An Intelligent Management System for Aquaculture's Environmental Monitoring and Energy Conservation

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Abstract—**The objective of the proposed system is to construct a highly profitable aqua-farming system, capable of processing the jobs of monitoring, intelligent control of the Internet of thing (IoT), abnormality awareness, and carbon emission reduction as well as energy conservation. While the aqua-farming environments are degraded, the proposed system can automatically resolve the accidentally incurred problems or send out a text message to the person(s) in charge; the reducing of the human negligence due to the past experiences as well as experiencing the risk of uncontrollable/ unpredictable environments of the traditional aqua-farming ponds can be accomplished in order to increase the survival rate and the aquaculture production.**

Keywords-energy conservation, carbon emission, Internet of thing, power monitoring, aquaculture industry, power supervisory/monitoring system

I. INTRODUCTION

Under the influences of environmental pollution, energy shortage, human being's aging, and lifestyle disease, people are more recently concerned about diet and health as well. More and more scientific data shows that eating aqua-farming food is helpful to one's health [1]. Aqua-farming food with low cholesterol content not only contains rich, easily digestive protein but also possesses highly unsaturated fatty acid, mineral, and vitamins. According to the reports published by the Organization for Economic Cooperation and Development (OECD) and Food and Agricultural Organization (FAO), the world's aquaculture products will reach 160 million tons, with 15% increase comparing with the amounts between 2008 and 2010. In [2], it predicts that aqua-farming will substitute fishery industry, becoming the major source of world's fishery products. In 2020, approximated half of the world's fishery products are contributed from aqua-farming [1]. Based on the preceding observations, it is possible that the substitution of fishery and animal husbandry industries by aquaculture will come true, a substantial component in the food chain.

A rapid increase of the ocean fishery product is almost impossible, associated with present fishery industry. On the contrary, a planned/scheduled aqua-farming one becomes dominant; therefore, the property of the 21st contrary's aqua-farming is undoubtedly based upon the traditional evolution, innovation, and skillfulness in association with marketing and environment-friendly attributes, avoiding the scarcity of the aquaculture resources [3].

Fishery sustainability is the future trend of Taiwan. Taiwanese aquaculture industry is small capital, small scale production [4]. Observing the features of them, they are basically family-based business, and their skills are depending on their own knowledge/experiences. Fortunately, with the help of modern technology, the water quality and those environment factors affecting aqua-farming can be quantized via machines. The nominal indices may include biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, ammonia nitrogen, Escherichia coli, turbidity, phosphate, and conductivity; they are totally 8 items [5]. Good water quality will make fish have appetite, less disease, leading to lower cost business; the poorness of the water quality is nevertheless judged by the color, sodium nitrite, ammonia, and pH [6]. Water quality maintenance is the key issue for aqua-farming employers. Most of the water quality monitoring systems performs on-site sampling and analysis to obtain the deviation of the water quality, whereas those accidentally pollution cases are not noticed immediately. Therefore, it is a must to construct a water quality monitoring system [7].

How to keep the ecological balance around the water surroundings for aquaculture is the key technology. A proverb from fisherman says "one needs to take care of the pond before nursing a school of fish in the pond [8]."

Water quality maintenance is the crucial component to achieve a healthy aqua-farming environment. Its main purpose is to control the following quantities, i.e., water temperature, pH, dissolved oxygen (DO), salinity, turbidity, ammonia nitrogen, chemical oxygen demand (COD), biochemical oxygen demand (BOD), etc., the parameters that strongly correlated to the incubation environment of aquaculture. Presently aqua-farming sites are lacking of constantly monitoring capability of the aforementioned parameters. Luckily, due to the wide spread of Internet uses and the advancement of sensory technologies, the Zigbee applications and its related technologies have been advocated/developed such as smart power grid, intelligent traffic control, intelligent architecture, home medication/nursing, environment monitoring, and being applied to lots of sites surveillances.

In fact, Chinese Prime Minister, Chai-Pau Wen, has announced the "Sensing China" in 2009 at Wu-Xi. Internet of thing is the trend for the blossom of industries in the next 10 years; the global economy will be booming in 2020 accordingly. The estimated growth will be up to tens of billion. Internet of Things (IoT) [8-12] will bring lot of convenience to all mankind, so every country around the world is focusing on it with strategic viewpoint [13].

After becoming the member of the WTO, the import of aqua-farming products is increasing and the selling prices are decreased; the domestic aqua-farming community is facing highly competitive situation. Basically, there is no alternative for the career change of the fisherman to make their living except aqua-farming[13], and at the same time due to the aging issue of the aqua-farming people, career alternation is not feasible. The downside of the Taiwanese aqua-farming industry is the resources scarcity of freshwater and the deterioration of the water quality for the seashore aqua-farming people. Being not fully redistributed for the water resource, the salient features of the underground freshwater, good quality and temperature, are most helpful to the aqua-farming people. The long-term overdrawn freshwater from aquifers are found in almost all aqua-farming individual, resulting in the problems of ground level sinking and salt water intrusion. Oxygen dissolved into the water is coming either from the interface of atmosphere with water or from the output of photosynthesis from sea plants. The OD is normally at 8-10mg/L. For most sea/water species including fish, they withdraw oxygen they need from water. OD decreases when water temperature rises, leading to the reducing of OD. Therefore, water temperature is strictly related to fish's food absorption, metabolism, and their growth; low OD will cause fish's suffocation and death. Generally speaking, very few fish can tolerate long-term exposure to the water with OD less than 3mg/L. Cool water has larger OD than lukewarm one. Raising water temperature will obviously result in death. There are three symptoms due to the depletion of the oxygen in the water for fish, namely, widely open mouth, gill turnover, head bending to the rear. Poor OD will affect fish's appetite, which can be identified when fish are being feed. If the salinity level is measured by conductivity, the worst case is 3, consequently causing the death. Fish death outbreak is the highest concern for aqua-farming people; this fact is due to the large variation of water temperature. Variation of water temperature is followed by the change of atmospheric temperature. Large variation of atmosphere temperature let fish not adopt to the abrupt change of water condition, leading to large amount of death.

Aqua-farming businesses are primarily located at the southern Taiwan. Fish and shrimp aqua-farming can be found along the sea shores.

When fish/shrimp grow in some extent, they must be separated to different ponds in order to reduce the population density, while reducing the loss due to mutual fighting. For the case of raising seabass, it is a carnival, aggressive species with fast growing speed; mutual fighting and swallowing always occur when the population density is too high. Currently, separation into different ponds is determined by the head size of the fish solely discriminated by person's naked eyes.

Local aqua-farming industry reaches its matured stage starting at 1998. These aqua-farming techniques consist of water recirculation, filtering facilities, and fish food, accounting for 84% of the aqua-farming technology.

With so many competitive markets in aqua-farming industry, focus should be put in the aspects of customer's requirement and monitoring technology of the environment.

How to work and coordinate with academics/research institutes is the issue that we must exert efforts in, that is, to work together to develop small volume, multi-functional, lower cost, and collector storing a large amount of data. With innovative technology and effective processing scenario will promote competition level, lessening the disadvantages coming from limited land area, high population density, and finite amount of water/land resource.

II. SYSTEM DESCRIPTION

To investigate the feasibility and applicability of the proposed technique for traditional outdoor aqua-farming sites, we had visited some local aqua-farming workers at Ping-Dong County. The specs of the generic system are

(1) Increment of aqua-farming production rate, energy conservation and carbon emission reduction, informing of the system safety events based on intelligent sensing, wireless sensor network, communication technology, intelligent processing/control, IOT technology development, on-line sampling of the water and its surroundings, wireless communication, intelligent handling, alarm message broadcasting, decision made, remote control are altogether integrated into one single unit of IOT.

(2) Aqua-farming personnel can attain the status of aqua-farming surroundings, and acquire abnormality and poor water quality alarm; appropriate control command can be executed based on those returned water quality data to fulfill scientific aqua-farming and management.

The ultimate goal is to achieve energy conservation and carbon emission reduction, green environment, and the increases of aqua-farming production and revenue.

(3) For large scale aqua-farming company, employee's working status and water quality information at different sites are transmitted on a network platform.

The proposed system architecture is shown in Fig.1. Its functionality includes water quality check, environmental monitoring, power monitoring, and web surveillance platform. The details are as follows.

(1)Water quality and environmental monitoring—the requirement for water quality monitoring may include the temperature, OD, pH, and conductance. Water quality sensor possesses the ability to automatically collect data needed, have mutual communication, and output/display standardized characters. The water pump will be activated according to the decision made by these collected water quality information, whereas the water in the pond may be withdrawn to vary the pH or temperature. Subsequently, those aqua-farming creatures will stay in a good surrounding condition.
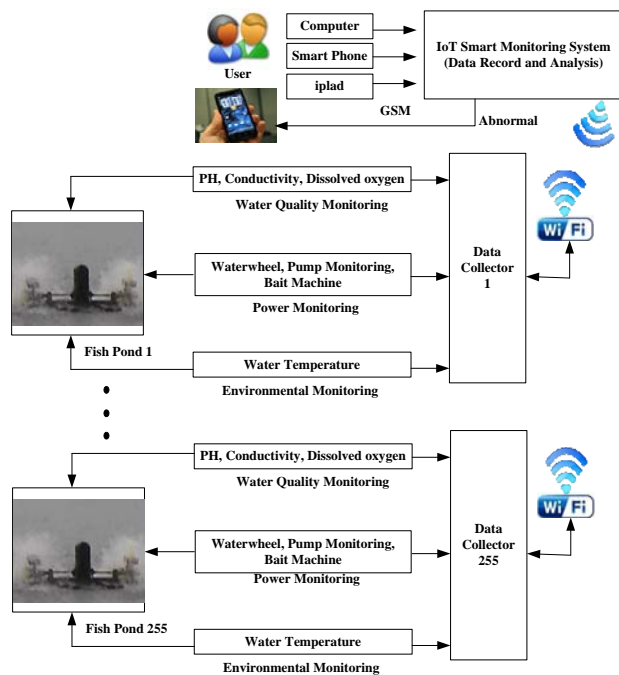

FIG.1. THE SCHEMATICS OF THE ENVIRONMENT MONITORING AND ENERGY CONSERVATION IN AQUACULTURE

(2)Power monitoring techniques: due to the scenario of large death count owning to the malfunctioning of pump/watermill as shown in Fig.2, our system will connect the power with motor and pump via the 3-phase, 220V distributor; the associated states information is read from the meter that directly connect to the outlet of the distributor. By using WiFi, data collector can transmit those data stored in the meter to the monitoring port of the computer. When the motor/pump is malfunctioning, the proposed system will inform the supervisor of the abnormal states through GSM; the supervisor will enable the crisis handling process to prevent the death of fish/shrimp. The flowchart of the generic intelligent system, composing of environmental monitoring and energy saving management systems, is illustrated in Fig.3, also showing the water quality status and power monitoring control portions. The proposed system can upgrade aqua-farming technology, reduce carbon emission, energy saving, and alleviate the problem of the overdrawn freshwater from aquifers.
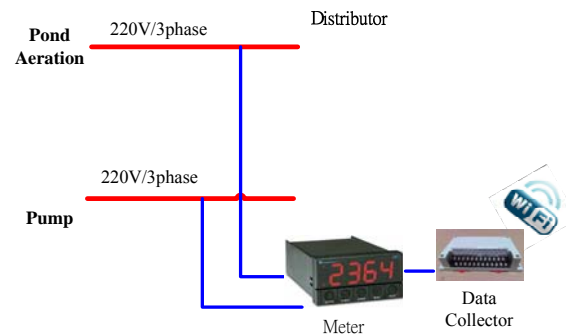

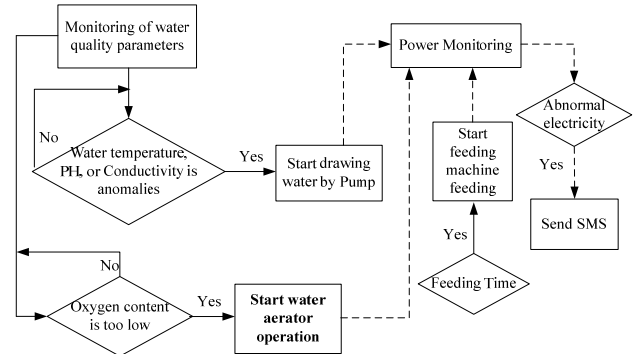FIG. 2. THE ILLUSTRATION OF THE POWER CONTROL

FIG. 3. THE FLOWCHART OF THE MONITORING SYSTEM

(3)Network monitoring platform : Fig.4 shows the system architecture of the platform. Key components are as follows, power meter with duplex communication capability and power plug, human body sensor module, data collector, and server PC. Users can access the system through the Internet remotely. Its software and hardware components are listed as the followings.

(a)Data collector—transmit the system's status data corresponding to water quality, power monitoring, video clips, environmental status to the server via the media, RS-485, Ethernet, or WiFi. By going through the designated wire reserved for control purpose, the power supply to the system can be adjusted.

(b)Remote login—user can login into the system using PC, tablet computer, or smart phone. All of the system

status data are displayed in web browser; even the power supply at any monitoring site can be terminated.

(c)System management—users need to provide both username and password in order to access the system, and the associated authentication, authorization, and account management are described as follows.

● Account management—provide an user demand-based interface for system's supervisor including those functions like add-in, delete, edit, and security level assignment

● Security administrations—provide an interface for the administrator to handle the work scheduling, adding, deleting, and administrator's level assignment.

● Programming management—provide an interface for the administrator to deal with the status management, adding, editing, deleting, and scalability.

(4) Operation monitoring—the proposed system can deal with the process of water quality monitoring, power monitoring, and various operations. For example, pump is activated whenever OD is lower than the designated threshold; otherwise, pump is disabling for power saving purpose. The water withdrawn pump is activated once the pH is too high or temperature is significantly deviating to maintain good water quality; consequently freshwater is not necessarily to be redrawn from aquifers to leverage the ground level sinking problem.

(5) Report editing —the system provides a database for the storage of power consumption; these record can be output to a table for a visualization of the power consumption curve.

(A) STATISTICS FOR POWER CONSUMPTION IS AS SHOWN IN FIG.5. THE SYSTEM PROVIDES THE DATA OF POWER CONSUMPTION, STATISTICS, DURATION OF POWER CONSUMPTION, AND PRINTING SERVICE.

(B) POWER CONSUMPTION ANALYSIS IS SHOWN IN FIG.6. THE SYSTEM PROVIDES THE DATA OF PEAK/AVERAGE POWER CONSUMPTION AND THEIR STATISTICS AND PRINTING SERVICE.

(6) BROADCASTING SYSTEM—OUR CONTROL SYSTEM MONITORS ALL ON-SITE WATER QUALITY, POWER SUPPLY, AND OPERATIONS OF ALL FACILITIES; ALL THOSE ASSOCIATED DATA ARE SENT BACK TO THE SERVER AFTER PASSING THROUGH DATA COLLECTOR, GATHERING VARIOUS DATA FROM SENSORS.

III. CONCLUSION

Based on the intuition from the Internet of thing (IOT) in association with network platform, sensor technology, and image processing technique, we construct an "intelligent system for aquaculture environmental monitoring and energy conservation." The scope for the proposed techniques and its services/applications are detailed as follows.

(1)The demand from aqua-farming people for maintaining water quality is satisfactory due to the introduction of the monitoring technology.

(2)Power monitoring technology—we develop an intelligent power saving and monitoring system. At any time instant of power abnormality, the supervisor will be informed by GSM; the power supply to the system can also be tuned through wire. All system states information is displayed in web browser; furthermore the power supply at any or all remote locations can be terminated.

(3) Network monitoring platform mainly consists of power meter with duplex communication capability and power plug, human body sensor module, data collector, and server PC. User can access the system via the Internet, meanwhile lowering date of facing so many uncontrollable/unpredictable situations outdoors, i.e., the surroundings of aqua-farming ponds, and increasing the survival rate and production.
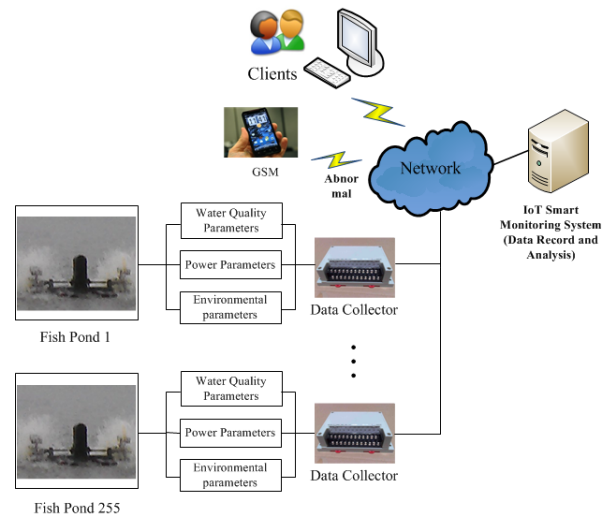

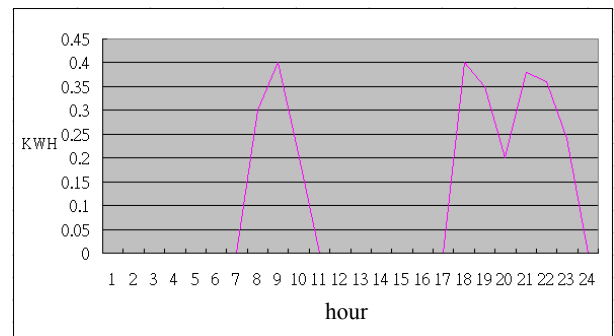FIG. 4. WEB PLATFORM ARCHITECTURE

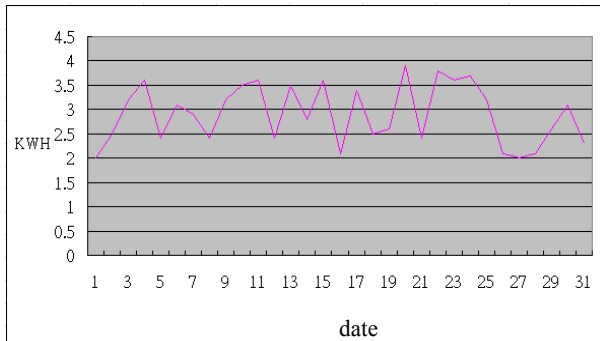FIG.5. THE POWER CONSUMPTION PER HOUR

FIG. 6. THE PEAKS STATISTICS OF DAILY POWER CONSUMPTION

The proposed technique will eventually upgrade the domestic aqua-farming techniques as well as increase the aquaculture employee's income and competition in the market.

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