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LETTER TO THE EDITOR

Route Planning Model of Directional Navigation Trajectory for Port Sailing in Stormy Ocean Environment

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Based on the stormy weather conditions, the optimal planning of the directional navigation route of the sailing boat is further improved, and a directional navigation route planning model for the port sailing in the stormy ocean environment is proposed. The relationship between the stormy marine environment and the directional navigation trajectory of the sailboat is analyzed. The corresponding influence relationship is found to be affected by the three disturbance factors of ocean waves, currents and sea breeze in the stormy marine environment. The dynamic planning theory is used to construct the directional navigation route planning model for the port sailing, realizing the real-time planning of the sailing trajectory. The experimental results show that the planning time of the proposed model can be kept stable for 35s, which fully realizes the real-time planning of the directional navigation route of the port sailing in the stormy ocean environment.
Torrential rain; marine environment; sailing; directional navigation; route planning

1. Introduction

A sailing competition is a sport in which an athlete drives a sailboat at a specified distance. The climatic conditions have a great impact on the sailing competition, especially the heavy rains will have a direct impact on the safety of the sailing trajectory. At present, the meteorological navigation system of ordinary sailing ships has been perfected, mainly based on the meteorological information track tracking system with energy saving and time saving as the goal. However, sailing ships sailing on the sea are greatly affected by environmental disturbances such as waves, sea breeze and currents. Therefore, how to plan the optimal driving path for a given voyage and limited channel width with the shortest sailing time as the target The path planning of ships is more difficult. In the early 1950s, when American mathematician Bellman and others studied the optimization problem of multi-stage decision-making process, the famous principle of decision optimality was proposed to transform the multi-stage process into a series of single-stage problems. Solve one by one and create a new method to solve such process optimization problems - dynamic programming. Dynamic planning has important and extensive applications in economic management, engineering and other fields, and has achieved remarkable results.

Xun Ji, Chunfu Shao published an article in the journal Ekoloji's 2019 Issue 107, entitled: "Modeling and Analysis of Free Flow Velocity in Heavy Rain Environment Based on Geomagnetic Detector Data", the article considers bad weather, especially Heavy rains occur frequently in the world. Heavy rains have seriously affected the normal operation of urban road traffic. In order to analyze the impact of heavy rain on traffic conditions, especially the influence of free flow velocity, this paper uses geomagnetic data and meteorological data to analyze the difference between free flow rate of normal and heavy rain. Based on the matching data, a free-flow velocity evolution model with rainfall intensity under heavy rain is established by using the fitting model. This evolution model is suitable for heavy rains, but there are few studies. Then the rate of decline of the free stream velocity was studied. The results show that the free flow velocity decreases with the increase of rainfall intensity under heavy rain; when the rainfall intensity reaches 2.2 mm/min, the free flow velocity decreases by more than 40%. In addition, an inflection point was found in the relationship between free flow rate and storm intensity. The results of this paper lay the foundation for studying the impact of heavy rain on urban traffic congestion.

In order to realize the automatic measurement of the ship's navigation trajectory and its drift angle information, a real-time measurement system of ship model navigation trajectory based on laser two-dimensional scanner is designed, including laser two-dimensional scanner and three-dimensional electronic compass. 4 parts of wireless communication module, data acquisition and processing software. (Kress et al., 2016)The scanner is fixed on the bank of the river to measure the ship model target in real time to obtain the position information of the ship model. The electronic compass is fixed on the ship model to monitor the pitch, roll and heading angle information of the ship model in real time. The two parts of data are communicated via Ethernet respectively. The wireless module is transmitted back to the computer. Based on the MFC architecture data processing software system, the target data processing algorithm is designed. The two parts of the data are used to fit and compensate the ship model target center in real time. The ship model navigation trajectory is drawn in real time on the interactive interface, and the drift angle data is calculated. The experimental results show that the measurement system can meet the accuracy requirement of ±8 mm on-site measurement in a large measurement range, accurately draw the navigation trajectory of the ship model, and provide a good test method for the detection and control of the ship model navigation test.

Peng et al relies on the Automatic Identification System (AIS) data, uses cloud computing and clustering algorithm to analyze the ship's historical data by trajectory clustering, and constructs the ship's normal trajectory model to detect the ship's abnormal trajectory in real time. Lay the foundation and provide a new way to improve the intelligence level of water traffic regulation.(Salem;Seddiek, 2016) Aiming at the low efficiency of current trajectory clustering algorithm, based on Spark memory computing technology and data partitioning idea, an improved parallel sub-tracking clustering algorithm SPDBSCANST (Parallel DBSCAN of Sub Trajectory Based on Spark) is proposed. Taking the navigation data of the Wuhan section of the Yangtze River Channel as an example, the test is verified and presented by visualization. The results show that the improved algorithm's clustering efficiency and effects are significantly improved. In order to solve the above problems, the research on the route planning model of the directional navigation path of the port sailing in the stormy marine environment is proposed.

2. Idea Description

Heavy rain caused by extreme weather events such as typhoon will bring a lot of fresh water input (wet sedimentation and runoff flow) to the sea environment, which will change the salinity and nutrient concentration of seawater, and change the primary productivity of the sea area. , spatial distribution and submarine structure have changed significantly. Before the launch of sailing, it is necessary to measure the various indicators of the sea environment. When the indicators of the port sea environment are within the safe range, sailing can be carried out to ensure personal safety. According to the changes of sea surface salinity, surface temperature and nutrient salt in the sea area near the port before and after the rainstorm, we found that the surface salinity of the sea area gradually increased from north to south after the rainstorm, and the surface salinity of the sea area decreased significantly. The average value was from before the rainstorm. The 29.99 fell to 28.25 after the rainstorm. And the concentration of nitrogen, silicon and phosphorus nutrients in seawater in the port sea environment has increased significantly (Liu et al 2018). This indicates that the sea environment after the rainstorm has a large risk factor for the sailing. The original trajectory of the directional navigation of the sailboat has a large safety risk. It is necessary to re-plan the trajectory of the directional navigation of the sailboat and update it in real time. .The steps for planning the directional navigation route of a ported sail in a stormy marine environment are as follows:

2.1 Analysis of the disturbance force of sailing navigation under the stormy ocean environment

The disturbances caused by sailing ships during directional navigation are more complicated. For sailing boats, the causes of disturbances can be roughly divided into three categories: wave interference, current disturbance and sea breeze interference [4].The waves are the most important factor in making sailboats sway in the sea environment of the port. It is a random phenomenon in nature. There are many factors affecting the wave. Even under the same conditions, the wave it presents is not completely determined. The characteristic values of waves such as wave height and wavelength are randomly changed, especially in heavy rain, the change of the wave is even harder to predict. Therefore, the wave is an extremely important factor in the planning of sailing trajectory.

In general, the impact of currents on sailing during heavy rains can be equivalent to additional disturbances and moments caused by changes in the relative speed of the sailboat relative to the seawater in the port. It only affects the sailing position of the sailboat without changing the course of the sail boat. The heavy rain brings a strong sea breeze. The influence of the sea breeze on the sailing, in addition to the corresponding force and moment generated by the waves, will directly act on the various devices of the sailboat above the waterline, thus generating corresponding forces and moments. The impact of the sea breeze can be divided into two parts, namely the constant sea breeze part and the variable sea breeze part. The force of the sea breeze on the sailboat can also be divided into two parts, namely the force on the hull and the force on the sail. The force of the sea breeze on the sails became the driving force behind the sailboat.

2.2 Directional navigation route planning model for port sailing based on dynamic programming theory

2.2.1 Dynamic Programming Theory

Dynamic programming is one of the basic methods to solve the problem of multi-stage decision-making process (Huang et al 2017).The so-called multi-stage decision-making process refers to such a kind of decision-making problem: the characteristics of the problem can be divided into several interconnected and mutually differentiated stages by time, space and other signs, which need to be made at each stage of the process. Make decisions so that the entire process achieves the best results. Therefore, the selection of decisions at each stage is not arbitrarily determined. It depends on the current state of the situation and affects future development. When the decision of each stage is determined, a decision sequence is formed, which in turn determines an activity route for the entire process. The dynamic programming theory can better realize the planning of the directional navigation route of the port sailing.

2.2.2 Construction of Directional Navigation Route Planning Model for Port Sailing

The dynamic planning theory is used to plan the navigation route of the port sailing. The basic idea of the optimal navigation route planning is to use the dynamic planning idea to divide the whole course into a series of single-stage problems and solve them one by one. The proposed sailing heading decision function adopts the sequential recursive method in dynamic programming to optimize the navigation route. Under heavy rain conditions, the decision-making results of each stage of the directional navigation of the sailboat are satisfied:

$$f_k = \min\{EV_{k,j} + f_{k-1}\}$$

In the formula, $EV_{k,j}$ A comprehensive evaluation function for the heading decision in the direction of the next movement of the sailboat in the first stage. According to the decision-making results of each stage of the directional navigation of the sailboat, it is possible to dynamically plan the optimal trajectory of the directional navigation of the port sailing under the stormy marine environment.

3 Results

Matlab programming is used to simulate the optimal route planning when the wind is sailing and the wind direction is 45 degrees. The environmental parameters of the stadium are: wind direction 60°, wind speed 3m/s, sea current flow direction 40°, sea current flow rate 1m/s, sea wave direction 30°, sea wave height 1m, sea wave period 6s, sail area 10m2. The planning model of this paper is used to plan the directional navigation route of the port sailing in the stormy marine environment. The planning time-consuming results of the planning model are shown in Figure 1:

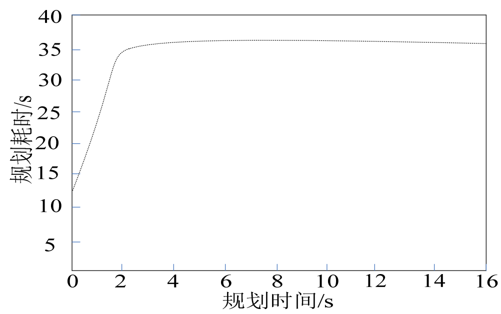

Figure 1 Planning time-consuming results of the planning model in this paper

It can be seen from the analysis of Figure 1 that in the process of planning the directional navigation route of the port sailing in the stormy marine environment, the planning time increases from the gradual upward trend to the steady trend. From 0 to 2s, the planning time is on the rise, starting from 2s, the planning is stable at 35s. It can be clearly seen that the planning model of this paper has better performance and can plan the directional navigation route of the port sailboat in real time under the stormy ocean environment.

4 Conclusion

Sailing boats sail on the sea. Under heavy rain, they are greatly affected by environmental disturbances such as sea areas, waves, sea breeze and currents. Then, according to the marine meteorological information of stormy weather and the characteristics of the course of the game, the most voyage of the whole game is planned. The excellent driving route is the key link for the game to win. This paper proposes a directional navigation route planning model for port sailing in a stormy marine environment. The experimental results show that the model can plan the directional navigation route of the harbor sailboat in real time under the stormy ocean environment.

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