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Research on seafloor geomagnetic observation technology based on CAN bus

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ABSTRACT

In order to study the geomagnetic observation technology of seafloor and make it feasible to implement the plan of ocean geomagnetic observation network in the future, we use the seabed geomagnetic acquisition system based on CAN bus to display the change of seabed geomagnetic data in real-time. The results show that the coverage algorithm based on a hexagon grid can save 30% buoy nodes compared with the traditional algorithm, and can effectively control the cost of a sensor network in the special marine environment. Conclusion: the submarine geomagnetic acquisition system based on CAN bus is an important technical support in the ocean geomagnetic observation network, which has important pre-research value and reference significance for the implementation of the plan, and improves the network coverage and data reliability.

Keywords: Seabed geomagnetism; Observation technology; CAN bus

1. Introduction

The ocean accounts for 70% of the earth's surface area. There has been a lack of high-precision geomagnetic observation data in the ocean for a long time, which restricts the systematic study of the global geomagnetic field. However, nowadays, the seabed observation technology has become a new hot spot, and the seabed observation system marks a new era of ocean research and development, marine science is moving towards a new revolution. The seafloor geomagnetic observation is not only an integral part of the study of the global geomagnetic field but also the need and necessity of the development of science and technology. Therefore, it is not only beneficial to the integration of traditional geomagnetism and marine science but also to improve the research level of marine geology and geophysics [1].

2. Literature review

The concept of the submarine observation network proposed by the United States has promoted the idea of a global seabed network. Since the 1990s, research on seabed observation network has been carried out abroad. At present, some countries in the West and Asia, such as Japan and South Korea, have invested a lot in the construction of submarine observation system, especially in the deep-sea environment, it is very difficult to realize the relevant technology [2]. The follow-up results are less reported, so the popularization and application research of the corresponding seabed geomagnetic observation technology and method is relatively backward. The progress of science and technology is always accompanied by the development of the national economy [3]. In terms of seabed observation research, China started relatively late. Under the "863" project of "national deep-sea environment monitoring system" and other "key projects of China's" 863 "project of" real-time ocean environment monitoring system in the adjacent strait and other key projects of China. It mainly includes the development of subsea junction box and transmission energy communication technology, seabed chemical environment in-situ monitoring technology, seabed dynamic environment in-situ monitoring technology, submarine network networking standard technology, submarine network test, deployment and maintenance technology, etc.

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Significant progress and breakthroughs have been made in the energy supply, information transmission, defense deployment and maintenance, networking standards and system integration of the submarine observation network. However, the monitoring network for long-term observation of seabed geomagnetic changes has not really been established [4–6]. Compared with developed countries, China is relatively backward in the construction of a long-term observation system. Based on the requirements of seismic monitoring and military anti-submarine in China, the research on submarine geomagnetic instruments and equipment and networking technology is an indispensable work in marine technology, future, it will be a key part of marine geomagnetic monitoring in China [7–10].

The innovation point of this paper: this paper analyzes the seabed geomagnetic observation technology and the related core technical problems, and when combined with the needs of the development of marine science, resource exploration, national defense and military, disaster prevention and mitigation, the application fields of seabed geomagnetic observation are analyzed. Finally, the related technical methods and the scientific and technological problems in future technology development and method research are discussed systematically.

3. Research methods

CAN bus belongs to the serial communication network. Compared with other field buses, CAN bus transmission has the characteristics of reliability, flexibility, ease of use and real-time. It is one of the most widely used field buses. Starting from the actual environment of the seabed observation system, after a comprehensive comparison of various buses, it is found that the CAN bus has greater applicability. Its main performance characteristics are summarized as follows: (1) flexible communication mode; (2) long transmission distance: the transmission rate of the CAN bus is less than 5 kbps; (3) the number of nodes that can be attached to the terminal is large; (4) the arbitration technology of non-destructive bus is used in CAN bus [11].

3.1. Establishment of the CAN design scheme

In the traditional ocean observation system, all kinds of sensors are directly connected with the main control system by wire. Each sensor needs a lot of signal lines to connect. In this way, there will be a lot of cable and signal line connectors. In the process of connection, transmission, assembly and maintenance, the stability of the whole system will be greatly reduced, the interface corresponding to each sensor is special, which brings inconvenience to the maintenance and system upgrade. If the bus structure which is widely used at present is used to make the sensor communicate with the main control system on the bus, it cannot only reduce the cost but also improve the stability and compatibility of the system. Therefore, the submarine geomagnetic observation system finally chooses the solution based on the CAN bus network to detect and study the change of seabed geomagnetism [12–14].

According to the functional requirements analysis, the design of the acquisition node is mainly divided into four parts: sensor acquisition module, microcontroller module, CAN bus communication interface module and power supply module, as shown in Fig. 1. The hardware circuit design and software program design of each module is described in detail.

3.2. Sea surface wireless sensor network system

The intelligent acquisition node transmits the seabed geomagnetic data to the intelligent control node through the CAN bus. When the control node collects the data, it transmits it to the buoy system on the sea surface by means of an acoustic communication machine. Therefore, the whole system will be composed of several buoys on the sea to form a wireless sensor network. The coverage problem of the wireless sensor network is the primary problem of sensor network topology management. This paper analyzes the coverage problem of wireless sensor networks from the perspective of coverage and energy.

A large number of sensor nodes are deployed in the sensing area to form a family structure network, which is used to collect the data of various environmental parameters, and then transmit the collected information to the operator through the base station. Generally speaking, the sensor node is an embedded system. In different application fields, the composition of sensor network nodes is different, but usually includes data acquisition, processing, data processing, and so on. Therefore, wireless sensor network design to sensor technology, network communication technology, wireless transmission technology, embedded technology, distributed information processing technology, microelectronics manufacturing technology, software programming and other interdisciplinary crosses hot research field. It will gradually penetrate into every aspect of the human life field of application.

3.3. Research on node deployment algorithm of wireless sensor network

3.3.1. Node deployment problem description

According to the introduction of sensor characteristics above, we can see that the deployment of nodes in a wireless sensor network determines the coverage rate of the network coverage area. It is an important branch of wireless sensor network research. The sensor node described here is the buoy node in the design of the sea system. How to deploy the buoy node, under the condition of ensuring a certain quality of service. To achieve the maximum network coverage, that is, to maximize the coverage with the least number of buoys, and to effectively control the network cost is the content of this section.

The algorithm for buoy node deployment is based on the following assumptions: the buoy node is stationary, the coverage of a node is a circular area with a radius of and a center of the node. The following three definitions are briefly introduced: (1) complete coverage: if each point in the monitored target area is covered by at least one sensor node, the coverage of a node is a circular area with a radius of; (2) redundant node: if the coverage of a node is completely covered by other nodes in the target area,

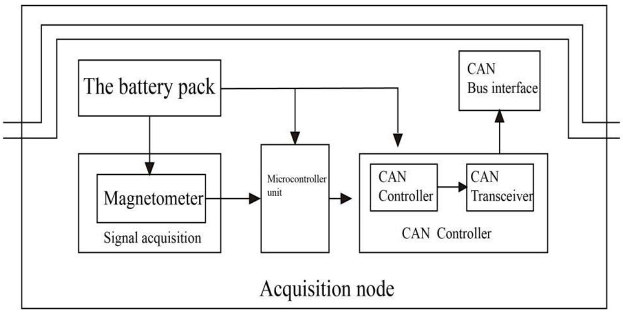

Fig. 1. Structure diagram of acquisition node.

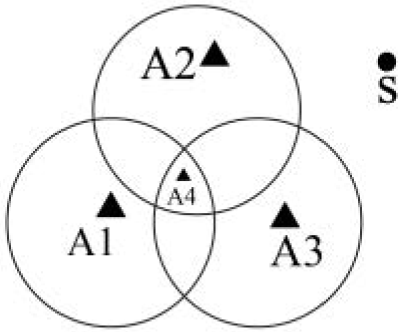

Fig. 2. Deployment of sensor nodes in the marked area.

then the node is called a redundant node; (3) vulnerability point: if all the points in the monitored target area are not completely covered by any sensor nodes, then this node is called a vulnerability point.

In order to better understand the three basic concepts, as shown in Fig. 2, the rectangular area represents the target area to be monitored. A1, A2, A3, and A4 are the four sensor nodes in the area, in which A4 a redundant node and S is a vulnerability point.

3.3.2. Node deployment algorithm based on a special grid

Considering the minimum deployment of buoy nodes in the target area, it is necessary to make full use of the coverage area of each sensor node, that is, the overlapping area of the coverage circle between nodes. Under the condition of meeting the full coverage of the target area, if the overlapping area is the smallest, the number of buoy nodes will be less. As shown in Fig. 3, a1, a2, a3, and a4 are the shadow areas of a1, a2, and a3, respectively, The objective function of the model is f = a1 + a2 + a3 + a4. If three circles with the same radius intersect each other and the coverage area is the largest, then the three circles must intersect at one point and the three circles intersect each other and intersect one point, and the three-circle centers are surrounded by an equilateral triangle, then the coverage area is the largest.

Bottom observation technology is mainly used in seabed scientific research, marine mineral resources exploration and other fields. Seabed geomagnetic observation technology is an important part of seabed observation. In recent years, seabed geomagnetic observation has been paid more and more attention and applied in practical research, the ocean geomagnetic observation network is a huge plan based on a wide range of seabed coverage and relying on the information transmission network. Its establishment will change the blank state of China in this high-end field. It has pioneering significance in marine science, environmental science, national defense and security.

4. Result analysis

4.1. Analysis of node deployment results in wireless sensor networks

The effectiveness of the algorithm is verified by simulation software. The simulation platform is programmed by MATLAB software developed by MATLAB company. Assuming that the coverage of buoy nodes is a circle with R radius and the target area is a square of H(58). Fig. 4 shows the simulation results when the radius is R. when the side length h of the target area is 4R, the algorithm only needs 9 nodes to cover the whole target area, the traditional algorithm needs 12 nodes. The advantages of the two algorithms are not obvious when the number of nodes is small. When the target area is expanding, such as when the edge length h of the target area is 24R, the algorithm needs 246 nodes, while the traditional algorithm needs 312 nodes. It can be seen that the coverage algorithm based on the hexagonal grid can save 30% buoy nodes than the traditional algorithm. If it is applied to the special marine environment, the cost of the sensor network will be effectively controlled, which shows the superiority of the new algorithm.

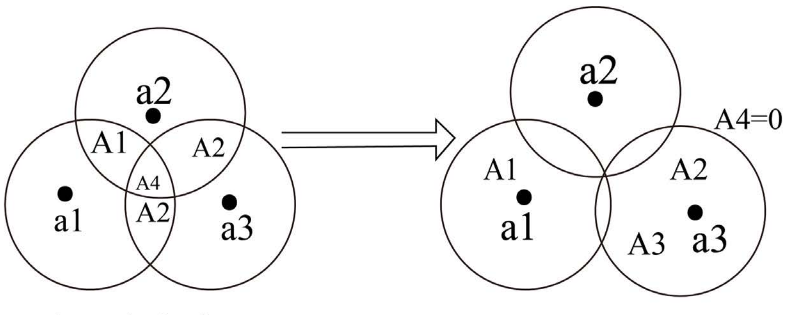

Fig. 3. Coincidence area of two circles intersecting each other.

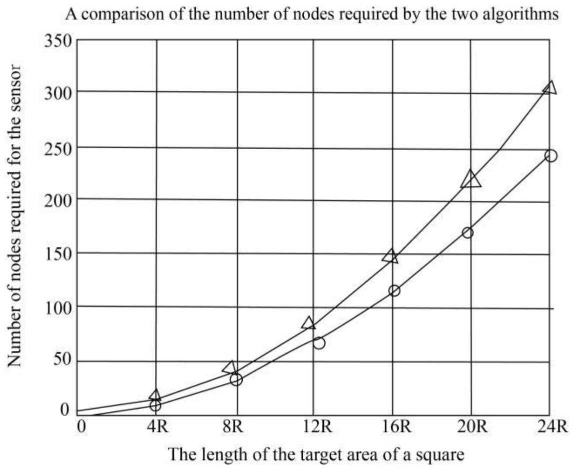

Fig. 4. Simulation comparison diagram.

4.2. Result analysis of wireless sensor network coverage algorithm

MATLAB 7.0 simulation platform is used to carry out simulation experiments, and the results are analyzed. The algorithm achieves the maximum coverage with the least number of sensor nodes through sensor networks. It is assumed that sensor nodes are randomly distributed in a 100 m × 100 m monitoring area.

Fig. 5 draws a conclusion from a series of experiments with different network sizes (200–600 nodes), in which the sensing radius Rs is 20 m. For each network size, the mean and standard deviation exist. We can observe that they improve significantly with the decrease in the number of active nodes. When the number of nodes is 200, the corresponding number of active nodes is 40. When the number of nodes is 400, the corresponding number of active nodes is 80; when the number of nodes increases to 600, the corresponding number of active nodes is 86.

4.3. Laboratory testing of seafloor sensor chains

The system debugging is mainly divided into two parts: the software and hardware debugging of function modules and the communication debugging of CAN data receiving and sending. Firstly, the test of each node unit is realized, and then the overall debugging of CAN network communication is carried out. Before that, the power supply time of the acquisition node in the seabed acquisition system is tested to test the actual battery consumption. The power supply voltage of the system is 9 V, and the dry battery power supply mode is adopted. The experimental process is relatively simple, that is, power on the acquisition system and continuously supply the dry battery. During this period, the voltage is measured every hour and the measured voltage value is recorded, the measured voltage value is drawn into the variation curve of battery supply voltage, as shown in Fig. 6. It can be seen from the figure that the power supply can meet the system working time index.

In the independent node, the first thing is to ensure that the data can be sent and received so that the whole system can be debugged. Here, mod. 2-bit self-test mode

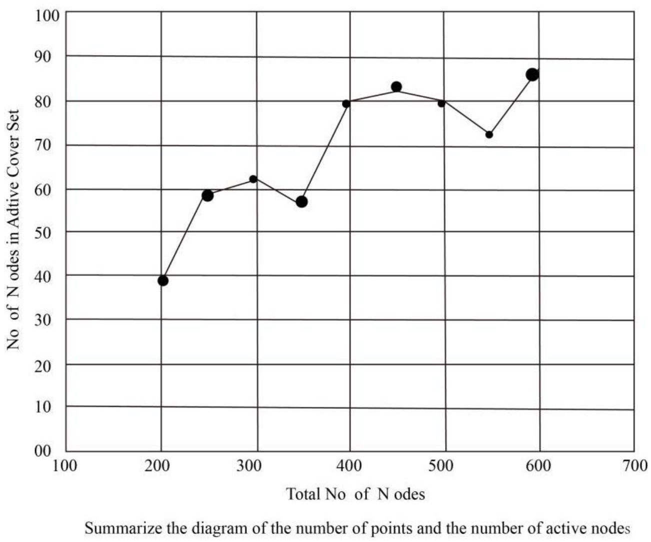

Fig. 5. Relationship between the total number of nodes and the number of active nodes.

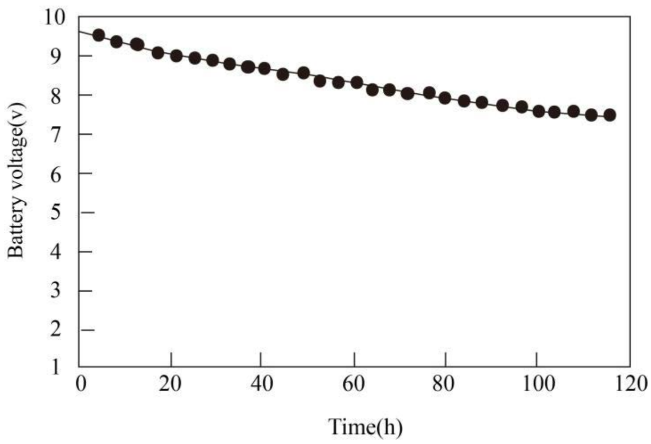

Fig. 6. Battery voltage consumption curve.

(TSM) in the mode register is used to test. When STM = 1, the self-test mode of a single node can be carried out without other nodes, the receiving buffer can be read to observe whether the transmitted data has been received. If it can communicate regularly in the self-test mode, it indicates that the data receiving and sending of the node is normal, and then the data transmission in the normal mode is carried out.

5. Conclusions

The background of seabed geomagnetic detection CAN bus technology, the design scheme of seabed geomagnetic acquisition and coverage of sea surface wireless sensor network are analyzed and studied in depth. Through the laboratory test, the system works normally and has stable performance. The wireless sensor network based on the buoy system connected by the submarine acquisition sensor chain is the research content of the system. The coverage problem of the wireless sensor network is analyzed from the perspective of coverage and energy. The node deployment algorithm and coverage algorithm based on the special network is proposed, and the effectiveness of the algorithm is verified by simulation. The seabed geomagnetic observation system based on CAN bus designed in this paper can transmit the geomagnetic data of the seabed to the shore-based observers in a wide range, which can provide real-time changes of the seabed geomagnetic data. It is an important technical support of the marine geomagnetic observation network. Although the observation system is not perfect, it is believed that after a long time of continuous research and improvement, there will be a more perfect and advanced system.

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