Research on Encrypted Transmission Method of Survey Data of Offshore Engineering Buoy

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Abstract. The measurement data of offshore engineering buoy includes vector data and grid data. Due to the large difference in structure and characteristics, the encrypted transmission time is long. Therefore, an encrypted transmission method of offshore engineering buoy measurement data is designed. On the basis of analyzing the motion performance of the buoy structure, the measurement data of the marine engineering buoy are obtained, and the characteristics of the marine environmental load are extracted. Unpack and sort the uplink data, sort the data that needs to be transmitted to other nodes into frames and output them to the downlink, and transfer the data that needs to be sent to the external network to the external interface, so as to improve the transmission efficiency of marine engineering buoy measurement data. The improved Logistic chaotic mapping algorithm is adopted as the main algorithm of data encryption transmission mode to ensure the security of buoy measurement data. The test results show that the encryption transmission method of marine engineering buoy measurement data designed this time can effectively reduce the encryption time and improve the encryption efficiency while ensuring the data security.

Keywords: Ocean engineering · Buoy survey · Load characteristics · Data encryption · Data transmission · Encrypted transmission

1 Introduction

Marine engineering buoy measurement data encryption takes geospatial cognition as a bridge, abstracts the real geographical world step by step, and obtains spatial concepts of different abstract levels, thus realizing the simulation of geographical systems. Ocean spatial data model is composed of three different levels: conceptual model, logical data model and physical data model. As one of the main ways of marine monitoring, marine data buoy is a modern marine observation facility. It is a surface floating automatic monitoring platform used to obtain physical and biochemical parameters such as marine

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hydrology, meteorology and water quality. It has the characteristics of long-term, all-weather, all-time, continuous, synchronous, comprehensive and low cost, and can realize automatic collection and automatic transmission of data [1]. Vector data and grid data are commonly used in offshore engineering buoy measurement. Due to the different structures and characteristics of these two data models, it is more difficult to encrypt and transmit data.

Reference [2] proposes a data encryption transmission method based on DES algorithm, which is a block encryption system with 64 bit cipher and a symmetric encryption algorithm with the same encryption key and decryption key. Through the entry parameters of DES algorithm, the replacement method of 64 bit block cipher is analyzed, and the data encryption steps are determined to complete the encrypted transmission. Reference [3] proposes a data encryption transmission method based on AES algorithm, introduces AES algorithm to encrypt sensitive data, designs a data encryption transmission scheme, introduces key expansion, data encryption and decryption optimization algorithm, and analyzes the flow of data encryption transmission method and the realization of data encryption. Reference [4] proposes a data encryption transmission method based on chaotic algorithm to obtain high-end equipment command sensitive data to be encrypted, so as to narrow the encryption range and remove redundant data. The encryption method based on chaotic mapping is used to realize the encrypted transmission of data.

Although the above method can complete the encrypted transmission of data, it has the problems of long time consumption and poor security. In order to solve the problems existing in the above encryption transmission methods, a new encryption transmission method of marine engineering buoy measurement data is proposed.

2 Research on Encrypted Transmission Method of Survey Data of Offshore Engineering Buoy

2.1 Obtain Survey Data of Offshore Engineering Buoy

Offshore engineering buoy is a kind of drifting buoy floating on the ocean surface. It has the characteristics of small volume, low cost and easy delivery. It can be used in large-scale marine environment monitoring, oil spill tracking, maritime search and rescue, military and other fields. Once the ocean engineering buoy came out, it has become an important means to obtain marine data. With the rapid development of satellite positioning and communication technology, its role in ocean observation can not be replaced. As a kind of offshore floating body, the basic design and theoretical research of offshore engineering buoy refer to the general theoretical research methods of offshore floating body structure. In order to better analyze the structure of offshore engineering buoy, this paper is based on three-dimensional potential flow theory. The complete system of offshore engineering buoy is usually composed of three parts: buoy body, water sail and data acquisition unit. Flexible connection is adopted between water sail and buoy body. The forms of water sail include umbrella type, curtain type and cylindrical type. The selection of water sail and its connecting length with buoy shall be appropriate to ensure the wave induction of buoy. Based on the basic analysis method of panel integration,

aiming at the basic structural parameters (shape, size, draft, center of gravity position, moment of inertia, etc.) affecting the motion response of buoy, the effects of these basic parameters on the force, motion performance and hydrodynamic parameters of buoy are analyzed in time domain and frequency domain. Natural period is an important index to measure the motion performance of floating body. Since the main floating body of the circular buoy is a symmetrical structure, when arranging the carrying instruments, the carrying instruments are generally symmetrically arranged. Therefore, the natural period of the buoy in the rolling and pitching directions is roughly the same. In the calculation of the natural period of the buoy, only the natural period in the rolling direction of the buoy needs to be considered. According to the theory of ship seakeeping, the approximate natural frequency of free rolling of floating body is:

$$Q = \frac{1}{2\pi}\sqrt{\frac{G_\delta}{\Delta V_{\delta-1}}} \tag{1}$$

In formula (1), G represents the displacement, V represents the moment of inertia of the rolling motion of the floating body, and δ represents the additional moment of inertia of the rolling motion of the floating body. At first, the ocean engineering buoy was limited to the measurement of ocean current. With the increasing maturity of ocean engineering buoy technology, the newly developed ocean engineering buoy covers the measurement of precipitation, ice drift, humidity, sea conditions and other data. It plays an irreplaceable role in business, civil and military, such as marine oil spill accident tracking, disaster prediction and so on. Since the motion response of the buoy is mainly affected by the external environmental load (mainly wave load), in order to better study the influence of the basic parameters of the buoy on the motion performance of the buoy, based on the analysis of the motion performance of the buoy structure, this paper will focus on the further detailed analysis of the hydrodynamic parameters of the buoy in the wave environment. The calculation formula of buoy heave natural frequency is as follows:

$$L = \frac{1}{2\pi}\sqrt{\frac{V}{\frac{E}{\eta} + d}} \tag{2}$$

In formula (2), E represents the additional mass of the free heave of the floating body, η represents the displacement of the floating body, and d represents the gravitational acceleration. Usually, ocean engineering buoys can continuously monitor ocean current data, meteorological data and marine hydrological information for a long time without interference and poor sea conditions. It can be put in manually or in large quantities by machinery. Small offshore engineering buoys can be evaluated for recovery cost to decide whether to recover or not. Offshore engineering buoys equipped with solar charging panels can work on the sea for a long time. During this period, a large amount of marine data can be obtained, and the smaller volume is less likely to be found and damaged. Therefore, they have been widely used in a short time. When analyzing the motion performance and hydrodynamic parameters of floating body at sea, the floating body at sea is usually considered as a rigid body structure. As a kind of rigid body, the buoy body can generally move freely in space. Therefore, when analyzing the motion

performance and hydrodynamic force of the ocean buoy, we should first establish an appropriate coordinate system for the studied ocean buoy structure, otherwise there will be a lack of reference. The numerical simulation method based on potential flow theory has the advantage of fast simulation speed, but because it ignores the viscosity of the fluid itself, it can not accurately describe the impact of wave climbing, diffraction, eddy current and other phenomena after the interaction between wave and buoy. It has a particularly obvious impact on the calculation results of small floating body, and finally causes irreversible error to the results. For the floating body on the sea, when it is only affected by gravity and buoyancy, the buoy is stationary in the vertical direction. If there is an external couple acting on the object, the object will tilt. When the external couple is withdrawn, the object rotates under the action of moment H, where:

$$H = \gamma \times \frac{\sqrt{\frac{G}{d}}}{r \times \sin\theta} \tag{3}$$

In formula (3), γ represents the distance from the center of gravity of the object to r, r represents the intersection of the vertical line of the floating center position of the object and the central axis of the object, and θ represents the inclination angle of the object. In addition, the draft is an important factor affecting the carrying performance of the buoy. On the basis of meeting the stability and movement performance, more environmental monitoring instruments should be carried as much as possible to maximize the economic benefits of the buoy. Therefore, it is necessary to analyze the stability and movement performance of the buoy based on the draft under the premise of determining the shape of the buoy, in order to provide a basis for the carrying performance design of the buoy. With the improvement of computer computing power, numerical wave flume based on incompressible viscous fluid shows its advantages in the field of ship and ocean engineering and is gradually widely used. This chapter will introduce the mathematical model, basic theory and numerical simulation method of numerical flume based on incompressible viscous fluid in detail, so as to provide a theoretical basis for the establishment and simulation calculation of subsequent numerical wave flume. For the shape of the hemispherical buoy selected above, keep the center of gravity position and mass moment of inertia unchanged in the analysis process, and analyze the motion of several degrees of freedom by changing the draft, that is, changing the carrying and counterweight, so as to provide reference for the selection and design of offshore small buoy. Hydrodynamic parameters (such as additional mass, additional damping, etc.) are important parameters to measure the motion performance of buoy. Therefore, before analyzing the influence of draft on the motion performance of buoy, it is necessary to analyze the hydrodynamic parameters of buoy according to different draft.

2.2 Extracting the Characteristics of Marine Environmental Load

As a kind of floating body on the sea, the loads borne by the buoy in the basic design process of its buoy structure mainly include the permanent load of the buoy's own weight and environmental loads such as wind, wave and current. These two parts of loads together constitute the main external environmental loads in the movement process of the buoy structure. The earth's surface is composed of the atmosphere. Due to the

influence of the earth's gravity, the atmosphere is unevenly distributed in the horizontal direction, which leads to the movement of air from the high-pressure area to the low-pressure area. This kind of air flow is wind. The wind has the following characteristics: the wind speed increases with the increase of height. As a kind of floating body on the sea, the upper instrument rack of offshore small ocean buoy is equipped with solar panels, which makes its wind receiving area account for a large proportion compared with the overall surface area, and the wind speed on the ocean is generally very high, which makes the movement of buoy more sensitive to the environmental factor of wind. Due to the influence of friction, the flow velocity of the air near the ground is small. With the increase of the ground, the flow velocity becomes larger, and the final velocity tends to be stable. Due to the Coriolis force, compared with the wind direction of the atmospheric boundary layer, the wind direction at the surface will deflect at a certain angle, and the deflection angles at different times and in different regions are also different, up to tens of degrees. When the offshore structure is subjected to the force of wind load, it will produce a large overturning moment. Therefore, the force generated by wind load needs to be considered when calculating the external load. Assuming that the wind field is two-dimensional and there is only wind parallel to the sea level, the instantaneous wind can be regarded as the superposition of average wind speed and fluctuating wind speed, which will produce average load force and fluctuating wind load force on the main body of the drifting buoy. The calculation formula is:

$$W_{\varphi} = \frac{1}{2}\sqrt{\mu + s^2} \times \frac{1}{\sqrt{(\varphi + 1)^2}} \tag{4}$$

In formula (4), μ represents the leeward area of the buoy body on the waterline, s represents the wind coefficient, and φ represents the windward area of the buoy body on the waterline. Under the action of the environmental factor of wind, the small floating body such as buoy will produce large overturning moment and anchoring force, and cause dynamic load with large frequency range, which will have a great impact on the motion response of small floating body such as buoy. Wind is one of the environmental factors in the design of offshore structures. The air in the atmospheric boundary layer has random turbulent flow. Its structure can be expressed by turbulence degree, Reynolds stress, correlation function and spectrum. The turbulence degree can reach 20%. There are three kinds of waves in the marine environment: wind wave, swell and mixed wave. Wind and waves are caused by sea breeze, which is the focus of this paper. Swells are waves caused by sea winds from other areas to this area. Ocean current is mainly composed of wind-driven current, tidal current, ocean circulation, internal wave current, etc. The current velocity varies with water depth. Under normal circumstances, in the ocean surface, the velocity is generally constant in direction, stable in magnitude and decreasing with water depth, so the calculation formula of velocity is:

$$R(\varpi) = T_{(\varpi)} + Z_{(\varpi - 1)} + \sqrt{\frac{1}{\mu^2}} \tag{5}$$

In formula (5), ϖ represents the velocity of wind-driven current, T represents the velocity of tidal current, and Z represents the velocity of ocean circulation. Because

the wind load will have a large overturning moment on the floating buoy on the sea surface and have a great impact on the buoy anchoring system to a great extent, it is necessary to select an appropriate wind load calculation formula when analyzing the movement of offshore small marine buoy in the marine environment. Due to the small water entry depth of the floating buoy, it can be approximately considered that the speed and direction of the current remain unchanged within a certain period of time, so the calculation formula of the current load force is:

$$M_\sigma = \frac{1}{2} \times N_\sigma + \left\| \frac{Z}{s} \right\|^2 \tag{6}$$

In formula (6), N represents the drag force coefficient and σ represents the density of seawater. Ocean current factor is also one of the important environmental factors in the design of offshore structures. The ocean current has a great drag force on offshore structures, which puts forward great requirements for the stability of small offshore floating bodies such as buoys and the design of mooring system. Mixed waves are waves with both wind and swell. The drifting buoy is affected by the wave load in the marine environment. The wave load is mainly divided into three parts: wave frequency force. The load force is obtained by deriving the first-order velocity potential. The average drift force, the load action is similar to the current load, and the wave height is positively correlated. The load force is obtained by solving the second-order velocity potential. Compared with the deep-water buoy, in the offshore sea area, due to the shallow water depth, the drag effect of ocean current on the mooring system is produced on most of the anchor cables. Therefore, ocean current is an environmental factor that can not be ignored in the process of buoy structure design. The characteristics of waves in different sea areas are different, and the motion law of wave particles in sea areas is also different. If the wavelength, relative water depth and relative wave height are different, the motion law of wave water quality points is also different. Linear wave theory, Stokes wave theory and stream function wave theory are often used in the field of marine engineering research. Although the differential equations and boundary conditions of traditional wave theory are different, the results are similar. The fundamental difference lies in the satisfaction of nonlinear motion and wave surface dynamic boundary conditions. Because the average drift force accounts for a relatively small proportion of wave load, it is ignored. The slowly varying drift force is neglected again because it accounts for a small proportion of the wave load. When the drifting buoy flows with the current at sea, it will not only be affected by the wind, waves and currents, but also be completely submerged by the sea due to some uncertain factors. Therefore, it is necessary to analyze the stability of the main body of the drifting buoy and judge its instability conditions. In the natural environment, the formation and movement of ocean waves is a random phenomenon, and their eigenvalues such as wave height, period and water depth are also changing randomly. In order to analyze the changes of waves on the ocean, some experts put forward the application of random process theory to waves, put forward the concept of wave spectrum, and put forward the means of wave spectrum analysis on this basis.

2.3 Build Data Frame Demand Model

In the transmission process, the concentrator multiplexes the uplink data into downlink frames with an interval of 125us in two ways. One is to receive the uplink data of each node independently; The other is to use time division multiplexing (TDMA) technology to centrally receive the uplink data of each node, and the concentrator has different processing methods for the uplink data received by these two methods. The security technology strategy of data transmission is an integrated and comprehensive solution. Mobile security access should adopt a number of security measures including terminal management and control, terminal reinforcement, channel encryption, authentication access, access control, gateway isolation and security management to build a security environment for mobile applications [5]. Unpack and sort the uplink data, sort the data to be transmitted to other nodes into frames and output to the downlink, and transmit the data to be sent to the external network to the external interface. The advantage of this method is that it improves the utilization of system channel to a great extent. At the same time, the technical means of intelligent perception and hybrid encryption are adopted in practical applications, such as adopting security technology at the transmission layer, session layer and application layer of the network, doing a good job in internal and external network data isolation, authentication access and access control, and implementing data preprocessing before data transmission. Such a comprehensive solution can play a more comprehensive security protection effect [6]. However, the concentrator is required to complete the functions of router, gateway and network management, which makes the structure of the concentrator complex and greatly increases the difficulty of implementation. The uplink data is forwarded in two ways: full forwarding and dynamic forwarding. The data forwarding mode is simple, but it is not easy to realize the data forwarding system, regardless of whether the uplink structure is simple or not [7]. The dynamic forwarding method is to monitor the node data and control the forwarding according to the data flow. The measurement data frame structure of offshore engineering buoy is shown in Fig. 1:

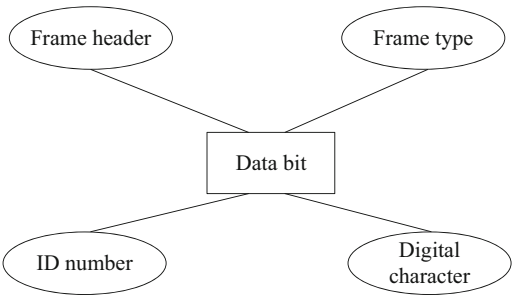

Fig. 1. Frame structure of measurement data of offshore engineering buoy

As can be seen from Fig. 1, the concept of data frame demand model is produced with the development of computer technology. Data frame demand model is a tool to describe the relationship between data content and data. It is one of the main symbols

to measure the strength of database capacity. The concept and idea of computer data modeling soon extend to the modeling of spatial data. People transform their cognition of the real geographical world into an implementation model that is convenient for mutual communication and understanding and suitable for computer interpretation and processing. This is the abstract process of geospatial. When the data flow demand is large, the transmission rate can be expanded to Zn times of the basic rate. When there is no data, the forwarding will be stopped. The complexity and efficiency of the system are between the processing forwarding mode and the full forwarding mode. In short, the efficiency of forwarding mode is lower than that of processing forwarding mode. Its advantage is that the connected equipment can be independent, the design of the equipment is relatively simple, and the system function can be increased by adding equipment. Geospatial cognitive process can be summarized into three abstract levels to realize modeling, that is, people first recognize, abstract and describe the real world, gradually obtain the conceptual model, then convert it into logical data frame demand model through coding, establishing spatial relationship and expression, and finally establish physical data frame demand model through data organization and structure. The time-sharing upload of uplink data is divided into fixed time slot upload and dynamic upload. Fixed time slot upload divides the upload channel into different time slots. Nodes upload data according to the fixed time slot. The concentrator generates time positioning data by ranging each node and transmits the time positioning data to each node to ensure time slot synchronization [8]. Dynamic upload is to send channel application when each node has data to upload, and the concentrator dynamically allocates time slots as needed. Dynamic upload mode is more efficient than fixed slot upload mode, but it is more complex to deal with.

2.4 Design Data Encryption Transmission Mode

The previous selective encryption technology of measurement data takes a specific format data as the research object, starting with the process of data coding and compression. There are many parameters involved in the coding process of multimedia data, such as I-frame data, P-frame data, B-frame data, macroblocks in I-frame, DCT coefficients or symbols, wavelet transform related parameters and entropy coding process related parameters, etc. Symmetric key cryptosystem means that the keys used to encrypt and decrypt data are the same or similar (that is, it is easy to push from one to another). Almost all mature symmetric key cryptosystems are characterized by fast encryption speed, high encryption strength (generally only strong cracking, also known as exhaustive cracking), easy implementation of software and hardware, especially suitable for encrypting large amounts of data. It is the first step of almost all data confidentiality work, With the computing power of today's computers, without symmetric key cryptography algorithm, there will be no data security and encryption. The fundamental purpose of data encryption transmission is to ensure the security of data. No matter what encryption algorithm and encryption method are used to encrypt and protect data, the effect of data encryption is the primary problem that needs to be seriously considered. Through the analysis and summary of previous studies, it can be found that in terms of encryption algorithms, most of them choose mature encryption algorithms that have been widely used and verified, such as DES, AES, RC4, RSA and so on. Through the

analysis of these parameters acting on the encoding process, some parameters that have a great impact on the encoding and decoding process are selected for encryption, so as to reduce the total amount of data encryption and ensure better encryption effect [9]. The research premise of dynamic data encryption technology is similar to the previous research on data selective encryption, which is also based on the analysis of encrypted data. Symmetric key cryptography can be divided into block cipher and sequence cipher according to different methods of data encryption. The encryption idea of block cipher is to divide the plaintext data into groups of equal size, and then encrypt each plaintext group with the key to obtain the ciphertext group. The size and quantity of ciphertext group and plaintext group are equal, that is, the encrypted data usually has no size expansion and compression. With the development of hardware technology, the bandwidth of both wired and wireless communication is greatly improved in the network, and the capacity of storage devices is also increasing in the storage aspect. Therefore, the lossy compression coding process, which aims to improve the compression ratio, is no longer particularly necessary. In this paper, the improved Logistic chaotic mapping algorithm is used as the main algorithm of data encryption transmission mode. The encryption scheme is shown in Fig. 2.

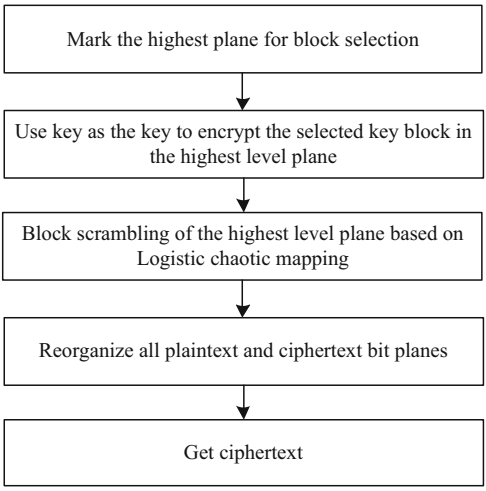

Fig. 2. Encryption scheme

Lyapunov exponent represents the numerical characteristics of the average exponential divergence rate of adjacent trajectories in phase space. It is an important numerical feature for identifying chaotic motion. It is the logarithm of geometric mean. The Lyapunov exponent of Logistic mapping is calculated as follows:

$$\alpha=\frac{1}{m}\sum_{m=0}^{m-1}\ln\left|\frac{df(\varpi,\vartheta)}{d\varpi}\right| \tag{7}$$

In formula (7), α represents Lyapunov exponent; m represents the number of iterations; f represents the mapping relationship; ϖ represents a state of the function; ϑ

is the control parameter. In terms of encryption methods, we should focus on encrypting the parts with high importance in the plaintext based on the characteristics of the encrypted data plaintext. The method of selecting the original text of fixed proportion data according to the equal spacing or random spacing has very limited practical significance, because this method does not distinguish the importance of different parts in the original text of data. Adopting this method will reduce the overall data encryption strength in equal proportion while reducing the encryption operation cost [10]. In addition, by referring to the two complete encryption methods introduced above, it is a desirable way to encrypt the less important part of the data with lightweight encryption algorithm. A great feature of most cryptographic algorithms based on this cryptosystem is iterative encryption. Iterative encryption refers to generating multiple key packets using the key and performing multiple operations with the plaintext data. The steps of each operation are often the same, but the key packets are different. After multiple operations, the ciphertext is generated, which fully realizes the confusion and diffusion of plaintext, making the relationship between plaintext and ciphertext very complex, Thus, the ciphertext has good anti statistical analysis ability and anti differential attack ability. In addition to ensuring data security and improving encryption efficiency, the dynamics of dynamic encryption technology is also reflected in meeting the needs of different security levels. Through the research and analysis of the plaintext of the encrypted data, it is not only necessary to select the most important part and encrypt it with a cryptographic algorithm with high encryption strength to ensure the data security. We should also further subdivide the importance of different parts of the data plaintext, so as to provide the possibility of encryption with different encryption algorithms to meet the needs of different security levels. The number and value range of parameters in chaotic mapping are related to the size of key space and directly affect the security of encryption algorithm. The improved logistic algorithm divides the chaotic mapping into two stages, and the number of pre iterations is significantly reduced compared with the classical logistic algorithm. The algorithm formula is:

$$\varpi_{m+1} = \begin{cases} 4\vartheta\varpi_m(0.5 - \varpi_m) \\ 1 - 4\vartheta(0.5 - \varpi_m)(1 - \varpi_m) \end{cases} \tag{8}$$

In formula (8), ϖ_m and ϖ_{m+1} represent the mapping states before and after iteration, respectively. After the vector data undergoes integer transformation, difference transformation and mean transformation, Gzip encoding is used for secondary data compression, and the compressed binary stream is encrypted. The encryption process adopts the symmetric encryption method, which is based on the improved Logistic chaotic map encryption to enhance the confidentiality of the data. In many applications, it is necessary to use or transmit lossless raw data without compression encoding. This kind of raw data generally does not have special compression coding and does not have a complex coding format, so it is impossible to select specific important parameters and apply the previous selective encryption method for multimedia data to encrypt such data. And because this kind of data is not compressed and encoded, compared with the general multimedia data that has been compressed and encoded, the data length is often several times that of the latter. So far, the design of the encryption transmission method of marine engineering buoy measurement data has been completed.

3 System Test

3.1 Test Preparation

In order to verify the security and effectiveness of the dynamic data encryption method proposed in this paper, the encryption transmission method of marine engineering buoy survey data designed in this paper is programmed. The motion performance and stability of the buoy meet the general specification requirements of the micro-buoy body. The swing period is between 1–3 s, and the maximum swing angle is less than 30° under normal conditions. For buoys with a main scale of 1.2–1.8 m, high initial stability is required between 0.3–0.4 m, and buoys with a main scale of less than 1.1 m. According to the environmental load of the working sea conditions and the functional requirements of the buoy design, and referring to the design parameters of the existing small drifting buoys, the basic parameters of the buoy body, such as the height of the center of gravity, the moment of inertia, etc. The arrangement provides the basis for the buoy to achieve optimum performance. Collect marine engineering buoy measurement data for encrypted transmission. The experimental server uses Microsoft Visual Studio as the development tool, the development language is C#, the supporting environment is Miscrsoft.Net Framework 4.6, and the database uses SQLite. The client development environment is Xamarin for Visual Studio, and the mobile GIS functions are developed based on the ArcGIS Runtime for Xamarin framework environment. The online mode directly calls the network map service published by the server, and uses the SQLite database to store the local data of the mobile terminal.

3.2 Test Results

The data volume of ocean engineering buoy measurement information is set to four Set the data volume of offshore engineering buoy measurement information to 10000 bits. Under the same experimental environment, take data encryption time and security of data encryption transmission as experimental comparison indicators, and compare and verify the method in this paper with the methods in reference [2], reference [3] and reference [4].

Four data encryption transmission methods are used to encrypt and transmit the buoy measurement information, and the time spent in encryption by different methods is counted. The comparison results of encryption time of different methods are shown in Table 1.

As shown in Table 1, the average data encryption time of the method in this paper is 2865.6 ms. Compared with the three literature comparison methods, the data encryption time of the method in this paper is reduced.

In order to further verify the performance of this method, the security of data encryption transmission is taken as the experimental comparison index, and the four methods are also tested. The comparison results of encrypted transmission security of the four methods are shown in Fig. 3.

From the comparison results of encrypted transmission security shown in Fig. 3, it can be seen that among the four methods, the method in this paper has the lowest intrusion rate, and the highest intrusion rate of the method in this paper does not exceed 0.5%. The

Table 1. Comparison of data encryption time (ms)

Number of experiments	Methods in this paper	Reference [2] method	Reference [3] method	Reference [4] method
10	2819	3401	3418	3214
20	2704	3533	3587	3395
30	2858	3459	3665	3363
40	2986	3586	3636	3225
50	2865	3648	3523	3438
60	2837	3574	3502	3406
70	3021	3418	3525	3382
80	2954	3426	3458	3201
90	2876	3535	3482	3319
100	2847	3544	3323	3460
110	2915	3558	3309	3327
120	2922	3421	3264	3448
130	2788	3430	3551	3291
140	2762	3356	3585	3138
150	2830	3491	3626	3264
Mean value	2865.6	3492	3496.9	3324.7

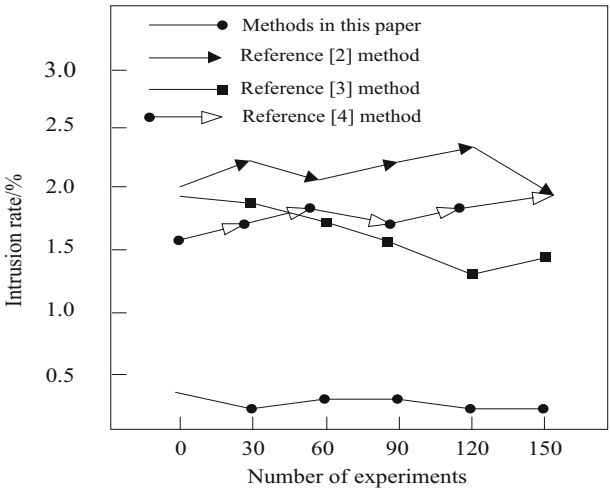

Fig. 3. Comparison results of encrypted transmission security

three literature comparison methods not only have strong volatility of intrusion rate, but also have high intrusion rate, which cannot fully ensure the security of data encryption transmission. Therefore, the above experimental results show that the method in this paper can effectively improve the security of the marine engineering buoy measurement data.

4 Concluding Remarks

In this paper, an encryption transmission method of marine engineering buoy survey data is designed, which can shorten the encryption time and ensure the security of data encryption and the availability of decrypted data at the same time. In order to improve the efficiency of real-time encryption, the raster data encryption algorithm used in this paper, the sequence generated by the chaotic map is directly operated with the plaintext in the way of stream cipher, and no plaintext feedback or ciphertext feedback is used to affect the iteration of the chaotic map. Therefore, the anti-attack performance needs to be further improved.

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