Research on Motion Prediction Algorithm Based on Nash Equilibrium

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Abstract—The Nash equilibrium method is studied in this paper, and a new motion prediction algorithm based on Nash equilibrium is proposed. This method includes 3 main contents: 1. Analyze and abstract the influencing factors of object motion. 2. Analyze the effects of each factor and list the Nash equilibrium equation. 3. Find the optimal solution of the system of equations. Nash equilibrium method is used to attain the purpose of overall consideration of all influencing factors of motion prediction. This algorithm can solve the problem that the current motion prediction algorithm can’t take all the influence factors into account. To verify this method, this method is introduced to the ocean drift motion prediction and prove the accuracy of the method through three sets of comparison experiments.

Keywords— Nash equilibrium; motion prediction algorithm; multi factors motion prediction; ship drift motion

I. ANALYSIS ON INFLUENCING FACTORS

Ships sailing on the real sea will be affected by a complex and changeable marine environment. Drifts will change its drift trajectory under the influence of wind pressure, waves, turbulence, currents, and self-factors of the drifts. Therefore, the premise of accurately predicting the movement of ship drift model is to be able to deal with the factors affecting ship drifts reasonably.

A. Influence of wind pressure on ship drift motion

Wind pressure vector is one of the main factors which can affect ship drifts. It is the most important thing to deal with the influence of wind pressure on the ship drift model reasonably.

In Figure 1, the wind pressure is decomposed into DWL and CWL\[^1\]. The actual wind pressure drift velocity is the sum of the vectors of the wind pressure in two directions.

In Figure 1, \( w_{10} \) is the vector of wind velocity whose height is 10m, and \( \theta \) is the angle of wind pressure\[^2\].

The AP98 model requires nine different parameters\[^3\]. It includes data of three regression equations obtained by vector decomposition and linear regression from wind pressure drift data, and all those data need to be obtained from many experiments. These data include slope, intercept and standard deviation of values, etc. And these data are used to predict the ship drift model. The expression of the model can be obtained and shown in Equation (1).

\[
\begin{align*}
\text{DWL:} & \quad L_d = a_d \times w_{10} + b_d + \epsilon_d \\
\text{+CWL:} & \quad L_{\theta+c} = a_{\theta+c} \times w_{10} + b_{\theta+c} + \epsilon_{\theta+c} \\
\text{-CWL:} & \quad L_{\theta-c} = a_{\theta-c} \times w_{10} + b_{\theta-c} + \epsilon_{\theta-c}
\end{align*}
\] (1)
The wind direction can be expressed with \( \alpha \), and the value range of the wind direction has four cases, \([0°, 90°), [90°, 180°), [180°, 270°), [270°, 360°)\) and because CWL can be chosen by two cases \( \pm \text{CWL} \), so it can be summarized as Equation (2) and (3).

\[
\begin{align*}
\begin{aligned}
u_{\text{wind}} &= D \cos \alpha - C \sin \alpha \\ u_{\text{wind}} &= D \sin \alpha + C \cos \alpha
\end{aligned}
\end{align*}
\]  

In Equation (4), \( A_z \) is the coefficient of friction between wind and sea water, \( z \) is the relative depth of sea face. \( T \) is the blowing force of the wind. \( \varphi \) is the latitude of the earth, and \( \omega \) is the angular velocity of the rotation of the earth.

\[
\begin{align*}
\begin{aligned}
u_c &= \frac{V_0}{e^{-az}\cos(45° - az) + \sin(45° - az)} \\ V_0 &= \frac{V_y}{\cos \varphi} \\ \alpha &= \sqrt{2\rho \lambda u \sin \varphi / A_z}
\end{aligned}
\end{align*}
\]

\( \nu_c \) is the wind speed as the measure and it can get different wind-driven current model.

\[
\begin{align*}
\begin{aligned}

\begin{cases}
W_c &= 0 \sim 0.35 \text{knots} \\
W_c &= (0.23045 + 0.0070957V_0)^2 + 0.17 \\
V_c &\leq 18
\end{cases}
\end{aligned}
\end{align*}
\]  

In the above three methods, each has its own advantages, but in this paper, the second method is adopted in the calculation of wind-driven flow, and the wind pressure angle of wind will be chosen 45 degrees when the velocity of wind is less than 18.

2) Tidal currents

The tidal current is greatly influenced by the celestial body motion and topography, and it has obvious periodicity, so the sine curve can be used to express the development law of the tidal current. In other words, according to the sine curve, the magnitude of the current velocity at each moment can be obtained by the maximum velocity of the current. The maximum current velocity can be measured or predicted, shown in Equation (7).

\[
v = v_m \sin \Delta T / T \times 180°
\]  

3) Rivers

The effects of rivers on floating objects at sea are relatively comparative. Some researchers have made a special study of this situation. They found that the drift object is subjected to pressure drag near the estuary, and they concluded that the velocity formula of objects in the estuary is Equation (8).

\[
V = V_0 + \sqrt{m \sin \theta / B}
\]  

4) Ocean currents

Now the calculation of the magnitude of the ocean current is based on the method of combining the storage of hydrographic charts and the database of relevant current data with computer simulation, and it is better to have the actual measurement at that time.

C. Influence of wave and turbulence on ship drift motion

1) Wind-driven currents

When the size of the drift object is smaller than the wavelength of the wave, the effect of the wave is greater, and the waves also have greater thrust on drifting object. It can be described as Equation (9). And the resistance of the fluid can be expressed by Equation (10).

\[
F_w = \frac{1}{2} \rho g D C_w H_w^2
\]  

\[
F_D = \frac{1}{2} \rho B C_D V^2
\]  

2) Turbulence

The turbulence near the sea surface is very complex and changeable, so the movement of sea water is difficult to predict. The drift distance of the drift objects under the action of turbulence is as Equation (11).

\[
\Delta \alpha = R \sqrt{6K_6 \Delta t}
\]  

\( \Delta \alpha \) is the drift distance in direction \( \alpha \). \( K_6 \) is the drift disturbance coefficient of the floating object; \( \Delta t \) is the interval of time. \( R \) is a random variable, and the value of \( R \) generally takes a uniformly distributed random number between -1 and 1.
For the randomness of turbulent vortex, the randomness of Monte Carlo method can be described appropriately.

II. RESEARCH ON THE PROCESSING METHOD

How to set up a high precision and high efficiency ship drift model is one of the most important things to deal with the influence factors of ship drift. In the current researches, wind fields and current fields are the main factors affecting the ship drifts. No method can take the wind, current, wave, turbulence, the factors of the drift itself and other factors that affect the ship's drift into account the same time, thus a reasonable model of ship's drift can be obtained. Therefore, this paper presents a method to deal with the influence factors of ocean drift motion by using Nash equilibrium. This method can take all factors into account and get better results.

A. The principle analysis of Nash equilibrium method

Nash equilibrium method is an optimization method for many participants to make decisions simultaneously. Nash equilibrium can only be achieved when all parties involved have a strategy which is best for them, so Nash equilibrium is the optimal equilibrium state for all parties to consider the influencing factors.

N represents the number of participants and represents the decision variables of N participants, it can be denoted as $x = (x_1, x_2, ..., x_N)$. $x^v$ represents the decision of the $v$th participant, and $x^v$ represents the decision of the other participants, where $x^v = (x_1, x_2, ..., x_{v-1}, x_{v+1}, ..., x_N)$. Solving Nash equilibrium problem is finding $x^v = (x_1, x_2, ..., x_N)$. Therefore, when the value of $x^v$ is $x^{v-v}$, $x^{v-v}$ is the solution of the following formula.

The Nash equilibrium model is basically composed of three elements, namely the participants, the participants' decision sets, and the value functions of the participants. Nash equilibrium is that all the participants participate in the decision, then combine these decisions and choose one of the strategic combinations. At the request of the chosen strategy combination, no participant can benefit from changing his or her decision again, and the Nash equilibrium is achieved.

B. Treatment of factors

In this section, Nash equilibrium method is used to deal with multiple factors affecting ship drift motion. This paper considers the drift motion of a ship with influence factors. In the process of ship drift, these influencing factors act on the ship drift together, but each factor has different effects, the purpose of which is to optimize the speed of ship drift. To optimize the drift speed, we set up a controller. Its role is to introduce the factors to Nash equilibrium. The decision made by each factor under the decision of the controller will optimize the influence on the ship drift motion. Then the problem becomes a Nash equilibrium problem.

The following uses abstract language to describe the whole drift process.

$N$: the decision sets of each factor:

$c^{i,v}_v$: the magnitude of initial force of the $v$th influence factor when the $i$th decision is chosen;

$m^{i,v}_v$: the magnitude of initial quality of the $v$th influence factor when the $i$th decision is chosen;

$P_i$: The magnitude of the force of the Nash function when the $i$th decision is chosen;

$Q_i$: The quality of Ship drift model of the Nash function when the $i$th decision is chosen;

$e_{ij}$: Loss of force from the $i$th decision to the $j$th decision;

$CAP^{i,v}_v$: the magnitude of force of the $v$th influence factor when the $i$th decision is chosen;

$x^{i,v}_v$: the magnitude of the force of the $v$th influence factor when the $i$th decision is chosen;

$f^{i,v}_v$: the magnitude of the ship’s force when the $v$th influence factors from the $i$th decision make the $j$th decision;

$S_i$: the total acceleration of all the influence factors from the $i$th decision making the $j$th decision;

$p_j$: Drift acceleration of all influence factors making the $j$th decision:

In this way, the optimal acceleration of ship drift is transformed into the optimal solution of Equation (12).

When we deal with above formula, it is known that the problem of NEP model with n participants is finding a point within $x^v = (x_1, x_2, ..., x_N)$. This point can serve one purpose that for each $v$ in $(1, 2, ..., n)$, when $x^{v-v}$ is fixed to $x^{v-v}$, $x^{v-v}$ is the optimal solution to the problems described in Equation (13).

$$\begin{align*}
\min_{i \in N} & \sum_{i \in N} [(p_i - c^{i,v}_v / m^{i,v}_v) + (e_{ij} + e^{i,v}_v / m^{i,v}_v)] \\
\text{s.t.} & \quad \text{subject to:} \quad \sum_{i \in N} CAP^{i,v}_v \geq p_i, \quad \forall i \in N \\
& \quad p_j(S_j) - p_i(S_i) \leq e_{ij}, \quad \forall (i, j) \in A \\
& \quad x^{i,v}_v \geq 0, \quad f^{i,v}_v \geq 0 \quad \forall (i, j) \in A \\
& \quad f^{i,v}(x^{v-v}) \quad s.t. \quad g(x^{v-v}) \leq 0, \quad g(x^{v-v}) \leq 0 \\
& \quad 0 \leq G(x^{v-v}, y, x^{v-v}) \quad \forall (i, j) \in A
\end{align*}$$

Although the above treatment can obtain the optimal solution of various factors in the process of ship drift in Nash equilibrium, for the complex and changeable marine environment, some unexpected factors can always lead to the destruction of Nash equilibrium. To deal with all factors of ship drift more comprehensively, and to keep Nash equilibrium for as long as possible, this paper introduces random factors into GNEP model. The obtained optimal solution is closer to the real condition of ship drift.

In the whole process of ship drift, the velocity of ship drift can be described by inverse velocity function $p(t, \xi(\omega))$. The velocity function can be represented as Equation (14).

$$\dot{R}(t, t^{-i}) = E[t^i p(T, \xi) - C^i(t^i)]$$
The influencing factors will decide a suitable time to maximize the velocity function. It can be said that each factor has reached the Nash equilibrium when the decision of all the influencing factors can reach the goal that there is no one factor can get greater influence by changing its own decision.

Then the so-called Nash equilibrium point (SNES) refers to such a vector \( \mathbf{t}^* = (t_1^*, t_2^*, ..., t_n^*) \), shown in Equation (15).

\[
-R^i(t_1^*, t_2^* - t_i) = \min_{t_i \in \mathcal{E}} - R^i(t_1, t_2^* - t_i)
\]

(15)

According to Equation (15), the equations can be transformed into the nonlinear equations in Equation (16).

\[
\begin{align*}
\Phi(t_i, \lambda_i, \mu_i, \xi) &= p(T, \xi) + t_i(p(T, \xi) - C_i(t_i) + (\lambda_i^T G_i(t_i, \xi)) G(t_i, \xi) + \mu_i \\
\text{SAA method is used to obtain the solution of Equation (16), that is, the optimal velocity of ship drift under Nash equilibrium.}
\end{align*}
\]

III. EXPERIMENTAL VERIFICATION

In this part of the experiment, Nash equilibrium method is used to deal with the influence factors of ship drift motion. The drift velocity and direction of ships in Nash equilibrium state are predicted. The results obtained are compared with the traditional vector decomposition method and vector mapping method. Drift accuracy (including direction accuracy and velocity accuracy) of the original data is analyzed. The drift precision of the predicted results (including direction accuracy and velocity accuracy) is analyzed. The accuracy evaluation of ship drift motion is based on the error between the prediction data and the original experimental data.

Different locations of drift will change the magnitude of each influence factor. Therefore, we choose three landforms to do experiments, which are offshore drift, island drift and ocean drift respectively.

In this experiment, the drift time is limited to 24 hours. To prevent unexpected factors from causing the experiment to fail, five samples are selected to do this experiment.

A. Offshore drift motion prediction

This part of the experiment chooses the coastal marine environment. To exclude the impact of the sample itself, each method can only be used once. At the same time, each method extracts five samples and calculates the average error of their velocity and the average error of the angle. The average error is compared with the maximum relative error. The original drift parameters which are obtained from original experiment are used as a criterion for comparison. Its drift velocity is 2.7137 knots and the angle of drift direction is 0°.

Five samples of offshore drift are predicted in this part. The experimental results are shown in Table 1 and Table 2.

Table 1 is the original data from our experiment. In this table, the "-" indicates the direction, in another word, the left side of the baseline is positive, and the right side is negative. The data in table 2 get from comparison calculation. The direction angle is the absolute value.

In Table 2, the Nash equilibrium method proposed in this paper reduces the speed average error by 1.5364 knots compared with the vector mapping method. And it reduces the speed average error of 0.725 knots compared with the vector decomposition method. The experiments show that the Nash equilibrium method has a better performance than the other two methods of predicting the motion of ship drift model. The average error of the drift direction of the ship can be obtained in the experiment. The average error of vector mapping method is 2 times that of Nash equilibrium method, and the error of the vector decomposition method is 1.76 times that of Nash equilibrium method. The results show that the Nash equilibrium method is closer to the real drift result in dealing with the factors affecting the ship drift motion. At the same time, the maximum relative error in the direction of Nash equilibrium method is about 1 / 2 of that of the other two methods. It shows that the range of sample drift is more concentrated.

### TABLE I. RAW DATA OF OFF-SHORE DRIFT MOTION PREDICTION

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|------------------------|----------------------------|-------------------------|
| Drift parameter   | Speed                  | Direction                  | Speed                   | Direction                  |
| Sample 1          | 4.3217                 | 3°17'                      | 3.7612                  | -2°37'                    | 3.9983                     | -1°13'                     |
| Sample 2          | 3.5324                 | -2°49'                     | 4.6673                  | 3°07'                     | 3.0974                     | 1°37'                      |
| Sample 3          | 5.1259                 | -3°42'                     | 4.1239                  | -1°15'                    | 2.7984                     | 1°21'                      |
| Sample 4          | 6.9421                 | 2°33'                      | 3.0972                  | -2°29'                    | 4.0371                     | 1°34'                      |
| Sample 5          | 4.7452                 | 2°31'                      | 5.2437                  | 3°49'                     | 3.3378                     | -1°47'                     |

### TABLE II. DRIFT ACCURACY ERROR DATA OF THE OFF-SHORE DRIFT MOTION PREDICTION

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|------------------------|----------------------------|-------------------------|
| Drift parameter   | Speed                  | Direction                  | Speed                   | Direction                  |
| Sample 1          | 1.0080                 | 3°17'                      | 1.0475                  | 2°37'                     | 1.2846                     | 1°13'                      |
| Sample 2          | 0.8187                 | 2°49'                      | 1.3516                  | 3°03'                     | 0.3837                     | 1°21'                      |
| Sample 3          | 2.4222                 | 3°42'                      | 1.4102                  | 2°15'                     | 0.0847                     | 1°21'                      |
| Sample 4          | 4.2284                 | 2°53'                      | 0.3825                  | 2°29'                     | 1.2324                     | 1°34'                      |
| Sample 5          | 2.0315                 | 2°31'                      | 2.3300                  | 2°49'                     | 0.6241                     | 1°44'                      |
| Average error     | 2.765                  | 2°92'                      | 1.4651                  | 2°39'                     | 0.7401                     | 1°30'                      |

To sum up, Nash equilibrium method is better than vector decomposition method and vector mapping method in dealing with the factors affecting the ship drift motion. At the same time, the maximum relative error in the direction of Nash equilibrium method is about 1 / 2 of that of the other two methods. It shows that the range of sample drift is more concentrated.
with the influence factors of ship drift motion in the near-shore drift environment. Nash equalization method obtained better results of motion prediction.

B. Island drift motion prediction

In this part, the environment of experiments selected the island environment. Similarly, to exclude the impact of the sample itself, each method can only be used once. At the same time, each method extracts five samples and calculates the average error of their velocity and the average error of the angle. The average error is compared with the maximum relative error. The original drift parameters which are obtained from original experiment are used as a criterion for comparison. Its drift velocity is 2.7137 knots and the angle of drift direction is 0°.

Five samples of offshore drift are predicted in this part. The experimental results are shown in Table 3 and Table 4.

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|-----------------------|-----------------------------|-------------------------|
| Drift precision parameter | Speed | Direction | Speed | Direction | Speed | Direction |
| Sample 1          | 3.6763 | 1°26’ | 2.7794 | 2°26’ | 2.4129 | −1°24’ |
| Sample 2          | 4.3352 | 2°35’ | 5.3265 | −1°53’ | 3.0192 | 1°15’ |
| Sample 3          | 5.0973 | −3°32’ | 4.0783 | 1°26’ | 2.1368 | 1°13’ |
| Sample 4          | 5.8739 | −2°47’ | 3.3798 | −3°35’ | 2.3387 | 1°44’ |
| Sample 5          | 4.0628 | 1°49’ | 4.6574 | −3°27’ | 2.7561 | −1°26’ |

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|-----------------------|-----------------------------|-------------------------|
| Drift precision parameter | Speed | Direction | Speed | Direction | Speed | Direction |
| Sample 1          | 1.6214 | 1°26’ | 0.7245 | 2°26’ | 0.3580 | 1°24’ |
| Sample 2          | 2.2803 | 2°35’ | 3.2716 | 1°53’ | 0.9643 | 1°15’ |
| Sample 3          | 3.0424 | 3°52’ | 2.0234 | 1°26’ | 0.0819 | 1°13’ |
| Sample 4          | 3.8190 | 2°47’ | 1.3240 | 3°35’ | 0.2838 | 1°44’ |
| Sample 5          | 2.0079 | 1°49’ | 2.6025 | 3°27’ | 0.7102 | 1°26’ |
| Average error     | 2.5542 | 2°30’ | 1.9893 | 2°33’ | 0.4795 | 1°25’ |
| Maximum angle relative error | ---- | 6°27’ | ---- | 6°01’ | ---- | 3°10’ |

In Table 4, the Nash equilibrium method proposed in this paper reduces the speed average error by 2.0747 knots compared with the vector mapping method. And it reduces the speed average error of 1.5098 knots compared with the vector decomposition method. The experiments show that the Nash equilibrium method has a better performance than the other two methods of predicting the motion of ship drift model. For the relative error of drift direction, vector mapping method and vector decomposition method are not very different. Their error is about 1 degree larger compared with the Nash equilibrium method in this paper. The least relative error is the Nash equilibrium.

To sum up, the Nash equilibrium method is better than vector mapping method and vector decomposition method in dealing with the influence factors of ship drift motion in the island environment. Nash equalization method obtained better results of motion prediction.

C. Ocean drift motion prediction

This part of the experiment is carried out in the ocean environment. The ocean drift experiment selects the same method, and the same time, but each sample is used only once to obtain the raw data from the table below. The standard drift velocity is 4.2481 knots and the original drift direction is 0°.

Five samples of offshore drift are predicted in this part. The experimental results are shown in Table 5 and Table 6.

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|-----------------------|-----------------------------|-------------------------|
| Drift precision parameter | Speed | Direction | Speed | Direction | Speed | Direction |
| Sample 1          | 1.5098 | 1°26’ | 0.7245 | 2°26’ | 0.3580 | 1°24’ |
| Sample 2          | 2.2803 | 2°35’ | 3.2716 | 1°53’ | 0.9643 | 1°15’ |
| Sample 3          | 3.0424 | 3°52’ | 2.0234 | 1°26’ | 0.0819 | 1°13’ |
| Sample 4          | 3.8190 | 2°47’ | 1.3240 | 3°35’ | 0.2838 | 1°44’ |
| Sample 5          | 2.0079 | 1°49’ | 2.6025 | 3°27’ | 0.7102 | 1°26’ |
| Average error     | 2.5542 | 2°30’ | 1.9893 | 2°33’ | 0.4795 | 1°25’ |
| Maximum angle relative error | ---- | 6°27’ | ---- | 6°01’ | ---- | 3°10’ |
The results of Nash equilibrium are more close to the reality prediction of ship drift motion in the coastal and islanded areas. Nash equilibrium state, so it has a good performance in the various factors of ship drift. The Nash equilibrium method mapping method ignore these factors when dealing with environment. The vector decomposition method and vector fluctuate greatly with time in the offshore and island velocity has been improved in ocean drift test. The average because factors such as tide, ocean current and turbulence in the environment of offshore drift and island drift. This is much better than the other two methods in prediction motion. It is obvious that the Nash equilibrium method proposed by us is very different, and the Nash equilibrium method is only 0.1759 and 0.2571 lower than the two methods. The average error of the drift velocity obtained by the three methods is not very different, and the Nash equilibrium method is only 0.1759 and 0.2571 lower than the two methods.

Through the experiments of the above three environments, it is obvious that the Nash equilibrium method proposed by us is much better than the other two methods in prediction motion in the environment of offshore drift and island drift. This is because factors such as tide, ocean current and turbulence fluctuate greatly with time in the offshore and island environment. The vector decomposition method and vector mapping method ignore these factors when dealing with various factors of ship drift. The Nash equilibrium method takes all factors into account and makes each factor reaches the Nash equilibrium state, so it has a good performance in the prediction of ship drift motion in the coastal and islanded areas. The results of Nash equilibrium are more close to the reality situation.

To sum up, Nash equilibrium is superior to the other two methods in predicting ship drift motion. The results predicted by Nash equilibrium method are basically consistent with those of actual ship drift, and the sample drift range is controlled within a certain range.

### TABLE VI. Drift Accuracy Error Data of the Ocean Drift Motion Prediction

| Processing method | Vector mapping method | Vector decomposition method | Nash equilibrium method |
|-------------------|-----------------------|----------------------------|-------------------------|
| Drift precision parameter | Speed | Direction | Speed | Direction | Speed | Direction |
| Sample 1 | 5.3672 | −3°36' | 4.8776 | 4°16' | 4.3708 | −2°44' |
| Sample 2 | 4.4139 | 2°48' | 5.7621 | 2°55' | 4.7841 | 3°19' |
| Sample 3 | 4.2789 | 4°12' | 4.3907 | −3°34' | 4.3325 | 2°31' |
| Sample 4 | 5.1784 | 5°21' | 5.0972 | −3°14' | 4.5773 | −3°17' |
| Sample 5 | 4.7847 | −3°39' | 4.3205 | −3°47' | 5.0792 | 2°36' |

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The Nash equilibrium method was studied in this paper, and a new motion prediction algorithm based on Nash equilibrium was therefore proposed to attain the purpose of overall considerate all influencing factors of motion prediction. This method includes 3 main contents: 1. Analyze and abstract the influencing factors of object motion. 2. Analyze the effects of each factor and list the Nash equilibrium equation. 3. Find the optimal solution of the system of equations. The algorithm can solve the problem that the current motion prediction algorithm can’t take all the influence factors into account. To verify this method, this method is introduced to the ocean drift motion prediction and proved the accuracy of the method through three sets of comparison experiments. According to the experimental results, the Nash equilibrium method has achieved excellent results in prediction of offshore drift motion, island drift motion and ocean drift motion. In the experiment of three groups of different environments, the accuracy of motion prediction of direction and velocity was increased by 51.31%, 52.81%, 50.95%, 27.23%, 25.37% and 31.60% respectively. It is fully demonstrated that this method has a good advantage in the prediction of the drift motion of complex terrain. This method can greatly improve the prediction accuracy of ocean drift motion and reduce the range of sample drift. This research is also applicable to other motion predictions in non-marine environment. At the same time, this study also has important reference significance for other researches of motion prediction algorithm based on Nash equilibrium.
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