Research on Ship Path Planning Algorithm Based on Coastline Model

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Abstract

With the continuous development of advanced technologies such as control theory, computer network and positioning technology, the long-distance shipping industry has developed rapidly. Due to the complex and changeable marine environment, the following problems such as low navigation efficiency and increasing frequency of marine accidents have emerged increasingly. Route planning is the embodiment of ship intelligence level, and its main purpose is to determine the best route based on optimization objectives, so as to ensure the safety and economy of ships in navigation. With the development of ship intelligence, people have higher and higher requirements for ship path planning and dynamic obstacle avoidance. Due to the complexity of marine environment, there may be various dangers when ships sail at sea, so route planning is an important link in the process of ship sailing. This paper designs a global static route planning method based on coastline model. The method can achieve the goals of fast obstacle avoidance and shortest route distance, shorten navigation time, save energy and reduce emissions, and enhance the practicability and safety of the route.

Keywords*: Ships, Path planning, Route, Optimization*

Ⅰ. Introduction

In recent years, with the continuous development of advanced technologies such as control theory, computer network and positioning technology, the long-distance shipping industry has developed rapidly [1]. Due to the complex and changeable marine environment, the following problems such as low navigation efficiency and increasing frequency of marine accidents are becoming increasingly prominent [2]. Ship path planning is to plan the optimal collision free path from the starting point to the end point for ships in a certain obstacle environment according to certain performance indicators [3]. For a long time, route planning is mainly based on Seafarers' experience and manual query on paper chart or electronic chart, which is neither time-consuming nor guaranteed to obtain the optimal route [4]. In recent years, with the emergence of various intelligent algorithms and their application to the planning algorithm, the planning algorithm has gradually developed towards intelligence and efficiency, and has achieved ideal planning results [5]. Route planning is the embodiment of the ship's intelligent level. Its main purpose is to determine the best route based on the optimization goal, so as to ensure that the ship takes into account safety and economy during navigation [6]. Safety is to ensure that the planned route can sail without collision with the non navigable area in the marine environment. Economy is to ensure that the ship follows the shortest route or the route with the least fuel consumption as far as possible.

The deviation of the ship from the planned trajectory may bring danger to the ship's navigation. However, the ship's navigation at sea is greatly affected by environmental disturbances such as waves, sea winds and currents [7]. With the continuous improvement of the density of maritime routes and the number of ships, and the impact of marine climate environment, container transport ship collision accidents occur from time to time, which not only causes huge economic losses to cargo transport companies, but also leads to serious consequences such as casualties [8]. With the continuous development of global economy, commodity trade around the world is becoming more and more frequent. As a transportation mode with the highest safety, low cost and large carrying capacity, maritime container transportation has achieved great development [9]. Compared with land, the navigation environment of marine ships is more complex and changeable, and the data processing of unmanned ship path planning is more complex. With the development of ship intelligence, people have higher and higher

requirements for ship path planning and dynamic obstacle avoidance. Due to the complexity of the marine environment, there may be various dangers when ships navigate at sea, so path planning is an important link in the process of ship navigation [10]. This paper designs a global static route planning method based on coastline model. This method can achieve the goal of fast obstacle avoidance and shortest route distance, shorten navigation time, save energy and reduce emission, and enhance the practicability and safety of the route.

Ⅱ. Requirement Analysis of Ship Route Planning System · ·

With the development of ship navigation technology, the number of navigation equipment is increasing, and more and more technical achievements of various disciplines are introduced into the field of ship navigation, resulting in the increasing scale of the system. With the development of science and computer technology, navigation has developed into a subject that continuously provides positioning, orientation, timing and speed measurement. The external navigation equipment transmits navigation information to the integrated navigation display and control console system, which receives effective navigation information through the interface and transmits the received navigation information to the interface management module and information processing module [11]. When it is found that the ship's traveling area is beyond the sea area, the system will send out two prompt modes, namely, sound alarm and text alarm, to prompt that the ship's traveling track deviates from the sea area. When the captain of the ship handles the alarm information in time and adjusts the position of the ship in the normal sea area, the alarm will be released. Parallelism of the system is very important. Generally, there is more than one external input interface of the integrated navigation display and control console system, and each interface needs to receive information. The integrated navigation display and control console system needs to process the information received at the same time, so it needs parallelism.

Ⅲ. Port Ship Dispatching Model

The original track data is processed by feature extraction, the track change feature point information is retained, and the track feature line segment is formed, which can greatly improve the query and analysis efficiency on the premise of ensuring the navigation track accuracy. In the image processing technology and computer vision technology, the starting point is to obtain the image produced by the target object by using image sensing equipment, and at the same time analyze and process the image with the help of computer technology, and extract the necessary feature information from it [12]. The starting point of image processing technology and computer vision technology is to acquire the image of the target object with image sensing equipment, and analyze and process the image with the help of computer technology to extract the required feature information. In the process of ship trajectory analysis based on image processing technology, it is very important to study the software and hardware system architecture and development process of computer.

Before the ship travels in the sea area, the chart information of the sea area will be input into the integrated navigation display and control system. When the ship travels in the sea area, the integrated path planning system will record the real-time position of the ship. The navigation information that users want is generally the information at a certain moment, but the target is always moving. The navigation information that users want is the information they need at the moment, so the guarantee of real-time makes the navigation information meaningful. Modern navigation needs not only positioning information, but also orientation, which requires high precision. In view of these requirements, path planning systems such as radio navigation, satellite navigation and inertial navigation have appeared one after another. Compared with the traditional single-machine navigation and positioning system, the ship integrated route planning system adopts cloud cluster platform to receive multidimensional navigation signals, and its architecture is shown in Figure 1.

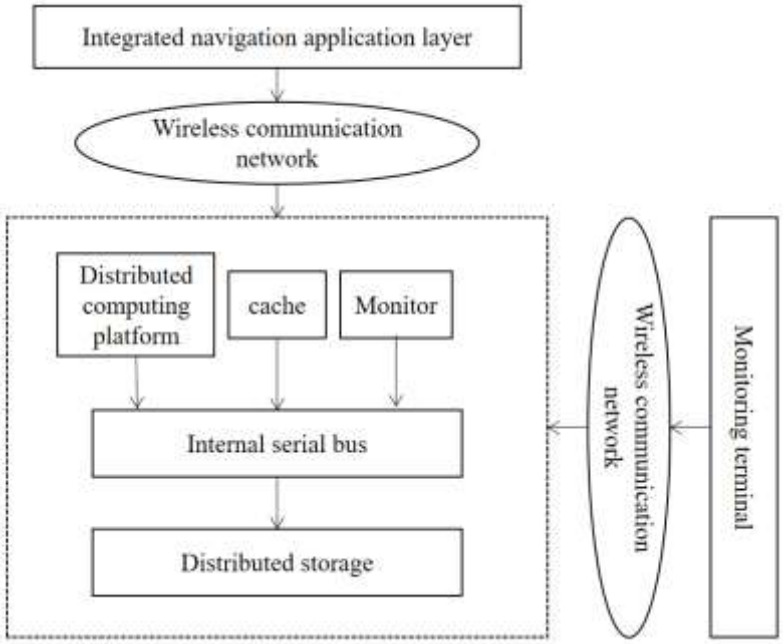

Fig.1 Cloud Platform Integrated Path Planning System Architecture

The transformation of track coordinate data realizes the storage of geographical features of ship track coordinate data and creates conditions for the application of geographical analysis of ship navigation track. In the present development process, the development of image processing technology and computer vision technology mainly depends on the technology in two fields, one is the technology of high-performance image sensor and computer and other related hardware equipment, and the other is the related software technology such as computer vision theory calculation method. The randomized path segmentation method is used to adaptively partition the port channel, and a 5-tuple representing the multi-route port channel is established:

$$Edge = \{StartID, EndID, c_a, x_a, t_a\} \quad (1)$$

Where: c_a is the directed edge of the channel in a multi-route port; x_a is the throughput of ships in the port; Edge is a directed edge; StartID is the starting point of the multi-route port grid partition; EndID is the end of the directed edge.

In the video image of ship surveillance, it is often disturbed by noise. For example, the electrical signal noise of the camera and the natural noise in the visual field environment. Therefore, in the pre-processing process, it is necessary to filter the image to remove noise, which greatly improves the computational performance of the subsequent algorithm processing. When the shipborne integrated navigation display and control console system sends data to external equipment, the processed data will be sent to the interface controller by the information processing module, and then sent to the interface by the interface controller through coding, and the data will be transmitted to external equipment through the interface. In the integrated navigation display and control station system, the fields in the access mode of navigation data mainly include latitude and longitude, speed, heading and voyage of navigation data.

Ⅳ. Multi-Route Real-Time Scheduling Strategy Based on Image Processing Technology

In the process of ship image acquisition, the remote sensing satellite will be disturbed by fog, clouds and other factors, and the remote sensing equipment itself also has a certain noise. Therefore, the initial ship trajectory image

contains a lot of noise, which requires relevant personnel to preprocess the image to achieve noise reduction and filtering. Ship basic information and real-time positioning tracking query. Establish a ship basic information database to query the detailed basic information of the designated ship [13]. By delimiting the spatial query range and specifying the navigation time interval, the ship trajectory query through a specific area in a specified time period is realized. In this part of the query content, the main focus is to obtain the ship information and ship route information passing through a specific area in a specified time interval, ignoring the detailed navigation information of each ship. In the process of collecting remote sensing images of marine ships, the difference interval between two consecutive remote sensing satellite images will have a certain impact on the image quality. Through the data mining analysis of ship navigation trajectory and the relevant experience and knowledge in the field of ship navigation, the conventional navigation trajectory and state of ships in some areas can be summarized.

Assume that the number of ships in the multi-route port is n, namely $\mathrm{N}_1, \ldots, \mathrm{N}_n$. Construct a multi-channel ship dispatching model in the entire port traffic network model. The directed edge sequence of the ship's channel is $\mathrm{L}_1, \ldots, \mathrm{L}_n$, the navigation density feature vector in the channel is $P_1^{\min}, \ldots, P_n^{\min}$, the density of the single channel lower channel is L_0, and the throughput load distribution of the up channel and the down channel is t_0 and t_j. Considering that the load of the ship in the two-way peer group is L_t, combined with the finite element analysis model, the ship scheduling is carried out in the big data environment, and the time cost of the ship scheduling is obtained as:

$$t_0 = \frac{L_0 - L_t}{P_0^{\min}} = \frac{L_j + L_t}{P_t^{\min}} = t_j \quad (2)$$

Solving for L_t can be obtained:

$$L_t = \frac{L_0 P_j^{\min} - L_j P_0^{\min}}{P_0^{\min} + P_j^{\min}} \quad (3)$$

The controller module sends the generated new route to all ships through the dynamic ship route scheduling algorithm, and the controller can add the new route and additional information of the current nearby ships to the dynamic ship route data for updating the route data in real time. There is a very obvious black-and-white boundary between the edge area and its adjacent area in the ship remote sensing image, so it is necessary to use edge detection technology to extract the edge information of landmark points. In the actual ship remote sensing images, most of the edges are slope edges, and the gray level near the edges will change gradually [14]. The monitoring area demarcation function provided by the system can not only meet the monitoring needs of users in different geographical areas in different periods, but also have the real-time monitoring and early warning function for multiple monitoring areas in the same period. Taking any starting point as the center, the algorithm of bypassing obstacles is used to find the nearest customary route, then the nearest route is used as the starting route, and the customary route is used to find the shortest distance to reach the port.

Due to the change of offshore conditions, the original route planning schedule is usually deviated. Considering that the specific navigation state and trajectory mode of ships in different geographical areas will be quite different, and at the same time, the user's criteria for judging the abnormity of ships in the monitoring area will also be different. Figure 2 shows the framework of ship navigation detection and tracking system using dense disparity variance technology.

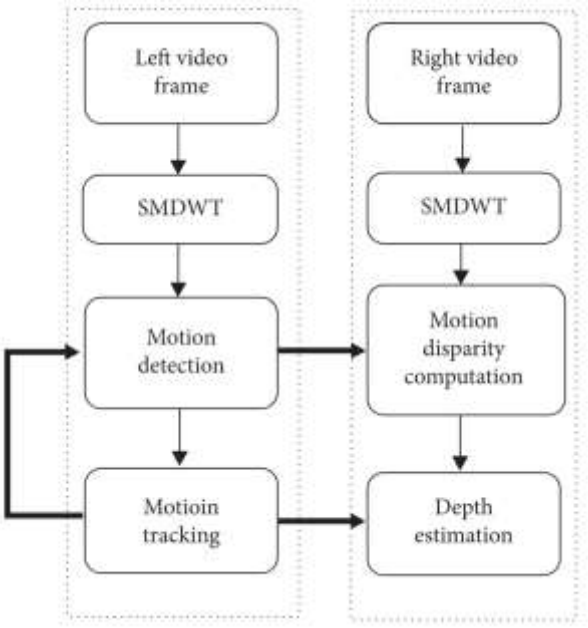

Fig.2 Ship Navigation Detection and Tracking System

In the colorful information society, video images contain a lot of information. It can be used as the carrier of objective things, and at the same time, it can vividly describe and intuitively express objective things. The purpose of computer vision is to realize the perception, understanding and interpretation of scenery and environment, so as to realize the simulation of human vision by computer. A good target tracking algorithm often needs to deal with a large amount of data per frame image, which requires a lot of operation time. The intelligent monitoring system adopts computer vision and digital image processing technology, and adds intelligent video related modules to the monitoring system based on pattern recognition. Images collected during ship navigation are usually disturbed by noise to varying degrees, and noise may be introduced in some link of image processing to interfere with the results. These noises will affect the imaging quality of the image, make the image unclear, and even lead to the loss of image features, which brings difficulties to the analysis. Usually, the faster the background model is updated, the better the effect order of the motion region is.

Ⅴ. Conclusions

With the rapid development of land-based positioning and navigation technology, marine positioning and navigation technology has also made considerable progress, with higher precision and wider application. Ship route planning plays an inestimable role in both civil and military fields, and it is an indispensable powerful weapon to show the comprehensive national strength. In the image processing technology and computer vision technology, the starting point is to obtain the image produced by the target object by using image sensing equipment, and at the same time, analyze and process the image with the help of computer technology, and extract the necessary feature information from it. The global environment static model is the basic model for route planning, and the real global environment model can well reflect the marine environment information and ensure the reliability of route planning. In the integrated navigation display and control station system, the fields in the access mode of navigation data mainly include latitude and longitude, speed, heading and voyage of navigation data. With the development of navigation sensor technology, network technology, information fusion theory, computer technology and chart display technology, integrated path planning system will develop towards automation, multi-function, multi-mode, high precision and high reliability.

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