Research on Internet of Things Technology for Intelligent Three-Dimensional Online Monitoring System of Marine Ranch

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Abstract. The online monitoring network of marine ranching ecological environment is one of the important development directions of marine ranching construction. Traditional marine monitoring systems are large in size, high in power consumption, and expensive. The investment in pasture construction cannot achieve a large amount of investment to form a monitoring network. There is an urgent need for a low-cost marine monitoring method that can afford a large area and high spatial density. This problem cannot be realized in traditional technology. Based on MEMS technology, this paper develops low-cost monitoring small floats that can be deployed in a large number of "swarm bees", with high spatial and temporal resolution, and take into account environmental and biological population characteristics monitoring. Each small float is connected to a multi-node sensor chain and video monitoring node. The low-cost surface and underwater wireless transmission and wireless communication means are used for networking observation, which proposes a brand-new solution for the construction of the intelligent three-dimensional monitoring of the marine pasture environment.

Keywords: Online monitoring, things technology, marine environment.

1. Introduction
Modern marine ranching is a new type of marine biological resource development model suitable for modern sustainable development strategies. The construction of modern marine ranching can promote the sustainable and healthy development of the marine economy [1]. One of the most important features of modern marine pastures that distinguishes them from traditional marine pastures is the use of modern science and technology and management methods to systematically manage biological resources, ecological environment, fishery production and related activities, so marine pasture environmental monitoring and underwater aquaculture Real-time biological monitoring has become an important direction for the construction of marine ranches. Traditional marine ranches have realized
the automation of some elements or part of space and time environmental monitoring, but there is still a long way to go in the multi-dimensional information monitoring of the wide-area ecological environment required by modern marine ranches. In recent years, in view of the common key technical bottleneck of real-time and efficient monitoring of marine ranching fishery water environment, the development of in-situ online monitoring technology for the water quality of typical fishery waters and the development of fishery water environment early warning and management decision support systems have become important technical directions.

2. The main problems existing in current marine pasture monitoring
Modern marine ranches need to establish a monitoring network for wide-area water bodies and ecological environment, which requires the deployment of multiple node sensors to conduct in-situ real-time monitoring of various environmental profile information such as ocean temperature, ecology, and biology. At the same time, it is also necessary to deploy multiple underwater video online monitoring nodes, so that the growth and development of fish and shrimp and other aquaculture products can be controlled at any time, and abnormal alarms such as automatic oxygenation, precise feeding, and fish disease diagnosis can be realized. At present, traditional monitoring techniques are still far away from the needs of modern marine ranches. For example, Shandong Marine Ranch uses CAN bus technology to design a seafloor online observation system, which realizes real-time online observation of underwater multi-element hydrological data and high-definition video. [2]. The system has only one submarine measurement node, which cannot achieve profile measurement that meets different depths of underwater data, and needs to transmit data and electrical energy through optical cables, which is costly and high in maintenance.

From the current technical point of view, there are two main bottlenecks in the realization of the goal of a modern multi-dimensional real-time monitoring network of marine ranches.

One is the current online monitoring technology of water quality and ecological environment in marine scenes, mainly using marine stations or buoys equipped with water quality and ecological environment monitoring sensors to complete in-situ online measurement. The problem with this model is that most of the existing water quality ecological environment monitoring sensors are large in size and high in power consumption. Although the measurement accuracy is higher than that of fishery monitoring requirements, they are expensive and have a short life span, and the marine stations and buoys they carry It is also large in scale and cannot be deployed in large quantities, that is, the deployment is mostly limited to the sea surface or the bottom of the sea. This makes the monitoring of the wide-area water body of the marine pasture a difficult problem. In this way, we can see that one of the main problems with the existing observation technology for the monitoring of wide-area water bodies in marine ranches is that most sensors are expensive and difficult to deploy widely, which makes multi-element oriented marine ranches. The comprehensive monitoring network is still blank.

The second is the distribution of multi-node sensors and monitoring nodes in the online monitoring network. A large amount of information (including monitoring data, images, videos, etc.) that will be formed needs to be transmitted in real time, and the requirements for the amount of transmitted data and the communication rate are very large. We know that because the cost of wired communication is very high and the adaptability of the marine environment is poor, it is easy to be destroyed, so the conventional marine environment online monitoring network data communication adopts wireless transmission mode, so the high-speed and high-reliability underwater and surface wireless communication technology is One of the most critical technologies to realize the interconnection of marine ranching monitoring networks. In particular, marine pastures are different from other marine monitoring networks in that they need to effectively control and track pasture biological behaviors, and efficiently detect and accurately assess biological resources. They must rely on underwater real-time image observation to obtain video and image information, which is further Increasing the amount of data transmission of the monitoring network has also become an important bottleneck restricting the development of the intelligent monitoring network of marine ranches. Because of this factor, marine pasture monitoring has to stay in the stage of analysis after manual or underwater robot carrying
underwater imaging equipment for on-site video recovery, failing to achieve continuous online monitoring.

In summary, in order to realize the three-dimensional online monitoring of wide-area water bodies and ecological environment by modern marine ranches, it is necessary to apply the so-called "Internet of Things" concept of ubiquitous sensing, which is booming on land, and break through the massive, low-cost, high-spatial resolution sensors. Technology and high-speed and high-reliability data interconnection technology bottlenecks, so as to build an intelligent three-dimensional monitoring network for the marine pasture environment.

3. Ways to realize the Internet of Things on-line monitoring of marine ranching ecological environment

3.1. The design concept of a marine pasture monitoring system based on the Internet of Things

As mentioned above, we can see that the existing observation technology, for the monitoring of wide-area water bodies of marine ranches, the main problem is that most of them are expensive and difficult to deploy widely, so the so-called Internet of Things with ubiquitous perception cannot be realized on ocean pastures.

Because the cost of continuous monitoring of wide-area oceans based on existing technology is unaffordable, the US Defense Advanced Research Projects Agency (DARPA) announced in December 2017 the launch of the “Ocean of Things” project in an attempt to integrate the ocean Perception leads to the era of the Internet of Things. DARPA plans to seek for low-cost small floats equipped with innovative and commercial sensors and intelligent data mining solutions on shore-based cloud platforms on a global scale. By combining commercial sensor technology with high-performance analysis tools, floating sensor networks composed of thousands of heterogeneous small floats (or micro-buoys) are created to greatly expand maritime perception capabilities. By combining commercial sensor technology with high-performance analysis tools, floating sensor networks composed of thousands of heterogeneous small floats (or micro-buoys) are created to greatly expand maritime perception capabilities. Awareness. DARPA requirements not only focus on collecting meteorological and hydrological information of important environmental significance, such as ocean temperature and sea conditions, but also seek to automatically detect, track, and identify the technical methods of the distribution of surrounding military and commercial ships or other identifiable features or other maritime activities. (Discern indicators), and mining data associations (data associations) [3-4].

3.2. The current status of the Internet of Things system

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Figure 1. Schematic diagram of DARPA's marine Internet of things program.

[Note: the left side is the front-end small float configured for different tasks, the middle is satellite communication and shore based system, and the right side is the superposition diagram of output environmental data products and target distribution situation]

The future vision of DARPA Internet of Things is that 50,000 can be deployed in any 1000km×1000km area in the world, that is, there are at least 5 marine IoT small floats in every 10km×10km grid; the communication between the small floats and shore-based communication uses low-orbit satellite communication (Iridium satellite or similar low-orbit IoT satellite channel) mode;
small float has certain front-end intelligence to perceive the environment and target state, shore-based system performs intelligent operation and control of small float group and data product of field environment and target distribution production; the future batch cost of each small float is controlled within $1000.

Here we draw on the technical concepts of the DARPA plan and the marine Internet of Things, and apply low-cost monitoring small floats that can be deployed in a large number of "swarm bees", high temporal and spatial resolution, and take into account the monitoring of environmental and biological population characteristics. The node sensor chain and the video monitoring node use low-cost surface and underwater wireless transmission and wireless communication methods for networking observation, thereby building an intelligent three-dimensional monitoring Internet of things for the marine pasture environment, as shown in Figure 2.

![Figure 2. Schematic diagram of intelligent three-dimensional monitoring Internet of things for marine pasture environment.](image)

In this three-dimensional monitoring network, the ocean pasture needs to monitor the wide-area water space divided into several grids, each grid is arranged with one or more small floats, and a multi-node sensor chain is suspended from the sensor chain under the small floats. In-situ real-time monitoring of various environmental information such as ocean temperature, ecology, biology, etc. At the same time, an underwater video online monitoring node is deployed at the end of the chain (undersea) to control the growth and development of aquatic products at any time. The multi-node sensor chain of each small float transmits the data to the water surface in real time, and then high-speed networking communication is carried out between multiple small floats on the water surface. In this way, low-cost micro-buoys and sensor chains are used to integrate multi-element sensor technology with massive sensor chains, micro-buoy networking, communication technology, etc. The monitoring and early warning center conducts big data analysis to form an intelligent marine pasture monitoring and early warning system.

3.2. The realization of low-cost small floats in the Internet of Things
The concept of low-cost small floats used in ocean ranch monitoring IoT is derived from drifting buoys commonly used in ocean observations, as shown in Figure 3. It is small in size, light in weight, low in cost, simple to deploy, without a huge and complicated mooring system, with sails under the
buoys, measuring sea surface currents with the Lagrangian method and conducting large-area sea areas and ocean surface hydrometeorological observations. It relies on the Argos satellite communication network to locate and upload various observed parameters, which are processed by the ground receiving station and provided to users [5-7].

Figure 3. Typical drifting buoy.

At present, most drifting buoys at home and abroad only focus on the measurement of surface temperature and flow rate parameters. They have a single working mode. There are still high-precision sensors that are expensive and rely on imports. As a result, the price of floats for single temperature measurement elements is about 10,000 yuan. The cost of drifting buoys of the elements will increase to more than 40,000 yuan, or even 200,000 yuan, which has also become an important issue that hinders the large-scale deployment and application of buoys.

In the future, the marine ranching and marine Internet of Things will require small floats to be anchored and not float with the current, intelligent, sturdy and durable, and can be equipped with sensor chains for long-term operation in the marine environment. In terms of the cost of floats, to form tens of thousands of deployment networks, the price of floats needs to be controlled at about 5,000 yuan. At the same time, the float needs to be made of environmentally friendly materials and cannot affect marine life.

Therefore, the small float we want to study is based on the structural characteristics and relatively low cost advantages of traditional surface drifting buoys, and optimizes its power supply, communication and control, and sensor chain connection structure and interface, and finally realizes a marine-oriented Internet of Things The new universal small float observation platform.
3.3. Realization of low-cost sensor chain

Traditional marine sensor technology has problems such as large size, high power consumption, heavy weight, and high cost, which cannot meet the needs of large-scale deployment of sensors in the Internet of Things of ocean ranches. In fact, our monitoring of marine pastures does not require a large number of high-precision, large-depth marine sensors, but more importantly, medium-precision, high-consistency, and low-cost sensors, which can afford large-area and high-space-density monitoring. Traditional technology cannot achieve this problem.

MEMS (Micro-Electro Mechanical System) is a device or micro system that can be produced in batches and integrates microstructures, micro sensors, micro actuators, and signal processing and control circuits. The main advantages are small size, light weight, low power consumption, good consistency, high reliability, high sensitivity, and easy integration. MEMS technology has continued to develop since its birth and has affected almost all industrial and consumer fields. Compared with traditional sensors, marine sensors based on MEMS technology have more advantages in building the Internet of Things in marine ranches.

Dongming He [8] of the University of Illinois in the United States and others processed a 0.1mm MEMS electrode probe, and the measurement error was within 4%. Hyldgard [9-11] of the Technical
University of Denmark and others have produced an open four-electrode conductivity sensor with a size of about 4mm×4mm based on silicon-based MEMS technology. The electrode shape is strip-shaped, and the measurement accuracy is ±0.6mS/cm. The new temperature and salt sensor developed by MEMS technology in this article has the characteristics of miniaturization, low power consumption and low cost. The design adopts platinum resistance temperature measurement and four-electrode probe to measure electrical conductivity. The design of sheet-type sensor substrate material, coating electrodes and resistors, coating oxidation, and integrated packaging, the sensor probe designed in this way can meet the requirements of medium and high precision and response time Fast and small, based on advanced MEMS technology, more than 100 temperature and salt sensor probes can be molded on a substrate at a time. Mass production greatly reduces costs, and the consistency is good, which further reduces the subsequent calibration and calibration of the sensor, Which greatly reduces manufacturing costs.

Based on the observation concept of such small-scale intelligent sensors and networking into arrays, a marine sensor chain is designed, and MEMS technology is used to produce temperature, salt depth, chlorophyll, dissolved oxygen and other parameter sensors with universal digital interfaces and intelligent self-calibration functions. Compared with the current sensor probes abroad, it is more miniaturized, high-consistency, low-power, and low-cost. It uses a universal transmission protocol to form a multi-node observation chain. (Degree), temperature, pressure, dissolved oxygen, ocean currents and other multi-parameter underwater observations.

3.4. Realization of low-cost, high-speed and high-reliability underwater data transmission of the Internet of Things

As mentioned earlier, the marine ranch online monitoring network is mainly composed of a monitoring platform (small float), monitoring sensors (chain) and a wireless data transmission network, as shown in Figure 6. Among them, the wireless data transmission network has to complete two important tasks: one is to transmit the sensor data of each underwater node to the water terminal of the small float by the underwater sensor networks (underwater sensor networks, USN), and the other is to be realized by the water network communication system. The small floats are interconnected with the
marine pasture monitoring and early warning center, so low-cost, high-speed and high-reliability underwater and surface communication technology is the key technology to realize the interconnection and interconnection of the marine pasture monitoring Internet of things.

**Figure 6.** Low-cost in-situ online monitoring of the ecological environment of marine pastures.

Currently, USN uses many communication technologies, mainly wired transmission and wireless transmission. The first is to use the same cable direct transmission method as on land, but it needs to solve the cable water tightness, multi-node communication reliability and The problem of underwater entanglement of communication cables and anchoring systems, especially to ensure that the cables of several hundred meters under the combined action of wind, waves and currents cannot be damaged or broken. Otherwise, not only data transmission problems will occur, but high-power electrical signal leakage will occur. Serious security issues. Another method is wireless transmission, which uses electromagnetic waves or acoustic principles to transmit data. Among them, underwater acoustic communication is the most commonly used technology to achieve long-distance transmission in seawater. Its transmission performance is affected by low bandwidth and time-varying. With the limitation of multipath propagation, high delay and Doppler diffusion [12], the data transmission rate can reach dozens of kpbs under long-distance (kms) communication. In this way, there is still a certain gap between the underwater acoustic transmission technology and the data transmission requirements of the marine pasture monitoring network [13]. Electromagnetic wave transmission has a higher bandwidth and faster speed, but in underwater applications, affected by parameters such as the conductivity of the seawater medium, its propagation range will be limited by fundamental wave attenuation and noise factors. It works at a frequency of 2.4 GHz. When the attenuation is about 1600 dB/m in seawater, only a short communication distance of tens of centimeters can be achieved [14]. In addition, the electromagnetic wave transmission method needs to solve complicated problems such as underwater connection, watertightness of cables or optical fiber cables, and cannot freely change positions, which greatly reduces the number of network nodes.

Due to the shortcomings of the above two methods, the international marine technology experts specially developed and applied the inductive coupling data transmission technology for the special task of real-time transmission of underwater measurement data from the marine fixed-point observation platform. This technology is between the two above. Between the methods, the small float is moored in a loop composed of a plastic-coated steel cable and sea water, and the electromagnetic induction principle is used to realize the data transmission of non-contact underwater multi-node
sensors. The transmission principle is equivalent to the principle of a two-stage transformer. The two ends of the plastic-coated steel cable for mooring the small float are in contact with seawater to form a single-turn loop. The data information of each underwater instrument is added to the primary of the coupling magnetic ring through the carrier. On the windings; a current is induced in a single-turn circuit formed by a steel cable and seawater in series; this current induces an electromotive force on the secondary winding of the magnetic ring coupling at the water terminal; the electromotive force is sent to the terminal for demodulation to obtain data sent underwater.

Because this transmission method does not have any direct electrical connection, it is obviously superior to other transmission methods in terms of reliability and cost; and the transmission distance is long, can cover the full depth of the ocean, and has the advantage of collecting and transmitting marine environment observation data in real time all-weather. At present, well-known ocean instrument manufacturers in the world have developed application products to meet the needs of multi-node ocean observation applications, with a transmission rate of up to 9600bps\[15\]; a large amount of monitoring data (including images, Video, etc.) for real-time transmission. In recent years, with the development of image and video intelligent recognition technology, the intelligent monitoring and recognition technology of seafood has made great progress. For example, Xu Fengqiang and Fu Xianping of Dalian Ocean University have adopted convolutional neural networks (CNN). The target detection algorithm realizes the intelligent detection of real-time behavior characteristics of a variety of seafood\[16\], so that all underwater video and image information can not be completely transmitted in real time, and only the key feature data to be extracted can be transmitted. In this way, the amount of data to be transmitted is greatly compressed, even so, the transmission rate must reach more than 500kbps. In addition, it is necessary to supply power to the sensor, and to complete the output of electric energy from water to underwater, all of which need to effectively improve the transmission capacity of the existing transmission system.

The power transmission is the same as the signal transmission circuit. There are solar panels and rechargeable batteries inside the floating body. The electric energy is converted to DC and AC, and high-voltage and high-frequency AC power is added to the transmission circuit. The steel core is connected, the grounding end is connected to the seawater through the upper electrode, and the steel core at the lower end of the plastic-clad steel cable is connected to the seawater through the lower electrode, and the conductive characteristics of the seawater are used to form a loop. The high-frequency power signal in the magnetic loop induction loop of each sensor node in the water is transmitted and received by the power receiving circuit. The energy is stored in the super capacitor in the node to provide power, power and signal transmission circuit for the operation of the underwater sensor node.

The traditional inductive transmission method has a low transmission rate and cannot achieve large-quantity transmission such as video or image. The transmission rate must be increased. However, due to the "narrowband" characteristics of the coupled channel, the use of traditional single-carrier modulation to increase the signal transmission rate will be affected by channel noise Tolerance and effective bandwidth limitation. Orthogonal Frequency Division Multiplexing (OFDM) technology is used to reduce the transmission rate of a single carrier to obtain higher signal-to-noise ratio gains, to increase the number of carriers to increase channel bandwidth utilization, and ultimately to improve the system transfer rate. In view of the flexibility of the sub-carrier modulation mode of OFDM technology, select the appropriate sub-carrier modulation mode according to the characteristics of the coupled channel. When the channel condition is poor, select the low-order modulation mode with strong error resistance performance (such as 2PSK, QPSK). When the conditions are better, choose a higher-order modulation method with higher transmission efficiency (such as 16QAM, 64QAM). When the modulation mode is determined, a reasonable constellation map is designed to increase the transmission rate of the coupled channel to 1Mbps, as shown in Figure 7.
3.5. Realization of Low-cost Water Surface Data Transmission Network of Internet of Things

In addition to the front-end smart buoy technology and low-cost sensor arrays, the key to supporting the core links of the Internet of Things for marine pasture monitoring is to find low-power, real-time, image-side video and other large data transmissions suitable for buoys. In addition, the surface wireless communication technology with stable operational capabilities, from the current point of view, the US Iridium satellite system used in the traditional observation system meets the requirements, but its communication cost is high, and it is not suitable for marine ranches. Considering from the networking mode, data transmission in the ocean ranch environment needs to cover a long distance, high power consumption requirements, and the ocean is a constantly moving environment, and the communication signal attenuation is relatively serious. Long-range LoRa is one of the most successful LPWAN technologies. First, it can realize reliable remote low-power communication [17], and its communication distance can reach more than 5 km. If data is collected every 1 minute, two AA batteries can work for LoRaWAN network nodes for about 3 years [18]. The LoRaWAN integration of LoRa technology follows the general integration rules of the Internet of Things system, which is very suitable for sensor data networking [19]; in terms of transmission rate, due to the wide distribution of nodes, each node has different transmission rates due to different distances from the gateway. The spreading factor is related, which results in a very low transmission rate for nodes that must be far away if all nodes use one parameter setting. In view of its slow communication rate [20], the LoRa rate adaptive mechanism is adopted. Devices with different transmission distances will use the fastest data
rate as much as possible according to the transmission conditions, which also makes the overall data transmission more efficient. In terms of price, the price of a single-node LoRa chip is tens of yuan, which is far lower than the current satellite communication price, which greatly reduces the application cost of the system. Therefore, the LoRaWAN networking technology is used to meet the requirements of long-distance, low-power, stable and reliable multi-element monitoring and massive data communication transmission of ocean farms.

The intelligent monitoring and early warning system for modern ocean pastures built by our goal is shown in Figure 8. The water area to be monitored by the entire system is 10×10 km and the water depth is 100 m. The upper end is fixed on a small float, and multiple environmental monitoring sensor nodes are placed under each chain, and their positions can be flexibly adjusted according to needs. The profile seawater environment information and the seabed video image feature extraction information are transmitted by inductive coupling, and the node on the watchdog platform of the water monitoring and early warning center acts as the master node in the entire network architecture as the server's general control end. The 4 gateway floats around it have LoRa gateways as slave nodes and act as LoRa base stations in the entire network architecture. The rest of the floats distributed in the water are sub-nodes as LoRa terminals in the entire network architecture, which can transmit data to the server as long as they are within the range of the LoRa network. After the information collected by the sensor is transmitted to the water through the inductive coupling channel, the LoRa terminal sends the collected information to the base station through the terminal node, and the base station sends the received data to the server, forming a distributed sensor network. The analysis of big data information can realize effective monitoring and early warning of the state of ocean pastures.

Figure 8. Schematic diagram of data transmission of modern marine pasture intelligent monitoring and early warning system.

4. Summary
Modern marine ranches require multi-element real-time monitoring of the ecological environment of the ranches. Traditional monitoring and data transmission methods have problems such as high costs and inability to deploy in large numbers, which have become a bottleneck problem in the construction of an intelligent monitoring and early warning system. Based on the so-called "Internet of Things" concept of ubiquitous perception that is booming on land, this paper designs a technology solution for ocean monitoring Internet of Things based on low-cost small floats. Specific solutions have been
proposed for the sensor chain, underwater data transmission, and surface network communication. These research results can provide technical support for the construction of marine pastures or other ocean observing systems, and will change to a certain extent the traditional, backward, low-efficiency, and low-level information technology problems that exist in the current monitoring system construction investment, and promote industrial transformation. upgrade.

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