagram



Circuit diagram

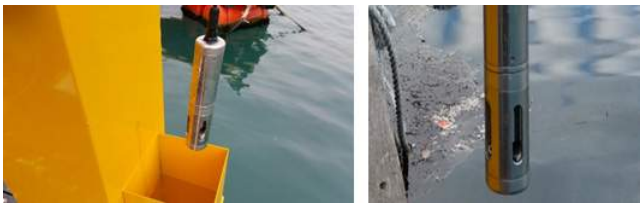
Picture 4 Block and circuit diagrams of IoT-based non-cleaning water quality measuring equipment

3.1.2. Non-cleaning measurement using a pulley

Water quality sensor is a driving device which is designed to prevent the attachment of contaminants as it is stored after washing with fresh water in normal times, and soaked in the sea water only when it is used for measuring. It is shown in [Picture 5]. It is a fully automatic system which prevents the contamination of the sensor, a core component of water quality measuring device, as much as possible, and it increases the replacement cycle of sensor.

Picture 5 Operation method of non-cleaning measuring equipment using a pulley

After a long-term use, we have found that the sensor is almost not contaminated comparing to the one in [Picture 1], which was soaked in the water at all times, even after 6 months, as shown in [Picture 6]. We believe that the sensor will not be contaminated if it is used this way consistently. It is because the materials attached to the sensor cannot survive the fresh water in the tube, and by using the sensor in fresh and salty water alternately, it will be rarely contaminated.



Picture 6 Sensor condition after 6 months

3.1.3. Water Quality Information Display

As it is an IoT-based system with a display which makes it possible to monitor the measured information on water quality at the office or home, it can be installed outside of buildings. It is shown in [Picture 5]. This display can be installed in diverse spaces, and displays the information on the water quality sensor in real time. In addition, it is an integrated ethernet network module, and a display

that can receive data from several water quality measuring equipments.

Picture 7 Installed display

3.2 Software Composition

3.2.1 Windows application for monitoring

We have developed a Windows application, which is a monitoring system, by using JAVA language to realize a high UI development speed and stable code development, as shown in [Picture 8]. Through this application, data can be sent to the cloud server to show it to the manager. In addition, by establishing a DB provided by comparing the sensing DB and that of the water quality of the past, we made it possible to check the information about the water quality on a monthly or daily basis. It is possible to monitor the conditions such as temperature, the depth of water, water temperature and DO.

Picture 8 Monitoring through Windows application

3.2.2 Smart phone application

Through a smart phone application, users can measure the water quality in real time as shown in [Picture 9], and they can check the water quality of aqua farm whenever or wherever they are. The application can be connected by entering IP address, and it has a client-server communication system utilizing HTTP library.

Picture 9 Smart phone application

4 Conclusion

This paper deals with the development of an IoT-based non-cleaning water quality measuring equipment. We have designed the equipment to be used in marine environment by waterproofing the exterior and interior of the frame based on IP67 standard. It is designed not to expose the module core to water, and to prevent the attachment of marine organisms like barnacles to protect the sensor from contamination, as it is soaked in salty water only when measuring the water quality using a pulley, and stored after washing with fresh water when not used. In addition, while using this equipment, users can check the information on the water quality measurement through a smart phone application in real time, which used to be possible only through a display of portable devices before, and the water quality of aqua farms can be checked in real time, at any

time and place.

However, the limit of this technology is that LTE service should be provided to the offshore aqua farms which are far away from the land. Nevertheless, as the system does not create that much data if using a remote communication system such as LoRa and RF, it can be applied without using LTE network which causes a maintenance cost. In addition, in case of the aqua farms which do not have electricity, the system can also be applied if using a small solar generation system.

IoT-based non-cleaning water quality measuring equipment that we have developed will have a big possibility to be commercialized comparing to other related technology systems as it can prevent the damage of sensor by using a pulley, and it is possible to check the water quality in real time even when the workers are not in the farm. In addition, by installing this system at the base aqua farm, it will be possible to monitor the water quality condition of the whole country in real time, and it may be used for diverse alert systems for red tide, low oxygen and low salinity by applying this system with a multiple water quality sensor to marine buoys and lighthouse facilities, if we consistently research on its commercialization. In addition, If we make a cloud system, and accumulate the information to make a data base, it will play a big role for the development of domestic marine fisheries business as it can be used for analyzing/predicting big data, or deep learning in the area of marine fisheries.

Acknowledgement

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