Tracking Method of Ocean Drifting Buoy Based on Spectrum Analysis

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Abstract. In view of the poor accuracy of buoy estimation and tracking results caused by ignoring the influence of the marine environment on buoys in the current tracking process of ocean drifting buoys, a tracking method of ocean drifting buoys based on spectrum analysis is proposed. By calculating the disturbing force and moment of the ocean current on the ship, the relative operating characteristics between the drifting buoy and the ocean current are obtained, and the ocean current motion model is constructed; According to the Newton Eulerian dynamic equation, the acceleration and external force of the floating body are calculated, and the motion spectrum characteristics of the floating buoy are extracted; According to the result of feature extraction, the trajectory of ocean drifting buoy is located and tracked by Kalman filter. So far, the tracking of the ocean drifting buoy is completed. The experimental results show that the tracking accuracy of this method is up to 100% without interference, and 99.81% with interference.

Keywords: Spectrum analysis · Underwater recovery · Trajectory tracking · Ocean drifting buoys

1 Introduction

Humanity has entered the 21st century, and the resources on land have been exhausted. Before human beings have found renewable energy sources, the ocean, as an untapped virgin land, has become the focus of national strategic competition, and thus has become an important field of high-tech research. my country is also a big country with 3 million square kilometers of "blue land", rich in marine resources, especially in the South China Sea, where considerable oil and gas resources have been proven, but many countries near the South China Sea are competing to exploit and plunder resources [1]. At present, many countries have clearly realized the importance of the ocean to the sustainable development of the country, society, economy and national security. In order to achieve the development goal of a maritime power, it is necessary to actively explore and develop

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the ocean. The ocean contains rich mineral resources and biological resources, and the ocean, which accounts for 49% of the earth's area, is a public area. The resources in this part of the area do not belong to any country. If a country has the technical strength, it can enjoy this resource exclusively. Independently develop this area. While developing renewable resources, people also turn their attention to the ocean. The boundless ocean not only provides human beings with shipping, aquatic products and rich minerals, but also contains huge energy. Ocean energy refers to the renewable energy attached to seawater. The ocean receives, stores and releases energy through various physical processes. These energy sources exist in the ocean in the form of tides, waves, temperature differences, salinity gradients, and ocean currents.

Only ordinary observations can only analyze the basic conditions of coastal areas and islands, and cannot play a role in ocean navigation. In order to deepen the research of marine resources, the marine buoy system has been established in the past few decades. The ocean drift buoy is an unmanned automatic ocean observation station, which is fixed in the designated sea area and fluctuates with the waves, just like the navigation marks on both sides of the channel [2]. It is not easy to affect the passing ships in the ocean, and can carry out long-term, continuous, all-weather work in any harsh environment, and regularly measure and report various hydrology, water quality and meteorological elements every day. It plays a vital role in the development and utilization of marine resources. The ultimate purpose of monitoring the marine environment is to benefit mankind. At present, there is a general shortage of energy worldwide, and the current energy shortage is increasingly becoming a "bottleneck" restricting the economic development of many countries. The development of renewable energy that can replace coal, oil and natural gas has become the focus of widespread attention. At the same time, the environmental impact brought by fossil fuels Pollution seriously affects the living environment of human beings.

There are existing literatures on the track tracking of ocean drifting buoys at home and abroad. At present, the research on track tracking of ocean drifting buoys mainly focuses on the track tracking and path following of ocean drifting buoys. For trajectory tracking problems, if conventional nonlinear control methods are used, at present, local feedback linearization and system model decoupling are mostly used. Linearization methods to solve the trajectory tracking problem [3].

The method in document [4] proposes a passive location and tracking method of short range moving target based on combined linear array, which adopts mutually perpendicular structural layout to solve the problem of single array azimuth positioning. The Kalman filter algorithm is used to predict and estimate the target trajectory, and the target positioning information is matched with the tracking trajectory information to complete the target tracking process. The method in document [5] proposes the design and research of the operation monitoring system of the marine meteorological drifting buoy, and uses the C/S framework to design the client software based on the net platform. All modules of the system are componentized, and the buoy operation monitoring system is designed by combining OpenGL, GDI+, GIS, SQL and other technologies. However, the above method has a problem of low tracking accuracy. In this regard, the tracking method of ocean driving buoy based on spectrum analysis is proposed to obtain the relative operating characteristics between the drifting buoy and the ocean current by calculating the disturbing force and moment of the ocean current on the hull, and to build the ocean current motion model; According to the Newton Eulerian dynamic equation, the acceleration and external force of the floating body are calculated, and the motion spectrum characteristics of the floating buoy are extracted; According to the result of feature extraction, the trajectory of ocean drifting buoy is located and tracked by Kalman filter. So far, the tracking of the ocean drifting buoy is completed. According to the experimental results, the tracking accuracy of the method in this paper can reach 100% at the highest under the condition of no interference, and 99.81% under the condition of interference. It can be seen that the tracking accuracy of the method in this paper is high, which can effectively improve the tracking accuracy of ocean drifting buoys, accelerate people's understanding and management of ocean resources, and have certain practicality.

2 Design of Track Tracking Method for Ocean Drifting Buoy Based on Spectrum Analysis

After a detailed analysis of the current track tracking process of ocean drifting buoys, the spectrum analysis technology is used as the core technology in this study to apply it to the track tracking process of buoys. In order to ensure the integrity of the ocean drifting buoy trajectory tracking method based on spectrum analysis, the trajectory tracking process is set as shown in Fig. 1.

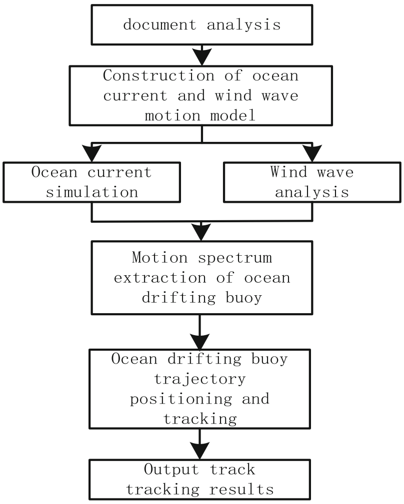


Fig. 1. Tracking process of ocean drifting buoy based on spectrum analysis

As shown in the figure above, this research will mainly address three questions:

(1) Analyze the impact of ocean currents on the trajectory of ocean drifting buoys, and overcome the impact of the external environment on the accuracy of trajectory tracking results.

(2) Analysis of the motion characteristics of ocean drifting buoys. Firstly, based on the force analysis of ocean drifting buoys, based on series expansion, it is explained that there is strong coupling and nonlinearity in the movement process of drifting buoys, and the physical constraints of the buoys and the controllability analysis are analyzed.
(3) Obtain the motion spectrum of the drifting buoy, combine it with the motion characteristics of the ocean drifting buoy, use appropriate techniques to analyze the overall motion process, and obtain the drifting trajectory of the ocean drifting buoy, so as to achieve the goal of this research.

2.1 Constructing Ocean Current Motion Model

At present, the moving target tracking technology has been widely used in various tasks on land, sea and air. The purpose of moving target tracking is to make the subject successfully track the last moving object, mainly including moving target modeling, estimation and tracking. How to extract sea surface state information from radar sea surface echo Doppler spectrum, it is necessary to understand the mechanism of the interaction between high frequency electromagnetic waves and the ocean surface. Therefore, it is necessary for us to understand the characteristics of high-frequency radar waves propagating on the ocean surface and their scattering. Since the object of this study is the ocean drifting buoy, when tracking its trajectory, it is necessary to refer to the marine environment issues and the influence of ocean currents on the movement range of the buoy. On the surface of the ocean, waves are the primary disturbance to anything. When the ocean drifting buoy is moving in the ocean, because the overall weight of the ocean drifting buoy is relatively light, the impact of the ocean waves on it is small, and it is mainly strongly disturbed by the ocean current [6]. Since the speed and direction of the ocean current change very slowly, this study treats it as a quantitative constant disturbance, and gives a formula for calculating the disturbance force and disturbance moment of the ocean current on the hull:

$$\begin{cases} X = \dfrac{\rho W A_x(\alpha) B}{2} \\ Y = \dfrac{\rho W A_y(\alpha) B'}{2} \\ N = \dfrac{\rho W A_n(\alpha) B}{2} * K \end{cases} \tag{1}$$

Among them, X, Y, and N represent the sway force, sway force and roll moment of the current on the drifting buoy, respectively; W, α are the speed and encounter angle of the current relative to the drifting buoy, respectively; B, B' are the water of the drifting buoy, respectively The transverse section and the longitudinal section of the lower part; K represents the resistance of the ocean water body; A_x, A_y and A_n are the current's sway force coefficient, sway force coefficient and roll force coefficient, respectively. In order to ensure that the calculation effect of this model is relatively stable, it is supplemented in this study. Assuming that the ocean current has a constant velocity $Q = (u_i, v_i, 0)$ in the earth coordinate system, and the velocity in the water coordinate system is $Q' = (u_i', v_i', r)$, the relationship between the ocean current velocity in these two coordinate systems can be expressed as:

$$Q = \Delta Q' \tag{2}$$

At this time, the relative velocity between the drifting buoy and the ocean current can be expressed as $V_I = (V_{Ix}, V_{Iy}, V_{Iz})$, and its relative operating characteristics can be expressed as:

$$\begin{cases} V_{Ix} = u_i - u_i' \\ V_{Iy} = v_i - v_i' \\ V_{Iz} = 0 - r \end{cases} \tag{3}$$

In the calculation, the size of the current in the vertical direction is not considered, so that the component of the current in the vertical direction is zero. The above calculation process is summarized and the ocean current motion model is constructed:

$$\kappa(t) = \kappa_0 + \sum_{j=1}^{n} e_j \cos(\varpi_i t + \zeta_i) \tag{4}$$

Where, κ represents the sea surface height, κ_0 represents the average sea surface height, κ_0 represents the amplitude of the j wave train, ϖ_i represents the angular frequency of the i wave train, and ζ_i represents the phase angle of the i wave train. Thus, simultaneous interpreting rough sea surface by waves with different wavelengths and different directions of propagation. The formula is combined with the above ocean current model as the calculation basis of the impact of external environment on buoy movement in this study. The specific construction process of ocean current motion model is as follows:

2.2 Extraction and Analysis of Motion Spectrum of Ocean Drifting Buoy

According to the ocean current motion model constructed above, the motion spectrum of the ocean drift buoy is extracted. Through literature analysis, it can be seen that the good conductor characteristics of sea water make the high-frequency electromagnetic wave spread further on the sea surface. At the same time, the propagation of electromagnetic wave on the sea surface is affected by the roughness of the sea surface, and the additional attenuation of electromagnetic wave is also different under different sea states [7]. With the increase of frequency, the additional attenuation value increases. In general, the higher the marine environmental interference, the greater the additional attenuation caused. The radar system used in this study is a fully coherent radar system, and the synchronous controller provides all timing control signals required by the system. It provides timing and control signals and interrupt request signals to each module of the system to control the coordinated work of frequency synthesizer, receiver switch, transmitter switch, sampling signal and sampling trigger signal. Through this radar system, the motion spectrum of ocean drifting buoy is obtained, sorted, extracted and analyzed.

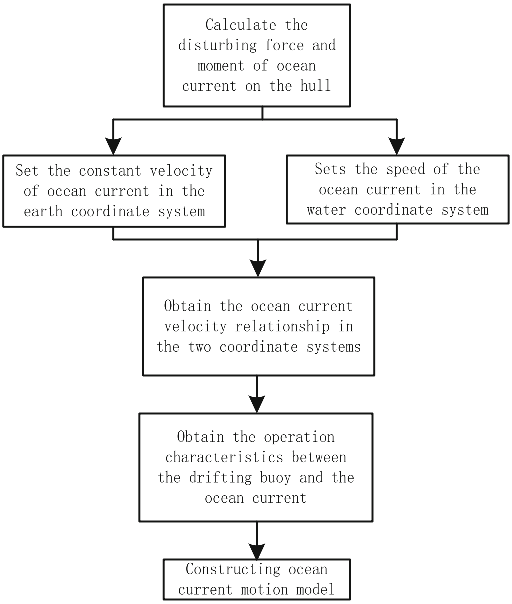


Fig. 2. Flow chart of ocean current motion model

n this study, based on the three-dimensional potential flow theory and Morrison equation, the hydrodynamic performance of the drifting buoy is analyzed, especially considering the influence of hydrodynamic interaction on the hydrodynamic performance of the buoy. The frequency domain analysis is carried out under the condition of free floating without considering the mooring system. For the ocean drifting buoy, according to the Newton Euler dynamic equation, the acceleration and external force of the floating body can be known as follows:

$$kg = F \tag{5}$$

$$[U]\overline{\psi} + \psi[U\psi] = D \tag{6}$$

Here, k is the mass of the floating body, g is the coordinate of the center of gravity of the floating body, U represents the moment of inertia, ψ represents the angular velocity of the floating body, and F and D represent the external force and bending moment on the floating body. Assuming that the rotational motion of the floating body is a small amount, formula (5) and formula (6) are simplified and combined as follows:

$$E(t) = FD \tag{7}$$

The degrees of freedom of the mass matrix, motion vector and force vector in formula (7) will be extended to $12n * 12n$, $12n$ and $12n$, where n is the number of floating bodies. The motion of multiple floating bodies is to consider the interaction of the flow field between floating bodies. First, two floating bodies are considered. By extracting the motion spectrum characteristics of ocean drifting buoys, the mass matrix, stiffness matrix and moment matrix of buoys are obtained [8]:

$$K = \begin{bmatrix} L^i & 0 \\ 1 & L^{ii} \end{bmatrix} \tag{8}$$

$$E = \begin{bmatrix} E^i & E^{i,ii} \\ E^{ii,i} & E^{ii,ii} \end{bmatrix} \tag{9}$$

$$\begin{cases} R_i = \begin{bmatrix} R_i^i \\ R_i^{ii} \end{bmatrix} \\ R_w = \begin{bmatrix} R_w^i \\ R_w^{ii} \end{bmatrix} \\ R_m = \begin{bmatrix} R_m^i \\ R_m^{ii} \end{bmatrix} \end{cases} \tag{10}$$

Superscript i and ii represent floating body 1 and floating body 2, and each floating body has 6 degrees of freedom. Where K is the mass submatrix of $12\,\mathrm{n} \times 12\,\mathrm{n}$, E is the additional mass submatrix, R_i is the delay function, [C] is the stiffness matrix, R_w is the displacement vector of the floating body, and R_m is the combined external force vector, where the force vector includes wave excitation force, drift force, wind force, current force and mooring force. The subscript N indicates the number of the object. When the subscripts are the same, it indicates the existence of a single floating body, and when the subscripts are different, it indicates the role from other floating bodies. In this study, based on the three-dimensional potential flow theory and starting from the boundary value problem, the first-order linear wave theory and the second-order nonlinear wave theory are derived by using the stoke method, and the diffraction potential theory of the drifting buoy is further analyzed. At the same time, the first-order and second-order velocity potential problems are solved by using the Green's function method (boundary element method). At the same time, the hydrodynamic interaction of the floating buoy system is determined, and the frequency domain and time domain equations of the dynamic response of single floating body and multi floating body are obtained. It provides a theoretical and analytical basis for the follow-up ocean drift buoy trajectory tracking.

2.3 Ocean Drifting Buoy Trajectory Positioning and Tracking

According to the above extracted motion spectrum characteristics of the ocean drift buoy, the trajectory of the ocean drift buoy is located and tracked by Kalman filter. The track location and tracking of ocean drifting buoy is an important link in this research. In order to track the ocean drifting buoy, we must first estimate the motion state of the ocean drifting buoy. The state estimation and prediction of ocean drifting buoy mainly includes: formation and processing of measurement data, target motion modeling, target identification and maneuver detection, filtering and prediction, etc. Motion estimation and target state estimation are very important. Common filtering methods include Kalman filter, particle filter and grey prediction [9, 10]. This chapter mainly introduces the Kalman filter, which is the most commonly used filter theory, and estimates the motion of the target based on the Kalman filter method. Before motion estimation, the buoy motion model is constructed according to the above research results. Due to the large lateral damping, the rolling motion of the buoy can be ignored in the analysis. Therefore, the following assumptions can be made:

$$B = \widetilde{B} = \delta = \overline{\delta} = 0 \tag{11}$$

Thus, the six degree of freedom spatial motion equation can be simplified to the motion in the direction of five degrees of freedom, so as to simplify the control design. Since the rolling angle and angular velocity are not included, the previous buoy motion model is rewritten assuming that the center of gravity and floating center of the buoy coincide, the size of gravity and buoyancy are equal, and the interference factors of external ocean currents are not considered. It can be seen from the optimized formula that when the longitudinal velocity $v1$ is stable, the vertical plane motion model is independent, while the horizontal plane motion model is affected by δ and $\overline{\delta}$. Therefore, it can be divided into three steps and analyzed by cascade system. The three-dimensional linear trajectory tracking of the buoy can be defined as finding the appropriate control inputs h and p on the basis of obtaining the stable longitudinal velocity $v1$ for the buoy at any initial position, so that the transverse error and vertical error tend to zero. The problems faced by trajectory tracking are the same as path following. It is difficult to obtain the model and ensure the robustness, adaptability and control performance of the system under complex environmental interference and model perturbation. Therefore, it is difficult to be applied in engineering practice. Aiming at these problems and considering the application of practical engineering, this paper proposes a trajectory tracking method of ocean drifting buoy based on spectrum analysis under the condition of ocean current interference. Referring to the pure tracking method, the motion relationship between buoys is displayed as shown in Fig. 3.

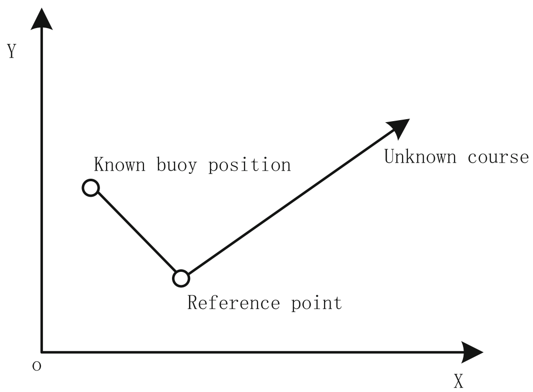


Fig. 3. Schematic diagram of buoy movement relationship

Combined with the content in the above figure, considering the original position information of the buoy, in the inertial coordinate system, the relative motion geometric relationship between the known buoy position and the target point is shown in Fig. 2, the reference line MN is selected, the drifting speed of the buoy is v'', and the speed of the target point is v''', τ and τ' are the angle between the speed of the buoy and the target point and the positive direction of MN, the distance from the buoy to the target is K, $\Im$ is the angle between the target line of sight and the reference line MN, and the movement direction of the buoy is along the line of sight direction, and finally achieve K reduced to a safe distance d, speed, $v'' = v'''$, $\Im = \Im'$. According to the above settings, the movement speed and basic movement distance of the buoy are obtained. According to this data, combined with the current trajectory tracking algorithm, the reference frequency analysis results and the marine environment simulation results, the buoy trajectory tracking in the marine environment is realized. Then there are:

$$\overline{V} = V_t + \frac{(V_{\max} + \lg(Z_{tt}) - V) * (Z_{tt}^2 - \overline{Z_{tt}})}{\sqrt{Z_{tt}^2 + \Delta_{tt}^2}} \tag{12}$$

$$\Re = a\tan(y_i - y(t), x_i - x(t)) \tag{13}$$

Among them, V_t represents the moving speed of the target point, $\overline{V}$ and $\Re$ represent the expected tracking speed and heading of the buoy; $V_{\max}$ represents the maximum drifting speed of the buoy; Z_{tt} represents the distance from the known buoy position to the unknown buoy, and Δ_{tt} represents the parameters for adjusting the calculation convergence speed. Arrange the above calculation contents to ensure the integrity and coherence of the calculation process. The calculation link set in this paper is combined with the current trajectory tracking method. So far, the design of the ocean drifting buoy trajectory tracking method based on spectrum analysis is completed.

3 Analysis of Experimental Demonstration

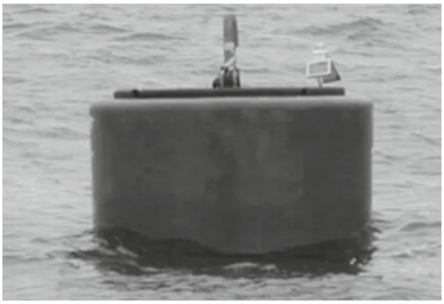
In this study, a method for tracking the trajectory of ocean drifting buoys based on spectrum analysis is proposed. Before this method is applied to practical work, an experimental link is first constructed to analyze its application effect to ensure that this method meets the current buoy trajectory tracking. Related requirements.

3.1 Experiment Preparation

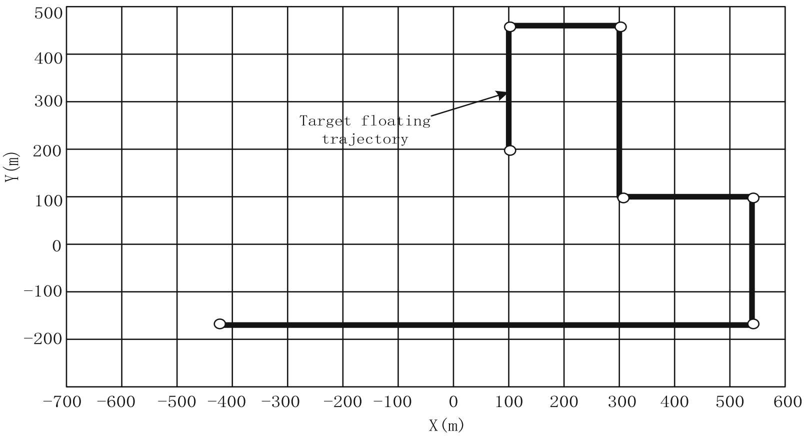
This experiment mainly carries out simulation tests on the above-mentioned buoy trajectory tracking method. Under the conditions of no interference and water flow interference, the application effects of the method in this paper, the method in literature [3] and the method in literature [4] in buoy trajectory tracking are compared. The buoy model in the simulation experiment is the same as the path following, and the calculation parameters remain unchanged. The maximum drifting speed of the buoy is set to $V_{\max} = 2.5$, and the initial drifting speed, drifting direction, position, and rudder angle are all zero in the simulation.

Assuming that the initial position of the buoy is (100, 200), it moves in a uniform straight line along the y axis at a speed of 10 m/s. at $t = 500-700$ s, the buoy makes a 90° slow turn to the x axis with an acceleration of $q_x = q_y = 0.12\,\mathrm{m/s}^2$. After the slow turn is completed, the acceleration drops to zero. At $t = 750\,\mathrm{s}$, the target makes a 90° fast turn to the y axis with an acceleration of $0.3\,\mathrm{m/s}^2$ at $t = 800\,\mathrm{s}$, end the turn, reduce the acceleration to zero, and then move at a uniform speed for a period of time. The parameters used by all methods in the simulation are as follows: weighted attenuation factor $\alpha = 0.90$, maneuver detection threshold, and exit maneuver detection threshold $T_J = 9.50$. Take the above contents as the basic calculation parameters of this experiment, and simulate the motion process of the buoy on the basis of this simulation parameters, so as to provide the basis for the subsequent experimental process.

In order to ensure the authenticity of this experiment, set the target buoy in the form shown in Fig. 4, and draw the ideal buoy trajectory according to the above simulation parameters. The specific contents are as follows.



(a) Target buoy



(b) Buoy trajectory

Fig. 4. Motion trajectory of ideal buoy

As shown in the figure above, in this study, the six segments of the motion trajectory and the distance between each two nodes are taken as an experimental segment, and the three selected methods are used to track it and compare the tracking accuracy between different methods. According to the calculation formula of accuracy index, it is set as follows:

$$A = \frac{s}{M} * 100\% \tag{14}$$

The obtained tracking result is s; M represents the ideal buoy trajectory; A indicates tracking accuracy. Use this index to analyze the use effect of different methods.

3.2 Analysis of Experimental Results

3.2.1 Analysis of Test Results Without Interference

According to the above settings, the experimental results of non-interference conditions are obtained, as shown in Fig. 5.

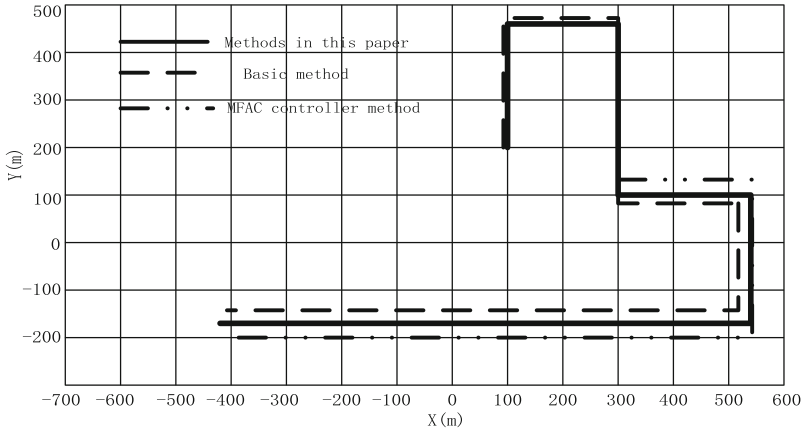


Fig. 5. Track tracking results of different methods without interference

Table 1. Track tracking accuracy of different methods without interference (unit /%)

Experimental section	The tracking accuracy of the proposed method	Tracking accuracy of method in reference [3]	Tracking accuracy of method in reference [4]
1	99.15	95.14	97.15
2	99.75	96.15	98.62
3	99.81	94.25	97.66
4	99.45	94.62	98.78
5	100.0	90.15	96.15
6	100.0	89.65	97.80

It can be seen from Fig. 5 that the trajectory tracking results of different methods are different. It can be preliminarily determined that the use effect of the method in this paper is better only through image observation. In order to make a more systematic analysis, the trajectory tracking accuracy of different methods is calculated, and the calculation results are shown in Table 1.

Through the analysis of the above experimental results, it can be seen that the tracking accuracy of the methods in this paper is above 99%, and the highest is 100%; The tracking accuracy of the method in literature [3] is 96.15% at the highest and 89.65% at the lowest; The tracking accuracy of the method in reference [4] is 98.78% at the highest and 96.15% at the lowest. The tracking accuracy of the method in this paper is obviously better than that of the method in reference [3] and that of the method in reference [4], but the overall difference between these three methods is small under the condition of no interference. By fusing the track tracking results of different methods under non-interference conditions with the track tracking accuracy of different methods under non-interference conditions, it can be seen that the tracking accuracy of each experimental section of the method in this paper is higher than that of the other two methods, and it can be seen that it has a better effect under non-interference conditions.

3.2.2 Analysis of Experimental Results of Ocean Interference Conditions

In the experimental environment without interference, the ocean current and wave interference are added to obtain the trajectory tracking results of different methods under the condition of ocean interference, as shown in Fig. 6.

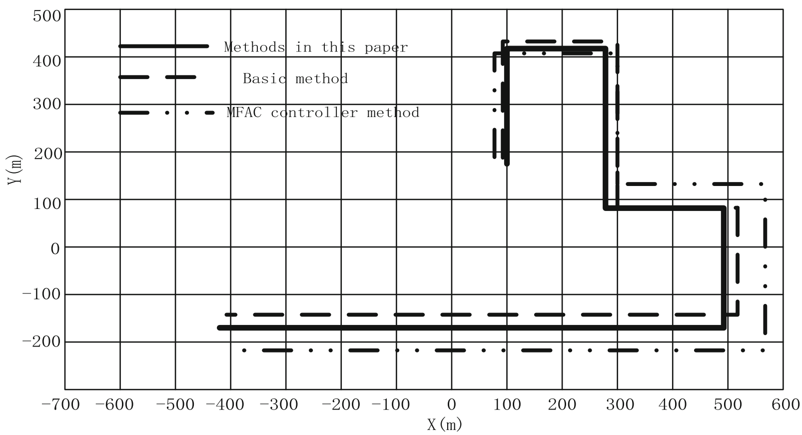


Fig. 6. Track tracking results of different methods under ocean interference conditions

It can be seen from Fig. 6 that after adding interference items in the experimental environment, the track tracking results of different methods are quite different. From image observation, we can see the price difference of the tracking effects of the two methods currently used. In order to make a more systematic analysis, the trajectory tracking accuracy of different methods is calculated, and the calculation results are shown in Table 2.

Table 2. Track tracking accuracy of different methods under ocean interference conditions (unit /%)

Experimental section	The tracking accuracy of the proposed method	Tracking accuracy of method in reference [3]	Tracking accuracy of method in reference [4]
1	99.15	89.17	91.52
2	99.75	89.68	93.51
3	99.81	88.62	93.54
4	99.45	87.94	93.44
5	98.62	89.15	92.11
6	98.75	87.05	92.77

Through the analysis of the above experimental results, it can be seen that the tracking accuracy of the method in this paper is as high as 99.81% when the ocean interference is added to the experimental environment; The tracking accuracy of the method in reference [3] is 89.68%; The tracking accuracy of the method in reference [4] is 93.51%. The tracking accuracy of the method in this paper is obviously better than that of the method in reference [3] and that of the method in reference [4]. The tracking accuracy of the method in document [3] is less than 90%. The tracking accuracy of the method in document [4] is relatively high, but not as good as the tracking accuracy of the algorithm in this paper. Combining the track tracking results of different methods under ocean interference conditions and the track tracking accuracy experimental results of different methods under ocean interference conditions, it can be seen that the method has a good effect in this experimental environment.

4 Discussion and Analysis

In this study, an ocean drifting buoy trajectory tracking method based on spectrum analysis is proposed. Through the experiments of non-interference conditions and ocean interference conditions, it is confirmed that the application effect of the method in this paper is better than the current method. For the buoy trajectory tracking problem, the spectrum analysis, water dynamics and trajectory tracking methods are applied to this study to solve the influence of water flow interference and increase the robustness of the tracking method. The simulation results show that the buoy tracking path can be obtained effectively and quickly under the influence of uncertainty.

In the process of spectrum analysis, combined with the characteristics of multi working state of radar, the design idea and specific scheme of time-sharing multi frequency/dual frequency are put forward. Multifrequency radar system is a system engineering, which needs to cooperate with multi band or broadband radar antenna and corresponding transmitting system. In the follow-up research, it is necessary to give relevant design and corresponding synchronous control sequence test results for radar control system and receiving and processing system. Buoy target tracking is a very complex problem and a research direction of great value. Due to the limitation of knowledge level and ability, this research is done under some simplified models and assumptions, so there are many places to be improved. The research on the following aspects has practical significance:

(1) This study only estimates the position of the target, does not estimate the speed and acceleration of the target, and only studies the motion estimation of the target in the horizontal plane, not the motion estimation of the space target;
(2) Although the simplified model used in the simulation verification of this study can reflect the motion characteristics of the buoy, it is not accurate enough, and in order to facilitate the design of the controller, the off diagonal elements of some model parameters are ignored. Therefore, in the future research, we should consider the actual motion characteristics of the buoy and establish a more comprehensive buoy mathematical model.

5 Concluding Remarks

In view of the shortcomings of the current methods of tracking the trajectory of drifting buoys in the application, a new method of tracking the trajectory of drifting buoys is proposed in this study. By calculating the disturbing force and moment of the ocean current on the ship, the relative operating characteristics between the drifting buoy and the ocean current are obtained, and the ocean current motion model is constructed; According to the Newton Eulerian dynamic equation, the acceleration and external force of the floating body are calculated, and the motion spectrum characteristics of the floating buoy are extracted; According to the result of feature extraction, the trajectory of ocean drifting buoy is located and tracked by Kalman filter. Complete the tracking of ocean drifting buoys. According to the experimental results, the tracking accuracy of this method can reach 100% at the highest under the condition of no interference, and 99.81% under the condition of interference, which proves that this method effectively improves the tracking accuracy of the trajectory of ocean drifting buoys, and the use effect also meets the current research requirements. This method still has some shortcomings in some links, and it needs to be optimized in future research.

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