A DESIGN OF MULTI-FUNCTION SENSOR FOR HIGH-TECH SHRIMP FARM

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Abstract. High-tech shrimp farming techniques have developed strongly and brought high potential in terms of economic efficiency for shrimp farming households in coastal areas in the Mekong Delta region. High-tech shrimp farming models require strict control of water environment parameters while equipping shrimp ponds with water environment sensors is expensive and difficult to maintain. This paper proposes an effective solution for monitoring the environmental parameters of shrimp pond water by using a handheld online multi-function sensor. From there, an effective design was proposed for a multi-function sensor to monitor the shrimp pond water environment such as dissolved oxygen, PH, oxidation reduction potential, temperature, and leftover feed at the bottom of the pond. The proposed design model is compact, portable, and connected with an IoT cloud so that farmers can not only easily move, measure and monitor pond water environmental parameters online via smartphone app, but also easily operate and maintain sensor probes. By using only one multi-function sensor to measure all shrimp ponds, the cost of investing in environmental monitoring equipment for shrimp farms has reduced many times compared to the current one. Therefore, the proposed multi-function sensor has high economic efficiency, durability, and stability. It is also very convenient for farmers and easy to implement practical applications.

Keywords. Shrimp farming, Aquaculture environment monitoring, Shrimp waste detection system, Internet of thing.

1 INTRODUCTION

Figure 1. HTSF model of Viet-Uc Group.

Aquaculture is one of the strong and important sectors in the economic development of Vietnam's Mekong Delta provinces. High-tech shrimp farms (HTSF) have developed strongly and brought a lot of potential in terms of economic efficiency for farming households. HTSF models require a tarpaulin-lined pond system, an oxygen aerator, and aeration fans to circulate water throughout the pond as in Figure 1. The ponds are lined with tarpaulins to prevent alum and sludge from entering the water, which reduces water quality. The oxygen generation system for the pond water consists of an aerator and aeration fans that help to circulate oxygen evenly throughout the pond. Normally, shrimp ponds are equipped with rainproof tarpaulins,

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because when there is heavy rain, it will change the PH of the water in the pond abnormally, easily causing diseases to shrimp.

1.1 Monitoring the environmental parameters of shrimp pond

Important water environmental parameters such as dissolved oxygen (DO), PH, oxidation reduction potential (ORP) and temperature are closely monitored for shrimp ponds and auxiliary ponds to timely assess water quality. Since then, shrimp farmers have made appropriate environmental treatment decisions. For example, if the dissolved oxygen in the water is low, there will be a lack of oxygen for the shrimp to breathe, if the lack is severe, it will cause the death of the shrimp. To handle this problem, the farmers will increase the number of aerators or increase the number of aeration fans. If leftover feed and waste accumulate in large quantities in shrimp ponds, it will trigger the growth of bacteria, producing toxic gases such as H2S, NH3 or NO2, which will reduce the ORP of the water environment, leading to shrimp poisoning. To deal with this problem, the farmers often use microbial products to lower ORP, discharge waste from ponds and replace clean water. If the pH of the water is lower than the permissible limit, slaked lime should be applied to increase the PH level. The temperature of the water affects the ability of shrimp to eat, so they should rely on this index to increase or decrease the amount of feed accordingly to avoid an excess of feed that pollutes the environment. The environment monitoring of shrimp ponds is usually performed in manual methods by famers with specialized meters for each parameter. There are few farmers using integrated monitoring stations to measure water environmental parameters online as shown in Figure 2. With this model, each pond is equipped with an environmental monitoring system. The cost for each environmental monitoring system is quite large, which can be up to hundreds of millions VND. Some of the companies that provide online water quality sensor systems for shrimp farms have been consulted for comparison, such as Thailand's HydroNeo, Germany's SENCET and Vietnam's EPLUSI. These companies only have water environmental sensors and do not have integrated endoscope cameras. The sensor systems of these companies are designed in the form of fixed placement in ponds. For example, with HydroNeo's sensor system, the cost of renting 2 sensors PH and a DO is about 4 million VND per month. While with SENECT's sensor system, the cost of 3 sensors DO, PH and ORP, is nearly 100 million VND. Meanwhile, each pond is about 500 square meters according to the standard, so HTFS often has many ponds. Therefore, the cost of equipping a monitoring station for the HTFS system is expensive. Moreover, the maintenance of these monitoring stations is a bigger difficulty because usually for about 1 to 2 weeks, the farmer is required to clean the sensor probes, or the measuring equipment will fail more and more.

Figure 2. Illustrate of EPLUSI's online water environmental monitoring systems.

In fact, most shrimp farmers, if equipped with online water environment monitoring stations, have little ability to maintain them periodically, because they do not have the technical expertise to remove the sensor probes for cleaning. Therefore, most of these environment monitoring stations from time to time make large errors. As a result, farmers only use it with reliable results in the beginning (about a few months) and then abandon the use of these monitoring stations because it is no longer accurate.

The author himself has designed and implemented the construction of an integrated monitoring station system (IMS) to measure online the water environment for a HTSF in Ben Tre province of Viet Nam, as shown in [1]. This system has the same model as Figure 2, costs about 52 million VND, and is permanently installed in the shrimp pond. At first, IMS worked well, but after 3 months of operation, the error of measurement indicators gradually increased. The maintaining of the sensor probes is difficult to perform, as the station must be brought ashore, so that the probes are disconnected, cleaned, and recalibrated.

There have been many studies to develop water environment monitoring and management systems for HTFS. These studies have the common feature of building an online environmental monitoring system for each pond, focusing on parameters of PH, DO, ORP, temperature and water quality. Some recent case studies are considered as follows:

J. Huan et al. [2] presents a comprehensive water quality monitoring system for aquaculture ponds utilizing Narrowband Internet of Things (NB-IoT) technology to addresses critical limitations in traditional aquaculture monitoring, including insufficient network coverage, high terminal power consumption, and elevated operational costs. NB-IoT technology, which uses a cellular network, enables the transmission of water environment monitoring data information over long distances with low power consumption of end-to-end IoT devices. The online sensor network system allows for automated measurement of water environmental parameters, such as DO, PH, and temperature to monitor the water environment and optimally control the amount of dissolved oxygen for each pond instead of using traditional manual measurement methods. The same approach, Capelo et al. [3] proposed a comprehensive cyber-physical system (CPS) designed to optimize shrimp farming operations in Ecuador through real-time monitoring and automated control of critical water quality parameters.

Setiawan et al. [4] proposed a smart aquaculture design for vannamei shrimp farming based on the Quality Function Development (QFD) method. In this study, the authors used water environment sensors for each pond such as PH, salinity, temperature and ultrasonic sensors placed on the automatic feeder container to monitor water quality and optimize shrimp feed. Rahman et al. [5] introduced a solution using RNN network to estimate the oxygen that must be supplied to the pond based on the DO parameter sensor system in the ponds sampled according to the time steps.

Orozco-Lugo et al. [6] presents a groundbreaking approach to water quality monitoring in shrimp farms using Flying Ad-hoc Networks (FANETs) to address the critical need for cost-effective aquaculture operations. To reduce costs, this model uses drones with sensors controlled via a mobile app to fly to ponds to measure DO, PH, Salinity and temperature parameters. This method is quite cost-effective when there are many ponds, we only cost 01 drone, and 01 sensor set for all ponds instead of having to spend one sensor set for each pond. On the other hand, this model is also very convenient and easy to maintain because the sensors on the drone will be easily cleaned immediately after each use. Some of the limitations of this study are that it has not yet been able to reason why online sensors are not fixed in shrimp ponds, but only drones use the sensor set to measure water environmental parameters at certain times of the day. The use of drones will incur costs for drones and the operation of controlling drones to fly to ponds and then manipulating the operation of updating the environmental parameters of each pond to the system. This really makes it difficult for farmers to use complex equipment with many operations.

1.2 Monitoring of leftover feed

The leftover feed at the bottom of the pond, if accumulated for a long time, will pollute the environment and cause diseases for shrimp. Therefore, the detection of leftover feed will help to clean the pond in time and adjust the amount of feed to suit the feeding needs of shrimp, avoiding excess. It is common to use a tray placed at the bottom of the pond to check for leftover feed as shown in Figure 3. However, the use of trays only directly observes a local area that cannot observe various locations to make more accurate conclusions about the amount of leftover feed. Only a more advanced method by Zainuddin et al. [7] has been found, which proposes to apply the Yolo algorithm to camera images of leftover feed from the bottom of the pond to automate the prediction of the amount of waste from leftover feed. From there, this system can automatically adjust the amount of shrimp feed to minimize the amount of leftover feed and avoid polluting the pond water.

Figure 3. Illustrate a tray used to monitor the leftover feed of shrimp ponds.

1.3 Proposing a solution for supervising the water environment

The question is whether the fixed placement of online environmental sensors on each shrimp pond as in previous studies is more effective than using only one multi-function sensor (MFS) for all shrimp ponds? The answer is not only less effective in terms of water quality management, but also more costly and inefficient in maintaining equipment. In fact, HTSFs all have ponds lined with plastic tarpaulins, so sudden changes in water environmental parameters are impossible. We will analyze the change of important parameters as follows:

- ✓ The solubility of oxygen in the water will change because breathing shrimp will absorb oxygen in the water and lead to a gradual decrease in the amount of DO if the pond water is not supplied with oxygen in time through the system of aerators and aeration fans. As drawn from [5], [8] and [9], a shrimp pond system with an aerator and aeration fans working regularly, the DO change of the pond is usually lowest in the early morning (when there is no sun), gradually increases at noon (when the sun is strongest), then gradually decreases at night. Under sunshine, the algae in the water photosynthesize to release oxygen, increasing the amount of DO. On the contrary, at night the algae absorb oxygen and cause a decrease in oxygen in the water. The change in DO during the day depends on the density of shrimp and the density of algae in the pond. With the aerator system and the aeration fans working stably, the DO range can vary from 4 mg/L to 6 mg/L during the day, while the DO range is good for shrimp is over 4 mg/L or over 60%, in units of saturation %. However, if the aerator system and aeration fans are not well controlled, one of these devices fails, will cause a sharp drop in oxygen, for example from 4 mg/L to 2 mg/L in a period of a few hours. This will cause mass shrimp deaths.
- ✓ The pH of shrimp pond water is affected by the amount of alkali accumulated in the water as shown in [10]. The amount of alkali that accumulates in the water caused by the metabolism of shrimp, plankton microorganisms and algae in the pond emits Carbon dioxide. This will change the pH level of water. Therefore, the pH level is increasing at day and decreasing at night. However, the average pH changes of the day compared to the night are usually only in the range of 1. While the optimal range for the pond water environment is between 6.5 and 9.
- ✓ The ORP level of water changes due to the waste of the pond water environment settling and accumulating for a long time, causing the phenomenon of releasing NH_3, H_2S, etc., which reduces the ORP as shown in [11]. However, this change is also very slow at -50mV after a few weeks of rearing. Not only that, but the accumulated waste will also decompose overtime into the water, and this makes algae thrive, leading to a change in pH as mentioned above.
- ✓ The temperature of the water changes very slowly, according to the weather of the day.

Thus, from the above analysis, we see that the process of measuring and sampling DO, pH, ORP and temperature does not need to be monitored online continuously throughout the day. In fact, farmers only need to measure 1 to 2 times a day, such as: early morning when there is no sunshine and noon when the sun is strongest, as shown in studies [12], [13], [14]. Therefore, if each shrimp pond we place an integrated sensor online, it will cost both investment costs and maintenance labor according to the number of ponds.

Therefore, stemming from the fact that the cost of equipping water environment monitoring stations for each shrimp pond and the difficulty of technical maintenance for the sensor probes, while the need to measure only few times a day, this paper proposes an effective design for MFS applied for HTSFs. A compactable and portable design for MFS which integrated DO, PH, ORP, temperature sensors, and underwater endoscopic camera. It allows with just one MFS to be able to monitor critical water quality indicators online and directly observe the amount of leftover feed at the bottom of all shrimp ponds.

2 MFS DESIGN METHODOLOGY

2.1 MFS block diagram

The block diagram and physical model of MFS are designed as shown in Figure 4. The lower end of the MFS is the DO, PH, ORP, temperature probes and the underwater endoscopy camera. The sensors and camera are wired to the control board at the top end. Because MFS aims to measure water environmental parameters at the bottom of the pond, while the average height of shrimp ponds is about 1.5 m and the height of the pond bank is 0.5 m. Therefore, the designed length of the MFS is 2 m. Because the system uses a camera, the data transmission bandwidth is relatively high. Therefore, Wi-Fi transmission technology was selected for MFS rather than NB-IoT technology to optimize transmission power as in [2].

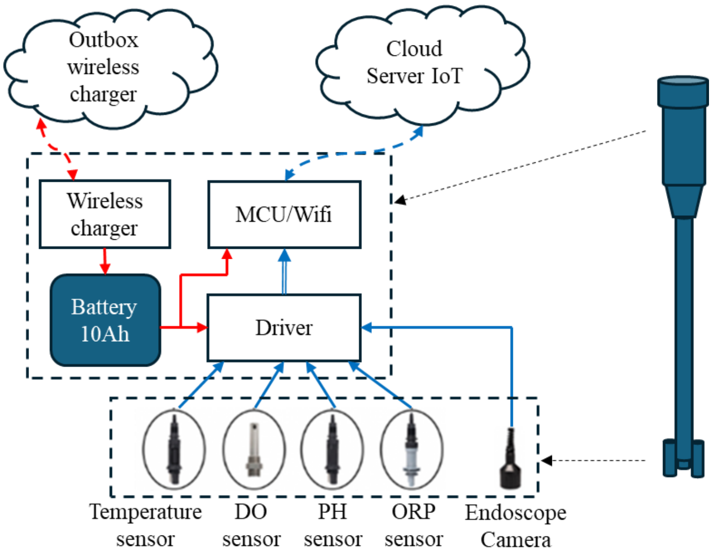


Figure 4. Block diagram and physical shape of MFS.

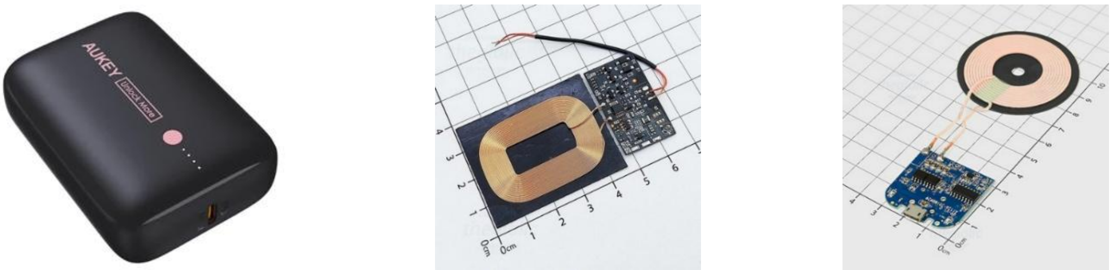
a) DO probe b) ORP probe c) PH probe

Figure 5. Illustration of Atlas-Scientific sensors.

a) DS18B20 b) Wifi Look c) Arduino UNO Wifi

Figure 6. Illustration of a) Temperature sensor, b) Endoscope Wi-Fi camera and c) MCU.

Atlas-scientific sensors [15] are selected for measuring DO, ORP, and pH parameters, as shown in Figure 5, because they have accuracy and durability of up to 18 months. The temperature sensor chosen is the DS18B20 type, which is waterproof, and the camera selected is the waterproof type of Wi-Fi Look is cheap as Figure 6. Due to the purpose of designing the MFS as a handheld device, a 10 Ah battery is selected for the power supply of MFS, as shown in Figure 7 a), to supply enough for measurements during the day. The selected wireless charging module is the transmitter circuit EK1854 WCT-1, and the receiver circuit WCR-1 with power 5 W and charging current 1 A which is suitable for the 10 Ah battery.



a) AUKEY b) WCR-1 5W c) EK1854 WCT-1

Figure 7. Illustration of a) Transmitter for wireless charging circuit, b) Receiver for wireless charging circuit, and c) Battery 10 Ah.

The designed schematic of MFS as shown in Figure 8. Since the PH, DO and ORP sensors are analog sensors, we use the Arduino Uno Wi-Fi R3 for MCU/Wi-Fi module. This module has multiple analog inputs and an integrated Wi-Fi module. Optocoupler circuits are used to control power for sensors to isolate them during measurement, avoiding parasitic interference from one sensor probe to another sensor probes, which skews the measurement value. In addition, the system is also designed with 2 more ON/OFF switches, the main power, and the power for the camera. The power supply from the Battery is led to the SW_POWER switch, then the output power of the SW_POWER is connected to the SW_CAM switch to choose whether to power the sensor circuit or the camera.

More details about the schematic are as follows:

- ❖ The temperature sensor is a digital sensor, with 1-Wire communication, so the driver circuit gives it a resistor R pulling up the power.
- ❖ The DO sensor is an analog sensor, with an Atlas-Scientific Surveyor DO Meter amplification circuit. The power supply circuit for the module driver uses an Optocoupler, with a 1 KΩ draging resistor for the control signal from the MCU.
- ❖ The PH sensor is an analog sensor, with an amplifier circuit Atlas-Scientific Sureveyor PH Meter. The power supply circuit for the module driver uses an Optocoupler, with a 1 KΩ draging resistor for the control signal from the MCU.

- ❖ The ORP sensor is an analog sensor, with an Atlas-Scientific Surveyor DO Meter amplification circuit. The power supply circuit for the module driver uses an Optocoupler, with a 1 KΩ draging resistor for the control signal from the MCU.
- ❖ The battery is wirelessly charged via the WCR-1 receiver module, type with 5 W capacity, 1 A charging current.

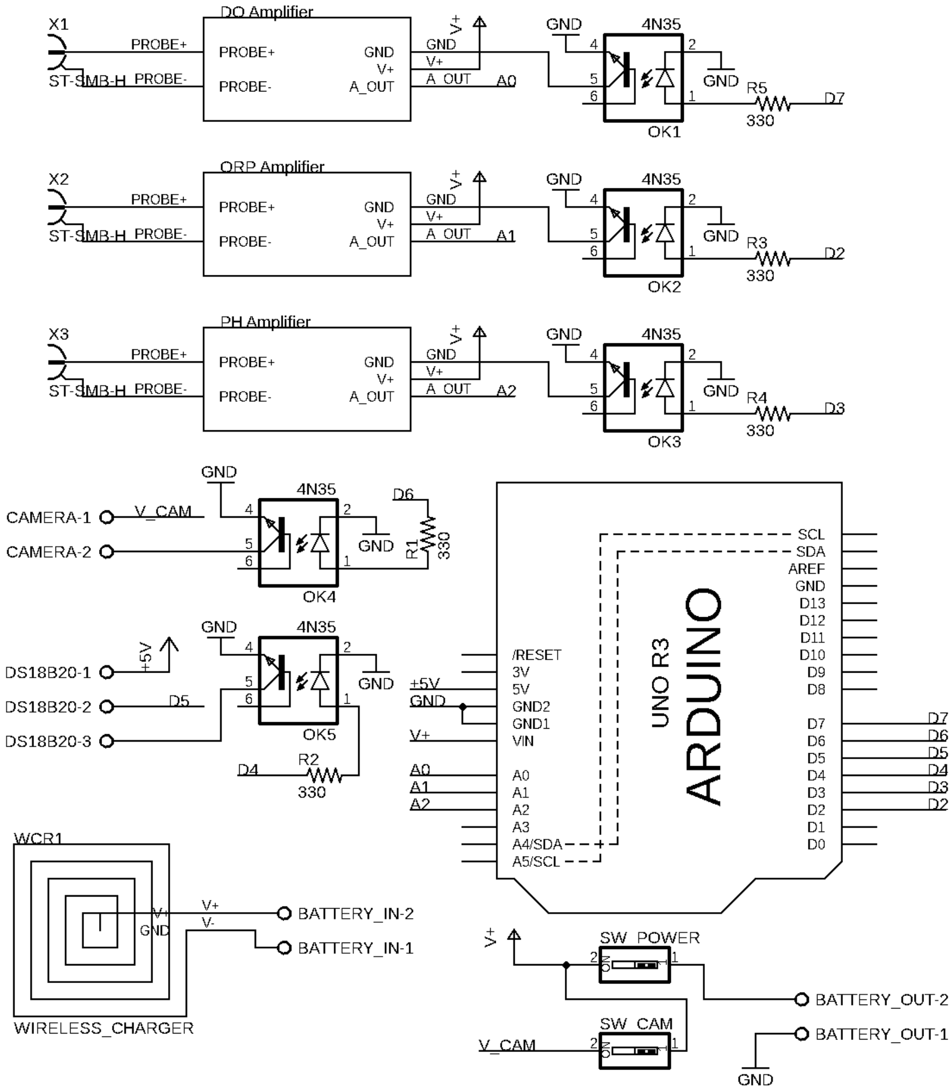


Figure 8. Schematic of the MFS.

2.2 Algorithm of MFS

The control algorithm of MFS is illustrated as Figure 9. Normally the temperature, DO, ORP, PH and camera sensor are powered off, to save energy. When the main power switch is turned on, the default selection is off the power to the camera and power the MCU to measure the sensor values. The MCU sequentially powers each sensor module and reads their values, then powers off that module and proceeds to the next sensor module. After measuring all the measurements, if any of the values are not within the allowable range, then a warning variable is updated with these values. Finally, the data status variables from the sensor and alerts are sent to the cloud IoT server. Here the data is updated with the value and status on the smartphone app. The camera consumes a large amount of power and generates power interference, causing deviations in the measured sensor value, so when it is necessary to observe the camera, the user uses control app to turn on the camera and then stop measuring the environment indicators.

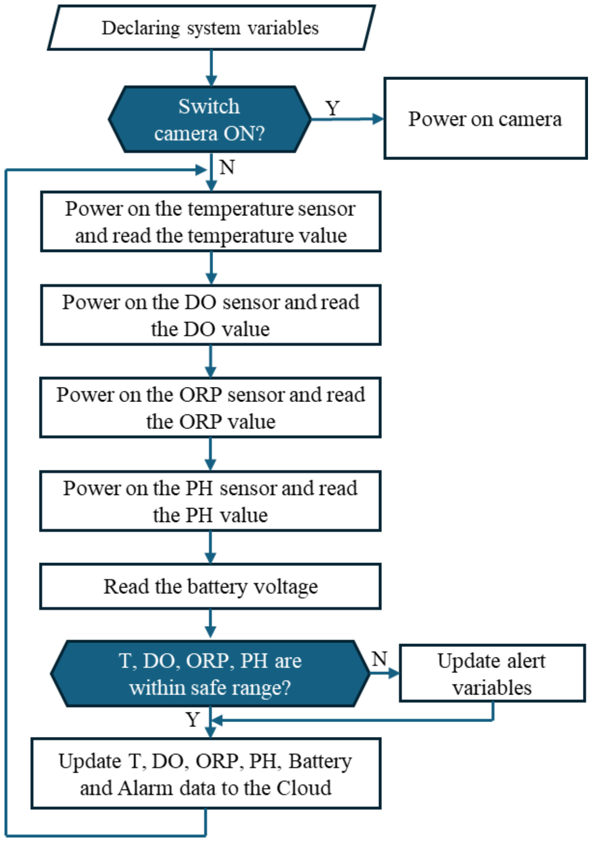


Figure 9. MFS Control Algorithm.

2.3 Assembly of MFS

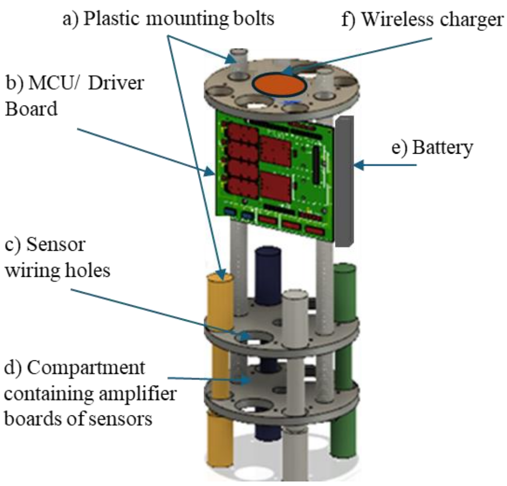


Figure 10. Describe the layout of the functional modules in the plastic frame.

To reduce weight and avoid short-circuiting for MFS, materials such as mica, plastic bolts and nuts are used as supporting frames for circuit boards as shown in Figure 10. PVC water pipes are used as protective covers for MFS, designed in a sealed form for waterproofing. Figures 11 a) and b) show the assembly layout of the component modules of the MFS. From bottom to top is the chamber for sensor amplification circuits and camera board. Next is the chamber for MCU/Driver and battery. At the top is the compartment for the wireless charging circuit that is pasted on the flap of the MFS. Figure 11 c) illustrates the installation of the MFS in a 500 L shrimp pond for the experiment.

a) Installation of component modules.
b) Full image of MFS.
c) Experimental image of MFS on water tanks.

Figure 11. Illustrate the process of installing, testing, and operating a smartphone monitoring app.

Because the user is a farmer, who does not know the technique, the MFS design is optimized by integrating functional modules into the sealed PVC pipe, for outdoor waterproofing. Charging the battery will be charged wirelessly by placing the charging cup on the top end of the MFS while the device is at rest. In the resting state, the MFS is placed in a bucket of clean water diluted with a little soap to clean the probe.

3 RESULTS AND DISCUSSION

The MFS has been evaluated by 8 experiments with different variable environmental samples. Chemicals such as soap, sour vinegar, tempered lime and Na_2SO_3 are mixed in different proportions to create an environment with varying DO, ORP, PH and temperature parameters. The measurement values are displayed on the smartphone app as shown in Figure 12. To measure the environmental parameters of any pond, we put the MFS into that pond and click Select Pond menu and select the corresponding pond name, then switch on the OPEN. The MFS will measure and transfer data to the IoT cloud for that pond. The specialized measuring equipment, such as EZDO's ORP, DO and temperature meter and EXTECH's PH meter, were also used to measure in these experiments.

Figure 12. Demonstration of MFS smartphone app control interface.

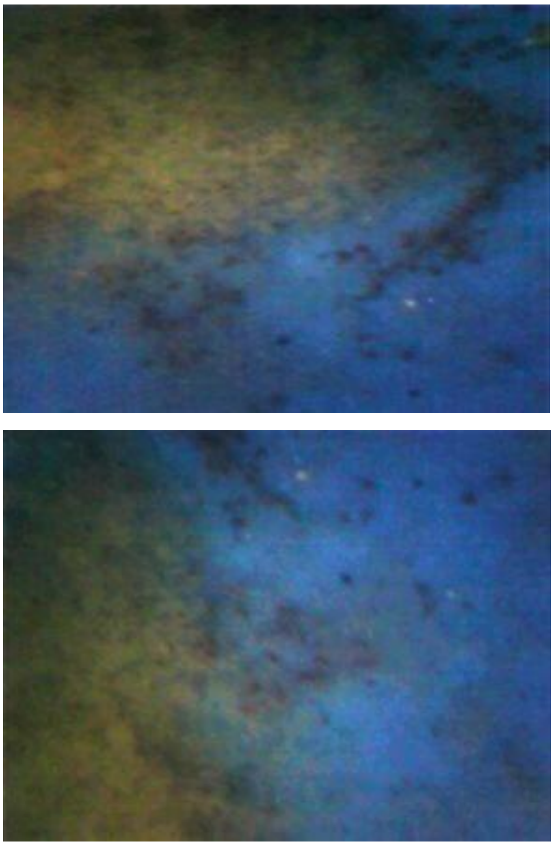


Figure 13. Display two images of the pond bottom captured by MFS.

Table 1. Statistics of experimental results on 8 diverse types of water environment samples.

No.	DO_MFS (%)	DO_ EZDO (%)	ORP_MFS (mV)	ORP_ EZDO (mV)	pH_MFS	pH_EXTECH	T_MFS (oC)	T_ EZDO (oC)
1	61	60,5	164	170	8,0	7,8	28,2	28,0
2	51	52,2	90	94	8,9	8,7	29,5	29,3
3	2	1,4	108	114	7,0	6,8	30,2	29,5
4	74	73,5	161	165	8,0	7,8	29,5	28,7
5	83	81,1	157	161	7,9	7,9	37,2	36,2
6	77	78,4	329	342	4,1	3,8	35,7	35,1
7	67	67,5	123	135	7,0	6,9	30,1	29,7
8	65	65,2	65	68	8,9	8,7	27,9	27,0
	$\Delta = \mathbf{6.4}\%$		$\Delta = \mathbf{4.4}\%$		$\Delta = \mathbf{3}\%$		$\Delta = \mathbf{1.9}\%$	

The statistic results are shown in Table 1, showing that the measurement value is relatively accurate when compared to the measurement results of specialized machines. The error of measurements between MFS and specialized meters is quite small, ranging from 1.9 to 6.4%, within an acceptable range. After the measurement is done, the MFS is immersed in a basin of water with little soap, to clean the sensor probes. Therefore, MFS will have high durability and stability in accuracy for measurement values for long time.

On the other hand, the endoscopic camera image for the bottom of the pond allows us to observe leftover feed and shrimp waste as shown in Figure 13. Compiling the images of the pond bottom observations in different areas of this pond will be a good basis for farmers to accurately assess the amount of leftover feed and make optimal decisions for volume feed that should be given for the next time.

The total cost of designing, constructing and assembling MFS is about 15 million VND, while the cost of a fixed-type water environmental monitoring system, with water environment measurement parameters similar to MFS but without a built-in endoscope camera, costs up to hundreds of millions of VND, as described in Section 1.1.

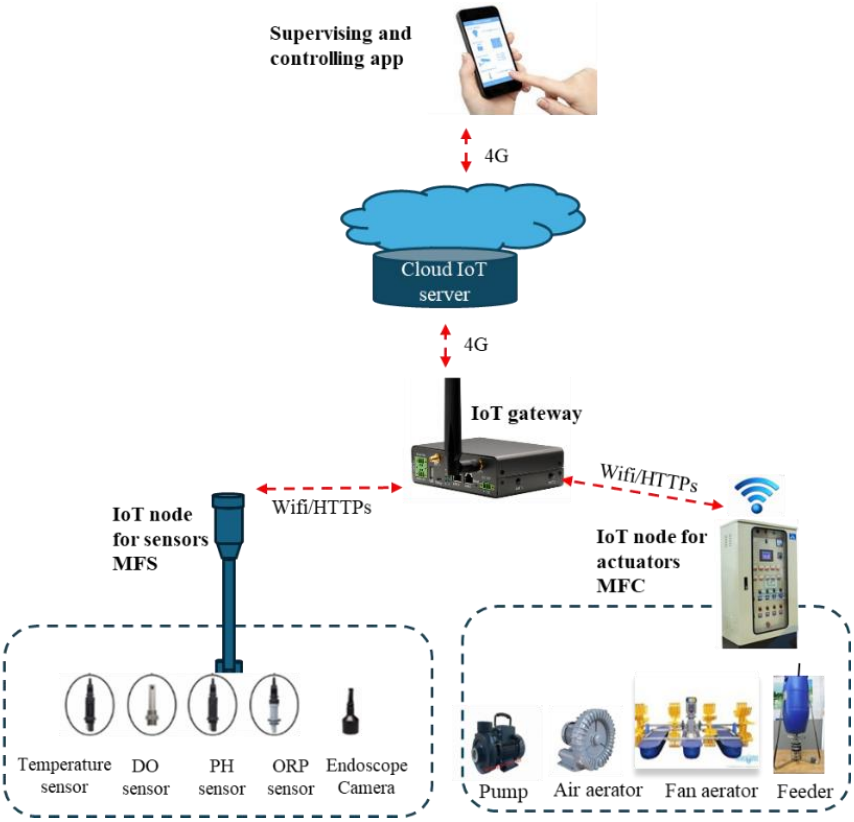


Figure 14. Illustration of the integration of MFS into the MFC automation control system for HTSF.

MFS has been integrated with a multi-function controller (MFC) for actuators [16], at a shrimp farm in Binh Dai District, Ben Tre Province. To integrate MFS into the monitoring and control system for HTSF, the D2G communication model was selected as Figure 14. The system is divided into 2 types of IoT nodes: sensor node MFS and actuator node MFC. This farm has 9 shrimp ponds and 2 sedimentation ponds, so it needs only one MFS and 11 MFCs, which each MFC controls all the actuators for a shrimp pond. Therefore, the cost of equipping water environment sensors has been reduced by 11 times. Not only that, the measurement and maintenance of MFS is extremely simple and easy for farmers. Farmers only need to hold the MFS to the pond to be measured, plug it into the area to be measured, observe the waste at the bottom of the pond, press the measurement button on the app, and they're done. The data of each measured pond is displayed on a smartphone app, which has been integrated with MFC's automatic control program, to allow monitoring and management water environmental quality of shrimp ponds. Therefore, in terms of economic efficiency, reliability and operational efficiency, the MFS proposal model is significantly better than the FANETs model of Orozco-Lugo et al. [6].

We found that the most important parameter, which is most likely to change during the day, is DO. When the MFS is integrated with the MFC, under normal circumstances, the DO parameter can be maintained at a stable level by controlling the increase or decrease in the number of aeration fans or air aerators based on the measurement data 3 times a day, in the morning at 5 a.m., at noon at 12 p.m. and in the afternoon at 5 p.m. In the event of sudden changes in dissolved oxygen due to malfunctions of aeration fans and air aerators, the MFC can also strictly control the aerators and agitators in this breakdown. In fact, the MFC is designed with load current consumption sensors for each actuator, so it has the function of detecting and alerting the farmer immediately when one of the actuator motors fails or loses phase voltage on the 3-phase grid to promptly replace the motor or replace the mains power supply with electricity from the generator.

The monitoring and disposal of leftover feed and shrimp waste at the bottom of the pond was researched in [7] and [17]. In these studies, the authors focused on using cameras placed on the pond surface in combination with deep learning algorithms such as Yolo to monitor the leftover feed at the bottom of the pond, thereby building an appropriate automatic flushing and water change program. In fact, it is not as simple as this, because the shrimp feed is in the form of bran balls and when the leftover feed settles to the bottom of the pond after a period of time, they will dissolve in the water. Moreover, there are some types of feed pellets that melt quickly and others that take a long time to dissolve. Not only that, but shrimp waste is also piled on top of this remnant as seen by observing the tray in Figure 3 or by the MFS's camera image in Figure 13. While the use of the Yolo algorithm is only highly accurate when the pellets have a fixed shape. Therefore, to avoid errors in the assessment of leftover feed and waste deposited at the bottom of the pond, the paper proposes to use only MFS endoscopic cameras to provide observation images of the pond bottom in different areas for farmers to evaluate. This is the simplest and most effective way. Farmers will rely on their experience to make decisions about discharge time or water replacement rates, and the right amount of feed for shrimp ponds.

4 CONCLUSIONS

This paper begins by highlighting Vietnam's strengths in fisheries development and the application of IoT devices and systems in monitoring and managing the water environment for high-tech shrimp ponds. Then analyze the current limited points in the research and application of deploying the use of online environmental monitoring equipment at HTSFs. Important aquatic environmental parameters affecting shrimp health and growth are analyzed, and mechanisms for maintaining these parameters within permissible limits are also explained. From there, the author proposes a solution to design an online MFS for measuring water environmental parameters, DO, PH, ORP and temperature, and monitoring the amount of leftover feed at the bottom of the pond. The proposed equipment MFS is integrated with the MFC, controller for the actuators, to stably manage the quality of shrimp pond water environment. An MFS can measure an unlimited number of ponds. Therefore, the cost of equipping a water environment monitoring system such as MFS has been greatly reduced compared to current environmental monitoring systems for HTSFs. In specially, MFS is extremely easy to operate and maintain for sensor probes, so it has durability, high-quality stability and is very convenient for farmers.

REFERENCES

[1] B. T. Cao, "Research and build a multi-sensor integrated system to support monitoring of brackish water environmental parameters at shrimp farms in Ho Chi Minh City," National Agency for Science and Technology Information and Statistics, Ministry of Science and Technology, Vienam, 08/2019.

[2] J. Huan, H. Li, F. Wu and W. Cao, "Design of water quality monitoring system for aquaculture ponds based on," *Aquacultural Engineering, Elsevier,* vol. 90, 2020.

[3] J. Capelo, E. Ruiz, V. Asanza, T. Toscano-Quiroga and N. N. Sánchez-Pozo, "Raspberry Pi-based IoT for shrimp farms Real-time remote monitoring with automated system," in *2021 International Conference on Applied Electronics (AE), IEEE,* Pilsen, Czech Republic, 2021.

[4] . B. Setiawan and N. Surantha, "Smart Aquaculture Design for Vannamei Shrimp Farming Based on Quality Function Development," *CommIT Journal,* vol. 18, no. 2, pp. 229-250, 2024.

[5] . A. Rahman, J. Dabrowski and J. McCulloch, " Dissolved oxygen prediction in prawn ponds from a," *Information Processing in Agriculture,* vol. 7, no. 2, pp. 307-317, 2020.

[6] A. G. Orozco-Lugo, D. C. McLernon, M. Lara, S. A. R. Zaidi, B. . J. González, O. Illescas, C. I. Pérez-Macías, V. Nájera-Bello, J. A. Balderas, J. L. Pizano-Escalante, C. M. Perera and R. Rodríguez-Vázquez, "Monitoring of water quality in a shrimp farm using a FANET," *Internet of Things, Elsevier,* vol. 18, 2022.

[7] Z. Zainuddin, J. Tuluran, A. Achmad, I. S. Areni and Z. Tahir, "The Waste Detection System of Shrimp Feeding with a Waterproof Camera using Yolo Algorithm," *Journal of Physics: Conference Series,* vol. 2312, 2022.

[8] L. . D. Dien, L. H. Hiep, S. J. Faggotter, C. Chen, J. Sammut and M. A. Burford, "Factors driving low oxygen conditions in integrated rice-shrimp ponds," *Aquaculture,* vol. 512, 2019.

[9] A. N. Araujo, C. . F. S. Andres, K. Q. Nguyen, T. L. Corby, M. A. Rhodes, J. García, L. A. Roy and D. A. Davis, "Effects of minimum dissolved oxygen setpoints for aeration in semi-intensive pond production of Pacific white shrimp (Litopenaeus vannamei)," *Aquaculture,* vol. 594, 2025.

[10] Supriatna, A. Darmawan and A. Maizar, "Pathway analysis of pH in whiteleg shrimp, Litopenaeus," in *IOP Publishing,* 2023.

[11] H. Lemonnier, F. Royer, F. Caradec, E. Lopez, C. Hubert, É. Rabiller, T. Desclaux, J.-M. Fernandez and F. Andrieux-Loyer, "Diagenetic Processes in Aquaculture Ponds Showing Metal Accumulation on Shrimp Gills," *Frontiers In Marine Science,* vol. 8, 2021.

[12] A. Ridlo, M. . L. M. Firdaus and J. Sumarwan, "Growth of Litopenaeus vannamei using Synbiotics Supplementation Diet in Outdoor Low-Salinity Ponds," *Journal of Marine Biotechnology and Immunology,* vol. 2, no. 2, pp. 32-36, 2024.

[13] G. D. Espeña, F. J. D. Libao, V. J. G. Comedia, N. A. P. U. D. Luna, A. . J. N. Mojica and M. D. Rivera, "Enhancing Water Quality Control and Monitoring in Shrimp Farms With LoRaWAN Technology," in *IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM),* Philippines, 2023.

[14] A. Zaini, D. P. Wulandari and R. Wulandari, "Data Visualization on Shrimp Pond Monitoring System Based on Temperature, pH, and DO (Dissolved Oxygen) with IoT," in *International Conference on Computer Engineering, Network, and Intelligent Multimedia (CENIM),* 2020.

[15] "AtlasScientific," [Online]. Available: https://atlas-scientific.com/.

[16] C. T. Bui, "An Improvement Design of Multi-Function Controller for High-Tech Shrimp Farm," *Journal of Computer Science and Cybernetics,* vol. 39, no. 2, pp. 191-206, 2023.

[17] Z. Zainullah and W. Waluyo, "An automatic waste cleaning system in shrimp ponds with digital image processing using the internet of things," *Jurnal Jartel Jurnal Jaringan Telekomunikasi,* vol. 13, no. 4, pp. 373-379, 2023.

THIẾT KẾ CẢM BIẾN ĐA NĂNG CHO TRANG TRẠI NUÔI TÔM CÔNG NGHỆ CAO

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Tóm tắt. Kỹ thuật nuôi tôm công nghệ cao đã phát triển mạnh mẽ và mang lại nhiều tiềm năng về hiệu quả kinh tế cho các hộ nuôi tôm ở vùng ven biển vùng Đồng bằng sông Cửu Long. Các mô hình nuôi tôm công nghệ cao đòi hỏi phải kiểm soát chặt chẽ các thông số môi trường nước trong khi việc trang bị cảm biến môi trường nước cho ao nuôi tôm rất tốn kém và khó bảo trì. Bài viết này đề xuất thiết kế tối ưu cho hệ thống cảm biến tích hợp đa chức năng để theo dõi môi trường nước ao nuôi tôm như oxy hòa tan, PH, oxy hóa khử ORP, nhiệt độ và theo dõi thức ăn dư thừa dưới đáy ao. Hệ thống được đề xuất nhỏ gọn, di động và có thể đo trực tuyến để giám sát nhiều ao nuôi tôm công nghệ cao với chi phí thấp và dễ bảo trì.

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