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REVIEW ARTICLE

NEW TECHNOLOGY AND NEW APPLICATION OF AUTOMATIC COLLISION AVOIDANCE FOR SHIPS UNDER THE STRATEGY OF E-NAVIGATION

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ABSTRACT

At the present stage, the world is vigorously developing the marine economy, and China has also attached greater importance to the implementation of the strategy of a strong maritime nation. In this context, e-navigation strategy has become an important direction of modern navigation. In order to enhance the combination of artificial intelligence, information technology and shipping, this paper explores the new technology and new application of automatic collision avoidance for ships under the e-navigation strategy, combines AIS technology, electronic charts and other technologies, and analyzes the application of new technology in collision avoidance for ships, in order to better guarantee the safety of ship navigation.

KEYWORDS

Ship Navigation Collision Avoidance, Blockchain, Big Data, Cloud Computing, Communication Technology

1. INTRODUCTION

At present, the International Maritime Organization (IMO) is promoting the strategy of e-Navigation, aiming to enhance the Informa ionization of navigation, and at the same time, promote the development of navigation science and technology, especially the development of ship driving automation and navigation intelligence, which can reduce human errors and reduce the workload of the navigating personnel, and play an excellent effect in ship navigation collision avoidance (Yan et al., 2023). With the arrival of the intelligent era, the development of navigation technology is facing the opportunities and challenges of the new era and must be reformed and innovated to keep pace with the times.

2. THE BASIC PROCESS ANALYSIS OF SHIP AUTOMATIC COLLISION AVOIDANCE

According to the actual navigation environment at sea, the basic process of automatic collision avoidance is shown in Figure 1.

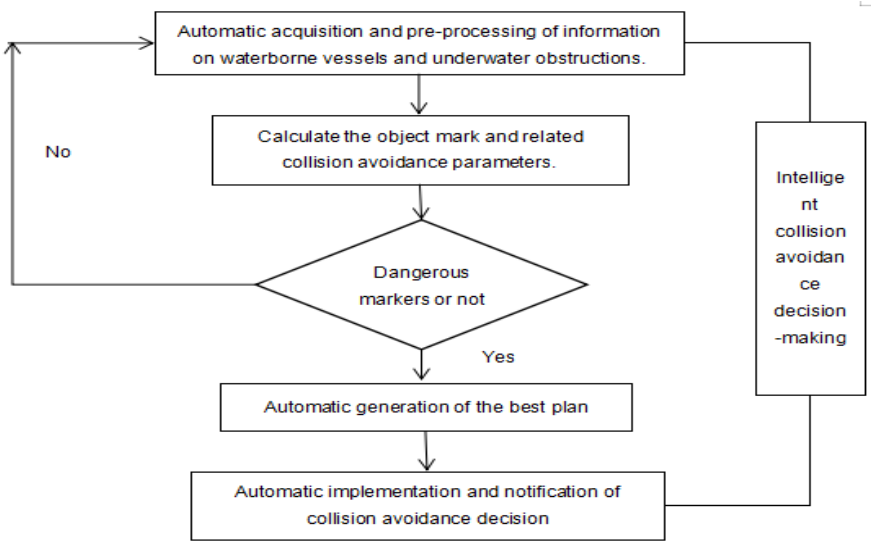

Figure 1: Basic process of automatic collision avoidance for ships

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Generally speaking, ship automatic collision avoidance should contain the following basic processes:

2.1 Identification and extraction of avoidance objects

Including the automatic acquisition and pre-processing of the information of waterborne ships and underwater obstructions, the dynamic information of waterborne ships can be obtained with the help of AIS, RADAR/ARPA or the fusion of the two ship information as the source of information and it is assumed that these sources of information are stable and reliable, whereas the information of underwater obstructions is extracted from the database of electronic nautical charts.

2.2 Processing of collision avoidance information

The basic data of collision avoidance include the position, speed, distance, relative bearing and other collision avoidance data of all kinds of avoidance objects, which will be used as the input information for collision avoidance decision support (Congping et al., 2023).

2.3 Automatic Generation of Dangerous Judgment and Optimal Decision Making

This step is the key point of automatic collision avoidance for ships, how to recognize the danger and how to take safe avoidance actions to get past all ships W and static obstructions is the core part of the intelligent collision avoidance automatic decision-making process (Rui, 2023). Under the premise of observing COLREGs or seafarers' common practice and excellent seafarers' good shipmanship in avoiding collisions between ships; determining a safe and economical avoidance scheme is the basic requirement for the automatic collision avoidance technology to be put into use on the real ship, any kind of automatic ship avoidance that leaves aside the COLREGs has a humongous seafaring practice and can not be accepted by the drivers of the ship.

2.4 Increase Intelligent Reminder

In nautical practice, the use of ship's VHF is very frequent, especially in the situation of multi-ship encounter, the use of VHF for ship negotiation collision avoidance is accepted by the majority of the crew, but due to the constraints of the language barrier, the use of this method will sometimes be counterproductive, delaying the avoidance of the best time to cause collision accidents, and with the rise of new navigation equipment such as AIS, ECDIS and so on, the operation of the automatic ship avoidance process is not easy to avoid (Bazhao, 2023). With the rise of AIS, ECDIS and other emerging navigation equipment, the automatic notification of the ship's intention to maneuver and the division of the avoidance responsibility and obligation of the ship's automatic collision avoidance process becomes possible, so on the basis of the original traditional automatic collision avoidance decision-making, which is only the automatic solution of its own avoidance scheme, the function of intelligent reminder of the avoidance responsibility of the dangerous yielding target ship can be further increased.

To summarize, a robust automatic collision avoidance decision support system should have the following basic features: the system should monitor all kinds of objects in the navigation environment in real time, and be able to give a safe and economical avoidance plan in real time under the premise of meeting the COLREGs or the seafarer's usual practice and the excellent seaman's good shipmanship (Yingjie, 2023).

3. New Technology and its Application of Automatic Collision Avoidance for Ships Under E-navigation Strategy

3.1 Application of AIS technology

In the process of practical application, the advantages of AIS technology are reflected in the large amount of information, target display, anti-weather interference, etc. As one of the sensors to support the realization of ship collision avoidance automation, it can provide more information for the decision-making, and as a source of information to promote the efficient acquisition of ship radar information. At the same time, during the operation period, the AIS technology can be used to transmit the intention to the target ship in the form of SMS, and synchronize the sending of relevant dynamic information of the ship, which involves the avoidance timing, recovery timing, avoidance range, and so on (Jun et al., 2021). In the design of collision avoidance system, the main modules include FPGA interface design, AIS information acquisition, DSP design and so on. For the design of AIS information acquisition module, it is necessary to achieve strict compliance with the flow chart of the application during the design period, and the specific design flow should include system initialization, 6-bit binary code, bit allocation, data calculation and display, and so on. As an important premise for the realization of ship collision avoidance automation function, AIS can be used as a carrier for the exchange of relevant data during ship navigation, thus providing reference for the thermal analysis of the navigation line, combining with the analysis of the heading planning and the surrounding weather, etc., and formulating the navigation control countermeasures that meet the actual collision avoidance requirements. Compared with the application of traditional collision avoidance mode, the collision avoidance automation based on AIS technology can avoid the impact on ship safety due to the personnel's subjective judgment errors, and realize the effective solution to the confusion of radar information (Yun and Jianhui, 2021).

Figure 2: AIS System

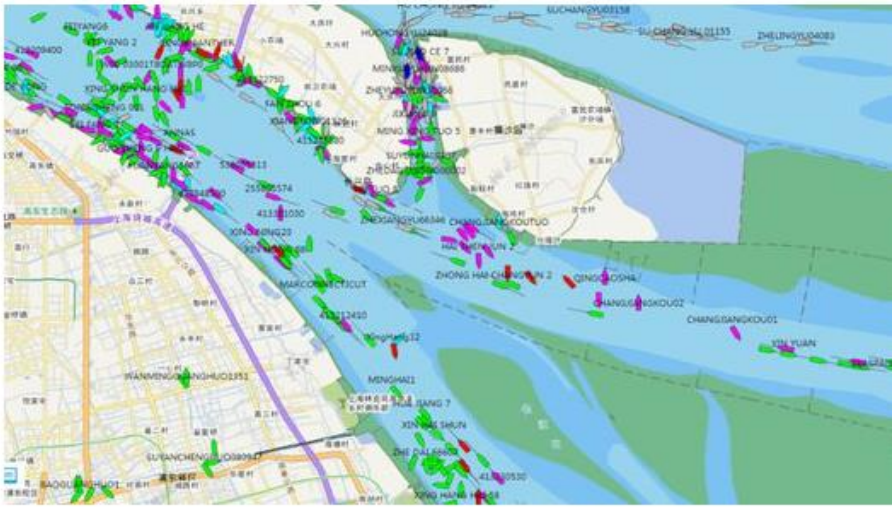

Figure 3: Vessel position localization

The AIS system combines MMSI code and GPS to accurately locate the position of registered vessels. The shore station can quickly obtain the specific information of the ship within the range, and at the same time, the ship can also obtain the static data such as the ship name, ship's captain, call sign, cargo type, etc. of the neighboring ships installing and using AIS in real time by means of the AIS system, and also know the dynamic data such as the heading, speed, position and relative distance, so as to communicate and coordinate in time, and take the necessary avoidance actions, which is of great help to the safety of the ship.

3.2 The role of digitization of chart information

At the present stage of ship navigation process, the effective application of chart information digitization in collision avoidance system can promote the significant improvement of ship collision avoidance ability, break through the limitations of previous collision avoidance system, and realize the control of ship collision accidents within the expected range (Xiancheng et al., 2020). At the same time, in the process of realizing collision avoidance automation function, the chart information technology can play the following roles: one is to comprehensively and quickly obtain the relevant static information of the ship, and the other is to achieve the organic fusion of the dynamic collision avoidance information and the static information, and to provide support for the safe navigation of the ship through the improvement of the collision avoidance system's information processing capability. In addition, in the process of actual use, the chart information digitization system consists of electronic display, sonar detection, information processing system, etc., through the integration of the sub-module system to realize the broadening of the scope of the ship's collision avoidance information collection. To maximize the role of chart information digitization, the ECDIS module can be set up according to the analysis of collision avoidance automation requirements, which provides the basis for the formulation of collision avoidance decision-making and combines the construction of dynamic and static interactive platforms to promote collision avoidance functions to give full play to (Hongbo, 2020).

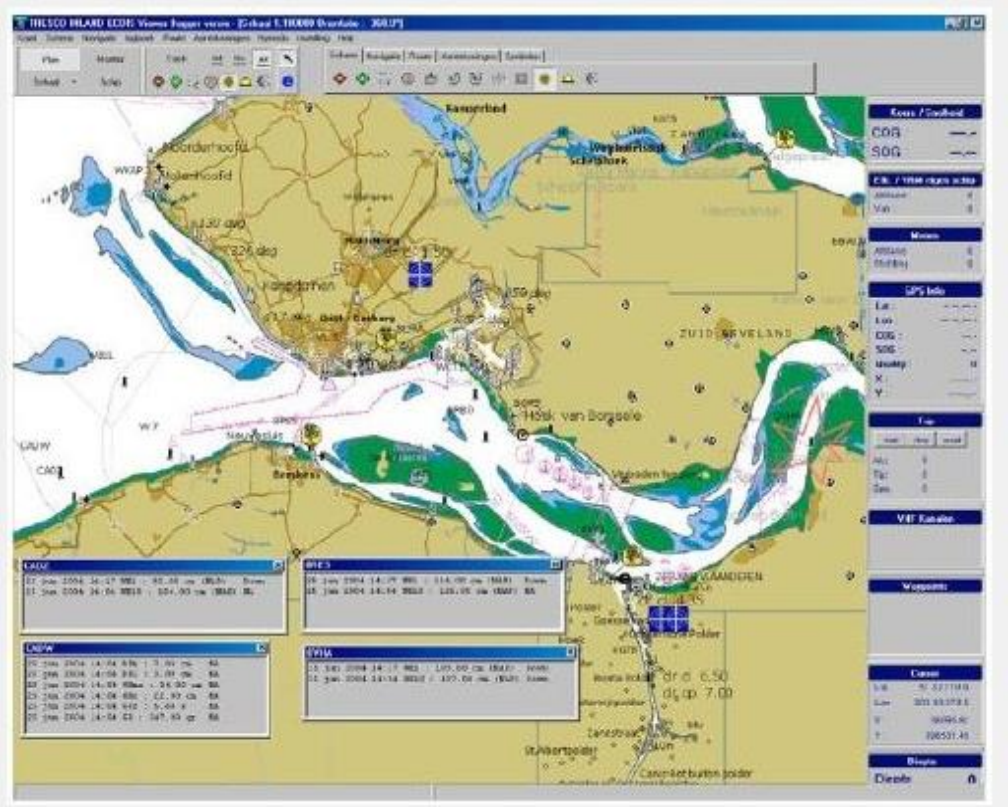

Figure 4: Electronic Chart Display System (ECDIS)

3.3 Monitoring and Alarm

In order to give full play to the functions and roles of the collision avoidance automation system, signal acquisition can be carried out on the basis of LAN field bus, and the effective construction of monitoring and alarm system can be combined to achieve the purpose of effective warning. According to the analysis of the operation requirements of the collision avoidance system, the industrial control computer is used as the management basis to realize the comprehensive collection of ship collision information and rapid response (Haicheng, 2019). In the actual operation process, the big screen in the control room will display the measurement and scanning parameters intuitively, and if one of the detection values is lower or higher than the threshold, the monitoring system will automatically issue an alarm, and the big screen will independently carry out the real-time update of the measurement values. At the same time, the monitoring and warning system can monitor the sensor operating status, if the sensor failure, abnormalities during use, the system will issue an early warning and pinpoint the location of the fault to help maintenance personnel to solve the problem at the first time. In addition, the monitoring system operation stage of the large screen can be done on the overall monitoring interface display, if the management personnel need to tour the measurement of parameter points to view, you can click on the parameter points of the measurement point form, by opening the function buttons to pop up the dialog box. Under the premise that the measurement value exceeds the threshold value, the monitoring system will automatically form an acoustic and visual alarm, and the management personnel can click "mute" to eliminate the alarm after grasping the situation, and the system is equipped with the function of real-time storage of the ship's measurement data.

4. Conclusion

Accompanied by the implementation of the e-navigation strategy and the increasing frequency of international trade exchanges, marine navigation technology is also facing the urgent requirement of upgrading. And ship collision avoidance, as the key direction of new navigation technology, should be combined with modern information technology, application of AIS technology, monitoring alarms, chart information digitization technology, etc., to continuously improve ship automation system, enhance the level of ship collision avoidance, and then enhance the safety of navigation.

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